An Analytical Framework for Assessing the Spatial and Economic Impacts of Transport Network Improvements - the Egnatia Motorway Case Study

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Abstract. This paper proposes an analytical framework for assessing the spatial and economic impacts of new transport links. It is exemplified by the case study of the Via Egnatia, a motorway of 680 km length currently under construction in Northern Greece. The assessment methodology comprises three hierarchical dimensions. First, the travel time reduction is assessed by calculating changes in travel times and by generating isochrones prior and after the opening of a new transport link. Second, the effect on the potential type accessibility is taken into consideration. Third, the possible effects of a transport link on the economic development of the affected regions is examined by employing an apposite simulation model. The three analysis steps lead to a differentiated assessment of the Egnatia motorway's effects. According to the isochrone approach, the impacts in term of travel time reduction are remarkable. The expected increase in potential-type accessibility is yet relatively small. Finally, the impacts of the new transport link on the regional economy measured by changes in gross domestic product (GDP) remain rather modest. The application of the proposed analytical assessment framework to the Egnatia case study underlines the importance of multi-dimensional impact analyses and the need for new simulation models.

Key words: accessibility, impact assessment, spatial impact, socio-economic impact, TEN, Greece, Via Egnatia

1 Introduction

The assessment of transport infrastructure improvements represents a classic task of transport planning disciplines. So far, most types of assessment are limited to measuring the direct impacts of network improvements on transport flows and modal split. However, recent progresses in the fields of simulation models and the use of geographic information systems allow to extend the impact assessment to spatial and socio-economic changes induced by new transport links.

The new technical assessment facilities hit a growing need for evaluating investments in transport networks. Currently, the Trans-European Transport Networks (TETN) programme of the European Union [2] is promoting the construction of new motorways and high-speed railways in many places of the European territory. Altogether, these masterplans for rail, roads, waterways, ports and airports require public and private investments of 400 to 500 billion Euro until the year 2010. One of the main objectives of these enormous infrastructure investments is to contribute to reducing the disparities between European regions and to achieving a more balanced economic growth. However, the impacts of these new transport infrastructures on the peripheral regions of Europe are uncertain.

The Institute of Spatial Planning (IRPUD) carried out a series of research projects on transport infrastructure and accessibility. They aim at modelling the relationships between improvements of transport infrastructure and regional development. This paper departs from the results and models developed in the context of two recent research projects: first, the European Peripherality Index developed for DG REGIO [5], and second, the SASI project (Socio-Economic and Spatial Impacts of Transport Infrastructure Investments and Transport System Improvements), part of the EUNET project conducted for DG TREN [3][4]. On the basis of the acquired research experiences, this paper proposes a hierarchical analytical framework for assessing the spatial and economic impacts of transport network improvements, taking into consideration travel time reductions, absolute and relative changes in accessibility and possible effects on socio-economic developments. In the subsequent sections, the proposed analytical framework is first presented and then tested against the example of the Greek Egnatia motorway.

2 The analytical framework: a three steps assessment of spatial and socio-economic impacts induced by new transport links

New transport links such as tunnels and bridges, railways and motorways, ports and airports inevitably affect not only the transport system itself, but also the highly interrelated systems of land-use and economy, society and environment. Corresponding to the complexity of interrelations, new assessment tools need to capture and to integrate various scientific approaches and models for analysing the impacts of changes in transport infrastructure, ranging from biology and geography to psychology and the classic engineering disciplines.

The analytical framework which is described in the following does not seek to reproduce all these dimensions. It rather focuses on the spatial and the socio-economic repercussions of transport network improvements. By aiming at an integrated view of accessibility structures and regional economic patterns, it goes far beyond the traditional approaches of transport planning. The description of interdependencies between the sectors of transport and economic activity departs from the so-called land-use-transport-feedback-cycle (Figure 1) which illustrates the single steps linking the changes in accessibility to changes in economic activities and vice versa. To summarise, it is presumed that an improved accessibility of locations increases their attractiveness for firms. Growths in economic activities in turn induce migration of households and through this a new demand for transport and transport infrastructure.

On the basis of these general assumptions, the assessment of spatial and socio-economic impacts includes three subsequent analysis steps:

- *travel time:* The first variable to regard is the travel time development. The hypothesis is that expected travel times directly influence the destination, mode and route choices of people, which lead to specific traffic flow patters.
- *accessibility:* The second analysis step takes into account the 'mass' of potential destinations. According to this so-called potential-type accessibility, the economic

potential of a region is the total of destinations in all regions weighted by a function of distance from the origin region. It is assumed that the potential for economic activity at any location is a function of both its proximity here expressed by 'travel time' to other economic centres and its economic size or 'mass'. This potential-type accessibility in turn acts on location decisions of firms and households.

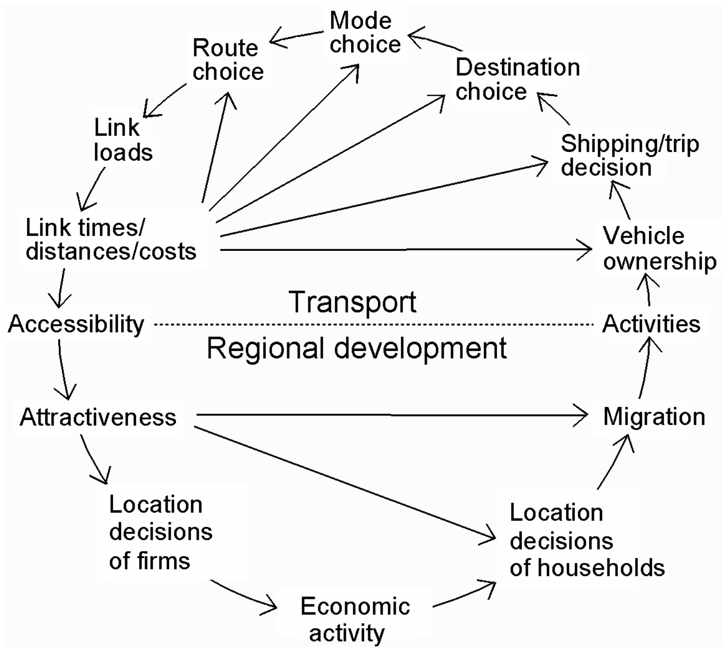

Figure 1. Interactions between transport system and regional development [6].

- *socio-economic development:* In order to anticipate the expected results of new transport links on the regional economic development, it is necessary to apply simulation models reproducing economic, demographic and accessibility-related variables and interrelations.

These three dimensions address the core controls for spatial behaviour of the land-use-transport-feedback-cycle. In order to assess the changes achieved through improvements of the transport network, the analysis steps should be applied to different scenarios of the transport network evolution.

3 The case study: the Egnatia motorway in Northern Greece

The Egnatia motorway is a priority project of the European Union's Trans-European Transport Networks (TETN) programme [2]. Following the alignment of the old roman Via Egnatia, the new Egnatia motorway is expected to become 'the backbone of Northern Greece's transport system'. The new motorway is to extend from Igoumenitsa on the Adriatic coast to Kipi on the north-eastern edge of the Aegean Sea, adding up to a total length of 680 km. It is planned as a closed dual carriageway motorway with two traffic lanes plus an emergency lane per direction, for a total paved width of 24.5 m over its greatest part, except for the road's mountainous sections. The construction is proceeding rapidly. Before 1994, only 94 km of the motorway had been completed. Today, 339 km of the motorway are opened to traffic, another 55 km are to be delivered in Summer 2002. 190 km are currently under construction, the remaining 96 km are ready to be tendered or in the design phase already. A total of 3.2 billion Euro of funding have been approved in order to make this ambitious infrastructure project possible. As the Egnatia motorway is to function as collector road for transport in the whole Balkans and South-Eastern Europe, the East-West motorway track will be complemented by nine vertical road axes in North-South direction [1].

Figure 2. The Egnatia and the P.A.T.H.E. corridor.

However, the Egnatia motorway is not the sole large motorway project in Greece. In parallel, the north-south connection is presently being improved by upgrading and completing the so-called PATHE motorway which links the cities of Patras, Athens, Thessaloniki and Evzonoi. Besides, the European Commission's TEN programme envisage further road infrastructure investments in different parts of Greece, namely the counties of Ilias and Messinias, Trikalon, Larditsis and Larisis.

4 Isochrones and travel times

Isochrones are a clear form of illustrating travel time reductions induced by infrastructure improvements. Therefore, they are often used for demonstrating the benefits of new transport links and hereby justifying the large expenditures required. However, from a theoretical point of view they are hardly suited to evidence the outcomes of improvements in transport networks. They fail to capture the size of destinations at the respective nodes of a transport route. Similarly, the mere calculation of travel times between two nodes of a transport link does not reveal much about the amount of expected movements and the economic importance of the link, and hence the need for investing in the reduction of travel time.

Exemplarily, Figure 3 shows isochrones prior and after the opening of the Egnatia motorway, taking Thessaloniki, the main city in northern Greece, as origin. The current situation reveals that regions surrounding the Thermaikos Bay (from south of Kalamaria to Katerini) can be reached within 60 min travel time, because important parts of the Egnatia and PATHE motorways were already opened to traffic in the late 90ies. Within 90 min, Serres and the borders to Bulgaria and former Yugoslavia can be reached.

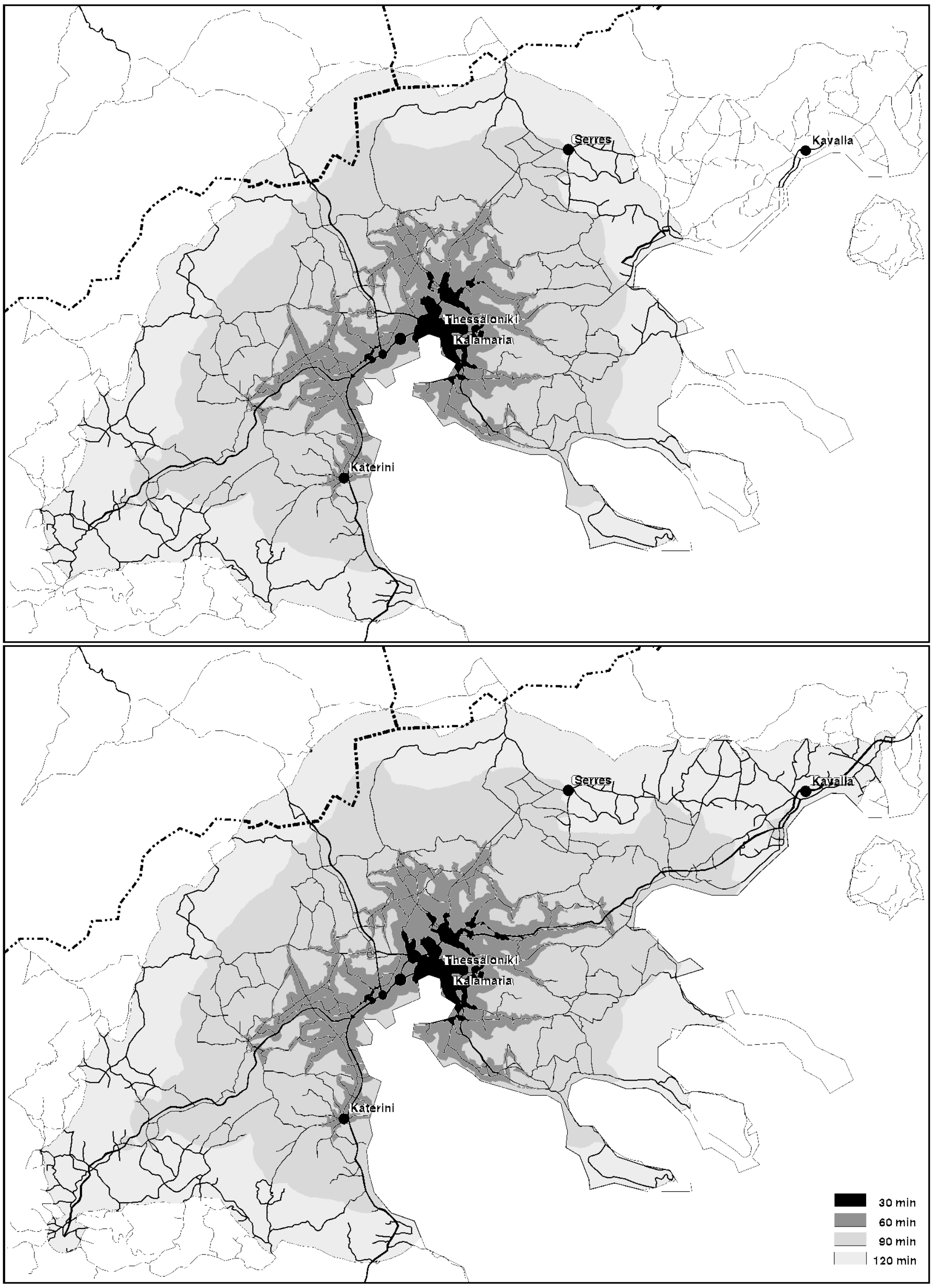

Figure 3: Isochrones prior (top) and after(bottom) the full implementation of the Egnatia motorway

A comparison with the future situation shows that greatest travel time reductions will take place north-east of Thessaloniki towards the city of Kavalla, when the motorway link is closed. Only very small improvements are likely to occur in south-west direction.

However, since the level of infrastructure provision in the Thessaloniki region is relatively good compared to other parts of Greece, these results are not very surprising. Although travel times from Igumenitsa will be diminished significantly (-30 min to Ioannina, even -100 min to Thessaloniki), the western part of northern Greece remains difficult to reach with remarkable long travel times to the main economic centres.

5 Potential type accessibility

In the context of simulation models, an appropriate way to describe the accessibility of locations is the potential-type accessibility (Figure 4). Belonging to the group of more complex accessibility indicators, the potential-type accessibility looks at the origins and destinations of traffic. It combines activity function (destinations to be reached) and impedance function (costs to reach a destination). The accessibility values referred to in this paper rely on the European Peripherality Index developed by [5].

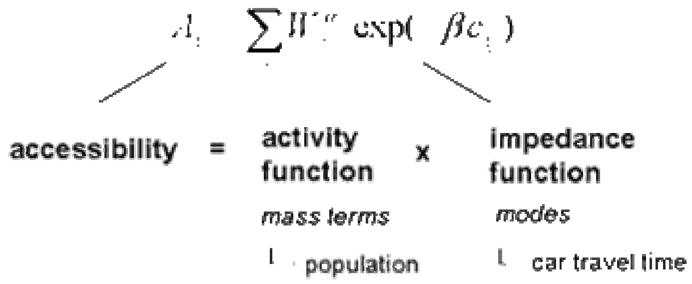

Figure 4: Accessibility calculations.

In this study, the impedance function is represented by car travel time. For the activity function the population mass term is employed. By applying this potential-type accessibility model to the Greek NUTS 3 regions, it is possible to foresee the increase of accessibility due to single infrastructure projects. As expected, the implementation of the Egnatia motorway leads to an advanced accessibility of all NUTS3 regions in Northern Greece. However, the accessibility increments are not limited to the regions adjacent to the new motorway route, but also extend to the more distant regions in central Greece. Totalling, the accessibility improvements are yet rather modest (Figure 5). The NUTS 3 region benefitting the most in accessibility terms is Xanthis in the North-Eastern part of the country. Its accessibility will rise by more than 4%. Similar gains in accessibility can be stated all along the Egnatia route, from Thesprotias and Prevezas on the Adriatic Coast to Rodopis and Evrou in the very East (+2 to +3%). The more distant regions such as Evias, Viotias and Fokidos will anyhow advance in accessibility by some 0.5 to 1 percent.

At a first glance, these results may surprise as the changes in accessibility turn up rather small. However, the low increments can easily be interpreted by recalling the above mentioned accessibility equation. Truly, the Egnatia motorway contributes to a clear reduction of travel times between the nodes of the motorway route as shown in the isochrone illustrations of the preceding analysis step. Thereby, the "impedance-factor" is diminished. The other half of the accessibility equation, the activity function, yet remains stable. In other words: the population directly reachable through the new motorway does not increase significantly, which results in only slight accessibility gains. Contrary, the realisation of the whole TEN Greek motorway projects, including the PATHE North-South corridor, will lead to clearly higher accessibility gains. The positive impacts of the PATHE link are not limited to its direct "neighbours", but comprises the whole of the Northern Greek regions. The improved access to the densely settled South of the country through the Egnatia *and* the PATHE motorways leads to relative accessibility increments of 10 to 15 percent in several of the Northern Greek regions along the Egnatia motorway.

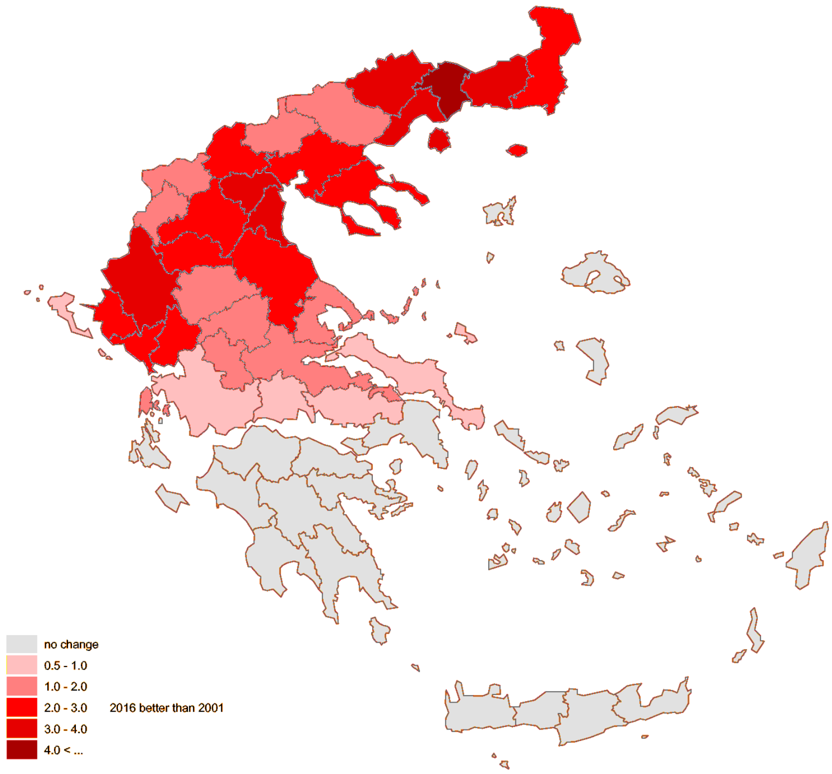

Figure 5: Via Egnatia v. current situation. Access to population by car for NUTS 3 regions. Relative differences in percentage points (GR current situation = 100)

6 Accessing socio-economic impacts

In order to forecast the socio-economic impact of the large European infrastructure projects, IRPUD developed simulation models of regional economic development. The project "Socio-economic and Spatial Impacts of Transport Infrastructure Investments and Transport System Improvements" (SASI) was conducted as part of the 4th Framework Programme for DG TREN as part of the EUNET project [3][4].

As Figure 6 shows, the SASI model consists of six interdependent forecasting submodels: European Developments, Regional GDP, Regional Employment, Regional

Accessibility, Regional Population and Regional Labour Force. A seventh submodel calculates socio-economic indicators with respect to efficiency and equity.

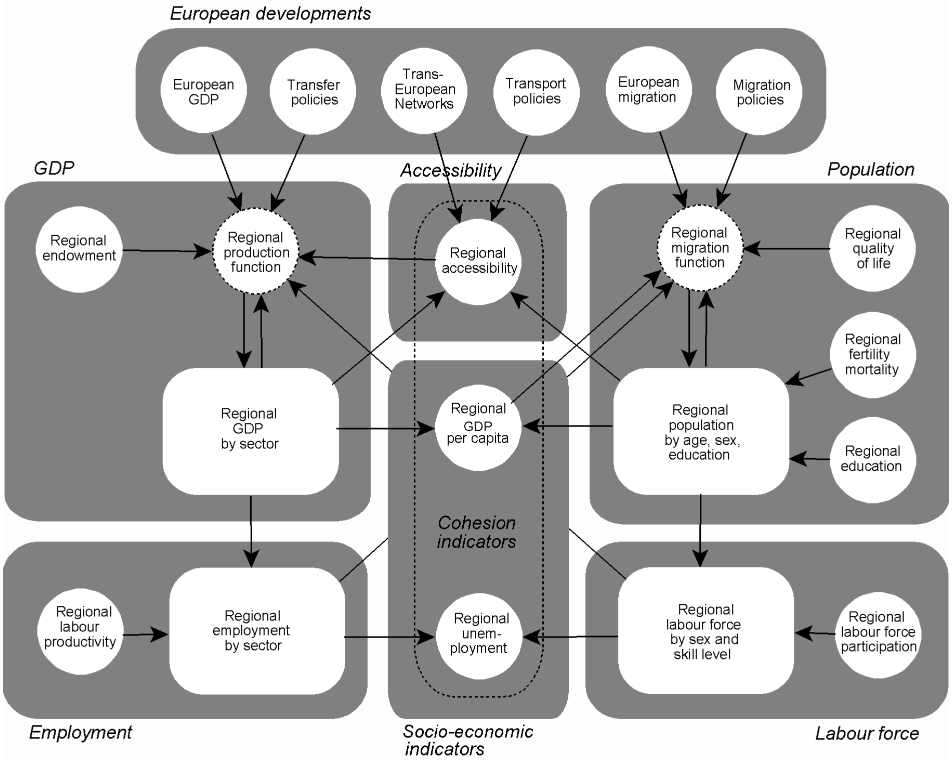

Figure 6: The structure of the SASI model [3][4].

The European Developments submodel comprises a number of exogenous assumptions about the economic, demographic and transport development. One of these exogenous variables are the trans-European networks which have a direct impact on the submodel of accessibility. Within this model, a change of the accessibility evokes changes in all other subsystems. Thereby, this model allows to quantify impacts of infrastructure improvements.

In order to demonstrate the impacts of different transport investments, the SASI model compares three basic scenarios, each of them referring to the forecasting horizon 2016: First, the “Do Nothing” scenario where the road and rail infrastructure does not change compared to the situation in the year 1996; second, the full TEN scenario where all planned road and rail projects funded by the EU are built - this scenario also includes the EGNATIA motorway. And third, the rail ten scenario where only the planned railway investments are implemented. A comparison of the different scenarios allows conclusions concerning the expected development of the accessibility and the resulting economic development of the Greek regions.

According to the SASI calculations, all European regions will experience an additional increase in accessibility through the implementation of the TETN. However, better accessibility does not necessarily correspond to more regional wealth. The most important results produced by the SASI model are therefore its predictions of GDP development. In order to illustrate the impact of the TEN infrastructure investments on the GDP-development of the affected regions, it is necessary to compare the rail-TEN and the TEN-scenario. This comparison allows to identify those European regions taking most advantage from the expected improvements of the road network (Figure 7).

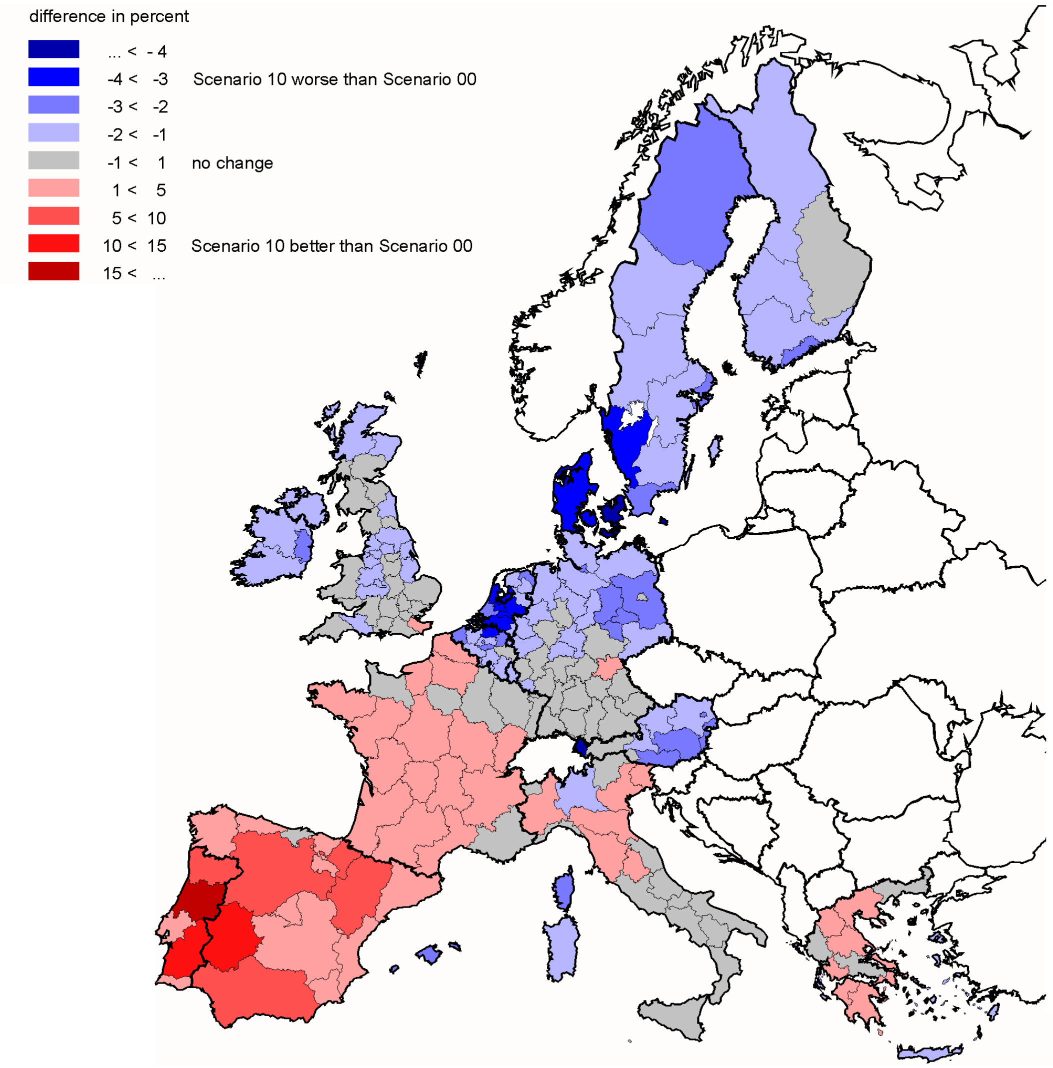

Figure 7: The impact of the TEN road and rail infrastructure investments on the relative development of the GDP in Europe (TEN-Scenario (10) v. Do-Nothing-Scenario (20), relative difference, 2016) [4].

According to the SASI model, all Greek mainland regions will benefit from the new Greek motorways built in East-West and North-South direction. Compared with other European countries, the Greek regions will benefit the most, together with Portugal and some regions in Spain and France. However, the SASI model also indicates that the GDP-increase specifically due to the transport infrastructure investments will remain rather modest. If the full TEN-Scenario and the "Do-Nothing"-Scenario are compared, the additional relative GDP-increase of Greek regions will be only of about 1 to 5 percent.

7 Conclusions and outlook

The application of the Egnatia example to the proposed analytical framework evidenced the need for a differentiated, multi-step analysis of spatial and socio-economic impacts. While the isochrone approach is easy to communicate, but ignores the ‘mass’ of potential destinations, the potential-type accessibility allows a sound assessment of the spatial impacts. The most relevant results can be attained by using a simulation model such as the SASI-model for reproducing the economic effects of new transport links.

Concerning the Egnatia motorway, the study found out that the relative increments in accessibility of the Northern Greek regions will remain rather small unless also further motorway projects, namely the PATHE motorway, are being implemented. An additional positive effect is to be expected by the vertical axes linking Egnatia to its hinterland, not considered in this study. Another result is that the expected effects of the Greek TEN projects on the GDP development are probably overestimated. Though the Greek regions will belong to those with the highest GDP gains in relative terms induced by road infrastructure improvements in Europe, the related increments in GDP will not exceed the 5 percent threshold (not to mention the absolute GDP level).

The analysis steps presented in this paper deliberately focus on the spatial and economic impacts of new transport links. Moreover, the SASI model is also capable to predict impacts on socio-economic variables such as employment and cohesion [4]. An overall assessment of impacts should also extend to further analysis dimensions, namely the effects on the transport system itself, measured in the traditional transport simulation models, and the environmental impacts (energy consumption, impact on landscape and eco-systems, discharges). Innovative approaches towards such a comprehensive evaluation are presently developed by the “Egnatia Motorway Spatial Impacts Observatory”, a co-operation of the Egnatia Odos A.E., the Aristotle University of Thessaloniki and the Hellenic Institute of Transport [1]. The integration of environmental submodels into regional economic simulation models can be rated as an important task for future research.

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