TRANS-EUROPEAN ROAD INVESTMENT AND COHESION: AN ASSESSMENT BY CGE ANALYSIS

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ABSTRACT

This paper studies the spatial impact an important aspect European transport policy, namely road infrastructure investments in the context of the Trans-European Transport Network program. In its White Paper [8] the European Commission has laid down a comprehensive programme of transport policy, aiming at increasing the efficiency of the transport industry, developing the Trans-European Networks and bringing the prices of transport services closer to the true 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 area of the EU. This paper studies the spatial impact of one aspect of these policies policies, namely road investments, 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. Regions interact by trade flows. 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 set up two policy scenarios on road transport and evaluate their impact on spatial equality or inequality using a bundle of indicators of spatial inequality.

1. 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 (see for example [11] and [12]). 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 30 priority projects. Furthermore, there is also a wider list of projects also called TEN as well as projects suggested by TINA, which are not priority projects, but are also co-financed by the European Union. For the purpose of this paper we analyze the impact of the road projects in these two lists of projects.

In this paper we analyse in two policy scenarios which benefits arise for the European regions from extending the road infrastructure, following the priorities expressed in the mentioned programs of the commission. 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 effects for a typical household per region due to the change of transport costs that comes from 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 variation, which measures 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. 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 are analysed. We describe the model outcomes and their evaluation with respect to a set of cohesion indicators and derive possible policy implications.

2. 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. [2], [3] and [4]. 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. They earn the local factor income and expend it for local as well as tradable goods.

The factor supply is always fully employed due to 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 [7]. 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.

Tradable goods firms produce a horizontally differentiated output under economies of scale and monopolistic competition. Each producer has a certain market power for his specific product variety allowing him to realize a mark-up of his price over marginal cost (the monopolistic element in the market), but entry into the market is free such that profits are eventually driven down to zero by market entry and exit.

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.

3. THE DATABASE

In the first step the model is calibrated on the base year 2000. For each country the respective gross output and GDP are obtained from the GTAP database [6]. By classifying industries as local and tradable, respectively, this database also allows for estimating gross output by these two sectors and by countries. Using the Eurostat NewCronos database [13] and the ESPON database, these figures have been broken down to regions. Furthermore, international trade data is needed in the form of bilateral trade flows in nominal values in Euro for each country pair. Though official sources for these data are easily accessible, we take them also from the GTAP data base, as they are made consistent with the other national account information form that base.

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 transport network. The respective database is developed and maintained by Schürmann, Spiekermann and Wegener [16]. The network contains data for all major transport links in Europe, including their specific characteristics of speed limits and likelihood of congestion. The database is used to calculate the transport costs per tonne and per passenger for each NUTS-3 region centroid pair.

The costs for freight transport are functions of travel time and distance. Both represent the most important cost components in transport. 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 (see [19], 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. 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). Logsums are computed for both, business passenger travel and freight. The semielasticities quantifying the responsiveness of choice on cost differentials stem from the SCENES project, the individual mode weight parameters are calibrated such that observed aggregate modal shares are reproduced in the equilibrium solution.

The costs are 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 the costs, 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 (see [1], [14] and [18]). 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.

In a second step we calibrate the model for the year 2020, using the information on bilateral trade impediments from the year 2000 calibration. For the year 2020 we take regional GDPs of the year 2000 and increase them by a country factor that is taken from the GDP predictions for the EU energy outlook for 2003. Furthermore, we turn the order in the calibration around and calibrate the trade flows such that they reproduce hypothetical trade impediments, which we choose such that they simulate a higher trade integration of the new member states. We take the average of the values of the trade impediments between EU15 states from the 2000 calibration and multiply the trade impediments between the new member states and from the new member states to the EU15 and vice versa by a factor, such that their average value is the same as between the EU15 in 2000, assuming that their accession leads to a quick trade integration which is as good as it is for the EU15 states. We assume trade impediments within the EU15 states to stay constant. With these two calibrations, for the year 2000 and 2020, we perform comparative-static policy analysis and compare the policy scenarios with the do-nothing scenario in both years.

4. MODEL OUTPUT

With 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. [17]), 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 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, with a regional deflator taking product diversity effects into account.

5. POLICY SCENARIOS

We run two policy scenarios. The first comprises the road projects of the TEN list of priority projects that have been recommended by the High level group on European transport policy [15]. This list contains the projects of the Essen list (see [9] and [10]) plus additional projects mainly located in the new member states. The list of projects is shown in table 1. No other infrastructure development is included.

Table 1: List of road projects of the TEN priority projects

Priority project	Countries covered
1 Fixed link road/rail Messina bridge	IT
7 Greek motorways (Via Egnatia, Pathe), motorways in	GR, BG, RO, 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

In the second scenario the road projects of the complete list of TEN and TINA projects plus corresponding road infrastructure in Norway and Switzerland is included. 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 [9] and the TINA Secretariat (see [20] and [21]). The scenario includes also the Motorways of the Sea which are treated as part of the road network for freight transport. It is easier to show a map (see the red and yellow links in figure 1) of the projects to illustrate the road links which are added to the transport networks than giving a list of the projects.

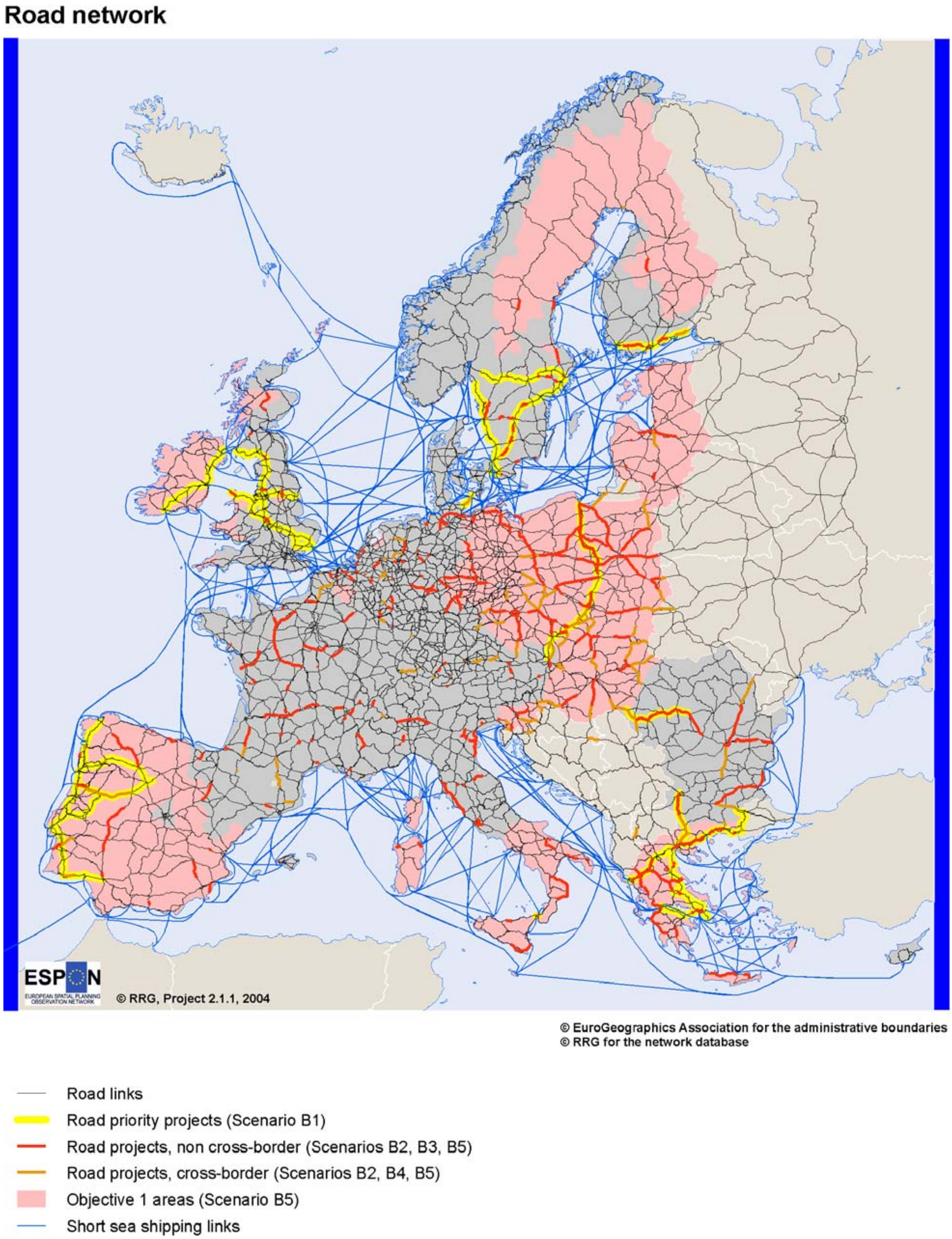

Figure 1- TEN and TINA road projects

6. SCENARIO RESULTS

Figures 2 to 6 illustrate results. The maps display the relative equivalent variation, i.e. the monetary equivalent of the welfare gain, given as a percentage of GDP. The darker the colour, the bigger the respective welfare gain. Table 2 shows the overall effects of the respective scenarios for the whole area of the EU-27 plus Switzerland and Norway, which we call EU27+2. Furthermore, we show the effects for the old EU15 and for the 12 new member states (NMS12).

Table 2 - Aggregated welfare changes, percent of GDP

	Priority Projects 2000	Priority projects 2020	TEN/ TINA 2000	TEN/TINA 2020	Road Pricing 2000
EU27+2	0.043	0.046	0.133	0.145	-0.281
EU15	0.040	0.041	0.120	0.128	-0.283
NMS12	0.091	0.142	0.396	0.572	-0.278

Scenario 1: Implementation of the TEN priority projects

The overall effect of the policy package seems small in relative terms: 0.043% of GDP of the area of EU27+2 in 2000 and 0.046% in 2020. The effect in the new member states, however, is considerably higher 0.091% and 0.142% respectively. The higher benefit in 2020 is due to the higher trade integration assumed for 2020, leading to bigger cross border flows, and hence to larger gains due to cost reductions for these flows. The spatial distribution of the benefits is displayed in figures 2 and 3. In the figures one can see that a couple of individual projects have a strong regional impact, such as the Nordic triangle plus the Øresund and Fehmarnbelt fixed links, the Irish and British road links, the motorway Warsaw-Kattowice-Brno-Vienna and the Greek motorways.

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. The overall effect of this scenario is a gain of 0.133% of GDP for the EU27+2 area in 2000 and 0.145% in 2020. As one can see in figures 4 and 5, most regions are positively affected. Only a few gain almost nothing like Paris, southern Ireland and Norway. In the 2000 calibration the new member states gain almost the triple of what the EU-15 countries gain, measured in relative terms. In 2020 it is almost a factor of 4. Note, however, that in per capita terms gains are still smaller in accession countries because of the lower level of per capita GDP.

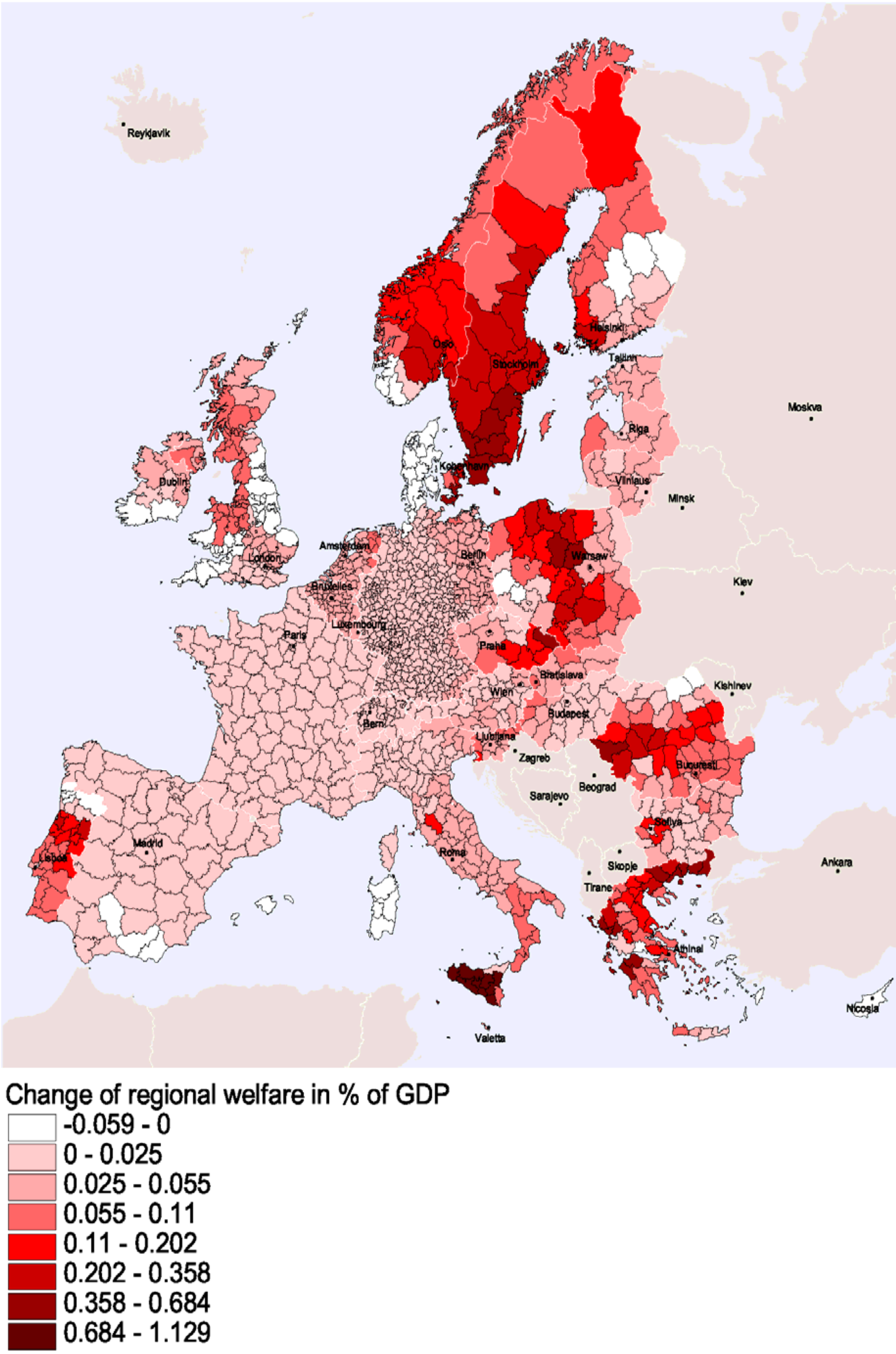

Figure 2 - Impacts of the road priority projects of the TEN in the 2000 calibration

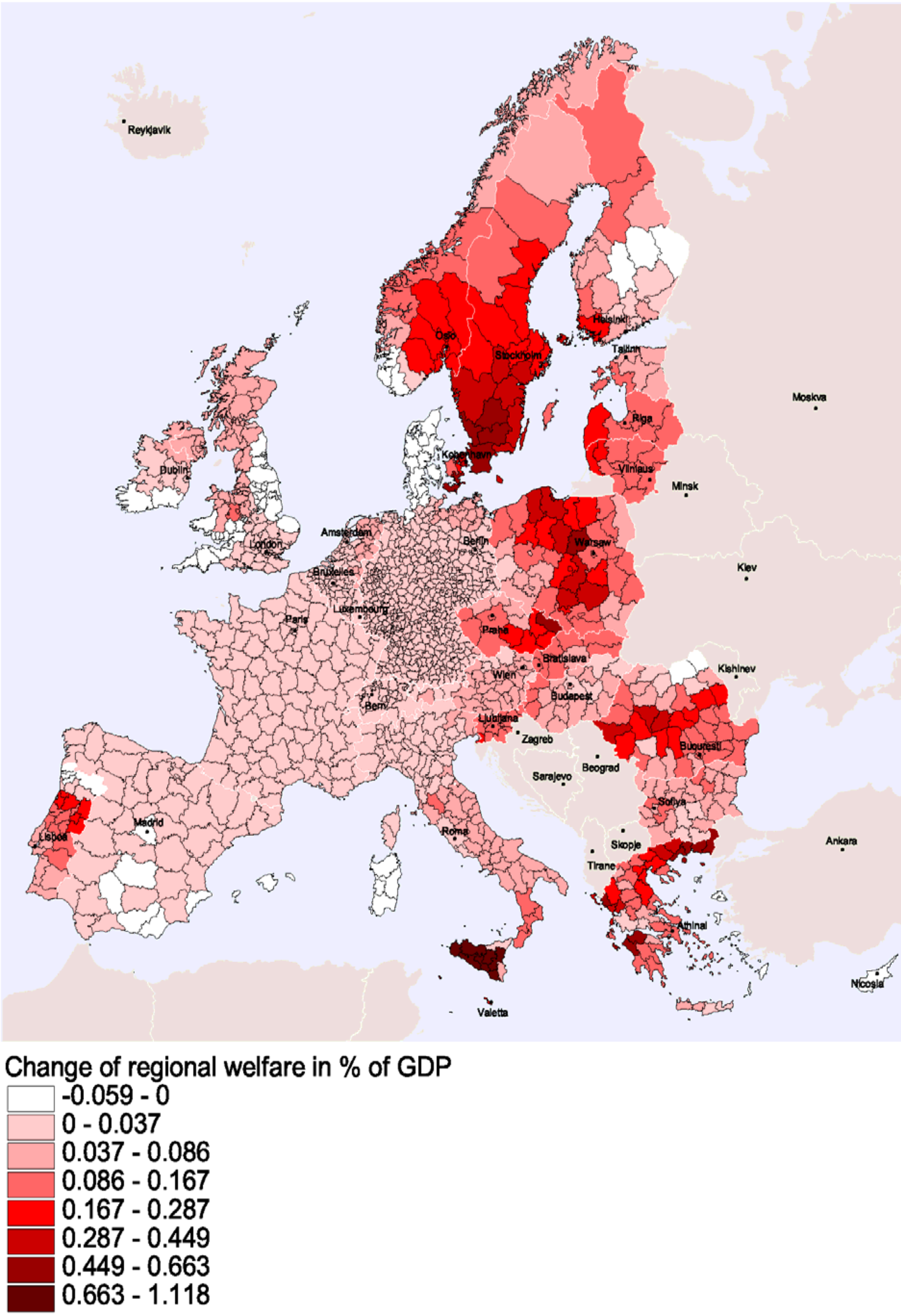

Figure 3 - Impacts of the road priority projects of the TEN in the 2020 calibration

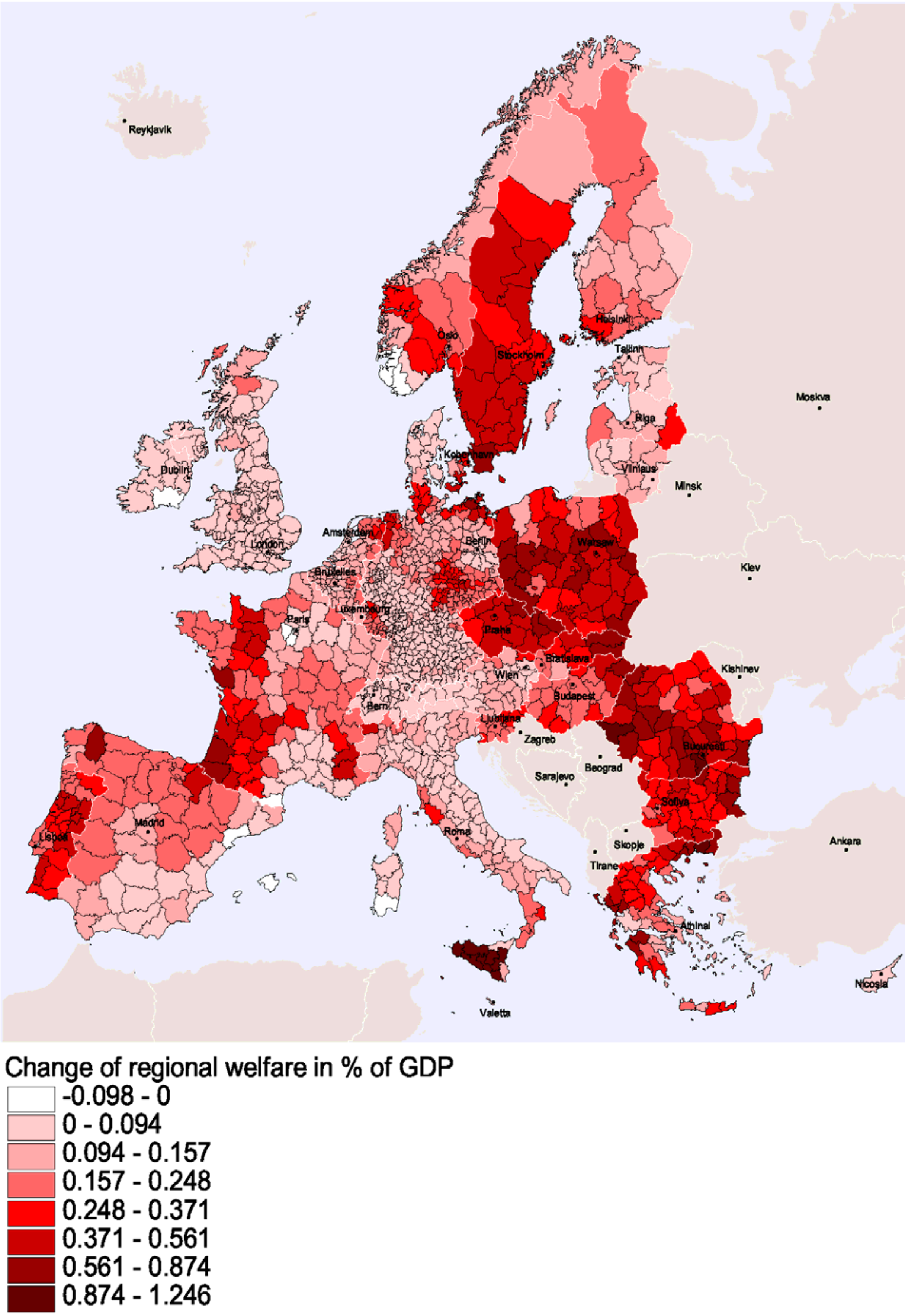

Figure 4 - Impacts of the road projects of the TEN and TINA in the 2000 calibration

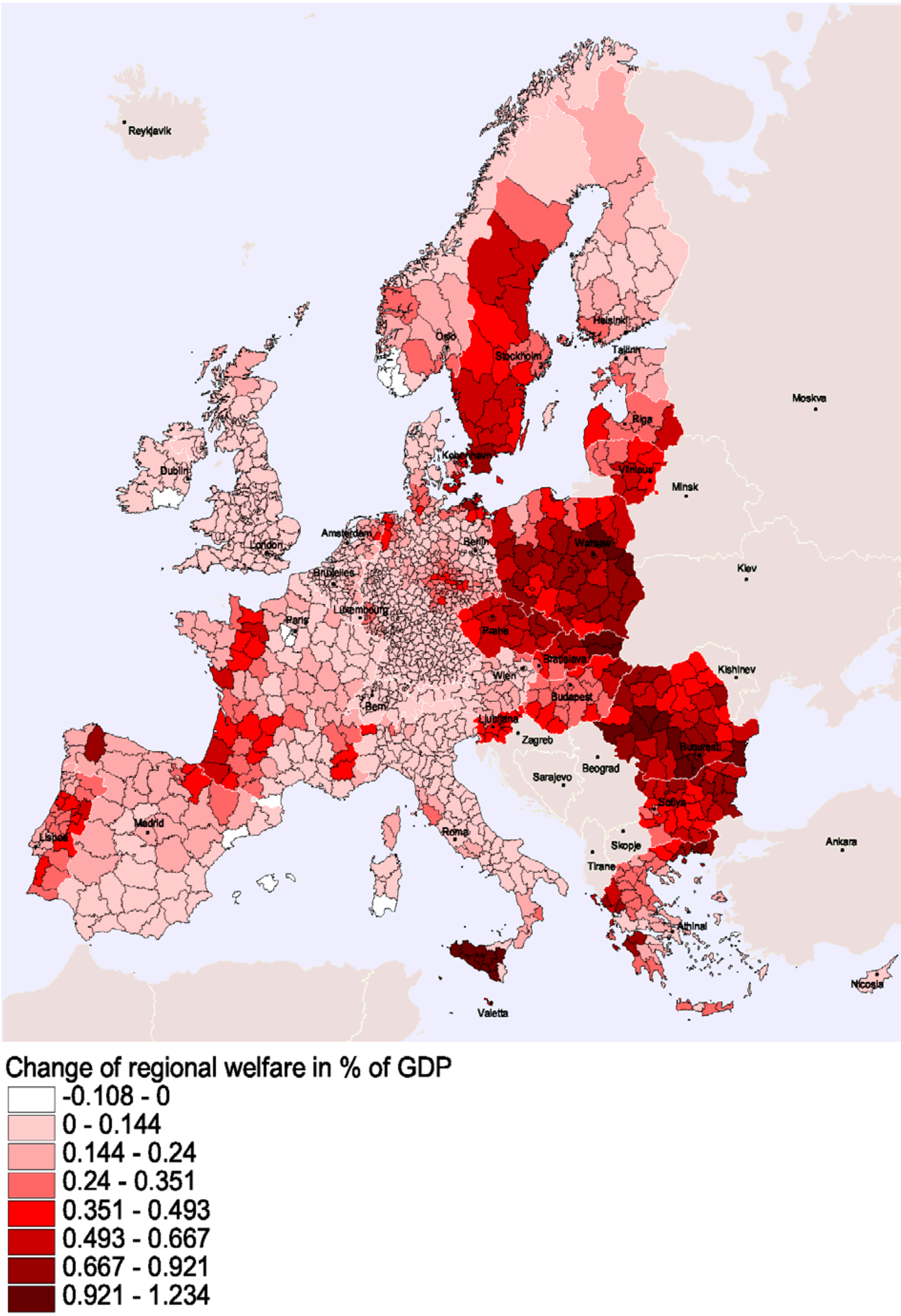

Figure 5 - Impacts of the road projects of the TEN and TINA in the 2020 calibration

7. SPATIAL DISTRIBUTION AND WELFARE

The spatial distribution of benefits of the scenarios can be assessed in different ways, first by traditional inequality indicators, the coefficient of variation (CoV) 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. Another indicator is the ratio of geometric to arithmetic mean of GDP (G/A). It compares two methods of averaging among observations: geometric (multiplicative) and arithmetic (additive) averaging. If all observations are equal, the geometric and arithmetic mean are identical, i.e. their ratio is one. If the observations are very heterogeneous, the geometric mean and hence the ratio of the geometric to the arithmetic mean goes towards zero. A final way to asses the distributional impact is to correlate the relative welfare effects against the benchmark GDP per capita (RC). A negative (positive) correlation indicates a gain (loss) in equality, as relatively poor regions gain more (less) than rich ones in relative terms. There is a fifth indicator in the table (AC) to be explained later.

Tables 3 to 5 give a rather homogeneous picture of the distributional impacts measured by the four indicators just described. To avoid confusion, a plus (minus) always means that the respective measure indicates an increase (decrease) in cohesion. In other words, for CoV and Gini plus means that the respective investment program makes these indicators smaller, while for G/A it means that the program makes it bigger. For RC a plus indicates a negative correlation of relative gains and benchmark levels of GDP per capita.

Taking EU27+2 as a whole, we see only positive signs, indicating that the spatial impact is largely what policy makers want it to be, namely cohesion enhancing. This is however partly due to the fact that the poorer new member countries gain more in relative terms, a result more pronounced for the full TEN/TINA scenario than for the priority list, and more pronounced for 2020 than for the 2000 experiment, as already shown in table 2 above.

Regarding the distribution within EU15 still there is no negative sign, but two of the indicators, CoV and Gini point to distributional neutrality. Hence, there is a certain, though weak tendency toward cohesion also within EU15 for this case. For the full TEN/TINA scenario we again observe positive signs only. Finally, tendencies are less clear for distributional effects within NMS12. Two measure (G/A and RC) indicate a slight increase of inequality for the priority list in 2020. No indicator points to more inequality for the full TEN/TINA list, but the pro-cohesion tendency seems to be small as well, as some of the measures turn out to be virtually zero. Comparing the different scenarios, the full TEN/TINA list for 2020 has (with one exception) pluses throughout, and is thus the program with the clearest pro-cohesion tendency.

There are two important caveats to this rather optimistic results, however. First, the distributional impact is, though clear with regard to the tendency, small in comparison to what policy makers might hope. If one tried to split the entire effect up into an overall efficiency effect on the one hand and a welfare gain due to an increase in cohesion, the latter turns out to be small in comparison to the former. Such a split up requires setting up a social welfare function and is not done here, see [5] for details.

Table 3 – Cohesion impacts in the EU27+2

Scenario	GDP/capita cohesion effects				
	CoV	Gini	G/A	RC	AC
Priority projects in 2000	+	+	+	+	-
Priority projects in 2020	+	+	+	+	-
TEN/TINA projects in 2000	+	+	+	+	-
TEN/TINA projects in 2020	+	+	+	+	-

Table 4 – Cohesion impacts in the EU-15

Scenario	GDP/capita cohesion effects (+/–)				
	CoV	Gini	G/A	RC	AC
Priority projects in 2000	0	0	+	+	0
Priority projects in 2020	0	0	+	+	-
TEN/TINA projects in 2000	+	+	+	+	-
TEN/TINA projects in 2020	+	+	+	+	-

Table 5 – Cohesion impacts in the NMS-12

Scenario	GDP/capita cohesion effects (+/–)				
	CoV	Gini	G/A	RC	AC
Priority projects in 2000	+	+	0	0	-
Priority projects in 2020	0	0	-	-	-
TEN/TINA projects in 2000	0	+	+	0	-
TEN/TINA projects in 2020	0	+	+	+	-

+	Pro-cohesion effect: disparities reduced
–	Anti-cohesion effect: disparities increased
0	Little or no cohesion effect
CoV	Coefficient of variation
Gini	Gini coefficient
G/A	Geometric/arithmetic mean
RC	Correlation relative change v. level
AC	Correlation absolute change v. level

One must second be aware that the distributional tendencies described so far are based on the value judgement to regard welfare effects as neutral with respect to the 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 turn out to be different. Poor regions gain more in relative terms, but as the percentage applies to a lower benchmark level, in absolute per capita terms their gain is still often smaller than in rich regions. One therefore observes for all scenarios studied and for all subspaces a positive correlation between absolute per capita gains and benchmark levels of GDP per capita. This is indicated by the negative signs in the last columns of tables 3 to 5 (under AC). As a tendency, poor regions gain more in relative. But less in absolute per capita terms. Thus, if we believed in the "absolute neutrality" benchmark, we would classify all effects as inequality enhancing. We stick to the usual convention, however, calling a distribution unchanged if ratios of GDP per capita remain unchanged.

8. 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 the construction of new infrastructure links within the TEN and TINA programs. Mapping the regional welfare affects clearly reveals how regions within the EU are differently affected by these programs. 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 tendency. “Relative neutrality” means 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 then 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.

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