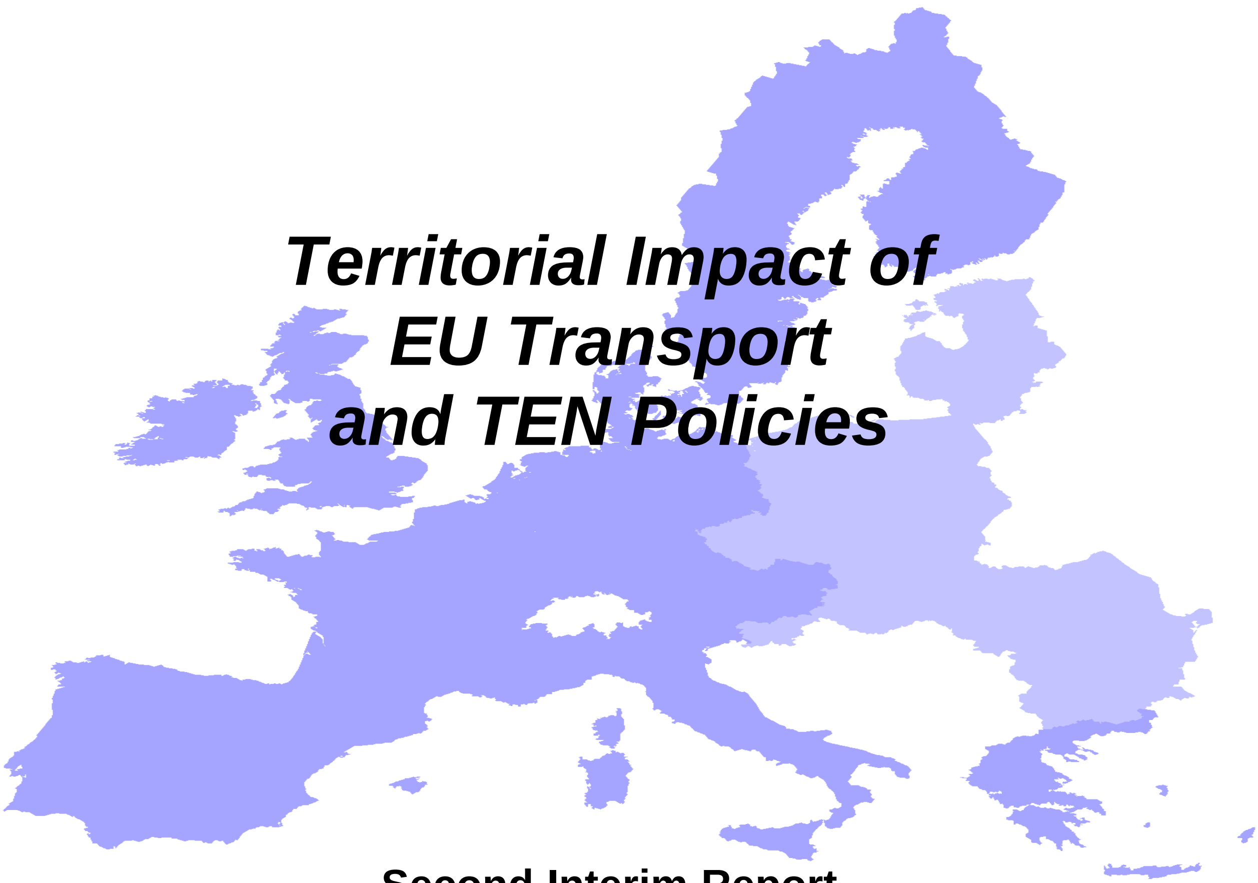

Territorial Impact of EU Transport and TEN Policies

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

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1 Introduction

This is the second interim report of the ESPON 2.1.1 Project. It describes in detail the methodology for the impact assessment of EU transport and TEN policies as well as ICT policies, that will be carried out by the ESPON 2.1.1 Transnational Project Group.
In this report we give a more detailed view at the indicators that can be computed for the analysis of the policies under review, the assessment of their impact and the evaluation of respective policies that have been conducted in the EU at national and supranational scale. The database necessary to compute these indicators and map-making standards are presented, that will be important for the evaluation of policies which are examined by presenting the distribution of the proposed indicators. Sample maps are enclosed that visualize the status quo of the most important indicator groups as well as the net plans of the TEN and TINA projects.

To build the database of indicators, that will be forecast, the toolbox will be described for the impact analysis, which address the direct economic impact, socio-economic impact, economic spillovers between transport and telecommunication network policy impact and causality analysis. At the end of the report the data are listed that are necessary as input of the methodologies proposed in the next chapter.

Building on the forecasting mechanisms and the output indicators, the assessment of the forecasting results is the next step in the development of the overall analysis of the territorial impact of transport and TEN policies. Attention will be given to the identification of regions most positively and negatively affected by the identified trends, that is in particular the TEN and TINA projects. The issues that will be discussed particularly in this respect are accessibility, the proposal of a typology of accessibility vs. the economic impact of a change in accessibility, which arise due to envisaged future policies and investments, the analysis of the impact on polycentrality in an enlarged Europe by the future trends, the impact on territorial cohesion and the presentation of hypotheses on the territorial effect of measures of transport policy.

In the last step it is the task of the interim report to give a diagnosis of the transport and TEN policies in an enlarged Europe. It gives a draft presentation of the interplay between EU and sub-EU spatial policies, recommend further policy developments in support of territorial cohesion and a polycentric and better balanced EU territory and to find appropriate instruments to improve the spatial co-ordination of EU and national sector policies and the ESDP.

These hypotheses stated are furthermore constituting part of a working report presenting provisional results of the research undertaken on the future trends and the spatial effects at EU level in terms of the economic relocation and other spatial criteria. In the formulation of the proposed typologies and the hypotheses on the issue of polycentrality, it has been taken account of the existing territorial imbalances and regional disparities in transport and TEN infrastructure.

As this report of the ESPON project 2.1.1 does not stand alone, but is part in the cluster of ESPON projects, it is also task of this report to provide input for the achievement of the horizontal projects under ESPON Priority 3 and give input for a cross-thematic analysis of the identified trends and the evaluation of the results of the other studies towards integrated results for the territorial development.

Structure of the Report

Part one gives a summary of the overall report and presents the main findings of the group constituted in the sections "Presentation of Approaches, Methodologies, Typologies, Concepts, Indicators, Data Availability and Mapping" and "Summary of Main Findings". Section III comments on the integration of the points raised in response to the first interim report and presents an overview of the application of the Common Platform and the networking, that has been undertaken towards ESPON projects and similar projects, financed by the EU or national agencies, that have a relation to the thematic concepts and the data needs of ESPON 2.1.1. The first part is concluded by a summary of the updated preliminary results and maps envisaged for the Third Interim Report.

Part two is the core part of the report. Chapter 2 describes indicators, which are considered most relevant by this project group for the assessment of territorial impacts of EU transport and TEN policies. They are distinguished with respect to the kind of territorial impact they measure, such as the effects on the distribution and location of economic activities, on the distribution of population and migration, on regional labour markets and on the sectoral structure of the regional economy as well as on regional accessibility with respect to transport telecommunication infrastructure. Indicators for measuring the spatial impacts of ICTs are also presented. Finally the standards for map-making are presented, a form of presentation that is most relevant for the visualization of spatial indicators, networks and typologies.

Chapter 3 describes the methodologies used by ESPON 2.1.1 in order to forecast the territorial impact of relevant policies in transport and ICT policies and investments, moving from methodologies addressing specific issues, such as causality analysis to more complex models, beginning with a quasi-production-function approach which is extended in chapter 3.3 for a measurement of the common impact of transport and ICT policies and infrastructure investments in one model and to analyse spillovers between both policy areas. This chapter is ended by the presentation of the CGEurope model, which is a spatial equilibrium model of trade and passenger flows.

Chapter 4 describes the assessment of the forecast results with respect to the building of typologies, that describe the impact of policies, the definition of the concept of polycentrism and a proposal on operationalisation and measuring this concept and to make recommendations on the evaluation of policy measures towards the strengthening of polycentrism in an enlarged Europe. Furthermore, there will be carried out an analysis of overloaded transport corridors taking especially into account the spatial objectives given in the ESDP. The chapter is concluded by a list of the main hypotheses that have been developed in the research undertaken so far.

Chapter 5 sets out the range of policy areas which interact with transport and TEN policies, such as other Community policies and different levels of policy implementation. It gives conclusions and recommendations on the improvement of the sector policies and related instruments. It also identifies the types of interactions which are likely to be relevant in order to suggest ways in which these might need to be incorporated in the definition of indicators and recommendations on the institutional aspects of the spatial co-ordination of EU and national policies.

Chapter 6 concludes this report.

Part One

I Presentation of Approaches, Methodologies, Typologies, Concepts, Indicators, Data availability and Mapping

This chapter and the chapter II: "summary of main findings" summarizes the detailed presentations laid out in the second part of this interim report. The approach of the ESPON 2.1.1 TPG is arranged in 5 steps:

1. Presentation of the indicators that can be computed with the methodology used by the TPG,
2. Presentation of the methodologies for the forecasting of the identified trends analysed policies and the definition of their mutual interfaces, that combines them into one tool,
3. The assessment of the forecasting results and the definition of typologies and indicators that measure the identified problems that arise from the policies,
4. The formulation of hypotheses that are drafted from the identified trends and planned policies,
5. The presentation of main policy fields and the horizontal and vertical co-ordination of these policies and draft recommendation for the respective sector policies.

In this chapter I it is the task to present the first three steps of this approach, chapter II presents the fourth and fifth step.

Methodologies

The toolbox for the forecasting of the territorial impact of EU TEN and transport as well as ICT networks covers four methodologies that will be used by the TPG. These methodologies include causality analysis, the SASI-model, the STIMA-model, which is an extension of the SASI-model, and the CGEurope-model.

Causality analysis

Causality analysis is the basis for the two models described hereafter. The tool described here has the task to solve the problem, which factor influences the other to what extent. The main problem is to explain to what extent regional production is influenced by accessibility, and to what extent is accessibility influenced by regional production. Even though this question is empirically difficult to answer, the availability of adequate data will allow for answering at least a part of these questions. The concepts that will be used is the method of Granger causality, which is widely used in academic context. In order to be able to carry out the causality analysis the use of panel data is strongly preferred over the use of a pure cross-section over regions. The latter will not allow for purging unobserved regional effects, such as, e.g., the regional institutional settings, and will therefore not be able to separately identify the effects of accessibility on production from institutional effects on production.

Therefore time-series data is required for analysing the causal direction. For most EU15-countries the data necessary to conduct the analysis is available at the REGIO-database or available in the project group, for the accession countries partly missing-data techniques have to be applied or, if time-series data on regional level is not available for all countries, the Causality Analysis could be conducted for sample countries or by using time-series data on national scale.

SASI

Using the causality analysis as input for the identification of the main driving socio-economic forces, the main concept of the SASI model is to explain locational structures and locational change in Europe in combined time-series/cross-section regressions, with accessibility indicators being a subset of a range of explanatory variables.

Accessibility is measured by spatially disaggregate accessibility indicators which take into account that accessibility within a region is not homogenous but rapidly decreases with increasing distance from the nodes of the networks. The focus of the regression approach is on long-term spatial distributional effects of transport policies. Factors of production including labour, capital and knowledge are considered as mobile in the long run, and the model incorporates determinants of the redistribution of factor stocks and population. The model is therefore suitable to check whether long-run tendencies in spatial development coincide with development objectives discussed above. Its application is restricted, however, in other respects: The model generates distributive, not generative effects of transport cost reductions, and it does not produce regional welfare assessments fitting into the framework of cost-benefit analysis.

The SASI model differs from other approaches to model the impacts of transport on regional development by modelling not only production (the demand side of regional labour markets) but also population (the supply side of regional labour markets), which makes it possible to model regional unemployment. A second distinct feature is its dynamic network database based on a 'strategic' subset of highly detailed pan-European road, rail and air networks including major historical network changes as far back as 1981 and forecasting expected network changes according to the most recent EU documents on the future evolution of the trans-European transport networks.

For the production of forecasts, the SASI model has seven submodels:

- European Developments
- Regional Accessibility
- Regional GDP
- Regional Employment
- Regional Population
- Regional Labour Force
- Socio-economic Indicators

In ESPON 2.1.1, the model will be validated by using the econometric results from the Causality Analysis between regional production and accessibility. In addition, the results of the STIMA model of the effects of telecommunications on regional development. It will be examined in the next period whether in a further step the quasi-production functions of both models can be merged.

STIMA

The methodology presented here assesses the impact of ICTs on both equity and efficiency. Given the importance of a quantitative assessment of ICTs investments, in the proposed methodology two economic indicators are applied:

- regional or local per capita income growth (measuring efficiency goals);
- differences in regional per capita income growth (measuring equity goals).

The impact of ICTs investments on income level, on income growth and on regional economic disparities is conceptually due to two main effects:

- an *accessibility effect*. Through ICTs, accessibility to knowledge and information highly increases, both in terms of quantity of information and knowledge achieved and of time through which information and knowledge are achieved. The greater availability of information and knowledge acts on the efficiency of local firms;
- an *employment effect*, which creates, via a multiplicative effect, an increase in total labour force and income. The creation of new ICTs infrastructure and of the service provision generate new employment, increases the competitiveness of exporting sectors and therefore generates an increase in income and in local development

In the STIMA model the impact of ICTs policies on regional development is analysed, measured by per capita regional income level and per capita regional income growth, and on regional disparities, measured by the differences in income levels among regions, before and after the policies' execution. These methodologies do not require a specific territorial disaggregation level of the data, so they can be tested at more aggregated territorial levels of analysis.

The main aim of this methodology is to describe the relationship which exists between ICTs endowment and regional development, and to provide a typology of territorial impacts. The methodology used to identify different typologies of ICTs impacts is a three-step procedure.

In the first step synthetic indicators are built on ICTs use, endowment and economic structure, through a factor analysis. In the second step, territorial units are aggregated on the basis of similar ICTs endowment, similar economic structure and similar ICTs use, through a cluster analysis. Finally, in the third step the results are presented on geographical maps and in synthetic charts.

Factor analysis: The first step helps in identifying indicators obtained as a statistical synthesis of different possible variables representing the same elements. Factor analysis is useful in this respect: it is a statistical procedure that groups similar indicators from the statistical point of view. It is thus possible to run a factor analysis on some indicators expressing similar elements, in order to obtain a comprehensive indicator that can be used in cluster analysis to produce a more interpretable result.

Cluster analysis: Once synthetic indicators are obtained, in the second step they are used in a cluster analysis. The *cluster analysis* is a statistical proceeding that groups the observations according to some characteristics to be specified from the researcher. Our intention is to use this methodology with the aim of providing a typology of regions, with a high homogeneity within each cluster and with high variations among clusters in terms of ICTs and economic dynamics indicators. We can run a cluster analysis using as clustering variables the change in accessibility, in regional income, in potential accessibility and in employment. The expected result from the application of this methodology is the identification of groups of regions that show a similar behaviour in terms of economic performance and ICTs use and adoption. In doing so, we are able to define different groups of regions, each witnessing a different degree of economic impact of ICTs.

CGEurope

The CGEurope model is a spatial-equilibrium model, in which transport costs explicitly appear as firms' expenditures for transport and other kinds of business travel and as households' costs of private passenger travel Transport policies are modelled by changing exogenously transport costs or travel times. As a response, prices as well as quantities react on the changes resulting in changes in income and welfare. The main indicator for the regional consequences is the welfare change of regional households as measured by the household's utility function, which is transformed to the so-called Hick's measures of variation, which measures the welfare change in monetary terms

The focus of the CGEurope model is on evaluating welfare effects in a comparative static equilibrium analysis, that means by comparing cases "with" and "without", leaving everything else unchanged. Hence the approach does not allow for long-term predictions of locational change. It studies welfare gains and losses given the spatial distribution of factors of production. Comparative static simulations will be carried out for a recent benchmark year, based on observed data, as well as for a future year, based on predictions of data, that is mainly for the TEN and TINA projects.

Three features give the CGEurope model its spatial dimension:

- the distinction of goods, factors, firms and households by location,
- the explicit incorporation of transport cost for goods (and services, regarded as a special kind of goods), depending on geography as well as national segmentation of markets, and
- the explicit incorporation of private passenger travel, with time costs and out-of-pocket costs depending on geography as well as national segmentation of space.

Typologies

ESPON 2.1.1 can develop a typology of regions with respect to their exposure to being affected by TEN policies. In addition, ESPON 2.1.1 can contribute to the development of a typology of urban regions in ESPON 1.1.1. However, main task of ESPON 2.1.1 is to forecast regional socio-economic impacts of EU transport and TEN policies. The main results of

ESPON 2.1.1 will be forecasts of regional socio-economic development under the assumption of different European transport and telecommunications policy scenarios. By comparing these results with those of a do-nothing or business-as-usual scenario, the effects of the policies of interest can be isolated and regions can be classified with respect to their likelihood of being positively or negatively affected by European transport and telecommunications policies.
What is discussed, that there exist different ways to present differences in regional socio-economic development:

- absolute change compared to a base year,
- relative change compared to a base year,
- absolute change compared to the EU average,
- relative change compared to the EU average,
- absolute difference compared to a do-nothing or business-as-usual scenario,
- relative difference compared to a do-nothing or business-as-usual scenario.

Depending on the difference chosen, a region can be classified as a winner or a loser with respect to a certain policy. This has to be considered carefully, as in a certain policy scenario a peripheral regions may gain in accessibility and GDP per capita in absolute and relative terms compared to its situation in the base year, but it may lose in relative terms as other more central regions gain more. It may even grow faster in relative terms than central regions but be still a loser as in absolute terms the central region gains more.

Main Concepts

Polycentrality

The approach proposed here is to identify and measure polycentrism in a basic way by identifying three dimensions: *size*, *morphology* and *connectivity*:

- *Size*. The first and most straightforward prerequisite of polycentrality is that there is a distribution of large and small cities. Rank-size distributions of cities in different European countries show that some countries have a predominantly monocentric city-size distribution (e.g. France), whereas other countries (e.g. Germany) have a historically grown polycentric urban system. A first step in analysing polycentrality of an urban system would therefore be to derive its population rank-size distribution. In addition other measures of city size and important may be used, such as economic activity, human capital, higher education, cultural importance, administrative status etc.

- *Morphology*. The second prerequisite of a polycentric urban system is that its centres of equal size or rank are equally spaced from each other – this prerequisite is derived from the optimal size of the catchment area or market area of centrally provided goods and services. Therefore, a uniform distribution of cities across a territory is more appropriate for a polycentric urban system than a highly polarised one where all major cities are clustered in one part of the territory. A second step of analysing polycentrality would therefore be to analyse the distribution of air line distances between cities of equal size or rank.

- *Connectivity.* The most difficult to measure property of polycentric urban systems is their connectivity. Ideally, the analysis would reveal functional relationships between cities of equal size or rank and between cities of different size or rank in the urban hierarchy. Appropriate indicators of such interactions would be flows of goods or services, travel flows or immaterial kinds of interactions, such as telephone calls or e-mails. At the level of municipalities, information on such interactions is rarely available or considered an economic asset, as in the case of travel flow data held by private transport carriers or telecommunications data held by private telecommunications operators. Proxies to be used instead of such data could be infrastructure supply, i.e. the level of road connections (motorways, roads) or the level of service of rail (number of trains) or air (number of flights) connections. The third step of analysing polycentrality would therefore be to analyse the quality of transport connections between cities of equal size or rank and between cities of different size or rank in the urban hierarchy.

With these three partial indicators of polycentrality, size, morphology and connectivity, a comprehensive indicator of polycentrality can be constructed.

Polycentric Connectivity and Overloaded Corridors

The ESDP focuses on interregional connectivity at different levels. Hence, it is desirable to evaluate the impacts of TEN measures on the quality of connections between a prescribed set of centres within different levels of the hierarchy of central places. The first part of this section deals with *polycentric and balanced development* and urban-rural partnership. It sketches an approach to evaluation that makes use of a systematic and structured selection of abstract links that connect places within the polycentric hierarchical system of centres all over Europe. The second part deals with *overloaded transport corridors.*

In a first step regions and corridors that are highly overloaded with the burden of transport have to be identified and classified empirically at the regional level. Then TEN projects are examined regarding their expected contribution to unburden the concerned regions and corridors. The relocation of transport streams and possibly expected modal shifts from road to rail or waterways should be used as an additional indicator for the reduction of the transport burden. This can be justified by a more sustainable use of infrastructure and lower external costs for these modes.

The analysis of overloaded transport corridors, however, has to be based on data of provided transport services and flows and on predictions, reassignments of flows resulting from TEN projects. This kind of data can not be calculated from the models used in the 2.1.1 consortium. Therefore this analysis has to rely on external work.

Cohesion Measurement

The inequality indicator we propose is the ratio between the arithmetic and the geometric mean of the incomes of the inhabitants of the European Union. It is often convenient to take the logarithm of this ratio.

The geometric and arithmetic means are equal to each other if all incomes are equal, but in all other cases the geometric mean is smaller. This means that the ratio of both is larger than 1 whenever there is income inequality. The indicator can be shown to satisfy the principle of transfers, which is an intuitive property of an inequality indicator. It can be linked to a welfare function that is a member of the class for which Atkinson (1970) developed his celebrated inequality indicator. Indeed, the measure proposed here is a special case of this indicator. Moreover, the logarithm of the ratio is additively decomposable. This implies that for an arbitrary regional division of the European Union it is the weighted sum of inequalities within regions and a term referring to inequality between regions.

Efficiency vs. Equity

In the previous section of this chapter an inequality indicator was proposed to measure cohesion. This inequality indicator is the ratio between the arithmetic and the geometric mean of the relevant variable. The arithmetic average of an indicator can often be interpreted as an indicator of efficiency. For instance, the level of unemployment in the European Union can be measured as the average unemployment rate in the whole European Union, whereas the regional variation in this variable can be measured by means of the ratio between the average unemployment rate and the geometric average of the regional unemployment rates. Efficiency and equity can, in this way, be related to each other.

Indicators

This is the list of the most important indicators that will be forecast by the proposed methodologies in the course of the further research.

- regional GDP per capita (NUTS-3)
- equivalent income measures of user benefits (NUTS-3)
- migration flows (NUTS-3)
- population by age (NUTS-3)
- employment (NUTS-3)
- labour force participation (NUTS-3)
- transport accessibility indicators (NUTS-3)
- by mode (road, rail, air) (NUTS-3)
- multimodal (logsum of road, rail, air and shipping) (NUTS-3)
    - telecommunication accessibility indicators (depending on data availability)
    - travel cost indicators (NUTS-3)
- employment in ICT (depending on data availability)
- cohesion indicators by country and for the entire study
- standard deviation of unemployment rates
- standard deviation of log of GDP per capita
- coefficient of variation of GDP per capita
- GINI coefficient of GDP vs. population
- Atkinson measure of spatial income inequality
    - standard deviation of unemployment rates
    - standard deviation of log of GDP per capita

- coefficient of variation of GDP per capita
- GINI coefficient of GDP vs. population
- Atkinson measure of spatial income inequality
- Ratio of geometric to arithmetic mean of GDP per capita

Data availability

For the quasi-production function approach data is sufficiently available to make appropriate forecasts on NUTS-3 level, as well as for the spatial-equilibrium model, which uses a similar data basis. Partly, as in the case of travel flows, data is only available at NUTS-2 level. For these data techniques for disaggregation are applied. A detailed table of the data needs and available data is complemented in the appendix.
For the causality analysis the database builds on the REGIO data provided by Eurostat, however existing data gaps have been filled and the series has been extended to more recent years using national data where available and backwards updates have been carried out.
The most problems concern the methodology of the STIMA model. ICTs data are not available at a disaggregated territorial level. After long telephone calls and face-to-face meetings with the ESPON 1.2.2 project coordinator (CURDS, University of Newcastle) on the availability of ICTs data, the conclusion achieved was that a sufficient time series and cross-section database on ICTs only exists for EU-27 at NUTS-0 level (Country level). Some attempts have been made by the Italian team to collect data at regional level for some specific Countries. In particular, this effort has been made for Italy and Finland. It has to be decided, if techniques will be applied to disaggregate the available national data or if case studies for those countries will be conducted, for which disaggregated spatial data on ICTs is available.

Mapping

For the mapping of the indicators, networks and typologies, the standard templates provided by ESPON 3.1 have been and will be used. Sample maps for the most important indicator groups for the status quo are presented in chapter 2.7.
For the ESPON-space (EU-27 at NUTS-3 level) a map-template exists, which is presented in figure 2.1. The figures 2.2 and 2.3 present the road and rail networks according to TEN/TINA masterplan. The figures 2.4 to 2.7 present samples of indicator maps.

II Main Findings

In this chapter the main hypotheses are summarized that are formulated in the fourth and fifth chapter and show the main findings so far that have been developed in the course of the assessment of the forecasting. In this section the hypotheses on the impact of transport as well as telecommunication networks are presented. Furthermore the main policy implications that arise from these hypotheses and identified trends are shown, complemented by two tables showing the opportunities and risks arising from the analysed policy measures.

Expected results

The assessment procedure will produce results on the spatial effects of the policies examined. These results will be presented in the form of maps, tables and diagrams. For instance, the potential for polycentric development can be assessed. The expected results will be performance of NUTS 3 regions according to the proposed indicators and the availability of data in the case of ICT policies and investments.

The performance of NUTS 3 regions according to the criteria used can be used to find an endogenous typology of regions in a similar way as was done in the CPMR study. Alternatively, the results for the NUTS 3 regions can be used to study how the various region types (e.g. urbanised areas in the "pentagon" or metropolitan areas in the periphery) perform according to, for instance, the quantitative indicators of potential for polycentric development.

Moreover, maps showing the performance of NUTS 3 regions according to single indicators, such as accessibility, may be an important tool in assessing the potential for polycentric development.

Similar remarks can be made with respect to spatial impact analysis, cohesion and the equity-efficiency trade-off.

Hypotheses about the territorial impact of EU TEN policies

The outcomes of the assessment procedure should be that insight into the territorial impact of EU TEN policies increases.

First of all, it seems useful to put the TEN EU policies in the broader perspective of economic development in the EU. Some hypotheses that appear to be plausible in the light of previous research are:

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

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

- In studies of daily accessibility of European cities, Erlandsson (1991) noted that, in a relative sense, 42 cities (out of 98) had lower outbound visit-time based accessibility 1988 compared to 1976. 33 of these also had a lower absolute level of outbound accessibility. A more positive picture is achieved if a contact-based outbound accessibility indicator is used. The network of most frequent air connections has been fairly stable between 1970 and 1978. The “pentagon” of most accessible European centres could easily be discovered at an early stage. The asymmetries of outbound and inbound accessibilities for peripheral locations (alluded to in Section 4.2.4) may therefore be an important barrier to location of headquarter functions. Road and rail investments are not very important for the European pattern of face-to-face accessibility, but they can be important for linking regional centres to European centres on a sub-European scale and for reducing congestion and increasing the efficiency of transport and hence increasing the efficiency of production.

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

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

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

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

- In the introduction to this chapter it was noticed that the effects on polycentric development that can be expected of transport and TEN policies may depend on the specific combinations of pricing and network components. Marginal cost pricing will mainly affect regions with high congestion, i.e. the congested corridors in the core region and some metropolitan areas in the periphery. The costs will increase but on the other hand transport times will be reduced. In metropolitan areas, the cost component tends to dominate for private person trips, while for business trips and freight transport the direct efficiency gain may exceed the direct cost increase. The distribution of impacts is to a large extent dependent on the indirect effects related to how the collected charges are to be used.

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

- TEN measures may support a polycentric and balanced spatial development.

- 8 of the 14 priority projects of the TEN are located in peripheral regions while 6 are mainly located in the “pentagon”. In general, the impact of transport investments on economic development can be expected to be larger in regions with less developed networks than in regions with dense and well developed networks. In well developed networks, extensive investment programmes may be required to substantially change the accessibility pattern. In urban areas radial transport investments tend to have decentralising impacts on location. This may also be the case in larger regional contexts. However, the overall impact of transport investments will depend on the competitiveness of the regional economies: a peripheral area may benefit from better market access but its production may, on the other hand, be subject to a higher degree of competition from imports.

- An earlier study of infrastructure investments in the Swedish context (Anderstig and Mattsson, 1989) showed a weak conflict between efficiency and equity criteria. However, the optimal distribution of investments over infrastructure types and regions differed substantially. Optimisation of the equity criterion led to more R&D investments at the expense of airport investments which dominated when the efficiency criterion was optimised. The study suggests that infrastructure investments in general and synergies between transportation and R&D policies might be used in regional policy without major sacrifices in terms of efficiency.

Presentation of hypotheses on territorial effects of relevant ICT policies

Policy scenarios

In this part of the report a list of significant ICTs policies is presented, which differ in terms of expected territorial impact and expected period of time in which the impact takes place. The three main policies are, according to the Action Plan of eEurope 2002 of the Community:

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

These three policies have different impacts, in terms of both the period of time in which the policy generates its positive effects, and the territorial impacts they generate:

- the first policy is a short-term policy, since its positive effects are captured by employment creation and potential accessibility increase; both generate a short-term multiplicative effect on income, but they do not act on real competitiveness. These policies are devoted to those areas where ICTs infrastructures endowment is below the European average;
- the second policy is a medium term policy, since it helps the adoption process to take place (it acts on the degree of real accessibility of an area). This policy can be applied both to advanced Countries and regions, as well as (in a strategic way) to lagging areas;
- the third policy is a long-term policy, since it aims at developing advanced ICTs services (and their employment) in the economy, influencing long term efficiency of the whole productive system.

Given a certain level of financial resources devoted to ICTs, some scenarios can be envisaged on the basis of the policies chosen:

Scenario 1: a widespread diffusion of ICTs infrastructures and services throughout Europe

A first scenario envisages the implementation of all three policies in all Countries and regions of the Communities, despite their economic level and their ICTs endowment level.

Scenario 2*:* ICTs policy implementation tailored upon each regions needs

This second scenario envisages the implementation of ICTs policies related to the needs of the different geographical areas. In this scenario:

- in lagging areas, ICTs infrastructure policies are developed, while limited resources are devoted to service promotion and adoption support;
- on the contrary, in advanced areas, ICTs service promotion policies are implemented, while little resources are devoted to ICTs infrastructure development.

Scenario 3*:* ICTs implementation policy only for lagging regions

This third scenario envisages the implementation of ICTs infrastructure only for lagging regions, as has been the case in the past with the STAR and Telematique projects.

Hypotheses on territorial impact of the scenarios

The three scenarios provide very different territorial impacts:

1. the first scenario should highlight a weak impact on efficiency and a little effect on regional disparities. The relatively low impact on efficiency is mainly due to the existence of indivisibilities in investments, that risk preventing for any positive income growth effects. The null effects on regional disparities is expected, since if any positive effect on efficiency is developed, it is equally distributed over regions;
2. the second scenario is expected to provide a positive impact on efficiency in all regions. The effect on regional disparities is not easily foreseeable;
3. the third scenario is expected to provide a positive impact on regional disparities, although the positive effect is expected only if not simple infrastructure policies are implemented. Also service promotion and adoption policies are important for generating long term positive effects.

Policy Recommendations

Institutional Structures and Polycentric Development

We have considered particularly the way in which institutional structures interrelate with the desire to achieve polycentric development. In a previous study (*Spatial Impacts of Community Policies and Costs of Non-Co-ordination*, by Agence Européenne "Territories and Synergies", EURE-CONSULT S.A., Nederlands Economisch Instituut, Quaternaire Portugal for DG Regio, 2001) a range of Community policies have been assessed for their impact on spatial development in terms of the spatial distribution of expenditures using Lorenz curves. One of the problems with transport expenditures, and TEN developments in particular, is that the spatial incidence of expenditure does not necessarily imply the actual spatial impact in terms of economic and social development. This presents a problem in understanding the impacts of such policies since there is no simple analysis based on inputs, but rather we need a modelling approach which estimates the likely effects of policy measures. *Ex post* analyses of previous policy implementations, given the time period for the effects to take place, run into the problem of being able to disentangle the impact of one specific policy measure from a range of other influences.

The extent of polycentric development may, in many cases, be determined not directly by the policy measure, but by the extent to which the policy interacts with other characteristics of economic and social structure. In different circumstances the same policy measure may lead to increased centralisation or increased decentralisation and greater polycentricity. In pure economic terms this interaction will be with such features as the degree of imperfect competition and rent seeking behaviour by firms, the extent of scale economies and market size. In institutional terms it introduces the need to recognise that similar market characteristics affect the agencies responsible for formulating policy and introducing accompanying measures. Thus different sizes of local government authority will have different powers to be able to rent-seek on behalf of their own residents. Competition, both horizontal and vertical, between authorities, may determine the final outcome of the distribution of impacts.

In the next stage of the study we shall be investigating the ways in which this competition between different levels of government and different authorities at the same level of government will affect the spatial distribution of policy impacts.

Table III.1 represents our first look at this in terms of a table which identifies the opportunities (indicated by +, ++ or +++ according to the possible strength of the positive opportunity) and the risks (indicated similarly by -, -- or ---) which are implied for each policy area by the implementation of the various transport and TEN policies. It should be stressed that this is an initial subjective view based on our first analysis of the policy interactions. A fuller analysis will require inputs from the modelling analysis to demonstrate the nature of the spatial impacts.

A particular concern is the interaction of the policies with the ESDP and hence we can use the same structure to analyse the interactions with the various objectives of the ESDP (Table III.2)

The next stage is to consider ways of applying a similar framework to the vertical conflicts likely to be present in these policies, but this will need to be implemented in the context of specific policies due to the considerable variations in detail.

Table III.1 Framework for Horizontal Policy Analysis

Opportunities / Risks	Transport Policy	Regional, Structural and Cohesion Policies	Environ-mental Policies	Common Agricultural Policy	Internal Market and Competition Policies	Stability and Growth Policies	European Spatial Development Perspectives
Implementing White Paper on Transport Policy	+++ ---	++ --	+++ --	++ --	++ -	+ -	+++ ---
Implementing Transport TENs	++ --	+++ ---	+++ ---	+ -	++ -	+ -	+++ ---
Implementing Energy TENS	+ -	++ --	+++ --	+ -	++ -	+ -	++ --
Implementing GALILEO	+++ --	++ --	++ -	+ -	+ -	+ -	++ --
Implementing ICT guidelines	++ -	+++ --	++ --	+ -	++ -	+ -	++ --

Table III.2 Framework for the detailed analysis of the ESDP

Opportunities / Risks	Polycentric Spatial Development	Urban-Rural Relationship	Parity of Access to Infrastructure	Wise Management of the Natural and Cultural Heritage
Implementing White Paper on Transport Policy	+++ ---	+++ ---	+++ ---	+++ ---
Implementing Transport TENs	+++ ---	++ --	++ --	++ --
Implementing Energy TENS	+++ --	++ --	++ --	++ --
Implementing GALILEO	+++ --	++ --	+++ -	++ -
Implementing ICT guidelines	+++ -	++ -	+++ -	++ -

III Integration of Points Raised in Response to First Interim Report

In this section we will report on the solutions that were looked for after the comments on the of the first interim report. In this chapter we take as reference the comments in the paper sent by the CU to the lead partner in December 2002.

Integration of Maritime Transport

Towards the inclusion of seaway transport: the TPG was contacted by the Norwegian Institute of Transport (TØI), that has offered to provide the group with data on seaway transport in the Baltic and North Sea. Available data include distance data and data on freight volume. These data will be included in the database of the project group as input for the impact analysis. Unfortunately, these data include just Northern European sea ports, so there is still no sufficient data available for the Mediterranean Sea and the southern Atlantic Ocean.

Co-operation with ESPON Projects 1.1.1, 1.2.1 and 1.2.2

An extensive co-operation has been sought with those ESPON projects, that seemed most useful for the ESPON 2.1.1 project group. Among these ESPON 1.1.1, 1.2.1, 1.2.2 and 3.1 are the most important links in the project network of ESPON. With ESPON 1.1.1 close co-operation was sought by KTH for the writing on the topic of polycentrism in chapter 4 of this report. Furthermore the chapter on typologies for the impact assessment have been written after extensive co-operation with ESPON 1.2.1 by the common project partner S&W and with ESPON 1.2.2, which was contacted by CAU to exchange ideas on typologies and by MIL with respect to building a common database on ICT indicators and data.

Selection of Cohesion Indicators

On the selection of cohesion indicators it is important to say, that there is extensive literature on welfare economic theory, which is well known to our project partners in charge of this matter, but that for most cohesion indicators the database does not allow a computation.
The proposed measure of cohesion is an indicator measuring inter-regional disparities. By the comparing the Atkinson-indicator before and after implementation of a policy measure, it is possible to make statements, if a policy measure increases or decreases disparities between NUTS-3 regions. It is possible to compute this indicator on European and national level, so that statements can be made with respect to the strengthening or weakening of European and national cohesion.
With the selection of the indicators proposed in chapter 4, it is also a good compromise on the complexity of the indicator and the feasibility of the computation of the indicators.

Typology of Regions

In chapter 4 of this report a proposal for a typology which have been approved by the TPG as suitable for the policy impact analysis is presented. For the development of this typology co-ordination with ESPON 1.1.1, 1.2.1 and 3.1 was sought. In the presentation it was taken account of the input of ESPON 1.1.1 so far, which has the task to present an urban typology for EU-27 suitable as a basis for all ESPON projects. Furthermore, co-ordination was conducted with the typology for ESPON 1.2.1, which have developed their typology at the same time as 2.1.1 did.

Integration of Tools and Structures

It was agreed in the project groups that the methodologies used in the impact projects are too different among themselves, so that a standardization on this level cannot be achieved. It was evaluated if certain common output indicators of the respective methodologies can be achieved. In this respect there are certain overlaps in the projects in priority 2, as they all measure the economic impact of the analysed policy measures.

IV Networking Undertaken toward other TPGs and Application of the Common Platform

Networking

For the co-ordination of this report networking with other ESPON projects has been undertaken, that have been considered useful for the provision of data, the co-ordination of output indicators and the development of typologies of regions for the assessment of the forecasting results.

Partly this co-operation was done by the lead partner, partly this was done by the partners. As some of our partners are working on several projects of the ESPON programme, there are natural synergies. Results that were developed in one project group were exchanged without great friction. The projects that are most relevant for this project group are the ESPON projects 1.1.1, 1.2.1 and 1.2.2 as well as the 5th Framework Programme project IASON. Furthermore it was evaluated if methodologies used in other policy impact projects could be standardized, among these 2.1.2:" Territorial impact of EU research and development policy" and 2.1.3: "The territorial impact of CAP and rural development policy" regarded most relevant. Finally, a close contact with ESPON 3.1 as the co-ordinating project was held, not only, because BBR as lead partner of 3.1 is as well project partner of ESPON 2.1.1 as ESPON contact point.

Regarding Polycentrism co-ordination has been sought with ESPON 1.1.1 and ESPON 3.1. However, more recent material in addition to the FIR of ESPON Project 1.1.1 and the Draft Guidance Paper prepared by ESPON 3.1 has not been available at the time of the writing of Sections 4.2 and 4.5. Further, co-ordination of the indicators and measures of polycentric development will take place based on the SIRs of ESPON 1.1.1 and ESPON 3.1 and subsequent material produced during the spring period. Furthermore typologies have been exchanged with projects 1.2.1, in which Spiekermann & Wegener have developed the typologies and 1.2.2, with which CAU has sought contact to exchange drafts of typologies.

In order to develop the methodology for ICTs territorial impact assessment, a strong coordination with ESPON project 1.2.2 - Telecommunication and Energy Services and Networks: Territorial Trends and Basic Supply of Infrastructure for Territorial Cohesion - has been maintained, furthermore ESPON 1.2.2 has taken over the task of collecting data on ICTs. In January 2003 MIL and ESPON 1.2.2 discussed the problem of the existence of data on ICTs at NUTS 2 and 3 levels, through telephone and e-mail discussions with the Lead Partner of ESPON 1.2.2, CURDS (Centre for Urban and Regional Development Studies, University of Newcastle, UK), represented by its director Prof. Andrew Gillespie and Prof. Ranald Richardson. In February 2003, Prof. Capello met Prof. Gillespie in Milan, facing the problem of the existence of ICTs data at regional level at least for one European Country.

Furthermore through the participation of S&W and CAU in IASON the database developed for this project is also available to the ESPON 2.1.1 project as well as a the list of TEN and TINA projects and further policy measures, as e.g. social marginal cost pricing. As soon as the forecasting of these scenarios in IASON have been finished, the outcome will be available to the project group.

Application of the Common platform

For the writing of this report the ideas developed in the TPG guidance paper have been taken account of, particularly in the field of polycentrism and the development of typologies the presentations were taken account of. This interim report furthermore presents the view of the TPG on concepts, that are of interest not only of the 2.1.1 TPG, but are of interest of several groups and the development of ESPON results for ESPON 3.1. Explicitly, these concepts are polycentric development, accessibility, territorial cohesion, spatial integration and connectivity.

V Outlook on Preliminary Results and Maps Envisaged for the Third Interim Report

Aim of this chapter is to give an outline of the envisaged indicators, maps and results, that will provisionally be computed and created during the research for the Third Interim Report. This outline should help the writers of the Third Cohesion Report to give them an outlook what can be computed before final results can be made available.

List of Indicators by Region

- regional GDP per capita (NUTS-3)
- equivalent income measures of user benefits (NUTS-3)
- migration flows (NUTS-3)
- population by age (NUTS-3)
- employment (NUTS-3)
- labour force participation (NUTS-3)
- transport accessibility indicators (NUTS-3)
    - by mode (road, rail, air) (NUTS-3)
    - multimodal (logsum of road, rail, air and shipping) (NUTS-3)
- telecommunication accessibility indicators (depending on data availability)
- travel cost indicators (NUTS-3)
- employment in ICT (depending on data availability)
- cohesion indicators by country and for the entire study
    - standard deviation of unemployment rates
    - standard deviation of log of GDP per capita
    - coefficient of variation of GDP per capita
    - GINI coefficient of GDP vs. population
    - Atkinson measure of spatial income inequality
    - Ratio of geometric to arithmetic mean of GDP per capita

List of Maps

We can map, at the territorial level for which we will have data, the following indicators, which can be forecast by our methodology and are the most important for our analysis:

- regional GDP
- change of regional GDP per capita after implementation of TEN project
- employment (change of employment)
- unemployment
- population
- accessibility indicators
- change of transport costs /distances after implementation of TEN project
- ICTs physical endowment
- accessibility by real use of ICT network
- employment in ICTs
- enabling factors of ICTs

Major foreseen results

- Forecasts of the spatial impacts of the TEN-T in selected policy scenarios
- identification of regions most positively and negatively affected by European transport policy with emphasis on those projects analysed in IASON
- An assessment of the hypotheses stated in Deliverable D2 in the light of the model results
- Socio-economic and technical macro trends, such as ageing of the population, shifting labour force participation and increases in labour productivity may have a much stronger impact on regional socio-economic development than different transport infrastructure scenarios.
- Implementation of the TEN will lead to a slightly less polarised distribution of accessibility and GDP among European regions. This slight cohesion effect of the TEN will, however, not be able to reverse the general trend towards economic polarisation.
- Relatively large improvements in accessibility will translate into only relatively small increases in regional economic activity.
- Through the TEN most European regions will improve their accessibility and economic performance in absolute terms. However, numerous changes in the relative positions of regions and countries are to be expected. There may be relative losses of some regions, which can lead to absolute losses in the increasing economic competition between regions in the long run.
- Apart from its effects on transport efficiency and economic benefits, TEN measures may support modal shifts from road to rail or waterways and relocate transport streams away from overloaded corridors.
- Regional disparities might not decrease, despite the investment and use of ICTs, because of the very high disparities in enabling factors among different regions.
- The impact of transport networks and ICTs is a highly uneven territorial process.

Additional Data Gathered and Planned

- cost and distance data for the base year for the TEN projects analysed in IASON (NUTS-3),
- change of cost and distance data forecast for the transport projects analysed in IASON (NUTS-3).

Part Two

2 Territorial Impact Indicators

This chapter presents indicators relevant for the assessment of territorial impacts of EU transport and TEN policies. The indicators are distinguished with respect to the kind of territorial impact they measure. Indicators measuring the impacts on economic activities, on population, the labour market, on transport accessibility and on ICT accessibility are presented in Sections 2.1-2.5. The proposed indicators are summarised in Section 2.6 including the spatial level at which the indicators will be forecast. Section 2.7 gives first illustrations of the current spatial distribution of some of the indicators.

For all indicator groups, in particular in the fields of the regional economy, population and labour force, there are numerous other indicators available that could describe past trends and the current situation in this field. However, one has to bear in mind that the focus is here on territorial impact indicators, i.e. indicators that are sensitive to the policies in questions and that can be forecast by the methodologies developed.

2.1 Economic Indicators

EU transport and TEN policies do have effects on the regional distribution and location of economic activities. This section provides a definition and description of indicators measuring the economic impacts of transport policy changes. The indicators mainly comprise GDP per capita and equivalent income measures of user benefits.

2.1.1 GDP per Capita

The Gross Domestic Product (GDP) per capita and the real GDP growth rate are the most common measures of the standard of living, wealth and economic growth. The GDP is a standard measure of the size and performance of a regional economy and its competitiveness.

Total GDP represents only the supply side of regional socio-economic development. To derive policy-relevant indicators, it has to be related to the demand side, i.e. to population. This is done by calculating total regional GDP per capita.

Regional GDP is designed to measure total output in a particular area, including services. However, it is also a measure of income, the main components being wages and salaries, profits and rent, though it excludes transfers of income, from individuals and companies (which might transfer part of their profits elsewhere) as well as from government, in the form, for example, of social benefits. This leads to a problem concerning the use of GDP as a measure of income in some regions, such as some city-regions, where commuting by people resident in other regions adds to the local work force and GDP. Income per head of the people living in the city is, therefore, overstated while that of neighbouring regions is understated.

For the assessment of the economic performance of regions it is important to observe and compare GDP per capita for certain years as well as the development over time. This is especially important to assess the convergence of regions and will be measured by the *change of regional GDP per capita.*

In order to facilitate international comparisons, the GDP in national currency of each Member State is converted into a common currency (ECU until 1998, Euro from the beginning of 1999) by means of its official exchange rate. The comparison of regional GDP on a Euro-basis reflects economic strength in an absolute dimension.

However GDP measured on Euro-basis does not necessarily reflect the actual purchasing power of each national currency on its economic territory, because the converted GDP is a function not only of the level of goods and services produced on the economic territory, but also of the general price level. Therefore, the simple use of the GDP converted into a common currency does not provide, in most cases, a correct indication of the volume of goods and services.

In order to remove the distortions due to price-level differences, transitive purchasing power parities (PPP) are calculated and used as a factor of conversion (exchange rate from national currency to PPP). These parities are obtained as a weighted average of relative price ratios regarding a homogeneous basket of goods and services, comparable and representative for each Member State. The 'comparable volume' values of GDP obtained in this way are hence expressed in terms of purchasing power standards (PPS), a unit that is independent of any national currency. It makes sense to analyse both indicators in this project (Euro and PPS).

Productivity of Regions can be characterised by the *GDP per employee*.

The sectoral structure of regions is characteristic for their level of economic development. *GDP by three or six basic economic sectors* such as agriculture, industry and service or agriculture, energy & manufacturing, construction, market services, non-market services and other services is a common indicator to describe sectoral structures of regions. If sectoral information is required on NUTS-3 level it will only be feasible to use the three sectors, since data on a more detailed sectoral level will not be available for all NUTS-3 regions of EU-27.

2.1.2 Equivalent Income Measures of User Benefits

In contrast to other economic indicators, such as changes in GDP per capita or changes in (disposable) income, the equivalent income measures of user benefits measure the welfare change resulting from a policy change, such as changes in transport and infrastructure investments. Considering the household's preference relations in consumption by introducing utility functions, one can investigate the normative side of consumer theory, called welfare analysis. In general, welfare analysis concerns itself with the evaluation of the effects of changes in the consumer's environment, such as policy changes, on his or her well-being. The level of well-being before and after the change only can be evaluated by the preference-based approach to consumer demand.

This microeconomic approach (see for example Varian, 1999; 1992) states that households gain benefits from the allocation of their income between consumption and savings. Consequently, how well off a policy change actually makes a household, depends on the effects of the policy change on prices, output, trade flows, income and how the household evaluates the benefits of these changes. This is given by the assumed utility function representing the consumer's preferences. By comparing the utility level before and after the policy change the welfare effects induced by the policy change can be measured. However, since utility levels only measure ordinal scales, they have to be translated into money metric terms. This can be done by applying the microeconomic concept of duality (see Deaton and Muellbauer, 1980) leading to a function, which gives the wealth (in monetary terms) required to reach a given level of utility when prices are constant. Using this (so-called money metric indirect utility) function, one can measure the welfare change expressed in monetary units (Euro) induced by a policy change.

One of the well-known measures of welfare change based on this function and originating in Hicks (1939) is the *Equivalent Variation* (EV). Calling the situation before the policy change the benchmark, the EV of a policy change can be defined as: The amount of money that must be added to the household's benchmark income (everything else held constant on benchmark levels), in order to make the household as well-off as under the policy change. Obviously, the EV is an equivalent income measure of user benefits, because it represents the money metric equivalent to the utility change brought about by the policy change. This also illustrates, that the EV is not the same as the income increase generated by the policy change. This would be so only if no variable influencing utility but income changed. However, as a consequence of e.g. transport infrastructure investments other variables like prices and travel times do change.

Obviously, one will not be able to directly observe equivalent income measures of user benefits in the real world. These indicators only can be derived by setting up models with a consistent microeconomic foundation of preference-based consumer behaviour. Computable General Equilibrium (CGE) models, such as CGEurope (see section 3.4), fulfil these requirements. CGE models inhabit additional attractive features, such as the possibility of introducing different assumptions about market forms, technologies and preferences, of taking into account different financial flows between the representative agents in the economy, or, in case of an open economy model, of considering the interactions between different regions or countries by e.g. trade, passenger travel or financial flows. The EV being the model's output then will measure welfare gains and losses including all effects generated by the specified economic setting, such as market imperfections etc. This shows that assessing policy changes by the EV is perfectly in line with the theoretical concepts in cost-benefit analysis. The danger of omitting indirect effects as well as the danger of double-counting is avoided.

In order to assess the spatial impacts of policy changes, such as transport and infrastructure investments, by means of an equivalent income measure of user benefits setting up a spatial CGE model (SCGE) is favourable. E.g. by assuming identical preferences of households in one region, the resulting EV will measure the welfare changes in each region and therefore gives information about the spatial distribution of welfare gains and losses of the respective policy change. However, in order to compare the spatial impacts over regions it is useful to express regional EV as per capita amounts or as shares in benchmark regional GDP. The latter is also called the Relative Equivalent Variation (REV) and is defined as the percentage increase of the benchmark income the region would need, in order to be as well-off as after the policy change (again holding everything else constant on benchmark levels).

2.2 Population Indicators

Regional population indicators are important in ESPON 2.1.1 because they inform about the attractiveness of a region as a place to live and work, which may be influenced by its accessibility, and hence by transport investments. There may be two kinds of population indicators:

2.2.1 Population by Age

Total population as such is not a suitable indicator because it predominantly measures the size of the region. Moreover, in empirical before-and after studies, in which the situation before the implementation of a transport policy is compared with the situation after its implementation, changes in population are not informative because they may be caused by a multitude of other reasons, among them fertility, mortality, which are not likely to be affected by transport policy, or immigration and outmigration for reasons unrelated to the transport measure. Only in model-based studies in which, besides the transport policy of interest, everything else is kept unchanged, the comparison between *total regional population* in a transport scenario in which a transport policy is implemented and a reference or business-as-usual scenario in which the measure is not implemented, is meaningful: If regional population in the policy scenario is different from the business-as-usual scenario, the change is due to the effect of the policy, for instance because an increase in regional accessibility has led to economic growth which in turn has attracted population.

A more appropriate indicator is *population change* because it neutralises the effect of region size. If after the opening of a new transport project the population in a region has increased more (or decreased less) than in the reference scenario, this may be an effect of the increase in accessibility, which may have led to economic growth in the region which in turn may have attracted population, as above.

Another population indicator of interest is related to age. In general, a younger population is associated with a successful, vibrant economy, whereas an ageing population may indicate a declining economy deserted by a large number of young and active people. On the other hand, a high proportion of elderly people may also result from high life expectancy caused by a good health system or from a high proportion of affluent pensioners, as in some Mediterranean regions. However that may be, a population age indicator should be collected.

Two population age indicators are frequently used: *mean age* and the *proportion of people over 60 (or 65).* In the ideal case, an age distribution, classified by gender, would be collected. In the case of a dynamic modelling approach forecasting population, such as the SASI model (see Section 3.2), population by age and gender would be required anyway.

2.2.2 Migration Flows

There is a clear causal link between transport policies and interregional migration. If a region is economically successful and so offers more and better paid job opportunities than other regions, it is likely to attract ceteris paribus job-seeking immigrants from poorer regions with fewer job opportunities. Consequently, if a region benefits economically from a transport infrastructure project, it will attract more immigrants. Regional positive net migration is therefore a good indicator of the socio-economic effect of a transport measure.

However, this applies only where international movements of labour are unrestricted. This, however, is almost nowhere the case. Even within the European Union, international labour migration is far below the level that could be expected given the differences in wages and job opportunities between the Member States. And immigration into the European Union is constrained by increasingly rigorous national immigration laws. It can be expected that after the pending enlargement of the European Union labour mobility will be constrained for several years. It follows that immigration to the more affluent countries will continue to be far lower than the attraction of these countries would suggest and will therefore not reflect the impact of transport policies.

Nevertheless, it will be desirable to consider *regional net migration*, either as total net migration or as net migration as percent of regional population, as regional indicator in ESPON 2.1.1. In a dynamic regional economic model such as the SASI model (see Section 3.2), interregional migration would be forecast anyway.

2.3 Labour Market Indicators

Regional labour market indicators provide important information on the territorial impacts of EU transport and TEN policies, because they link the regional economy with the regional population. Therefore, indicators describing the regional labour markets have to take into account the supply and the demand sides of labour markets and its balance. Consequently, there may be three kinds of labour market indicators:

2.3.1 Employment

Employment is one of the main indicators measuring economic wealth and individual participation on economic prosperity. For empirical purposes employment is measured as follows on EU level: "Persons in employment are those who during the reference week did any work for pay or profit for at least one hour, or were not working but had jobs from which they were temporarily absent. Family workers are also included." (see Eurostat, 1999c).

Employment by sector might give information on the level of economic development of a region. Low proportions of employment in the agricultural sector indicate an advanced economic structure. In contrast, a high proportion of employment in the service sector is usually considered indicative of an advanced economic structure. This is not true in every case. There are many service sector jobs that do not necessarily point to an advanced economic structure. On the other hand, a highly productive industrial sector does not necessarily indicate a weak economic structure. In addition to these conceptual problems, there are also problems with interpreting the data as companies categorised as industrial may incorporate a high share of service occupations.

2.3.2 Labour Force Participation

The *regional labour force* represents the supply side of the regional labour market and is insofar an important input factor for regional economic development. Labour force is the sum of those employed and those unemployed.

Demographic and economic prospects have implications for the size and age composition of the labour force leading to different *labour force participation rates,* i.e. labour force related to population in working age. Labour force participation rates are determined by a range of factors, such as attitudes towards further education, the age of retirement and women working, as well as the availability of child-care facilities, the nature of pension schemes and the possibility of early retirement and the structure of households. They are also affected by economic factors, especially the ease or difficulty of finding a job, which has a strong effect on people's motivation to join the labour force. Participation, therefore, tends to increase as net job creation rises and to decline when it falls.

Moreover, demographic trends can potentially influence participation rates and vice versa. For example, a reduction in working-age population relative to the demand for labour encourages more people to join the labour force or growth of economic activity stimulates an increase in net inward migration. Given the wide range of factors affecting participation and the complex nature of the interrelationships between them, any projections of the labour force in future years are considerably more uncertain than those of population and are surrounded by a very wide margin of error.

The prospective ageing of the work force and the increased number of older workers raises questions about the effect on the ability to adapt to changes in technology and new ways of working. In the past, the steady stream of young, freshly educated people joining the labour market provided employers, in some degree, with up-to-date technical knowledge and recently acquired skills at a relatively low wage. The changing qualification and education of a country's labour force is therefore also considered as a factor of increasing economic importance and can be measured as *regional labour force by educational attainment.*

2.3.3 Unemployment

Imbalances on labour markets can be directly identified by looking at unemployment indicators. Empirical data on unemployment indicate the scale of economic and social problems caused by the labour market. Measuring unemployment in a quite detailed manner is essential for elaborating the regional economic effects of infrastructure policy.

On the EU level unemployment is defined and measured as follows: Unemployed persons are those who, during the reference week had no employment, were available to start work within the next two weeks, and had actively sought employment at some time during the previous four weeks. In addition, unemployed persons include those who had no employment and had already found a job to start later.

Unemployment rates represent unemployed persons as a percentage of the labour force. To measure unemployment and its regional outcome the unemployment rate is defined as the total number unemployed relative to the total number of the labour force.

2.4 Accessibility Indicators

In the context of spatial development, the quality of transport infrastructure in terms of capacity, connectivity, travel speeds etc. determines the quality of locations relative to other locations, i.e. the competitive advantage of locations which is usually measured as accessibility. Investment in transport infrastructure leads to changing locational qualities and may induce changes in spatial development patterns.

There are numerous definitions and concepts of accessibility. A general definition is that "accessibility indicators describe the location of an area with respect to opportunities, activities or assets existing in other areas and in the area itself, where 'area' may be a region, a city or a corridor" (Wegener et al., 2002). Accessibility indicators can differ in complexity.

- Simple accessibility indicators take only transport infrastructure in the area itself into account. They describe the transport infrastructure endowment. This is then measured as the total length of roads, motorways or rail lines, number of railway stations or motorway exits or as travel time to the nearest nodes of high-level networks. These indicators may express important information about the area itself, but they do not reflect the fact that many destinations of interest are outside the area.

- More complex accessibility indicators take account of the connectivity of transport networks by distinguishing between the network itself and the activities or opportunities that can be reached by it. These indicators always include in their formulation a spatial impedance term that describes the ease of reaching other such destinations of interest. Impedance can be measured in terms of travel time, cost or inconvenience.

In the context of territorial impacts of TEN investments, the simple accessibility indicators are of limited value, because they do describe the transport endowment of a region only. And this changes directly according to investments. Useful for territorial impact assessment are the more complex accessibility indicators, because they describe the changing locational advantages and opportunities as consequences of transport infrastructure investments or other transport policies.

Therefore, the more complex accessibility indicators are considered only in which accessibility is a construct of two functions, one representing the activities or opportunities to be reached and one representing the effort, time, distance or cost needed to reach them:

$$A_i = \sum_j \mathrm{g}(W_j)\,\mathrm{f}\,(c_{ij})$$

where A_i is the accessibility of area i, W_j is the activity W to be reached in area j, and c_{ij} is the generalised cost of reaching area j from area i. The functions $g(W_{ij})$ and $f(c_{ij})$ are called *activity functions* and *impedance functions*, respectively. They are associated multiplicatively, i.e. are weights to each other. That is, both are necessary elements of accessibility. Ai is the total of the activities reachable at j weighted by the ease of getting from i to j.

These more complex accessibility indictors can be classified by their specification of the destination and the impedance functions (Schürmann et al., 1997, Wegener et al, 2002).

- *Travel cost indicators* measure the accumulated or average travel cost to a pre-defined set of destinations, for instance, the average travel time to all cities with more than 500,000 inhabitants.

- *Daily accessibility* is based on the notion of a fixed budget for travel in which a destination has to be reached to be of interest. The indicator is derived from the example of a business traveller who wishes to travel to a certain place in order to conduct business there and who wants to be back home in the evening (Törnqvist, 1970). Maximum travel times of between three and five hours one-way are commonly used for this indicator type.

- *Potential accessibility* is based on the assumption that the attraction of a destination increases with size, and declines with distance, travel time or cost. Destination size is usually represented by population or economic indicators such as GDP or income.

Each of the different accessibility types can be seen to have their own advantages and disadvantages. Travel time indicators and daily accessibility indicators are easy to understand and to communicate though they generally lack a theoretical foundation. Potential accessibility is founded on sound behavioural principles but contain parameters that need to be calibrated and their values cannot be expressed in familiar units.

Modal accessibility indicators are usually presented separately to demonstrate differences between modes. Or, they may be integrated into one indicator expressing the combined effect of alternative modes for a location. There are essentially two methods of integration. One is to select the fastest mode to each destination, which in general will be air for distant destinations and road or rail for shorter distances, and to ignore the remaining modes. Another way is to calculate an aggregate accessibility measure combining the information contained in the modal accessibility indicators by a 'composite' generalised travel cost. This is superior to average travel costs across modes because it makes sure that the removal of a mode with higher costs does not result in a – false – reduction in aggregate travel cost.

Out of the large set of possible accessibility indicator, only a small sub-set can be used in ESPON 2.1.1 to assess the impact of transport policies with respect to changing locational qualities. For reasons of theoretical soundness and explanatory power, the SASI model provides and uses potential accessibility indicator (Fürst et al., 2000) which are proposed to serve as indicator for the project as well. The accessibility indicators include modal and multimodal indicators and consist of *accessibility potential by road, accessibility potential by rail, accessibility potential by air, multimodal (road, rail) accessibility potential, multimodal (road, rail, air) accessibility potential.*

2.5 ICT Accessibility

Since the 1980s, there was a common recognition of the importance of Information and Communications Technologies (ICT) for the economic competitiveness of firms and territories. This idea was strongly reinforced during the 1990s, when the widespread territorial diffusion of telecommunications networks - able to transmit data, texts and images (i.e. the diffusion of Internet) - was interpreted as an important step towards the “death of distance”.

Moreover, it is widely recognised that all advanced economies are moving towards an information society, in which information and knowledge act as key elements for the competitive advantages of firms and the comparative advantages of regions. In this perspective, ICT networks become the competitive resources upon which the competitiveness of firms and territories lies, given the basic principle that, through ICT networks, territories can achieve information and knowledge, despite their location and their physical accessibility.

For these reasons, in order to measure the contribution of ICT networks to regional competitiveness and development, the accessibility generated by the presence of ICT networks. the *ICT accessibility*, has to be considered. It can be added to physical accessibility, induced by transport networks, to have a comprehensive view on regional accessibility.

ICT represent an increase in the territorial endowment of location factors, thus influencing both the efficiency and the quality of production factors, which, on their turn, positively impact on the economic growth of the area (*efficiency*) and on the location choices of firms (*attractiveness*). As a recent empirical analysis demonstrates on data on innovation patterns in the United Kingdom, innovative firms are more likely to locate in regions where the transport and communications infrastructure is more advanced than in other UK regions (Simmie and Sennet, 1999).

Despite the conceptual recognition of a relationship between ICT investments and income growth, empirical evidence has demonstrated that the linkage between ICT investments and income growth is not so straightforward: adoption does not necessarily mean use, and use does not necessarily mean innovative use, the latter being defined as the achievement of new markets and new business opportunities, leading to a real market increase at microeconomic level and to greater competitiveness at the territorial level.

Two different ICT accessibility indicators are introduced in the ICT assessment methodology (see Section 3.3) covering the supply and the demand side of ICT. The first is related to telecommunications infrastructure endowment and the second to the intensity of telecommunication use. A clear conceptual difference exists between these two accessibility measurement indicators: the first measures what we call *endowment*, since it represents the supply of ICT infrastructures and not necessarily the real use, while the second is *(real) accessibility*, since it measures the real use of these technologies.

The *ICT endowment* indicator is calculated as the sum of the available ICT infrastructures (number of telephone lines, number of internet hosts, etc.), weighted for the type of networks. A higher weight is in fact assigned to the advanced networks, since they guarantee a higher accessibility, thanks to greater communication transmission quality and speed, and/or a higher service quality supplied on the networks. Moreover, the even and widespread territorial diffusion of basic telephone lines risks to cancel differences among areas.

The *ICT (real) accessibility* indicator is based on a gravity type model. The accessibility of region ***r*** is given by the number of people of other regions that could easily interact with ***r***'s population. Consequently, the accessibility is calculated as the weighted sum of the population of the other regions. The weight is the "spatial friction" which hinders the interaction. It is direct function of the physical distance in km between regions and inverse function of the intensity of ICT use.

The best indicator of ICT use is the telephone or Internet traffic, respectively measured by minutes of conversation, number of telephone calls or minutes spent on line. The problem is that such data are not easily made available at territorial disaggregated level, in particular data on advanced telecommunications network traffic are difficult to be obtained. A possible proxy for ICT use is the number of service subscribers. However, the use of such a proxy is based on the assumption that the subscription to a service necessarily means use (which is not always the case).

2.6 The Territorial Impact Indicator System

This section summarises all indicators proposed above for measuring the territorial impacts of transport and TEN policies. With a few exceptions for the ICT based indicators, all territorial impact indicators will be forecast for the NUTS 3 level of the ESPON space (Figure 2.1). Table 2.1 summarises the ESPON regional system on a country by country base.

Table 2.2 presents all indicators which will be forecast by the methodologies used in ESPON Action 2.1.1 (see Section 3). The methodologies' outputs include economic indicators, population indicators, labour market indicators, sectoral structure indicators, transport accessibility indicators and ICT accessibility indicators. The list presents the indicators as raw indicators. However, the most important aspect of the methodologies developed is that they allow to compare changes of indicator values over time or between different policy options.

The ESPON 2.1.1 First Interim Report gave also a wish list of additional indicators being desirable for evaluating the outcome of the methodologies used in ESPON 2.1.1. However, due to rare data availability the calculation of these indicators is not feasible.

Table 2.1 ESPON Space, NUTS 3 Regions by Country.

Country code	*Country*	*Population (in 1,000)*	*Number of regions*	*Average regional population (in 1,000)*
AT	OESTERREICH	8,102.6	35	231.5
BE	BELGIQUE	10,239.1	43	238.1
BG	BALGARIJA	8,190.9	28	292.5
CH	SUISSE	6,817.4	26	262.2
CY	KIBRIS	771.1	1	771.1
CZ	CZECH REPUBLIC	10,278.3	14	734.1
DE	DEUTSCHLAND	82,163.5	441	186.3

DK	DANMARK	5,330.0	15	355.3
EE	EESTI	1,439.2	5	287.8
ES	ESPANIA	38,070.8	50	761.4
FI	FINLAND	5,171.3	20	258.6
FR	FRANCE	58,748.7	96	612-0
GR	GREECE	10,706.7	51	209.9
HU	MAGYARORSZAG	10,043.3	20	502.2
IE	IRELAND	3,776.6	8	472.1
IT	ITALIA	57,679.9	103	560.0
LT	LITHUANIA	3,698.5	10	369.9
LU	LUXEMBOURG	435.7	1	435.7
LV	LATVIJA	2,424.2	5	484.8
MT	MALTA	319.4	2	159.7
NL	NEDERLAND	15,864.0	40	396.6
NO	NORGE	4,474.6	19	235.5
PL	POLSKA	38,644.2	44	878.3
PT	PORTUGAL	10,018.1	28	357.8
RO	ROMANIA	22,455.4	42	534.7
SE	SVERIGE	8,861.4	21	422.0
SI	SLOVENIJA	1,987.8	8	248.5
SK	SLOVENSKA REPUBLICA	5,398.6	12	449.9
UK	UNITED KINGDOM	59,623.5	133	448.3
EU27+2	*Total*	*491,734.8*	*1,321*	*372.2*

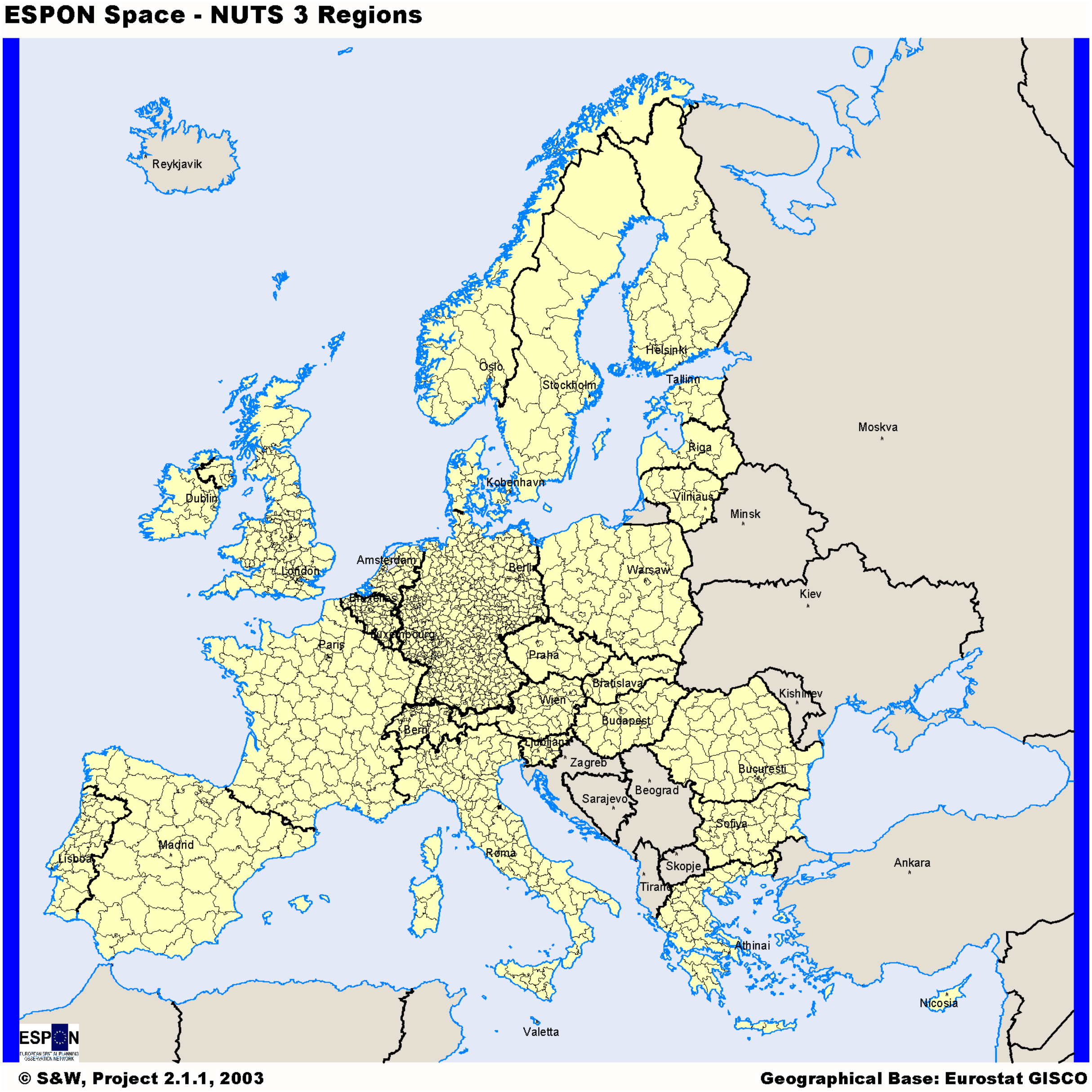


Figure 2.1. The ESPON Space - NUTS 3 Regions.

Table 2.2 Territorial Impact Indicators Forecast in ESPON Action 2.1.1.

Indicator group	*Indicator*	*NUTS level*
Economic indicators	Regional GDP per capita (in Euro)	3
	Regional GDP per capita (in PPS)	3
	Regional GDP per employee (in Euro)	3
	Regional GDP by sector (in Euro)	
	Equivalent variation	3
	Equivalent variation per capita	3
	Relative equivalent variation	3
Population indicators	Total regional population (number)	3
	Mean age of regional population (years)	3
	Percent persons over 60 years (%)	3
	Net migration (%)	3
Labour market indicators	Regional employment by sector (number)	3
	Regional labour force (number)	3
	Regional labour force participation rate (%)	3
	Regional labour force by educational level (%)	3
	Regional unemployment rate (%)	3
Transport accessibility indicators	Accessibility potential by road	3
	Accessibility potential by rail	3
	Accessibility potential by air	3
	Multimodal (road, rail) accessibility potential	3
	Multimodal (road, rail, air) accessibility potential	3
ICT accessibility indicators	ICT endowment	0
	ICT (real) accessibility	0

2.7 Map Illustrations of Networks and Indicators

This section presents two features of the methodologies to be applied in map form: transport infrastructure networks and current spatial distribution of indicators.

Figures 2.2 and 2.3 present the road and rail networks to be used by the different models (see Chapter 3); the air network and the inland waterway and short sea shipping network are not displayed. The networks constitute input information for the models. The networks contain all links of the TEN/TINA outline plans plus additional links which are necessary for connecting all NUTS 3 regions and the non-ESPON space. At the same time they constitute one of the means by which different policy scenarios can be introduced to the modelling system by removing, adding, modifying transport links of European interest.

Figures 2.4 - 2.7 present the current spatial distribution of one selected indicator for each of the indicator groups presented in the previous sections. Figure 2.4 shows GDP per capita as an example for the economic indicator. Figure 2.5 illustrates the share of elderly people as an example for the population indicators. Figure 2.6 displays unemployment rates as an example for the labour market indicators. Finally, Figure 2.7 maps multimodal accessibility potential as an example for the accessibility indicators.

Once the methodologies are operational, these indicators and the others previously described indicators will be forecast. By then it will be possible to draw maps showing the future spatial distribution of these indicators and maps showing differences between today and the future and between different transport policies, i.e. maps showing the territorial impact of transport policies isolated from other concurrent developments.

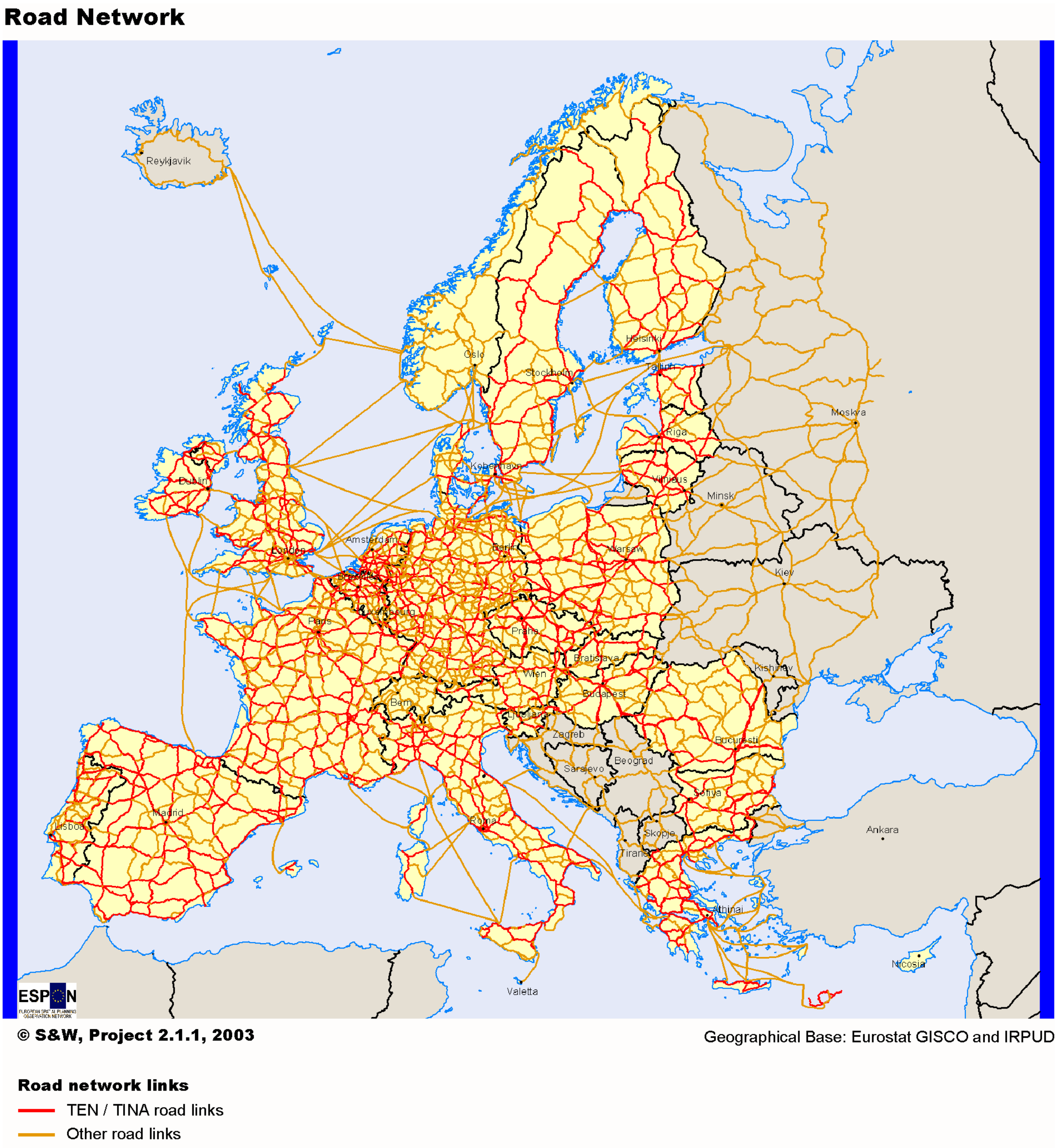


Figure 2.2. Road network.

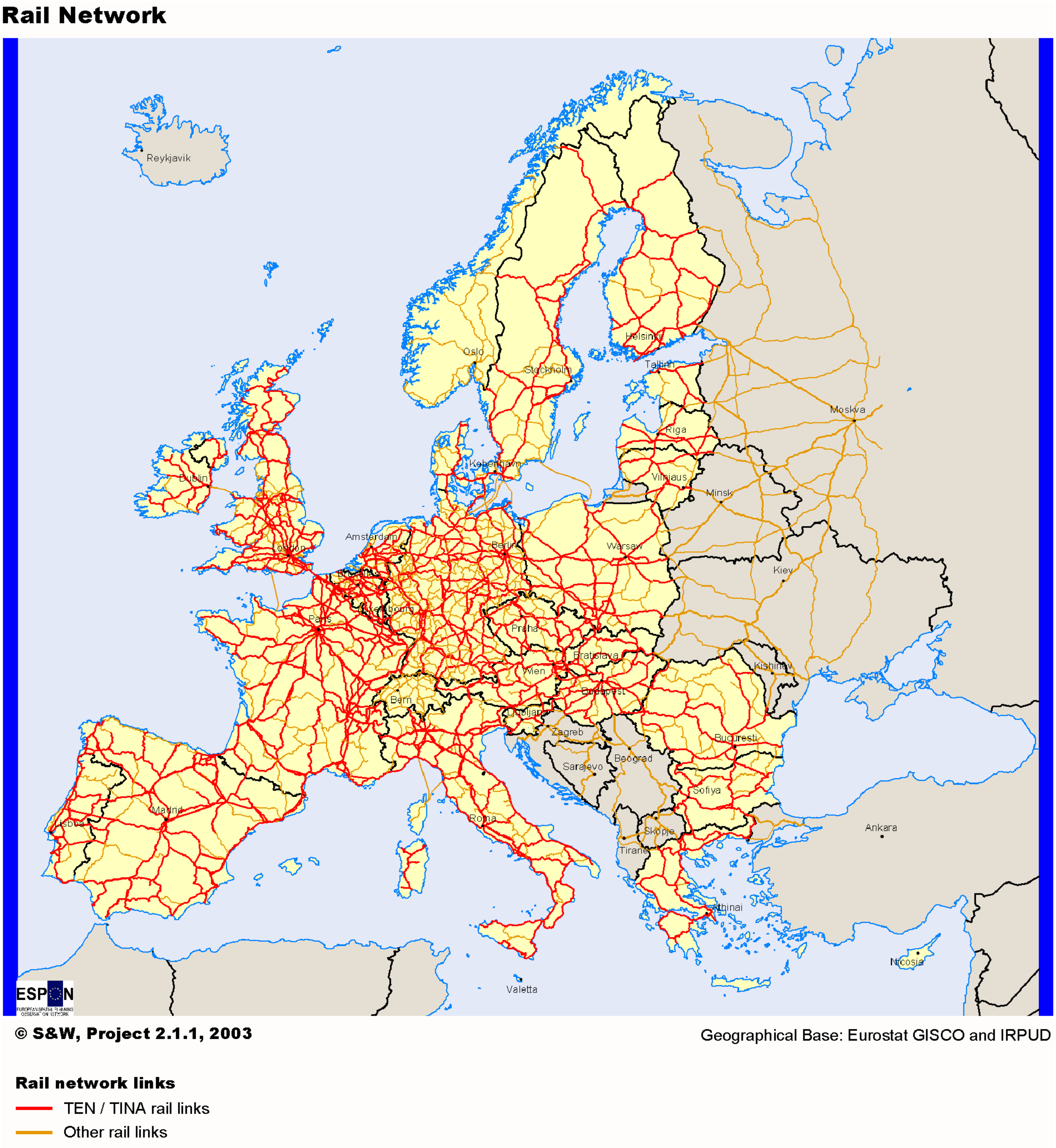


Figure 2.3. Rail network.

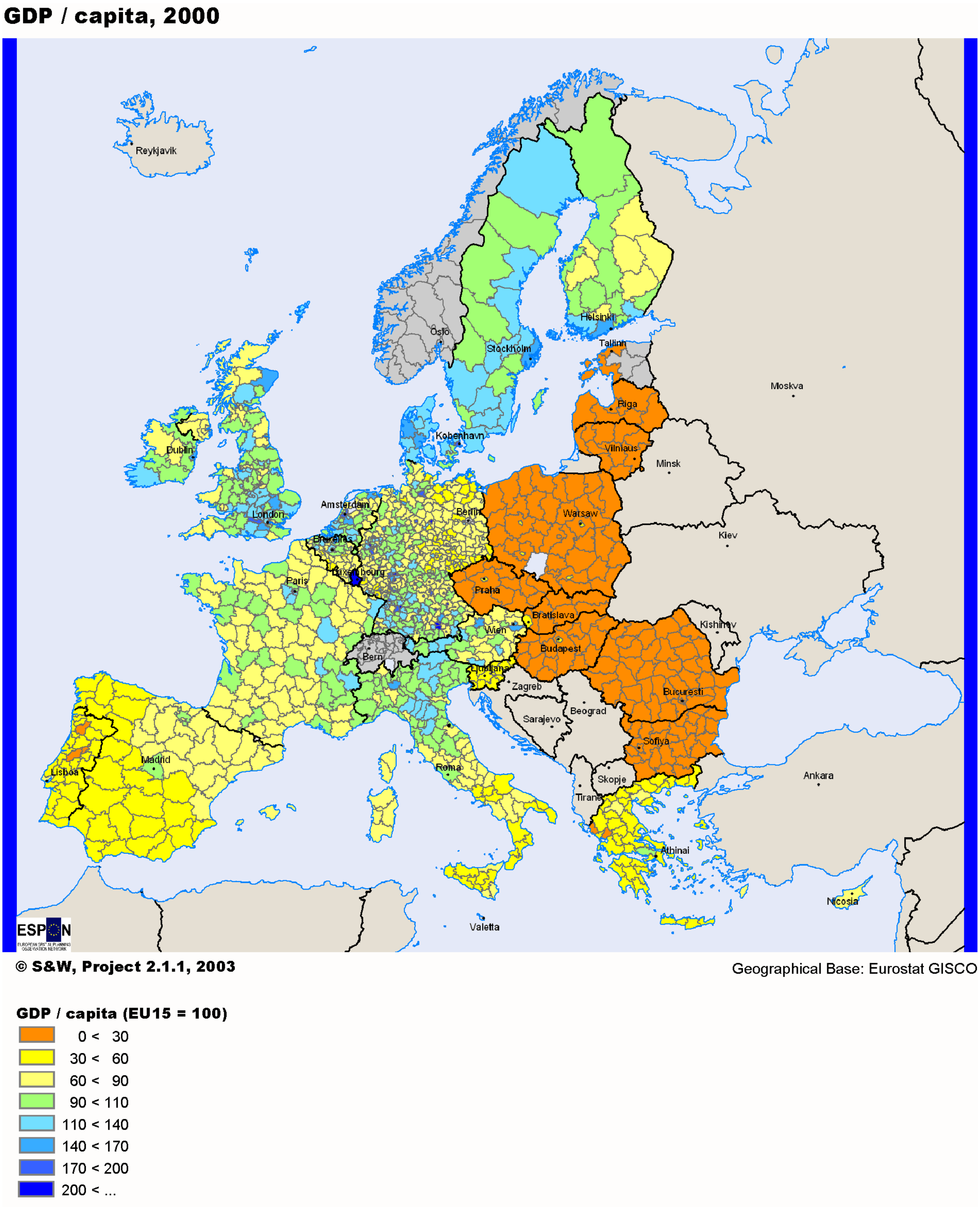


Figure 2.4. GDP per capita.

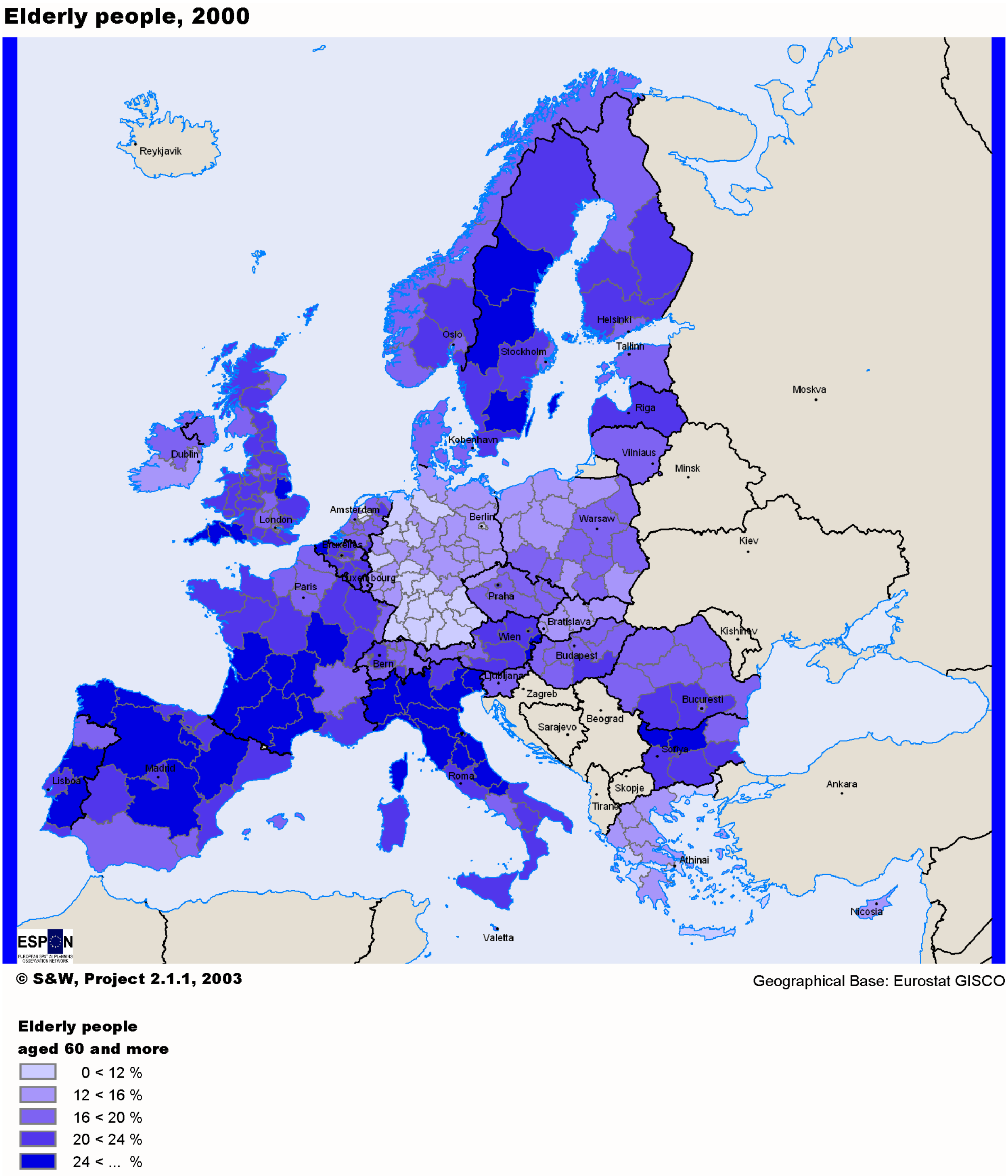


Figure 2.5. Elderly population.

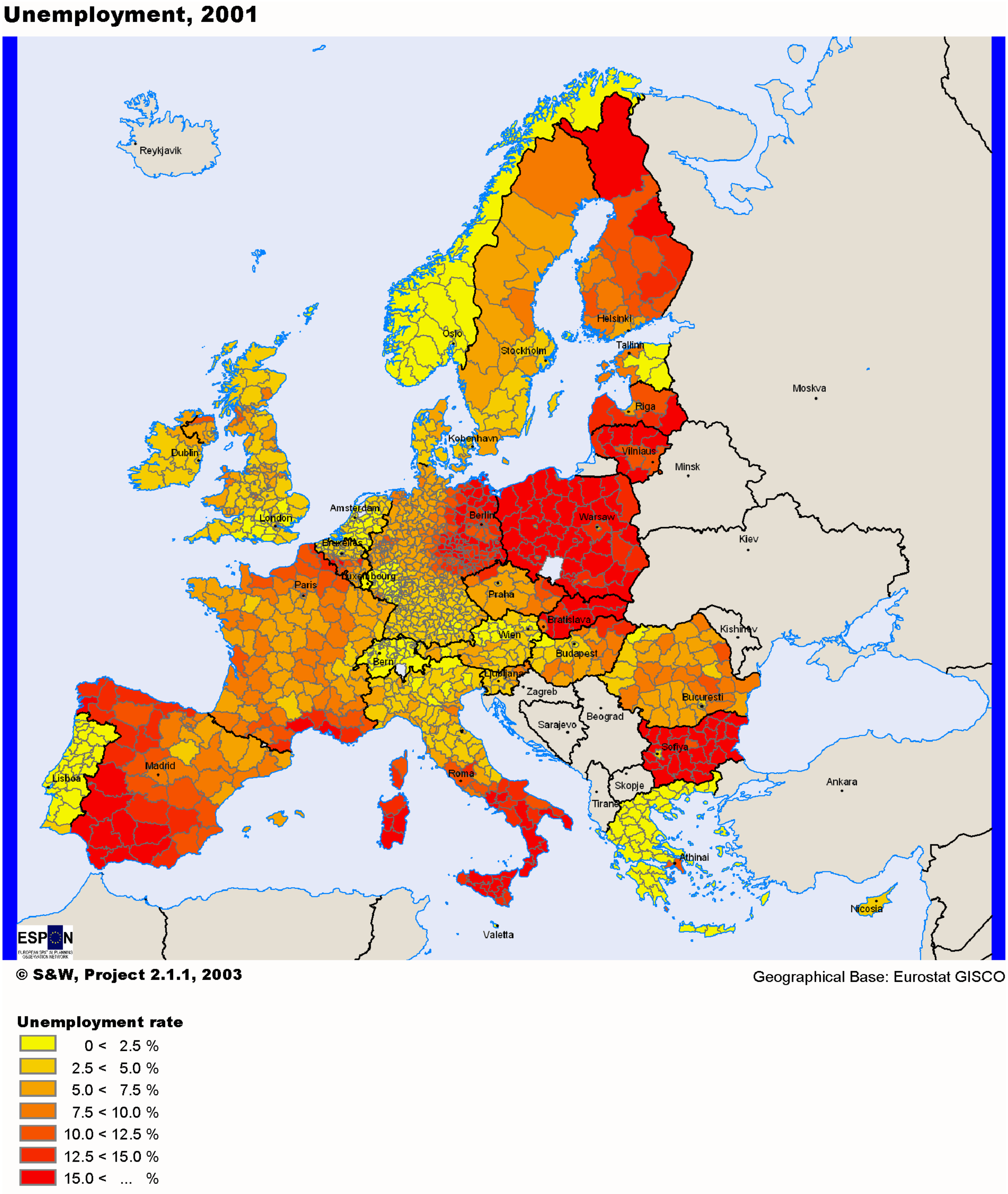


Figure 2.6. Unemployment rate.

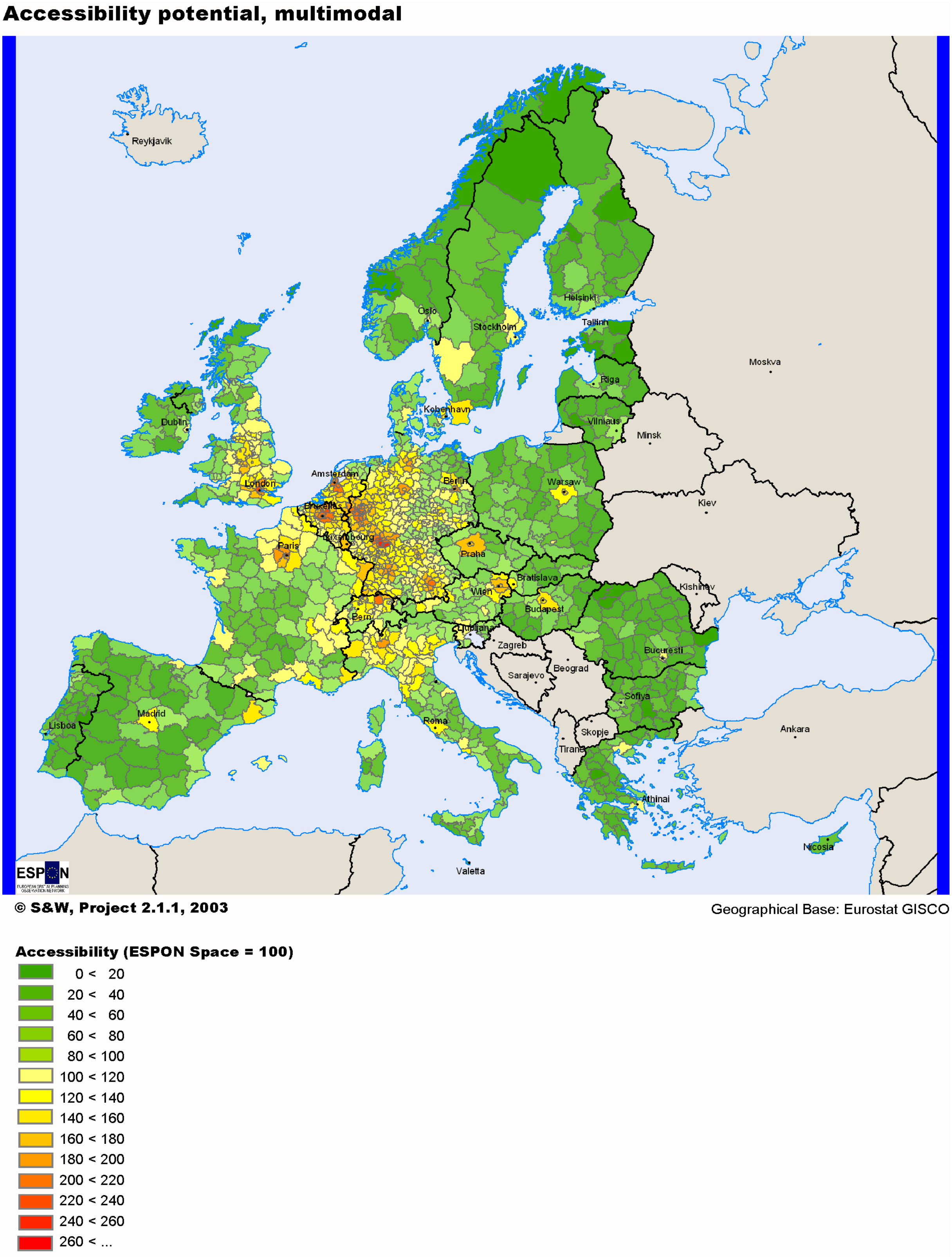


Figure 2.7. Accessibility potential, multimodal

3 Methodologies for the Forecasting of the Territorial Impact of Transport and ICT Policies

In this chapter we further develop the models for the territorial impact assessment of transport and policies and investment, that were already laid out in the first interim report. As in the first interim report we begin with the specific methodology of causality analysis of regional production and accessibility. After this follows the presentation of the quasi-production function model with accessibility, the SASI model. Building on this model in chapter 3.3 an extension of the SASI model is presented that models the territorial impact of ICT policies and investments and models spillover effects of investments in transport and ICT network structure. This model has been developed for this project by the Politecnico Milano and is described in this report in detail, because this methodology has not been published yet.
The chapter is concluded by the presentation of a spatial computable general equilibrium model of trade and passenger flows incorporating product diversity and monopolistic competition.

The proposed models are not stand-alone models. The causality analysis is basis for a validation of the results of the SASI model regarding the causal relationship between regional production and accessibility. SASI and STIMA have generally a similar structure and build on a common database of economic factors, differing only in this respect that SASI uses transport cost and accessibility measures and STIMA ICT infrastructure endowments and telecommunication network data for the forecasting. Outputs of the SASI model, especially interregional cost and distance data are, input of the CGEurope model, otherwise it depends on the same database of trade and production data.

3.1 Causality Analysis

Regional production is generally influenced by a number of factors, such as capital, human capital, and accessibility. It is the latter that we are interested in here. It is often thought that accessibility will have a positive impact on regional production. However, the converse relation may hold true as well: highly productive regions may want to invest parts of their wealth in infrastructure, hence improving regional accessibility. Thus, there is the problem of *causality*: which factor influences the other to what extent? To what extent is regional production influenced by accessibility, and to what extent is accessibility influenced by regional production? The empirical answer to these questions will, in general, be difficult to obtain. Nevertheless, the availability of adequate data will allow for answering at least a part of these questions. Hence, we propose some approaches addressing the problem of causality.

Let us first give a general specification of the theoretical model. Let production P be a function F of accessibility A and other factors X, and let accessibility be a function G of production P and other factors Y:

$$\begin{aligned} P &= F(A, X) \\ A &= G(P, Y) \end{aligned} \quad (1)$$

Note that accessibility will often be measured by an indicator function, so that G will map (P,Y) on a scale of 0 to 1.[1]
In practice, there exist a number of ways to proceed with this general model. Ideally, one would want to estimate a *structural model*, which is directly based on (1). Such a specification would take the form

$$\begin{aligned} P &= F(A, X, e_1) \\ A &= G(P, Y, e_2) \end{aligned} \qquad (2)$$

where the random variables e_1 and e_2 are most often assumed to follow a normal distribution. This specification would match the theoretical specification in (1), and, most importantly, identify all its parameters. However, a practical drawback of this approach is that the actual specification of F and G typically restricts the domain of the model parameters, so that in terms of model flexibility, other approaches are to be preferred.[2] Estimation of the parameters of the system in (2) takes place by *Full Information Maximum Likelihood* (FIML).

A second approach, known as estimation with *Instrumental Variables* (IV), exclusively focuses on the first equation in (1). It proceeds by (i) regressing A on a set of exogenous variables, and (ii) inserting the predicted values $\hat{A}$ from this regression into the production function specification:

$$P = F(\hat{A}, X, e_1) \qquad (3)$$

This last specification can then be estimated by Least Squares (if possible) or Maximum Likelihood techniques, both yielding consistent parameter estimates.
A few remarks are in order here. Firstly, A will often be constrained to the domain (0,1), so that the first stage regression will be of the form

$$H^{-1}(A) = Z'g \qquad (4)$$

for some probability distribution function H and g representing the parameter vector. For instance, the well-known Probit-specification assumes H to be equal to the standard normal distribution function. The requirement that Z exclusively contains exogenous regressors implies that production cannot be included as an explanatory variable in (4). Thus, this approach will only gauge the causal effect of accessibility on production, and not vice versa. Note that the special case where $Z = X$ is also known as *Two Stage Least Squares* (2SLS).

Secondly, it is important to note that this method is only theoretically consistent if the specification in (3) is of the form

$$F_0(P) = F_1(A) + F_2(X, e_1) \qquad (5)$$

[1] Although it is not necessarily the case that A lies within this range, it will be assumed so for the moment, without loss of generality.
[2] See, e.g., MaCurdy et al. (1990), who discuss the estimation of structural models for labour demand.

and if the predicted values for $F_1(A)$ are inserted into this equation, and *not* $F_1(\hat{A})$. For example, if logarithmic transformations are preferred, then one could estimate the model

$$\text{STEP 1:}\quad a = Z'g + e_2$$
$$\text{STEP 2:}\quad \ln P = b_0 + b_1\hat{a} + X'b_2 + e_1$$

where $a \equiv \ln A$.[3] If the specification is not linear in F_1 and F_2 as in (5), then estimation with IV is still possible, but will require a generalised approach (see e.g. McFadden, 1999). Thirdly, it is noted that one could apply this same approach in order to assess the impact of production on accessibility, simply by "predicting" production first, and substituting the predicted value into the second equation of (2).

Finally, it should be realised that the success of this approach crucially depends on the availability of proper instruments. In practice, this is often a problem. However, if appropriate instruments are available, then this method has the advantage over the estimation of a structural model in the fact that it is more flexible.

Examples of instrumental variables to be used here are physical features of regions such as peripherality of location, flatness of surface, presence of natural barriers and other variables such as regional population, population density and labour force. It is clear that the first variables have a clearly exogenous character and are therefore very suitable as instruments. Variables such as labour force may be less suitable as instruments since they may be closely related to regional production.

A third way of dealing with the above-sketched problem is based on the *Granger causality test*.[4] This test first postulates a specification describing one part of the relation between production P and accessibility A, and then performs a statistical test on whether there *is* a causal relation. For instance, the linear specification

$$P_t = a_0 + \sum_{j=1}^{n} a_j P_{t-j} + \sum_{j=1}^{n} b_j A_{t-j} + g'X_t + e_t \qquad (6)$$

leads to a causality test of the form:

$$b_1 = \ldots = b_n = 0.$$

In trying to identify the causal relation between regional production and accessibility one could estimate (6), as well as its counterpart with A on the left hand side, and hence perform the Granger causality test. Note that under the assumption of normal iid error terms, this test is nothing but a standard F-test.

In order to be able to carry out the Causality Analysis the use of panel data is strongly preferred over the use of a pure cross-section over regions. The latter will not allow for purging unobserved regional effects, such as, e.g., the regional institutional settings, and will therefore not be able to separately identify the effects of accessibility on production from

[3] One could, however, doubt the normality assumption of e_2 here, because a will be strictly negative.
[4] See Granger (1969).

institutional effects on production. Conversely, if regional data are recorded during a certain time period, then one is able to filter away such effects, by making use of a "fixed effects" specification. Therefore time-series data is required for analysing the causal direction. Information on regional production by sector could be purchased from Cambridge Econometrics providing time-series data on Gross Value Added and employment by sector on NUTS-2 level. The database builds on the REGIO data provided by Eurostat, however existing data gaps have been filled and the series has been extended to more recent years using national data where available and backwards updates have been carried out.

If time-series data on regional level is not available for all countries considered in ESPON, the Causality Analysis could be conducted for sample countries or by using time-series data on national scale.

3.2 Quasi-Production Function Model with Accessibility

This type of model is based on an extension of the production-function approach in which the classical production factors are complemented by one or more variables representing the locational advantage, or accessibility of a region. As an example of a quasi-production function model, the SASI model developed in the 4th RTD Framework SASI project and updated and extended in the 5th RTD Framework IASON project will be used. In this section the description of the SASI model presented in the First Interim Report of ESPON 2.1.1 is updated and extended where necessary.

The SASI model is a recursive simulation model of socio-economic development of regions in Europe subject to exogenous assumptions about the economic and demographic development of the European Union as a whole and transport infrastructure investments and transport system improvements, in particular of the trans-European transport networks. For each region the model forecasts the development of accessibility, GDP per capita and unemployment. In addition cohesion indicators expressing the impact of transport infrastructure investments and transport system improvements on the convergence (or divergence) of socio-economic development in the regions of the European Union are calculated.

The main concept of the SASI model is to explain locational structures and locational change in Europe in combined time-series/cross-section regressions, with accessibility indicators being a subset of a range of explanatory variables. Accessibility is measured by spatially disaggregate accessibility indicators which take into account that accessibility within a region is not homogenous but rapidly decreases with increasing distance from the nodes of the networks. The focus of the regression approach is on long-term spatial distributional effects of transport policies. Factors of production including labour, capital and knowledge are considered as mobile in the long run, and the model incorporates determinants of the redistribution of factor stocks and population. The model is therefore suitable to check whether long-run tendencies in spatial development coincide with development objectives discussed above. Its application is restricted, however, in other respects: The model generates distributive, not generative effects of transport cost reductions, and it does not produce regional welfare assessments fitting into the framework of cost-benefit analysis.

The SASI model differs from other approaches to model the impacts of transport on regional development by modelling not only production (the demand side of regional labour markets) but also population (the supply side of regional labour markets), which makes it possible to model regional unemployment. A second distinct feature is its dynamic network database based on a 'strategic' subset of highly detailed pan-European road, rail and air networks including major historical network changes as far back as 1981 and forecasting expected network changes according to the most recent EU documents on the future evolution of the trans-European transport networks.

The SASI model has seven submodels. Figure 3.1 visualises the interactions between these submodels.

- *European Developments.* Here assumptions about European developments are entered that are processed by the subsequent 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. Another relevant European policy field are transfer payments by the European Union via the Structural Funds or the Common Agricultural Policy or by national governments to assist specific regions, which, because of their concentration on peripheral regions, are responsible for a sizeable part of their economic growth. The last group of assumptions are those about policy decisions on the trans-European networks. A network scenario is a time-sequenced investment programme for addition, upgrading or closure of links of the road, rail or air networks.

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

- *Regional GDP.* This submodel forecasts gross domestic product (GDP) by industrial sector generated in each region by a quasi-production function incorporating endowment indicators and accessibility. Endowment indicators are indicators measuring the suitability or capacity of the region for economic activity. They include traditional location factors such as availability of skilled labour and business services, capital stock (i.e. production facilities) and intraregional transport infrastructure as well as 'soft' location factors such as indicators describing the spatial organisation of the region, i.e. its settlement structure and internal transport system, or institutions of higher education, cultural facilities, good housing and a pleasant climate and environment.

- *Regional Employment.* Regional employment is derived from regional GDP by exogenous forecasts of regional labour productivity by industrial sector (GDP per worker) modified by effects of changes in regional accessibility.

- *Regional Population.* Regional population changes 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. Interregional migration within the European Union 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.

- *Regional Labour Force.* Regional labour force is derived from regional GDP and exogenous forecasts of regional labour force participation rates modified by effects of regional 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.

The *spatial* dimension of the model is established by the subdivision of the European Union and the 12 candidate countries in eastern Europe and Liechtenstein, Norway and Switzerland into 1,321 regions and by connecting these regions by road, rail, air and waterway networks.

The *temporal* dimension of the model is established by dividing time into periods of one year duration. By modelling relatively short time periods both short- and long-term lagged impacts can be taken into account. 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.

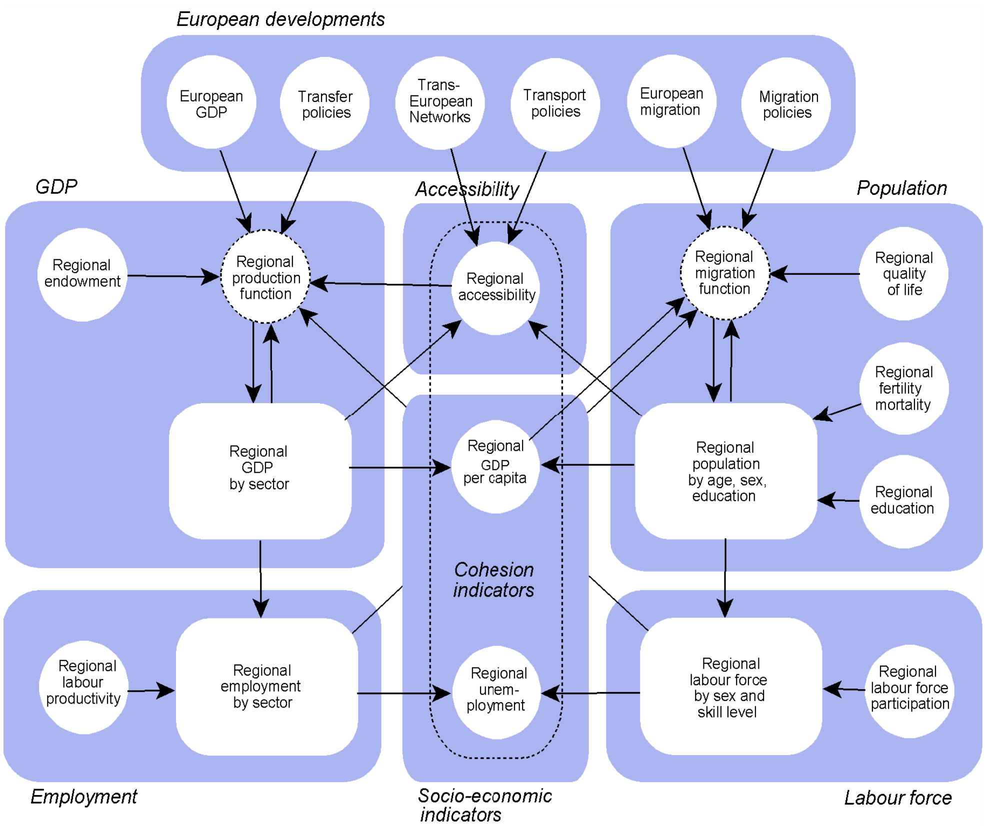


Figure 3.1 The SASI Model

The SASI model developed in the SASI project is presently being updated and extended in the IASON project in several dimensions:

New ideas from growth theory as well as new evidence on firm location are being reviewed and transformed into operational indicators of locational advantage and disadvantage and incorporated into the econometric approach. The following changes are being made:

- *Rates v. levels*. The traditional production function approach relates the *level* of output to the *level* of infrastructure. New growth theory suggests that a link might also exist between the level of infrastructure and the *rate* of growth, because good accessibility means good access to diversity making research and development more productive. It is being examined whether this effect can be incorporated into the model functions by exploring the feasibility of forecasting *rates* of change of regional economic development rather than the *levels* of regional production,

- *Productivity.* The feasibility of forecasting regional sectoral labour productivity endogenously as a function of accessibility and other variables instead of using exogenous productivity forecasts is being explored.

- *Accessibility.* In the accessibility calculations, not only travel time but also transport costs is being considered. The possibility to explicitly consider wage levels and/or production costs of potential suppliers in other regions in the accessibility submodel is being examined. It is expected that this will enhance the contribution of the accessibility indicators to the explanation of regional economic development in the regional production functions.

- *Migration*. Work is underway to forecast migration *flows* as a function of regional employment and/or unemployment and other indicators expressing the attractiveness of the region as a place of employment and a place to live instead of the present *net* migration. It is expected that this will improve the explanatory power of the migration model in the Population submodel.

In ESPON 2.1.1, the model will be validated by using the econometric results from the Causality Analysis between regional production and accessibility as presented in section 3.1. In addition, the results of the STIMA model of the effects of telecommunications on regional development presented in Section 3.3 will be taken into account. It will be examined whether in a further step the quasi-production functions of both models can be merged.

The specification of the original SASI model is contained in SASI Deliverable 8 (Wegener and Bökemann, 1998). The implementation of the original SASI model, i.e. the application of empirical data to it and the estimation and calibration of its parameters, was described in EUNET/SASI Deliverable 11 (Fürst et al., 1999). The software system of the original SASI model was described in SASI Deliverable 13 (Wegener et al., 2000). The results of the demonstration scenario simulations with the original SASI model were presented in SASI Deliverable D15 (Fürst et al., 2000). The specification of the extended SASI model is contained in Bröcker et al. (2002).

3.3 Methodology for ICTs Territorial Impact Assessment

3.3.1 The Conceptual Framework

Since the 1980s, there was a common recognition of the importance of Information and Communications Technologies (ICTs) for the economic competitiveness of firms and territories. This idea was strongly reinforced during the 1990s, when the widespread territorial diffusion of telecommunications networks - able to transmit data, texts and images (i.e. the diffusion of Internet) - was interpreted as an important step towards the "death of distance".

Moreover, it is widely recognised that all advanced economies are moving towards an Information Society, in which information and knowledge act as key elements for the competitive advantages of firms and the comparative advantages of regions. In this perspective, ICTs networks become the competitive resources upon which the competitiveness of firms and territories lies, given the basic principle that, through ICTs networks, territories can achieve information and knowledge, despite their location and their physical accessibility.

For these reasons, it has long been the aim of policy makers within Europe to use ICTs networks to increase regional competitiveness and regional cohesion by supporting regional and local development and promoting integration. The general policy goals can be related to the fundamental policy principles of "efficiency" and "equity": goals of economic growth are addressed to efficiency, whereas the promotion of social cohesion and solidarity to equity.

The methodology presented here assesses the impact of ICTs on both equity and efficiency. It has been widely discussed that these goals are difficult to be measured: they are the result of complex socio-economic processes, which are very difficult to be captured in quantitative indicators. However, given the importance of a quantitative assessment of ICTs investments, in our methodology two purely economic indicators are applied:

- regional or local per capita income growth (measuring efficiency goals);
- differences in regional per capita income growth (measuring equity goals).

Some cautiousness will be used while interpreting the results, since the dynamics of per capita indicators are the results of two different processes: an economic process (changes of income level) and a social process (changes of population level)[5].

The impact of ICTs investments on income level, on income growth and on regional economic disparities is conceptually due to two main effects[6]:

- an *accessibility effect*. Through ICTs, accessibility to knowledge and information highly increases, both in terms of quantity of information and knowledge achieved and of time through which information and knowledge are achieved. The greater availability of information and knowledge acts on the efficiency of local firms;

[5] To deal with this problem, a population submodel can be added to our model. See section 0.
[6] Our methodology will underline such effects (see section 3.3.2.2).

- an *employment effect*, which creates, via a m.ultiplicative effect, an increase in total labour force and income. The creation of new ICTs infrastructure and of the service provision generate new employment, increases the competitiveness of exporting sectors and therefore generates an increase in income and in local development.

ICTs represent an increase in the territorial endowment of location factors, thus influencing both the efficiency and the quality of production factors, which, on their turn, positively impact on the economic growth of the area (*efficiency*) and on the location choices of firms (*attractiveness*). As a recent empirical analysis demonstrates on data on innovation patterns in the United Kingdom, innovative firms are more likely to locate in regions where the transport and communications infrastructure is more advanced than in other UK regions[7].

Despite the conceptual recognition of a relationship between ICTs investments and income growth, in the past empirical evidence has demonstrated that the linkage between ICTs investments and income growth is not so straightforward: adoption does not necessarily mean use, and use does not necessarily mean innovative use, the latter being defined as the achievement of new markets and new business opportunities, leading to a real market increase at microeconomic level and to greater competitiveness at the territorial level.

The linkage between adoption and innovative use is guaranteed by the presence of some "enabling factors", at both national and local level. At the Country level, the main enabling factors, or main conditions under which ICTs investments and adoption lead to regional growth, are twofold:

- the *general level of economic development* of the Country analysed, which reflects the level of innovative activity, of R&D expenditure, of technological culture and knowledge present in the Nation;
- the *regulatory régime* that characterises the ICTs market in the Country. In most developed Countries, the change from monopolistic to competitive ICTs market structure has dramatically raised the rhythm of investments and the rhythm of adoption, increasing the rate of diffusion of ICTs. On the other hand, the process of privatisation has strongly affected the geographical distribution of ICTs investments, concentrating them in the richest areas of the Country.

Even at the local level some enabling factors exist, which facilitate the positive effects of ICTs investments to take place:

- the *economic structure* of the local area. Given the fact that large firms and high-tech sectors are more influenced by ICTs technologies than small and traditional sectors, the MIX of sectors and firm size locally present may explain the degree of effectiveness of ICTs on the regional performance;
- the *innovative capacity* of the local area, which is in its turn the consequence of three elements: a) the productive structure of the local area, b) the level of development of the local area and c) social and cultural factors.

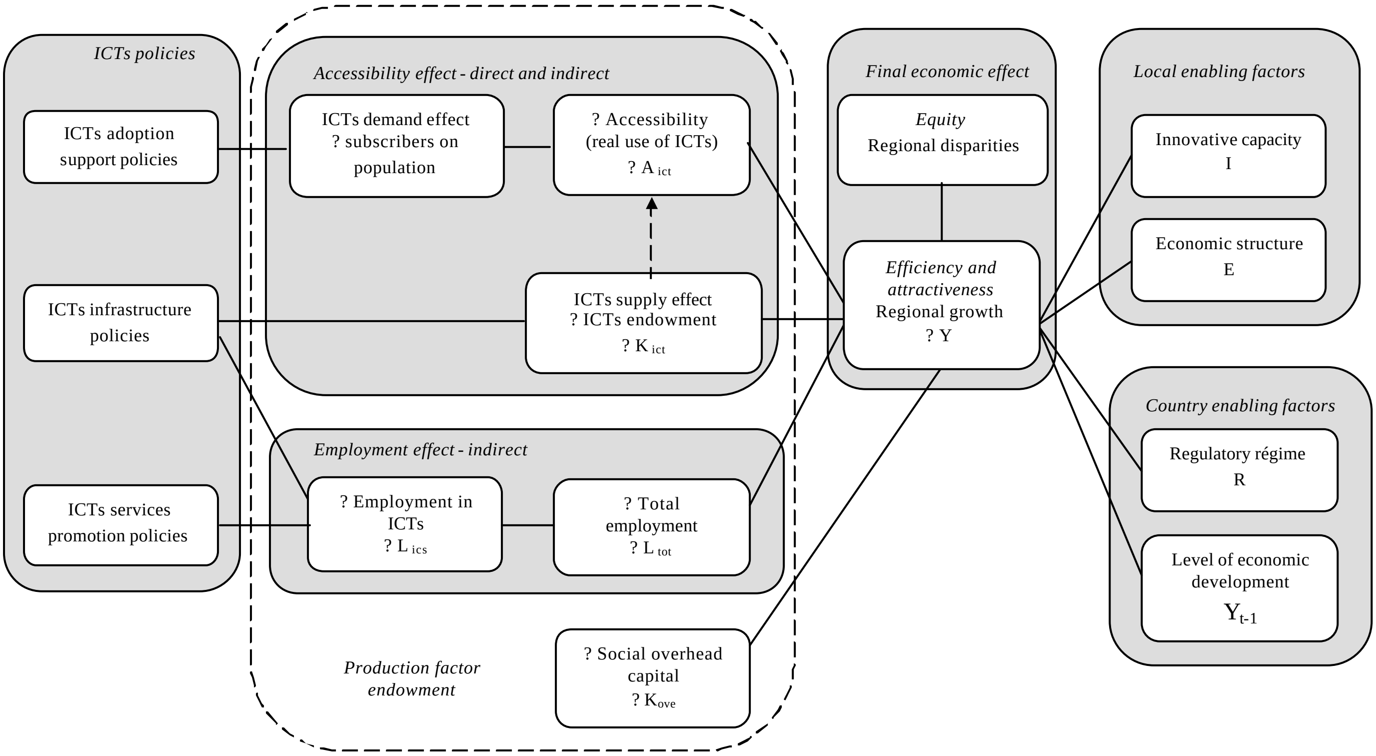
All these aspects are taken into consideration in the methodology for ICTs spatial economic impact assessment. The conceptual approach of our methodology, described above, is

[7] Simmie and Sennet (1999).

summarised in Fig. 3.2 the final economic effect of ICTs policies, i.e. the achievement of equity and efficiency goals, is explained via the presence of accessibility effects, employment effects and production factor endowment. Moreover, these linkages strongly depend on the presence of local and national enabling factors.

In section 3.3.2 we present the methodology used for the ICTs spatial economic impact, which deals with the quantitative impact measurement of ICTs investments on per capita income level, income dynamics and regional disparities.

Fig. 3.2 - Model for ICTs Spatial Economic Impact Assessment



3.3.2 Methodology for the Assessment of ICTs Spatial Economic Impact

The *ICTs spatial economic impact* concerns the economic effects that ICTs investments have from the point of view of both efficiency and equity goals.

To put into practice the conceptual elements explained in section 3.3.2.1, we analyse the impact of ICTs policies on regional development, measured by per capita regional income level and per capita regional income growth, and on regional disparities, measured by the differences in income levels among regions, before and after the policies' execution.

In order to quantify such impacts, we suggest two kinds of methodologies: one interpretative methodology (section 3.3.2.1) and one descriptive methodology (section 3.3.2.2). These methodologies are consistent with the methodology for transport policy impact assessment presented by our ESPON group. It is thus possible to build more comprehensive indicators of accessibility and capital, so they can be applied both to transport and telecommunications infrastructures, in order to provide a comprehensive impact analysis at the same level of territorial disaggregation[8]. Moreover, these methodologies do not require a specific territorial disaggregation level of the data, so they can be tested at more aggregated territorial levels of analysis.

This aspect is quite important, since the ICTs data are not available at a disaggregated territorial level. After long telephone calls and face-to-face meetings with the ESPON 1.2.2 project coordinator (CURDS, University of Newcastle) on the availability of ICTs data, the conclusion achieved was that a sufficient time series and cross-section database on ICTs only exists for EU-27 at NUTS-0 level (Country level). Some attempts have been made by the Italian team to collect data at regional level for some specific Countries. In particular, this effort has been made for Italy and Finland.

For Italy, managers of the TLC Authority and TLC carriers (i.e. Telecom Italia) were contacted. For Finland, several telephone calls and inquiries have been made with the National Statistical Office. Up to now (March 2003), no concrete and positive answers were provided to our request. However, other attempts will be made in the next months, and, if data at regional level are available at least for one Country, the methodology will be applied.

3.3.2.1 Interpretative Methodology for ICTs Spatial Economic Impact Assessment: the STIMA Model

In this section, we present our STIMA model (Spatial Telecommunications IMpact Assessment)[9]; based on the estimate of a *quasi production function*, it allows measuring the role that ICTs (adoption and use; advanced or basic networks and services) play on regional performance. This *interpretative* methodology is consistent with the one used to measure the role of transport networks on territorial performance. If data are available at the same territorial disaggregation level, a unique methodological impact analysis can be run[10].

As mentioned before, this methodology can be used either for national, regional or subregional analyses.

Our aim is to assess the impact of ICTs from the point of view of efficiency and equity, the two EU most important political goals. As a measure of efficiency, we use the regional income level and income growth (per capita): by measuring the ICTs investment projects impact on regional income growth, we can assess the efficiency of those projects.

From the equity point of view, we will measure the impact of those projects on the differences in regional per capita income among different regions.

The methodology estimates the following quasi production function:

[8] Section 3.3.3 deals with the integration of transport and telecommunications impact methodologies.
[9] In Italian, "stima" means estimate, assessment and esteem.
[10] See Section 3.3.2.3.

$$Y_{rt} = f(LTOT_{rt}, KOVE_{rt}, KICT_{rt}, AICT_{rt}, I_{rt}, E_{rt}, Y_{r(t-1)}, R_{rt}) \quad (7)$$

which summarises the conceptual framework presented in *Fig. 3.2*: regional income level (Y_{rt}) depends on the level of production factors available locally and on the presence of the enabling factors. In our methodology, the production factors are threefold: two traditional production factors - labour (L_{TOTrt}) and social overhead capital (K_{OVErt}) - and a particular production factor, strictly linked with ICTs endowment and use, i.e. accessibility. The latter is measured in terms of telecommunications infrastructure endowment (K_{ICTrt}) and telecommunications intensity of use (A_{ICTrt}). A wide conceptual difference exists between the two accessibility measurement indicators: the former measures what we call ICTs endowment as a measure of potential accessibility, since it represents the supply of ICTs infrastructures and not necessarily the real use, while the latter is what we label "accessibility", since it measures the real use of these technologies.

Equation (7) also contains the enabling factors which are necessary to understand the relationship between ICTs and regional development, as discussed in the previous section: I_{rt}, E_{rt}, $Y_{r(t-1)}$, R_{rt} represent respectively the innovative capacity, the economic structure, the regional growth and the ICTs regulatory régime; all influence the impact that ICTs have on economic development. Each variable is conceptually part of a submodel. In our conceptual framework, submodels are in number of six: *ICTs Policies, Accessibility, Employment, Local* and *Country Enabling Factors* and *Final Economic Effect*. The accessibility submodel is in its turn divided into two submodels.

i) ICTs policies submodel

This submodel contains the assumptions about the policy framework, that will be needed for measuring the impact of ICTs on regional development and for providing different scenarios[11].

ICTs policies can be split into three main typologies, following the guidelines of the eEurope 2002 Action Plan of the European Union[12]:

- *a cheaper, faster, secure Internet*. This policy is organised in different actions: cheaper and faster Internet access; faster Internet for researchers and students; secure networks and smart cards;
- *investing in people and skills*. This second objective concerns the following actions: European youth into the digital age; working in the knowledge-based economy; participation for all in the knowledge-based economy;
- *stimulate the use of the Internet*, by implementing advanced services. This policy regards: accelerating e-commerce; government online (electronic access to public services); health online; European digital content for global networks; intelligent transport systems.

As mentioned before, these three types of policies have different effects on the other submodels:

- the first kind of policies are *ICTs infrastructure policies*. The primary aim of these policies is to increase the physical endowment of ICTs networks. These are the policies

[11] The scenarios are presented in Section 3.3.3.
[12] Council of the European Union (2002).

with the highest financial investment. In the STIMA model, ICTs infrastructure policies will influence the ICTs endowment and employment submodels;
- the second are *ICTs adoption support policies*. These policies support the development of additional services, that should facilitate the ICTs adoption and use in the regions, i.e. support and advice services. This kind of policies will influence the accessibility submodel of the STIMA model;
- finally, the last are *ICTs services promotion policies*. These policies try to develop the advanced services linked to ICTs, such as e-commerce, e-government and so on, by favouring the developing of ICTs-based firms; ICTs services promotion policies will influence the employment submodel, by increasing ICTs sector employment[13] and, subsequently, total employment.

From the implementation of the different policies, different scenarios may be envisaged. By developing the analysis according with the different scenarios, we are able to understand the real impact of ICTs policies on regional growth[14].

The ICTs policies submodel should be included in an integrated transport-telecommunications analysis (see below, section 3.3.2.3).

ii) Accessibility submodel

This submodel concerns one of the two major effects of ICTs on regional development: the *accessibility effect*. It aggregates two different submodels: the first is a *ICTs endowment submodel*, that calculates the effects of ICTs supply on regional growth, both indirect (through accessibility submodel) and direct; the second is the *accessibility submodel*, that tries to estimate the effects of real use of ICTs networks on regional growth.

ii-a)ICTs endowment submodel - direct and indirect effect

This submodel aims at describing the direct and indirect effect of ICTs supply on regional growth. For this purpose, this submodel calculates an indicator of ICTs endowment for region r in year t (K_{ICTrt}) expressing the availability (the endowment) of ICTs networks (*supply effect*), weighted for the type of networks:

$$K_{ICTrt} = \sum_{i} a_i n_{irt} \tag{8}$$

where

K_{ICTrt} = ICTs endowment of region r in year t

a_i = 0,3 for i = traditional networks (telephone lines and fax) of region r
0,7 for i = advanced networks (wireless communication, Internet and other)

n_{irt} = network size of line i in region r in year t, expressed by:
- number of main telephone lines;
- number of Internet host
- number of cellular phones subscribers.

[13] The ICTs sector employment is defined as "full-time staff employed by telecommunication network operators in the Country for the provision of public telecommunication services. As far as possible, staff not working principally for the provision of telecommunications services (e.g., those working in postal services or broadcast operations) should be excluded" (ITU, 2003).
[14] See hypotheses.

A higher weight is assigned to the advanced networks since they guarantee a higher accessibility, thanks to greater communication transmission quality and speed, and/or a higher service quality supplied on the networks. Moreover, the even and widespread territorial diffusion of basic telephone lines risks to cancel differences among areas.

The assignment of a different coefficient, such as $a_i = 0{,}3$ for traditional networks, and $a_i = 0{,}7$ for advanced networks (Internet, wireless communications and other), is useful in this respect. This coefficient is assumed to remain unchanged among regions and years, this is why it lacks the sub-index for regions and time (r and t).

ii-b) Accessibility submodel - direct effect

This submodel aims at describing the effect of real use of ICTs on regional growth. It builds an indicator of accessibility for region r in year t (A_{ICTrt}), expressing the real use of ICTs networks. It is calculated as follows:

$$A_{ICTrt} = \left(\sum_s \frac{P_{st}}{d_{sr}^{g_{rt}}} \right) \qquad (9)$$

where
A_{ICTrt} = accessibility of region r in year t
r, s = regions
P_{st} = population of region s in year t
d_{sr} = distance in km between region s and region r $\forall\ s \neq r$
(if s=r, d_{sr} is assumed to be = 1, because a division by zero is not allowed)
g_{rt} = spatial friction between r and s, measured by the inverse of the intensity of ICTs use.

The intensity of ICTs use (u_{rt}) is calculated as follows:

$$u_{rt} = 1/g_{rt} = T_{rt} \,/\, P_{rt} \qquad (10)$$

where
u_{rt} = intensity of ICTs usage in region r in year t
i = ICT network
r = region
t = time (year)
T_{rt} = traffic on the network i in region r in year t
P_{rt} = population of region r in year t

The best indicator of ICTs use is the telephone or Internet traffic, respectively measured by minutes of conversation or number of telephone calls or minutes spent on line. The problem is that such data are not easily made available at territorial disaggregated level, in particular data on advanced telecommunications network traffic are difficult to be obtained. A possible proxy for ICTs use is

$$u'_{rt} = 1/g'_{rt} = \left(\sum_i a_i s_{irt} \right) / P_{rt} \qquad (11)$$

where
u'_{rt} = intensity of ICTs usage in region r in year t
a_i = 0,3 for i = traditional networks (telephone lines and fax)

0,7 for i = advanced networks (wireless communication, Internet and other)
s_{irt} = subscribers of network i in region r in year t
P_{rt} = population of region r in year t

The assumption made in this proxy is that the subscription to a service necessarily means use (which is not always the case).

It is also possible to build separate indicators (both for ICTs endowment and for accessibility) for traditional and advanced networks. The alternative formulas for each indicator would be as follows (where p stands for traditional networks and d for advanced networks):

- ICTs endowment
  - traditional networks: $K_{ICTrtp} = (S_i\, n_{irtp}) / P_{rt}$ (12)
  - advanced networks: $K_{ICTrtd} = (S_i\, n_{irtd}) / P_{rt}$ (13)

- intensity of use
  - traditional networks: $u_{rtp} = 1/g_{rtp} = (S_i\, s_{irtp}) / P_{rt}$ (14)
  - advanced networks: $u_{rtd} = 1/g_{rtd} = (S_i\, s_{irtd}) / P_{rt}$ (15)

As presented here, our model does not contain any population submodel. It is nevertheless possible to add such a submodel, concerning migration and natural flows, that will influence the indicators of ICTs endowment and ICTs use, by modifying the term P_{rt}[15].

iii) Employment submodel

This model deals with the second major effect of ICTs policies: *employment effect*. It calculates the variation in total employment due to a variation in the employment in ICTs sector[16]:

$$?L_{TOTrt} = 1/ (1-b_{rt}) * ?L_{ICTrt} \quad (16)$$

where
$? L_{TOTrt}$ = increase in total employment in region r in year t, due to an increase in ICTs employment
$? L_{ICTrt}$ = increase in employment in ICTs sectors in region r in year t

The idea behind this submodel is that ICTs sector development can increase the competitiveness of other sectors, therefore increasing total employment. The size of the increase depends on the coefficient b, which represents the share of non-basic sectors[17].

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[15] On this point, see also submodel vi.
[16] For ICTs sector definition, see note 13.
[17] This model was first developed by Hoyt in the 1930s, following a supply-oriented approach. The model considers two kind of sectors, the basic and non-basic sectors. The basic sectors are the sectors capable to pull the growth of the area. We identify as "basic sectors" the specialised sectors, i.e. the sectors with a localisation quotient higher than 1.

This submodel cannot take into consideration another important effect of ICTs, frequently highlighted by many authors: the quality change of the work force. In fact, it is often stated that a higher diffusion of ICTs means a higher percentage of white-collar workers, at the expenses of blue-collars. Since this qualitative change is very difficult to measure at an aggregate level, we choose to restrict the analysis to the variation in the number of workers.

iv) Local enabling factors

This submodel defines some indicators of the local factors that should facilitate the impact of ICTs on regional growth. We identify two main local enabling factors:

- I_{rt} = *innovative capacity* of region r in year t, measured by R&D investments or patents;
- E_{rt} = *economic structure* of region r in year t, measured as percentage of employees in sectors sensitive to ICTs on the total of employees.

The innovative capacity is a very important enabling factor, since it is a proxy for the region's speed of reaction to innovation in general. A higher innovative capacity facilitates a positive impact of ICTs on regional growth, and it shortens the time for ICTs to become effective.

Introducing the economic structure as a local enabling factor is a way to include the sectoral element in our analysis.

The classification of sectors as sensitive to ICTs is quite arbitrary: the best proxy is the share of high-tech sectors present in the area, since these sectors are reasonably expected to be the most sensitive to ICTs adoption[18].

v) Country enabling factors

This submodel covers the national factors that should facilitate the ICTs impact on regional growth. We identify two important elements:

- R_{nt} = ICTs regulatory régime in nation n in year t
- D_{nt} = level of economic development of nation n in year t-1.

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

The model is constituted by the following equations:

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

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

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

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

[18] For high-tech sector, we mean one nace-clio branch at RR17 disaggregation: the manufacturing sector of metal products, machinery, equipment and electrical goods.

The indicator of regulatory régime should be either a dummy or a time-dependent indicator, as it is important to know whether the market is liberalised or not, and if it is, how many years passed from the liberalisation.

The level of economic development is a dummy based on the national income level. D_{nt} will be equal to 0 if the Country presents an income level lower than the European average, while $D_{nt} = 1$ if the national income level is above the European average. It depends from income growth, so in this way we introduce a recursive element in the model.

vi) Final economic effect

This is the core submodel of our conceptual framework. It measures regional growth and, consequently, regional disparities, measured by differences in regional income among regions.

Since the policy aims respond to two main goals (efficiency and equity), we identify separate indicators for each of them.

Efficiency indicators

We chose as efficiency indicator regional income and its growth. Regional income is calculated as follows:

$$Y_{rt} = f\,(K_{ICTrt}, A_{ICTrt}, L_{TOTrt}, K_{OVErt}, I_{rt}, E_{rt}, D_{nt}, R_{nt}) \qquad (17)$$

where

Y_{rt} = income of region r in year t

K_{ICTrt} = potential accessib. of region r in year t

A_{ICTrt} = accessibility of region r in year t

L_{TOTrt} = total employment of region r in year t

K_{OVErt} = social overhead capital of region r in year t

I_{rt} = innovative capacity of region r in year t

E_{rt} = economic structure of region r in year t

D_{nt} = regional growth of nation n (dummy)

R_{nt} = ICTs regulatory régime of nation n in year t

The social overhead capital includes non-ICT capital stock and other “soft” location factors such as cultural facilities, educational structure and so on. It is a part of the attractiveness effect, together with the other endowment factors, such as employment and ICTs supply.

The change in regional income (? Y_{rt}), due to the decisions in ICTs policies, is our efficiency indicator.

$$?y_{rt} = f\,(?K_{ICTrt}, ?A_{ICTrt}, ?L_{TOTrt}, ?K_{OVErt}, ?I_{rt}, ?E_{rt}, ?Y_{r(t-1)}, ?R_{rt}, ?P_{rt}) \qquad (18)$$

3.3.2.2 Descriptive Methodology for ICTs Spatial Economic Impact Assessment: a Typology of ICTs Territorial Impacts

The main aim of this methodology is to describe the relationship which exists between ICTs endowment and regional development, and to provide a typology of territorial impacts. The methodology used to identify different typologies of ICTs impacts is a three-step procedure.

In the first step synthetic indicators are built on ICTs use, endowment and economic structure, through a factor analysis. In the second step, territorial units are aggregated on the basis of similar ICTs endowment, similar economic structure and similar ICTs use, through a cluster analysis. Finally, in the third step the results are presented on geographical maps and in synthetic charts.

3.3.2.2.1 Factor Analysis

The first step helps in identifying indicators obtained as a statistical synthesis of different possible variables representing the same elements. Factor analysis is useful in this respect: it is a statistical procedure that groups similar indicators from the statistical point of view. It is thus possible to run a factor analysis on some indicators expressing similar elements, in order to obtain a comprehensive indicator that can be used in cluster analysis to produce a more interpretable result.

3.3.2.2.2 Cluster Analysis

Once synthetic indicators are obtained, in the second step they are used in a cluster analysis. The *cluster analysis* is a statistical proceeding that groups the observations according to some characteristics to be specified from the researcher. Our intention is to use this methodology with the aim of providing a typology of regions, with a high homogeneity within each cluster and with high variations among clusters in terms of ICTs and economic dynamics indicators. We can run a cluster analysis using as clustering variables the change in accessibility, in regional income, in ICTs endowment and in employment. The expected result from the application of this methodology is the identification of groups of regions that show a similar behaviour in terms of economic performance and ICTs use and adoption. In doing so, we are able to define different groups of regions, each witnessing a different degree of economic impact of ICTs.

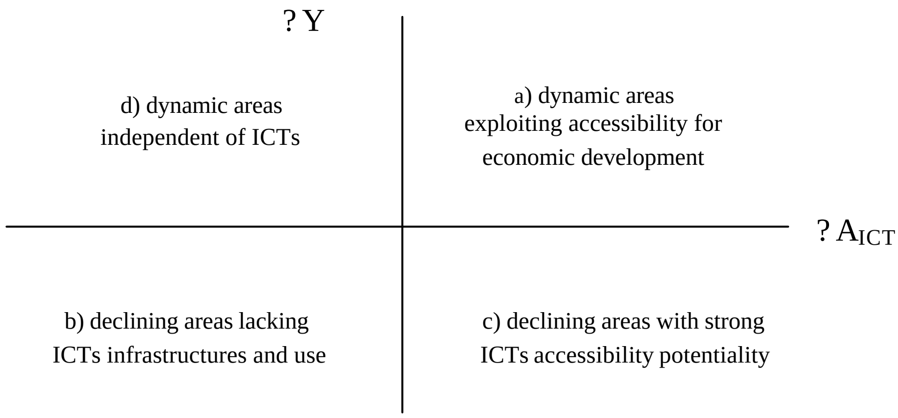
3.3.2.3 Graphic Plotting and Maps

In the third step, the results of the clusters are presented on geographical maps and synthetic charts.

A chart can highlight the variation in regional income (?Y) and in ICTs endowment (?K_{ICT}) or use (? A_{ICT}) (Fig. 3.3). In this chart we can identify four different situations, corresponding to the four quadrants of the chart:

a) the regions (or clusters) that lie in the area of the chart where ?Y and ?K_{ICT} are both positive are characterised by a growth in ICTs endowment and in regional income. This represents a positive impact on the accessibility of the region, i.e. *dynamic areas exploiting accessibility for economic development*;
b) on the contrary, in the regions located in the quadrant where ?Y and ?K_{ict} are both negative, *the lack of ICTs endowment is accompanied by a declining economic performance*;
c) the cluster of regions that lie in the area in which regional income increases, while ICTs endowment decreases, are territorial units where *economic performance is not related to ICTs endowment and use*;
d) finally, the clusters of regions that present positive ?K_{ICT} but negative ?Y are *territorial units with strong accessibility potentialities*.

Fig. 3.3 - Typology of Spatial Economic Impacts of ICTs



3.3.3 Interactions with Transport Networks Impact Assessment Methodologies

As pointed out in the introduction, our methodology is consistent with the methodology used for forecasting the impact of TEN policies, so they can be integrated or run as a unique methodologies.

In particular, we refer to the SASI model[19], developed in the 4th RTD Framework SASI project and extended in the 5th RTD Framework IASON project. In fact, it is possible to build comprehensive indicators of accessibility and capital, in order to include both ICTs and transport factors and effects in SASI or STIMA model: we can either modify SASI indicators in order to include ICTs aspect, or modify STIMA indicators to include transport aspects.

In SASI, three main changes shall be done:

[19] Fürst *et al.* (1999); Wegener and Bökemann (1998); Wegener *et al*. (2000).

- the policies submodel should include the ICTs-specific policies, that will be the determinants of the regional growth;
- the regional accessibility indicator used for SASI should include our indicator of accessibility A_{ICTrt} that concerns the use of ICTs networks;
- the regional capital indicator should include also ICTs infrastructures, our K_{ICTrt} indicator.

3.4 Spatial-Equilibrium Model of Trade and Passenger Flows

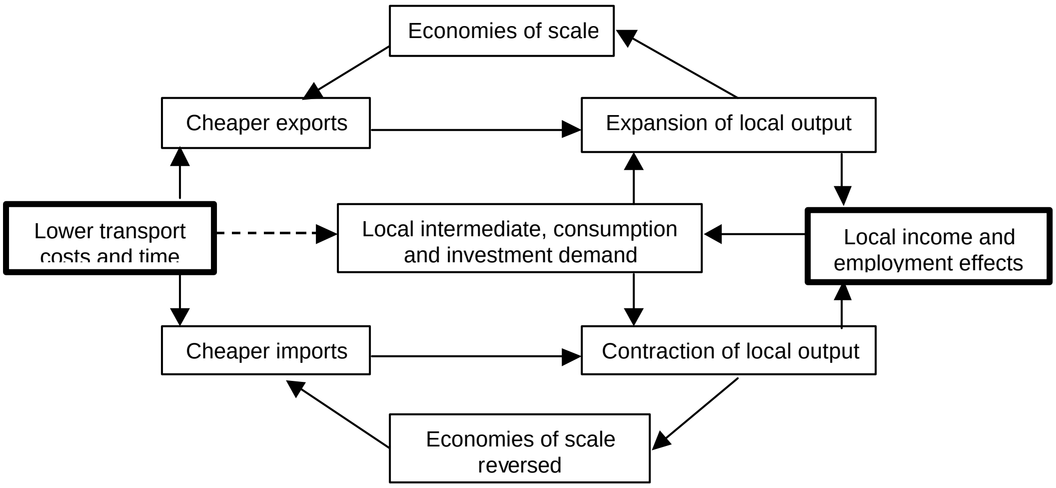
Although extensive research is already under way for assessing the infrastructure needs as well as costs and benefits of individual projects, very little is still known about the spatial distribution of the benefits. Traditional approaches to cost benefit and regional impact analysis are not really capable of taking account of the complex mechanisms by which transport cost changes affect the spatial allocation. This holds true already in a static framework, not to speak about the even more complex channels through which the transport system aspects economic dynamics. The critical issue is to assign the benefits from using the transport links to regions. Assigning costs and benefits from construction and maintenance to regions is less of a problem, and traditional techniques like multiplier analysis are acceptable. Assessing the benefits from newly installed capacities and answering the question where they accrue, however, is much more difficult.

Therefore an additional approach will be applied, largely drawing on the same database as the production function approach. The aim is to set up a multi-regional computable general equilibrium, in which transport costs explicitly appear as firms' expenditures for transport and other kinds of business travel and as households' costs of private passenger travel (for examples see Venables and Gasiorek, 1998, Bröcker, 1998a).

This is done in the CGEurope model (see Bröcker, 1998a, 1999, 2000, 2001). The CGEurope model has been developed in an academic environment in a project financed by a national research council and has been extended in the IASON project financed be the European Commission. CGEurope is a multiregional computable general equilibrium model, incorporating innovative features from recent developments in the literature like product diversity and monopolistic competition, explicit modelling of out-of-pocket as well as time costs of business transport as well as private passenger transport.

Computable general equilibrium models have a strict microeconomic foundation. Different assumptions about market forms, technologies and preferences can be introduced, and financial flows between the actors and markets in the economy (Figure 3.4) are taken into account in a theoretically consistent manner.

Figure 3.4: Conceptual Model of Transport-Economy Interaction Embodied in SCGE Models



Source: Oosterhaven and Knaap, 2000

Transport policies are modelled by changing exogenously transport costs or travel times. As a response, prices as well as quantities react on the changes resulting in changes in income and welfare. The main indicator for the regional consequences one is looking at is the welfare change of regional households as measured by the household's utility functions. Though an ordinal utility index as it stands has no operational meaning, it can be transformed to the so-called Hick's measures of variation, which measures the welfare change in monetary terms (see section 2.1.2).

The focus of the CGEurope model is on evaluating welfare effects in a comparative static equilibrium analysis, that means by comparing cases "with" and "without", leaving everything else unchanged. Hence the approach does not allow for long-term predictions of locational change. It studies welfare gains and losses given the spatial distribution of factors of production. Comparative static simulations will be carried out for a recent benchmark year, based on observed data, as well as for a future year, based on predictions of data.

However, the developers of CGEurope note that a potential advantage over standard project assessments is that it is possible to quantify the distribution of welfare gains and losses, and that general equilibrium repercussions are consistently taken into consideration, including effects generated by economies of scale and agglomeration. This ensures that indirect effects are addressed, as well as the policy issue of spatial distribution.

CGEurope is a multiregional model for a closed system of regions, treating separately each region and linking them through endogenous trade. The world is subdivided into a large number of regions.[20] Each region shelters a set of households owning a bundle of immobile production factors used by regional firms for producing goods. The CGEurope model distinguishes between two different sectors: tradable goods as well as non-tradable (local)

[20] In ESPON 2.1.1 the spatial dimension of the model is established by the subdivision of the European Union and the 12 candidate countries in eastern Europe and Liechtenstein, Norway and Switzerland into 1,321 regions and by connecting these regions by road, rail, air and waterway networks.

goods. Beyond factor services, firms also use 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 transport.

The factor supply is always fully employed due to the assumption of perfect price flexibility, which implies the assumption that the rate of unemployment remains unaffected by the exogenous influences under study. Effects on integration and unemployment are not subject of the modelling exercise by the CGEurope model , but will be studied within the SASI methodology (see section 3.2).

Regional final demand, including investment and public sector demand, is modelled as expenditure of utility maximising regional households, who spend their total disposable income in the respective period. Disposable income stems from returns on regional production factors, which, by assumption, are exclusively owned by regional households, and a net transfer payment from the rest of the world. This transfer income can be positive or negative, depending on whether the region has a trade deficit or surplus. Transfers are held constant in our simulations. Introducing fixed interregional income transfers is a simplified way to get rid of a detailed modelling of interregional factor income flows, and of all kinds of interregional flows of private and public funds. Households act as price taking utility maximizers and expend their income for local and tradable goods as well as for travel. The vector of travel demand is differentiated by purpose of travel and destination. Households gain utility from a set of activities connected with travel (like tourism) and suffer from disutility for spending travel time.

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

Firms maximize profits. Local goods producers take prices for inputs as well as for local goods sold to households and other firms as given. Due to linear homogeneity, the price of local good equals its unit cost obtained from cost minimisation under given input prices. Tradable goods producers take only prices for inputs as given. They produce a raw output by a technology designed in the same way as for local goods producers. Instead of directly selling their output, however, they transform the homogeneous raw output into a final differentiated output. The respective technology is increasing returns, with a decreasing ratio of average to marginal input. Firms are free to compete in the market for a tradable good, which already exists, or to sell a new one not yet in the market. The latter turns out to be always the better choice. Hence, only one firm monopolistically supplies each good, 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.

This is the well-known mechanism of Chamberlinian monopolistic competition determining the number of goods in the market as well as the quantity of each single good (see Krugman, 1991, Fujita et al., 1999, Bröcker, 1998a). Due to free entry, the price of a tradable good just equals its average unit cost. It turns out that under the assumption of a constant price elasticity of demand for each variety of goods, which is valid in our framework, output per variety is also constant, such that output variations come in the form of variations in the number of varieties, and real output is the endogenous measure of variety.

Certainly, assuming local markets to be perfectly competitive lacks empirical plausibility. Local goods producers may in fact exert some monopoly power, local goods might be diversified, just like tradables, et cetera. The reason why this assumption is nevertheless preferred is that this is the simplest way to get rid of the local sectors, which only play a secondary role in an analysis focusing on interregional trade. Another choice without major technical problems would be to assume monopolistic competition for the local sectors as well. This, however, is not recommended, because it introduces a size-of-region effect. Large regions in our system (like the Asian part of Russia, for example) would support a high diversity of local goods, generating an unrealistic low prices of composite local goods, given the factor price(s) and technology in the region.

Three features give the CGEurope model its spatial dimension:

- the distinction of goods, factors, firms and households by location,
- the explicit incorporation of transport cost for goods (and services, regarded as a special kind of goods), depending on geography as well as national segmentation of markets, and
- the explicit incorporation of private passenger travel, with time costs and out-of-pocket costs depending on geography as well as national segmentation of space.

Summarising the basic philosophy of our approach, it obviously strongly relies on neo-classical ideas, even though it departs from the traditional computable general equilibrium approach by allowing for imperfect markets. In other respects, however, the strictness of neo-classical assumptions is retained: firms and households act perfectly rationally, prices are flexible, and markets are cleared, including labour markets. Though these assumptions are often criticised for contrasting with reality, there is no better choice. Even if households don't maximize utility subject to a budget constraint, it is not questioned that they react on prices and that the budget constraint must eventually hold. Neo-classical demand theory is just an easy way to represent these reactions consistently in a formal way. Similar comments apply to modelling reactions of firms.

4 Assessment of Forecasting Results

These models of Chapter 3 will be applied to transport and ICT policy scenarios for European infrastructure and its use. They produce information about the effects of the policies considered on population, output, productivity and accessibility, to mention a few important variables.

Assumptions on pricing and assumptions on network investments constitute two components of such transport policy scenarios:

- Pricing: introducing social marginal cost pricing of road vehicles, or alternatively from all modes. Pricing scenarios are entered into the models by changing the monetary travel cost functions.
- Network investments: different time schedules of implementing the trans-European (TEN-T) and TINA networks. Network scenarios are entered into the models by changing the underlying network databases.

Depending on the final combinations of pricing and network components, the expected effect of transport and TEN policies on polycentric development may be very different. Marginal cost pricing will mainly affect regions with high congestion, i.e. the congested corridors in the core region and some metropolitan areas in the periphery. The costs will increase but on the other hand transport times will be reduced. In metropolitan areas, the cost component tends to dominate for private person trips, while for business trips and freight transport the direct efficiency gain may exceed the direct cost increase. The distribution of impacts is to a large extent dependent on the indirect effects related to how the collected charges are to be used.

The evaluation of such effects is a nontrivial task. This chapter proposes an evaluation procedure which uses the concept of polycentrality. The chapter starts with a section on regional typologies that concludes that polycentrality is the most important aspect of the classification of urban regions. Section 4.2 gives a discussion of polycentrality, suggesting its measurement along three dimensions: size, morphology and connectivity. Section 4.3 integrates the polycentrality concept into a spatial impact analysis. An important element of policy evaluation is the measurement of its effect on spatial inequality. In section 4.4 an indicator for inequality measurement that is derived from the economic literature is proposed. Section 4.5 discusses the trade-off between equity and efficiency, linking both to polycentrality. Section 4.6 concludes.

4.1 Typologies

According to the ESPON 'Guidance Paper', all ESPON projects are to contribute to identifying spatial typologies. Spatial typologies are to be used for further analysis, quantitative and qualitative, for statistical analysis and for the selection of representative case studies.

A number of ESPON 'core' typologies were proposed:

- a typology of urban regions
- a typology of rural regions
- a typology of central v. peripheral regions

- a typology of coastal regions
- a typology of mountainous regions
- a typology of border regions
- a typology of Interreg IIIA regions
- a typology of Interreg IIIB regions
- a typology of Objective 1 regions
- a typology of regions threatened by natural hazards

ESPON 2.1.1 will be responsible for developing, together with ESPON 1.2.1, a typology for central v. peripheral regions. ESPON 2.1.1 can also develop a typology of regions with respect to their being affected by TEN policies. In addition, ESPON 2.1.1 can contribute to the development of a typology of urban regions in ESPON 1.1.1.

4.1.1 Typology of Central v. Peripheral Regions

Centrality and peripherality will be measured on a continuous scale as accessibility or lack of accessibility: Central regions are the most accessible ones and peripheral regions the more remote ones, with different levels of centrality, or peripherality, in between.

The accessibility indicators used for classifying regions by centrality or peripherality will be the same as the ones used in the different methods used to forecast the impacts of trans-European transport networks. Most likely, accessibility indicators of the 'potential' type will be used. The economic or population potential of a region is the total of destinations (firms or population) in all regions of Europe weighted by a function of distance from the origin region. The accessibility indicators calculated will be based on the NUTS-3 regions of the ESPON Space and aggregated to NUTS levels 2, 1 and 0 as a weighted average of the corresponding NUTS-3 regions. Distance measures used for calculating road accessibility will be average road, rail and air travel times of passengers and goods taking account of road types, speed limits for cars and lorries, congestion in urban regions and of delays due to mountainous areas, national borders and maximum driving hours of lorry drivers. Distance measures in the rail and air networks will be mean travel times including access to rail stations and airports. By standardizing accessibility indicators, e.g. as percent of the EU-25 average, changes in the relative position of regions over time can be assessed.

Work on the typology of central and peripheral regions will benefit from the experience of project partners in developing the European Peripherality Index (E.P.I.) used for the most recent Cohesion Report of the European Union (Schürmann and Talaat, 2000) and from their work on accessibility indicators in Working Group 'Geographical Position' of the Study Programme on European Spatial Planning SPESP (Wegener et al., 2001).

4.1.2 Typology of Regions Affected by TEN Policies

It is the main task of ESPON 2.1.1 to forecast regional socio-economic impacts of EU transport and TEN policies. The main results of ESPON 2.1.1 will be forecasts of regional socio-economic development under the assumption of different European transport and telecommunications policy scenarios. By comparing these results with those of a do-nothing or business-as-usual scenario, the effects of the policies of interest can be isolated and regions can be classified with respect to their likelihood of being positively or negatively affected by European transport and telecommunications policies. This typology would be in a sense the dynamic complement to the typology of central and peripheral regions discussed above.

There exist different ways to present differences in regional socio-economic development:

- absolute change compared to a base year,
- relative change compared to a base year,
- absolute change compared to the EU average,
- relative change compared to the EU average,
- absolute difference compared to a do-nothing or business-as-usual scenario,
- relative difference compared to a do-nothing or business-as-usual scenario.

Depending on the difference chosen, a region can be classified as a winner or a loser with respect to a certain policy. For instance, in a certain policy scenario a peripheral regions may gain in accessibility and GDP per capita in absolute and relative terms compared to its situation in the base year, but it may lose in relative terms as other more central regions gain more. It may even grow faster in relative terms than central regions but be still a loser as in absolute terms the central region gains more.

To develop a typology of winner and loser regions with respect to territorial impacts of EU transport and TEN policies is therefore not a trivial task. It will require systematic experimentation to develop a set of difference indicators that is policy relevant, robust and easy to communicate.

4.1.3 Typology of Urban Regions

There are innumerable ways of developing typologies of urban regions. Cities may be classified by their size, their location (coastal cities, port cities, border cities, etc.), their administrative function (national capitals, regional capitals, etc.), their economic function (global cities, financial centres, industrial cities, etc.) or by their function in the transport network (railway nodes, airport hubs, etc.). All of these typologies are of interest for certain purposes.

However, for spatial planning the most interesting aspect for the classification of cities is their position in the multilevel polycentric urban system. Polycentric development has emerged as a key concept during the European Spatial Development Perspective (ESDP) process. In ESDP (1999, p 20) this is motivated in the following way: “The concept of polycentric development has to be pursued, to ensure regionally balanced development, because the EU is becoming fully integrated in the global economy. Pursuit of this concept will help to avoid further excessive economic and demographic concentration in the core area of the EU.”

The interest in polycentric development is fuelled by the hypothesis put forward in the ESDP that polycentric urban systems are more efficient, more sustainable and more equitable than both monocentric urban systems and dispersed small settlements. This hypothesis is based on the concept of central-place theory that different goods and services command catchment areas of different size (cf. Christaller, 1933) and on the theory of optimal market areas of industries by Lösch (1940). It is supported by recent results of economic geography showing that different constellations of economies of scale and spatial interaction costs lead to different spatial arrangements of production and consumption (Fujita et al., 1999).

Two policy options are stated in support of polycentric development across the European territory:

- Strengthening of several larger zones of global economic integration in the EU, equipped with high-quality, global functions and services, including the peripheral areas, through transnational spatial development strategies.
- Strengthening a polycentric and more balanced system of metropolitan regions, city clusters and city networks through closer co-operation between structural policy and the policy on the Trans-European Networks (TENs) and improvement of the links between international/national and regional/local transport networks.

By encouraging polycentric urban regions, the competitive potential of these regions should improve and dynamic global integration zones might be formed beyond the "pentagon" (defined by the metropolises of London, Paris, Milan, Munich and Hamburg).

A method for identifying polycentric urban systems will be presented in the subsequent Section 4.2. ESPON 2.1.1 can contribute to the development of a typology of urban regions in co-operation with ESPON 1.1.1 by providing forecasts of population size and economic activity in NUTS-3 regions for future years. Based on these forecasts, the three partial indicators of polycentrality proposed in Section 4.2, size, morphology and functionality, can be constructed and aggregated to a comprehensive indicator of polycentrality. The indicator would classify each country on a continuous scale of polycentrality and at the same time assign each city a place and level in the national and European urban hierarchy. It may also be possible to apply cluster analysis to verify and validate the polycentric urban system so derived.

4.2 Polycentrality Measurement/Indicators

In this section preliminary indicators for measuring polycentrism and for linking forecasting results from the methodologies presented in Chapter 3 with polycentrism will be discussed.[21]

4.2.1 Earlier Typologies Using Polycentrism

Earlier studies have developed typologies of urban systems with respect to polycentrality. In this subsection some relevant cases are discussed.

The CPMR Study

[21] The discussion that follows is partly based on ESDP (1999), the First Interim Report (FIR) of ESPON Project 1.1.1 "The role, specific situation and potentials of urban areas as nodes in a polycentric development", the "Study on the construction of a polycentric and balanced development model for the European territory" (CPMR, 2002) and "From project results to ESPON results – a draft guidance paper prepared by ESPON 3.1".

A typology of urban systems with regard to European polycentrism was proposed in the CPMR study. It was based on the following indicators:

- Competitiveness: GDP per capita (in ppp) relative to the European average, productivity
- Economic decision-making centres: number of headquarters of the top 1500 European firms
- Human capital: share of total employment in R&D, share of population between 25-59 years of age with high education
- Connectivity: number of international flights and number of international destinations
- Drivers of change: growth of GDP per capita relative to the European average, growth of productivity.

Regional performance was classified as high, average or poor according to threshold values of these indicators. By cross-referencing the outcome for the five factors, the peripheral urban systems were divided into five types (peripheral gateways, rising stars, promising systems, dilemma systems, most peripheral systems).

The First Interim Report of ESPON 1.1.1

The method for assessing the potential for polycentric development proposed in the FIR of ESPON 1.1.1 relies on indicators discussed in CPMR study. The following main categories are analysed:

- Mass: population, population density, gross regional production (GDP). The idea is that, all things being equal, the greater the mass, the greater the chances of benefiting from a wide range of services, development factors, a large labour market, economies of scale, etc.
- Competitiveness: GDP per capita (relative to the European average), productivity, location of decision-making centres, research and development activity and the level of education. This is considered to be the key criterion on the capacity of urban systems to be, or to become, focal points in the European polycentric system.
- Connectivity: linkages by road, rail and air with main European and world development poles. This criterion concerns the core factor of polycentrism, i.e. the flows between urban systems, and helps to identify internal and external "hubs" in the transportation networks.
- Motors of change: population growth, growth in GDP/capita, growth in relative productivity. The criterion reflects the dynamic character of urban systems.

In ESPON 1.1.1 these quantitative criteria will be used to assess polycentrism of European Functional Urban Areas (EFUAs). These EFUAs are defined as aggregates of NUTS 5 units or proxies (local labour market area or NUTS 4) if data on the NUTS 5 level are not available. The detailed list of variables to measure the four criteria is provided in the FIR of ESPON 1.1.1. In total 38 variables are listed. Further elaboration of indicators of functional and economic specialisation and functional linkages between EFUAs are foreseen.

The final item on the list of 38 variables is *Daily and/or potential accessibility*. While Connectivity is measured by variables reflecting capacity of terminals and outgoing flights and high-speed rail connections, accessibility reflects the possibilities of interaction with all destinations by all modes of transportation and over the complete European transportation networks. The accessibility assessment of European polycentrism by ESPON 1.1.1 will be carried out on the NUTS 3 spatial level, with disaggregation to the NUTS 5 spatial level for selected urban systems.

Draft Guidance Paper of ESPON 3.1

Another model for presenting results on polycentrism is offered by the three level typology of European urban systems envisaged in the Draft Guidance Paper prepared by ESPON 3.1:

- Macro level: distinction between core (the "pentagon"), periphery (EU-15 outside the "pentagon"), accession countries and neighbouring countries
- Meso level: distinction between metropolitan areas, urbanised areas and non-urban (rural) areas
- Micro level: distinction between metropoles, cities, towns and villages.

Each NUTS 5 region will be classified by its membership in the macro, meso and micro categories. There will be a transformation function from the NUTS 5 meso level into the NUTS 3 meso level, i.e. each NUTS 3 region will be assigned unambiguously to one meso level group, based on the characterisation of its NUTS 5 members. This means that each European NUTS 3 region will be characterised by its membership in one macro level group and one meso level group (12 types in total).

In ESPON 2.1.1. we will use the typologies and definitions that were developed in 1.1.1 and 3.1. In addition, we will develop an alternative approach, which is discussed in the next subsection.
It may be observed that the importance of measuring polycentrality directly is underlined by the fact that ESPON 1.1.1 regards regional GDP as one of the variables indicating the potential for polycentrality, whereas this variable may also be regarded as a variable that is determined partly by polycentrality.

4.2.2 Three Dimensions

The approach proposed here is to identify and measure polycentrism in a basic way by identifying three dimensions: *size*, *morphology* and *connectivity*:

- *Size*. The first and most straightforward prerequisite of polycentrality is that there is a distribution of large and small cities. It can be shown empirically and postulated normatively that the ideal rank-size distribution in a territory is loglinear. Rank-size distributions of cities in different European countries show that some countries have a predominantly monocentric city-size distribution (e.g. France), whereas other countries (e.g. Germany) have a historically grown polycentric urban system. A first step in analysing polycentrality of an urban system would therefore be to derive its population rank-size distribution. In addition other measures of city size and important may be used, such as economic activity, human capital, higher education, cultural importance, administrative status etc.

- *Morphology*. The second prerequisite of a polycentric urban system is that its centres of equal size or rank are equally spaced from each other – this prerequisite is derived from the optimal size of the catchment area or market area of centrally provided goods and services.

Therefore, a uniform distribution of cities across a territory is more appropriate for a polycentric urban system than a highly polarised one where all major cities are clustered in one part of the territory. A second step of analysing polycentrality would therefore be to analyse the distribution of air line distances between cities of equal size or rank.

- *Connectivity.* The most difficult to measure property of polycentric urban systems is their connectivity. Ideally, the analysis would reveal functional relationships between cities of equal size or rank and between cities of different size or rank in the urban hierarchy. Appropriate indicators of such interactions would be flows of goods or services, travel flows or immaterial kinds of interactions, such as telephone calls or e-mails. At the level of municipalities, information on such interactions is rarely available or considered an economic asset, as in the case of travel flow data held by private transport carriers or telecommunications data held by private telecommunications operators. Proxies to be used instead of such data could be infrastructure supply, i.e. the level of road connections (motorways, roads) or the level of service of rail (number of trains) or air (number of flights) connections. The third step of analysing polycentrality would therefore be to analyse the quality of transport connections between cities of equal size or rank and between cities of different size or rank in the urban hierarchy.

With these three partial indicators of polycentrality, size, morphology and connectivity, a comprehensive indicator of polycentrality can be constructed.

The proposed method would differ from normative approaches to polycentrality in which a system of central places in a country, e.g. taken from a national planning document, is taken as given.

Note also that in choosing this approach, measurement of polycentrality is separated from measurement of the target variables which it is supposed to influence, such as efficiency, sustainability and equity.

4.3 Polycentric Connectivity and Overloaded Corridors

This section proposes a *Spatial Impact Assessment* for the assessment of the results of ESDP measures on polycentric connectivity and overloaded corridors. This approach is based on concepts developed in Germany by the Federal Office for Building and Regional Planning together with the Federal Ministry of Transport, Building and Housing. It was designed and carried out to complement cost-benefit analysis methods.[22] This method has to be adapted and modified to the European scale and the ESDP provided that its approach turns out to be practicable. Most of the regional and network data required for carrying out this analysis especially for the polycentric development is covered by the other methods of territorial impact analysis. This is the case for road and rail network data, interregional time/cost matrices for different scenarios and typologies of regions.

[22] The method was developed originally in the review of the Federal Transport Infrastructure and Investment Plan of 1992 (BVWP ‘92). A brochure entitled "Federal Transport Infrastructure Plan 2003: Basic features of the macroeconomic evaluation methodology", can be downloaded as a PDF file from:
http://www.bmvbw.de/Bundesverkehrswegeplan-.806.13237/Federal-Transport-Infrastructure-Plan-2003-Basic...htm

The ESDP focuses on interregional connectivity at different levels. Hence, it is desirable to evaluate the impacts of TEN measures on the quality of connections between a prescribed set of centres within different levels of the hierarchy of central places. The first part of this section deals with *polycentric and balanced development* and urban-rural partnership. It sketches an approach to evaluation that makes use of a systematic and structured selection of abstract links that connect places within the polycentric hierarchical system of centres all over Europe. The second part deals with *overloaded transport corridors*.

4.3.1 Polycentric Connectivity

Two Aspects

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

- Polycentric accessibility. Based on the methodological approach developed in the review of the Federal Transport Infrastructure and Investment Plan of Germany two kind of abstract spatial priority links will be generated by following a recursive hub and spoke principle from the geographical position of settlements.
  The procedure will use the urban typology to be elaborated by project 1.1.1 of the ESPON framework. The hierarchical system of centres is mapped to different types of links with according specific levels of service. The whole set of links then will be classified by accessibility deficiencies regarding the appropriate standard levels of service of every link type.
- Structurally lagging regions. To emphasise the balanced polycentric development each priority link is also classified by the structural strength respectively backwardness of the two connected centres.

Other Indicators

Furthermore, it is intended to use an economic classification of the centres/regions based on a simple regional NUTS-level-3 ranking of a combined indicator (unemployment rate weighted by 60 percent, GDP per head weighted by 40 percent). From this data basis, that still has to be constructed, the class of the regions with most severe structural problems can be identified. For instance, it may be defined as the regions that have the lowest scores on this combined indicator with a total population that does not exceed one third of the ESPON-Space total population. Alternatively an indicator according to the criteria of the Structural Funds (regions covered by Objective 1 and Objective 2) and to dedicated typologies of other ESPON projects is also to be taken into account.

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

The resulting pattern of classified links provides the spatial priority evaluation framework of high priority links for TEN project evaluation in order to further a balanced polycentric development within the ESPON space.

Impact Analysis
At last the TEN projects are examined regarding their contribution to improve priority links. Whenever an improvement of accessibility is significant (by reduced travel times or higher beeline speeds), the weighted value of each improved relevant priority link directly can be assigned to the causing project based on the evaluation matrix.

Expected Results

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

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

Indicators, Typologies and Maps

All indicators and typologies will be illustrated in maps:

- input typology: applied urban/rural typology (referring to project 1.1.1/1.1.2)
- input indicator: combination of regional (NUTS-level-3) unemployment rate (weighted by 60 percent) and GDP per head (weighted by 40 percent) or similar indicator referring to other projects (e.g. Objective I regions typology, project 3.1)
- intermediate result regional (NUTS-level-3) typology: regional structural problems
- intermediate result typology: priority links by levels of service regarding type of connected centres and covered distance class
- intermediate result typology: priority links by accessibility deficiencies regarding the appropriate levels of service
- intermediate result typology: high priority links by accessibility deficiencies and assigned regional structural problems (as evaluation framework)
- result typology: TEN projects (respectively groups of TEN projects) by significance of expected effects on priority links
- result link typology: priority links by expected effects caused by the realisation of TEN projects (respectively groups of TEN projects)
- result regional typology: centres/regions gaining by expected effects caused by the realisation of TEN projects (respectively groups of TEN projects) on high priority links (in the sense of polycentric and balanced development)

4.3.2 Overloaded Transport Corridors

Regarding sustainable use of infrastructure in urbanized regions a special analysis of *overloaded transport corridors* is desirable too. The needs and sources for data and classifications are not yet completely evaluated within the ESPON framework, but a general sketch of the approach can be given.

In a first step regions and corridors that are highly overloaded with the burden of transport have to be identified and classified empirically at the regional level. Then TEN projects are examined regarding their expected contribution to unburden the concerned regions and corridors. The relocation of transport streams and possibly expected modal shifts from road to rail or waterways should be used as an additional indicator for the reduction of the transport burden. This can be justified by a more sustainable use of infrastructure and lower external costs for these modes.

Operationalization

For an adequate definition and selection of Overloaded Corridors at regional level beside highly congested urban areas two determining factors with strict focus on road transport should be taken into account:

- volume of road traffic (cars, trucks)
- road network density

The two factors have to be standardised and added together in form of an overall regional indicator.

Combined Evaluation Matrix

In this field, too, an evaluation matrix is to be built up, which combines and classifies the grade of overloading for selected regions and corridors with the expected extent of relief from traffic overload.

Impact Analysis

The evaluation benchmark for the TEN-project impact analysis is the extent to which they contribute to relief in highly congested corridors and regions by attracting traffic volume away from the roads. In general this can be achieved in two ways:

- modal shift to rail and waterway transport networks (high priority)
- large scale by-pass (low priority)

The analysis of overloaded transport corridors, however, has to be based on data of provided transport services and flows and on predictions, reassignments of flows resulting from TEN projects. This kind of data can not be calculated from the models used in the 2.1.1 consortium. Therefore this analysis has to rely on external work.

First results of a DG TREN study regarding “Scenarios, traffic forecasts and analysis of corridors on the Trans-European Transport Network”, are expected in June 2003. In its first phase, the study will produce traffic forecasts in 2020, including traffic assignment, estimation of international traffic load on the network and socio-economic and environmental impacts according to different scenarios.

4.4 Cohesion Measurement

Quantitative indicators of relevant concepts can be useful in policy evaluation. The present section gives a discussion of such an indicator that can be used to measure (spatial) inequality of a policy variable. Equality of certain key variables is often an important policy target, even though there are important differences. Some are in favor of equality of opportunity, others tend to stress equality of outcomes. Pronounced inequality threatens the cohesion of a society or a community and is therefore undesirable. In all cases, the measurement of equality is an important issue.

4.4.1 Two Approaches

In order to measure cohesion we make use of the economic literature on the measurement of inequality. In this literature two branches can be distinguished: one stresses the relation between social welfare and inequality, the other focuses on particular desirable aspects of inequality indicators and asks which indicators satisfy combinations these requirements. The latter is often referred to as the axiomatic approach to inequality measurement. After a brief introductory discussion of these two approaches, the proposed indicator is presented: it is the ratio between the arithmetic and geometric average of per capita income. Some of the properties of this indicator are discussed in the main text. A more formal derivation is given in the appendix. As an example inequality in per capita GDP in the European Union in the period 1995-2000 is measured. The welfare economic interpretation of inequality allows for an evaluation of the cost of inequality in monetary terms.

Welfare Functions

Social welfare is usually described by a function that links the welfare of individual agents (or of basic units such as regions) to that of a group (or a set of basic units, such as a country or the European community). For instance, if one regards average welfare as the main indicator for well-being in a community, this might be interpreted as saying that one's social welfare function *is* the average welfare of all members of that community. One specific aspect of this welfare function is that it does not pay attention to the way welfare is distributed over the basic units. Any given level of average welfare can be reached by (a) giving all regions the average level of welfare and (b) giving one region a very high level of welfare and all the others a very low level. (There are of course many intermediate possibilities as well.) Most of us would prefer the former distribution to the latter. This means that we do not only care about the average welfare, but also about its distribution. Hence the appropriate welfare function is not simply the average welfare level, but another function of the regional welfare levels that takes into account the distributional aspects.

Economist have tried to specify such alternative welfare functions. If we care about the way welfare is distributed over the regions, there is another aspect, apart from average welfare, that is relevant for our overall experience of welfare. That other aspect can be interpreted as a preference for equality of welfare levels. It has therefore been proposed (among others by Atkinson, 1970) that inequality indicators should correspond to and (ideally) be derived from a welfare function. A very general way of doing this would be to compare the social welfare level that would be reached if all regions had the same average welfare level with the one that is actually reached. In general, the social welfare level that corresponds with equally distributed average welfare is higher than the actual welfare level. The difference between the two welfare levels can be interpreted as the welfare cost of inequality. Every appropriate indicator of inequality is an indicator of the welfare cost associated with inequality.

Axiomatic Approach

Although the axiomatic approach to the measurement of inequality has a completely different starting point, difference with the welfare theoretic approach is not as large as it may appear to be at first sight. For instance, a well known axiom for inequality indicators is the so-called principle of transfers, which says that taking some welfare from a rich region and giving it to a poor one (while keeping the relative positions of the regions unchanged) should result in a decrease if the inequality indicator. This axiom can be interpreted as a reflection of a preference for equality, which is a property of a social welfare function.

However, it is true that some other reasonable axioms are not so easily linked to welfare functions. An example that is particularly relevant in the present context is that of (additive) decomposability. It holds that total inequality (for instance, in the European Union) must be the sum of inequalities in the groups in which the total can be split (for instance, the countries of the Union), plus a term referring to between-group inequality (for instance inequality between the countries of the European Union). For research with a spatial dimension this decomposability is an extremely convenient property.

4.4.2 The Proposed Indicator

The inequality indicator we propose is the ratio between the arithmetic and the geometric mean of the incomes of the inhabitants of the European Union. It is often convenient to take the logarithm of this ratio.

The geometric and arithmetic means are equal to each other if all incomes are equal, but in all other cases the geometric mean is smaller. This means that the ratio of both is larger than 1 whenever there is income inequality. The indicator can be shown to satisfy the principle of transfers, which is an intuitive property of an inequality indicator. It can be linked to a welfare function that is a member of the class for which Atkinson (1970) developed his celebrated inequality indicator. Indeed, the measure proposed here is a special case of this indicator. Moreover, the logarithm of the ratio is additively decomposable. This implies that for an arbitrary regional division of the European Union it is the weighted sum of inequalities within regions and a term referring to inequality between regions.

Comparison with other Indicators

Only a few indicators satisfy the requirements for decomposability, which is crucial for the purposes of the present study. For instance, the Gini-coefficient does not satisfy this requirement. The best known inequality indicator satisfying the decomposability requirement is probably Theil's inequality index. One advantage of the alternative function proposed here is that it is easier to interpret from a welfare economic point of view, whereas it has the similar decomposability properties as Theil's index. For instance, Theil's index cannot be interpreted as a special case of Atkinson's inequality index. Another indicator that is decomposable is coefficient of variation. However, this indicator does not satisfy the principle of transfers, which makes it less attractive.

4.4.3 An illustrative Application

We apply our inequality index to per capita GDP in the European Union. We have data on the NUTS3 level for the years 1995-2000.[23]
Ideally, one would like to measure inequality from the most basic level, that of individuals. However, the data do not allow us to do this. Due to the decomposability properties of the indicator, we can regard total inequality in Europe as the sum of inequality between the average per capita GDP's of countries, plus the inequality between the average per capita GDP's between regions in these countries, plus the inequality in the per capita GDP's within regions. We miss the latter term, and our computations will therefore measure only a part of total inequality. In Table 1 we present the result of our computations. The figures shown there are the logarithms of the ratio of the arithmetic and geometric mean. This logarithm is approximately equal to the percentage difference between the two means. In all computations we used population size of the year 2000, since data for the other years were not available.

It is clear from the Table that inequality is relatively stable over time. In one country there is a downward trend (Austria), in some other countries an upward trend (Germany, Sweden), but the ranking of the countries within the Union does not change much. Larger countries tend to have more inequality than small countries. Luxembourg is a single NUTS3 region, so for this country no inequality could be measured. Sweden has a very low level of inequality, but differences in per capita GDP are increasing. The well-known division between South and North in Italy does not lead to an exceptional high inequality score. Regional differences in Belgium, Germany, France, Portugal and the United Kingdom appear to be even larger than in Italy. Inequality in the European Union as a whole is a population weighted average of the within country inequalities, plus a term referring to inequality between countries. The latter is only a small part of the total inequality.

It was noted above that the inequality indicator used here has a welfare economic interpretation. This interpretation requires that income (or, in this case, GDP) is regarded as a valid measure of money metric utility. At the individual level this requires adjustment for differences in needs associated with the number (and age) of the persons in the household. Moreover, in as far as utility is also determined by non-monetary goods (such as the availability of social security, subsidized public transport, easy access to health care, et

[23] Data for East and West Berlin (Germany) are lacking. The figures for Germany refer to the rest of the country only.

cetera), this should in principle also be taken into account. Such refinements are not easy to carry out, and we confine ourselves here to an analysis of the inequality in per capita GDP.

Table 4.1 Inequality in per Capita GDP in the European Union

	1995	1996	1997	1998	1999	2000
Austria	0.046	0.044	0.043	0.041	0.041	0.040
Belgium	0.061	0.064	0.064	0.065	0.065	0.065
Germany	0.075	0.075	0.075	0.078	0.079	0.082
Denmark	0.032	0.029	0.029	0.027	0.027	0.030
Spain	0.025	0.025	0.026	0.027	0.027	0.027
Finland	0.022	0.025	0.023	0.029	0.031	0.032
France	0.055	0.057	0.057	0.056	0.056	0.057
Greece	0.025	0.027	0.024	0.024	0.022	0.022
Ireland	0.022	0.022	0.026	0.032	0.030	0.030
Italy	0.047	0.048	0.046	0.046	0.046	0.046
Luxembourg	0.000	0.000	0.000	0.000	0.000	0.000
Netherlands	0.019	0.021	0.021	0.022	0.022	0.022
Portugal	0.062	0.066	0.058	0.062	0.063	0.063
Sweden	0.007	0.007	0.010	0.011	0.013	0.013
United Kingdom	0.058	0.057	0.059	0.062	0.060	0.060
Between countries	0.009	0.008	0.007	0.008	0.007	0.007
Europe	0.060	0.059	0.059	0.060	0.059	0.060

Table 4.2 Welfare Cost of Inequality in Euro's per Capita

	1995	1996	1997	1998	1999	2000
Austria	871	894	898	887	935	1008
Belgium	1178	1270	1350	1415	1422	1523
Germany	1399	1437	1518	1612	1725	1894
Denmark	650	634	673	642	673	809
Spain	336	358	396	423	458	484
Finland	379	448	441	585	647	750
France	997	1036	1072	1092	1156	1263
Greece	286	326	298	316	318	330
Ireland	366	371	511	679	692	764
Italy	849	902	893	950	982	1053
Luxemburg	-	-	-	-	-	-
Netherlands	367	418	456	501	528	552
Portugal	753	836	816	894	942	1007
Sweden	117	140	201	232	274	301
United Kingdom	958	1025	1138	1256	1251	1317
Between countries	152	144	145	154	140	156
Europe	1019	1058	1107	1181	1217	1321

We can interpret the geometric mean as the equally distributed per capita GDP that would give a welfare level that is identical to the present level of social welfare. The difference between this hypothetical equally distributed per capita GDP and actual (arithmetic) average GDP can therefore be interpreted as the ‘cost’ of inequality measured in terms of welfare. The percentage difference between the geometric and the arithmetic means, as indicated in Table 1, indicates this cost. The difference between the two means can also be expressed in Euros, and since average GDP differs among the countries in Europe, this gives some additional information. The relevant figures are presented in Table 2. It shows, for instance, that despite the decreasing trend in inequality in Austria, the monetary costs of inequality are rising.
The reason is the growth in Austrian GDP, which makes a smaller percentage correspond to a larger number. The cost of inequality is increasing in every country.

The last two lines of the Table show that the cost of inequality are also increasing for Europe as a whole, but confirm the result of Table that the inequality between countries is only a small part of total inequality. Figures like those presented in Table 2 could be used in cost benefit analysis (for instance, of transport improvements) in order to evaluate expected effects on regional inequality.

4.4.4 Conclusion

The use of the inequality measure proposed here is not confined to income (or closely related measures) although in other applications the welfare economic interpretation is not available. The indicator can also be used to measure inequality in unemployment rates, accessibility, population density, et cetera. Note also that the decomposability property of the indicator can be used for arbitrary regional divisions. One may, for instance, apply it to decompose total inequality into inequality between and within classes corresponding to a particular typology of regions or into inequality between and within overloaded transport corridors and other geographical units.

In previous sections much attention has been paid to polycentrality. This concept may be related to a kind of limited equality. A hierarchy of central places can presumably be associated with equality of all cities/regions of the same level and inequality between the levels. The inequality is limited since because of the hierarchy of central places and the optimality of catchment areas which prevents unlimited concentration of activities at a single location. At the same time, the inequality is useful as it is a relation to an efficient spatial distribution of economic activities. If here would be complete equality in the distribution of economic activities, the total amount of these activities would probably be smaller. This means that there is a trade-off between equality (as measured, for instance, as the ration between the arithmetic and geometric means) and efficiency (as measured, for instance, as the value of the arithmetic mean). The usefulness of the indicator proposed here for such trade-offs will be discussed in the next section.

Note that polycentrality does not necessarily imply that there is inequality in *all* relevant variables. For instance, it is possible that people living in central places of a different level have similar levels of well being or income. Living in large cities may have attractive features (more amenities, better accessibility) that are compensated by disadvantages (high house prices, congestion). The variables determining well being may therefore be unequally distributed, while well being itself is equal everywhere.

4.5 Efficiency vs. Equity

Two of the underlying objectives of the European Spatial Development Perspective (ESPD) are:

- a more balanced competitiveness of the European territory, and
- economic and social cohesion.

The aim for polycentric and balanced spatial development is related to both efficiency and equity criteria. It can be seen as an aim to reconcile potential conflicts between European competitiveness and territorial cohesion. The third underlying objective extends this aim for reconciliation to environmental development.

While the analysis of the impacts of transport and TEN policies on polycentric development focuses on the balancing of spatial structures and/or urban systems, it is the aim of this Section to explicitly study potential trade-offs between the aims for efficiency (competitiveness) and equity (cohesion).

4.5.1 Other Studies

In the FIR of ESPON 2.1.1 the following types of trade-offs were outlined:

- trade-offs between territorial indicators for any particular region or set of regions: each policy scenario will result in forecasts of e.g. income and employment for the region(s) in question. The outcome for all policy scenarios can be reported in a table. The values of any combination of two territorial indicators for all policy scenarios can be plotted in a diagram for assessing potential trade-offs.
- trade-offs between efficiency and equity: each policy scenario will result in forecasts of economic development measured in GDP, equivalent variation or labour market conditions. These results may be aggregated to European totals (or averages) reflecting efficiency. The disparities in economic development between regions will be measured in terms of the cohesion indicators developed in Section 4.4. The values of the efficiency and equity indicators for each one of all the policy scenarios can be displayed in a table or plotted in a diagram.

One example of a similar analysis is Figure 1 of ESDP (1999, p 9) which illustrates regional (NUTS 2) disparities in GDP per capita (pps) for EU member states in 1996. The figure indicates that countries with average income above the European average tend to exhibit greater regional disparities than countries with average income below the European average. Hence, one gets the impression that there exists a trade-off between efficiency and equity at the national level.

In our case we will focus on impacts of transport and TEN policy scenarios on efficiency and equity indicators and analyses of trade-offs at the European level. A potentially useful measure that can be used in addition to those mentioned in the present subsection is discussed below.

4.5.2 Inequality and Efficiency

In the previous section of this chapter an inequality indicator was proposed to measure cohesion. This inequality indicator is the ratio between the arithmetic and the geometric mean of the relevant variable. The arithmetic average of an indicator can often be interpreted as an indicator of efficiency. For instance, the level of unemployment in the European Union can be measured as the average unemployment rate in the whole European Union, whereas the regional variation in this variable can be measured by means of the ratio between the average unemployment rate and the geometric average of the regional unemployment rates. Efficiency and equity can, in this way, be related to each other. The figures may also suggest that the goals of a low average unemployment rate and low inequality in the regional rates are, to some extent, incompatible: more equality in European regional unemployment rates can only be achieved at the cost of a higher average unemployment rate. In such a situation policy makers face a trade-off between efficiency and equity. Since the inequality measure proposed in the previous section is closely linked to the arithmetic mean, which can often be regarded as a measure of efficiency, it seems useful also for the purpose of considering this type of questions.

This link between equality and efficiency can be made more explicit if the analysis refers to income, since in that case the geometric mean can be interpreted as a welfare function. Social welfare can then be decomposed into a measure of efficiency (average income) and equity (the inequality indicator).[24] The trade-off between equity in efficiency is in this case determined by the social welfare function: it is the cost of inequality as presented in Table 2 above.

An earlier study of infrastructure investments in the Swedish context (Anderstig and Mattsson (1989)) showed a weak conflict between efficiency and equity criteria. However, the optimal distribution of investments over infrastructure types and regions differed substantially. Optimisation of the equity criterion led to more R&D investments at the expense of airport investments, which dominated when the efficiency criterion was optimised. The study indicates that infrastructure investments in general and synergies between transportation and R&D policies might be used in regional policy without major sacrifices in terms of efficiency.

4.6 Conclusion

The previous sections have sketched a rough outline of a of an assessment procedure for the forecasting results. In this concluding section some attention is paid to the inputs needed and the results to be expected.

[24] See Atkinson (1970).

4.6.1 Data Inputs from Forecasting Models

The forecasting models of Chapter 3 will produce the basic information needed for the assessment procedure (such as changes in population, output, productivity and accessibility). These models themselves also use information that is also needed for the assessment procedure: such as indicators of connectivity (terminals (air, rail, sea), flight connections, high-speed rail connections) and competitiveness (educational attainment). This information can be used in all elements of the assessment procedure.
For some relevant variables information from other sources will be needed. For instance, the models or the database for the forecasting models presented in the FIR of ESPON 2.1.1 do not contain any information on the location of decision-making centres or on the level of R&D activities, a variable that is useful for measuring polycentrality (the functional dimension, competitiveness). The preliminary data requirements of ESPON 2.1.1 were summarised in Table 4.2 of the FIR. However, data on R&D investments are to be used in an indicator of regional innovative capacity in the ICT impact assessment model (see Section 3.3).

4.6.2 Expected results

The assessment procedure will produce results on the spatial effects of the policies examined. These results will be presented in the form of maps, tables and diagrams.
For instance, by exploring the methods outlined in Section 4.2 the potential for polycentric development can be assessed. The expected results will be performance of NUTS 3 regions according to the proposed indicators.
The performance of NUTS 3 regions according to the criteria used can be used to find an endogenous typology of regions in a similar way as was done in the CPMR study (see Section 4.2.1). Alternatively, the results for the NUTS 3 regions can be used to study how the various region types (e.g. urbanised areas in the “pentagon” or metropolitan areas in the periphery) perform according to, for instance, the quantitative indicators of potential for polycentric development.
Moreover, maps showing the performance of NUTS 3 regions according to single indicators, such as accessibility, may be an important tool in assessing the potential for polycentric development.
Similar remarks can be made with respect to spatial impact analysis, cohesion and the equity-efficiency trade-off.

4.6.3 Conclusion: Hypotheses about the Territorial Impact of EU TEN Policies

The outcomes of the assessment procedure should be that insight into the territorial impact of EU TEN policies increases. In this concluding section a number of issues on which light may be shed are discussed.

First of all, it seems useful to put the TEN EU policies in the broader perspective of economic development in the EU. Some hypotheses that appear to be plausible in the light of previous research are:

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

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

- In studies of daily accessibility of European cities, Erlandsson (1991) noted that, in a relative sense, 42 cities (out of 98) had lower outbound visit-time based accessibility 1988 compared to 1976. 33 of these also had a lower absolute level of outbound accessibility. A more positive picture is achieved if a contact-based outbound accessibility indicator is used. The network of most frequent air connections has been fairly stable between 1970 and 1978. The "pentagon" of most accessible European centres could easily be discovered at an early stage. The asymmetries of outbound and inbound accessibilities for peripheral locations (alluded to in Section 4.2.4) may therefore be an important barrier to location of headquarter functions. Road and rail investments are not very important for the European pattern of face-to-face accessibility, but they can be important for linking regional centres to European centres on a sub-European scale and for reducing congestion and increasing the efficiency of transport and hence increasing the efficiency of production.

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

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

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

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

- In the introduction to this chapter it was noticed that the effects on polycentric development that can be expected of transport and TEN policies may depend on the specific combinations of pricing and network components. Marginal cost pricing will mainly affect regions with high congestion, i.e. the congested corridors in the core region and some metropolitan areas in the periphery. The costs will increase but on the other hand transport times will be reduced. In metropolitan areas, the cost component tends to dominate for private person trips, while for business trips and freight transport the direct efficiency gain may exceed the direct cost increase. The distribution of impacts is to a large extent dependent on the indirect effects related to how the collected charges are to be used.

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

- TEN measures may support a polycentric and balanced spatial development.

- 8 of the 14 priority projects of the TEN are located in peripheral regions while 6 are mainly located in the “pentagon”. In general, the impact of transport investments on economic development can be expected to be larger in regions with less developed networks than in regions with dense and well developed networks. In well developed networks, extensive investment programmes may be required to substantially change the accessibility pattern. In urban areas radial transport investments tend to have decentralising impacts on location. This may also be the case in larger regional contexts. However, the overall impact of transport investments will depend on the competitiveness of the regional economies: a peripheral area may benefit from better market access but its production may, on the other hand, be subject to a higher degree of competition from imports.

- An earlier study of infrastructure investments in the Swedish context (Anderstig and Mattsson, 1989) showed a weak conflict between efficiency and equity criteria. However, the optimal distribution of investments over infrastructure types and regions differed substantially. Optimisation of the equity criterion led to more R&D investments at the expense of airport investments which dominated when the efficiency criterion was optimised. The study suggests that infrastructure investments in general and synergies between transportation and R&D policies might be used in regional policy without major sacrifices in terms of efficiency.

5. Recommendations on Relevant Sector Policies

5.1 Introduction

In the 1st Interim Report we detailed the various key transport and transport TEN policy measures and considered a first approach to the other policy areas which interact with these in order to provide a basis for understanding the *horizontal co-ordination* between policies. The principal policy areas which were identified in that Report were transport policy itself; regional, structural and cohesion policies; environmental policies; Common Agricultural Policy; internal market, competition and stability and growth policies; and the European Spatial Development Policy. In this report we add consideration of relevant energy and ICT policies and provide a first outline of the analytical framework for future analysis of these interactions, including the key relationship with polycentric development.

5.2 Transport Policy

Transport policy in the EU has two main objectives: to ensure efficient operation and development of the transport sector; and to ensure that transport contributes to the completion of the single market. The 2001 White Paper on European Transport Policy recognised the extent to which the period since the previous White Paper (1992) has seen a considerable opening up of European transport markets, even if these remain more distorted than would be ideal. Unbalanced growth has occurred in the different modes, most notably in the freight transport sector, resulting in excessive congestion and problems of environmental pollution. The 1992 White Paper focussed on infrastructure development as a solution to the problem, a position reaffirmed by the 1993 White Paper on Growth, Competitiveness and Employment which reinforced the role of TENs as a means of securing both increased competitiveness and greater cohesion.

Increasingly during the 1990s it was recognised that, although there were substantial infrastructure needs within the EU, and even more so in the candidate countries, simply building new infrastructure was not always the best solution. In many cases new building would not be practical. In other cases new building may fail to address the real needs and solve the specific problem, be that one of accessibility or of excessive congestion. Thus emphasis shifted towards a parallel policy of ensuring a consistent charging framework for the use of transport infrastructure. The effect of charging would be to ensure a more efficient use of existing infrastructure, and thus potentially to reduce the effective cost to essential users. This has important implications both for the measurement of effective accessibility on the network and thus for interactions with policies dealing with location and regional development.

The 2001 White Paper has three main themes of relevance to an evaluation of the TENs:

- Shifting the balance between modes
  - road quality, rail integration and modernisation, air traffic growth, waterways integration, intermodalility
  - regulation vs competition, increased efficiency may lead to further growth
- Eliminating bottlenecks
  - corridor investments, priority links, but problems with finance

- Placing users at the heart of policy
  - safety, charging and taxes
  - pricing, investment and subsidiarity

Thus regulation, investment and pricing are all seen as playing a role and hence the impact of each has to be evaluated. There remain, however, key questions relating to the role of mobility in the current transport policy. The policy aims for sustainable mobility, but also sees mobility as, to some extent, a right which is considered as a key indicator of welfare, particularly in lagging regions.

Relevance for Indicators:

The main relevance for indicators is in terms of identifying the way in which the transport projects in question meets policy needs. In practice this is to identify whether a particular project is primarily addressed toward modal shift, bottleneck elimination or increasing the efficiency of use.

5.3 Regional and Cohesion Policies

ERDF expenditures were historically heavily directed towards infrastructure and although the proportion of the Structural and Cohesion Funds devoted to infrastructure has fallen, the increase in the size of the Funds still leaves a large volume of expenditure on infrastructure. There is a clear message that transport, and transport infrastructure in particular, is seen as a major contributor to the Commission's cohesion policy. It is important that this link is clearly identified. However, there is also the link in the reverse direction. Structural Fund expenditures which are effective in changing the economic position of regions will have an impact on the demand for transport and hence the use of the transport networks, both in that region and in other regions.

A particularly important distinction is that to be made between expenditure devoted to improving the internal infrastructure of assisted regions and that to inter-regional infrastructures such as the TENs. The latter requires us to look carefully at the distribution of benefits between regions, including regions geographically remote from the infrastructure. The former is more likely to have a direct positive impact on the productivity of regional enterprises and regional competitiveness. Productivity improvements have been seen to have a greater impact on cohesion than infrastructure and accessibility improvements alone.

Current Structural Fund expenditures are heavily weighted towards assistance to Objective 1 regions, those with GDP/capita below 75% of the EU average, both in terms of the total expenditure and the contribution which can be made towards any particular project. Evidence on the effectiveness of Structural Fund expenditure in raising income levels is mixed This reaffirms the need to examine projects carefully on an individual basis. Whereas it could be argued that the regional implications of transport projects have often not been thoroughly evaluated, it is also clear that a basic assumption has often been made that transport infrastructure investment is good for a region and the wider implications, both for the transport sector and for the transport using sector, have not been thoroughly evaluated. This is a critical link between policy areas.

The future enlargement of the EU poses major questions for the Structural Funds and their operation after 2006. The two main questions of relevance here are the future geographical distribution of funds, and how this relates to the future development of the network, and any changes in the basis for funding which would change the nature of eligible projects.

Relevance for Indicators:

The primary distinction here is one of identifying whether projects are located in, or directly affect designated assisted regions, and which Structural Fund Objective. Ideally a rather wider definition of the geographical area affected by a project needs to be taken in order to ensure that the genuine net effect is identified.

5.4 Environmental Policy

There is a strong direct relationship between environmental policy and transport policy embodied in the drive towards sustainability in transport policy. Transport has a relationship with all four priority areas in the Sixth Environment Action Programme:

- climate change;
- nature and biodiversity;
- environment and health;
- natural resources and waste.

Developments of the TENs have a direct environmental impact through their impacts on mobility, which affect both climate change and local environmental health. Although this is a largely negative impact, the potential diversion of traffic from modes with greater environmental damage to those which are more environmentally friendly is an important objective of transport policy. However, at the same time increasing technological advances to address direct environmental pollution issues may be leading to greater efficiency which lowers costs and increases mobility, creating other types of environmental pressure such as the demand for more infrastructure.

Environmental constraints on industry can also have important transport implications through affecting the location of economic activity and through policies on waste disposal which can be transport creating. New infrastructure has an immediate effect on natural habitats. The Action Programme identifies the need for environmental concerns to be integrated into all EU policies and for existing legislation to be implemented. Information is important in ensuring that individuals, firms and other organisations take consistent decisions with regard to the environment and that appropriate incentive structures exist to encourage this.

Land use and planning decisions are seen as having a key link with environmental policy; both of these interact with transport policy. The key link between policy areas is ensuring both the right information and the appropriate signals and incentives to ensure consistent decision making. Proper environmental evaluation has a direct link with policies on charging for the use of infrastructure; full implementation of the Action Programme has major implications for the effective cost of using infrastructure, on the balance of costs between different modes and on the benefits of greater emphasis on intermodality.

Relevance for indicators:

The contribution to environmental policy is a critical aspect of transport network developments. Environmental impact analysis is already a requirement of transport investments, here we need a basic indication of the specific contribution to the goals of the Action Programme.

5.5 Common Agricultural Policy

As one of the EU's major policy areas, CAP has a major potential impact on transport. CAP support policies maintain agricultural production in regions where they would not survive in a free market and lead to EU domestic production being relatively greater (and imports relatively smaller) than they would be in the absence of support. In the reverse direction, the improvement of transport links to remote regions can change the relative competitiveness of their agricultural production as well as reducing the dependence of these regions on agriculture.

There are modal implications as well: for non-perishable goods the improvement of links such as short sea shipping can have positive benefits for agricultural markets; for perishable goods the improvement of high-speed rail and road networks can led to lower prices and enlarged markets. As well as price support policies, guidance measures under the CAP as part of the Structural Funds have an important impact on the development of rural communities for which accessibility and choice in transport remain major areas of concern. The reform of CAP implies the strengthening of agricultural production in some regions but also the restructuring in others.

The emphasis on increasing market orientation in the farming sector requires that inputs to the sector should also be priced in a way which reflects costs to avoid further distortion, and this includes transport. The benefits from improved transport can be reduced where these can be lost in subsidised transport-using sectors.

The extension of the CAP regime to the candidate countries could imply a long-term realignment of markets with important transport consequences.

Relevance for Indicators:

The importance of CAP as a policy area in the EU requires that regions which have a significant agricultural (or rural) sector need to receive special consideration. This can easily be achieved through an indicator of sectoral structure of each region, although ideally we should define this more precisely according to the nature of the agricultural activity in the region.

5.6 Internal Market and Competition Policies

It is already clear that the substantial growth in freight tonne-km in the EU over the past decade is related to the process of integration in markets following the completion of the

Single Market. Cross-border manufacturing trade continues to grow faster than GDP. The pressure to seek scale economies and thus concentration of activities, the search for new markets and sources of supply, and the move towards integration within sectors all lead to an increased demand for transport. Thus the linkages within and between industries are a significant determinant of industries' transport needs.

At the same time the changing structure of the EU's industrial base, including the increasing emphasis on the tertiary sector, has changed the nature of that demand for transport, largely reducing the overall significance of transport costs in total costs, but increasing the need for faster and, above all, reliable transport. Thus the emphasis has switched from simply providing a given capacity of transport, to ensuring that the quality of the service offered by that capacity meets the increasingly demanding needs of industry and commerce.

The extent of integration which has been achieved within the EU's internal market is a reflection of the integration which has been achieved within the transport sector, but as the recent Transport White Paper identifies, there is still much to be done, not least in removing the many remaining barriers to full integration of the transport sector itself, both within and between modes. The transport sector has an important role to play in the process of reform to ensure a more competitive European economy and promote economic growth.

The Broad Economic Policy Guidelines sit centrally in the economic reform process, providing a key linkage between the core centrally determined policy areas such as monetary policy and the exchange rate and the more decentralised policies on labour market reform, product and capital markets etc. following the Cardiff, Luxembourg and Cologne processes. Essentially this provides a framework for dialogue leading to the setting of strategies. Transport is not specifically mentioned as part of this process, but implicitly is clearly both affected by more efficient labour and product markets which might lead to further integration and has its part to play in securing such greater efficiency. Above all, as a sector in which labour costs are a substantial share of total costs, improvements in labour market flexibility and efficiency will have an impact on the organisation and effectiveness of the transport sector.

The advantage of the procedure established under the Cardiff Process is that it is designed to bring out issues in the development of markets in the member states which can provide the basis for future planning as brought out both by the BEPG and the Economic Policy Committees in their work on individual member states proposals. This transparency will be advantageous in identifying where future transport needs may arise.

Relevance for indicators:

It is more difficult to determine a direct link into an easily usable indicator for this area of policy. What we need ideally is a set of indicators which link the transport usage of individual sectors so that the progress of economic integration and reform can be built in. Further work is needed on trying to map the best way of dealing with this important linkage.

5.7 Stability and Growth Policies

As well as the process of economic reform embodied in the Cardiff Process the overall growth of the EU economy is an important driver of transport demand. The efficiency of the transport system contributes to the elimination of bottlenecks which help to improve overall growth potential and reduce differential inflationary pressures. Conversely the need to maintain control of public expenditure in order to meet the limits set by the Stability and Growth Pact limits the rate of improvement of transport infrastructure unless private investment can fill the gap.

Relevance for Indicators:

Evidence of the position of different member states within the SGP can give an indication of the likelihood of being able to undertake major infrastructure schemes, and in some cases where these may have the effect of removing bottlenecks which could cause problems within the constraints of the SGP.

5.8 European Spatial Development Plan (ESDP).

Cutting across many of the policy areas identified above is the ESDP. The three guidelines of the ESDP are significant in understanding the relationship between transport and other policy areas:

- polycentric spatial development and a new urban-rural relationship;
- parity of access to infrastructure;
- wise management of the natural and cultural heritage.

The core first guideline illustrates the tension between the competitiveness and cohesion objectives of the EU and how this requires a careful balance between policies which strengthen the infrastructure of individual city regions and those which develop the links between them.

The ESDP parallels the broad objective of increasing cohesion, but places it in the context of a specific spatial structure in which there is an aim for polycentric development rather than increasing concentration. However, increasing concentration has been the logic of the competitiveness objective in securing scale economies and greater efficiency and there is increasing evidence of this process dominating. The question is thus how to interpret polycentric development. Is it a force which is supposed to operate all over the EU and at all spatial levels: a polycentric EU of polycentric nation states comprising polycentric regions? Or is it consistent with this approach to see increasing centralisation within regions in order that they can be competitive but ensure a degree of polycentrism at national and EU levels? The appropriate transport infrastructure, and policies to achieve this would be very different.

We develop this a little further in section 5.12 below.

5.9 Energy Policy

The guidelines for the Trans-European Energy Networks as adopted in 1997 provide for the development of the main transportation networks for electricity (high voltage lines, submarine links and protection monitoring and control systems) and natural gas (high pressure pipelines, underground storage, reception, storage and regasification for liquefied natural gas and protection monitoring and control. In neither case does it include distribution networks. The key objectives resemble those for the transport TENS: to ensure efficient operation of internal market and to strengthen cohesion by reducing the isolation of less-favoured regions, as well as reinforcing the security of supply. This includes the connection to third countries in the Baltic, Eastern Europe, Baltic and Mediterranean. Particular attention is given to reducing obstacles to co-operation between member states (and third countries) and private operators within them.

In 2001 the Commission reported on the implementation of the guidelines (European Commission, Report from the Commission on the Implementation of the guidelines for Trans-European Energy Networks in the period 1996-2001, Brussels 14.12.2001). Ninety projects of common interest had been identified of which 36 were either in operation or under construction. These included the 10 priority projects of the Essen list (of which 7 had made decisive progress by 2001) and 30 projects involving third countries. Some €122.8 million had been allocated by the Commission to the Energy TENs in the period 1995-2001. In the light of this the Commission recommended introducing a list of priority projects; redefining priorities to support liberalisation of energy markets, reinforcing supply, the integration of energy from renewable sources, and to consider enlargement and the protection of peripheral and ultra-peripheral regions.

The basic interaction with other EU policy areas is essentially as for transport, as reported in the 1st Interim Report. Like transport, energy is a key input and securing supplies and ensuring that these are available at reasonable prices is critical to the operation of a range of other policies concerned with the completion of the single market, growth and stability and particularly regional development and cohesion. However, whilst we can identify clearly the impact which a given transport improvement can have on the direct costs of users, it is much more difficult to do this in the case of improvements to the energy TENS. Energy users do not use the networks directly and hence do not perceive the equivalent of accessibility improvements. Furthermore, they depend on local distributors who are not typically the operators of the high-level networks.

5.10 ICT Policies

There is only one area of ICT policy which is specifically part of the TENs, the Galileo project. Galileo is, however, in many respects seen as a transport policy and features prominently in the Transport *White Paper* since the GPS capability which Galileo will provide will have a significant impact on the efficiency of transport provision and the costs of transport users, as well as providing the technology to allow for the implementation of measures to help tackle congestion and enable efficient user charges.

However, general policies towards the wider adoption of ICT do have significance and impact in a similar ways to transport and energy TEN policies. Thus the *e*Europe 2002 Action Plan was launched in 2000 as part of the Lisbon process of improving the EU's economic, social and environmental renewal. The Action Plan identified 11 action areas and 64 targets. These cover internet connectivity for households, business and schools; competition to reduce prices, and especially with respect to the introduction of broadband; the development of fast research networks; providing the necessary legislative framework for electronic communication networks and services; and stimulating the use of the internet across all aspects of business, commerce, education, government and social life. The Final Report on *e*Europe 2002 (European Commission) claims that most of the 64 targets have been achieved with more than 90% of schools and businesses online and more than 50% of citizens are regular users. The fast research network GEANT has been a great success, but the remaining challenge is to ensure the take-up of fact access by households and small businesses. The wide availability of broadband access is a main objective of *e*Europe 2005.

For our purposes the improvement of basic ICT networks has a similar impact to the Energy TENs, since for most people it is the indirect impact which affects their costs. However, it is clear that there are substantial national variations in internet penetration which depend on both the market for internet provisions in each member state, but also on the availability of the relevant hardware networks. Five member states (France, Italy, Portugal, Spain and Greece) have household internet penetration less than the EU average of 42.6% (in the case of Greece it is as low as 14%) whilst in the Netherlands, Denmark and Sweden it is 66% or above. Some €10 billion of the Structural Funds is being spent to improve infrastructure development and the EIB has approved some €14.4 billion of loans. It is recognised that widespread, efficient and cost-effective access to the internet is essential to ensure the wider deployment of e-commerce and e-government which could have significant impacts on transport in the longer term. This need not necessarily be as a substitute for transport, since much e-business is transport creating, but it can be part of the process of ensuring a more efficient use of the transport network.

5.11 Towards an Analytical Framework

What we require is a framework within which we can make some assessment of the interactions between policy areas and the potential impact which the implementation of transport and TEN polices can have on different policy areas of the EU, especially those concerned with the spatial development of the EDU territory.

Table 5.1 represents our first look at this in terms of a table which identifies the opportunities (indicated by +, ++ or +++ according to the possible strength of the positive opportunity) and the risks (indicated similarly by -, -- or ---) which are implied for each policy area by the implementation of the various transport and TEN policies. It should be stressed that this is an initial subjective view based on our first analysis of the policy interactions. A fuller analysis will require inputs from the modelling analysis to demonstrate the nature of the spatial impacts.

A particular concern is the interaction of the policies with the ESDP and hence we can use the same structure to analyse the interactions with the various objectives of the ESDP (Table 5.2)

The next stage is to consider ways of applying a similar framework to the vertical conflicts likely to be present in these policies, but this will need to be implemented in the context of specific policies due to the considerable variations in detail.

5.12 Institutional Structures and Polycentric Development

We have considered particularly the way in which institutional structures interrelate with the desire to achieve polycentric development. In a previous study (*Spatial Impacts of Community Policies and Costs of Non-Co-ordination*, by Agence Européenne "Territories and Synergies", EURE-CONSULT S.A., Nederlands Economisch Instituut, Quaternaire Portugal for DG Regio, 2001) a range of Community policies have been assessed for their impact on spatial development in terms of the spatial distribution of expenditures using Lorenz curves. One of the problems with transport expenditures, and TEN developments in particular, is that the spatial incidence of expenditure does not necessarily imply the actual spatial impact in terms of economic and social development. This presents a problem in understanding the impacts of such policies since there is no simple analysis based on inputs, but rather we need a modelling approach which estimates the likely effects of policy measures. *Ex post* analyses of previous policy implementations, given the time period for the effects to take place, run into the problem of being able to disentangle the impact of one specific policy measure from a range of other influences.

The extent of polycentric development may, in many cases, be determined not directly by the policy measure, but by the extent to which the policy interacts with other characteristics of economic and social structure. In different circumstances the same policy measure may lead to increased centralisation or increased decentralisation and greater polycentricity. In pure economic terms this interaction will be with such features as the degree of imperfect competition and rent seeking behaviour by firms, the extent of scale economies and market size. In institutional terms it introduces the need to recognise that similar market characteristics affect the agencies responsible for formulating policy and introducing accompanying measures. Thus different sizes of local government authority will have different powers to be able to rent-seek on behalf of their own residents. Competition, both horizontal and vertical, between authorities, may determine the final outcome of the distribution of impacts.

In the next stage of the study we shall be investigating the ways in which this competition between different levels of government and different authorities at the same level of government will affect the spatial distribution of policy impacts.

Table 5.1 Framework for Horizontal Policy Analysis

Opportunities / Risks	Transport Policy	Regional, Structural and Cohesion Policies	Environmental Policies	Common Agricultural Policy	Internal Market and Competition Policies	Stability and Growth Policies	European Spatial Development Perspectives
Implementing White Paper on Transport Policy	+++ ---	++ --	+++ --	++ --	++ -	+ -	+++ ---
Implementing Transport TENs	++ --	+++ ---	+++ ---	+ -	++ -	+ -	+++ ---
Implementing Energy TENS	+ -	++ --	+++ --	+ -	++ -	+ -	++ --
Implementing GALILEO	+++ --	++ --	++ -	+ -	+ -	+ -	++ --
Implementing ICT guidelines	++ -	+++ --	++ --	+ -	++ -	+ -	++ --

Table 5.2 Framework for Detailed Analysis of ESDP

Opportunities / Risks	Polycentric Spatial Development	Urban-Rural Relationship	Parity of Access to Infrastructure
Implementing White Paper on Transport Policy	+++ ---	+++ ---	+++ ---
Implementing Transport TENs	+++ ---	++ --	++ --
Implementing Energy TENS	+++ --	++ --	++ --
Implementing GALILEO	+++ --	++ --	+++ -
Implementing ICT guidelines	+++ -	++ -	+++ -

6 Conclusions

This report concludes the second work period of the ESPON 2.1.1, it described in detail the methodology used in the future for the impact assessment of EU transport and TEN policies and investments in telecommunication networks.

A consensus on indicators for measuring and assessing the territorial impacts of EU transport and TEN policies was found and presented in the report.

The methodologies of the territorial impact analysis have been set up and their mutual interfaces were defined, with which the methodologies interlink. The methodology for addressing the particular issue of the causality analysis of regional production and transport investment is presented first. This is the basis for the extension of a quasi-production-function approach for the measurement the impact of EU transport and TEN policies by accessibility and socio-economic indicators, the SASI-model. Furthermore, an extension of the quasi-production-function approach was presented, which has been developed for this project, which uses the methodology of the SASI-model and extends it to explain the impact of investments and policies affecting the regional accessibility of telecommunication-networks. Finally, the CGEurope model, a multi-regional computable general equilibrium model of trade and passenger flows incorporating product diversity and monopolistic competition is presented, which builds on the database produced by the SASI-model.

After the methodological part the structure of the impact assessment was described, defining indicators, typologies and concepts that will be used in the forthcoming reports of the study, among these a proposal on a typology for the identification of regions most positively and negatively affected by transport policy, the indicators for the cohesion measurement, a contribution to the discussion on the measurement of polycentrality, the analysis of overloaded transport corridors and the concept of efficiency vs. equity of transport policy.

Furthermore, a draft analysis and recommendations on sector policy towards impacts of transport and TEN policies were presented taking up the spatial objectives given in the ESDP and analysing the opportunities and risks of relevant sector policies on policy areas for recommendations on horizontal policy co-ordination and on the possible impact of policies on the spatial goals of the ESDP.

The proposed methodologies will be implemented and used for analysing and diagnosing the territorial impacts of EU transport and TEN policies. The interactions between EU transport and TEN policies and other spatially relevant Community policies and the institutional context in which such policies are designed and implemented will be analysed. Based on the results of the case studies and policy scenarios carried out in ESPON 2.1.1 conclusions and recommendations for policy adjustments and improvements in the EU transport and TEN policies, for further policy developments in support of territorial cohesion and a better balanced EU territory, as well as for improving the spatial co-ordination of EU and national sector policies will be drawn, particularly referring to the ESDP.

Lessons Learned

The development of a typology for this project group has started and drafts have been presented in chapter 4 of this report. Furthermore research has been undertaken towards the impact of transport and ICTs policies on polycentrism. However, the concept of polycentrism needs to be defined in a clearly founded way and indicators have to be developed which measure the concept of polycentrism quantitatively. These have been proposed, but still need validation and input from other ESPON projects and spatial planners. As soon as such indicators become available, it is very desirable to measure the impact of planned transport policies towards a polycentric and better balanced Europe.
Even though it was possible to develop a model to incorporate the developments in telecommunication networks into the impact analysis, the data availability becomes the greatest impediment in the analysis, as regional disaggregated data in this field is scarce as well as for EU-15 as for the accession countries, where even desirable national data is scarce.

Next Steps

It has been agreed that for the evaluation and forecasting of the transport policies especially the scenarios also computed in IASON will be analysed. Among these special attention will be given to the TEN and TINA scenarios. Through the availability of the SCENES data for passenger transport, there is the possibility to incorporate passenger travel into the modelling and the assessment of transport policies. The evaluation process in IASON is currently underway, so that the TPG is waiting for the outcomes of the evaluation process and the availability of the data base of accessibility indicators and socio-economic impacts. For the methodology of overloaded corridors results from the DG TREN study regarding "Scenarios, traffic forecasts and analysis of corridors on the Trans-European Transport network" are expected in June 2003, which will the basis for the impact assessment of the load of networks and congested transport networks.
After the definition of the methodology for the forecasting of the common impact of transport and telecommunication investments and policies, it will be evaluated if the proposed model produces plausible forecasts. The consistency of methodology will be checked, and it will be checked if the methodology is feasible due to the availability of data. It will be examined whether in a further step the quasi-production functions of both models can be merged.

Further Research

The work on the ESPON 2.1.1 methodology has also highlighted the need for further collection of data, especially in the sector of telecommunication networks. The lack of consistent, complete and harmonised data on socio-economic development at the level of NUTS-3 regions is a serious impediment for policy analysis and project appraisal in important areas of European policy making. The future enlargement of the European Union by countries with very different social, economic and political experiences and traditions will further aggravate this impediment.

Furthermore, for the analysis of polycentrism, it is crucial to have a common typology of urban-areas, which are classified according to a clear quantitative concept and can be mapped to more aggregated regional classification, desirably NUTS-3. This is a typology, which we are looking for as input from ESPON 1.1.1., even though this is an ambitious task, particularly building this urban typology for the accession countries.

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Appendix

A Common Database

Table A.1: Data need for proposed methodologies

Data description	Spatial level	Comment
European developments		
Total European GDP by industrial sector, 1981–2021	Europe (15+12+3)	
Total European immigration and outmigration, 1981–2021	Europe (15+12+3)	
Total transfer payments by the EU, 1981–2021	Europe (15+12+3)	
Transport networks and policies		
Road network, 1981-2021	Europe (15+12+3 +external)	
Rail network, 1981-2021	Europe (15+12+3 +external)	
Air network, 1981-2021	Europe (15+12+3 +external)	
Waterway network, 1981-2021	Europe (15+12+3 +external)	Only inland waterway network available
Transport policy decisions, 2002-2021	Europe (15+12+3 +external)	TEN-T and TINA development paths available
National Economic Data		
National accounts, 1997	NUTS 0 (15+12+3)	have been harmonised from different sources
International trade, 1997	NUTS 0 (15+12+3 +external)	have been harmonised from different sources
National demographic data		
Fertility rates by age group of mothers, 1981–2021	NUTS 0 (15+12+3)	data gaps in candidate countries
Mortality rates by year of age and gender, 1981–2021	NUTS 0 (15+12+3)	data gaps in candidate countries
Migration flows, 1981-2001	NUTS 0 (15+12+3)	data gaps still existing
Im-, out-, net migration, 1981–2001	NUTS 0 (15+12+3)	data gaps still existing
Immigration limits 1997–2021	NUTS 0 (15+12+3)	
Regional economic data		
GDP by sector	NUTS 3 (15+12+3)	missing data, estimation techniques to be applied

Gross value added by sector, 1997	NUTS 3 (15+12+3)	missing data estimation techniques applied
Employment by sector	NUTS 3 (15+12+3)	missing data, estimation techniques to be applied
Employment by sector, 1981-2001	NUTS 3 (15)	missing data, estimation techniques to be applied
Unemployment, 1981–2001	NUTS 3 (15+12+3)	missing data estimation techniques applied
Interregional passenger flow data, 1997	NUTS 2 (15+12+3)	possible data-source: SCENES
Regional transfer data, 1981–2021	NUTS 3 (15+12+3)	partly based on spatial disaggregation
Regional population data		
Population by age and gender, 1981–2001	NUTS 3 (15+12+3)	missing data estimation techniques applied
Educational attainment, 1981–2021	NUTS 2 (15+12+3)	NUTS 2 data used for NUTS 3, partly based on national developments
Labour force participation rates by gender, 1981–2021	NUTS 3 (15+12+3)	missing data estimation techniques applied
Information for classifying the urban system	NUTS 3 (15+12+3)	
Regional attractiveness		
Quality of life indicator	NUTS 3 (15+12+3)	Composite indicator
Accessibility by distance		
Mountain region	NUTS 3 (15+12+3)	
Sea border region	NUTS 3 (15+12+3)	
Telephone network size		
Telephone main line in operation	NUTS 0 (15+12+3)	
Total capacity of local public switching	NUTS 0 (15+12+3)	
Main telephone lines connected to digital exchanges	NUTS 0 (15+12+3)	
Main telephone lines for residential use	NUTS 0 (15+12+3)	
Main telephone lines for urban areas (to be defined)	NUTS 0 (15+12+3)	
Public pay phones	NUTS 0 (15+12+3)	
Percentage of capacity used of main telephone lines	NUTS 0 (15+12+3)	
Advanced network size		
Number of Internet host	NUTS 0 (15+12+3)	
Estimated number of Internet Service Providers	NUTS 0 (15+12+3)	
Number of public Internet access points	NUTS 0 (15+12+3)	
Number of Internet access technologies by transmission speed	NUTS 0 (15+12+3)	

Number of Integrated Broadband Networks (IBN) subscribers	NUTS 0 (15+12+3)	
Number of packet switching (X25) data network subscribers	NUTS 0 (15+12+3)	
c. Basic services		
Number of telephone subscribers (home/office subscribers)	NUTS 0 (15+12+3)	
Number of telex subscribers line	NUTS 0 (15+12+3)	
Number of leased analogue circuits	NUTS 0 (15+12+3)	
Number of leased digital circuits	NUTS 0 (15+12+3)	
Number of videotex subscribers	NUTS 0 (15+12+3)	
Advanced services		
Number of Internet subscribers (at home/at work/both)	NUTS 0 (15+12+3)	
Number of Internet subscribers by technology lines	NUTS 0 (15+12+3)	
Number of installed PC connected to Internet	NUTS 0 (15+12+3)	
Number of ISDN subscribers	NUTS 0 (15+12+3)	
Number of Videoconference available rooms	NUTS 0 (15+12+3)	
Number of packet switching (X25) data network subscribers	NUTS 0 (15+12+3)	
Number of cellular telephone subscribers	NUTS 0 (15+12+3)	
Number of private and public firms using E-commerce enabling technologies	NUTS 0 (15+12+3)	
Number of Web sites	NUTS 0 (15+12+3)	
Number of businesses with Web sites	NUTS 0 (15+12+3)	
Internet purchases and sales (E-commerce diffusion)	NUTS 0 (15+12+3)	
Cable TV subscribers	NUTS 0 (15+12+3)	
Quality of basic services		
Waiting list for main lines	NUTS 0 (15+12+3)	
Percentage of calls which fall during the busy hour	NUTS 0 (15+12+3)	
Telephone main lines faults	NUTS 0 (15+12+3)	
Percentage of calls for operator service answered within 15 minutes	NUTS 0 (15+12+3)	
Use of networks and services		
International telephone traffic	NUTS 0 (15+12+3)	
National telephone traffic	NUTS 0 (15+12+3)	
Local telephone traffic	NUTS 0 (15+12+3)	

Cellular mobile traffic	NUTS 0 (15+12+3)	
Average daily time spent on-line	NUTS 0 (15+12+3)	
Traffic from fixed lines to cellular lines	NUTS 0 (15+12+3)	
Traffic from mobile telephones to fixed lines	NUTS 0 (15+12+3)	
Market revenues and expenses		
Total revenues (sum of revenues of single operator)	NUTS 0 (15+12+3)	
Revenue from leased lines	NUTS 0 (15+12+3)	
Revenue from installation charges	NUTS 0 (15+12+3)	
Revenues from calls (local, national, international)	NUTS 0 (15+12+3)	
Internet access revenue	NUTS 0 (15+12+3)	
Revenue from mobile telecommunications services	NUTS 0 (15+12+3)	
Total current expenditures for all telecommunications services	NUTS 0 (15+12+3)	
Internet access revenues of PTOs and incumbent	NUTS 0 (15+12+3)	
Revenues from mobile services	NUTS 0 (15+12+3)	
Revenues from fixed telephone lines	NUTS 0 (15+12+3)	
Internet access costs	NUTS 0 (15+12+3)	
Monthly Internet Service Providers charge	NUTS 0 (15+12+3)	
Fixed telephone call charges (local, national, international)	NUTS 0 (15+12+3)	
Mobile call charges	NUTS 0 (15+12+3)	
Price of least lines	NUTS 0 (15+12+3)	
Investments in ICTS		
Telecommunications investments	NUTS 0 (15+12+3)	
Telecommunications investments by type of networks	NUTS 0 (15+12+3)	
Telecommunications investments by geographical areas	NUTS 0 (15+12+3)	
Telecommunications investments by economic sectors of activity	NUTS 0 (15+12+3)	
ICTs employment		
Total staff in fixed telecommunications providers services	NUTS 0 (15+12+3)	
Total staff in mobile telecommunications providers services	NUTS 0 (15+12+3)	
Total staff employed by Internet Service Providers	NUTS 0 (15+12+3)	
ICTs regulatory régime		
Kind of regulatory régime, by Country	NUTS 0	

	(15+12+3)	
Year in which deregulation (if exists) took place, by Country	NUTS 0 (15+12+3)	