Modelling Socio-Economic Impacts of European Transport Infrastructure with and without the Øresund Link

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1. Introduction

The relationship between transport infrastructure and economic development has become more complex than ever. There are successful regions in the European core confirming the theoretical expectation that location matters. However, there are also centrally located regions suffering from industrial decline and high unemployment. On the other side of the spectrum the poorest regions, as theory would predict, are at the periphery, but there are also prosperous peripheral regions such as the Scandinavian countries. To make things even more difficult, some of the economically fastest growing regions are among the most peripheral ones.

In this situation, the European Union expects to contribute to reducing the socio-economic disparities between its regions by the development of the trans-European networks (TEN). The TEN are one of the most ambitious initiatives of the European Community since its foundation. The masterplans for rail, road, waterways, ports and airports together require public and private investment between 400 and 500 billion ECU until the year 2010. However, the TEN programme is not undisputed. Critics argue that many of the new connections do not link peripheral countries to the core but strengthen the ties between central countries and so reinforce their accessibility advantage. Some analysts argue that regional development policies based on the creation of infrastructure in lagging regions have not succeeded in reducing regional disparities in Europe, whereas others point out that it has yet to be ascertained that the reduction of barriers between regions has disadvantaged peripheral regions. From a theoretical point of view, both effects can occur. A new motorway or high-speed rail connection between a peripheral and a central region, for instance, makes it easier for producers in the peripheral region to market their products in large cities, however, it may also expose the region to the competition of more advanced products from the centre and so endanger formerly secure regional monopolies.

In the face of this uncertainty, the consistent prediction and the rational and transparent evaluation of likely socio-economic impacts of major transport infrastructure investments has become of great political importance. A comprehensive and transferable model for forecasting socio-economic and spatial impacts of large transport investments in Europe, in particular of different scenarios of TEN development, was developed in the project "Socio-Economic and Spatial Impacts of Transport Infrastructure Investments and Transport System Improvements" (SASI). With respect to the cohesion objective of the European Union, the model is to answer the question whether the TEN will lead to a reduction of regional disparities and which regions of the European Union are likely to benefit from the TEN and which regions are likely to be disadvantaged (Wegener and Bökemann, 1998; Fürst et al., 1999; Fürst et al., 2000).

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This paper presents the structure and scope of the SASI model and illustrates its application by forecasts of the socio-economic impacts of the TEN with and without the Øresund link project. The Øresund rail and road link connecting Denmark and Sweden is one of the TEN priority projects designed to better link peripheral regions to the European mainland. However, the Øresund link is special in that it does not link a poor periphery to the rich centre but that it connects two countries which are among the most affluent in Europe.

2. Model Overview

The SASI model is innovative in that it is based on measurable indicators derived from advanced location theory to explain and predict the locational behaviour of investment capital, manufacturing and services and population. It is pragmatic in that it does not require massive collection of data on socio-economic distributions or trade flows and travel patterns. It is designed to facilitate political discussion and negotiation by being transparent and open for new indicators and issues that may become relevant in the future.

2.1 Submodels

The SASI model consists of six forecasting submodels: *European Developments*, *Regional Accessibility*, *Regional GDP*, *Regional Employment*, *Regional Population* and *Regional Labour Force*. A seventh submodel calculates *Socio-Economic Indicators* with respect to efficiency and equity (Figure 1).

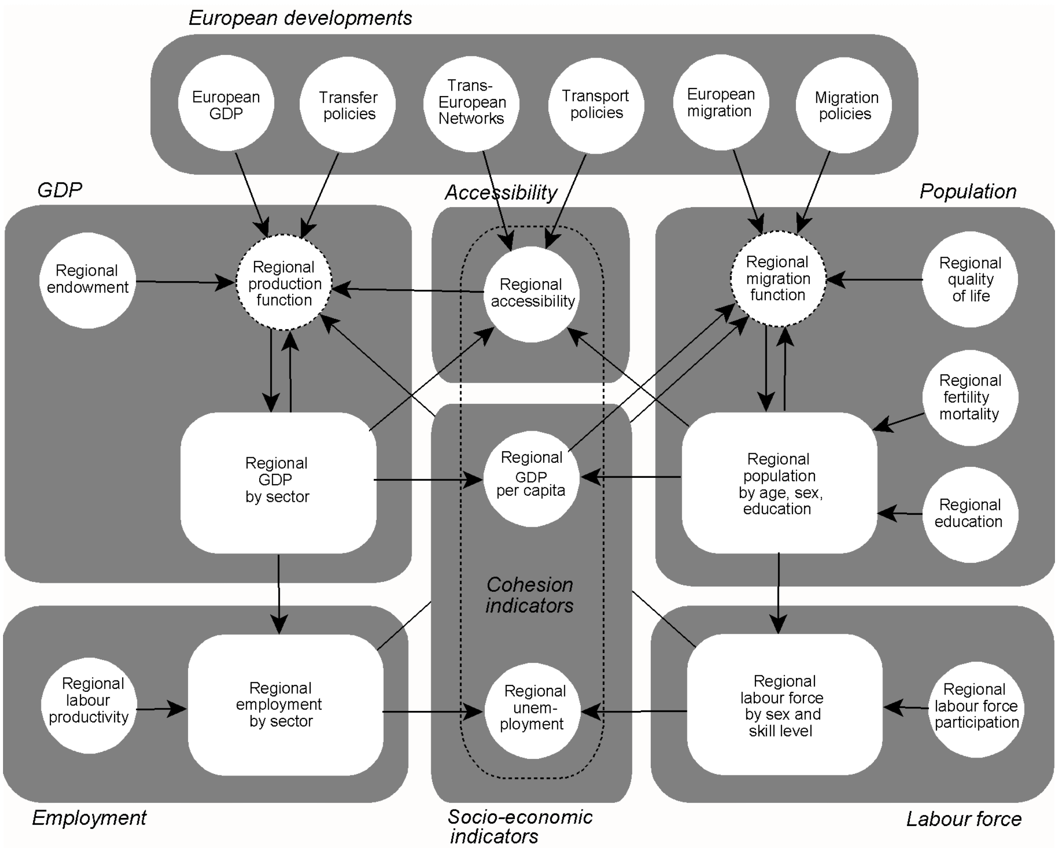

Figure 1. The SASI model

European Developments

The *European* Developments submodel is not a 'submodel' as it contains no forecasting equations. It simply prepares the exogenous assumptions about the wider economic and policy framework of the simulation for subsequent processing by the other submodels. European developments include assumptions about the future performance of the European economy as a whole and the level of immigration and outmigration across Europe's borders. They serve as constraints to ensure that the regional forecasts of economic development and population are consistent with external developments not modelled. Given the expected rapid population growth and lack of economic opportunity in many origin countries, total European immigration will be largely a function of immigration policies by national governments of the countries of the European Union. Another relevant European policy field are transfer payments by the European Union or by national governments, which are responsible for a sizeable part of their economic growth in some regions. The last group of assumptions concern policy decisions on the trans-European networks. As these are of focal interest in SASI, they are modelled with considerable detail. Besides a 'baseline' scenario several TEN scenarios reflecting different investment programmes for the road, rail or air networks were specified.

Regional Accessibility

This submodel calculates regional accessibility indicators expressing the locational advantage of each region with respect to relevant destinations as a function of travel time or travel cost (or both) to reach these destinations by the strategic road, rail and air networks. From a variety of accessibility indicators, potential accessibility expressed as logsum of road, rail and air networks were selected as most relevant for explaining the locational behaviour of firms. Schürmann et al. (1997) present the method of calculating accessibility indicators; the choice of accessibility indicators for the model is explained in Fürst et al. (1999).

Regional GDP

This is the core submodel of the SASI model. It forecasts gross domestic product (GDP) by industrial sector (agriculture, manufacturing, services) generated in each region as a function of economic structure, labour force, endowment indicators and accessibility. Endowment indicators measure the suitability or capacity of a region for economic activity. They include traditional location factors such as availability of business services, capital stock (i.e. production facilities) and intraregional transport infrastructure as well as 'soft' location factors, such as cultural facilities, housing and a pleasant climate and environment. Accessibility indicators are derived from the *Regional Accessibility* submodel. In addition, monetary transfers by the European Union or by national governments are considered, as these account for a sizeable portion of the economic development of peripheral regions. The results of the regional GDP per capita forecasts are adjusted in a way that the total of all regional forecasts multiplied by regional population meets the exogenous forecast of economic development (GDP) of Europe as a whole as defined in the *European Developments* submodel.

Regional Employment

Regional employment is calculated by combining the results of the GDP submodel with exogenous forecasts of regional labour productivity by industrial sector (GDP per worker), which in addition may be changed by effects of changes in regional accessibility. It is assumed that labour productivity grows by an average sector-specific growth rate and is co-determined by historical conditions in the region, i.e. by its composition of industries and products, technologies and education and skill of labour.

Regional Population
Population forecasts are needed to represent the demand side of regional labour markets. The *Regional Population* submodel therefore predicts regional population change due to natural change and migration. Births and deaths are modelled by a cohort-survival model subject to exogenous forecasts of regional fertility and mortality rates. Migration is modelled in a simplified migration model as annual net migration as a function of regional unemployment and other indicators expressing the attractiveness of the region as a place of employment and a place to live. The migration forecasts are adjusted to comply with total European immigration and outmigration forecast in the *European Developments* submodel and the limits on immigration set by individual countries. In addition, educational attainment, i.e. the proportion of residents with higher education, is forecast as a function of national education policy.

Regional Labour Force
Regional labour force is derived from regional population and exogenous forecasts of regional labour force participation rates modified by effects of regional unemployment. It is assumed that labour force participation grows by an average country-specific rate and is co- determined by historical conditions in the region, i.e. by cultural and religious traditions and education, and that it is positively affected by availability of jobs (or negatively by unemployment).

Socio-economic Indicators
Total GDP and employment are related to population and labour force by calculating total regional GDP per capita and regional unemployment. Accessibility, besides being a factor determining regional production, is also considered a policy-relevant output of the model. In addition, equity or cohesion indicators describing the distribution of accessibility, GDP per capita and unemployment across regions are calculated.

2.2 Space and Time

The SASI model forecasts socio-economic development for 201 regions at the NUTS-2 level for the fifteen EU countries (Eurostat, 1995). These are the 'internal' regions of the model. 27 regions defined for the rest of Europe are the 'external' regions used as additional destinations when calculating accessibility indicators.

The spatial dimension of the model is established by the connection of the regions via networks. In SASI road, rail and air networks are considered. The 'strategic' road and rail networks used in SASI are subsets of the pan-European road and rail networks developed by IRPUD (1999) and adopted by Eurostat for the GISCO spatial reference database. The strategic road and rail networks contain all TEN links laid down in Decision No. 1692/96/CE of the European Parliament and the Council (European Communities, 1996) and the east European road and rail corridors identified by the Pan-European Transport Conference in Crete in 1994 as well as additional links selected for connectivity reasons (European Communities, 1995).

The temporal dimension of the model is established by dividing time into discrete time intervals of one year duration. By modelling relatively short time periods both short- and long-term lagged impacts can be taken into account. The base year of the simulations is 1981 in order to demonstrate that the model is able to reproduce the main trends of spatial development in Europe over a significant time period of the past with satisfactory accuracy. The forecasting horizon is 2016.

In each simulation year the seven submodels of the SASI model are processed in a recursive way, i.e. sequentially one after another. This implies that within one simulation period no equilibrium between model variables is established; in other words, all endogenous effects in the model are lagged by one or more years. Figure 2 illustrates the recursive organisation of the model.

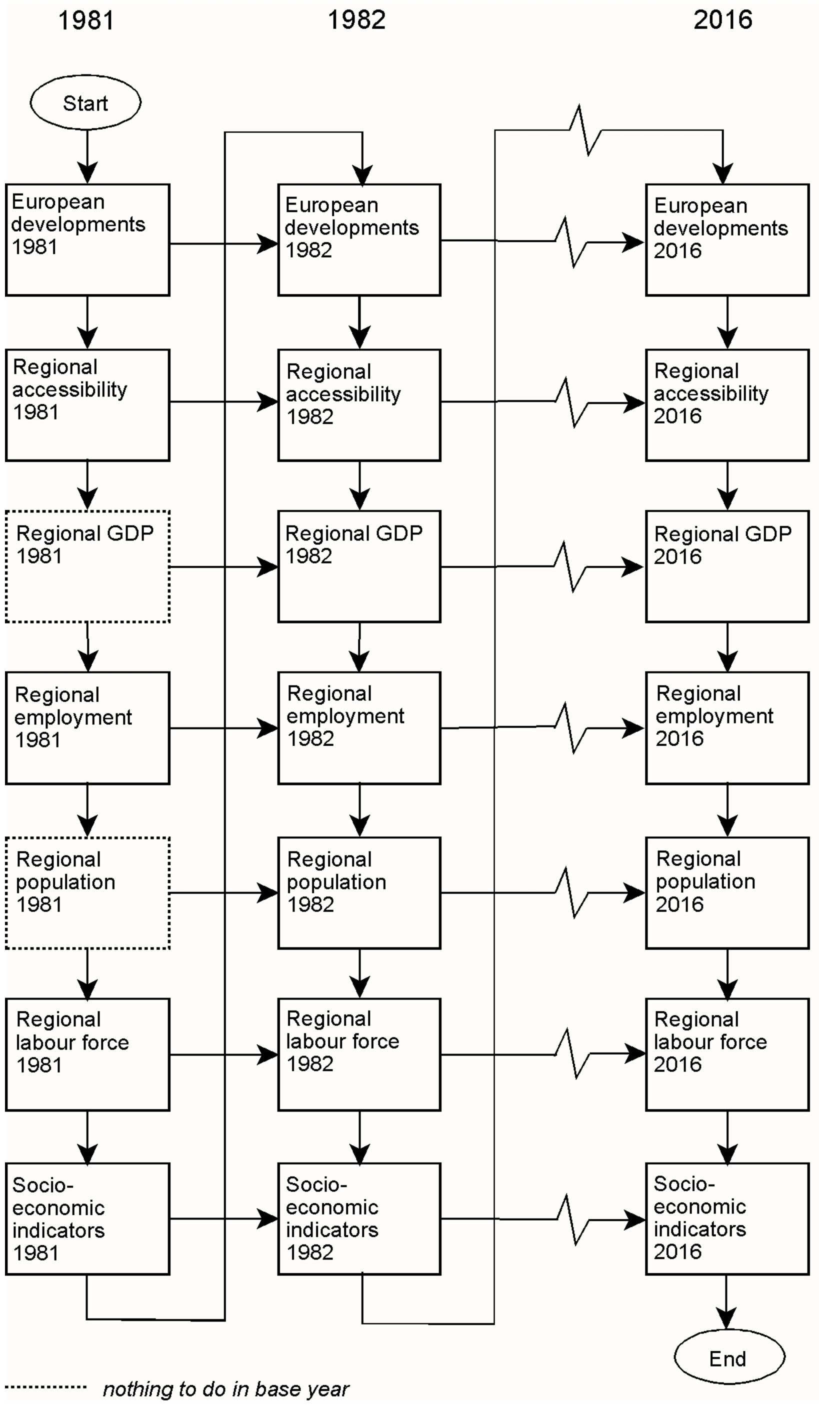

Figure 2. The recursive organisation of the SASI model

2.3 Network Scenarios

As the purpose of the SASI model is to forecast impacts of TEN policy decision, several policy scenarios were defined to demonstrate the application of the model.

The 'backbone' of these scenarios is the network evolution over time from 1981 to 2016. All scenarios are based on assumptions about the development of trans-European transport networks. The implementation of these assumptions starts from a 'backcast' of the evolution of the road, rail and air networks between 1981 and 1996. This backcast is similar for all transport infrastructure scenarios. The scenarios differ in their assumptions on the future development of the networks between 1996 and 2016.

An infrastructure scenario is a time-sequenced investment programme for addition, upgrading or closure of links of the trans-European road or rail networks. Because of the inherent characteristics of aviation networks, which depend mainly on the distribution of slots among air lines, it is impossible to define reasonable future air networks, wherefore the 1996 air network remains unchanged for future years. The assumptions of the road and rail network scenarios will be implemented in five-year increments.

Currently four scenarios are implemented for the SASI model: a 'do-nothing scenario', two scenarios based on assumptions about the overall development strategy for the TEN and one scenario involving a single project (Table 1):

Table 1. Scenarios

Scenario number	Scenario name	Description
Scenario 00	Do-nothing	No network changes beyond 1996
Scenario 10	TEN	Evolution of road and rail networks according to the TEN programme
Scenario 20	Rail TEN	Evolution of rail network according to the TEN programme, no change for road beyond 1996
Scenario 09	Øresund Ferry	Scenario 10 in which the Øresund bridge is replaced by current ferry services

In the *Do-nothing Scenario* (00) no development of the trans-European transport infrastructure is foreseen, i.e. the networks remain constant in future years as in 1996. Even new links currently under construction or even in operation are not part of this scenario. The purpose of the Do-nothing Scenario is to serve as reference and benchmark for the other scenarios.

The *TEN Scenario* (10) assumes that all road and rail links of the TEN network will be implemented until 2016. In the *Rail TEN Scenario* (20) it is assumed that only the rail links of the TEN programme are implemented and that nothing happens with respect to road. All TEN projects are applied to these two scenarios with respect to their estimated completion times as laid down in the TEN implementation report (European Commission, 1998). If no completion year is available, the projects are first introduced in the 2011 networks. Figure 3 shows as an example for the network scenarios the evolution of planned TEN railway links for the TEN Scenario with respect to their estimated completion year.

Figure 3. Evolution of the strategic rail network in the TEN Scenario (10)

In Figure 3 those TEN projects are highlighted which will be newly constructed or result in changing network capacities on existing links (e.g. adding a second track) or changing speeds, whereas other projects such as removing level crossings and links without improvements are displayed with thin lines.

As an example of a project scenario, the *Øresund Ferry Scenario* (09) is presented. This scenario is identical to the TEN Scenario except that the Øresund bridge and tunnel are replaced by current ferry services in the future road and rail networks. Because the remaining networks are identical, it is possible to isolate the socio-economic impacts of the Øresund link project. The results of this scenario will be presented in more detail below.

3. The Regional Impact of the Øresund Link

The Øresund link is especially suitable for assessing the impact of an individual project because it connects two previously physically separated countries. The bridge and tunnel are expected to open in July 2000 and connect the Danish region of Copenhagen and the Swedish region of Malmö. This link is important because it relieves one of the main infrastructure bottlenecks for passenger and goods transports from and to Sweden and Finland. It is an important infrastructure endowment for the 3.5 million inhabitants living within 100 km from the Øresund and for a considerably higher number of transit passengers. For this reason the Øresund link is part of the so-called priority projects of the TEN infrastructure programme.

The assessment of the socio-economic impacts of the Øresund bridge is performed by comparing the TEN Scenario (10) including the new bridge and tunnel with the Øresund Ferry Scenario (09) in which bridge and tunnel are replaced by ferry services as they exist today.

Figure 4 shows a comparison of the TEN Scenario (10) with the Øresund Ferry Scenario (09) with respect to accessibility for selected regions around the Øresund. It is apparent that due to the implementation of the TEN programme accessibility is increasing for the three regions Copenhagen (CP), Malmö (ML) and Stockholm (ST). In the regions of Copenhagen and Malmö differences in the accessibility trajectories of the two scenarios are visible, while there are no significant accessibility differences in the more distant region of Stockholm.

Figure 5 shows an equivalent comparison of the scenarios with respect to differences in GDP per capita. It can be observed that the better accessibility generated by the Øresund link leads to increased economic performance. Better accessibility results in easier movement of persons and goods between the regions and consequently in higher economic performance. The effects of the Øresund link are highest for Copenhagen because Copenhagen is much closer to the European mainland and its main market areas. The effects for the more distant region of Stockholm are again negligible.

The two maps in Figure 6 show the spatial distribution of impacts. The left-hand map shows that marginal gains in accessibility are to be expected mainly in the Nordic countries and not so much on the European mainland. It is also obvious that the accessibility impact of the link weakens with distance from the link. While the accessibility of Malmö and Copenhagen increase by 1.9 and 1.6 percent, respectively, the effect for all other regions north of the Øresund is below one percent. On the European mainland, only the Danish region Vest for Storebælt and Schleswig-Holstein in Germany experience a slight gain in accessibility through the Øresund link. The accessibility impact on all other regions is negligible.

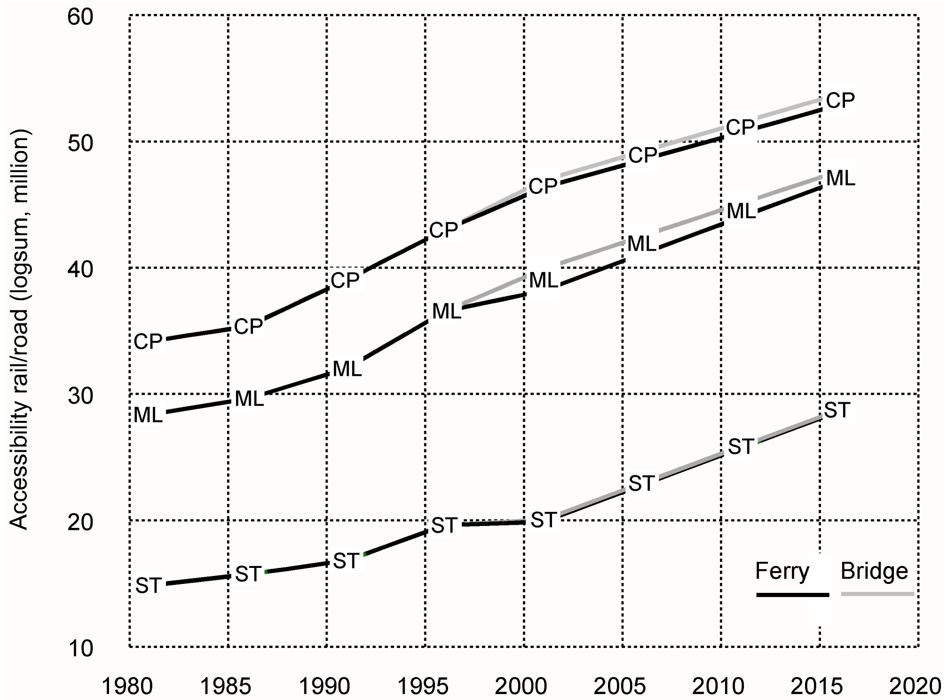

Figure 4. Øresund Ferry Scenario (09) and TEN Scenario (10): accessibility, 1981-2016

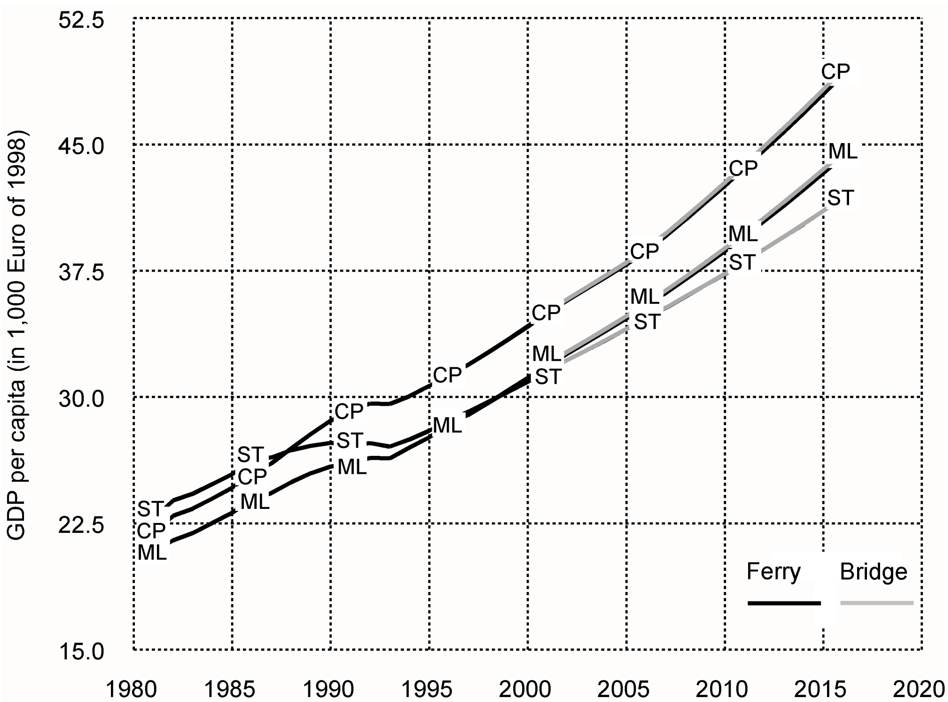

Figure 5. Øresund Ferry Scenario (09) and TEN Scenario (10): GDP per capita, 1981-2016

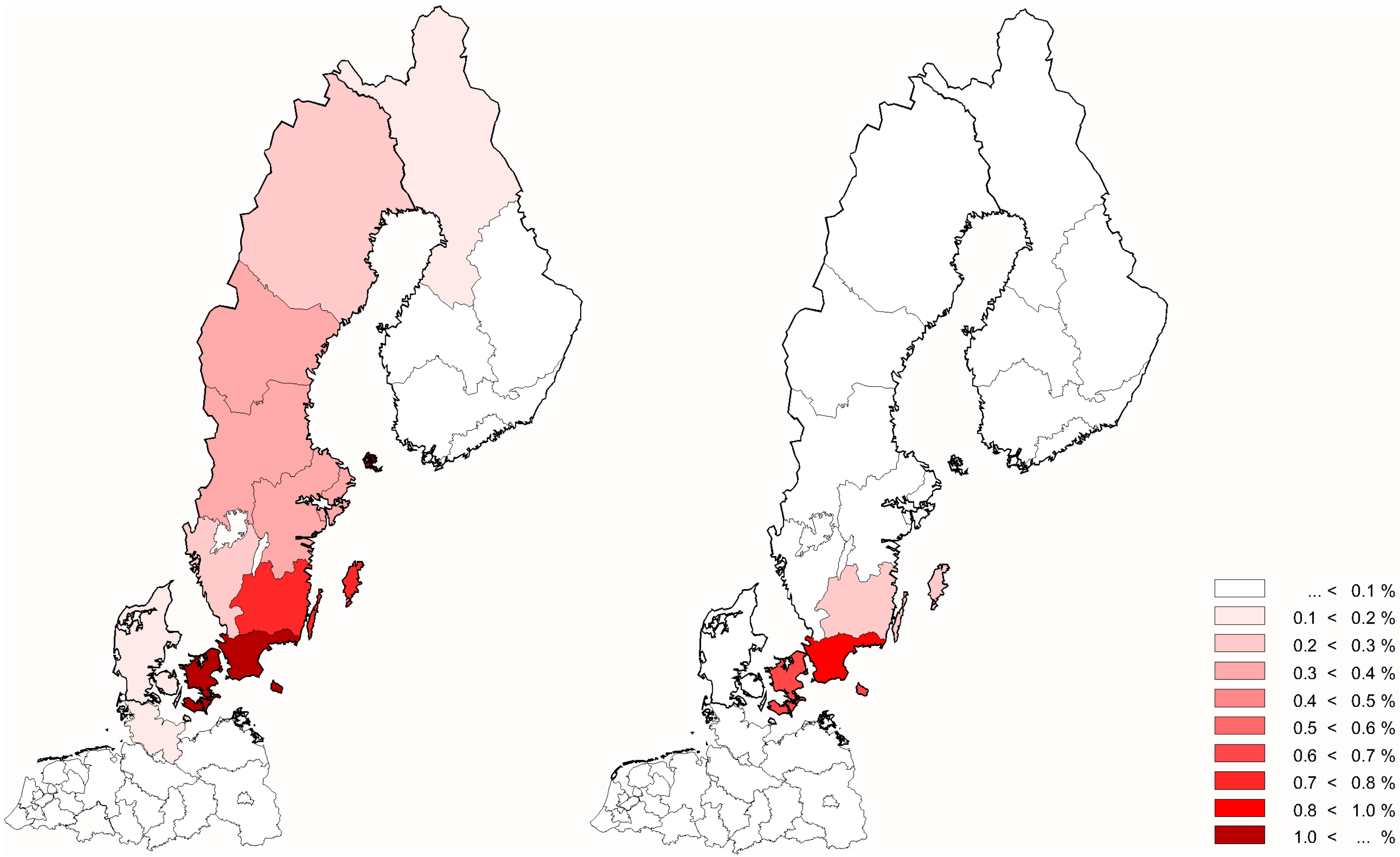

Figure 6. Øresund Ferry Scenario (09) and TEN Scenario (10), relative difference in accessibility (left) and GDP per capita (right), 2016

The right-hand map in Figure 6 shows that the number of regions experiencing gains of over 0.1 percent in GDP through the Øresund link is even smaller than for accessibility. The difference amounts to 0.8 percent in the region of Malmö and 0.6 percent in the region of Copenhagen. The region of Jönköping increases its GDP by about 0.23 percent through the link.

The example of the Øresund link demonstrates that the SASI model is sufficiently sensitive to assess individual infrastructure projects with regard to their impact on accessibility and regional economic development. The results are plausible at the regional level even in a range of below one percent of the respective total indicator value.

4. Conclusions

The main task of the SASI project has been to identify the way transport infrastructure contributes to regional socio-economic development in different regional contexts. The examination of the results of the Øresund link scenario showed that accessibility and economic performance impacts are strongest in the regions adjacent to the project site and that benefits occur mainly in southern Sweden as a consequence of the removal of a general transport bottleneck towards the European core regions. However, the characteristic of the Øresund link project is not only the removal of a bottleneck, but also that it links relatively affluent Danish and Swedish regions. So it is not surprising that the effects of the Øresund link are small compared to the overall economic development.

These results have to be seen in the context of the overall impacts of the TEN infrastructure investment programme. The assessment of the other three scenarios (Do-nothing, TEN, Rail-TEN) shows (Fürst et al., 2000):

- The development trajectories of the European regions are similar for all scenarios, thus confirming the assumption that socio-economic and technical macro trends, such as ageing of the population, shifting labour force participation and increasing labour productivity, are the most powerful driving forces of regional development and have a much stronger impact than different transport infrastructure scenarios.

- In all network policy scenarios most European regions will improve their accessibility and economic performance in absolute terms. However, differences in relative terms reveal that numerous changes in the relative positions of regions and countries are to be expected. This implies that there may be relative losses of some regions which can lead to absolute losses in the increasing economic competition between regions in the long run.

- The full TEN scenario leads to a slightly less polarised distribution of accessibility and GDP among European regions than the rail-only TEN and the do-nothing scenario. This slight cohesion effect of the TEN will, however, not be able to reverse the general trend towards economic polarisation in the European Union.

The example of the Øresund link confirms these findings: that even significant local differences in accessibility caused by a major transport infrastructure project result in only small changes in economic performance, and that these changes are much smaller than the general growth in economic performance due to other socio-economic trends. However, this does not preclude that the project changes the perception of public and private regional actors and triggers other policies and investments which may put the region on a new trajectory.

5. References

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