European Transport Policy and Cohesion: An Assessment by CGE Analysis

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Abstract

This paper studies the spatial impact of two main aspects of European transport policy, namely infrastructure investments and pricing. In its "White Paper: European Transport Policy for 2010: Time to Decide" the European Commission has laid down a comprehensive programme of transport policy within the EU, aiming at increasing the efficiency of the transport industry, developing the so-called trans-European infrastructure network and bringing the prices of transport services closer to the true marginal social cost. It is an important political issue whether the policy will enhance spatial cohesion in Europe or run counter the objective of a balanced economic development in the entire area of the EU. For one thing this is because spatial development objectives are themselves prominent goals among the catalogue of objectives to be attained by transport policy. Particularly infrastructure investments which are co-financed by the structural funds, are regarded a means of regional policy supporting less favoured regions. Furthermore, transport policies motivated by efficiency or environmental reasons may have undesired regional side effects, that could generate political backlash, unless one offers some compensation. The spatial impact of the two named policies is studied with the help of a spatial computable general equilibrium model, called CGEurope. It is a static model with a large number of regions covering the whole area of the EU including the new member states, plus neighbouring countries, some of them also subdivided by regions. Regions interact by trade flows. Interregional trade is costly, with trade costs depending inter alia on the state of infrastructure and on gasoline prices and infrastructure charges. Transport policies are simulated by varying the costs of transport and quantifying the impact on the welfare of households brought about by changes in goods and factor prices. We develop a series of policy scenarios and evaluate their impact an spatial equality or inequality using a whole bundle of indicators of spatial inequality. The paper documents theses scenarios, explains the modelling framework in brief, discusses the inequality indicators to be used and maps and tabulates the main results.

Keywords: Transport Policy, Impact analysis, Spatial CGE Model

I. Introduction

The European Commission has launched a comprehensive programme for the European transport policy with its White Paper on European Transport Policy with the aim to eliminate bottlenecks in transport by building up Trans-European Networks of Transport (TEN-T) and to guarantee fair and efficient pricing of transport. The aim of the transport infrastructure package that was promoted in the European initiative for growth was to support the European growth objective of the Lisbon agenda and to support territorial cohesion for Europe. That is why much of the invested sum that goes into the financing of the TEN-T is financed by structural funds, e.g. by the cohesion fund. In the last revision the list of priority projects of the TEN-T of 20 projects has been extended to a list of now 29 priority projects. Furthermore, we will also study the impact of the further projects also called TEN as well as projects suggested by TINA for Eastern Europe, which are not priority projects, but are also co-financed by the European Union. The second big issue in European transport policy is the issue of transport pricing to internalise the external costs of transport that are generated by users of transport and to establish a price structure that better reflects the marginal social cost. First initiatives have been made to introduce toll systems that collect tolls from those vehicle types which generate the biggest amount of external cost, heavy goods vehicles that cause a considerable amount of environmental damage, noise, accidents and time lost through congestion on the network, just to name the most important sources of external costs of transport.

In this paper we will analyze what are the benefits of the European regions that arise from infrastructure and transport pricing policies in a series of policy scenarios. We apply a spatial general equilibrium model, the CGEurope model, to evaluate the benefits for the NUTS-3 regions of Europe. The model evaluates the welfare benefits due to the change of transport costs caused by the policy packages which are analysed in each policy scenario. Changes of transport cost also mean changes in prices that have to be paid by consumers and firms, of prices obtained by firms, and of factor prices. The impact of these changes in prices is evaluated in terms of relative equivalent variations, which measure utility changes on a money-metric scale. We furthermore analyze the impact of the policy scenarios on the spatial income distribution by applying measures of cohesion. We assess, if these policy packages are successful in promoting cohesion in the enlarged European Union. This paper presents the main results of our research for the research projects IASON, funded by the fifth framework programme of the EU, and ESPON 2.1.1 “Territorial Impact of EU Transport Policies", funded by Interreg IIIb.

The structure of this article is as follows: first the model framework for the analysis is described verbally, followed by the description of the policy scenarios, which were analysed. We describe the model outcomes and their evaluation with respect to a set of cohesion indicators and derive possible policy implications.

II. Model Description

This section briefly describes the CGEurope model that is applied to the impact assessment. For a complete description of the model we refer to recent papers and reports describing the model in more detail, e.g. Bröcker (1998a, 1998b, 2000) and Bröcker et al. (2004). CGEurope is a comparative static non-monetary spatial computable equilibrium model. The world is subdivided into 1373 regions. 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 mainly non-tariff barriers like language barriers, differing 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. Households are the owners of the factor stocks in their respective regions of residence. Disposable income stems from returns on regional production factors 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 introduced for technical reasons only. They allow for keeping the budgets of the agents balanced without explicitly modelling interregional flows of funds. Transfers in real terms 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. With regard to labour, this amounts to assuming a natural rate of unemployment which is held constant by the appropriate wage adjustments. 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 (Dixit and Stiglitz, 1977). 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 may stem from producers in different regions. Therefore relative prices of tradables react on changes of interregional transfer cost. These changes induce substitution effects and further price effects on goods and factor markets, that eventually lead to welfare changes in the regions.

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 horizontally differentiated output, requiring a certain amount of fixed cost per variety, plus constant marginal cost. Hence, the 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.

Monopolistic competition allows for modelling additional welfare effects of transportation cost changes that would not be present in traditional perfect competition models. Due to economies of scale on the firm level, the size of markets influences the cost or well being of downstream firms or consumers. If transportation cost is reduced, firms and consumers buying tradables may gain not just from the cost reduction for transferring goods, but also from increasing product diversity due to entrance of new firms into the market. A cost reduction may however also harm a consumer: if I was a household with good access to a location that looses demand due to a demand shift to other places, I would suffer from a decline of product diversity in my place. Effects work in the opposite direction, of course, in case of a transfer cost increase.

III. The Database

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 NewCronos database 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 country. 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 has been obtained from OECD data and partly national sources for the CEEC.

Goods prices in the model differ between origin and destination by interregional transfer costs. Costs representing a reference situation without the respective policy measures in place ("without-costs") are used for calibrating the benchmark equilibrium. For policy simulation, costs representing a situation after introducing the respective policy ("with-costs") are substituted for "without-costs". Cost calculations are based on shortest routes through the multi-modal network developed and maintained by Schürmann, Spiekermann and Wegener (IRPUD, 2001). The network contains data for all major links in Europe, including their specific characteristics of speed limits and likelihood of congestion.

In order to allow for simulating EU transport infrastructure policy, the road and rail networks comprise 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) as well as latest revisions of the TEN guidelines provided by the European Commission (1999; 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.

Costs for interregional goods transfer are both functions of travel 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 as well as salary and opportunity cost of the business traveller. The parameter values for both components stem from the SCENES project (ME&P, 2000, pp. 38-42). Transport costs are computed for three transport modes, road, rail and air, and for two travel purposes, freight transport and business travel.

Transfer costs for goods flows are assumed to incur two types of costs, namely freight costs and costs of personal contacts for exchanging business information. These costs are measured as costs of passenger business travel. Both types of costs, freight costs as well as passenger travel costs are multimodal costs, composed of costs for road, rail and air. It is assumed that users choose between modes according to a logit choice model, which is the standard and well established approach in mode choice modelling. 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 so-called logsum):

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

c_{rsm} is the cost from r to s for mode m, α_m is a parameter representing mode-specific preferences, γ is the semielasticity measuring the sensitivity of choice with respect to cost differentials, and c_{rs} is the composite cost from r to s. Logsums according to Equation (1) are computed for both, business passenger travel and freight. The semielasticities stem from the SCENES project already mentioned, the α-parameters are calibrated such that observed aggregate modal shares are reproduced in the equilibrium solution. c_{rsm} is measured per ton and per person for freight and passengers, respectively, while we need per value costs for calibrating the model. Per ton numbers are translated to per value numbers by scaling c_{rs} such that aggregate freight costs in the model's benchmark solution coincide with observed freight cost. A similar approach applies to business travel.

In addition to the transfer costs just described, an extra cost category is introduced for international trade, representing impediments to international trade. If a pair of regions belongs to different countries, then the trade costs between these regions are increased by a specific mark-up factor for this country pair. One cost component per pair of countries is calibrated such that international trade flows generated in the models' equilibrium are equal to observed trade flows for each pair of countries. It is well documented in the literature, that cross border transactions are much smaller than transactions within a country, everything else being equal (Bröcker, 1984; MacCallum, 1995; Helliwell, 1998). This holds true within the present EU, but even more so for transactions between EU countries and other countries and those among other countries. This is due to a wide range of barriers to interaction ranging from institutional differences, different languages and cultural barriers to obvious costs like time costs for border controls outside the Schengen area, or tariffs, quotas et cetera outside the EU. Omitting this cost component would lead to a severe overestimation of cross border flows and hence to a bias in project evaluation in favour of cross border links.

IV. Model Output

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; 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 monetary equivalent is Hicks' measure of equivalent variation (see e.g. Mas-Colell, Whinston and Green, 1995, p. 82), expressing the amount of money one had to pay to the household in the “without-world” in order to make him as well off as he would be in the “with-world”. The amount is of course negative if the household suffered from a utility loss. 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.

It is important to note, that the distribution of the revenues of the charges and the way of financing of the specific road or rail projects in the scenario is not considered in the analysis. The calculated impact isolates the effect from using the infrastructure and paying the charge from the effects arising from the distribution of the revenues or the burden of financing the infrastructure. Considering that revenue from a toll is earmarked to building and maintaining road infrastructure, it is not modelled endogenously which projects could be realised with the revenue. Regarding infrastructure scenarios, especially in tax-financed infrastructure projects, it is difficult, if not impossible, to obtain information on financial sources and their spatial distribution.

As all pricing policies to be evaluated consist in raising extra charges on top of present user costs, and as the revenues are not channelled back into the economy ("revenue-burning"), welfare effects are obviously negative. This does of course not mean that charging Pigouvian taxes for externalities in transport is a welfare loss. The very reason why one wants them to be introduced is the expected welfare gain due to internalising the externalities. The apparent loss in our results is entirely due to the neglect of revenues. We are not interested here in the overall net welfare effect, which our approach is not apt for. What we want to focus on is the spatial distribution of the effects due to charging the user.

V. Policy Scenarios

In this section we define the infrastructure and pricing parameters that are changed in the four policy scenarios. The first scenario is a transport infrastructure scenario of the extended list of priority projects that have been recommended by the High level group on European transport policy (see High Level Group, 2003). This list contains the projects of the Essen list (see European Commission, 2002a, 2002b) plus additional projects mainly located in the new member states. The list of projects is shown in table 1.

Table 1: List of priority projects

Priority project		Countries covered
Rail network		
1	High speed train combined transport North-South, w. Messina bridge	DE, AT, IT
2	High speed rail Paris-Cologne-Amsterdam-London	FR, BE, NL, DE, UK
3	High speed rail south: Madrid-Barcelon-Montpellier/Madrid-Dax	ES, FR
4	High speed rail Paris-Karlsruhe/Luxembourg/Saarbruecken	FR, LU, DE
5	Betuwe line Rotterdam-Rhein/ruhr	NL, DE
6	High-speed rail Lyon-Venice-Trieste/Koper-Ljubljana-Budapest	FR, IT, SI, HU
8	Multimodal link Portugal-Spain-Central Europe	PT, ES, FR
9	Rail Cork-Dublin-Belfast-Larne-Stranraer	IE, UK
11	Øresund rail/road link	DK, SE
12	Nordic triangle	SE, FI
14	West coast main line	UK
16	High capacity rail across the Pyrenees, freight line Sines-Badajoz	ES, FR, PT
17	High speed train, combined transport East-West	FR, DE, AT, SK
20	Fixed link Fehmarn Belt	DE, DK
22	Rail Athina-Kulata-Sofia-Budapest-Vienna-Praha-Nuernberg	GR,BG,HU,AT,CZ,DE
23	Rail Gdansk-Warsaw-Katowice-Brno/Zilinia	PL. CZ, SK
24	Rail Lyon/Geneva-Basel-Duisburg-Rotterdam-Antwerp	FR, DE, NL, BE
26	Multi-modal link Ireland/UK/continental Europe	IE, UK, BE, FR
27	Rail Baltica	EE, LT, LV, PL
28	Eurocaprail Brussels-Luxembourg-Strasbourg	BE, LU, FR
29	Intermodal corridor Ioannian Sea/Adria	GR
Road network		
1	Fixed link road/rail Messina bridge	IT
7	Greek motorways (Via Egnatia, Pathe), motorways in BG / RO	GR, BG, RO
8	Motorway Lisboa-Valladolid	PT, ES
11	Øresund rail/road link	DK, SE
12	Nordic triangle	SE, FI
13	Ireland / UK / Benelux road link	IE, UK, BE
20	Fixed link Fehmarn Belt	DE, DK
25	Motorway Gdansk-Katowice-Brno-Vienna	PL, CZ, SK, AT
26	Multi-modal link Ireland/UK/continental Europe	IE, UK, BE, FR

No other infrastructure development is included. This scenario gives insight into the impacts of the current political priorities concerning transport infrastructure development.

In the second scenario the complete list of TEN and TINA projects for road and rail transport plus corresponding infrastructure in Norway and Switzerland is realised. This is a long list of projects co-financed by the European Union. The full description of these projects can be found in the respective documents of the European Commission (see European Commission, 1999 and 2002a) and the TINA Secretariat (see TINA Secretariat, 1999, 2002). The scenario includes also the Motorways of the Sea which are treated as part of the road network for freight transport. We show a map (Figure 1) of the projects to illustrate the road and rail links which are added to the transport networks.

The third scenario is a road pricing scenario, applying a toll to the entire road network in the area of the extended EU plus Bulgaria and Romania (so-called EU 27). Other modes are not subject to an extra charge. We have chosen a charge of 10% of the original price for road transport as the charge to be collected. We assume that this charge is collected on all links that are located within the EU-27. We do not make any assumption about the revenue that could be collected from this charge, but we model the impact of this charging scheme on the regional welfare that arise from the higher prices for freight transport due to this charge.

The forth scenario is a combined infrastructure and pricing scenario. In this scenario we apply a charge of 10% of transport prices on all modes of transport, for passenger as well as for freight transport. At the same time, we assume an infrastructure development according to the list of TEN and TINA projects as in the second scenario. This scenario is for evaluating the combined effect of both types of transport policies, and is supposed to represent a realistic policy scenario for the two decades to come.

VI. Scenario results

The model outcomes of the scenarios are illustrated in Figure 2 to 5. The maps display the relative equivalent variation, i.e. the monetary equivalent of the welfare gain, given as a percentage of GDP. Gains in utility are marked in red colour, losses in blue colour. The darker the colour, the bigger is the respective welfare gain or loss. In table 2 we show the overall effects of the respective scenarios for the whole area of the EU-25 including the two candidate countries Bulgaria, Romania, Switzerland and Norway, which we call EU-27+2. Furthermore, the effects for EU-15 and for the 10 accession countries including Bulgaria and Romania (AC-12) are shown.

Table 2: Aggregated welfare changes, percent of GDP

	Priority Projects	TEN/ TINA	Road Pricing	TEN/TINA+Pricing
EU27+2	0.144	0.262	-0.285	-0.092
EU15	0.144	0.251	-0.285	-0.103
AC12	0.165	0.504	-0.281	0.174

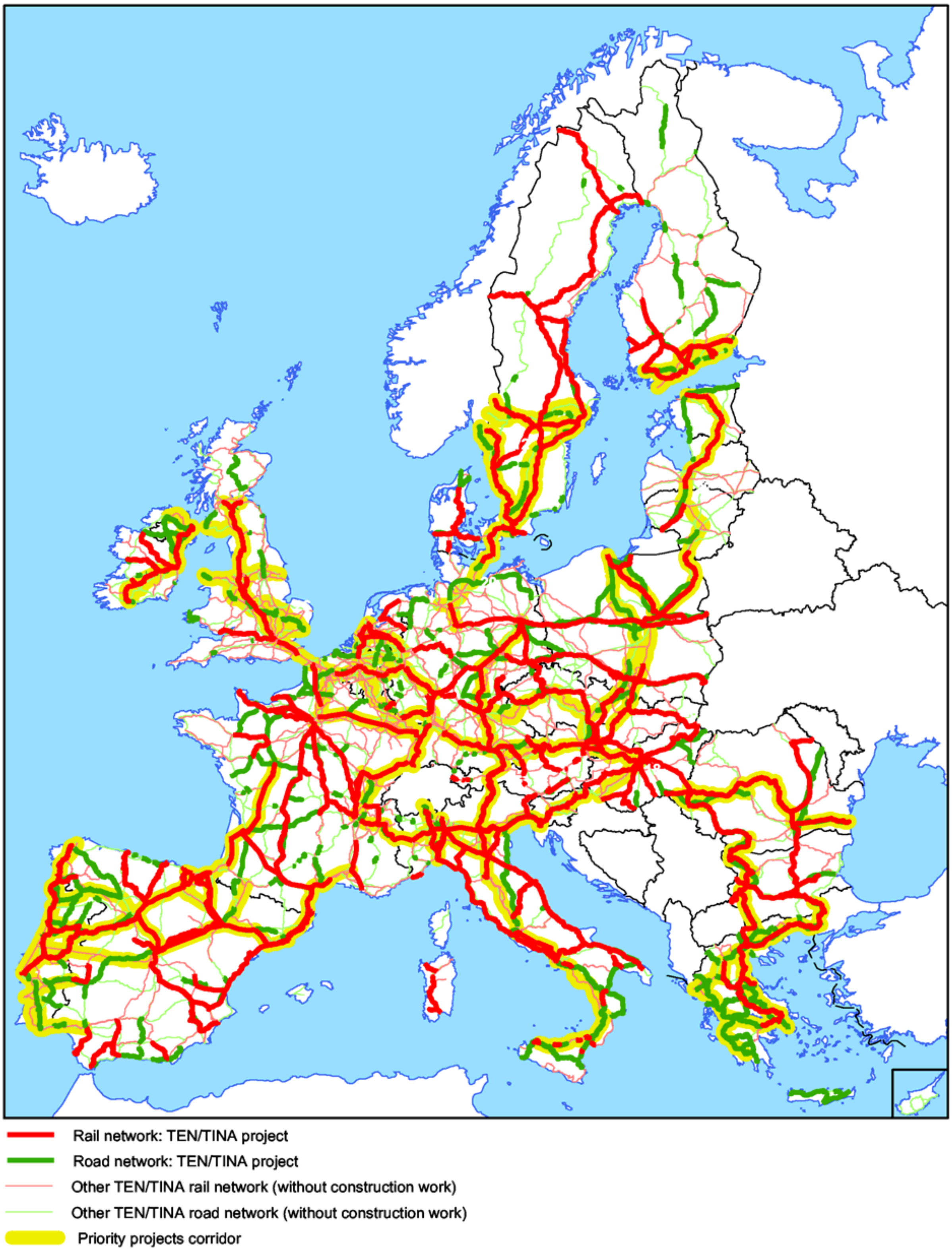

Figure 1: TEN and TINA rail and road projects

Scenario 1: Implementation of the TEN priority projects
This scenario covers the projects of the TEN priority projects, including the extensions proposed in 2004. The overall effect of the policy package seems small in relative terms: 0.144% of GDP of the area of EU-27+2, that is including the prospective members Bulgaria and Romania plus Switzerland and Norway. Yet given predicted costs of the projects of 225 billion €, the annual return would be almost 7% p.a., using the 2004 Figure on the EU27+2 GDP of € 1.08 10^{13} p.a. (Eurostat, online access). This would be an acceptable rate of return, though it must not be taken at face value. On the one hand, returns will increase with an increasing GDP, but on the other hand maintenance has to be subtracted. Above average benefits (0.210% on average) are observed in the objective-1 regions, a desirable outcome from a cohesion point of view. Furthermore, the so-called Pentagon, the central area of the EU marked by the cities London, Hamburg, Munich, Milan and Paris, gains less than the average (0.093 %). The distribution of the benefits is displayed in Figure 2.

A couple of individual projects have a strong regional impact, such as the Nordic triangle plus the Øresund and Fehmarnbelt fixed links, the projects on the Iberian peninsula, the Irish road and rail projects, the road link and West cost main line in Britain and the Greek motorways. In some cases gains generated by a certain link spread over a large area in the prolongation of the respective link. Cases in point are the Italian West coast south of Naples plus Sicily participating in the gains from the North-South high speed train (No. 1 from the Essen list), the French West coast participating in the gains from the multimodal link Portugal-Spain-Central Europe (No. 8), or North-East Germany and North-West Poland participating in the gains at the Northern end of the North-South high speed train.

The new projects that have been added to the Essen list show additional positive impacts in Eastern Europe, especially in Poland, the Czech Republic, Hungary and Western Romania. Furthermore, the additional projects in England and Ireland and the railway axis Lyon/Genova-Basel-Duisburg-Rotterdam/Antwerpen cause extra positive impacts in England, Ireland and the Benelux.

Scenario 2: Implementation of the full list of TEN and TINA projects
This is the most comprehensive scenario containing projects that cover more or less the whole area of EU-27 except Switzerland. The overall effect of this scenario is a gain of 0.262% of GDP for the EU-27+2 area. Most regions are positively affected. Only a few gain almost nothing like Paris, East-England and some central regions in Germany and agglomerations in Italy. Accession countries gain almost the double of what EU-15 countries gain, in relative terms. Note, however, that in per capita terms gains are still smaller in accession countries because of the lower level of per capita GDP. The distribution of the benefits in this scenario is shown in Figure 3.

Scenario 3: Pricing policy for road freight transport
An interesting spatial pattern emerges from SMCP, that leads to a general increase in travel cost and transportation cost. Note that, in order to isolate the spatial effect of the pricing itself, we assume no redistribution of revenues. Revenues are "burnt". Exactly the same spatial pattern would emerge, if a lump-sum redistribution proportional to GDP instead of burning was assumed. Only the level would be different, the weighted average of effects would be close to zero. In fact it would be slightly negative, because the welfare loss exceeds the

revenue slightly. Note, however, that this is only the case because the intended welfare gain resulting from internalisation of externalities is not included in our model. Neither do travel times react on a reduction of travel flows induced by higher out-of-pocket costs, nor is an improved environment felt by the households as a utility gain in our model. We repeat this in order to emphasise that the overall negative welfare impact of the pricing scenarios must not be misinterpreted as a statement against efficiency gains from SMCP. Our experiments just isolate the effects form the cost side.

The spatial pattern is an overlay of two centre-periphery patterns, a national and a European one. Within each country, regions with a high market potential suffer from the smallest losses, those in the national periphery lose most. This is most clearly observable in large countries like UK, France, Germany, Spain, Italy and Poland, but even in smaller countries such as Greece (see the light colour around Athens on the map in Figure 4) or Denmark. These national patterns are overlaid by a similar, though less pronounced pattern on a European scale, so that regions suffer most, which are far from national as well as from European markets, such as Portugal, Scotland, Southern Italy or Northern Norway and Finland.

Scenario 4: Combined infrastructure development and pricing

This 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 as clear as for the others, because two patterns overlay: the pattern of the pricing effects showing a tendency of harming the periphery in relative terms, and the pattern of the infrastructure effects with a certain tendency to favour the periphery.

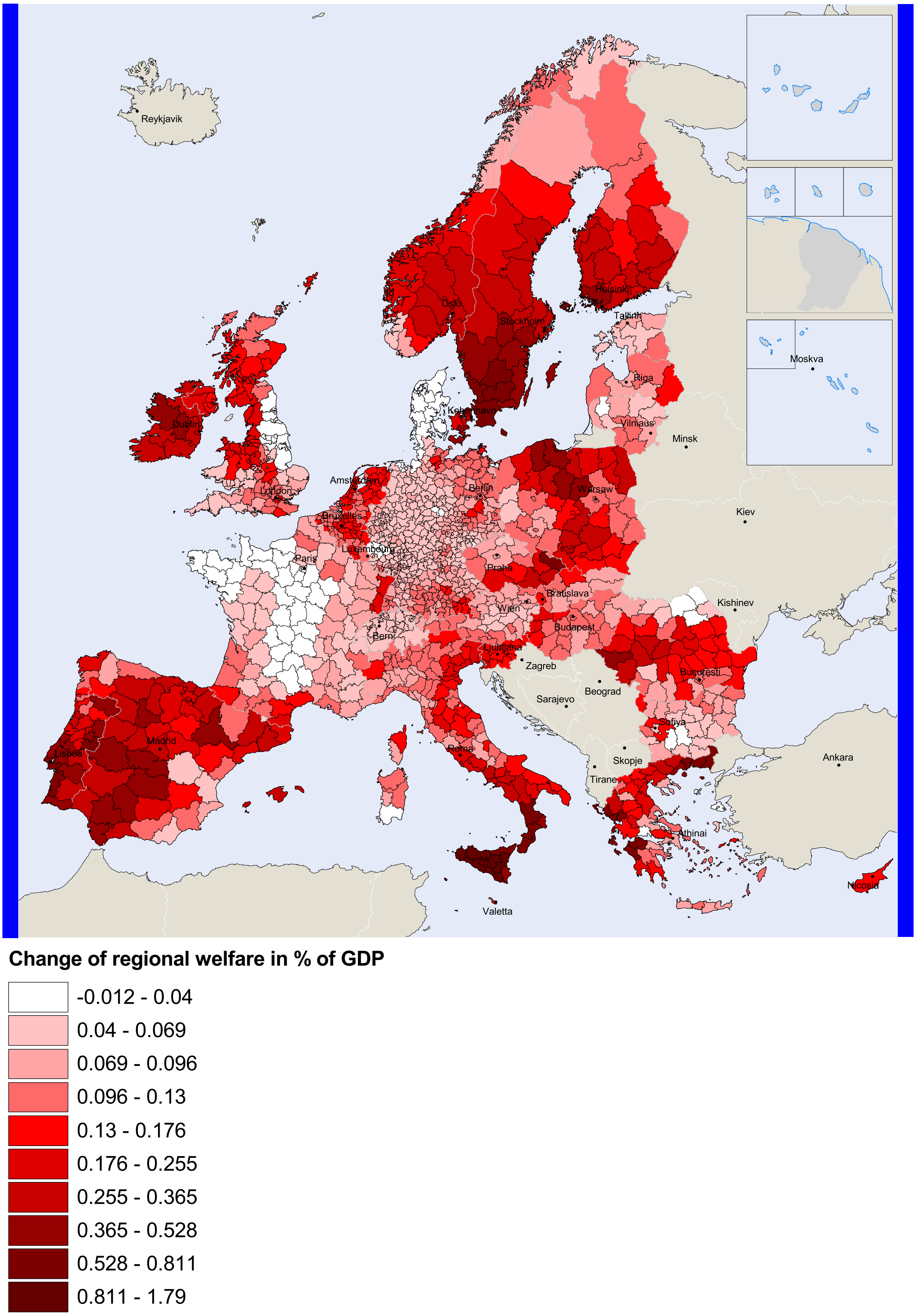

Figure 2: Implementation of new list of priority projects for road and rail

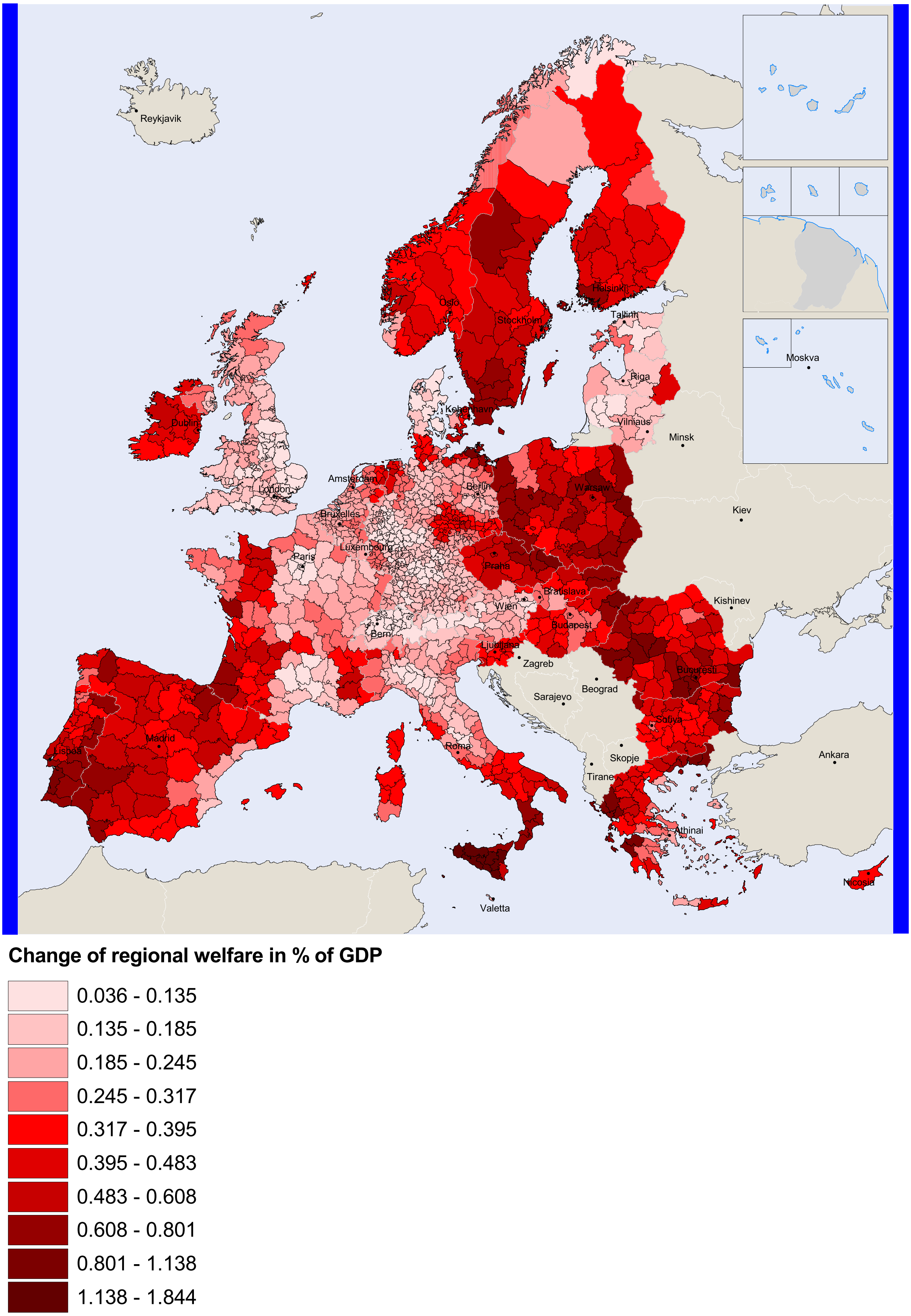

Figure 3: Fast implementation of the TEN and TINA projects

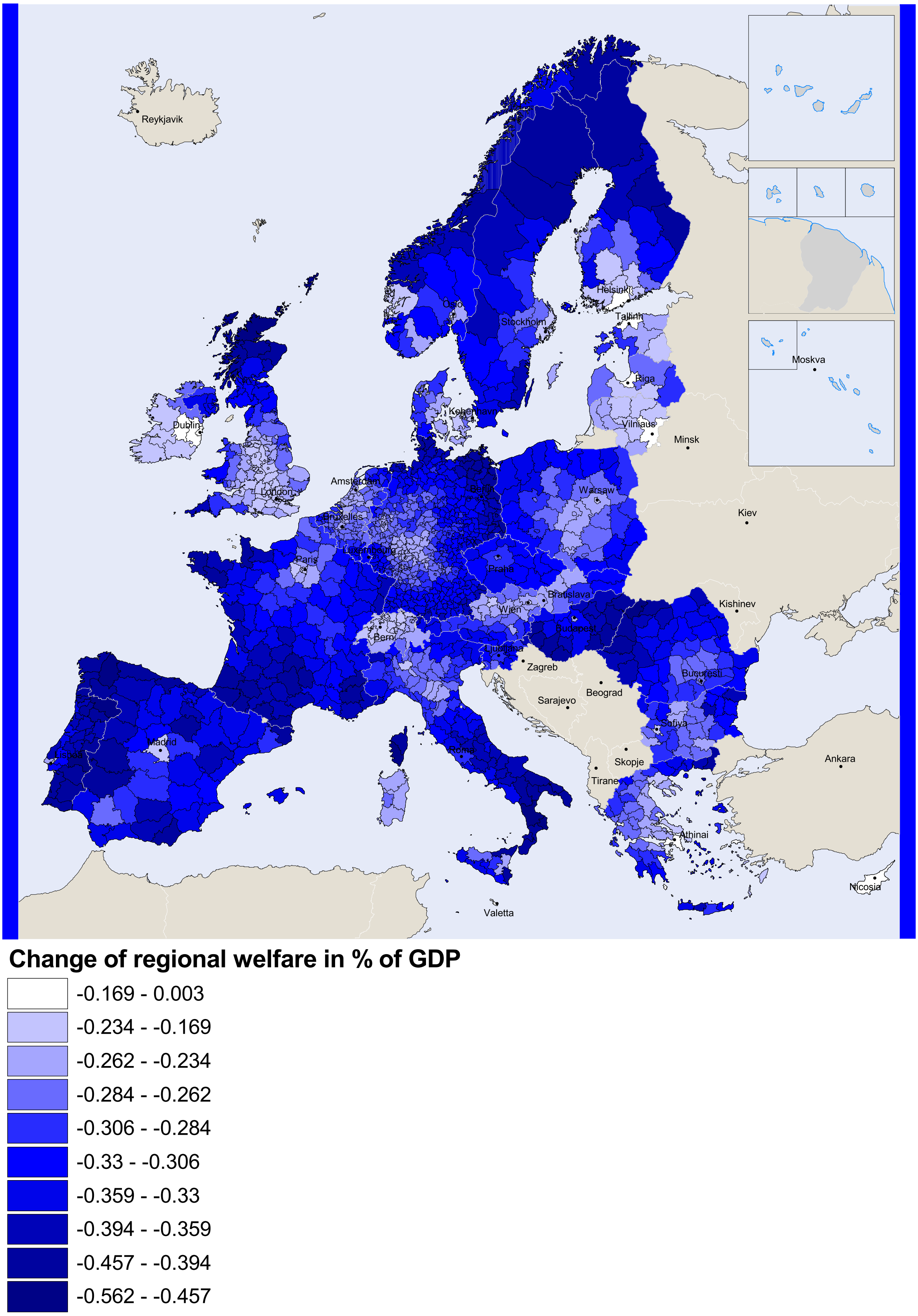

Figure 4: Pricing applied to road freight

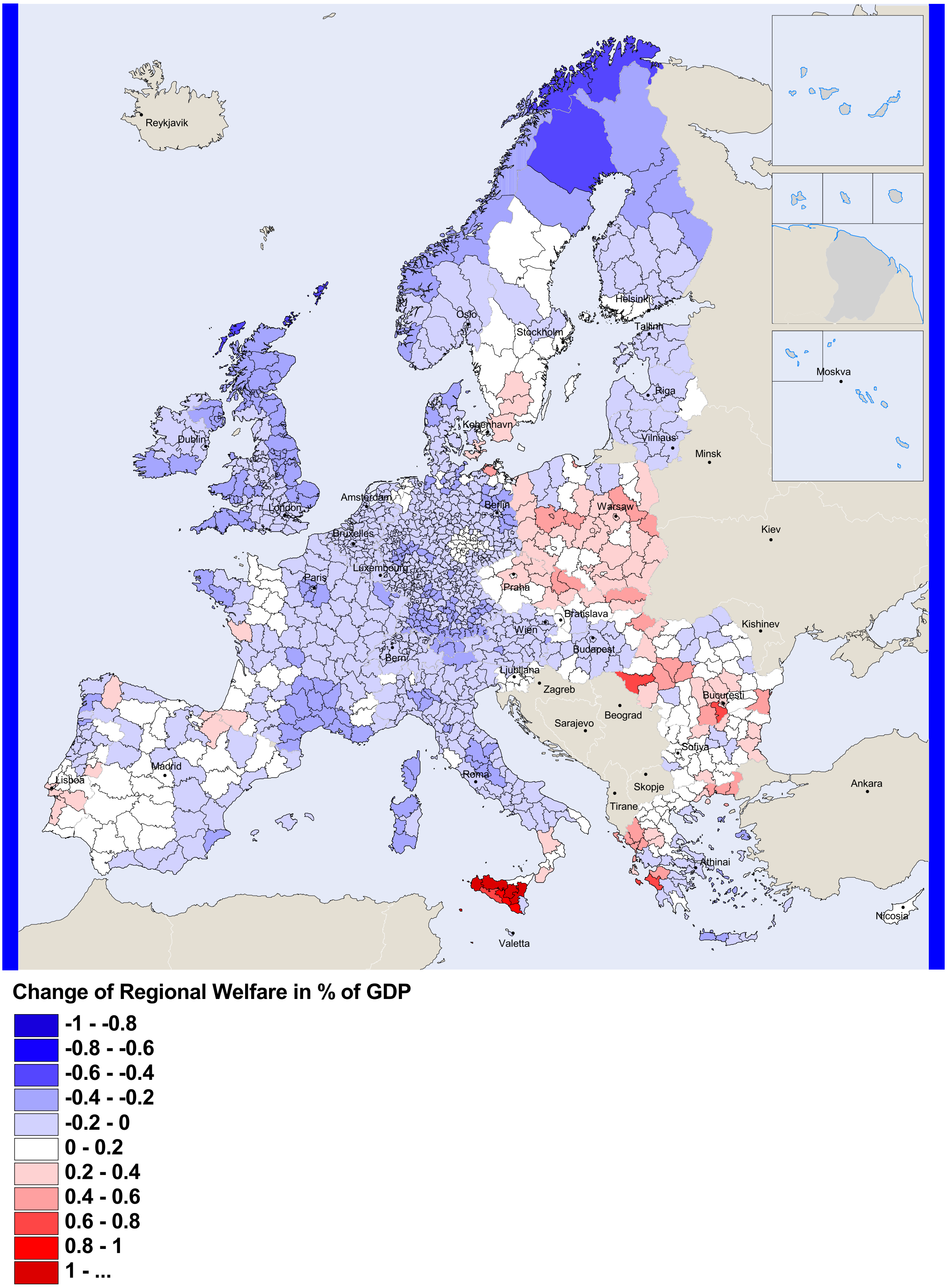

Figure 5: Implementation of TEN and TINA projects combined with pricing of all modes of transport

VII. Spatial Distribution and Welfare

The spatial distribution of benefits (or incurred losses) of the scenarios can be assessed by traditional inequality indicators such as the coefficient of variation and the Gini coefficient. A decrease of these indicators indicates a tendency in favour of cohesion, i.e. a more balanced distribution of GDP per capita within the study area after implementing the policy than before. The calculated values can be found in Table 3. Given the relatively small size of the policy effects, it comes as no surprise that the effects on the inequality indicators are very small. Another way to asses the distributional impact is to correlate the relative welfare effects against the benchmark GDP per capita. A negative (positive) correlation indicates a gain (loss) in equality, as relatively poor regions gain more (less) than relatively rich ones. Table 3 shows the respective results in the last three columns. Note that in Table 3 a negative (positive) sign always points towards more (less) cohesion due to the respective policy in the respective study area.

Table 3: Effects of policy scenarios on relative inequality

	Change in oefficient of variation (in %)			Change in Gini coefficient (in %)			Correl. of rel. effect with GDP p.c.		
	EU -27+2	EU -15	AC -12	EU -27+2	EU -15	AC -12	EU -27+2	EU -15	AC -12
Priority projects	-0.03	-0.03	-0.01	-0.017	-0.022	0.005	-0.14	-0.20	0.09
TEN/TINA	-0.08	-0.08	-0.04	-0.041	-0.040	-0.009	-0.48	-0.32	-0.08
Road pricing	0.03	0.04	0.05	0.011	0.014	0.011	0.27	0.37	0.35
TEN/TINA+Pricing	-0.04	-0.03	-0.02	-0.026	-0.019	0.001	-0.46	-0.20	0.02

The results in Table 3 give a rather homogeneous picture of the impacts on distribution. The first scenario, the implementation of the priority projects, tends to be pro-cohesive for the EU-15 and the whole study area, but neutral or slightly anti-cohesive within the new member states and accession countries. The latter could stem from the fact that the new priority projects aim at connecting the capital regions of the new member states, which can widen disparities within these countries. For the second scenario, the implementation of the TEN and TINA projects, these indicators all point into the same direction: this scenario is pro-cohesive within all three areas considered, and the pro-cohesion tendency is clear cut for the whole study area and the EU-15, but weak within AC-12.

For road pricing all indicators point into the same direction as well, but the sign is reversed; this scenario widens the gap between poorer and richer regions within all study areas, because in this scenario peripheral regions lose most, which are in most cases also the least well-off within their respective country.

Finally, for the combined TEN/TINA and pricing scenario, the spatial distribution after implementation is more equal than in the reference situation for the whole study area and the EU-15, which is due to the dominance of the infrastructure effects, whereas the distribution within the new member states is virtually unaffected due to the opposite tendencies of infrastructure and pricing.

Even though the documented distributional effects are interesting from a regional policy point of view, they have to be qualified with regard to their relevance for the welfare of the society. As a matter of fact, all transportation scenarios have an impact on the level of incomes as well as on the distribution. Our results are confined to distribution in space. How important is the distributional dimension as compared to the impact on average levels? This question can only be answered if a welfare index is at hand allowing to weight the level effect and the distributional effect against each other.

We use the approach of Atkinson (1970) who defined a class of inequality measures on the basis of a social welfare function, as follows. Let social welfare *W* be the sum of the contributions of each individual to social welfare, which in turn are increasing functions *f* of individual income per capita y_i,

$W = \sum_i f(y_i)$.

The function *f* is assumed to be concave, implying that one € given to rich person contributes less to welfare than one € given to a poor one. Now let y_i^0 denote benchmark income per capita (i.e. per capita income in the "without" situation), let e_i denote the per capita equivalent variation of the policy impact, and let $y_i^1 = y_i^0 + e_i$. let $W^1 = \sum_i f(y_i^1)$ be the welfare attained in the "with" situation. The same welfare could be attained by incomes that deviate from y_i^0 by a common factor α, that is by incomes that stand in the same proportion to each other as in the "without" situation:

$W^1 = \sum_i f(\alpha y_i^0)$.

Now we can compare the *relative equivalent variation* for the entire study area, defined as $\text{REV} = 100 \cdot \sum_i e_i / \sum_i y_i$, with the *relative social welfare effect*, defined as $\text{RSW} = 100 \cdot (\alpha - 1)$. The latter is the percentage income change required to generate the same social welfare change as the one actually generated by the policy, if incomes changed everywhere by the same rate. If the latter exceeds (falls short of) the former, then the policy is equality (inequality) increasing, because on average it favours rich persons relatively less (more) than poor ones. The difference RDE=RSW-REV, called the *relative distribution effect*, is the monetary measure of the welfare gain due to equality increase, expressed as a percentage of GDP. There is a loss due to inequality increase, if the measure is negative, of course.

For applying the concept to regions, we assume each individual in a region to earn the same income, the per capita GDP of the region, and to gain (ore lose) the same per capita equivalent variation from the respective policy measure. For the welfare contribution *f* the log function is taken in Table 4, meaning that the marginal contribution of one € to social welfare is inversely proportional to benchmark GDP per capita (inequality aversion equal to 1).

Table 4: Comparison of relative equivalent variation (REV) and relative social welfare effect (RSW), percent of GDP, inequality aversion equal to 1

	EU-27+2			EU-15			AC-12		
	REV	RSW	RDE	REV	RSW	RDE	REV	RSW	RDE
Priority projects	0.144	0.161	0.016	0.144	0.161	0.018	0.164	0.158	-0.006
TEN/TINA	0.262	0.334	0.072	0.251	0.282	0.031	0.504	0.514	0.010
Road pricing	-0.285	-0.295	-0.010	-0.285	-0.296	-0.010	-0.281	-0.294	-0.013
TEN/TINA+Pricing	-0.092	-0.030	0.061	-0.103	-0.088	0.016	0.174	0.171	-0.003

The calculations of the welfare indicator for the scenarios are show in Table 4. Columns under REV are the same as rows in Table 2. As positive numbers under RDE indicate an equality increase, we should see the same pattern as in Table 3, with the sign reversed. This is in fact the case; even though the distributional impact is small, all distributional indicators focussing on relative changes give the same answer as to the broad tendencies of the respective scenarios.

Furthermore, Table 4 clearly shows a very moderate role of the distributional dimension. In most cases, the welfare gain or loss is almost entirely due to the level effect; taking the distribution into account modifies the estimated welfare effect only slightly. A notable exception is the distributional impact of the most comprehensive TEN/TINA scenario on the entire study area; the social welfare gain including the distributional aspect (RSW=0.33%) exceeds the relative equivalent variation (REV=0.26%) by one quarter. The impact is much less equalising within EU-15 and within AC-12. The relatively strong effect for the total area is due to the fact, that the relative equivalent variation in AC-12 is twice that in EU-15.

To be sure, the distributional dimension increases in importance if we assumed a stronger inequality aversion than that implied by the log function. Table 5 assumes inequality aversion equal to 2, meaning that the marginal contributions of one € to social welfare are inversely proportional to benchmark GDP per capita squared. The qualitative result with regard to distributional tendencies, reflected by the sign pattern in the RDE-columns, remains unchanged, and the distributional welfare component remains still small in comparison to the level of effects, with the noted exception which shows up now in a more pronounced way.

Table 5: Comparison of relative equivalent variation (REV) and relative social welfare effect (RSW), percent of GDP, inequality aversion equal to 2

	EU-27+2			EU-15			AC-12		
	REV	RSW	RDE	REV	RSW	RDE	REV	RSW	RDE
Priority projects	0.144	0.155	0.011	0.144	0.183	0.039	0.164	0.143	-0.021
TEN/TINA	0.262	0.451	0.189	0.251	0.316	0.065	0.504	0.513	0.009
Road pricing	-0.285	-0.303	-0.018	-0.285	-0.305	-0.020	-0.281	-0.302	-0.021
TEN/TINA+Pricing	-0.092	0.087	0.179	-0.103	-0.069	0.034	0.174	0.159	-0.015

All distributional indicators considered so far focus on distribution effects in relative terms. They indicate a gain in equality, if poorer regions gain more than richer ones in percentage terms, even though the absolute gain of the poor ones may be less than that of the rich ones. If instead the judgement is based on absolute par capita gains, the picture changes completely, as revealed by Table 6, showing the correlation between absolute per capita gains and the reference GDP per capita. The broad pattern is just the reverse of what we have seen before: the poorer a region is, the less it gains in absolute terms from the infrastructure programs, but the less it also suffers from losses caused by pricing. This is because positive as well as negative per capita effects are absolutely smaller for poorer than for richer regions.

Table 6: Correlation between effects and per capita GDP

	EU-27+2	EU-15	AC-12
Priority projects	0.39	0.21	0.59
TEN/TINA	0.46	0.22	0.81
Road pricing	-0.92	-0.85	-0.81
TEN/TINA+Pricing	-0.59	-0.49	0.44

One must therefore be aware that the distributional tendencies described before are based on the value judgement to regard effects on individual welfare as neutral with respect to spatial distribution if all regions are affected to the same extent *in percentage terms*. Let us call this the assumption of "relative neutrality". If instead we begin with the premise of "absolute neutrality", which is to regard equal *absolute per capita gains* as neutral with respect to distribution, results in Table 6 rather than those in Table 3 apply.

The conclusions from the welfare approach documented in Tables 4 and 5 are based on the assumption of relative neutrality as well, because the RDE-indicator is zero by definition, if all regional effects are the same percentage of regional GDP. An analogous welfare approach can be applied based on the assumption of absolute neutrality. Instead off attaining W^1 by a hypothetical equal percentage income change, we can think of attaining it by the same absolute income change per capita β:

$W^1 = \sum_i f(\beta + y_i^0)$.

The amount ASW=β is called the *absolute social welfare effect*, measured in terms of € per capita p.a. Now we can compare the ASW with the *absolute equivalent variation* AEV, which is just the average of per capita equivalent variations e_i, measured in € per capita p.a. as well. If the former exceeds (falls short of) the latter, then the policy is equality (inequality) increasing, because on average it favours rich persons absolutely less (more) than poor ones. The difference ADE=ASW-AEV, called the *absolute distribution effect*, is the monetary measure of the welfare gain due to equality increase, expressed in € per capita p.a. There is a loss due to inequality increase, if the measure is negative, of course.

Table 7: Comparison of absolute equivalent variation (AEV) and absolute social welfare effect (ASW), € per capita p.a., inequality aversion equal to 1

	EU-27+2			EU-15			AC-12		
	AEV	ASW	ADE	AEV	ASW	ADE	AEV	ASW	ADE
Priority projects	22.8	10.7	-12.1	27.9	26.5	-1.4	5.0	3.4	-1.5
TEN/TINA	41.4	22.2	-19.2	48.9	46.5	-2.4	15.2	11.1	-4.1
Road pricing	-45.1	-19.7	25.4	-55.6	-48.7	6.9	-8.5	-6.3	2.1
TEN/TINA+Pricing	-14.5	-2.0	12.5	-20.1	-14.4	5.7	5.3	3.7	-1.6

Results are shown in Tables 7 and 8 for inequality aversion equal to 1 and 2, respectively. As positive numbers under ADE again indicate an equality increase, we should see the same pattern as in Table 6, with the sign reversed. This is in fact the case for both tables. As the tables reveal, not only are the tendencies reversed if we go from relative to absolute measurement, but also the quantitative welfare impact of distribution now matters more in some cases. Within the EU-15 it still holds true that the distributional component of welfare is negligible, but it is important within AC-12 and for the entire study area. Gains from infrastructure investment and losses from pricing are reduced to two thirds in absolute value by taking the distribution into account in the welfare measure. For EU-27+2 gains and losses are even halved. This is because of absolute distribution effects between old and new member countries. In absolute terms, old member countries are much more affected than new ones.

The same conclusions can be drawn from Table 8, but the distribution effects are more pronounced; they lead to a reduction of social welfare per capita to one half in AC-12 and to one third in the whole area, in absolute value.

Table 8: Comparison of absolute equivalent variation (AEV) and abslute social welfare effect (ASW), € per capita p.a., inequality aversion equal to 2

	EU-27+2			EU-15			AC-12		
	AEV	ASW	ADE	AEV	ASW	ADE	AEV	ASW	ADE
Priority projects	22.8	3.4	-19.4	27.9	20.9	-7.1	5.0	2.3	-2.6
TEN/TINA	41.4	10	-31.4	48.9	36.1	-12.8	15.2	8.3	-6.9
Road pricing	-45.1	-6.7	38.4	-55.6	-34.8	20.7	-8.5	-4.9	3.6
TEN/TINA+Pricing	-14.5	1.9	16.4	-20.1	-7.9	12.3	5.3	2.6	-2.7

VIII. Conclusion

The paper has shown that computable equilibrium methods can successfully be applied to evaluating spatial welfare effects of transport policy in an environment with a very large number of regions. The approach has been applied to evaluate two strands of transport policy playing a major role in the recent development strategy of the commission, namely the construction of new infrastructure links within the TEN and TINA programs, and pricing policies aiming at closing the gap between private and social marginal cost. Mapping the regional welfare affects clearly reveals how regions within the EU are differently affected by these policies. An important issue is whether these policies are in line with the regional policy aims of the EU, favouring cohesion and a balanced spatial development, or have spatial implications contradicting these aims. We were able to derive clear cut answers to this question for the infrastructure and pricing scenario studied, as long as we relied on equality/inequality measures based on what we called the "relative neutrality" assumption: The infrastructure policy has a pro-cohesive and the pricing policy has an anti-cohesive tendency. For the mixed scenario studied the pattern is mixed. It could also be shown that the distributional component counts rather little in a social welfare evaluation, even though this result of course hinges upon the willingness to accept the assumed degree of inequality aversion.

As mentioned, these conclusions presume that the "relative neutrality" assumption is accepted, meaning that effects are regarded as neutral with respect to their distributional impact, if the gains are proportional to benchmark levels of GDP per capita. This is the assumption that most studies dealing with spatial income distribution such as the cohesion report and the standard convergence regressions adhere to. A warning is in order, however: if we based our conclusions on the premise of "absolute neutrality", meaning that equal per capita amounts are valued as neutral with regard to distribution, results change dramatically. By and large, infrastructure policy than appears as anti-cohesive because absolute per capita gains are (though larger in relative terms) smaller in poor than in rich regions in absolute terms; pricing appears to be pro-cohesive, because relative losses do not vary much across regions, such that they turn out to be larger in absolute per capita terms in rich than in poor regions.

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