ESPON

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ESPON project 3.2
Spatial Scenarios and Orientations in relation to the ESDP and Cohesion Policy

Final Report
October 2006

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Volume 4
Elements of support for the scenario building process

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1 Introduction: Scenario approach

This volume presents the elements of support for the scenario building process. The aim of this project was to elaborate territorial scenarios for Europe on the basis of the existing ESPON results and using the data collected by the other ESPON projects. From the beginning of the project it was obvious, however, that in spite of all the achievements made by ESPON, this would not be sufficient for the elaboration of the integrated scenarios. The reason for this is that the scenarios have to take into account many more factors than the ESPON programme could cover and much longer time series than the ESPON database contains.

From the outset it was also decided to develop a scenario approach, combining qualitative and quantitative techniques. This is particularly true for the integrated scenarios, described in volume 2. In order to develop these scenarios the outcomes of literature reviews, creative thinking, and workshops have been combined with data bases and the outcomes of model calculations. The thematic scenarios, described in volume 3, are mainly of a qualitative nature. The main steps of the applied scenario approach are:

- *Making thematic scenario bases*: collecting and integrating for each theme a wide range of information sources in order to understand the past and present trends and driving forces and in order to be able to explore the future development of the theme in a realistic way.

- *Building thematic scenarios*: elaborating for each theme two or more alternative policy scenarios taking into account the virtual context justifying the policy, the policy itself, its territorial impacts, and the final image of the EU.

- *Combining them into integrated scenarios*: using the thematic scenario bases to develop an integrated scenario base and using the thematic scenarios to feed the integrated scenarios, taking the mutual relations between the themes into account.

- *Testing the integrated scenarios*: using some different 'wild cards' (low-probability-high-impact-events, like a very different exchange-rate between the euro and the dollar) to test the stability of the integrated scenarios and to introduce surprises.

The integrated scenarios have been developed with the aid of the MASST model (Macroeconomic, Social and Territorial) and the KTEN model (Know Trans-European Networks). Both models, described in chapter 2 and 3 of this volume, have been built as parts of the scenario project. Complementary to those two complex models, a few fairly simple demographic models have been used and the results presented in the form of an indicator of sustainable demographic development which combines life expectancy and median age. This was part of the attempt to construct a European Territorial Cohesion Index (ETCI), presented in chapter 4, which was supposed to provide quantitative support to the scenarios in dimensions complementary to competitiveness (MASST) and accessibility (KTEN), notably the social dimension. This attempt, however, failed because of the lack of regionalised social data in the ESPON space.
Several approaches have been tested in the downscaling of the scenarios, i.e. the representation of their effects at a more local scale. These are presented in chapter 5. An attempt was also made to test the scenarios in the light of different high-impact events through the use of so-called wild cards. While the actual wild cards are presented in volume 2, chapter 6 discusses their theoretical background.
Scenarios are essentially communication tools and as such have to be disseminated. Chapter 7 presents the strategies used during the project for this dissemination, including

the different techniques used to visualise the scenario and the special web site, the Knowledge and Communication (K&C) tool which combines communication and interactive dynamic visualisation. Finally, we present a short chapter summarising the validation processes used during the elaboration of the scenarios.

2 MASST - MAcroeconomic, Sectoral, Social and Territorial model

2.1 Introduction

The MASST model was created within the ESPON 3.2 project in order to quantify and territorialise the scenario forecasts developed within 3.2. MASST is a macroeconomic forecasting model consistent with the general ESPON philosophy that considers the efficiency and quality of territorial assets and socio-economic relationships to be the driving forces behind regional competitiveness and performance. Factors like accessibility, infrastructure endowment, local innovative capacity, local urban structure and geographical position are intrinsic to the logic of the model, and have been identified as crucial variables in the economic explanation of regional success in Europe. These local factors are complemented by macroeconomic, national ones which also play an important role in the model's logic for the interpretation of regional performance.
The model is therefore a predictive model for regional growth able to forecast territorial scenarios on different assumptions concerning: a) national macroeconomic tendencies and policies (e.g. interest rates, exchange rates, inflation rate, public expenditures, geographical reorientation and size of FDI, trend in public debts, revision of the Maastricht parameters, increase in energy price, attitude towards East-West and North-South migration, trend in fertility rate and in population aging, trend in saving ratio); b) new institutional arrangements (widening vs. deepening of the European Union); c) European policies (e.g. geographical orientation and amount of structural funds and community agricultural policy; transport infrastructure priority choices; flexible vs. rigid respect of the Lisbon agenda and of Maastricht parameters).
The MASST model is able to forecast medium to long term trends in real regional GDP growth and convergence trends, as well as in demographic variables (population growth and migration flows) at NUTS 2 level, under alternative assumptions on macroeconomic tendencies and policy options. When these qualitative assumptions are 'translated' into quantitative terms and inserted into the MASST model, the latter enables the magnitude of the likely effects to be identified. The results should be interpreted as the tendencies and relative behavioural paths of regional GDP and population growth that will take place under certain conditions.

2.2 The structure of the MASST model

2.2.1 The logic of the Model

Regional growth is in most recent theories (territorial endogenous growth theories) the result of[1]:
- a competitive process, based on supply rather than demand elements, like quality (and quantity) of local resources, product and process innovation, technological advances, local knowledge. Pure demand driven growth models are therefore non-appropriate;

[1] Capello, R. (2005) A quantitative territorial model for the measurement of regional growth in the new Europe, paper presented to the ERSA conference of Amsterdam, August 2005.

- a social process, since it is based not only on material production factors, but also on non-material resources. Social elements (like social capital à la Putman, relational capital à la Camagni, trust à la Becattini, leadership à la Stimson and Stough) give rise to local cumulative processes of knowledge creation, to processes of collective and interactive learning, reinforcing decision-making processes of local actors. These elements have an active and vital role in defining local economic competitiveness and growth. Traditional local growth models based merely on resource endowment have a limited interpretative power in this respect;
- a territorial and spatial process, interpreting territory as an autonomous production factor, rather than the mere geographical place where development occurs. Territory generates increasing returns, cumulative self-reinforcing mechanisms of growth in the form of dynamic agglomeration economies; in this perspective, local economic growth is also the result of spatial processes, rather than of a mere efficient resource allocation or of an increase in resources endowment. A-spatial local growth models are for this reason non-appropriate;
- an interactive process of the local economy within the wider national and international economic system. Pure bottom-up models refrain from the opportunity of measuring national-regional linkages, and have therefore to be avoided.

The specification of our MASST (MAcroeconomic, Sectoral, Social and Territorial) model reflects two specific needs. The first need has a theoretical nature. The MASST model wishes to keep the above-mentioned theoretical elements into account; it has first of all to be a territorial model, where spatial linkages among regions (like proximity effects) and the territorial structure of regions (urbanised, agglomerated, rural structure of regions) find a role in explaining local growth. It has to be a local competitive model, in which the dynamics of the local economy is merely explained by supply elements like quality and quantity of resource endowment; last, it is a macroeconomic model, since it has an aggregate approach to growth, where the dynamics of aggregate macro-economic components play a role.

The second need has a practical nature, since it is strictly related to the forecasting use we want to make of the model. The MASST model is intended to be a forecasting model, in which the main spontaneous and normative driving forces of change that will characterise the dynamics of the European Economy in the next fifteen years have to find a role. For this reason, the MASST model has to incorporate:

- macroeconomic elements, in order to model macroeconomic tendencies and policies;
- institutional elements, in order to measure future policy choices concerning the 'deepening' or 'widening' of the present institutional agreements;
- strategic economic resources, recognised to have a crucial role in the future of the European Economy either by official governmental documents (like human resources in science and technology or infrastructure endowment in the Lisbon agenda), or by their intrinsic nature (like energy use);
- territorial elements, in order to obtain differentiated territorial scenarios.

2.2.2 The general structure of the econometric model

2.2.2.1 The general structure

The MASST model reflects the modern conceptualization of regional growth. The model specification, in fact, defines regional growth as a competitive, bottom-up, endogenous and cumulative process. The endowment of local material resources, such as labour and infrastructures, and of non-material resources like the quality of human capital and the presence of value added functions, are all elements that in the MASST model explains the capacity of a region to grow at a rate above the national average. Regional competitiveness is therefore closely linked with the presence of endogenous resources and with the region's

ability to exploit its potentialities.
In MASST the link between the national factors and regional ones concerning growth is assured by the structure of the model, which interprets regional growth as the result a national growth component and a differential regional growth component:

$$\Delta Y_r = \Delta Y_n + s \qquad (1)$$

where ΔY_r and ΔY_n denote the GDP growth rate respectively of the region and the nation, and *s* represents the regional differential growth with respect to the nation.
Fig. 1 presents the logic of the model, in which it is clear that the econometric model consists of two intertwined blocks of equations, a national block and a regional one, giving to both the regional and national component a role on local economic trajectories.

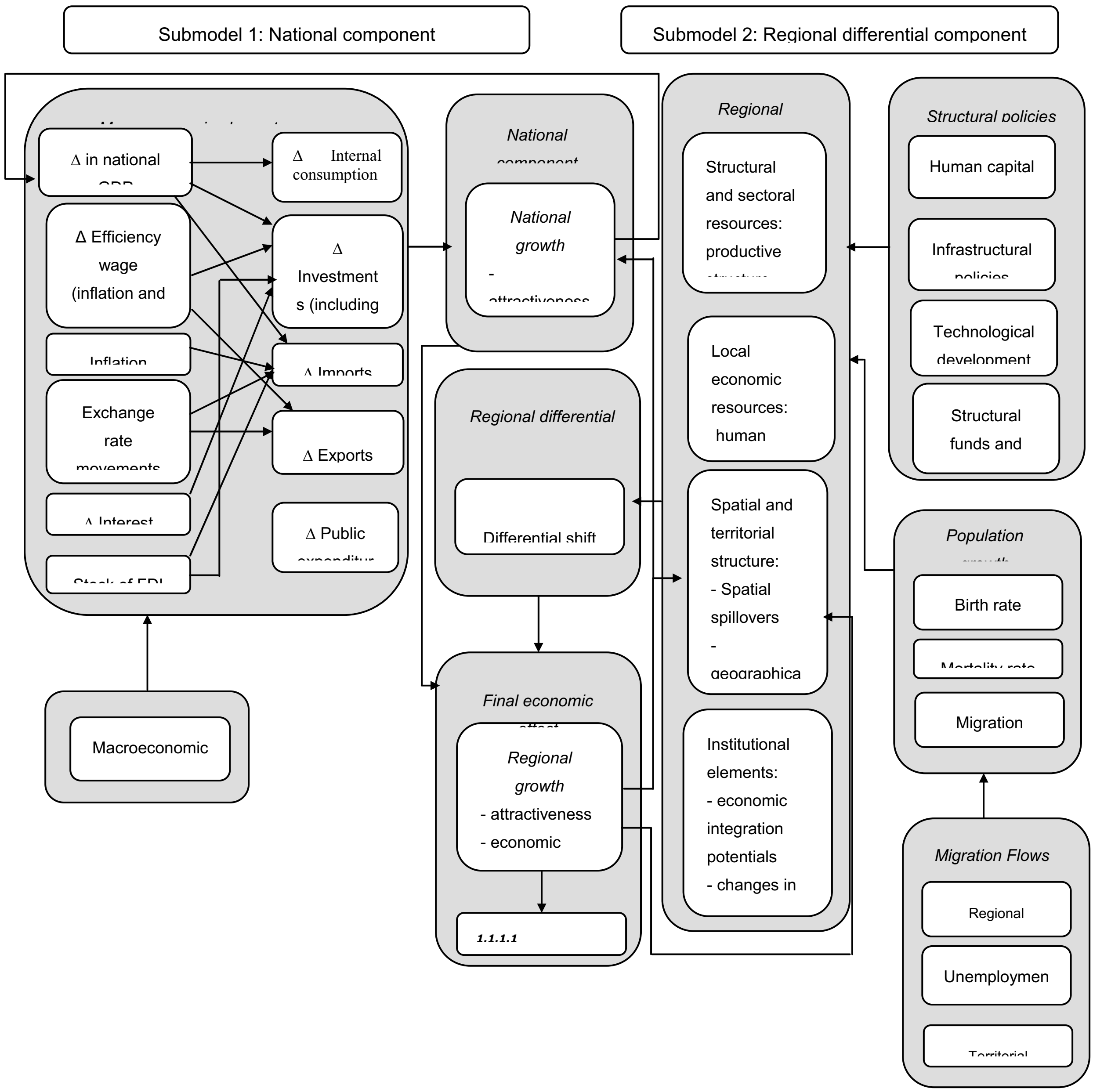


Figure 1 MASST Model Specification

As presented in Fig. 1 national growth depends on the dynamics of the macroeconomic aggregate elements: private consumption growth, private investment growth, public expenditure growth and export and import growth. This part of the model is able to capture macroeconomic (national) effects generated by spontaneous trends and/or policies on regional growth; macroeconomic policies and trends in interest rates, in public expenditure, in inflation rates, in investment rates differ radically among European Countries (especially between Eastern and Western Countries); even within the old EU 15 countries the difference existing in macroeconomic conditions (like inflation rates or efficiency wages) explains the different regional growth patterns. The national growth component allows to capture the specific country effects on local growth.

On its turn, the regional differential component (the shift component, i.e. the relative regional growth), is dependent on the competitiveness of the local system, based on the efficiency of local resources: the increase in the quality and quantity of production factors (like human capital and population) in infrastructure endowment, in energy resources, as well as the sectoral and territorial structure of the regions and the interregional spatial linkages are the main elements that make regions grow more than the nation they belong to. In this respect, MASST differs substantially from the regional growth econometric models that exist in the literature, in which a direct interpretation of absolute regional growth is presented, either replicating national macroeconomic models, or through complex systems of equations for each region that are linked to both national aggregate economy and to the other regional economies through input output technical coefficients that determine intra and inter regional trade and output.

2.2.2.2 The national sub-model

The first sub-model is a macroeconomic model applied to each of the 27 European countries in our sample (the 25 EU countries plus Bulgaria and Romania), very much similar to the standard macroeconometric models used by national governments and central banks as programming and policy devising tools during the seventies and eighties. MASST differs from these traditional standard models in that in MASST only goods and service markets are specified, while the monetary market, the labour market, the public sector balance sheet have no endogenous outcome. MASST is therefore a partial equilibrium model, in which prices, wages, interest and exchange rates, public spending are taken as exogenous variables. If this characteristic of MASST can be interpreted as a limit, the fairly simplified model fulfils the requirements imposed upon the model to be able to explain real growth as a function of all variables that are policy instruments (interest rates, exchange rate, government expenditure) or policy targets (inflation, unemployment), influenced by national or international macroeconomic trends.
The specification of the national sub-model consists of five equations. The first equation specifies private consumption growth rate in a traditional Keynesian approach, depending on the growth of income in a positive way (Table 1).
Private investment growth equation has also a traditional structure, making investment growth rate be dependent on the growth of output (as the accelerator theory suggest), positively, on interest rates, negatively, on a measure of the country competitiveness (in our case, unit labour costs growth rate, the inverse of productivity growth, and therefore negatively linked to investment growth rate) and on the share of FDI on domestic investments made in a country, given the domino effect that a flow of FDI may generate on domestic investment growth (Table 1).
Import growth equation is made dependent on changes in domestic demand, positively, on nominal exchange rate negatively linked; on internal inflation rate, and on the share of FDI flows on domestic investments made in the Country, linked positively to import growth because of the domino effect that FDI may generate not only on internal investment growth but also in import growth (see Table 1).

Lastly, *export growth equation* is expected to depend on changes in domestic demand and on nominal exchange rate; for both explicative variables, the relationship is expected to be positive (Table 1).
Government expenditure growth rate is an independent variable of the model.
The national growth rate is determined by a *'pseudo' identity equation* where the national GDP growth rate is equal to the weighted sum of average growth rates of all aggregate demand components, the weights being the partial derivative of GDP with respect to each aggregate demand component (Table 1).

	Explanatory variables	Change in domestic output ($\%Y_N$)	Interest rates	Internal Inflation	Nominal effective exchange rates index	Change in unit labor costs	Share of FDI flows on internal investments
Estimated equations							
1	Consumption growth rate (%C)	+					
2	Investment growth rate (% I)	+	-			-	+
3	Imports growth rate (%M)	+		+	+		+
4	Exports growth rate (%X)				-	-	
5	(Pseudo) identity	Output (	$\%Y_N$)= a_1 a_4	%C + a_2 %X - a_5		%I + a_3 %M	%G +
%G = Government expenditure growth rate							

Table 1 Outline of the MASST sub-national blocks of equations

2.2.2.3 The regional sub-model

The regional part of the MASST model has the aim to explain the relative regional growth with respect to the national one, and it represents the novelty with respect to traditional regional econometric models of the seventies and eighties.

In the logic of MASST, the higher/lower relative capacity of a region to grow depends on its structural elements: its productive structure, its relative position, its accessibility, its settlement structure, its degree of economic and social integration are all elements that identify a particular economic trajectory of a local economy which might differ from the national one.

Table 2 identifies the blocks of equations that characterise the regional sub-model.

The first equation is the regional shift equation represented as a quasi-production function in a reduced form function of factors that are thought to determine regional production capacity. These factors, stemming from the modern theories of regional growth, without denying the importance of traditional growth theories are the following:

- *local material inputs*, like quantity and quality of human capital, availability of energy resources, presence of self-employment, as stated by the traditional micro-territorial and behavioural theories of growth;
- *accessibility*, as the main regional development theories have underlined since the sixties, whose role has been emphasised by the traditional micro-territorial and behavioural theories of growth;
- *the economic integration process*, which provides a larger market potentials for regions, as the custom union theory underlines;
- *the relative geographical position*, which emphasises growth opportunities of a region dependent on its neighbouring regions' dynamics (spatial spillovers of growth), as emphasised by the modern theories of regional development underline;
- the *settlement structure* of region, a good proxy to capture the role of agglomeration

and urbanisation economies on regional performance, enabling parameters of the different explicative variables to vary across different settlement structures present in space, again emphasising the strategic elements, like agglomeration economies, underlined by advanced regional development theories.
Not all the explicative variables are exogenous in the model; three of them are endogenous and allow for cumulative processes, namely:
- *self-employment* is in part dependent on structural funds expenditures, as the creation of new firms is seeing as one of the most productive effects of structural funds expenditures (Table 2);
- *demographic changes* (population growth rate) are dependent on birth and death rates and on in-migration (Table 2);
- that part of regional growth dependent on the other regions' dynamics (*spatial spillovers*) is dependent on the regional growth of neighbouring regions in the previous year.
On its turn, in-migration is made dependent on regional income differentials, unemployment rate, and on the different settlement structures of regions (Table 2).

1)	Dependent variable: *regional differential shift* Independent variables:				
	Local material inputs and resources:	Accessibility:	Economic integration processes:	Relative geographical position:	Settlement structure:
	- quality of human capital - energy resources - selfemploym.* - CAP expenses -population growth*	-infrastructure endowment	- change in economic potential	-spatial spillovers*	- rural vs. agglomerated vs. urban regions; mega regions
2)	Dependent variable: *Self-employment* Independent variable: Structural funds expenses				
3)	Dependent variable: *population growth* Independent variables:				
	Birth rates	Death rates	Net in-migration*		
4)	Dependent variable: *net-immigration* Independent variables:				
	Regional differential growth	Unemployment rate	Regions' settlement structure		

*Variables with * are endogenous variables in the model.*

Table 2 Outline of the MASST sub-regional blocks of equations

2.2.3 The characteristics of MASST

Given the above-mentioned logical and analytical characteristics of the model, the main technical specifications of the MASST model can be summarised as follows[2]:
(a) the model is first of all an interactive national-regional model. It combines top-down and bottom-up approaches, so that an interdependent system of national and regional effects is built. Such a structure allows vertical feedbacks between the regional and national economy to be taken into account;
(b) it is an integrated model. In its structure, the model finds a specific place for both socio-economic and spatial (horizontal) feedbacks among regional economies. While the former are captured by the socio-economic conditions generating interregional migration flows, the latter are measured by spatial spillover effects, as explained below;
(c) it is a spatial-territorial model. The spatial and territorial dimensions have a role in the explanation of regional growth in two ways. First of all, the model directly captures proximity effects through the measurement of spatial spillovers (i.e. the growth rate of a region also depending on the growth rate of neighbouring regions); moreover, with the introduction of variables interpreting the territorial (agglomerated, urbanised, rural) structure, the model indirectly measures the agglomeration economy (diseconomy) effects that influence growth (decline) in a cumulative way;
(d) it is an endogenous and local competitiveness driven model in the explanation of regional growth differentials. Regional differential growth is explained by local factors and interregional competitiveness stems from specific locational and local resource endowment of a region;
(e) it is a macroeconomic (multinational) model. Short term (macroeconomic) effects are dealt with at national level, and their feedbacks on national economies taken into consideration in explaining local growth;
(f) it is a recursive dynamic model. The outcome of one period of time at both national and regional level enters the definition of the output of the following period, in a cumulative and self-defining development pattern;
(g) given the above characteristics, the model is a multi-layer policy impact assessment model. The structure of the model allows in fact to measure the impact of national (and supranational) policy instruments on both regional and national growth, and the impact of regional policies on regional growth.

Needless to say, some interpretative limits characterise the MASST model. The main limits regard some choices made in the specification of the model and data unavailability, namely:
- the impossibility to have differentiated regional feedbacks of national policies and trends. In its present specification, the MASST model captures the vertical feedbacks of a national policy on regional growth, but distributes them uniformly among regions;
- for what concerns missing data, the MASST model suffers from the lack of data capturing social (intangible) elements; the role of these elements, highly emphasised in modern literature, will therefore not be measured in our model.

2.3 Database of the MASST Model

The estimation and simulation of the MASST model requires the use of a large dataset.
This has been completed for 27 countries, the EU25 plus Bulgaria and Romania. Two countries of the Espon Space, Switzerland and Norway are at present out of the estimation dataset due to missing data. They may be included again if relevant data for these countries become available before the end of the project.

[2] See Capello (2005), A quantitative territorial model for the measurement of regional growth in the new Europe, paper presented to the ERSA conference of Amsterdam, August 2005.

2.3.1 Sources of data

The dataset is based on two main sources: the Espon database, in its June 2005 update, and the Eurostat database, which is constantly updated on-line and made available through the website http://epp.eurostat.cec.eu.int/pls/portal. Most data from the Eurostat database have been downloaded during the spring of 2005. A small amount of data come from differentiated sources such as the OECD.
Since it is composed by two components, the estimation of the model requires two separate databases: one for the data at national level and one for the data at regional level. The two dataset, however, are fully compatible since the database at regional level includes some relevant national data, which are entered using the same *id* that they had at national level. For example, in the regional dataset, national real GDP per capita growth rate in regions of country number *x* is the same for all regions of that country and has the same value it has in the national dataset.
The data at both national and regional levels have been collected for a period covering 8 years, from 1995 to 2002 included. This has allowed to use panel estimation techniques at national level. Other data, especially when coming from the Espon database, were available only for 1 year (tipically 2000) and were consequently used as structural variables.
The data at regional level have been collected at NUTS2 level, because many relevant data were not available at the smaller NUTS3 level. In a limited number of cases that will be described below, the NUTS2 level data come actually from the aggregation of NUTS3 level data. This process was sometimes computationally intensive but never theoretically challenging.
The use of two different sources was at the basis of some problems of compatibility, in particular at regional level. In fact, the Espon database is based on an older classification of NUTS with respect to the latest available Eurostat data.
Since this is an Espon project, the choice was to use the Espon NUTS and to make the Eurostat data compatible with this classification when they were not so originally. This included the use of techniques of aggregation/disaggregation, interpolation, extrapolation. This has especially affected some specific regions of countries, such as Finland, for which the new Nuts are very different from the old ones.

2.3.2 Description of data

For what concerns national data, no heavy problems exist in data collection. The national data used in our model are contained in the Eurostat database, a rich collection of national data including macroeconomic variables, in time series for all European Countries. The interest in having 27 EU Countries (25 EU Member States, Bulgaria and Romania) involved in our study has hampered a long time series application; Eastern Country data is in fact available in a consistent way since 1995. Table 3 presents the indicators built for our model, available annually between 1995 and 2002 for the 27 Countries. A set of dummy variables identifying Eastern Countries, new EU member Countries has easily been built and added to the dataset.
These data are almost all coming from the Eurostat database and taken at ESA95. It has to be noticed that economic data, when included in the Espon database, are normally coming from Eurostat.
At regional level, the situation of data availability is very different. As is often the case, data availability represents one of the main limits for regional econometric model applications. Our case is not an exception in this respect. The main novelty concerning data has been the existence of the ESPON database, containing interesting and unusual data at NUTS2 and NUTS3 regions collected by research partners within the different ESPON projects.

The originality of our database consists in (a) specific and so far unavailable territorial and socio-economic data; (b) specific spatial effects indicators, built in order to capture proximity effects, in line with the large and settled literature on this issue[3]; (c) a merged Eurostat and ESPON economic data base, which allowed us filling gaps and checking for data consistency.

National variables (NUTS0 level)	*Definitions*	*Period covered*	*Source of raw data*
GDP growth rate	Annual % growth rate of real GDP	1995-2002	Eurostat
Annual change in interest rate	Absolute change in short-term interest rates (3 months)	1995-2002	Eurostat
Annual change in unit labour cost	Absolute change in unit labour cost (calculated as unit salary * number of employees / GDP)	1995-2002	Eurostat
Share of FDI on total internal investments	% Flow of FDI / Gross Fixed Capital Formation	1995-2002	OECD
Nominal exchange rate	Nominal effective exchange rate calculated on 41 countries (NEER41)	1995-2002	Eurostat
Inflation rate	Inflation rate (%change of CPI over previous year)	1995-2002	Eurostat
Consumption growth	% annual real consumption growth rate	1995-2002	Eurostat
Investment growth	% annual real gross fixed capital formation growth rate	1995-2002	Eurostat
Import growth	% annual real import growth	1995-2002	Eurostat
Eastern Countries	All former Eastern Economies	dummy	
New EU Countries	The 10 new Member Countries who joined the EU on the 1/5/04	dummy	

Table 3 Variables used by the MASST at national level

(a) Specific and so far unavailable territorial data.

The new and original territorial variables are (Table 4):
- a typology of regions according to their settlement structure. Regions are in fact divided into agglomerated, urban and rural regions, on the basis of the type of urban system (dimension and density of cities) present in the region;
- a typology of best performing regions, defined *MEGAs* (Metropolitan European Growth Areas), selected on the basis of five functional specialisation and performance indicators, namely: population, accessibility, manufacturing specialisation, degree of knowledge and distribution of headquarters of top European firms. All these variables have been collected at FUA (Functional Urban Area) level and combined to give an overall ranking of FUAs; the 76 FUAs with the highest average score have been labelled *MEGAs*. *MEGA* regions are the NUTS2 level administrative areas with at least one of the 76 FUAs located in it;
- a definition of Pentagon regions, indicating the regions located within the Pentagon area delineated by the five European cities of Munich, Milan, Paris, London and Amsterdam.

[3] See among others Cheshire 1995; Cheshire and Carbonaro, 1996, and the wide literature on spatial econometrics (Anselin 1988; Anselin and Florax, 1995).

Data	*Definition*	*Source of raw data*
Agglomerated regions	With a centre of > 300.000 inhabitants and a population density > 300inhabitants / km sq. or a population density 150 – 300 inhabitants / km sq.	Espon database
Urban regions	With a centre between 150.000 and 300.000 inhabitants and a population density 150 – 300 inhabitants / km sq. (or a smaller population density – 100-150 inh. /km with a bigger centre (>300.000) or a population density between 100 – 150 inh./km sq.	Espon database
Rural regions	With a population density < 100 / km sq. and a centre > 125.000 inh. or a population density < 100 / km sq. with a centre < 125.000.	Espon database
Megas regions	Regions with the location of at least one of the 76 FUAs with the highest average score in a combined indicator of transport, population, manufacturing, knowledge, decision-making in the private sectors.	Espon database
Pentagon regions	Regions located within the Pentagon formed by the five European cities of Milan, Munich, Amsterdam, London, Paris.	Espon database
Net immigration flows (people between 17-27 years)	Average net immigration flows of people between 17-27 years in the period 1/1/95 – 1/1/00 at NUTS 2	Espon database
Net immigration flows (people between 32-42 years)	Average net immigration flows of people between 32-42 years in the period 1/1/95 – 1/1/00 at NUTS 2	Espon database
Net immigration flows (people between 52-67 years)	Average net immigration flows of people between 52-67 years in the period 1/1/95 – 1/1/00 at NUTS 2	Espon database
Regional birth rate	Share of births on population at NUTS 2	Espon database
Regional mortality rate	Share of deaths on population at NUTS 2	Espon database

Table 4 Territorial and socio-economic data

The socio-economic variables collected by the ESPON projects, which would be otherwise unavailable at NUTS 2 level, concern (Table 4)[4]:

[4] See different ESPON projects for technical details. The final reports are available on the Espon web-site www.espon.lu.

- total energy consumption, obtained by summing the different sources of energy consumption (travel, industrial and domestic use), once estimated at regional level through an input-output model;
- interregional and international migration flows, for different population age;
- birth and death rates;
- structural funds expenses;
- agricultural support funds.

(b) Specific spatial effects indicators.

Specific indicators for spatial effects concern (Table 5):
- a *spatial spillover* indicator for a generic region *i*, as the sum of the annual absolute difference between income growth rates of all other regions than region *i* divided by the distance between each other region and region *i*, defined as:

$$SP_{rt} = \sum_{j=1}^{n} \frac{1}{n} \frac{\Delta Y_{jt}}{d_{rjt}} \quad (2)$$

- an *economic potential* indicator for a generic region *i*, as the sum of the annual absolute difference between per capita income levels of region *j* and region *i* divided by the distance between region *i* and all other regions *j*. The concept of economic potential is here defined following Clark et al. (1969), as the accessibility to total income at any location allowing for distance;
- a *European integration potential* indicator for a generic region *i*, obtained as the difference between the economic potential indicator described above and an economic potential indicator calculated by squaring distance for those regions at the border between Eastern and Western Countries. This variable hence affected only the regions at the borders, and was hence calculated as:

$$IP_{rt} = \sum_{j=1}^{n} \frac{1}{n} \frac{\Delta Y_{jt} - Y\Delta_{rt}}{d_{rj}} - \sum_{j=1}^{n} \frac{1}{n} \frac{\Delta Y_{jt} - Y\Delta_{rt}}{d_{rj}^{2}} \quad (3)$$

where:
ΔY_t = income growth
Y_t = income
j = all neighbouring regions of region r
d_{rj}= physical distance between region r and j
n = number of neighbour regions
m = weight given to physical distance between regions, measuring higher spatial friction when economic barriers are present (tariff, transport costs).
The second one was aimed at measuring the effects of a barrier fall on regional GDP; in particular, it was used to measure the effects of the integration of the integration of the 10 New member states inside the EU and of the possible integration of Bulgaria and Romania.

Indicators	*Definition*	*Source of raw data*
Spatial spillovers	Sum of the relative annual regional growth rates of all other regions than region *i* divided by the distance between each other region and region *i*.	Eurostat
Economic potentials	Sum of the annual absolute difference between income growth rates of regions *j* and region *i* divided by the distance between region *i* and all other regions *j*.	Eurostat
Integration potential	Change in the sum of the annual absolute difference between income growth rates of regions *j* and region *i* divided by the distance between region *i* and all other regions *j*, when in the second term distance is squared for those regions at the border between Eastern and Western Countries.	Eurostat

Table 5 Specific spatial effects indicators

(c) Traditional variables available in both Eurostat and Espon databases.

More traditional, variables available in both Eurostat and Espon databases have been useful in the estimation of the MASST model, and indicators have been built with them, namely (Table 6):
- share of human resources in S&T;
- regional average annual population growth rate;
- relative regional infrastructure density (km of roads on surface at NUTS 2 with respect to the national average);
- regional share of tertiary activity;
- regional average annual differential GDP growth rate;
- regional differential per capita GDP.

For the above mentioned indicators, the availability is for all 259 NUTS 2 European regions belonging to 27 European Countries (25 EU Member Countries, Romania and Bulgaria). Data availability is instead rather poor once a time series database at NUTS 2 level is required. Most of the Espon data is available only for one year (for example energy consumption and migration flows); for other data, the spatial coverage is unacceptable when extending the database to time series. As we will see in the next section, our choice has been to have the maximum spatial coverage of the database, by restricting the estimate at NUTS 2 level to a cross-section database. This choice is justified by (a) the structural nature of the characteristics expressed in the indicators; (b) our main interest to cover most of the European territory.

Indicators	*Definition*	*Source of raw data*
Regional share of human resources in S&T	% of people working in S&T on population at NUTS 2 in the year 2000	Eurostat
Regional average annual population growth rate	Average annual population growth rate at NUTS 2 in the period 1995-2002	Eurostat
Relative regional density of infrastructure endowment	Km of roads on surface at NUTS 2 on km of roads on surface at NUTS 0 in the year 2001	Espon database
Regional energy consumption by population	Total energy consumption on population at NUTS 2 in the year 2002	Espon database
Pillar 2 expenses per agricultural working unit (awu)	Total funds devoted to Pillar 2 on the number of agricultural working unit	Espon database
Per capita structural funds	Total structural funds expenditures in the period 1994-1999 on population	Espon database
Regional share of tertiary activity	People employed in services in 2001 in percentage of the total at NUTS 2	Espon database
Regional average annual differential GDP growth rate	Annual average relative percentage GDP growth rate at NUTS 2 in the period 1999-2002	Eurostat
Regional differential GDP	Absolute difference between per capita GDP level at NUTS 2 and per capita GDP level at EU level in the period 1995-2002	Eurostat

Table 6 Traditional economic variables

2.4 Econometric specifications of the model

As shown in the previous section, (see table 4 in particular) data on most relevant variables at Nuts2 level is only available for one year, while data were collected at the National level for the European countries in the sample over years 1995 through 2002. Due to the different characteristics of the two data sets, different techniques had to be used to estimate the National and Regional models. The estimation procedure and the results obtained for the National block of equations, shown in Table 7, will be discussed first. Table 8 summarizes the estimated coefficients for the Regional part of the Econometric model. For this second component of MASST great care was given to the treatment of potential spatial dependence in the data.

2.4.1 The national model estimates

The estimates for the parameters of the equations of the national model were obtained using a panel of data on 27 European countries for the years between 1995 and 2002. The actual number of observations varies across equations due to data availability issues and none of the equations has been estimated on a balanced panel. All specifications are in fact reduced form equations where only exogenous and predetermined variables enter as regressors. In particular the lagged income is considered a predetermined variable that proxies current income growth , so that we are able to avoid to deal with simultaneity issues that would arise if we used the current income as a regressor in the consumption, investment and imports equations. After testing for the presence of individual effects, for the presence of serial correlation within each individual (country) and for heteroskedasticity, all equations ended up being estimated by robust OLS that ensure consistent but not necessarily efficient estimates of the parameters. Let's now comment on each equation in turn.

2.4.1.1 The consumption equation (see table 7, column 2)

Theory tells us that consumption depends primarily on income. Which among past, current or expected income is the 'right' measure to use in a consumption equation is both a theoretical and empirical issue, and a lot has been written on this topic. In MASST we choose to specify and estimate the aggregate growth rate of consumption as a linear function of the lagged aggregate income growth rate, allowing for different coefficients between the old and the new EU members[5], as well as a dummy that changes the intercept of the equation for the new EU member countries. We estimate the consumption equation by Ordinary Least Squares on a panel of data from 1996 through 2002 for the 27 European countries in the sample[6]. Neither fixed nor random individual effects were found statistically significant which allowed us to use OLS rather than panel specific estimation techniques. We tested for serial correlation within each country in the OLS residuals and we accepted the null hypothesis of no serial correlation, which we took as support of taking the lagged income growth variable as a predetermined variable. We did not test for spatial correlation in the residuals of the consumption equation but we decided to estimate robust standard errors[7] of the parameters of the equation to be sure to be able to make correct statistical inference on the parameters themselves even if the error terms were heteroskedastic or somehow correlated across observations.

The estimates show that consumption follows significantly different patterns of behaviour between old and new EU member countries. In particular the growth rate of consumption is on average greater in the New countries, while the marginal rate of consumption relative to income is larger for the Old countries: the latter save less and they have already reached and almost steady state consumption growth rate.

[5] In this equation Bulgary and Romany are added to the set of the 10 new EU members.
[6] For some of those countries data are only available from 1998.
[7] See the "robust" option in the STATA command "regress". Such an option produces the so called "sandwich coefficient covariance matrix" which is a consistent estimate of the coefficient covariance matrix even when there exists heteroskedasticity or correlation among residuals.

	$\Delta\%C$	$\Delta\%I$	$\Delta\%X$	$\Delta\%M$	$\Delta\%Y_N$
$\Delta\%Y_{N,-1}$	.53**	1.012**		.561**	.739*%C
$\Delta\%Y_{N,1}$*dnew1	-0.29*				+ .104*Δ%I
$\Delta i3_{N,-1}$		-.529**			+ .015*Δ%G
$\Delta\%P_N$				.34**	+ .266*Δ%X
$\Delta NEER_N$			-.573**	.135**	- .186*Δ%M
$\Delta\%ULC_{N,-1}$		-.434*	-.648**		
FDI*deast		.048		.035	
dnew1	1.899 **				
Constant	.909 **	.597	8.458**	4.055**	
R^2	0.302	0.247	0.232	0.112	
#observations	183	132	150	178	

** Significant at 5% or 1%
* Significant at 10%

Table 7 National estimates

2.4.1.2 The investment equation (see table 7, column 3)

From a standard Keynesian approach, aggregate investment depends positively on aggregate demand, i.e. income, (both current and expected), and it depends negatively on interest rates, a proxy for cost of capital. The literature on investment equations is at least as wide as the literature on consumption[8], but once again in MASST we choose to specify aggregate investment growth as a simple linear function of the lagged income growth and of the nominal 3 months interest rate, we add the lagged unit labor costs growth rate and the amount of FDI's received by eastern European countries. The latter variable is not significant, but it has the expected positive sign, that is foreign direct investments push domestic investments. The negative and significant coefficient of the unit labor cost variable, instead, tells us that as labor costs grow investments decline, which would mean that labor and capital are complements rather than substitutes. It is plausible to assume that what these estimates capture is the fact that the countries in the sample where labour costs are low and do not rise too much in time are the countries where investments were growing at a faster rate in the years 1996-2002. The coefficients attached to lagged income and interest rates are highly significant and of the expected sign. Interest rates enter lagged one year and are considered a predetermined variable; they will be treated as an economic policy instrument when devising simulation scenarios.
We performed the same tests on the estimated residuals of the investment equation as those done on the consumption equation residuals, with the same results. In particular no individual effects were found significant and we used robust pooled OLS to estimate the coefficients and their standard errors.

2.4.1.3 The imports equation (see table 7, column 5)

Aggregate imports growth depends positively and significantly on lagged income growth, on inflation, and on changes in the exchange rate: imports increase if internal demand grows, if domestic prices increase (and domestic goods are substituted with imported goods), and

[8] See Galeotti, Journal of Economic surveys, 1999 for a review of the literature on investment equations

if the nominal effective exchange rate[9] increases. There is a slight evidence that FDI's finance imports in Eastern European countries (The coefficient attached to FDI is positive but not significant).
In MASST inflation and exchange rates are not endogenously modelled and are actually taken as exogenous variables under the assumption that they are economic policy instruments controlled by national or supranational (in the case of EMU members) authorities.
We estimated the parameters of this equation using robust pooled OLS.

2.4.1.4 The exports equation (see table 7, column 4)

In standard Keynesian demand driven macro models, exports are taken as exogenous, that is they are only determined by the demand of the Rest of the World. We prefer to model exports in European countries as a function of supply as well as demand factors, in particular as a function of internal competitivity as measured by both unit labor costs and the exchange rate. A decrease in competitivity (i.e. an increase in unit labor costs) will slow down exports and so will an increase in the nominal effective exchange rates . The constant in this equation where the dependent variable is the growth rate of aggregate exports may be interpreted as the average rest of the world's demand growth.
The estimation was done with robust pooled OLS on a sample which excludes some outlier observations, mainly the observations relative to Romany before 1999, where and when inflation took on up to four digits values.

2.4.1.5 The 'pseudo' identity (see table 7, column 6)

The last equation in the national model is derived from the National Accounts identity: aggregate income plus imports (Y+M) must equal the sum of consumption, investments , public expenditures and exports, (C+I+G+X). By applying the total differential formula to the identity and by doing some simple algebraic manipulations we obtain:

$$
\begin{aligned}
& Y = C + I + G + X - M \rightarrow \Delta Y = \frac{\partial Y}{\partial C}\Delta C + \frac{\partial Y}{\partial I}\Delta I + \frac{\partial Y}{\partial G}\Delta G + \frac{\partial Y}{\partial X}\Delta X - \frac{\partial Y}{\partial M}\Delta M \\
& \rightarrow \frac{\Delta Y}{Y} = \frac{\partial Y}{\partial C}\frac{C}{Y}\frac{\Delta C}{C} + \frac{\partial Y}{\partial I}\frac{I}{Y}\frac{\Delta I}{I} + \frac{\partial Y}{\partial G}\frac{G}{Y}\frac{\Delta G}{G} + \frac{\partial Y}{\partial X}\frac{X}{Y}\frac{\Delta X}{X} - \frac{\partial Y}{\partial M}\frac{M}{Y}\frac{\Delta M}{M} \qquad (4) \\
& \rightarrow \frac{\Delta Y}{Y} = \eta_{YC}\frac{\Delta C}{C} + \eta_{YI}\frac{\Delta I}{I} + \eta_{YG}\frac{\Delta G}{G} + \eta_{YX}\frac{\Delta X}{X} - \eta_{YM}\frac{\Delta M}{M}
\end{aligned}
$$

The result in [1] states that the income growth rate is equal to the weighted sum of the aggregate demand components and the weights are the elasticities of income with respect to each component, ($\eta_{Yj}, j = C, I, G, X, M$).

2.4.2 The regional estimates

The approach followed to estimate the parameters in the regional block of equations was mostly imposed by data availability issues. Some of the variables needed to estimate the regional growth differential equation and the population and migration equations are available for almost all 259 regions in our sample for years 1995 through 2002. Such was the case for regional income as well as for population , for example. However, some other

[9] See Table 2.1 for the exact definition of the variable NEER. This indicator of the nominal effective exchange rate computed by Eurostat, increases as the country's competitivity decreases, due either to an increase of inflation relative to commercial partners' inflation, or due to a revaluation of domestic currency relative to partners' currencies.

relevant variables, such as human capital (HK) or accessibility and infrastructure measured through the kilometers of available roads in any region, are available only for one year, year 2000 in most cases. Lastly some territorial variables keep constant through time because of their nature. Thus it was not possible to use the available data as a panel and estimate the relevant parameters using panel techniques. We chose to estimate all equations in the regional block on one cross-section, i.e. on the sample that consists of 259 regions for one year. As it is going to be made clearer later on, the information along the time dimension whenever available hasn't been forgotten and it has been used to solve some specification and strictly econometric issues that relate to the possible correlation between some of the regressors and the error term of the equations and to the likely presence of spatial correlation in the estimated residuals[10]. All equations have been tested for spatial dependence using the spatial regression and testing modules in STATA[11], and a distance matrix consisting of the distances in kilometres between all couples of regions in the sample.

It results that only in one of the equations, the young workers net immigration equation (see later on) , the residuals are characterized by spatial dependence, and the appropriate estimation technique needed to be used. For all other equations robust OLS estimates were performed.

[10] See Anselin, 1999.

[11] See Maurizio Pisati, Tools for spatial data analysis, STATA Technical Bulletin Reprints Vol.10, pp.277-298,2001

Regional Growth Differential	
	s_r
Δ%POP $_{r,-1}$	0.646**
Sp	91.231*
Sp*agglom	-88.376**
Sp*urban*deast	-98.691**
Lbarrier*deast	-29.030
Lbarrier* dwest	14.276
HK*Deast	0.075**
HK*urban	-0.012
Noroad	-0.133
Noroad*agglom	0.127
Energy	0.007**
Energy*empter	0.000**
empter	0.059**
Selfempl	0.045**
pillar2	0.030**
Megas	0.520**
Rural	-0.570
Constant	-5.253**
R2	0.3
#observations	227

Block of Demographic equations					
	Migration 17-27	*Migration 32-42*	*Migration 52-67*	*Δ%POP*	*Selfempl*
Migration 17-27				0.012**	
Migration 32-42				0.046**	
Migration 52-67				-0.014	
$Y^{pc}_{r,-1} - Y^{pc}_{-r,-1}$	1.140**				
$(Y^{pc}_{r,-1} - Y^{pc}_{EU,-1})$*deast		0.199**			
$(Y^{pc}_{r,-1} - Y^{pc}_{EU,-1})$*dwest		-0.341**	-0.359**		
unemployment $_{r,-1}$	-0.730**	-0.926**	-0.570**		
Share of tertiary activities $_{r,-1}$			0.053**		
Mega regions	3.590**				
Dummy east	15.290**				
Agglomerated regions	5.408**	-2.268**	-2.878**	-0.181**	
Birth rate_r $_{r,-1}$				0.104**	
Death rate r $_{r,-1}$				-0.079**	
dnew12				-0.333**	
Structural funds					.012**
constant	1.589	7.611**	1.791	-0.084	11.07**
R2	.339	.304	.328	.646	.427
#observations	250	250	250	257	191
Lambda	-1.4E-05**				

Table 8 Regional estimates

2.4.2.1 The regional growth differential equation (table 8, columns 1 and 2)

As explained in the overall description of MASST, this equation is a quasi production function where potential regional output is determined by factors such as economic and human resources, structural and sectoral characteristics, spatial processes, integration processes and territorial specificities. More precisely, the dependent variable in this equation is s_r, the difference between regional and national growth: $s_r = \Delta\%Y_r - \Delta\%Y_N ; r \in N$, while table 9 lists and classifies all the relevant explanatory variables.

Let's discuss the estimated specification in detail starting with the dependent variable.

- Regional income is available for years 1995 through 2002 for most regions, and income growth rates and s_r from 1996 on. Yearly growth rates measure, by definition, only short term fluctuations and it does not seem correct to estimate a function that links output to structural factors using strictly short term variations in output as the dependent variable: how can you try and explain the relation between, say, human capital and output when you limit your attention to the change in output in just one given year, when lots of observable and unobservable contingent factors may have caused an abnormal change in output in that year in any subset of regions? We prefer to use as the dependent variable the average regional-national income growth differential between 1999 and 2002, so as to smooth out any abnormal fluctuations in regional income.
- While dealing with production functions we must acknowledge that output and production factors are actually jointly determined : output is a function of production factors, but the latter are demanded by firms as a function of (planned) output (as well as of factor prices). In econometric terms, production factors used as regressors and measured

at the same time as the dependent variable will be correlated with the error term of the equation, and induce inconsistent parameter estimates. For this reason, in the s_r equation we introduce the lagged in time proxies of the production factors whenever possible: labor, for instance, is proxied by the average population growth rate between 1995 and 1998. This regressor may be defined as a predetermined variable and will not be correlated with the error term in the equation, which we assume to be serially independent.[12]

- Unfortunately, for other production factors and sectoral characteristics (share of tertiary employment, for example) we only have data collected in year 2000 (one of the years used to compute the dependent variable). In this case (see the human capital, the energy resource and the infrastructure variables) we make the assumption that their quantity, although measured in year 2000 was actually determined by previous years' incomes and activity levels. Thus we treat also these variables as predetermined variables and we assume them to be uncorrelated with the error term in the equation.
- The economic (spillover) and integration potential variables (sp98 and lbarrier) are computed, for each region/observation as weighted averages of the income growth rates of the other regions in the sample, using as weight the distance matrix. If there exists spatial correlation among the error terms in the regional differential income growth equation, these spatially lagged regressors will be contemporaneously correlated with the error term. To avoid this simultaneity problem, and given the availability of data on regional income for years before 1999, we used spillover and potential integration variables computed on lagged in time income growths. Once again we rely on the property of consistency of OLS estimators that holds when regressors and error term are not contemporaneously correlated and error terms are not serially correlated.
- We tested for spatial dependence and found we could accept the null hypothesis of no spatial correlation in the error terms. We estimated the model with robust OLS.

Classification	*Label*	*Type*	*Definition*
Production factor	Δ%POP	predetermined	Lagged (in time) Population growth
Economic and integration potential factors	Sp	predetermined	Lagged (in time) spillover variable $Sp_{r,t} = \sum_{j \neq r} \Delta\%Y_{j,t-1} / dist_{jr}$ *
	Lbarrier	predetermined	Lagged (in time) potential economic integration $lbarrier_{r,t} = \sum_{j \neq r} \left(\Delta\%Y_{j,t-.1} - \Delta\%Y_{r,t-1}\right) / dist_{jr} - \sum_{j \neq r} \left(\Delta\%Y_{j,t-1} - \Delta\%Y_{r,t-1}\right) / dist_{jr}^{m}$
Production factors and sectoral characteristics	Human capital	predetermined	Human capital
	noroad	predetermined	Infrastructure
	energy	predetermined	Energy resources
	Share of tertiary activity	Predetermined/intermediate policy target	Share of tertiary employment
	selfempl	F(Structural funds)	Selfemployed
Economic policy instrument	pillar2	Policy instrument	Agriculture transfer funds
Territorial specificities	Megas, agglom, Rural,urban,deast	Dummy variables	

* $dist_{jr}$ is the distance in km between region r and region j.

Table 9 List of variables in the s_r equation

[12] It is not possible to test for serial correlation within each region, given that ,with the available data ,we can only estimate one crossection in time.

Columns 1 and 2 in Table 8 show the estimation results. The R^2 of the equation is 0.3, not terribly large. Once again remember the dependent variable in this equation is a difference in growth rates, almost a random variable itself. The coefficients of most of the relevant variables are however statistically significant.
On the whole, the estimated regression tells us that regional income grows if the neighbouring regions grow, where labor, human capital and energy are more available, where the share of tertiary economic activities is larger, and in response to 'Pillar' funds. Spillover effects and productivity of all factors of production tend however to become negative in agglomerated and urban areas, where, presumably, economies of scale have already been exhausted, while negative externalities from over concentrated activities tend to become sizeable. Note the opposite (although non significant) sign for the potential economic integration variable between East European and West European countries: dropping the barrier between the 15 old and the 10 new EU members benefits the old EU members that find a new market to expand into, while the ten new EU members suffer, at least initially (as theory predicts, see the J effect), a loss of potential growth. In 2007 Bulgaria and Romania are going to enter the European Union and it is plausible to think that the fall of this further legal and economic barrier will induce in the border regions the same type of effect as the one captured by these estimates: border regions belonging to the current 25 EU countries will enjoy benefits from the opening of new markets, while the border regions belonging to Romania and Bulgaria will lose some of their potential production.
Lastly, self-employed labor force enters with a positive sign into the regression. Note that the model specifies and estimates (see column 8 in table 8) self-employed as affected by structural funds decided upon jointly by European and National Economic policy makers, thus MASST is able to analyse the effects of another relevant policy instrument on regional growth.

2.4.3 The migration equations (see Table 8 columns 4, 5 and 6)

The model contains three equations that track the pattern of net immigration by age group: young, middle aged and older workers. Each of the three variables depends on time lagged income differentials between the region and the average EU income and on unemployment rates in the region. Territorial and socio-economic variables characterize each equation. After estimation, it results that younger work force migrates towards agglomerated and fast growing regions. Middle aged and especially older workers, instead, migrate away from highly concentrated and industrialized regions towards regions with a larger share of tertiary activities. Everybody runs away from areas with large unemployment rates.
We found statistical evidence of spatial dependence in the error term of the young workers net immigration equation, but not for the other two migration equations. Accordingly, we jointly estimated the parameters of the young workers equation and the coefficient of spatial dependence by Maximum Likelihood in the first equation[13], while using robust OLS for the parameters of the other two equations

[13] See Anselin, 1999, p. 16; see also the *spatreg* procedure in STATA by Pisati.

Classification	Label	Type	Definition
Economic factors	$Y^{pc}_{r,-1}$ - $Y^{pc}_{EU,-1}$	predetermined	Lagged (in time) per capita income differential between region r and average EU: $Y^{pc}_{r,t-1} - Y^{pc}_{EU,t-1} = \frac{Y_{r,t-1}}{POP_{r,t-1}} - \frac{Y_{EU,t-1}}{POP_{EU,t-1}}$
	$unem_{r,-1}$	predetermined	Lagged (in time) Unemployment rate in region r
Sectoral characteristics	empter	predetermined/intermediate policy target	Share of tertiary employment
Territorial specificities	Megas, agglom, deast, dwest	Dummy variables	

Table 10 List of variables in the migration equations

2.4.3.1 The population growth equation (See Table 8, column 7)

Last equation in the demographic block, population growth is specified as a function of net immigration, birth and death rates and territorial variables. Note that population growth also depends, via the contemporaneous migration variables on the lagged regional income. In fact, the demographic block of equations has been built along a recursive pattern: we assume that population depends on migration but migration does depend simultaneously on population growth. This very plausible assumption allows to treat the migration variables as non contemporaneously correlated with the error term of the population equation and to avoid simultaneity issues.
The dependent variable has been computed as the average population growth between 1999 and 2002 for reasons similar to those given for the choice of dependent variable in the growth differential equation.

Classification	Label	Type	Definition
Immigration variables	Migration between 17-27, Migration between 32-42, Migration between 52-67	endogenous	Net immigration by age group
Demographic variables	Birth rate	exogenous	Birth rate
	Death $rate_{r,-1}$	exogenous	Death rate
Territorial specificities	agglom, dnew12	Dummy variables	

Table 11 List of variables in the population growth equation

The tests accepted the null hypotheses of no spatial dependence or spatial lag and robust OLS were used to estimate the parameters of the equation. All the coefficients show the expected sign and are statistically significant with the exception of the one related to net immigration for older workers: this variable is irrelevant for population growth. The average population growth rate is lower in agglomerated areas and in regions belonging to the new EU member countries. The R^2 measure of goodness of fit reaches 65%.

2.5 Simulations with the MASST

2.5.1 The methodology of simulation

The MASST model, once it is estimated and all coefficients are obtained, behaves similarly to a normal forecasting model. The latest available actual data in sample (normally 2002, when not available an extrapolation on the past) is used to forecast the variables of the first period of simulation, the year 2003. After this year, all forecasts are based on the data forecasted for the previous year and on the values of the exogenous variables.

All equations are those described in section 2 of the report. In particular, it is important to remark that regional growth, in the model, is composed by the national component and the differential shift. For this reason:

- the model first forecasts the national growth rate using the equations of the national part;
- it then produces all the forecasts of the endogenous components of the regional differential shift;
- finally, the regional growth rate is obtained by adding the national growth rate and the differential shift.

With this growth rate, it is possible to forecast the level of GDP. The same procedure is applied to the population. Hence, GDP per capita estimates are possible.
The national and the regional growth rates produced in the model are fully compatible. In fact, the growth rate of the sum of GDPs of the regions of one country are identical to the growth rate forecasted by the national component of the model.
The model includes some endogenous and some exogenous variables. The endogenous variables are calculated by the model at each run (i.e. at each year), using the equations with the estimated coefficients.

There are a total of 12 endogenous variables:

At national level:
- real GDP growth rate;
- consumption growth;
- investment growth;
- import growth;
- export growth.

At regional level:
- real GDP growth rate calculated as differential shift;
- the share of self employed on total workforce;
- population growth;
- immigration of people between 17-27 years;
- immigration of people between 32-42 years;
- immigration of people between 52-67 years)
- spillovers, i.e. regional growth due to the growth of neighbouring regions.

All other variables are exogenous in the model, and can hence be used to produce different scenarios.
In order to produce simulations, the values of the exogenous variables are to be introduced for each year and each geographical unit. This can be accomplished with an ad-hoc procedure, providing ad-hoc values, but this procedure would be very hard in terms of data entering and, more important, would not make explicit enough the actual hypotheses on

which the scenario is built upon. To have an idea, to simulate the model for 13 year, the period until 2015, 2108 values of exogenous variables are needed at national level and 30303 at regional level.
A significant reduction in the number of values to be entered can be achieved through the procedure of 'targets'. We can in fact assume that any regional or national starting value tends to achieve a long-run value, adjusting to it with a given speed of adjustment. The formula is therefore:

$$x_t = x_{t-1} + s(T - x_{t-1}) \qquad (5)$$

where *x* is the value of the exogenous territorial variable for a given region/country, *T* is the long run (target) value to which the variable converges and *s* is the speed of adjustment. A value of 1 in the speed of adjustment implies an immediate adjustment (in one year) of the variable to its target.
The target values can be the same for all geographical units (for example, at national level, the growth rate of public expenditure in the baseline scenario), can be different for each geographical unit and entered as a vector (for example, at regional level, the CAP expenditure) or can be differentiated by regional/country typologies.
The latter is a very interesting feature given by the MASST model: for example, the targets of employment in tertiary activities has been differentiated by regional typologies, i.e. megas and agglomerated regions versus urban and rural regions in addition to EU15 and other countries. The use of targets implicitly implies the convergence of the same type of regions towards the same long run value.
Also the speed of adjustment can be differentiated between geographical units and/or by type of variable. In the scenario design process, structural variables (e.g. the birth and death rates) are always assumed to adjust very slowly, with an adjustment coefficient of 0.1. The non structural values are assumed to react more rapidly. In the same way, the adjustment speed of policy variables is generally higher, but can be differentiated according to the assumed efficiency of public administrations in the implementation of policies, for instance, it is always assumed to be 0.8 for old EU15 members and 0.5 for the new members of the EU.

2.5.2 The simulation algorithm

The way in which the recursive mechanism works over time in a forecasting model is of great importance for the full understanding of the logic hidden behind the simulation procedure.
In the case of our MASST model, the simulation algorithm has a particular role, that of creating a purely generative forecasting model of regional growth. In other words, our intention was to create a model in which regional dynamic patterns play an active role in explaining national growth, and not only a distributive role of national growth.
A conceptual difference between ex-post and ex-ante national growth can be useful, and finds an operational treatment in MASST. The ex-post national growth cannot be anything else than the weighted sum of regional growth of all regions belonging to that nation. If an ex-post, competitive, approach to growth is chosen, the regional blocks of equations play only the role of distributing national growth among regions of the country. On the contrary, an ex-ante, generative, approach leaves open the possibility that national growth is obtained thanks to the performance of single regions, and therefore that regional growth plays an active role in defining national growth.
Our conceptual and operational approach follows the second definition: in MASST, the regional sub-model explains part of the national performance, as is the case in bottom-up, regional growth model, in which the competitiveness of single regions participate actively in the identification of national growth patterns.

	year 2003		year 2004 (and following)
Estimated national growth	A_{2003}) Calculation of actual *national growth* with the national model. (output of MASST in 2003).	→	A_{2004}) Calculation of actual *national growth* with the national model. (output of MASST in 2004).
	B_{2003}) Calculation of *regional differential shift* with the regional blocks of equations.		B_{2004}) Calculation of *regional differential shift* with the regional model.
Estimated regional growth	C_{2003}) Regional growth is calculated as the *sum of A and B*, where B is rescaled to have 0 mean within each country. (Output of MASST in 2003).		C_{2004}) Regional growth is calculated as the *sum of A and B*, where B is rescaled to have 0 mean within each country. (Output of MASST in 2004).
	D_{2003}) Potential regional growth is equal to the *sum of A and B*. Potential national growth is equal to the weighed average of potential regional growth rates.		D_{2004}) Potential regional growth is equal to the *sum of A and B*, non rescaled. Potential national growth is equal to the weighed average of potential regional growth rates.

** Last year with actual data is 2002.*

Table 12 Logic of the simulation procedure

Operationally, MASST treats ex-ante and ex-post national growth rates as follows. In the first year of simulation (2003), a value for national growth is obtained from the national sub-model (point A in Table 12); at the same time a value for the differential shift is obtained from the regional sub-model (point B in Table 12). The purely generative feature of the MASST model is contained in its simulation algorithm, by distinguishing between:

1) *ex-post national growth rates*, obtained as the sum of the weighted regional growth rates of the nation, rescaled in order to obtain from the regional blocks of equation the same national values as the one obtained by the national blocks of equation (point C in Table 12). In other words, the increase in national growth obtained by the increase of regional economies is proportionally subtracted in order to cancel the generative effect: by doing so, the regional blocks of equations have ex-post only a distributive role of national growth; and
2) *ex-ante national growth*, conceptually embedding the potential production capacities of each single region and influences national growth. Operationally, the generative element is taken into consideration through the inclusion of the weighted sum of the

regional growth rates, influencing national growth through choices regarding investments, consumption, imports at the beginning of the following year (point D in Table 12). Thanks to this simulation algorithm, MASST is purely generative: ex-ante regional growth rates play an active role in defining national growth. Ex-post, the national identity is fulfilled.

2.5.3 A sub-model for Switzerland and Norway

As agreed by the ESPON Monitoring Committee and by the Coordination Unit, Switzerland and Norway have been introduced in the quantitative forecasts on the basis of a simplified, extrapolative / comparative sub-model. The main trends and driving forces present in each scenario are considered and included in the forecasting process, as well as the importance of the territorial specificities of the single regions of the two countries. What is not replicated is the comprehensive interregional interaction logic of the whole model (with the international spill-over effects stemming from the two added countries) and the internal consistency of the macroeconomic forecasts. Therefore, as far as the internal work of project 3.2. is concerned, nothing has changed with respect to the forecasts on 15+10+2 countries.

As in this case the MASST model has not been re-calibrated, present availability of data concerning the two countries have been sufficient. Results, integrating the MASST maps with extensions to the two countries, are provided in this report, and comments are made on the relative position of the two countries vis-à-vis the main tendencies emerged in MASST.

2.6 Intrinsic characteristics of the quantitative forecasts

2.6.1 The logic of the forecasting methodology

A correct interpretation of the results requires a deep knowledge about the logic behind the forecasting methodology and behind the model itself.
Concerning the methodology used for the quantitative scenario formulation, our approach assumes the characteristics of an integrated process, of an analytic and synthetic approach at the same time; it links past and future in a joint effort of imagination and control of the complex causal relations revealed by the estimation procedure (on past trends and structure). The logic behind is the following:

- starting from a 'seminal idea' on the driving forces which are believed to characterize the future economic-territorial development and
- going through an examination of the main past tendencies of these elements (developed together with the all Espon 3.2 group)
- the basic elements of a scenario are built (the big conditional elements, the big possible bifurcations in the driving forces)
- a model of careful analysis of the past causal relationship and trends is built (an econometric model)
- on which a forecast is possible if the conditional assumptions assumed in the first steps are introduced in the estimated model.

The scenarios which are built therefore have the characteristics to be:

- *conditional scenarios*, since they depend on the hypotheses of evolution of the driving forces chosen as determinant for the development of the economic-territorial system;
- *quali-quantitative scenarios*, since the conditional (quantitative) assumptions are based on the evolution of the driving forces, formulated in qualitative terms. When these assumptions are inserted in a quantitative model estimating the causal relations, they

allow to identify the magnitude of the likely effects. Therefore, our scenarios depict *tendencies and relative behavioural paths* of the endogenous variables in each single region that will take place in the economies under certain conditions, i.e. probable states of the systems which could become real under certain conditions exogenously assumed; therefore they should not be taken as precise quantitative values of the endogenous variables in the single regions and countries.

2.6.2 Consequences on the forecasting exercise

It is in the logic of the forecasting methodology that the assumptions made on the different scenarios orient the forecasting results. *However, they do not explain all the results* because of the existence of a huge complexity in the causal relationships estimated; regional growth, in fact, does not depend solely on exogenous assumptions made and imposed to exogenous variables but also on the interaction among them and with the endogenous variables (like spatial spillovers, or effects of the increase in potential market due to EU enlargement). The final result cannot deterministically be linked to the value of single exogenous variables and could not easily be obtained without or outside the model.
Moreover, the *complexity of the causal relations* internal to the model explaining regional growth is responsible for *counterintuitive results* with respect to the assumptions made or to some straightforward expectations. An example of a counterintuitive result is the increasing regional disparities inside the single country even in the cohesive scenario, built on assumptions supporting growth in less advanced, peripheral and rural areas.
The results are therefore obtained by a complex and intertwined set of causal relationships; assuming the same structural relationship between endogenous and exogenous forces as in the past, the model is able to predict which regions will be winners and losers under certain conditions.
The structural sub-model explaining demographic trends is built with a lower degree of *complexity*; as a result, the outcome of the forecasting exercise is more directly linked to the assumptions made. In fact, in the case of the demographic trends, the qualitative predictions made in the whole Espon 3.2 group has strongly influenced the aggregate result; the model was in fact calibrated according to the assumption that the total population level in EU27 should remain stable. Moreover, the qualitative assumptions regarding natural population growth and migration flows are exactly the opposite in the baseline and in the cohesive scenarios, with the result that the aggregate population level reached in the two scenarios is rather similar.

For what concerns the exogenous elements (the driving forces) that differentiate among the three scenarios, the assumptions on their future trend have been differentiated:

- by *old (EU15), New 10 and future Accession countries (Bulgaria and Romania)*, for what concerns the national sub-model;
- by *macro-typologies of regions* - urban and rural, on one side, and megas and agglomerated on the other – and by *old (EU15) and new (plus Bulgaria and Romania) European countries*, ending up with four categories, for what concerns the regional sub-model.

The territorial distinctions are necessary given the very high discrepancy among countries in the past trend of the exogenous variables. A unique target value for all regions and countries would have had the consequence of:

- imposing exogenously a convergence trend towards a single value for each driving force, independently from the present value (the starting point) of each country or region;
- favouring exogenously some territories with respect to others.

On the other hand, the distinction of different target values for the driving forces allows us:

- to take structural distinctions into account;

- to overcome the limitation that *not all possible driving forces* are taken directly into consideration in our model. Some important driving forces, like technological changes, climate changes, changes towards a knowledge society - missing in our model – would certainly have differentiated territorial effects, which are partially taken into consideration by giving different target values to the driving forces taken into consideration.

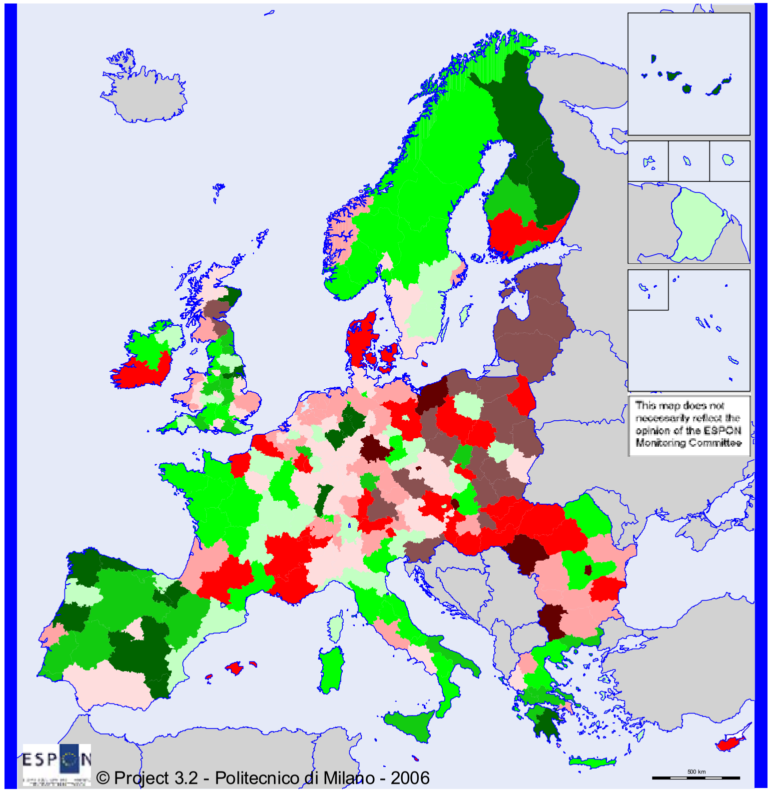
As explained before, the applied methodology provides future economic and demographic *trends*, and not precise *values* of the economic and demographic variables in he single region in the future; both the values assigned to the target variables and the values emerging from the final results indicate an *order of magnitude* and *behavioural classes* (high-medium-low increase or decrease) rather than precise quantitative values.

2.7 Results of the baseline scenario

Map 1 presents the GDP growth rate in 2015 under the baseline scenario assumptions. The results are the following:

- *a clear Eastward shift of the European barycentre of growth*, with a clear advantage for Eastern countries;
- *a greater performance of the Eastern border regions in Western European (EU-15) countries*, from Denmark to Germany and Austria, accompanied by *a general slow-down in the growth of more peripheral countries and southern regions*;
- *a mitigation of the Irish miracle*, in particular in the north of the Irish Republic;
- *a general lower growth of GDP of all Western Europe* with respect to Eastern countries, and in particular in Central and Southern Italy, Greece, North-Western Iberia, North-Western France, Western England, Northern countries;
- *a general relatively good but not a top performance of global cities* (mega and agglomerated regions): London, Paris, Madrid, Barcelona, Lisbon, Milan, Rome, Helsinki, Berlin, Vienna, Warsaw, Hamburg, Frankfurt, Düsseldorf, Stuttgart, Munich and Zurich. The present scale diseconomies and bottlenecks accompanying today the growth of large cities show their negative effects also in the future;
- *a relatively higher performance of 'potential megas'*; among them, Lyon (Rhône-Alpes), Nice and Marseille (Provence-Côte d'Azur), Le Havre (Haute Normandie), Toulouse (Midi-Pyrénées), Edinburgh, Oslo (Norway).

Map 1	*Map 2*
Real GDP growth rate 2015 - Baseline scenario	Per capita GDP in 2015 - Baseline scenario



Annual % change
- < 2.28
- 2.28 - 2.46
- 2.46 - 2.63
- 2.63 - 2.81
- 2.81 - 2.99
- 2.99 - 3.26
- 3.26 - 3.62
- 3.62 - 4.12
- > 4.12
- No data

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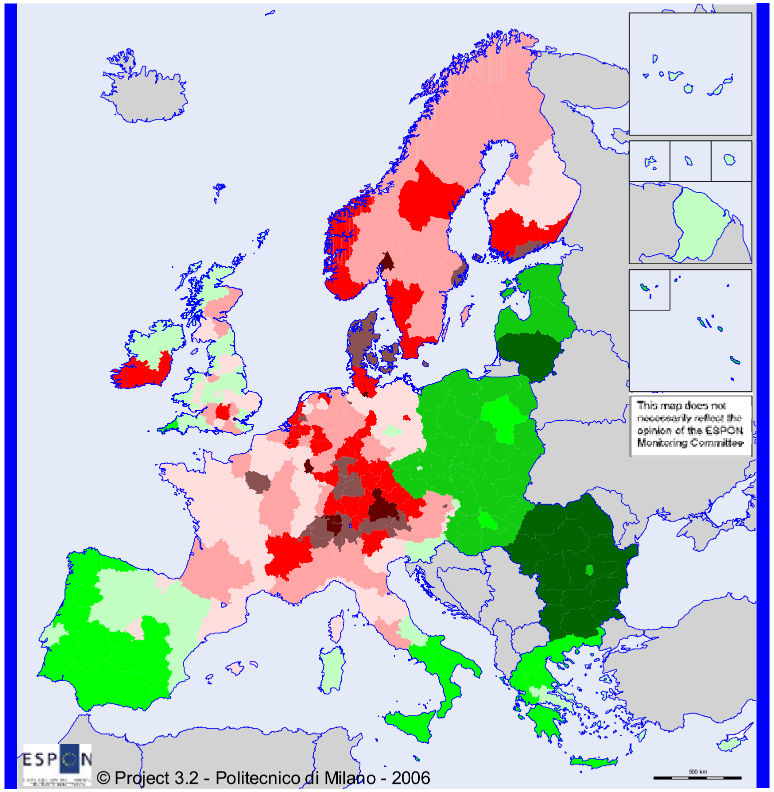
Source of data: output of MASST model, 2006



Thousands of Euro at 2000 prices
- 1.329 - 3.609
- 3.609 - 7.059
- 7.059 - 15.676
- 15.676 - 21.456
- 21.456 - 26.509
- 26.509 - 31.614
- 31.614 - 40.246
- 40.246 - 53.669
- 53.669 - 69.875
- No data

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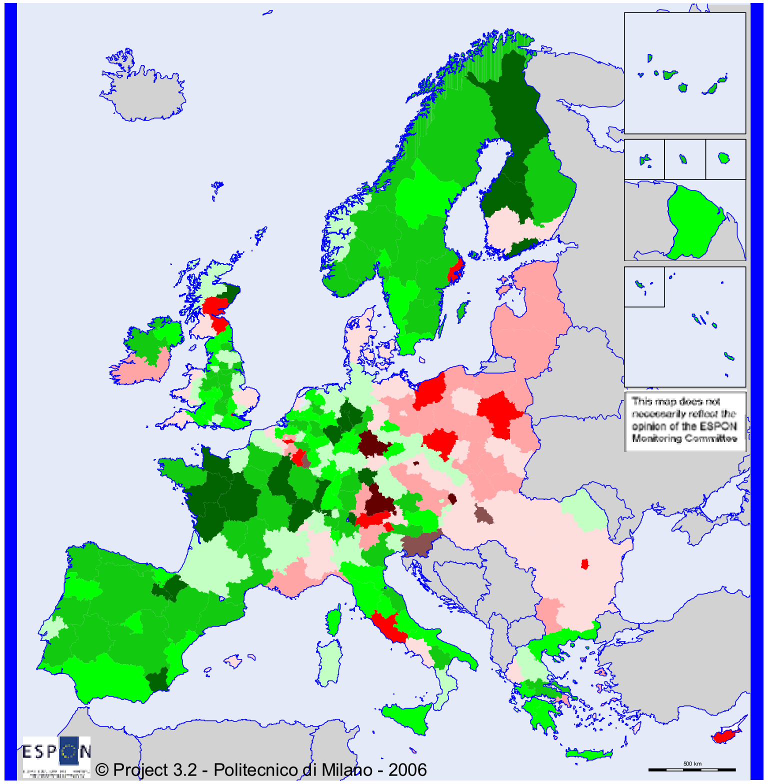
Source of data: output of MASST model, 2006

Map 3	Map 4

Map 3

Change in relative position 2002-2015 - Baseline scenario



% of EU27 mean
- < -10
- -10 - -5
- -5 - -2.5
- -2.5 - 0
- 0 - 2.5
- 2.5 - 5
- 5 - 10
- 10 - 15
- > 15
- No data

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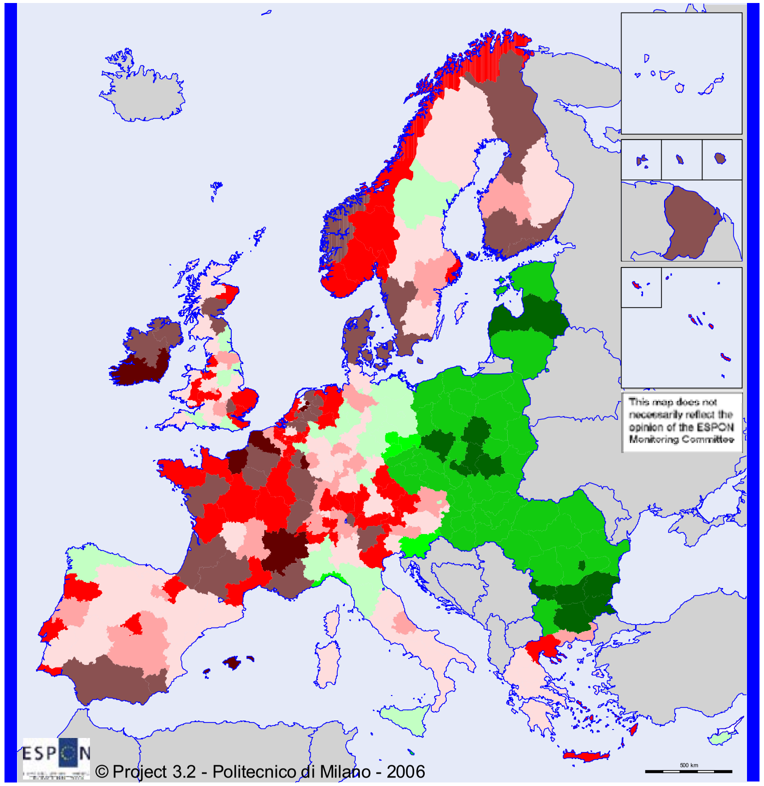
Source of data: output of MASST model, 2006

Map 4

Population growth rate 2015 - Baseline scenario



Annual % change
- < -0.66
- -0.66 - -0.46
- -0.46 - -0.2
- -0.2 - -0.09
- -0.09 - 0
- 0 - 0.03
- 0.03 - 0.1
- 0.1 - 0.2
- > 0.2
- No data

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Source of data: output of MASST model, 2006

Map 2 presents the results of the per capita GDP level achieved in 2015, witnessing additional tendencies, namely:

- *the catching-up of Eastern countries remains rather incomplete*, since the East-West per-capita GDP differential will persist in the future. Among Eastern countries, the lowest level of per capita GDP is registered in Romania and Bulgaria, which suffer from the assumption in the baseline scenario that they will benefit from European structural funds only since 2007;
- regional disparities will very slightly decrease in the baseline scenario, as a result of two opposite tendencies: a decrease of the disparities among countries, counterbalanced by an increase of the disparities within countries (see the Theil index in Fig. 2);
- *peripheral regions of Western countries confirm their lower income level with respect to the EU average*: Greece, Southern Italy, Spain (with the exception of Madrid), Portugal, Northern Ireland still demonstrate their weakness, despite the assumption that the structural and cohesion funds are maintained;
- *the Pentagon area maintains its relatively high income level*, together with France and Northern and Central Italy;
- *the highest per capita income level is measured in Central-Southern Europe and in some regions of Northern countries*, and in particular in Southern Germany and Austria, and also in regions like the Randstadt-Holland, Southern Ireland, Denmark and some southern regions of Scandinavian countries.

Map 3 represents winners and losers; in fact, it shows the change in the relative position (with respect to the EU 27 mean) in per capita GDP level between 2002 and 2015. Winners are mostly present in Eastern countries; within Eastern countries, the most successful areas are the agglomerated regions (namely capital regions and large city regions). A different picture is presented in Western Europe. In this part of Europe, in general regions lose their relative position with respect to the EU average: the loss is higher in rural areas (central part of France, most of Spain, of Portugal, of Greece), while it is more contained in agglomerated and mega regions, like the Pentagon area, Southern England, Southern Ireland, most of Italian and Greek regions, Catalonia, Madrid and Valencia in Spain, Lisbon and Porto (Norte) in Portugal.

The demographic trends are presented in map 4, and they are the result of the assumptions on both the natural demographic trends and the migration flows. The emerging picture emphasises:

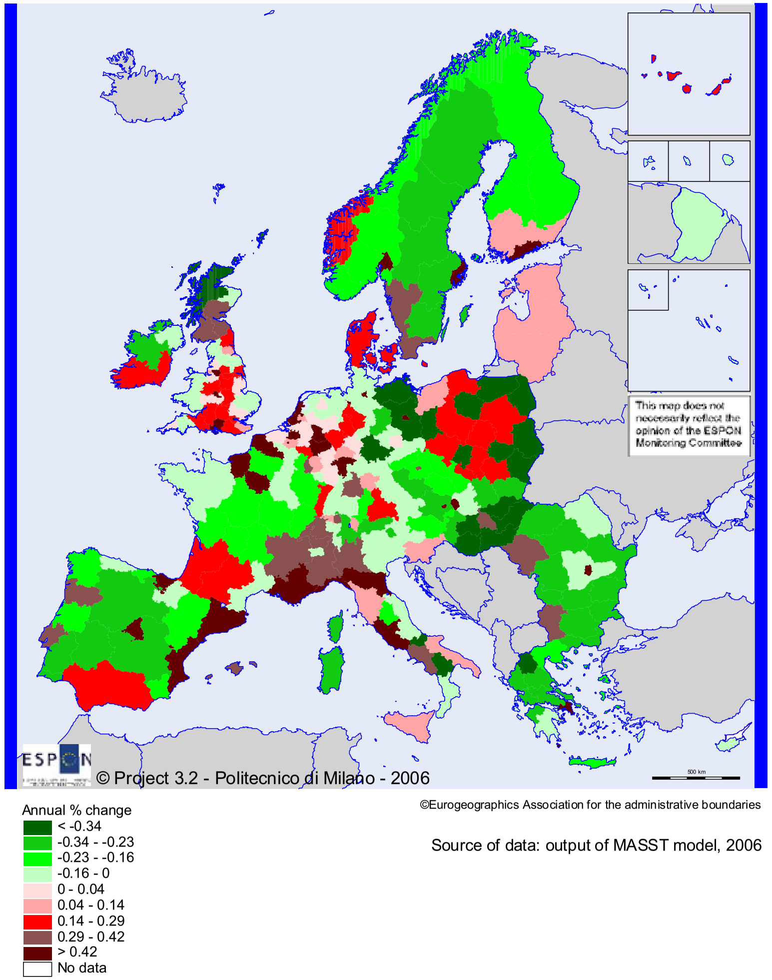
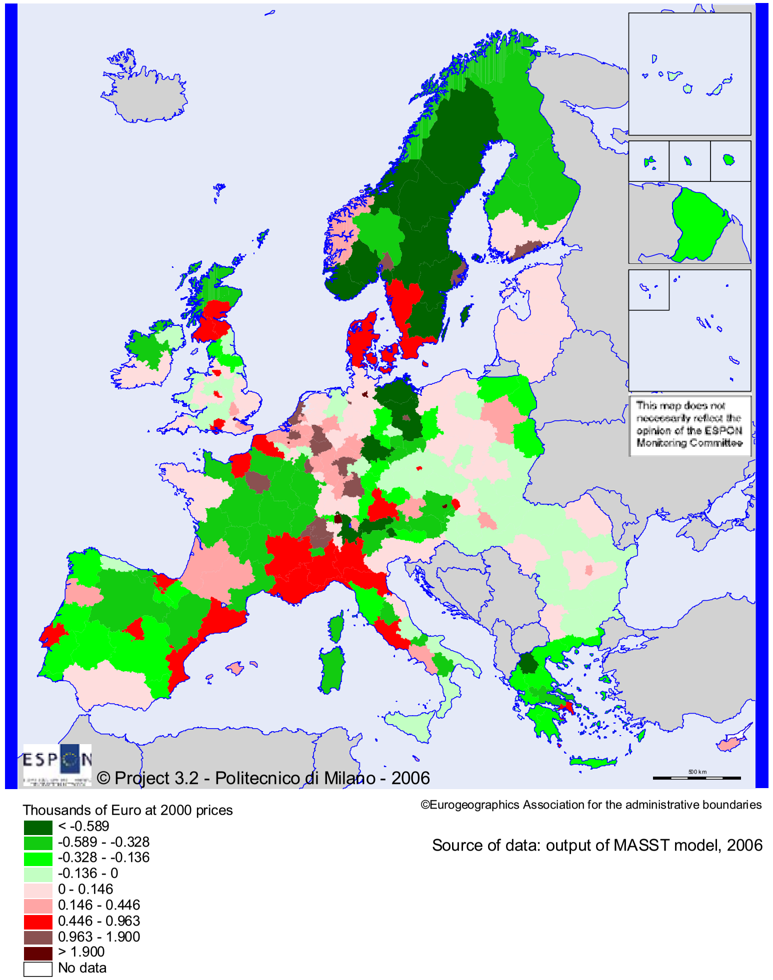
- the *strong negative demographic trend in all Eastern countries*, especially as a result of out-migration flows;
- *a tendency in Western countries towards a negative population growth*; this is especially true for rural areas in Spain, most of Italy, most of Germany, most of Greece, part of Great Britain;
- *a counter-tendency towards an increasing population* in France (a country with a high natural demographic growth also today), in most of Portugal, in both the Irish Republic and Northern Ireland, in Denmark, in The Netherlands, in South-Western Swedish regions, in most of Finnish and Norway regions, in Tyrol and Salzburg in Austria, and in Trentino Alto Adige (Italy).

2.8 Results of the competitive scenario

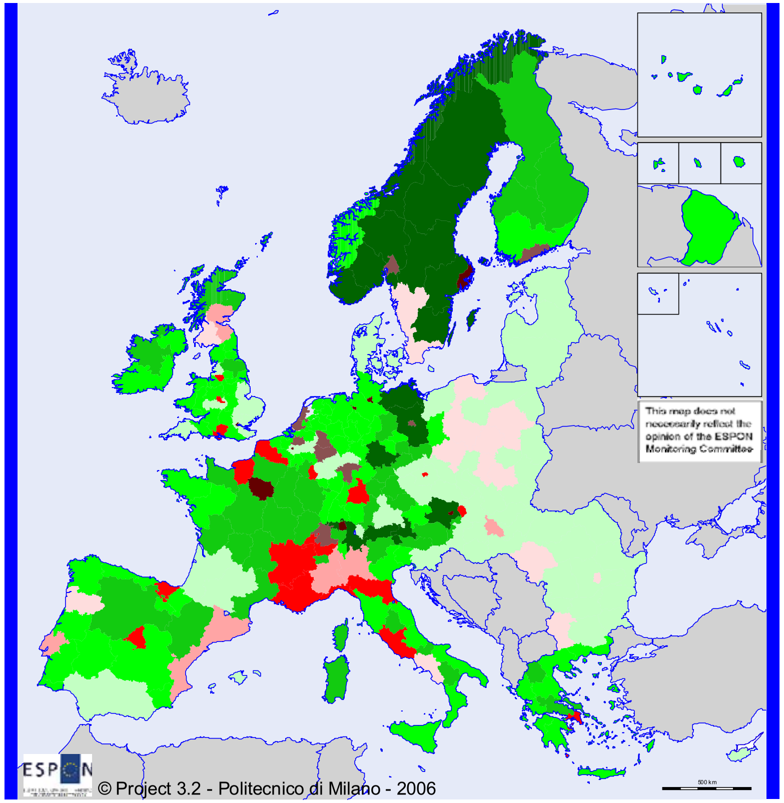
The competitive scenario registers a more expansive aggregate growth rate for Europe as a whole with respect to the baseline scenario, in line with the more generous assumptions on some target variables (0.19 percentage point higher than the baseline in all EU 27). The greatest increase in the GDP growth is registered in the EU 15 (0.20 percentage point more), followed by the New 10 area (0.08 percentage point more) and by Bulgaria and Romania (0.01 percentage point more), as last ones (Table 13).
With respect to the baseline, the more expansive GDP growth rate is in reality unevenly distributed in European regions. Map 5 in fact shows, with respect to the baseline scenario:

- *a clear tendency towards a more concentrated development in strong areas of each country*, reflecting the 'champions' growth assumptions. This tendency is confirmed by the Theil index presented in Fig. 3, where the intra-regional disparities drastically increase (and increase more than in the baseline scenario);

as a consequence, in Western Europe, *a reinforcement of some regions of the Pentagon area, together with most of Great Britain and Northern and Central Italy* countervail *the low relative performance of mainly rural areas* especially of Greece, Central France, Central Spain, Northern Scotland, Northern Ireland, the north of the Republic of Ireland and Denmark, and some Western regions of Norway ;

Map 5	*Map 6*
Real GDP growth rate 2015 - Difference between Competitive and Baseline scenario	Per capita GDP in 2015 - Difference between Competitive and Baseline scenario
	

Map 7	*Map 8*
Change in relative position 2002-2015 - Difference between Competitive and Baseline scenari	Population growth rate 2015 - Difference between Competitive and Baseline scenario



% of EU27 mean
- < -4
- -4 - -2.5
- -2.5 - -1
- -1 - 0
- 0 - 0.8
- 0.8 - 1.5
- 1.5 - 2.5
- 2.5 - 4
- > 4
- No data

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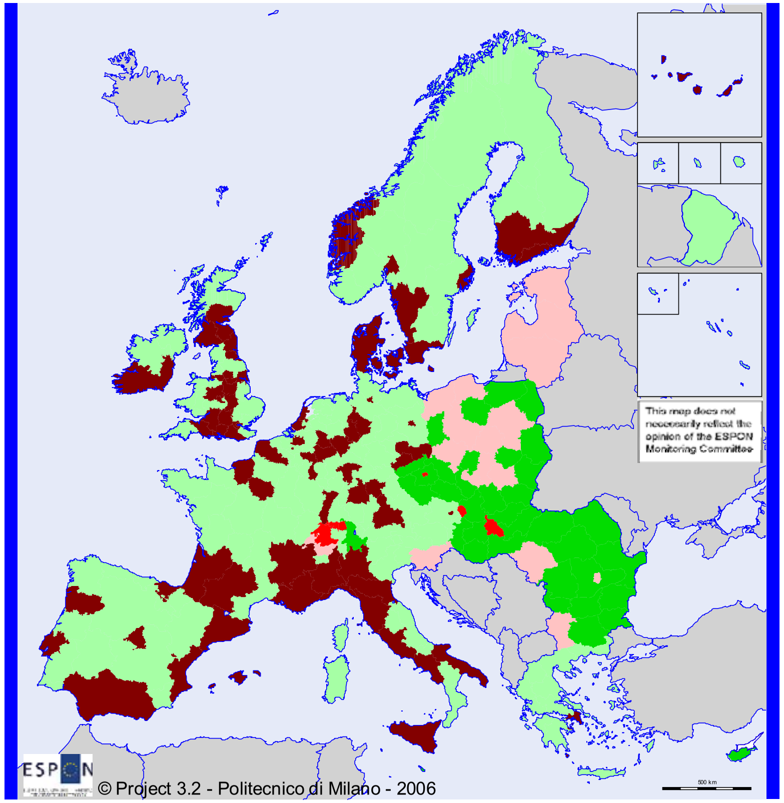
Source of data: output of MASST model, 2006



Annual % change
- -0.2 - -0.1
- -0.1 - 0
- 0 - 0.1
- 0.1 - 0.15
- 0.15 - 5
- No data

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Source of data: output of MASST model, 2006

- while the most peripheral regions are those performing relatively lower than the baseline scenario, *within peripheral areas, exceptions are presented by most of the megas*, reinforcing the tendency of a concentrated development. Lisbon and Porto in Portugal, Madrid, Catalonia, Valencia and Bilbao in Spain, Athens in Greece, Paris, Haute Normandie and Nord-Pas de Calais in Northern France, Oslo in Norway are all regions with a higher performance than in the baseline;
- while the assumptions favour growth in the megas and agglomerated areas, a less intuitive result is *the good relative performance with respect to the baseline scenario registered also by the potential megas*, like Cologne, Bonn, Bologna (in Emilia-Romagna), Nice and Marseille (Provence Côte-d'Azur), Zurich and Lyon (Rhônes-Alpes), Bratislava and Budapest;
- the trend towards *a more concentrated development is clearly evident in Eastern countries*, where all capital regions (with the addition of Timisoara) register a greater performance with respect to the baseline. On the contrary, in these countries*, all rural areas register a lower performance* than in the baseline.

Map 6 presents the per capita GDP level achieved in 2015 under the competitive scenario assumptions with respect to the baseline. Some main trends emerge, namely:

- the *catching up process between Eastern and Western countries is more pronounced* in the agglomerated and mega regions. In Eastern countries, these areas achieve in fact, with respect to the baseline, a higher per capita GDP. This trend explains the decisive increase in the intra-national regional disparities with respect to the baseline, presented by the Theil index in Fig. 2;
- a *higher per capita GDP level with respect to the baseline emerges in some regions of Western countries*, especially in the agglomerated and mega regions, in part of Scotland, in southern Ireland and in some regions of the Pentagon area, especially in Western Germany, in Benelux, in south-eastern England and in Western regions in Norway;
- the *same positive trend favouring mega and agglomerated areas* is depicted by the change in the relative position (map 7). With respect to the baseline scenario, agglomerated, capital, and mega regions are the winning regions, showing a better position relative to the European mean in 2015 than in 2002;
- on the contrary, the *relatively less favoured regions with respect to the baseline scenario* are mainly the rural regions; this is generally true for both Eastern and Western countries.

As a result of these trends, while intra-national disparities grow with respect to the baseline scenario, disparities among countries decrease more than in the baseline, thanks to strong catching up processes in lagging countries through their national champions (Fig. 2).

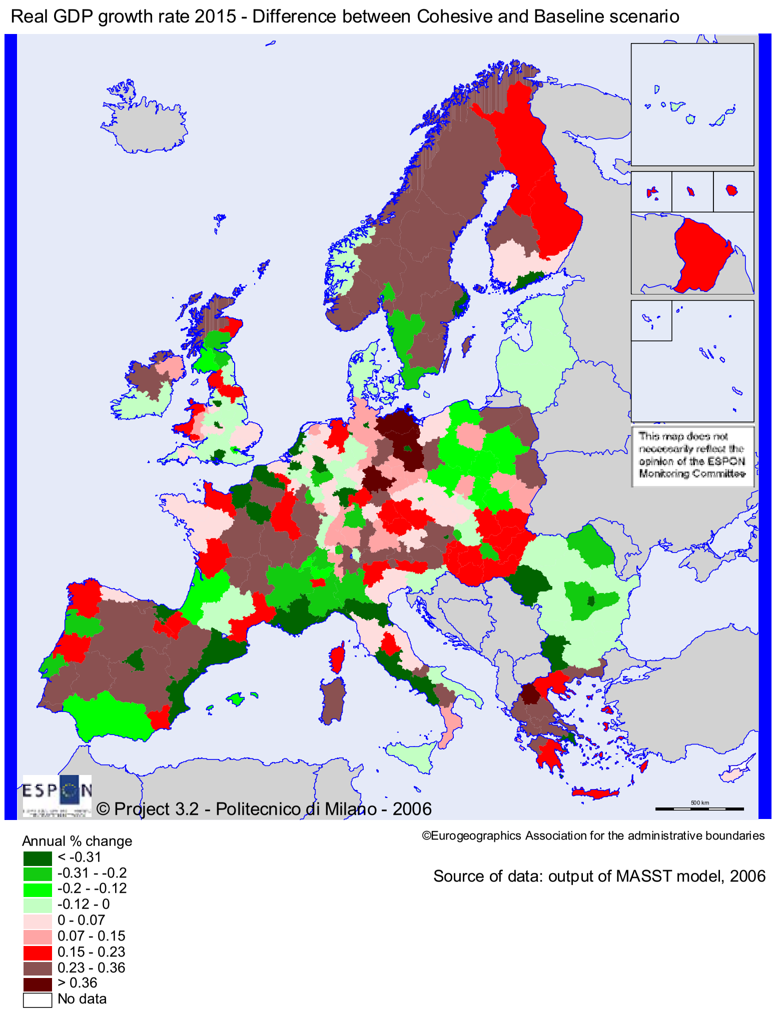
For what concerns winners and losers, map 7 shows the change in the relative position with respect to the baseline scenario. Interesting enough, most regions are losers with respect to the baseline scenario. Some exceptions exist namely: a) the northern-western and south-eastern regions in France and Italy, the capital regions in most countries (Rome, Madrid, Lisbon, Paris, London, Stockholm, Oslo and Helsinki); b) some coastal regions in The Netherlands and France; c) in Eastern countries, all agglomerated regions in Poland, and the industrialised regions of Bulgaria and Romania.

In terms of demographic trends, map 8 shows the following tendencies with respect to the baseline:

- *a concentrated development scenario emerges also in terms of population*. All megas and the engines of Europe register in fact a greater increase in population with respect to the baseline;
- *a more fragmented territorial trend is depicted in Eastern countries with respect to the baseline*. In particular, rural regions lose population more than in the baseline, while agglomerated and mega regions lose less population;
- *a clear concentration of population in economically growing areas is foreseen*; in the logic of the MASST model, in fact, population is at the same time attracted by and source of economic growth;

- *in Western countries, the same strong tendency towards concentration in agglomerated regions emerges*. All capital city regions in Western countries foresee a greater increase of population than in the baseline scenario;
- *some regions still keep the relatively better population growth they had in the baseline scenario also in the competitive scenario*; Denmark, South-Western Swedish regions, western regions in Norway, southern regions in Finland, Southern Ireland, Haute Normandie, Paris, Andalusia, Baleares, and the Costal Dutch regions present this relatively good performance in both scenarios.

Map 9


Real GDP growth rate 2015 - Difference between Cohesive and Baseline scenario
This map does not necessarily reflect the opinion of the ESPON Monitoring Committee
ESPON
© Project 3.2 - Politecnico di Milano - 2006
Annual % change
< -0.31
-0.31 - -0.2
-0.2 - -0.12
-0.12 - 0
0 - 0.07
0.07 - 0.15
0.15 - 0.23
0.23 - 0.36
> 0.36
No data
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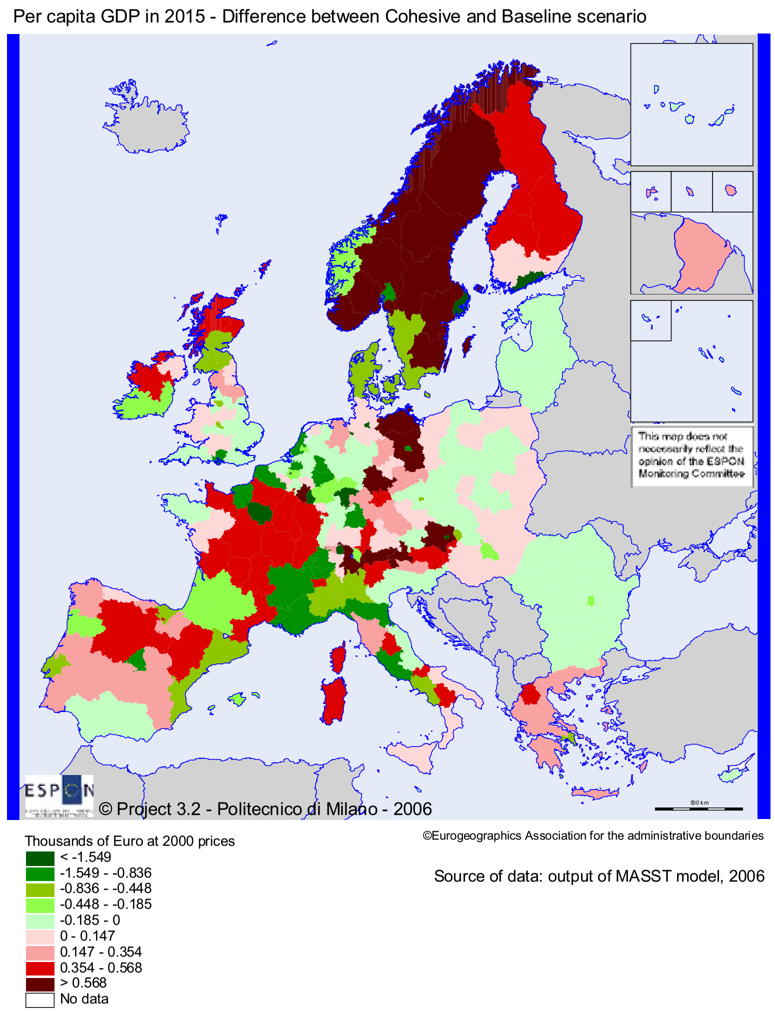
Source of data: output of MASST model, 2006

Map 10


Per capita GDP in 2015 - Difference between Cohesive and Baseline scenario
This map does not necessarily reflect the opinion of the ESPON Monitoring Committee
ESPON
© Project 3.2 - Politecnico di Milano - 2006
Thousands of Euro at 2000 prices
< -1.549
-1.549 - -0.836
-0.836 - -0.448
-0.448 - -0.185
-0.185 - 0
0 - 0.147
0.147 - 0.354
0.354 - 0.568
> 0.568
No data
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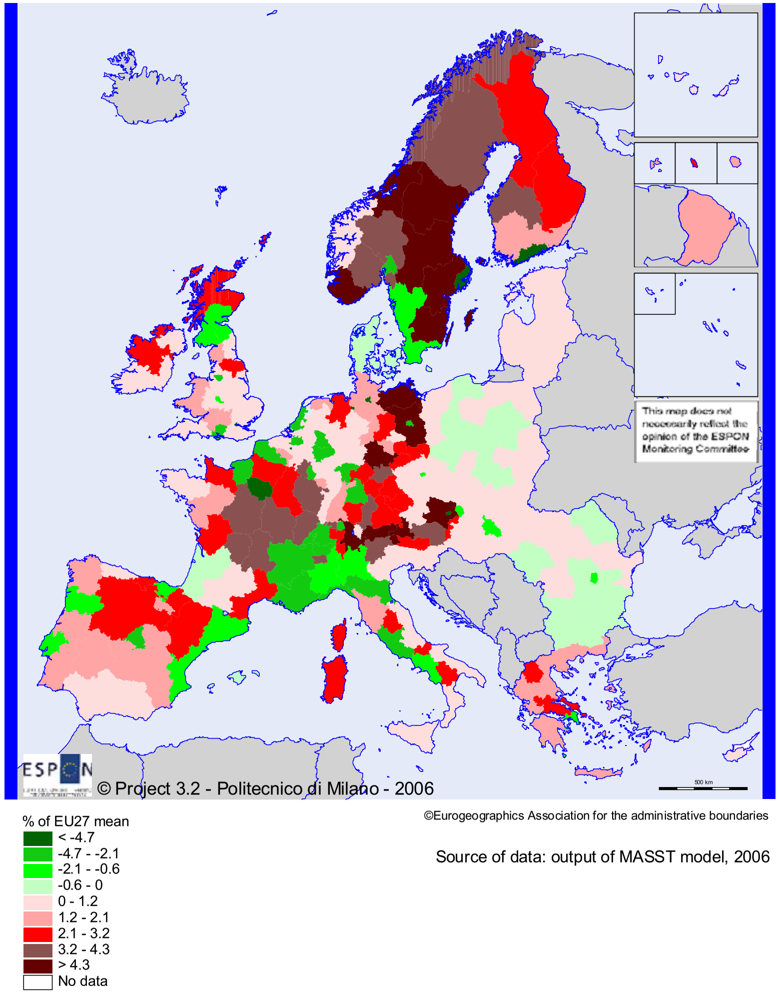
Source of data: output of MASST model, 2006

Map 11	*Map 12*
Change in relative position 2002-2015 - Difference between Cohesive and Baseline scenario	Population growth rate 2015 - Difference between Cohesive and Baseline scenario



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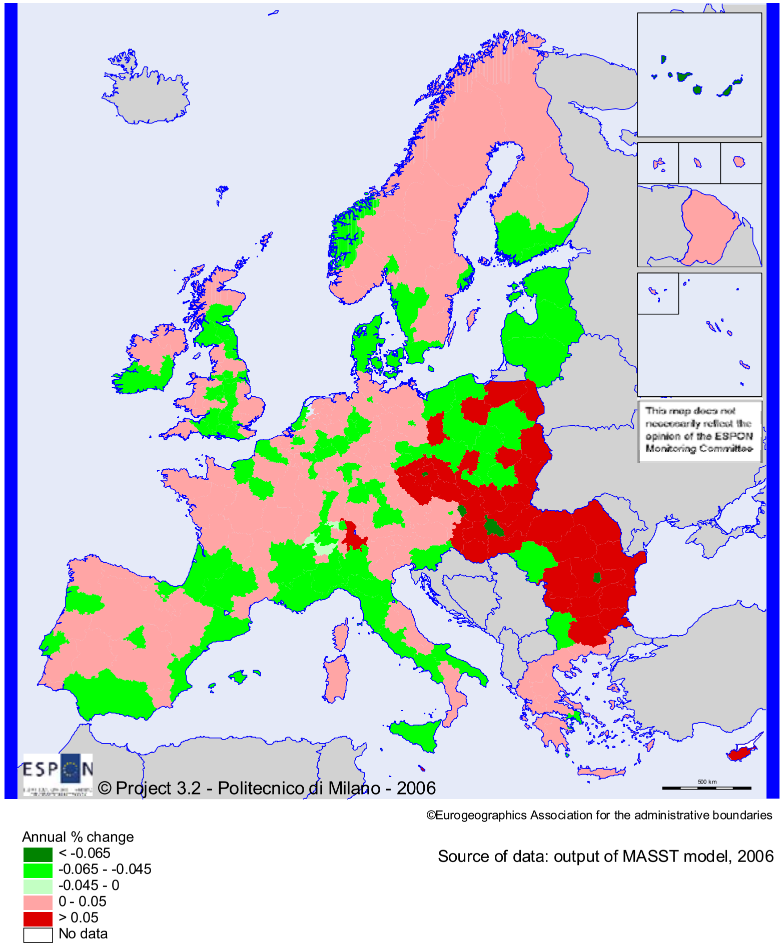
Source of data: output of MASST model, 2006



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Source of data: output of MASST model, 2006

2.9 Results of the cohesive scenario

The cohesive scenario is a less expansive scenario with respect to the baseline (-0.08% lower growth rate than in the baseline) (Table 13). The lower relative GDP growth rate is registered for EU as a whole, and it is lower for the EU15 (-0.09% lower growth rate than in the baseline). Also the New 10 countries show a lower performance than in the baseline scenario, but the difference is more contained than in the EU15 (-0.04% lower growth rate than in the baseline); this result is not surprising given the more favouring assumptions provided for the weaker regions. On the contrary, Bulgaria and Romania show a remarkably lower GDP growth (0.21% lower than the baseline), given the assumption that these two countries join the EU later than 2007.
The lower performance registered at the aggregate level in the cohesive scenario with respect to the baseline is not equally distributed at regional level. Some regions are in fact able to show greater GDP growth rate in 2015 with respect to the baseline scenario, as map 9 shows. In particular, the following territorial trends emerge with respect to the baseline scenario:

- in general, the cohesive scenario provides *a more diffused development*, especially in more rural regions, in peripheral regions, and in regions with a medium-low income level;
- the *barycentre of growth moves towards South-Eastern Europe*, a tendency witnessed by a greater performance in the ex-DDR, Austria, Hungary, Greece, part of Central and Southern Italy;
- in general, *the periphery of Europe grows more than in the baseline scenario*; Greece, Sardinia and Corsica, most regions of Spain, Northern Ireland, the Northern part of the Irish Republic and all Northern countries;
- interestingly enough, and contrary to some assumptions made, *in Eastern countries fragmentation of relative growth rates is limited*. First of all, despite the favouring assumptions, no typology of regions perform much better than in the baseline scenario, with the exception of some Hungarian regions and the Eastern regions of Poland; the relative higher performance is registered in rural areas, while agglomerated and mega regions perform relatively low but still better than the western ones;
- *a more fragmented territorial picture characterises EU15 countries*, where the variance between lower and higher relative performance is more pronounced;
- *capital city regions in general lose their relative better position* obtained in the baseline scenario, in both Eastern and Western countries; this is true for Athens, Rome, Madrid, Paris, Bruxelles, Luxembourg, London, Copenhagen, Stockholm, Helsinki, Berlin, Vienna, Praga, Budapest, Bucarest and Sophia. The *relative bad performance of capital cities is also registered for the engines of Europe*, like Milan, Barcelona, Frankfurt, Malmo, Munich, Stuttgart, Düsseldorf, Cologne, Oslo, Helsinki, Copenhagen;
- in Western countries, some *relatively better performing regions can be found also in agglomerated and urban regions in peripheral areas*, like Bretagne, Pais-de-la-Loire, Champagne-Ardenne and Languedoc in France, Toscana, Marche, Abruzzo, Calabria, Veneto and Friuli in Italy, East-Anglia, South-West, in UK, Northern Irland, Schleswing-Holstein in Germany.

By looking at the per capita GDP level achieved in 2015 in the cohesive scenario with respect to the baseline, some interesting trends emerge (map 10):

- *the relative effect of the cohesive scenario on the catching-up process of Eastern countries is a limited one*; only a few regions register in fact a greater per capita GDP level than in the baseline scenario, and this is especially true for the weakest and lowest level income regions. At the same time, the strong areas in Eastern

countries have a lower per capita GDP level. This double trend decreases intra-national disparities but increase international disparities, as shown in Fig. 4;
- *in Western countries, a higher per capita GDP level is achieved in the periphery of Europe, in most remote areas with respect to the Pentagon*. The latter, on the contrary, is in general losing its per capita income level with respect to the baseline;
- *the areas registering the highest increase in per capita GDP with respect to the baseline are the western regions along the north-south border with the former Socialist countries*, from Eastern Germany, towards Southern Germany, Austria and Trentino and Sud Tirol in Italy.

If the change in the relative position is taken into consideration, the previous tendencies are confirmed, namely (map 11):
- *in Eastern countries the relative winning regions are the peripheral and more low-income regions*. The agglomerated and capital city regions in Eastern countries are losers with respect to the baseline scenario;
- *in Western countries, the winning regions are in general rural and peripheral areas, as well as the western border areas with the Eastern countries*;
- *some additional areas emerge as winners, especially in the Pentagon areas and in Central and Southern countries*, due to the relatively lower increase in population growth.

Finally, map 12 presents the relative demographic growth in the cohesive scenario. With respect to the baseline scenario the emerging picture demonstrates that the cohesive scenario registers:
- *a relatively lower population loss in rural and peripheral areas of Western countries*, from Greece, to Central and Southern Italy (with some exceptions), to Central Spanish regions with the exception of Madrid, rural French and German regions, Northern Ireland and the North of the Irish Republic, urban and rural areas of Great Britain and most of the Northern countries;
- *a decisive lower decrease of population with respect to the baseline in Eastern countries*, especially in the Czech Republic, Slovakia, Romania, Bulgaria and rural areas of Poland;
- *a relatively higher population loss of the agglomerated and mega regions of both Western and Eastern countries*, where also a lower economic growth is foreseen.

	Difference between the competitive and the baseline scenario	*Difference between the cohesive and the baseline scenario*
EU 27	0.19	-0.08
EU 15	0.20	-0.09
New 10	0.08	-0.04
Bulgaria and Romania	0.01	-0.21

Table 13 Difference in DGP growth rates in 2015 between the three scenarios

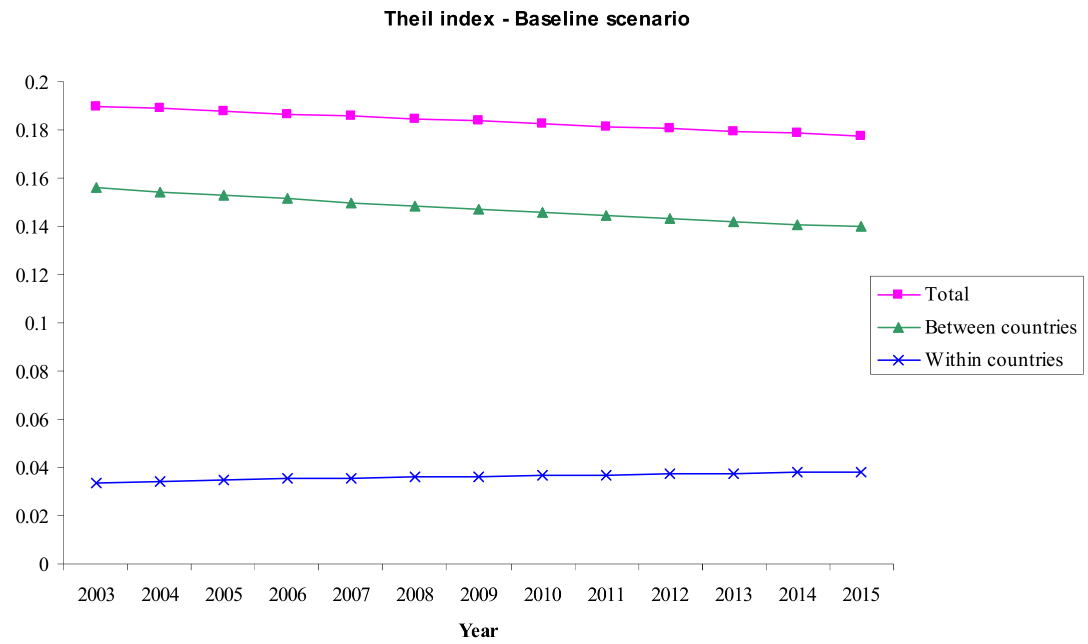


Figure 2 Regional Disparities in the Baseline Scenario

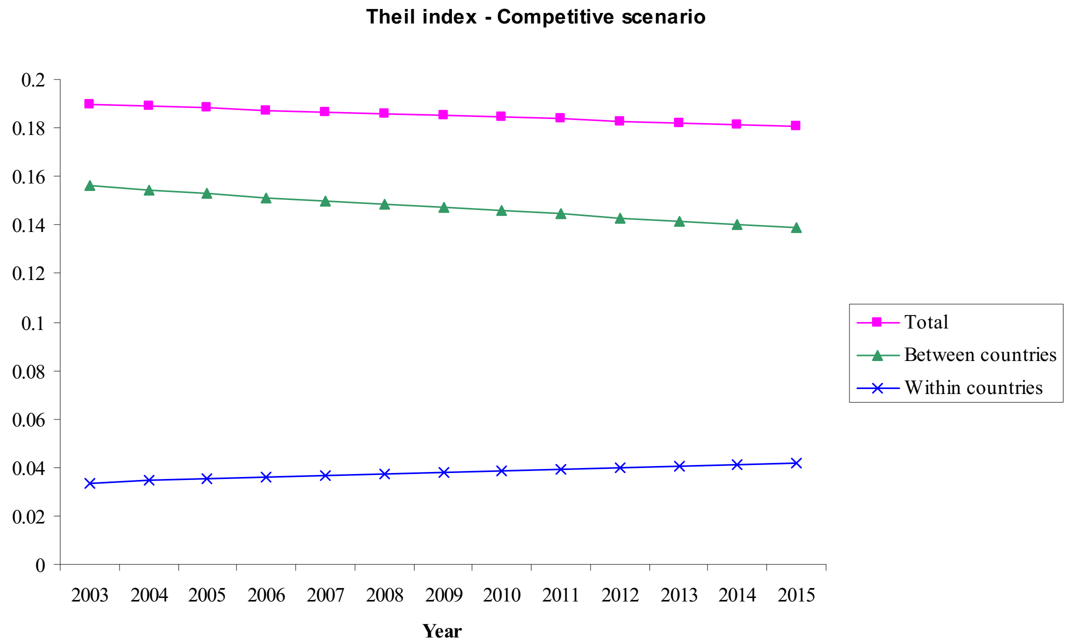


Figure 3 Regional Disparities in the Competitive Scenario

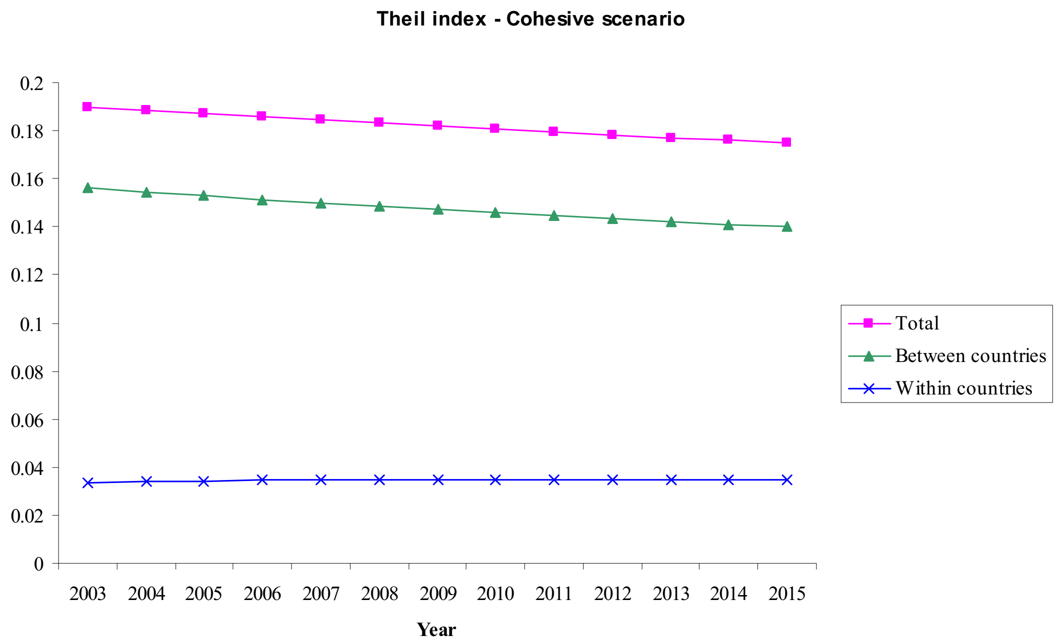


Figure 4 Regional Disparities in the Cohesive Scenario

2.10 Conclusions

MASST is an innovative regional forecasting model able to strengthen territorial scenario forecasts from various perspectives. Firstly, its strong interdependence between the regional and national levels of analysis allows emphasis to be given to both local and national trends and policies on regional (and national) growth at the same time. From this perspective, MASST is a multi-layer ex-ante impact assessment econometric model. Indeed, the model allows measurement of the impact of national (and supranational) trends and policy options on both regional and national growth, as well as the impact of regional dynamics and policies on national and regional growth, doing so in a way unprecedented in the literature.

Secondly, MASST gives spatial and social elements a role in explanation of regional growth. The MASST model comprises cumulative and self-reinforcing growth processes rooted in well known territorial increasing returns and in proximity advantages; in modern terms, in dynamic agglomeration economies and spatial spillovers.

Thirdly, MASST can be integrated with another ESPON model, the KTEN model. The latter yields the values of future accessibility at NUTS 2 level under different assumptions on European transport policy choices in TEN and TINA projects. These values are an input to the MASST model, which in its turn forecasts regional per-capita GDP levels and GDP growth; the MASST outcome becomes an input to the KTEN model, which, on the basis of these values, forecasts future traffic flows at NUTS 2 level.

MASST is a useful instrument for ex-ante policy assessment and territorial forecasts. However, in the future its potentialities could be increased in several respects. Firstly, the model could be enlarged in order to include the role of the sectoral component on regional growth; this would allow regional forecasts to be differentiated also on the basis of the productive structures of the regions. Secondly, MASST could incorporate a more direct linkage between single macroeconomic factors and policies and their regional impact.

Thirdly, the model could be made more sensitive to the effects of specific orientations of structural policies (e.g. orientation of cities towards SMEs, towards R&D and innovation) and trade policies. Fourthly, the macroeconomic part of the model could be improved by reinforcing its internal logic. Lastly, if sufficient data are available, the model could be estimated and run at NUTS 3 level.

3 KTEN - Know trans-European Networks - METAMODEL

3.1 Introduction and overview

This section provides an overview of KTEN. Next sections presents KTEN in depth and main results already achieved (definition of transport infrastructure scenarios, definition of demand scenarios, and traffic forecast for the year 2000 and 2030 considering all Transeuropean networks operational). Next steps will be to apply the model for three scenarios and two time periods, and the calculation of all spatial development and environmental indicators.

Transport infrastructure scenarios are based on selecting those road and rail projects within TENs more likely to be built according to the policy-aims defined for each ESPON 3.2 scenario (baseline, cohesive and competitive); Transport demand scenarios are based on defining passenger and freight growth and modal share, also according to the policy aims of each scenario. Both definitions of infrastructure and demand scenarios are based on quantitative objective criteria that reflect European policy aims.

Concerning the initial definition of the modeling exercise, two main improvements have being implemented:

- Using the baseline demand scenario, and supposing all Transeuropean networks being operational in 2030, a number of indicators have been calculated for each link and/or region: profitability or European interest based on a user's marginal cost proxy, reduction of regional infrastructure gap, support to less developed regions in terms of GDP per capita. These indicators are then used as a reference to define the actual infrastructure scenarios.

- Trip and freight forecast matrices were disaggregated at NUTS3 (the model produces forecast at NUTS2, and afterwards are disaggregated based on a gravitatory formulation in order to get flows at NUT3, which are needed to make the traffic assignment exercise precise enough to calculate the indicators needed to define infrastructure scenarios.

Next, a detailed description of KTEN, and KTEN relation with MASST is introduced:

KTEN Purpose: KTEN, together with MASST, have been used to precise qualitative scenarios into quantitative ones, providing an economic, spatial and environmental strategic assessment of them. In particular, KTEN is used to define transport network scenarios and evaluate them, from an European perspective.

KTEN Definition: ("Know trans-European Networks") is a passenger and freight traffic forecast metamodel developed to facilitate a strategic analysis of the trans-European Transport Networks in a wider pan-European and Mediterranean scale.

KTEN Formulation: It is a sequential Four-steps model, with combined modal split and assignment on multimodal networks; assignment of interurban trips and freight between NUTS3 is made without congestion constraints (1 complete run of KTEN takes about 4 days; KTEN is 4GB large in total).

KTEN Information: It uses STREAMS results, WTO and EUROSTAT Air Traffic OD databases, ETIS-BASE freight matrices.

KTEN Integration with MASST: infrastructure regional endowment as output for MASST, GDP and population predictions from MASST as inputs.

KTEN main outputs: Multimodal passenger trips and costs and freight forecast between NUTS2 (disaggregated into NUTS3), traffics on rail, road, air and maritime links, relative European interest of road and rail links (considering interurban NUTS3 relation), spatial development and environmental aggregated indicators.

KTEN steps:

1. Definition of infrastructure scenarios using IGIS project database according to the scenarios sketched by ESPON 3.2 TPG, following expert criteria.

2. Calculation of construction costs, which are sent to MASST.

3. MASST provides provisional GDP and population forecasts.

4. Calculation of travel costs between NUTS2 capitals for different transport modes in a year 2000 scenario and a complete scenario with all infrastructures finished.

5. Creation of future passenger and freight matrices for the complete scenario.

6. Assignment of matrices and calculation of indicators.

7. Redefinition of infrastructure scenarios using calculated indicators.

8. Calculation of construction costs, which are sent again to MASST.

9. MASST provides definitive GDP and population forecasts.

10. Calculation of travel costs between NUTS2 capitals for different transport modes and all scenarios.

11. Creation of future passenger and freight matrices for all scenarios.

12. Assignment of matrices and calculation of indicators.

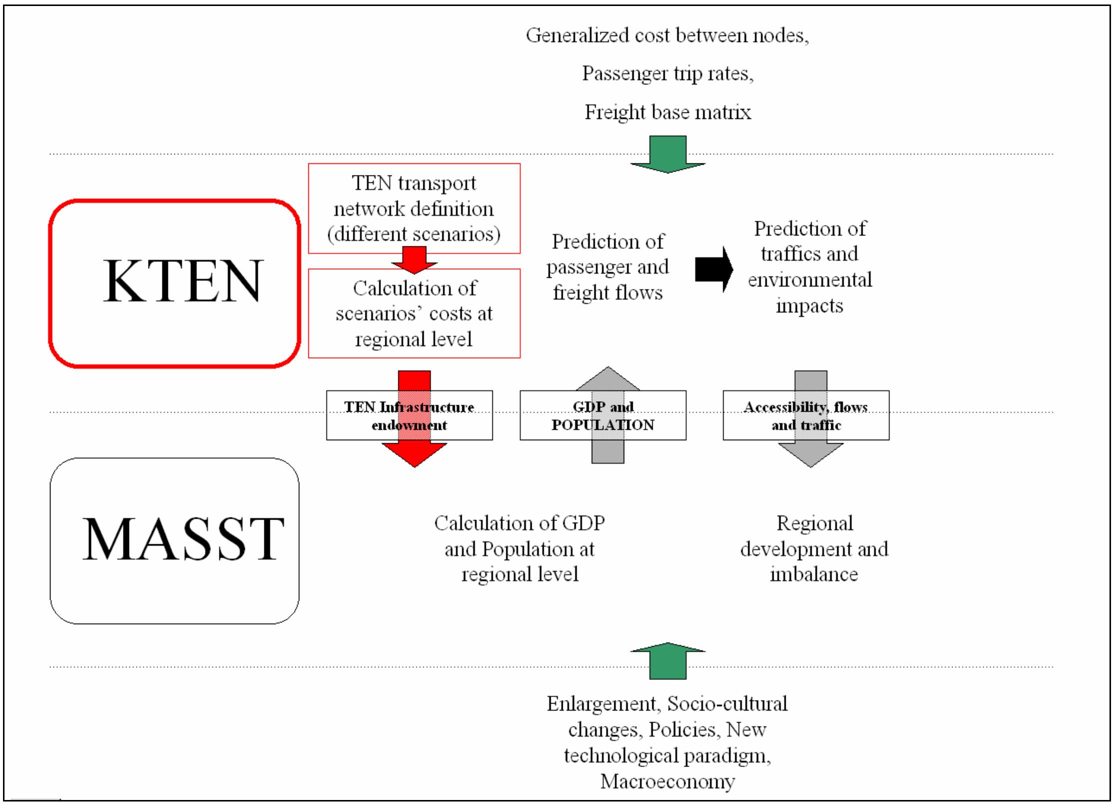


Figure 5 Scheme of interrelation between KTEN and MASST models

3.2 Scenario definition

3.2.1 Policy definition of scenarios

The infrastructure scenarios are defined based on both political aims and scientific criteria; policy aims determine maximum budget lines for road and rail, for 2015 and 2030, and the decision-making frame. No significant differences concerning ports and airports, and urban infrastructure, are considered in the scenarios.

- Competitive scenario: projects are selected based on socioeconomic profitability only. There is no preference for rail and no strong policies in favour of modal shift; it is assumed in the scenario that the improvement of road vehicle efficiency, road traffic management systems, will produce more efficient use of road and much less environmental impacts. Road pricing is applied on all roads and rail services tend to be adapted to demand and have market prices with no subsidies. This is the most efficient scenario from a transport-economics point of view (the one with the lowest marginal costs in both roads and rail).

- Cohesive scenario: projects are selected based on reducing the infrastructure endowment gap between regions. Policy is based on more roads for regions with less road endowment, and a balanced investment on roads and rail in regions with higher levels of road transport endowment. This is the scenario that can have higher impact inducing economic growth in less developed regions.

- Baseline scenario: projects are selected based on socioeconomic profitability but regions with GDP below the average have a specific budget. Strong policies to induce modal shift. It is assumed that rail technology and rail management will improve enough to carry this traffic increases. This scenario can be considered as the most sustainable, assuming an improvement in rail management.

3.2.1.1 Competitive scenario

Infrastructures are built according to their socioeconomic profitability, based on a Cost-Benefit Analysis (CBA) appraisal that includes both environmental externalities and indirect territorial impacts. The RAILPAG defined by the European Investment Bank, for instance, proposes an updated methodology to evaluate rail infrastructure projects; according to CBA, the selection criteria could be not to build projects with CBA below a given threshold (measuring CBA in vehicle flow increase per invested €, and fixing priorities based on a CBA ranking). A proxy of this CBA is the marginal cost of the foreseen increase in passenger and freight traffic, and the savings of the existing traffic thanks to the time and cost reductions produced for the new infrastructure project. The total budget to be allocated could be separated into a 'road budget' and 'rail budget'. The relative budget for roads or rail is then a political decision based on policy aims more global than the transport policy. The total investment in infrastructure will be less than the total possible, since projects with low profitability will not be built.

Method to define the infrastructure scenarios:

- Evaluation of the current road and rail CBA proxy
- From the European list of projects, ranked according to CBA proxy, select until the total budget allocated is reached

3.2.1.2 Cohesive scenario

Infrastructures are built according to territorial criteria, based on assuring a minimum level of accessibility to cities and regions, without regarding the existing traffic or the economic development level. Since less developed regions use to have less resources available to build infrastructures, this policy requires transfers from most developed regions. Priorities are fixed based on reducing territorial gaps, starting by building those projects with higher expectations on traffic (so those that may induce more mobility, relations and development opportunities).

Method to define the infrastructure scenarios:

- Evaluation of the current road and rail densities, and relative gaps.
- Regional distribution of road and rail budgets based on gaps
- From the regional list of projects, ranked according to CBA proxy, select until the regional allocated budget is reached

3.2.1.3 Baseline scenario

Infrastructures are selected based on both CBA and GDP gaps. Regions are classified into two groups, based on GDP (those above the average and those below). For each group, infrastructures are selected based on CBA ranks similar to the competitive scenario (CBA thresholds will be smaller in the baseline scenario than in the competitive).

Method to define the infrastructure scenarios:

- Evaluation of the current road and rail CBA.
- Analysis of GDP evolution
- From the list of projects for both group of regions, ranked according to CBA, select until the regional allocated budget to rail and road is reached.

3.2.2 Demand scenarios

Coherent with the infrastructure and supply management scenarios, there are demand scenarios that are based on assumptions regarding population, economic growth, spatial patterns, and other key elements relatively exogenous to transport infrastructure.

The following table summarizes the different variables that define the demand scenarios (shown values are somehow 'qualitative' and can not be directly used in the model, they first need a re-scaling):

SCENARIO	**2015 BASELINE**	**2015 COHESIVE**	**2015 COMPETITIVE**	**2030 BASELINE**	**2030 COHESIVE**	**2030 COMPETITIVE**
	Environmental	**Territorial**	**Economic**	**Environmental**	**Territorial**	**Economic**
Main indicator	Development GDP	Endowment ACC	Efficiency CBA	Development GDP	Endowment ACC	Efficiency CBA
Main aim	Balancing modes	Balancing regions	Balancing sectors	Balancing modes	Balancing regions	Balancing sectors
PASSENGER						
GDP elasticity	1,0%	1,5%	1,0%	1,0%	1,0%	0,5%
POP elasticity	0,5%	1,0%	0,5%	0,5%	0,5%	0,5%
Work trips/worker per day	2,2	2,5	2	2,2	2,1	2
Study trips/student per day	2	2	2	2	2	2
Maximum trips/person per year	1000	1100	1050	1000	1100	1050
Minimum trips/person per year	100	125	110	100	125	110
Maximum leisure/personal trip ratio	60%	55%	65%	60%	55%	65%
Minimum leisure/personal trip ratio	40%	40%	40%	40%	40%	40%
Users' costs perception	70,0%	55,0%	80,0%	80,0%	75,0%	100,0%
FREIGHT						
GDP elasticity	1,5%	2,0%	1,5%	1,5%	1,5%	1,0%
POP elasticity	1,0%	1,5%	1,0%	1,0%	1,0%	0,8%
Market integration level of EU-15	1	1	1	1	1	1
Market integration level of EU-25	2	2	2	1	1	1
Market integration level of EU-27	2	2	3	2	2	2
Market integration level of EFTA countries	2	2	3	1	1	2
Market integration level of Future Candidate countries	2	1	4	2	2	3
Market integration level of Rest of the World	2	1	4	2	2	3
Carriers' costs perception	75,0%	60,0%	90,0%	80,0%	75,0%	100,0%
Cost allocation to roads	40,0%	60,0%	60,0%	40,0%	60,0%	60,0%
Cost allocation to rails	40,0%	40,0%	20,0%	40,0%	40,0%	20,0%

Table 14 Demand scenarios variables

3.3 Model description

This chapter intends to be a basic description of the steps required to run the model.

As it has been previously said KTEN model is interrelated with MASST model, which provides GDP and Population predictions. However KTEN can be used standalone in future predictions, applying the GDP and Population values obtained from MASST during the first run of the model, and project profitability ratios previously calculated.

KTEN is divided in five modules:

1. Infrastructure definition module: it allows to define which infrastructures will be constructed in each scenario.
2. Passenger forecast module: it generates the future passenger flows between NUTS3 for each scenario.
3. Freight forecast module: it generates the future freight flows between NUTS3 for each scenario.
4. Assignation module: it assigns the passenger and freight flows to the infrastructure network.
5. Spatial and environmental indicators module: calculates different indicators based on the obtained traffics.

3.3.1 Infrastructure definition module

The definition of infrastructure scenarios is done through a set of parameters which control the amount of budget to be spent and its spatial and temporal distribution.

For the three scenarios, baseline, cohesive and competitive, the first step is to choose the minimum acceptable profitability of the infrastructure projects, measured as the ratio of vehicle increase forecast divided by the monetary cost of the project.

Three different profitability limits must be defined for every scenario, one for each transport mode (road, rail and inland waterways).

3.3.1.1 Competitive scenario infrastructure parameters

The competitive scenario is based only on profitability, so apart from profitability thresholds it has only parameters concerning temporal distribution of budget for each transport mode. The following table summarizes all the parameters for competitive scenario with example values:

	Profitability threshold	2015	2030
Road budget	5Mveh/M€	60%	40%
Rail budget	0,5Mveh/M€	50%	50%
Inland waterways budget	0,05Mveh/M€	45%	55%

Table 15 Infrastructure definition parameters for competitive scenario

3.3.1.2 Cohesive scenario infrastructure parameters

The cohesive scenario attempts to reduce the infrastructure gap between regions and a new variable has to be introduced to achieve this objective. The density of each network is calculated for each NUTS2 region in the year 2000 and compared with the European average. Then we classify regions above and below the average of infrastructure density and distribute the budget according to user-defined percentages between regions and time periods.

The following table summarizes all the parameters for cohesive scenario with example values:

	Profitability threshold	GAP <1	GAP >1	2015	2030
Road budget	3Mveh/M€	60%	40%	45%	55%
Rail budget	0,1Mveh/M€	57%	43%	40%	60%
Inland waterways budget	0,09Mveh/M€	50%	50%	50%	50%

Table 16 Infrastructure definition parameters for competitive scenario

3.3.1.3 Baseline scenario infrastructure parameters

The construction of the baseline scenario is based on the GDP gap between regions. The GDP per capita of each NUTS2 region in the year 2000 is calculated and compared with the European average. Then regions are classified in two groups above and below the average of GDP per capita and the budget is distributed according to user-defined percentages between regions and time periods.

The following table summarizes all the parameters for cohesive scenario with example values:

	Profitability threshold	GAP <1	GAP >1	2015	2030
Road budget	2Mveh/M€	55%	45%	45%	55%
Rail budget	0,15Mveh/M€	60%	40%	40%	60%
Inland waterways budget	0,21Mveh/M€	50%	50%	50%	50%

Table 17 Infrastructure definition parameters for baseline scenario

After all these parameters are defined, KTEN updates the network attributes and calculates the matrix of generalized cost of travel between each NUTS2 region for each scenario and time period. This is a total of six cost matrices that will be used in the following modules.

3.3.2 Passenger forecast module

The passenger forecast module generates the matrices of passenger trips between NUTS2 regions. The mathematical formulation of the model is described later in depth in its specific chapter.

The passenger module needs some inputs to produce a forecast matrix that is consistent with the scenario being defined. It also incorporates the cost matrices calculated in the infrastructure definition module to define the modal split.

3.3.2.1 Horizon year

The model allows selecting the desired horizon year for the simulation. This directly affects the values of GDP and Population used.

There is a built-in table with the predictions of GDP and Population change provided by MASST model for the three scenarios (Baseline, Cohesive and Competitive) and two horizons (2015 and 2030). Values for countries not covered by MASST model are extracted from the paper 'European Energy and Transport trends 2030'. Values from EUROSTAT are taken as year 2000 base values. Simulated years are 2015 and 2030.

3.3.2.2 GDP elasticity

Elasticity of GDP is a parameter that allows simulating the direct relation between economy and people movement. It controls the decoupling of trip generation and economy growth.

Present trends show that improvement of the economy in a given region, which we can measure with an indicator such as GDP, implies a growth of generated trips. However, this trend can change in the future reinforcing or decreasing the relation.

The quotient $\frac{\Delta trips / trips_i}{\Delta GDP / GDP_i}$ is what we call elasticity ε and measures how much does the trips volume change for a given GDP variation. Both variations are relative %

The model allows controlling the GDP elasticity with the parameter ***GDP ε.*** A change of 1% in the elasticity is translated into a 1% variation of the predicted flow. Any number can be chosen, either negative or fractionary; a value of 0 means the model assumes present trend will not change in time.

This parameter should only be different from 0 in case there is a change of trends between present and forecast scenarios.

Recommended values range from –3% up to 3%

3.3.2.3 POPULATION elasticity

Elasticity of POPULATION is a parameter that allows simulating the direct relation between demography and people movement. It controls the decoupling of trip attraction and population growth.

Present trends show that a growth of population in a region, implies a growth of trips towards it. However, this trend can change in the future reinforcing or decreasing the relation.

The quotient $\dfrac{\Delta trips / trips_i}{\Delta POP / POP_i}$ is what we call elasticity ε and measures how much does the freight tonnage change for a given POP variation. Both variations are relative %

The model allows controlling the POP elasticity with the parameter ***POP ε.*** A change of 1% in the elasticity is translated into a 1% variation of the predicted flow. Any number can be chosen, either negative or fractionary; a value of 0 means the model assumes present trend will not change in time.

This parameter should only be different from 0 in case there is a change of trends between present and forecast scenarios.

Recommended values range from –3% up to 3%

3.3.2.4 Work trip rate

This parameter indicates how many daily trips are done for work purpose, and is defined at regional level (NUTS2), i.e. one value for each region to allow the simulation of different socio-cultural tendencies. 2 is the minimum value, but as some people go home for lunch the average value rises to 2.2.

3.3.2.5 Study trip rate

This parameter indicates how many daily trips are done for study purpose, and is defined again at regional level (NUTS2), so one value for each region should be chosen. 2 is the average value.

3.3.2.6 Leisure and personal trips

The model defines the number of leisure and personal trips at regional level depending on the GDP. The user must define the minimum and maximum total trips per year and the parameters of the equation relating GDP and trips. Then work and study trips are deducted from this total of trips and the result are the leisure and personal trips.

3.3.2.7 Leisure / Personal ratio

To determine the ratio between leisure and personal trips the model applies an equation based on the ratio of foreign population. The user should provide the minimum and maximum leisure/personal ratios and the equation parameters.

3.3.2.8 Passengers' cost perception

The model divides the trips in three modes, road, rail and air (modal split), according to distribution curves that define the percentage of each mode depending on the straight line distance. To simulate future scenarios the distance in each relation is reduced according to the cost variation (that is calculated in the scenario definition module) affected by the Passengers' cost perception factor.

This factor can be interpreted as the user's perception of costs. A value of 0 means that cost variation will not affect the user's choice. 1 is the recommended value and the higher it is, the higher the modal change will be.

The effect of modal change depends on the initial point on the modal split curves, so it can not be determined a priori. However, due to the shape of the curves, a decrease in the cost of a relation means that the share of air mode will decrease in favour of road and rail.

Once a passenger trip matrix is created, the module disaggregates it from NUTS2 to NUTS3 according to the year 2000 NUTS3 population distribution in each NUTS2.

3.3.3 Freight forecast module

The freight forecast module generates the matrices of freight flows between NUTS2 regions. The mathematical formulation of the model is described later in depth in its specific chapter.

The freight module needs some inputs to produce a forecast matrix that is consistent with the scenario being defined. It also incorporates the cost matrices calculated in the infrastructure definition module to define the modal split.

3.3.3.1 Horizon year

The model allows selecting the desired horizon year for the simulation. This affects directly on the values of GDP and Population used.

There is a built-in table with the predictions of GDP and Population change provided by MASST model for the three scenarios (Baseline, Cohesive and Competitive) and two horizons (2015 and 2030). Values for countries not covered by MASST model are extracted from the paper 'European Energy and Transport trends 2030'. Values from EUROSTAT are taken as year 2000 base values. Simulated years are 2015 and 2030.

3.3.3.2 GDP elasticity

Elasticity of GDP is a parameter that allows simulating the direct relation between economy and freight. It controls the decoupling of freight generation and economy growth.

Present trends show that improvement of the economy in a given region, which we can measure with an indicator such as GDP, implies a growth of generated freight goods. However, this trend can change in the future reinforcing or decreasing the relation.

The quotient $\dfrac{\Delta freight / freight_i}{\Delta GDP / GDP_i}$ is what we call elasticity ε and measures how much does the freight tonnage change for a given GDP variation. Both variations are relative %

The model allows controlling the GDP elasticity with the parameter ***GDP ε.*** A change of 1% in the elasticity is translated into a 1% variation of the predicted flow. Any number can be chosen, either negative or fractionary; a value of 0 means the model assumes present trend will not change in time.

Variation of elasticity is only possible if strategies are developed, so this parameter should only be different from 0 in case there is a change of trends between present and forecast scenarios.

Recommended values range from –3% up to 3%

3.3.3.3 POPULATION elasticity

Elasticity of POPULATION is a parameter that allows simulating the direct relation between demography and freight. It controls the decoupling of freight attraction and population growth.

Present trends show that a growth of population in a region, implies a growth of consumed freight goods. However, this trend can change in the future reinforcing or decreasing the relation.

The quotient $\frac{\Delta freight / freight_i}{\Delta POP / POP_i}$ is what we call elasticity ε and measures how much does the freight tonnage change for a given POP variation. Both variations are relative %

The model allows controlling the POP elasticity with the parameter ***POP ε.*** A change of 1% in the elasticity is translated into a 1% variation of the predicted flow. Any number can be chosen, either negative or fractionary; a value of 0 means the model assumes present trend will not change in time.

Variation of elasticity is only possible if strategies are developed, so this parameter should only be different from 0 in case there is a change of trends between present and forecast scenarios.

Recommended values range from –3% up to 3%

3.3.3.4 Market integration

The present level of commercial relations between the different countries can suffer variations in the future. The enlargement of the EU will translate in a growth of freight interchange between accession countries and older members.

There can be changes too with the EFTA countries, Iceland, Norway and Switzerland, and with other possible accession candidates like Turkey or the Balkans, as well as with the rest of the world.

This degree of relation is simulated by the dummy parameter K_{ij} in the model equations. There are 17 different values to represent these relations, which have been calibrated against ETIS original data. To allow changes in this parameter the flows have been grouped in 6 mutually excluding categories:

EU-15: Includes all flows with origin an destination inside the EU-15

EU-25: Includes flows with origin and destination inside the 10 new members and between these and EU-15

EU-27: Includes flows with origin and destination inside Bulgaria and Romania and between these and EU-25

EFTA: Includes flows with origin and destination between Iceland, Norway and Switzerland and EU-27

Future Candidates: Includes flows with origin and destination between Turkey and the Balkans and the EU-27

Rest of the World: Flows not included in the previous categories, divided in different zones (rest Europe, Maghreb, Asia, America-Australia, Africa-Mid Asia)

The model lets the user select one out of four different qualitative changes to each one of the six categories, none / low / middle / high improvement, which translate directly in a multiplying factor for the K_{ij} values yielding the following growths for the considered relation: 0%, 50%, 100%, 200%

Depending on the combination of values selected the final predicted tonnage can vary in a range between 0 and 200%. Provided that the most important flows are those concerning the EU-15 category, changes here will greatly vary the total tonnage generating a global impact on the network. On the other hand the lesser flows from the other categories will only have a minor impact when changed.

3.3.3.5 Carriers' cost perception

This parameter controls the global variation of modal distribution and can be interpreted as the impact of pricing changes in the carriers' modal choice. Mathematically it is the power affecting the cost variation.

A value of 0 means the cost variation does not affect modal distribution. Each increment of 1 unit translates in a 1% variation of flow for a mode with a 1% cost variation. For example, if road cost decreases 5% for a given relation and change factor is 1, road quote will increase 5% taken from the rail.

A good value is 1. If policies of rail encouragement are adopted, the number can be increased meaning that users are more sensitive to rail improvements.

3.3.3.6 Cost allocation

This parameter has two values that can be changed, one for road and another for rail, which represent the average variation of costs. The purpose of this parameter is to simulate policies that encourage or discourage a certain transport mode like toll or oil taxes.

The effect of changing the global cost is directly linked to the selected Carriers' cost perception, so if change factor is 0 the global cost will not change the modal distribution.

User can choose whether the parameter refers to a year variation or a variation of the whole simulated period.

It must be noticed that a high increase in costs will reduce the volume of freight transported, provided that cost between nodes is a factor that affects it directly. Given the low share of rail transport comparing to road, a little variation of road costs can generate an important change in total volume, so to simulate an encouraging of rail mode the rail cost should be decreased, whereas an increase in road cost should lead to a similar modal split but the total volume would be noticeably affected.

Once a freight flow matrix is created, the module disaggregates it from NUTS2 to NUTS3 according to the year 2000 NUTS3 population distribution in each NUTS2.

3.3.4 Assignation module

Once the matrices are calculated the next step is assigning them onto the infrastructure networks. The process of assignation is described in depth in its specific chapter.

Here there are no parameters to change, provided that the infrastructure network itself has a set of velocity values depending on the type of link.

The results of this module are the flows of freight and passengers in each of the network links.

3.3.5 Spatial and environmental indicators module

The previously obtained flows are used to calculate different indicators to assess the territorial impact by means of accessibility, infrastructure endowment or traffic congestion, and the environmental impact by means of CO2 generation.

Some parameters need to be defined in order to calculate the indicators. The first ones are the mean occupation rates of the vehicles, i.e. how many people travel in one single car or train wagon, or how many tones does a truck carry.

The following table shows these occupation rates:

	Road (car or truck)	Rail (passenger or freight wagon)	Short sea shipping or Ferry	Inland waterways
Mean occupation (Pax/veh)	2	100	500	-
Mean tonnage (T/veh)	14	40	17.000	2.000

Table 18 Occupation rates

Other parameters that need to be defined are the CO2 emission rates for each transport mode:

	Road (car)	Road (rail)
CO2 generation (Kg/veh-km)	0,204	0, 636

Table 19 CO_2 emission ratios

Indicators are based on these parameters and the traffic results of matrices assignations.

3.3.5.1 Endowment indicators

Indicator name	Subvariables	Units	Geographic scope	Description	Formula
Infrastructure density	Road, Rail	$\frac{km}{km^2}$	NUTS3	Surface density of high capacity infrastructure (motorways and high speed rails)	$\frac{Infrastructure\ length}{surface}$
Infrastructure per capita	Road, Rail	$\frac{km}{inh}$	NUTS2	High capacity infrastructure (motorways and high speed rails) per capita	$\frac{Infrastructure\ length}{population}$
Infrastructure investment	Road, Rail	$\frac{€}{inh}$	NUTS2	Investment per capita in new or upgraded infrastructure	$\frac{Infrastructure\ investment}{population}$

These indicators are calculated using the infrastructure scenarios results, showing where there are new or upgraded links. MASST population predictions are also used.

The result is the road and rail endowment measured in different ways.

3.3.5.2 Accessibility indicators

Indicator name	Subvariables	Units	Geographic scope	Description	Formula
Accessibility as average travel cost	-	€	NUTS2	Average travel cost from one region to all the other regions using road and rail	$\frac{\sum_i Cost_{NUTS2_{x \to i}}}{n}$
Accessible population at less than 10 hours	-	*inh*	NUTS2	Total population that can be accessed in less than 10 hours using road and rail	
Accessible GDP at less than 10 hours	-	€	NUTS2	Total GDP that can be accessed in less than 10 hours using road and rail	

This three indicators show the spatial impact of new infrastructures using KTEN calculations of travel time and distance between NUTS2 capitals as well as MASST population and GDP predictions.

To calculate the travel times KTEN relies on standard speeds on the networks, but as this can not represent fairly the conservation state or the quality of service, which is in general worse at the new 10 members, a handicap is defined for correcting it.
The handicap is based on GDP per capita and reduces the link speed according to it. Thus poorer regions will have a worse network represented by lower speeds, while the richer ones will have network speeds closer to the theoretical maximums.

The GDP gap decreases with time and so the handicap also diminishes.

The accessibility as average travel cost measures how well a region is connected with the rest of Europe, while accessible GDP and population measure the impact of new infrastructures in the accessible market.

3.3.5.3 Modal share indicators

Indicator name	Subvariables	Units	Geographic scope	Description	Formula
Passenger modal share	Road, Rail	%	NUTS3	Passenger modal share for road and rail at regional level	$\frac{(Pax \cdot km)_{road\ or\ rail}}{(Pax \cdot km)_{total}}$
Freight modal share	Road, Rail	%	NUTS3	Freight modal share for road and rail at regional level	$\frac{(Tons \cdot km)_{road\ or\ rail}}{(Tons \cdot km)_{total}}$

Modal share measures the quote of road and rail for both passenger and freight traffic using pax-km and tons-km. The results are aggregated at NUTS3 level to give an idea of the rail impact in mobility.

3.3.5.4 Environmental indicator

Indicator name	Subvariables	Units	Geographic scope	Description	Formula
CO2 emissions density	-	$\frac{MTCO_2}{km^2}$	NUTS3	CO_2 emissions per surface due to passenger and freight interurban road traffic	$\frac{CO_2\ emissions}{surface}$

KTEN calculates CO_2 emissions based on road traffics, using different standard emission factors for private vehicles and trucks.

3.3.5.5 Flow generation indicators

Indicator name	Subvariables	Units	Geographic scope	Description	Formula
Trip generation per capita	-	$\frac{Trips}{inh}$	NUTS2	Interurban trips generated per inhabitant	$\frac{Trip\ generation}{population}$
Freight generation per GDP	-	$\frac{Tons}{€}$	NUTS2	Interurban freight tons generated per unit of GDP	$\frac{Freight\ generation}{GDP}$

Trip generation per capita measures the number of interurban annual trips per inhabitant giving an idea of the changes in travel habitudes.

Freight generation measures the degree of decoupling between economic growth and traffic of goods.

3.3.5.6 Traffic indicators

Indicator name	Subvariables	Units	Geographic scope	Description	Formula
Passenger traffic density	-	$\frac{Pax \cdot km}{km^2}$	NUTS3	Passenger-km per surface at regional level	$\frac{Passenger\ traffic}{surface}$
Freight traffic density	-	$\frac{Tons \cdot km}{km^2}$	NUTS3	Freight tons-km per surface at regional level	$\frac{Freight\ traffic}{surface}$

Passenger and freight traffics measure the movement of people and goods using the matrix assignation data. Results are aggregated at NUTS3 level and then divided by the region surface so that the data is homogeneous and comparable for the differently sized NUTS.

3.4 Passenger forecast module

3.4.1 Trip generation

Trip generation is calculated considering zone-based ratios (by NUTS 2 or equivalent) and the trip purposes are business (trips from home to workplace and study place or vice versa, i.e. the obligated mobility), leisure (trips which are not obligated, like holidays) and visit (personal trips which do not respond to a leisure purpose and are not obligated). Business trips depend on the work and study trips rates by group of age, internal trip rates to define the self containing trips, and the external trip rates. (see Fig. 6)

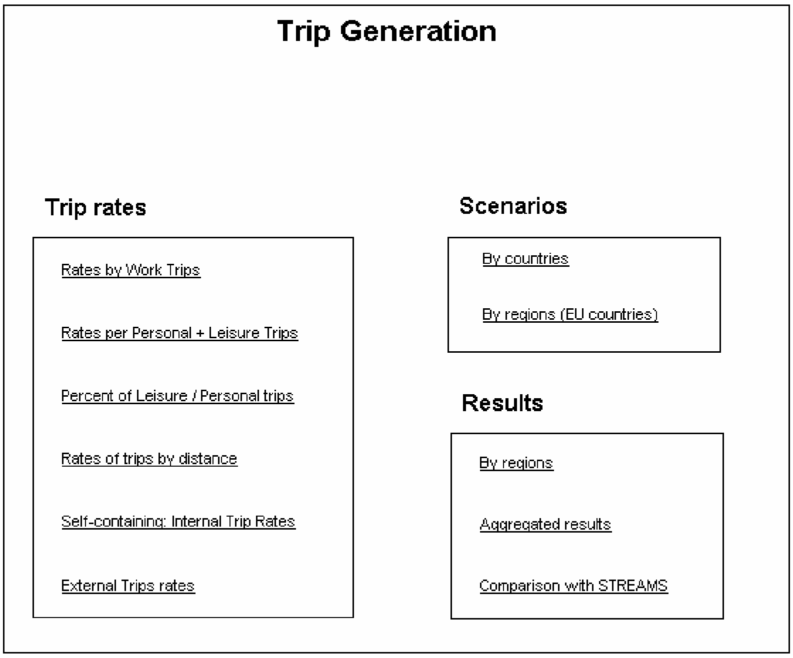


Figure 6 Main interface of KTEN passenger Trip generation module

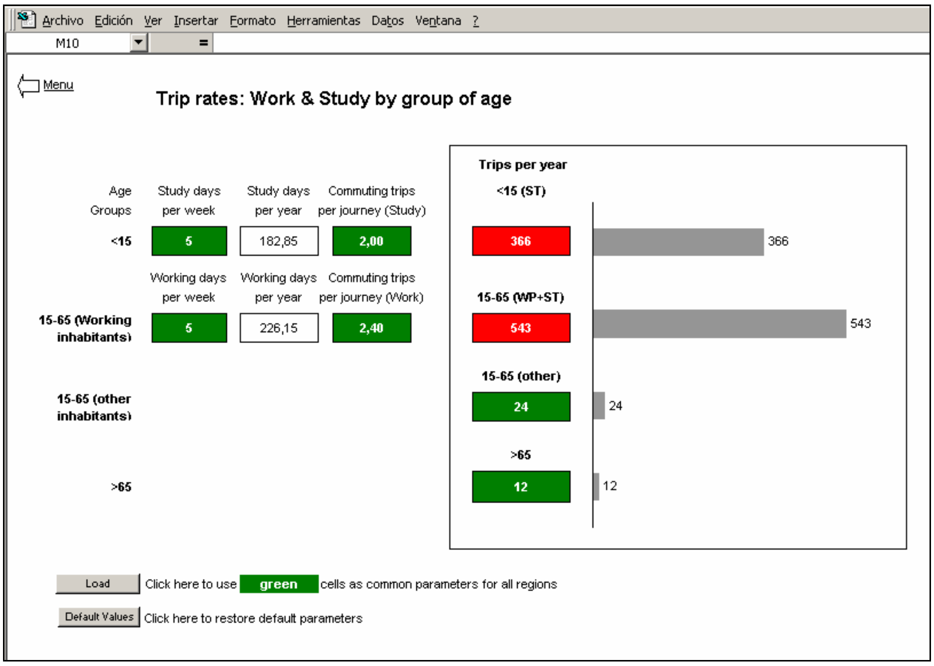


Figure 7 Trip rates interface of KTEN passenger Trip generation module

Leisure and personal trips, as well as annual commuting trips, need a maximum and minimum annual trip asymptotes per inhabitant. Leisure and personal annual trips depending on the GDP are calculated following a logistic function:

$$f(x) = A_i + \frac{1}{\frac{1}{A_s - A_i} + ab^x}$$

where A_s and A_i are the superior and inferior asynptotes of leisure and personal anual trips, a and b are parameters and x is the GDP per capita. The percentage of leisure trips regarding total leisure and personal trips is calculated with the same function. In this case x is the percentage of non-national inhabitants (the more non-national inhabitants live in a given region, the more trips by visit purpose will be generated instead of leisure purpose, as it is supposed that being non-national will make you spend your spare time in visiting the familiars in your origin country) and A_s and A_i are the superior and inferior asynptotes of the percentage of leisure and personal to total anual trips. The percentage of personal trips is the complementary of the leisure trips. (see Fig. 8 and 9)

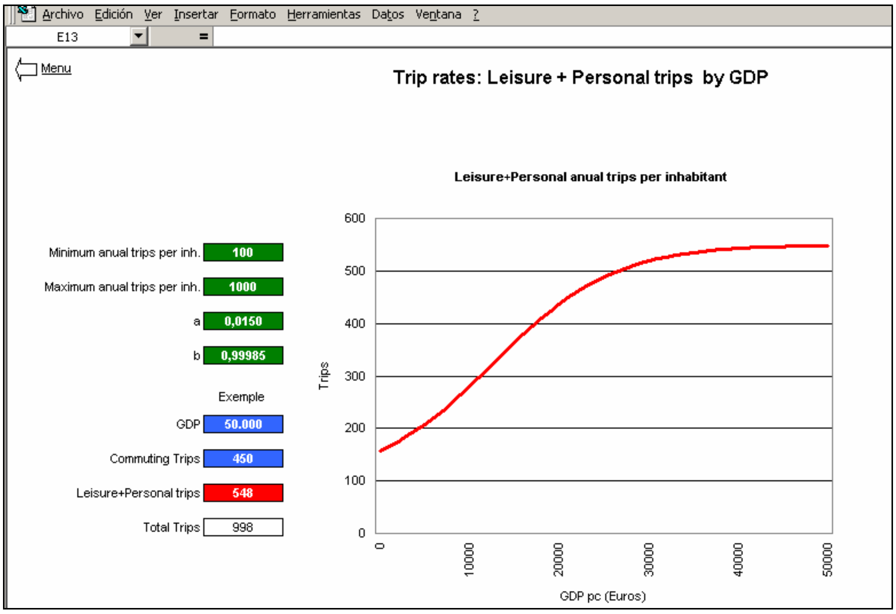


Figure 8 **Leisure and Personal trips by GDP of the KTEN passenger Trip generation module**

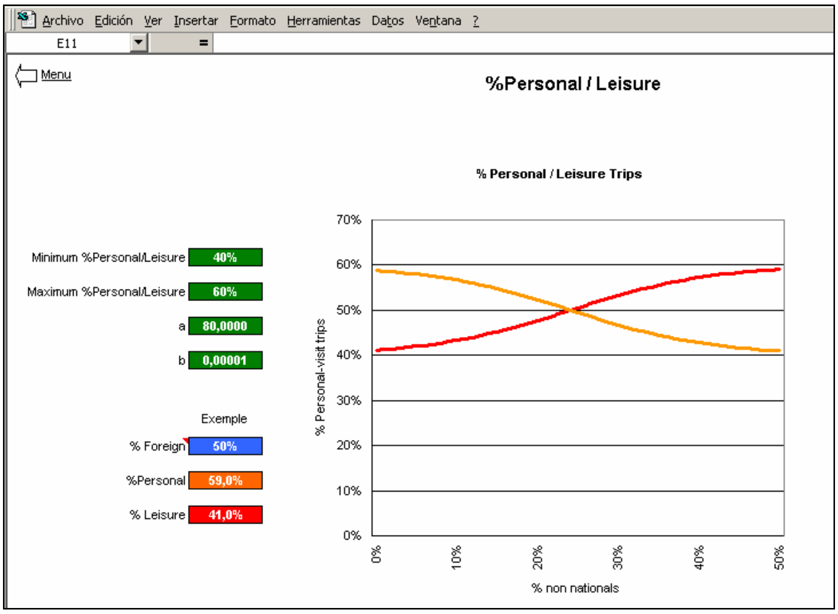


Figure 9 **Relation between Leisure and Personal trips of the KTEN passenger Trip generation module**

3.4.2 Trip Distribution

To calculate business trip distribution, KTEN uses the following expression:

$$V_{i,j} = O_i \cdot A_i \cdot K_{i,j}^{\alpha} \cdot Cap_j^{\beta} \cdot Pop_j^{\gamma} \cdot Gdp_j^{\delta} \cdot C_{i,j}^{\rho}$$

where,

$V_{i,j}$ trips between zone (i) and zone (j)
O_i the origins from zone (i)
A_i calibration parameter to reach the Origins condition
$K_{i,j}^{\alpha}$ relationship between the countries containing the zones (i) and (j)
Cap_j^{β} capitatility index (4 for European Capitality ,2 for capital of country and 1 for others)
Pop_j^{α} population of zone (j)
Gdp_j^{δ} gross domestic product of zone (j)
$C_{i,j}^{\rho}$ cost to travel from zone (i) to zone (j)

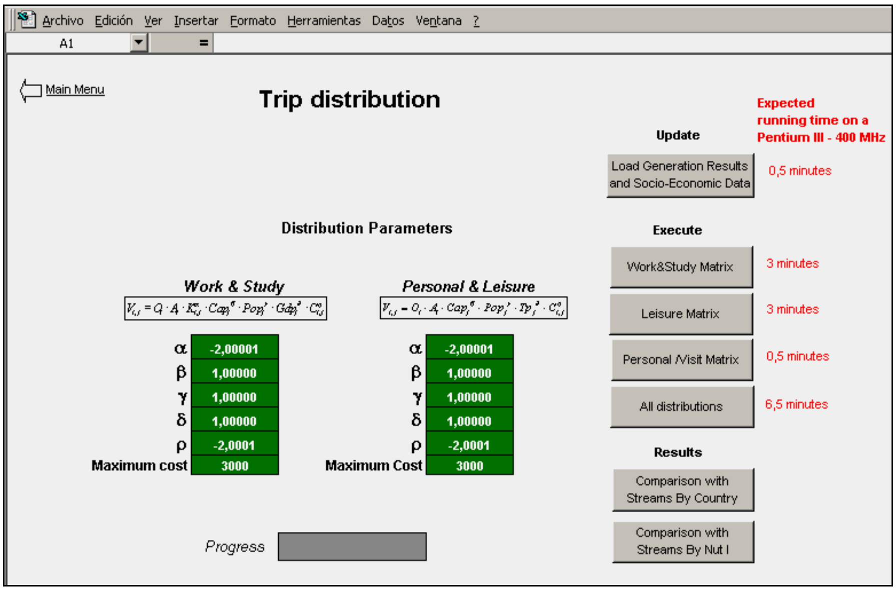


Figure 10 Interface of KTEN passenger Trip distribution module

Leisure and personal trip distribution is calculated using the following expression :

$$V_{i,j} = O_i \cdot A_i \cdot Cap_j^{\beta} \cdot Pop_j^{\gamma} \cdot Tp_j^{\delta} \cdot C_{i,j}^{\rho}$$

where,
$V_{i,j}$ the trips between zone (i) and zone (j)
O_i the origins from zone (i)
A_i calibration parameter to reach the Origins condition
Cap_j^{β} capitatility index (4 for European Capitality,2 for capital of country and 1 for others)
Pop_j^{α} population of zone (j)
Tp_j^{δ} Tourist pressure on site of zone (j)
$C_{i,j}^{\rho}$ cost to travel from zone (i) to zone (j)

3.4.3 Modal Split and Assignment

Modal split is calculated considering the following percentages for every mode (see Figure 11) depending on the distance in km from zone (i) to zone (j) using road network and ferry lines.

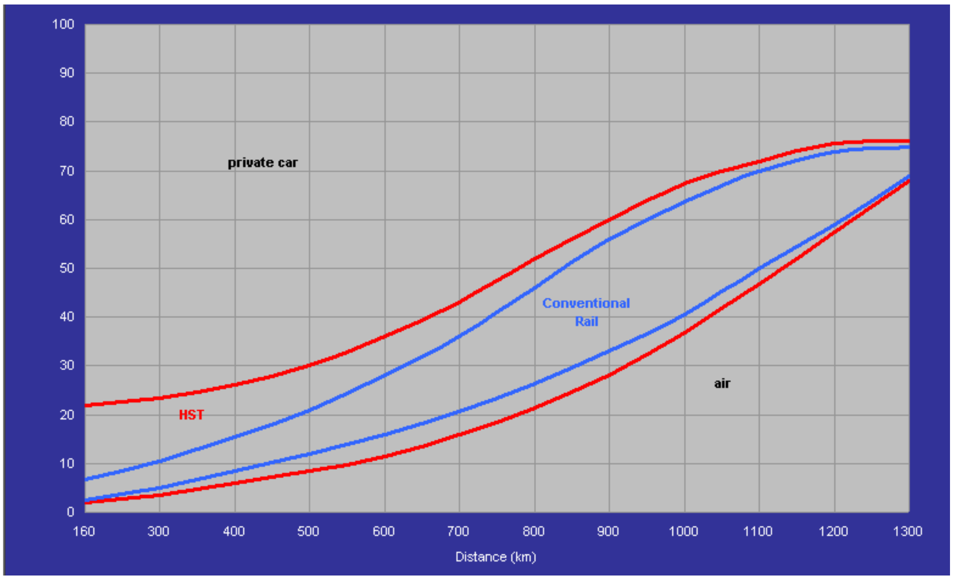


Figure 11 Modal split for interregional trips. Source: ESPON Project 1.2.1, Mcrit.

The average length of business trips by car from zone (i) is calculated with the expression:

$$K_{ijk} = \left(\sum_n L_{ijn} * N_{ijkn} \right) / \sum_n N_{ijkn}$$

Where
K_{ijk} km per person per mode *j* by purpose *k* in NUTS3 *i*
L_{ijn} cost (in km) from $NUTS2_i$ to $NUTS2_n$ using the mode *j*
N_{ijkn} number of trips from $NUTS2_i$ to $NUTS2_n$ using the mode *j* by purpose *k*.

Assignment: Matrices of trips can be taken from passenger module and assigned on the transport network of the GIS system.

3.5 Freight forecast module

3.5.1 ETIS matrix

The underlying basic data of the freight module are the ETIS-BASE freight matrices. First of all ETIS matrices have been tested against EUROSTAT's COMEXT database to check their accuracy. ETIS matrices have been aggregated by transport mode, freight type and region, obtaining flows between countries. These values are compared with real COMEXT data (which is aggregated at NUTS0 level):

	ETIS	COMEXT	Relative diff	ETIS distribution	COMEXT distribution	Relative diff
	Export	Export	Export	Export	Export	Export
AT	30.348.805	31.934.850	-5%	2,20%	2,54%	-1,32%
BE	158.568.092	155.737.933	2%	11,51%	12,39%	2,35%
CZ	27.452.112	28.237.130	-3%	1,99%	2,25%	-0,65%
DE	223.737.186	217.984.312	3%	16,24%	17,34%	4,78%
DK	31.612.422	35.553.067	-11%	2,29%	2,83%	-3,27%
EE	9.063.575	7.547.784	20%	0,66%	0,60%	1,26%
ES	56.851.628	57.459.546	-1%	4,13%	4,57%	-0,50%
FI	27.895.338	26.547.050	5%	2,03%	2,11%	1,12%
FR	152.721.675	151.713.462	1%	11,09%	12,07%	0,84%
GR	9.014.981	9.555.236	-6%	0,65%	0,76%	-0,45%
HU	12.427.058	12.445.236	0%	0,90%	0,99%	-0,02%
IE	9.007.666	7.386.507	22%	0,65%	0,59%	1,35%
IT	70.281.371	72.665.063	-3%	5,10%	5,78%	-1,98%
LT	9.575.129	6.825.395	40%	0,70%	0,54%	2,28%
LU	11.545.012	14.321.617	-19%	0,84%	1,14%	-2,31%
LV	10.642.898	8.171.735	30%	0,77%	0,65%	2,05%
MT	497.426	40.532	1127%	0,04%	0,00%	0,38%
NL	324.873.149	206.543.341	57%	23,58%	16,43%	98,23%
PT	12.903.071	12.357.560	4%	0,94%	0,98%	0,45%
SE	49.888.028	50.406.293	-1%	3,62%	4,01%	-0,43%
SI	3.397.230	5.293.453	-36%	0,25%	0,42%	-1,57%
UK	135.170.173	138.290.698	-2%	9,81%	11,00%	-2,59%
Total	1.377.474.025	1.257.017.801	10%	100,00%	100,00%	100,00%

Table 20 Comparison between ETIS and COMEXT exportation databases

There is a good prediction in the total export freight volume and the distribution of most of the countries. However, analyzing each country in detail, islands and little countries are less well adjusted, especially the Netherlands. On the other hand, where the volume of exportations is high, relative differences are lesser.

	ETIS Import	COMEXT Import	Relative diff Import	ETIS distribution Import	COMEXT distribution Import	Relative diff Import
AT	39.464.147	38.495.073	3%	2,86%	3,18%	0,58%
BE	202.006.840	175.897.279	15%	14,67%	14,54%	15,56%
CZ	12.299.262	11.785.849	4%	0,89%	0,97%	0,31%
DE	315.258.678	276.228.633	14%	22,89%	22,83%	23,27%
DK	22.755.434	21.835.027	4%	1,65%	1,80%	0,55%
EE	2.062.542	1.997.264	3%	0,15%	0,17%	0,04%
ES	68.328.560	65.852.505	4%	4,96%	5,44%	1,48%
FI	21.341.393	21.333.461	0%	1,55%	1,76%	0,00%
FR	171.048.606	155.505.491	10%	12,42%	12,85%	9,26%
GR	16.843.180	12.078.571	39%	1,22%	1,00%	2,84%
HU	9.192.556	9.089.334	1%	0,67%	0,75%	0,06%
IE	19.766.969	15.683.739	26%	1,44%	1,30%	2,43%
IT	91.829.415	94.567.178	-3%	6,67%	7,82%	-1,63%
LT	2.011.987	2.005.366	0%	0,15%	0,17%	0,00%
LU	17.325.695	18.368.157	-6%	1,26%	1,52%	-0,62%
LV	6.115.373	2.108.614	190%	0,44%	0,17%	2,39%
MT	3.811.619	1.496.856	155%	0,28%	0,12%	1,38%
NL	194.769.493	132.832.821	47%	14,14%	10,98%	36,92%
PT	25.840.810	25.121.342	3%	1,88%	2,08%	0,43%
SE	39.777.223	37.307.487	7%	2,89%	3,08%	1,47%
SI	7.247.378	6.951.181	4%	0,53%	0,57%	0,18%
UK	88.376.865	83.170.858	6%	6,42%	6,88%	3,10%
Total	1.377.474.025	1.209.712.085	14%	100,00%	100,00%	100,00%

Table 21 Comparison between ETIS and COMEXT importation databases

Concerning importations, the global error is higher but is quite well distributed. Now the most significant differences are for Netherlands, Belgium and Germany.

The following maps illustrate the ETIS-BASE data both in terms of both total freight generated per NUTS3 region (figure 1) and in terms of freight flows by corridors (figure 13). In order to create the later an All-or-Nothing assignation model was used for the assignation of regional traffics onto corridors:

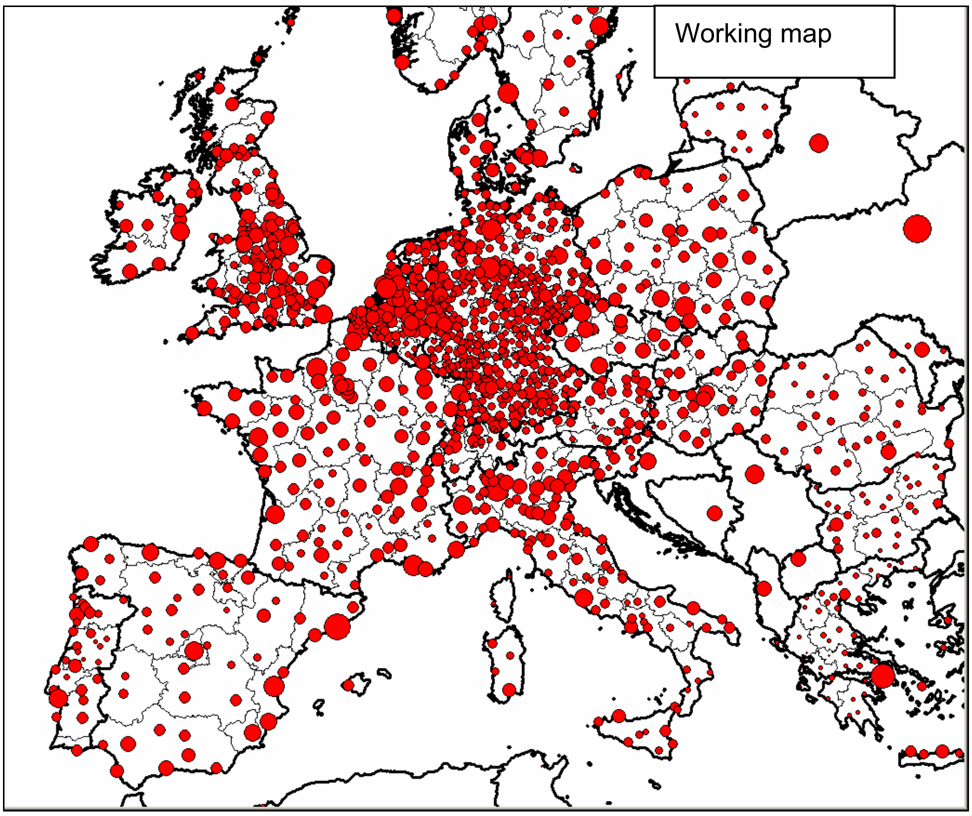


Figure 12 Road freight generation at NUTS3 level

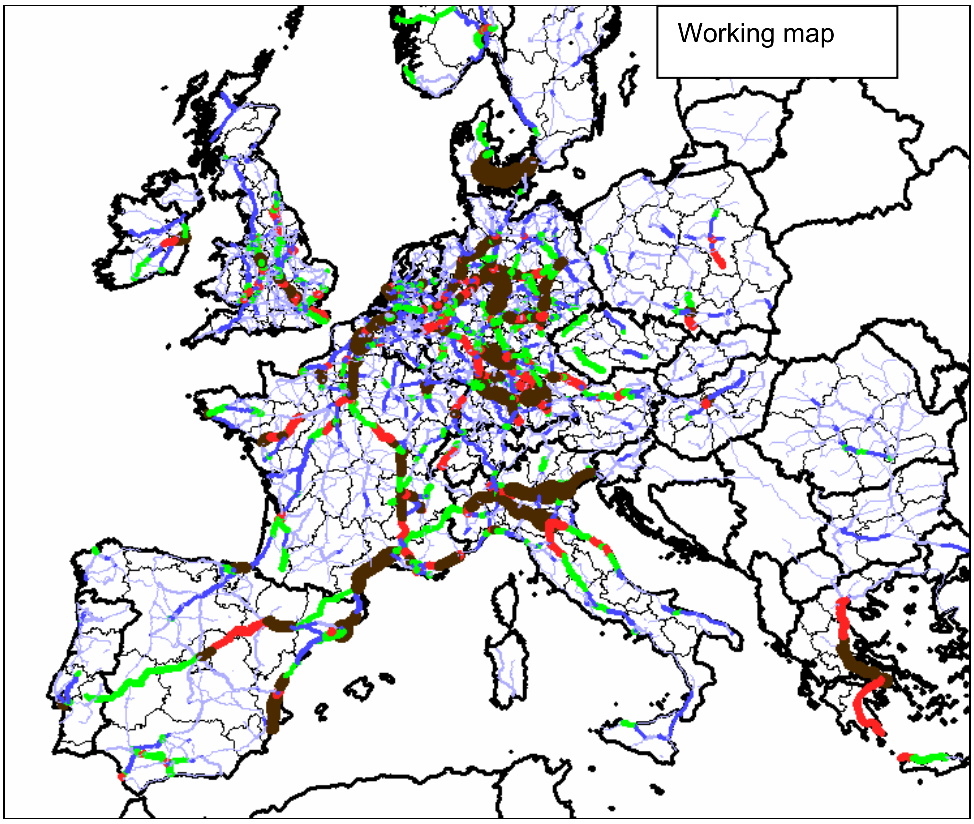


Figure 13 Road freight traffics

3.5.2 Generation - Distribution model

Since there is little available data at regional level, the model will estimate directly generation-distribution, based on two parameters: GDP at origin and Population at destination. In addition a dummy parameter will be calculated to simulate the growth of commercial operations between old, new and future EU members.

The gravitational equation used in the model is as follows:

$$V_{ij} = K_{ij}^{\alpha} \cdot GDP_{o}^{\beta} \cdot POP_{d}^{\gamma} \cdot e^{-\delta C_{ij}}$$

Where

V_{ij} = Tones transported from zone i to zone j
K_{ij} = Dummy between country of zone i and country of zone j
GDP_o = GDP for the origin zone
POP_d = Population at destination zone
C_{ij} = Cost of travel between zones i and j
α, β, γ, δ = regression fitting parameters

3.5.3 Modal split

A modal split model has to be applied afterwards in order to obtain the flows for road and rail, given that the generation-distribution model only predicts total flows between origin and destination but not the transport mode of the flow.

The modal split model has to provide the modal split for both the base and the predicted year. As ETIS-BASE matrices provide an initial modal split for year 2000, the two most typical formulations will be tested to reproduce it.

First of all costs are calculated using the existing infrastructure network graph. The model chooses the cheapest route between each pair O-D in terms of time, and calculates the distance and time of travel. This has to be done thrice, one for road, one for rail and one for short sea shipping and inland waterways.

Now we can calculate the generalized cost introducing two new values, the value of time and operational cost. Thus there are three costs, road, rail and water modes, for each O-D pair:

$$C_{ij} = T_{ij} \cdot VT + D_{ij} \cdot OC$$

Where

T_{ij} = time of travel between i and j
VT = value of time
D_{ij} = distance between i and j
OC = operational cost

The most typical discrete choice model is the logit:

$$\%V_{ij}^{a} = \frac{e^{-kC_{ij}^{a}}}{e^{-kC_{ij}^{a}} + e^{-kC_{ij}^{b}}}$$

Where

$\%V_{ij}^{a}$ = percent of tones transported by mode a between i and j
k = logit parameter
C_{ij}^{n} = cost of travel between i and j by mode n
a, b = transport modes

We try to reproduce ETIS-BASE modal split by calibrating the logit formula through three parameters, k, VT and OC. Results show a low fitting, as best logit prediction and original data have a correlation of ρ = 0,02426

As results are not satisfactory another option is essayed, the binary probit model:

$$P^{a} = \Phi\left[\frac{\left(C_{ij}^{a} - C_{ij}^{b}\right)}{\sigma_{\varepsilon}}\right]$$

Which states that the probability of choosing mode a, equals to the accumulated standard normal distribution. Here σ_{ε} allows standardization and is obtained from the statistical parameters of the cost functions for each mode:

$$\sigma_{\varepsilon}^{2} = \sigma_{a}^{2} + \sigma_{b}^{2} - 2\rho\sigma_{a}\sigma_{b}$$

The only parameters in this model are those that vary the cost functions; that is Value of Time and Operational Cost. Again, results are poor with a value of ρ = 0,02424.

Due to the bad results, the modal split from ETIS-BASE freight is applied directly to calculate the generalized costs of the network for each O-D pair in the base year.

3.5.4 Calibration

Now the generation-distribution model has to be calibrated against ETIS flow data to ensure it provides correct results. Free variables for calibration are the following:

- α, β, γ: powers for dummy K_{ij}, Population and GDP
- δ: power of the negative exponential formula for Generalized Cost
- K_{ij}: values of the dummy variable for each type of O-D relation
- VT, OC: although not truly Value of Time and Operative Costs, these variables are used for calibration, and provided that they are free to change, their real meaning is no more than mere adjusting factors. However, these values are applied afterwards when assigning the matrices, so they must be within some limits or the assignation will not behave correctly.

The dummy variable K_{ij} controls the level of relation between countries and allows to simulate the changes in the common market due to the admission of new countries. This way we are able to reproduce the enhancement of commercial relations between EU-15, the new EU-25 countries and the future candidates like Bulgaria and Romania.

Relations have been classified depending on the following factors:

- Belonging group (BENELUX, EU-15, EU-25, EU-27, EFTA, Future accessing countries, rest of non-EU Europe, Rest of the world)
- Islands

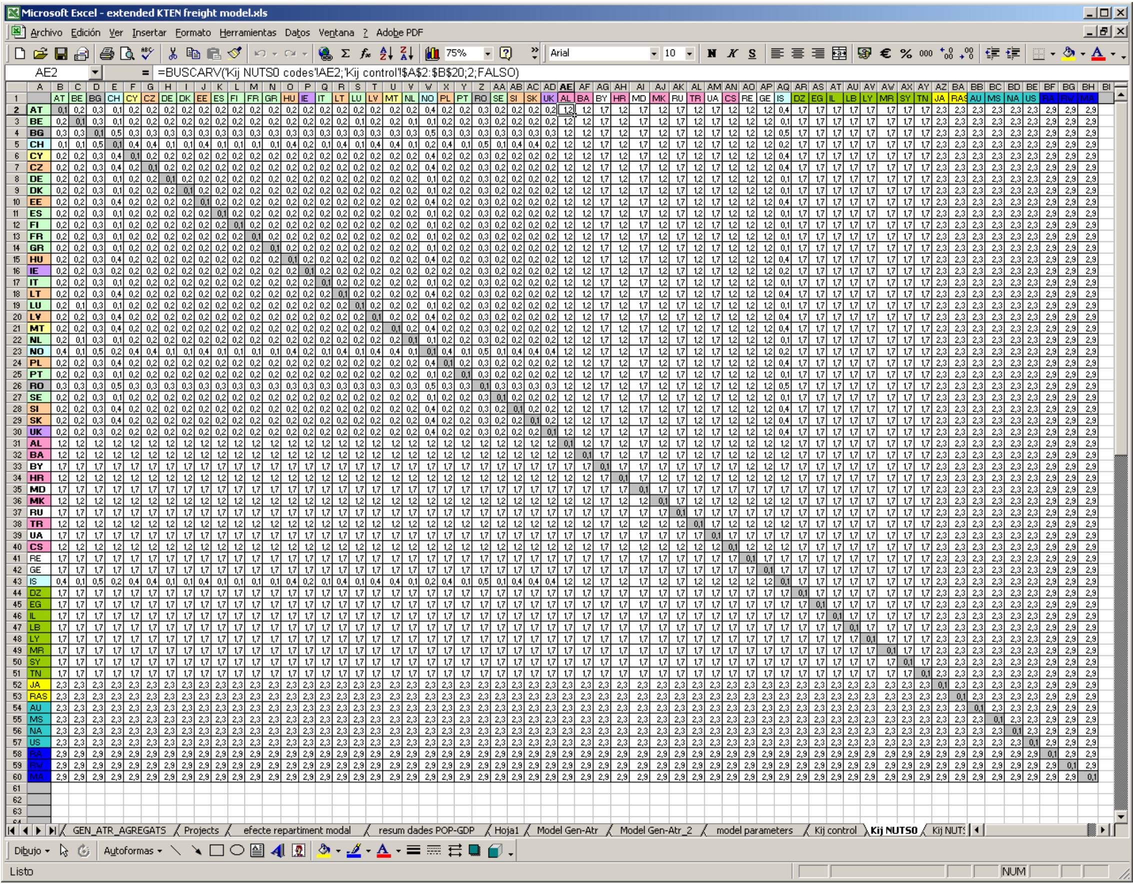


Figure 14 Dummy variable combination map

The possible categories and their adjusted K_{ij} values are shown in table 22. The values can be interpreted as a friction factor, i.e. a resistance to commercial exchanges, so the higher the K_{ij} the lesser the exchanges.

The next step is to compare the data and the model by means of cost distribution. The calibration allows obtaining a first approach to the data, but to ensure the network will behave similarly to one with the real flows, the model is tested comparing the distribution of costs of transport.
The O-D pairs are grouped according to their generalized cost in incremental groups of 100 cost units.
The following graphic shows the distribution of costs according to the number of tones transported versus cost of transport:

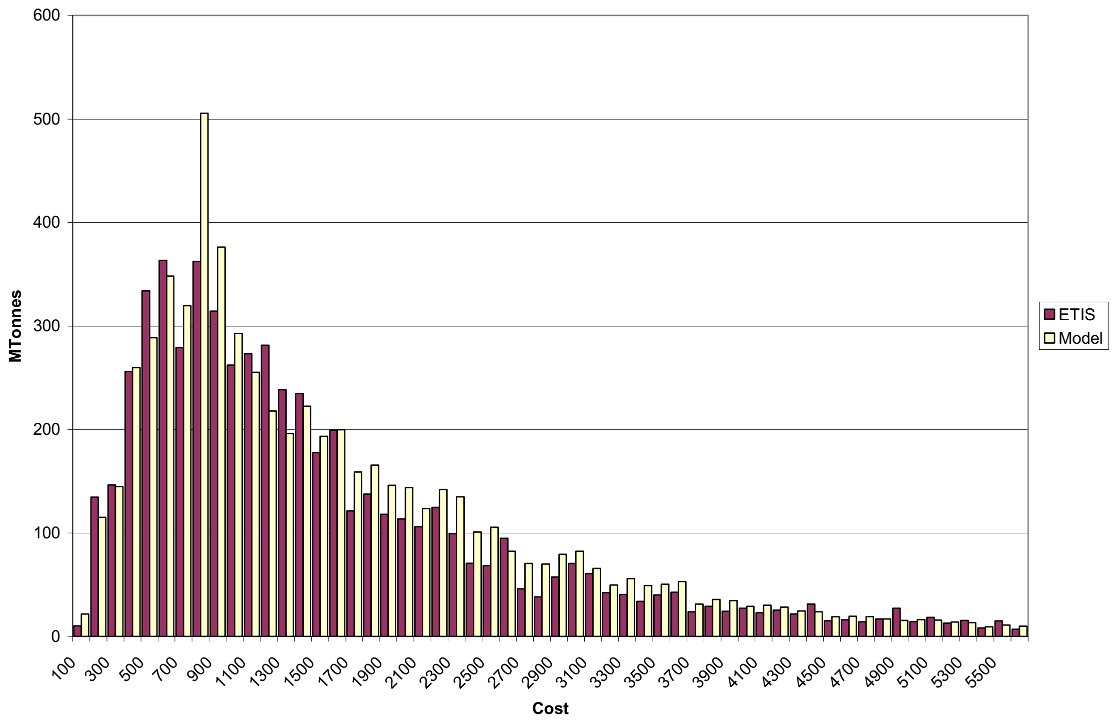


Figure 15 Calibration of developed model against ETIS matrix

The parameter values after calibration are the following:

α	-1,9357
β	0,4477
γ	0,8940
δ	0,0118
VT	10
OC	0,2

Number	Group 1	Group 2	Starting value	Calibrated value
0	All	Intracountry with cost<1000	1,1	0,05
1	All	Intracountry with cost>1000	1,1	0,09
2	EU-15 no island	EU-15 no island	1,2	0,3
3	EU-15 island	EU-15 island/no island	1,3	0,31
4	EU-25 no island	EU-25 no island	1,4	0,4
5	EU-25 island	EU-25 island/no island	1,5	0,5
6	EU-27 no island	EU-27 no island	1,6	0,6
7	EU-27 island	EU-27 island/no island	1,7	0,7
8	EFTA	EU-15 no island	1,15	0,2
9	EFTA	EU-15 island	1,25	0,33
10	EFTA	EU-25 no island	1,35	0,63
11	EFTA	EU-25 island	1,45	0,73
12	EFTA	EU-27 no island	1,55	0,83
13	EFTA	EU-27 island	1,65	0,93
14	Possible members	EU-27 / EFTA	2	2

Number	Group 1	Group 2	Starting value	Calibrated value
15	rest Europe	EU-27 / EFTA	2,5	3
16	Maghreb-Mediterranean	EU-27 / EFTA	3	3
17	Asia	EU-27 / EFTA	4	4
18	America-Australia	EU-27 / EFTA	4	4
19	Africa-Mid Asia	EU-27 / EFTA	4	5

Table 22 Model parameters after calibration

The correlation between data and model is ρ= 0,476

A careful inspection of the obtained values in comparison with the ETIS freight matrix shows a clear imbalance between long range traffic and short or middle range traffic. But nothing can be done to solve this given the structure of the proposed model, for when a segment of traffic is adjusted better the rest gets worse.

3.5.5 Incremental model

As the results of calibration are not satisfactory the calibrated model will then be used in an incremental form. This means that the model will not predict flows but variation of flows.

The model assumes ETIS base values for the year 2000 as initial flows. Using the calibrated gravitational model, future flows are predicted as increments of base flows:

$$V_{ij}^{MODELfut} = \left(K_{ij}^{fut}\right)^{\alpha} \cdot \left(1+\varepsilon_{GDP}\right) \cdot \left(GDP_{o}^{fut}\right)^{\beta} \cdot \left(1+\varepsilon_{POP}\right) \cdot \left(POP_{d}^{fut}\right)^{\gamma} \cdot e^{-\delta C_{ij}^{fut}}$$

$$V_{ij}^{fut} = V_{ij}^{ETIS2000} \cdot \left(\frac{V_{ij}^{MODELfut}}{V_{ij}^{MODEL2000}} \right)$$

Parameters are substituted by their future values according to the desired horizon year. The final flows are calculated as a product of the original ETIS flows and a growth factor, obtained from the predicted variation of flows in the model.

GDP and Population growths for EU-27 are taken from MASST model results. The rest of regions and countries are extracted from the Commission's paper 'European energy and transport trends to 2030', where we find predictions each five years until 2030.

K_{ij} country relation values can be changed to reflect the improvement of commercial relations. They have been separated in 6 groups: EU-15, EU-25, EU-27, EFTA, Future Candidates and Rest of the world. Any of these groups can be assigned a qualitative change: none, low improvement, middle improvement or high improvement. This translates numerically into changes of per year global freight growth, which allows simulating different trends and policies of traffic/economic growth decoupling.

The future costs of travel are estimated for three different scenarios and two time horizons yielding a total of six different infrastructure networks. Using network graph, travel costs are calculated for each pair O-D and for each transport mode.

The generalized cost applied is calculated after making a modal redistribution with the following formula:

$$\%A_{ij}^{fut} = \frac{\%A_{ij}^{act} \cdot \left(\frac{\left(C_{ij}^{A}\right)^{fut}}{\left(C_{ij}^{A}\right)^{act}} \right)^{-\mu}}{\sum_{n} \%n_{ij}^{act} \cdot \left(\frac{\left(C_{ij}^{n}\right)^{fut}}{\left(C_{ij}^{n}\right)^{act}} \right)^{-\mu}}$$

The formula calculates the future share of the n modes for each pair O-D ponderating with the cost variation of the mode to a power. The higher the power is, more redistribution is made, and so this parameter models the perception of users of the costs change.

The formula resembles the logit distribution model, but it uses the variation of costs as input and not the future costs, allowing to use original ETIS modal distribution as initial value.

Two more parameters can be changed in order to have more control to define the desired scenarios. GDP and POP values are affected by a coefficient (1+ε) that enhances or decreases their influence in the predicted flow.

The following image shows the provisional main model interface, where all parameters can be controlled:

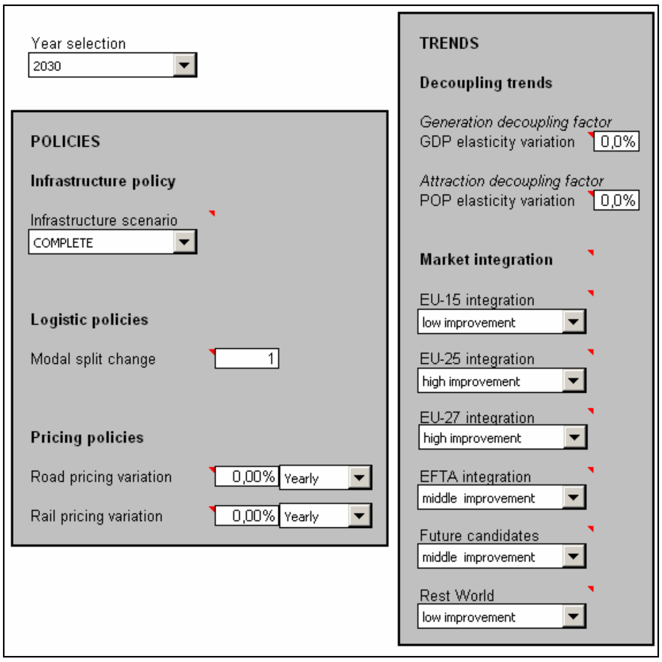


Figure 16 Main interface of KTEN freight module

3.6 Transport infrastructure graph

The basic cartographic pan-European multimodal transport networks used to support the KTEN model come from ASSEMBLING research (4th EU Framework Programme, DGTREN) (see Fig. 7). Other complementary geographic layers (mountains, rivers, administrative levels...) were produced by Mcrit in previous works and all are free from third parties copy-rights. While the inclusion of other databases (e.g. Administrative limits at NUTS V level, Nature2000, etc.) can be of interest, the existing databases mostly cover the current needs of KTEN.

The graph covers EU and Eastern European countries including Russia, as well as North of Africa and Middle East. It contains trans-European links (roads, rail, ports, airports, inland waterways). The transport network contains all existing and planned high speed, upgraded, conventional and main rail lines, and existing and planned motorways, expressways, main and regional road, local roads, streets, and roads connecting ports and airports to the rest of the network (61.000 road links and 30.000 rail links). The rail and road network database contains information on speed and TEN and TINA programmes.

Apart from the road and rail transport links, the cartography contains 749 airports separated in different levels of passengers per year, and 37 airlines. Concerning ports, it contains 842 seaports and 1.012 port lines, and 30 riverports, as well as 158 inland lines.

1.308 projects have been geo-referenced, 424 of which, mostly concerning transport projects, have been introduced with cartographic precision and graph structure (e.g. for road projects all sections are included and linked to the existing road network).

Regarding geo-referenced projects, they are classified as follows:

- 684 transport projects
- 283 water projects
- 165 urban projects
- 176 others (industrial, environment, etc.)

Regarding transport projects, these are represented as graphs, so as to enable network analysis:

- 240 road projects
- 34 railway projects
- 67 airports
- 47 ports
- 10 combined transport projects

The geographic scale of core networks is approximately 1: 500.000, with more detail in cities and around transport terminals.

3.7 Scenario definition results

The following maps show the CBA proxy analysis for the three scenarios (baseline, cohesive, competitive).

3.7.1 Baseline scenario

The profitability of projects (lines) is higher when the colour is darker while gap in GDP (NUTS2 regions) is above 1 for dark blue regions and below 1 for light blue ones:

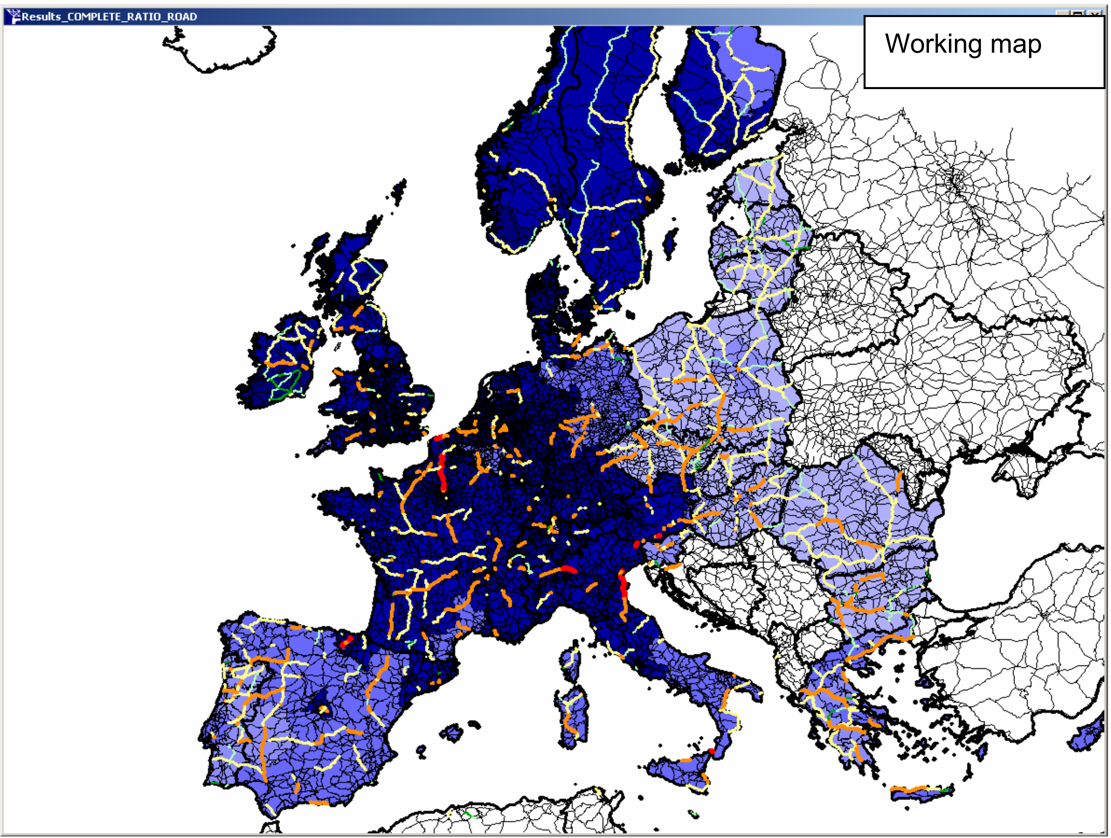


Figure 17 Road project evaluation for Baseline scenario

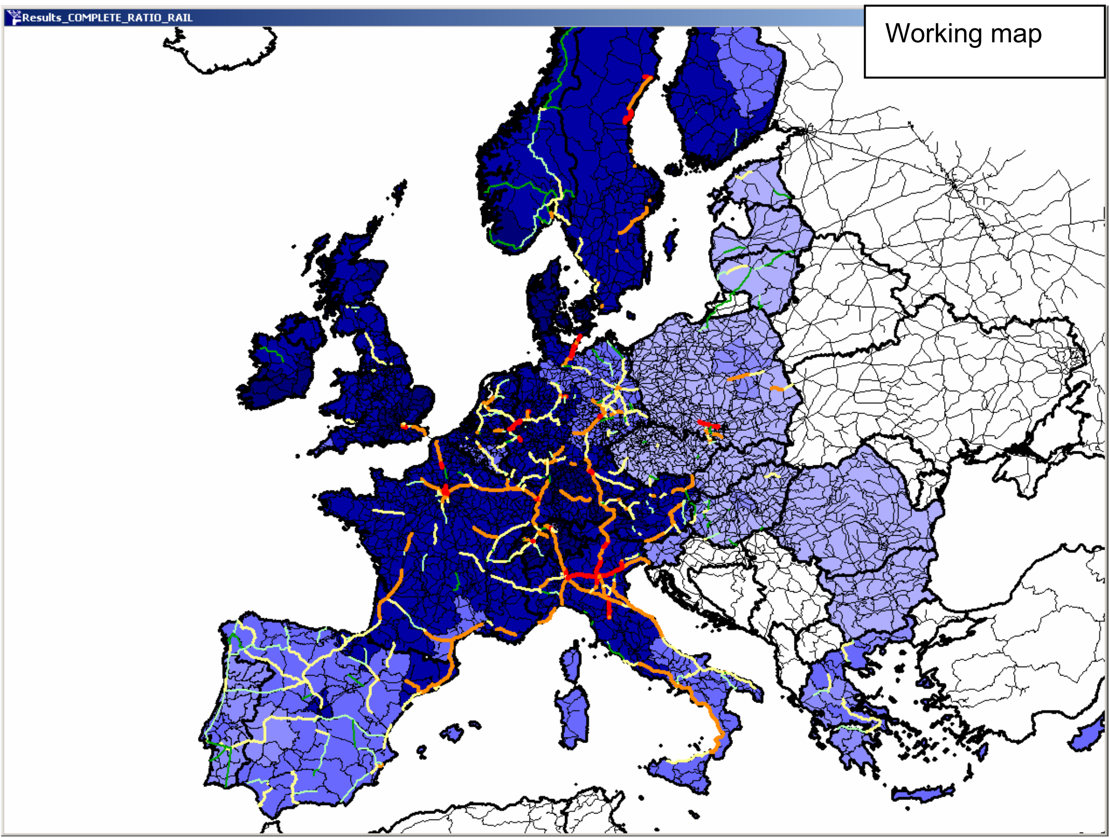


Figure 18 Rail project evaluation for Baseline scenario

3.7.2 Cohesive scenario

The profitability of projects (lines) is higher when the colour is darker while the gap in density of infrastructure (NUTS2 regions) is above 1 for dark blue regions and below 1 for light blue ones:

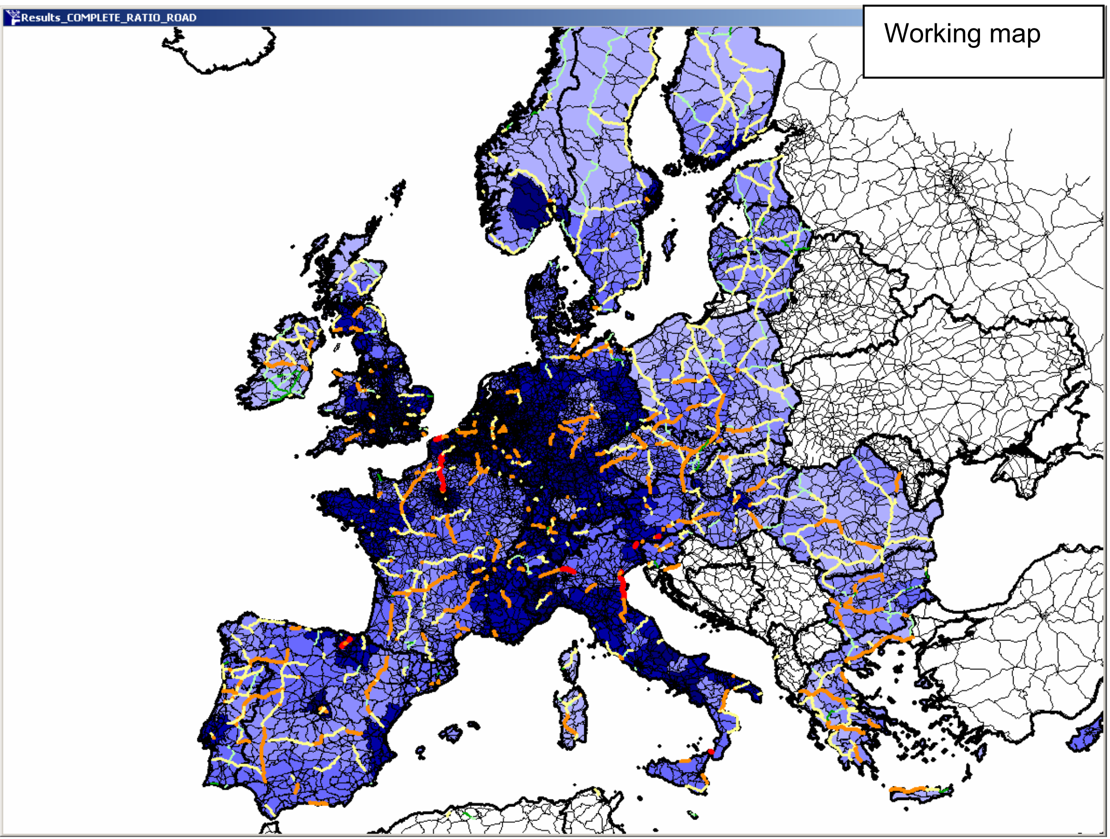


Figure 19 Road project evaluation for Cohesive scenario

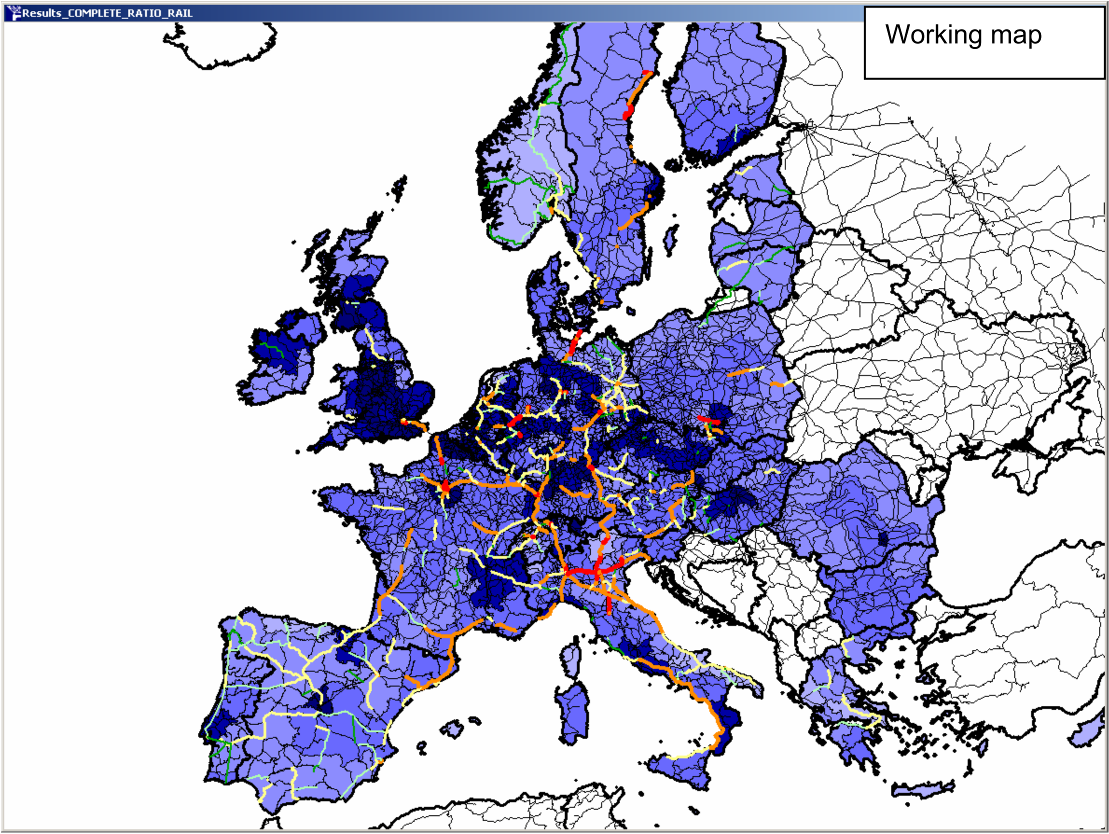


Figure 20 Rail project evaluation for Cohesive scenario

3.7.3 Competitive scenario

The profitability of projects (lines) is higher when the colour is darker:

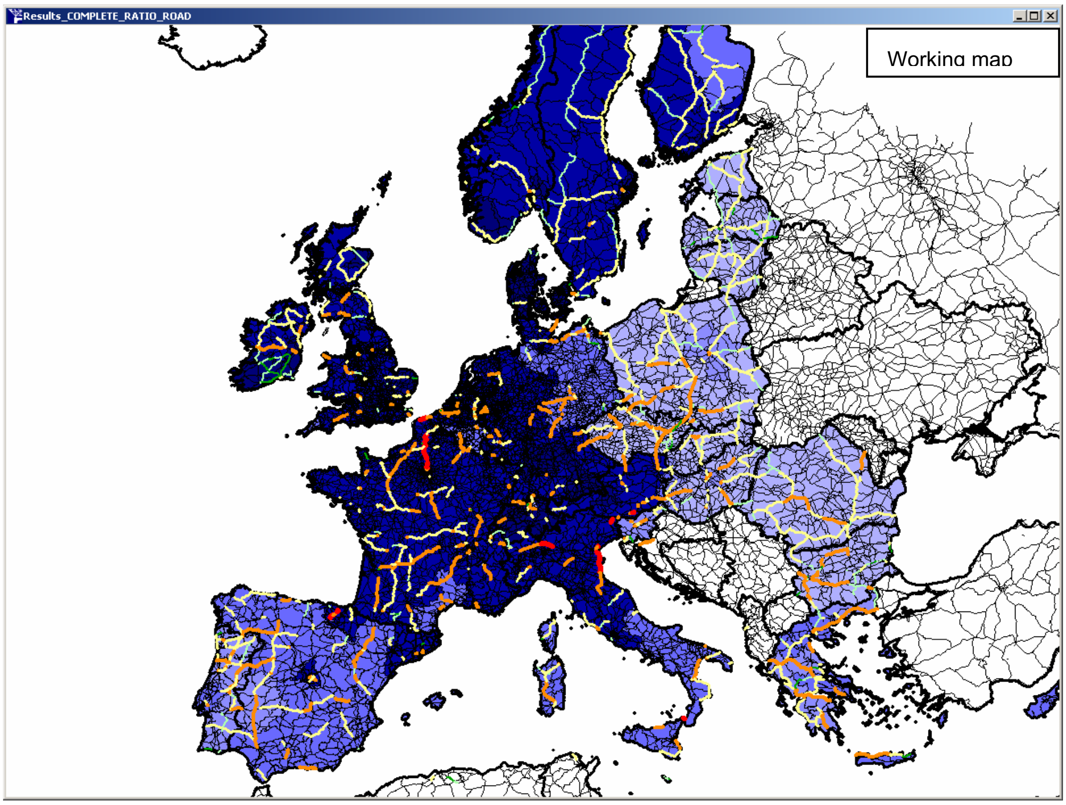


Figure 21 Road projects CBA proxy analysis for Competitive scenario

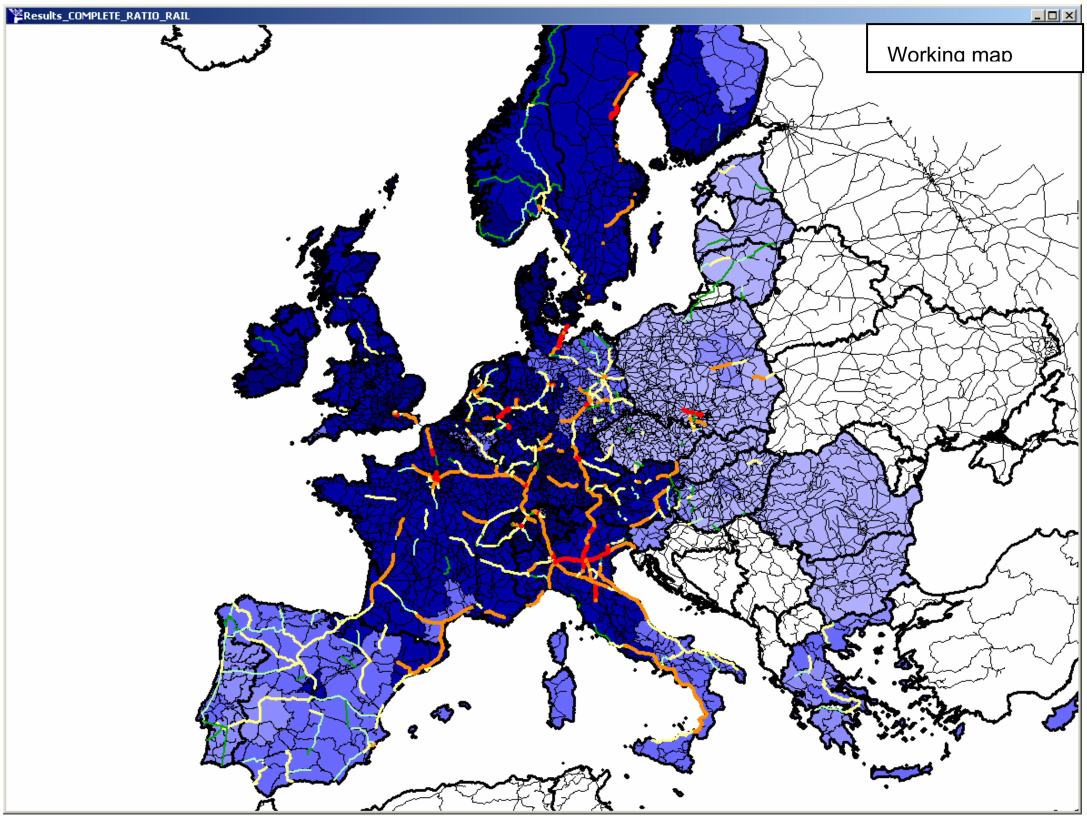


Figure 22 Rail projects CBA proxy analysis for Competitive scenario

3.8 Main KTEN results

This first two maps show the investment in road and rail TENs for the whole 2000-2030 period in the baseline scenario.

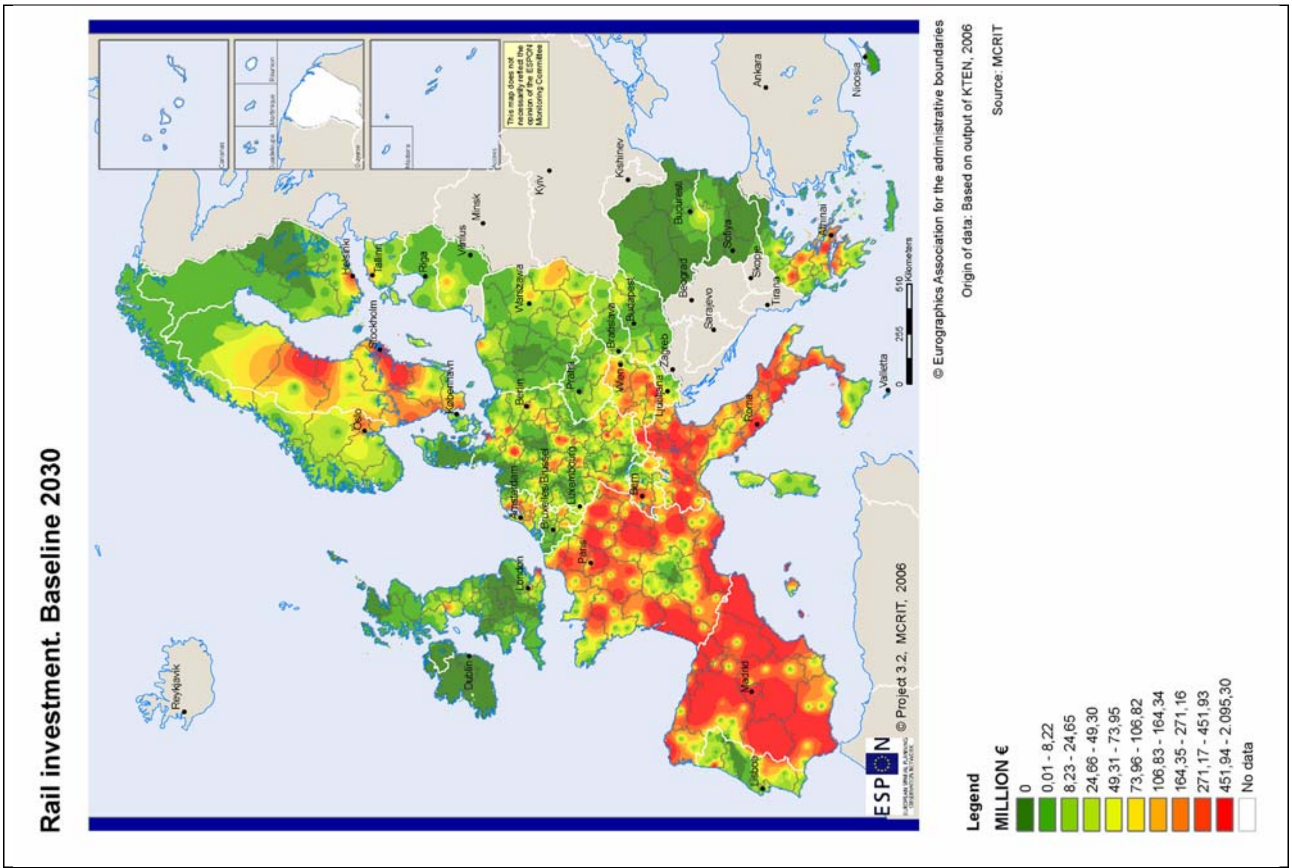
3.8.1 Infrastructure investment

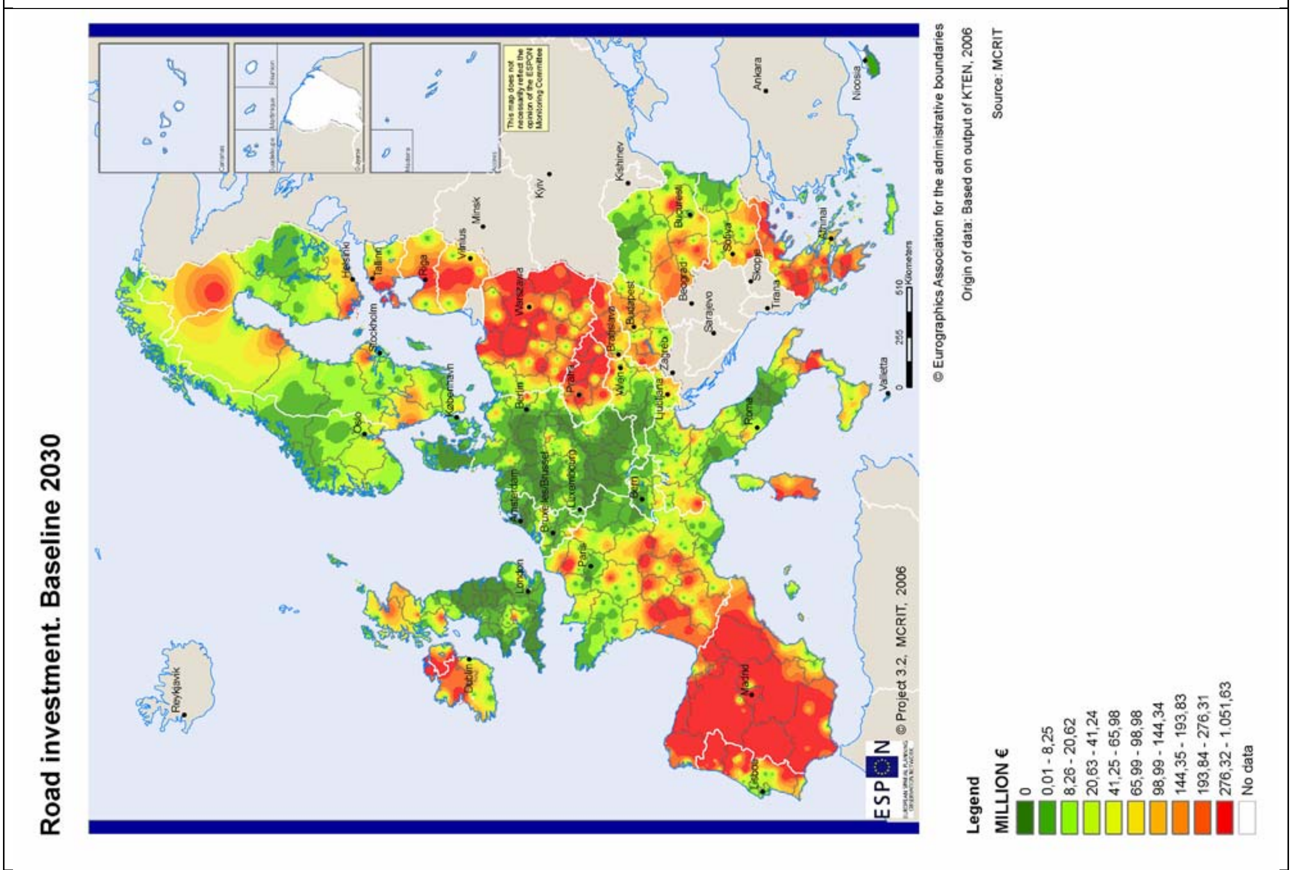
Road investment, Baseline:

- There is a strong investment in Spain, Poland and Greece.
- Vertical axes in eastern Europe gain in continuity besides from quality.
- Southern France and some peripheral regions like western Ireland, southern Italy, Sardinia or northern Finland have an important road investment that will help to increase local accessibility.

Rail investment, Baseline:

- In general there is more investment in the EU-15 because the projected lines are concentrated in this zone.
- The highest investments apply to Spain and its developing High Speed Network.
- In France both the Atlantic and East TGV are upgraded and finished, thus finishing the axe between the Mediterranean zone and the northwest Europe.
- Northern and Southern Italy high speed rails are finished making the network available to almost all the territory.
- Sweden, Austria and Greece also see some benefit although not as much as the previously mentioned zones.
- Minor investments appear in some eastern Europe regions, especially in the border between Poland and Ukraine.


Rail investment. Baseline 2030
Legend
MILLION €
0
0,01 - 8,22
8,23 - 24,65
24,66 - 49,30
49,31 - 73,95
73,96 - 106,82
106,83 - 164,34
164,35 - 271,16
271,17 - 451,93
451,94 - 2.095,30
No data
© Project 3.2, MCRIT, 2006
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT

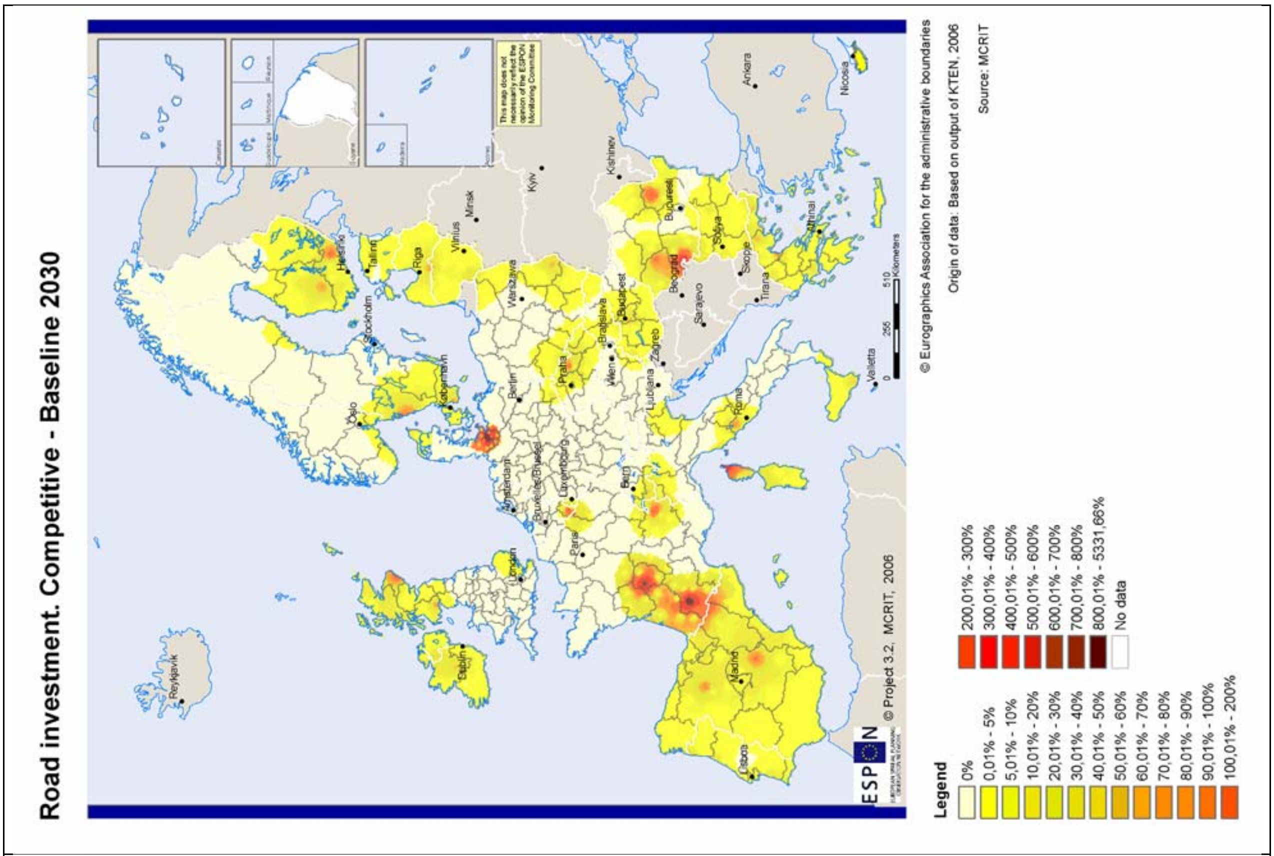

Road investment. Baseline 2030
Legend
MILLION €
0
0,01 - 8,25
8,26 - 20,62
20,63 - 41,24
41,25 - 65,98
65,99 - 98,98
98,99 - 144,34
144,35 - 193,83
193,84 - 276,31
276,32 - 1.051,63
No data
© Project 3.2, MCRIT, 2006
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT

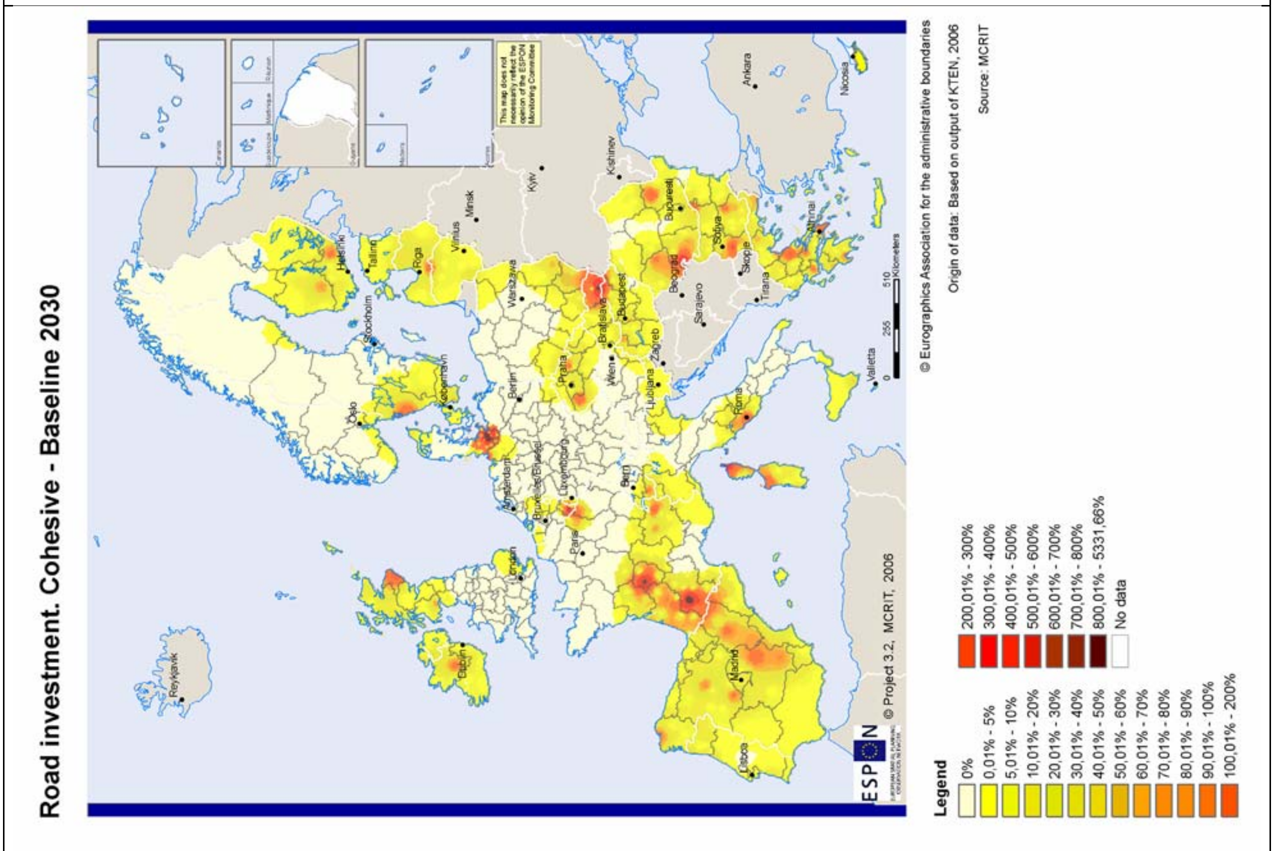
Road investment, Cohesive:

- Investment generally concentrates in peripheral regions in the cohesive scenario.
- The most benefited regions are eastern Slovakia, south Atlantic France and eastern and western Romania and Bulgaria.

Road investment, Competitive:

- Differences with baseline scenario are similar to these of the cohesive scenario, but the overall investment is lower.
- Bulgaria, Greece and central Spain inversions are lower than in the cohesive scenario because the profitability of these links does not reach the minimum performance defined in the scenario definition.


Road investment. Competitive - Baseline 2030
Legend
0%
0,01% - 5%
5,01% - 10%
10,01% - 20%
20,01% - 30%
30,01% - 40%
40,01% - 50%
50,01% - 60%
60,01% - 70%
70,01% - 80%
80,01% - 90%
90,01% - 100%
100,01% - 200%
200,01% - 300%
300,01% - 400%
400,01% - 500%
500,01% - 600%
600,01% - 700%
700,01% - 800%
800,01% - 5331,66%
No data
© Project 3.2, MCRIT, 2006
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT

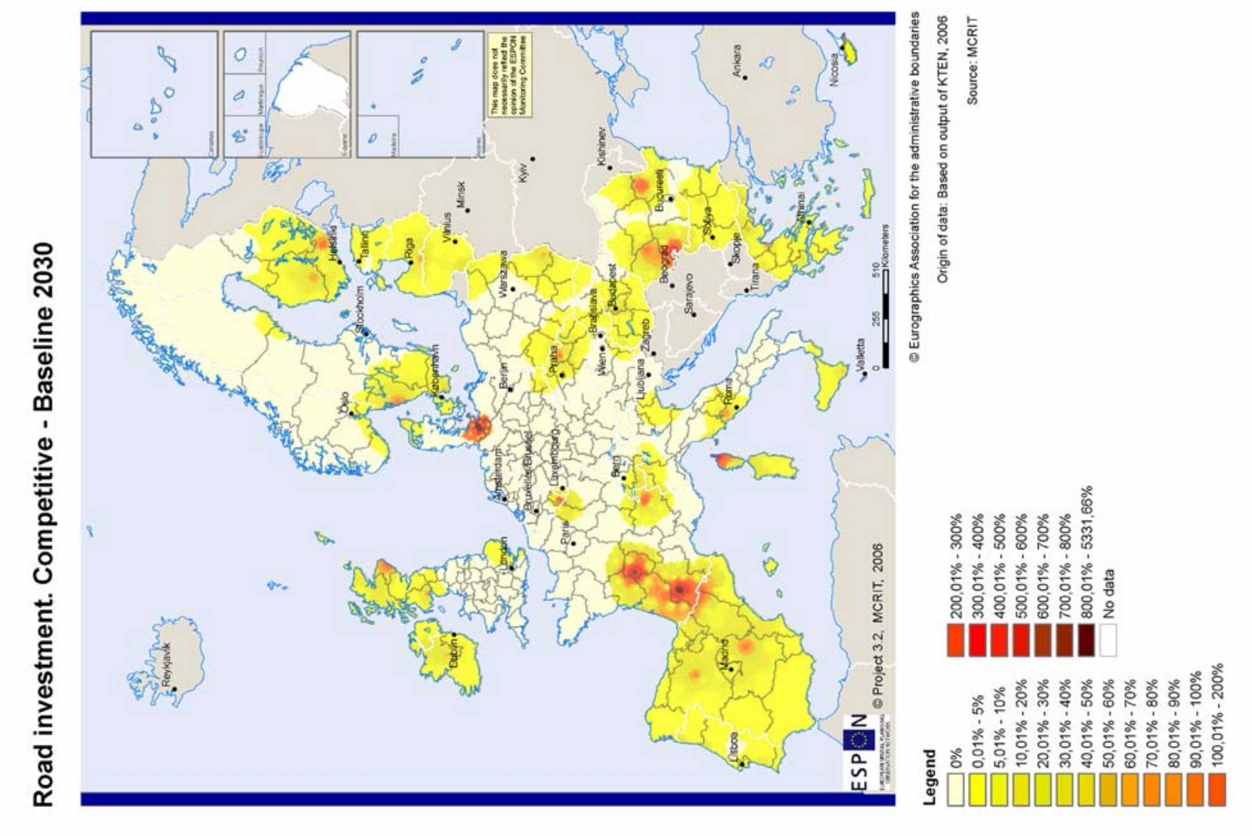

Road investment. Cohesive - Baseline 2030
Legend
0%
0,01% - 5%
5,01% - 10%
10,01% - 20%
20,01% - 30%
30,01% - 40%
40,01% - 50%
50,01% - 60%
60,01% - 70%
70,01% - 80%
80,01% - 90%
90,01% - 100%
100,01% - 200%
200,01% - 300%
300,01% - 400%
400,01% - 500%
500,01% - 600%
600,01% - 700%
700,01% - 800%
800,01% - 5331,66%
No data
© Project 3.2, MCRIT, 2006
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT

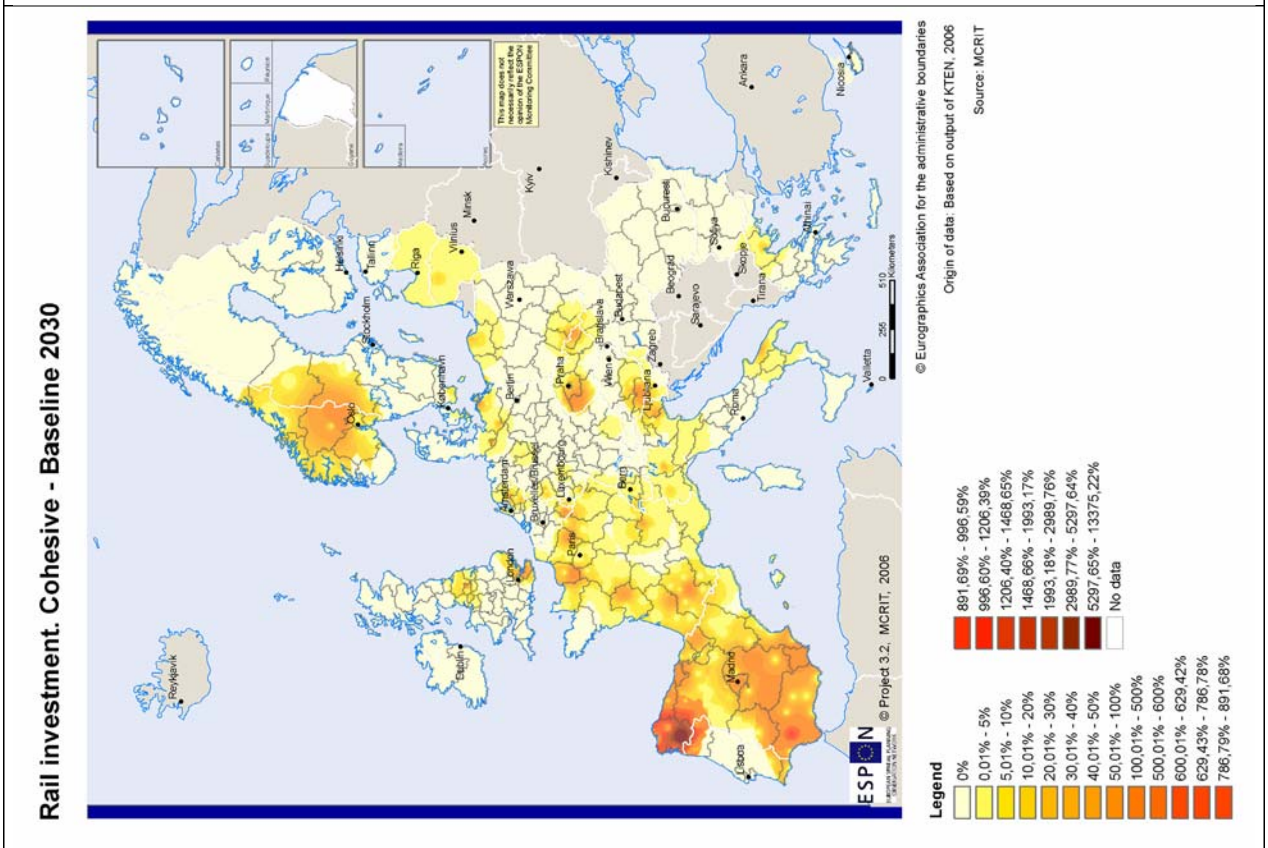
Rail investment, Cohesive:

- There is an overall increase of investment in the cohesive scenario.
- The most benefited regions are north and south Spain, southern Scandinavia, Czech Republic, western France and the border between Slovenia, Austria and Italy.

Rail investment, Competitive:

- The competitive scenario has an overall decrease of rail investment given that the profitability is low in general and the strategy of the scenario focuses mainly on developing an efficient road network.
- The most relevant links that remain in the competitive scenario are the southeast TGV in France and the international connection between Poland and Ukraine.


Road investment. Competitive - Baseline 2030
Legend
0%
0,01% - 5%
5,01% - 10%
10,01% - 20%
20,01% - 30%
30,01% - 40%
40,01% - 50%
50,01% - 60%
60,01% - 70%
70,01% - 80%
80,01% - 90%
90,01% - 100%
100,01% - 200%
200,01% - 300%
300,01% - 400%
400,01% - 500%
500,01% - 600%
600,01% - 700%
700,01% - 800%
800,01% - 5331,66%
No data
© Project 3.2, MCRIT, 2006
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT


Rail investment. Cohesive - Baseline 2030
Legend
0%
0,01% - 5%
5,01% - 10%
10,01% - 20%
20,01% - 30%
30,01% - 40%
40,01% - 50%
50,01% - 100%
100,01% - 500%
500,01% - 600%
600,01% - 629,42%
629,43% - 786,78%
786,79% - 891,68%
891,69% - 996,59%
996,60% - 1206,39%
1206,40% - 1468,65%
1468,66% - 1993,17%
1993,18% - 2989,76%
2989,77% - 5297,64%
5297,65% - 13375,22%
No data
© Project 3.2, MCRIT, 2006
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT

3.8.2 Accessibility

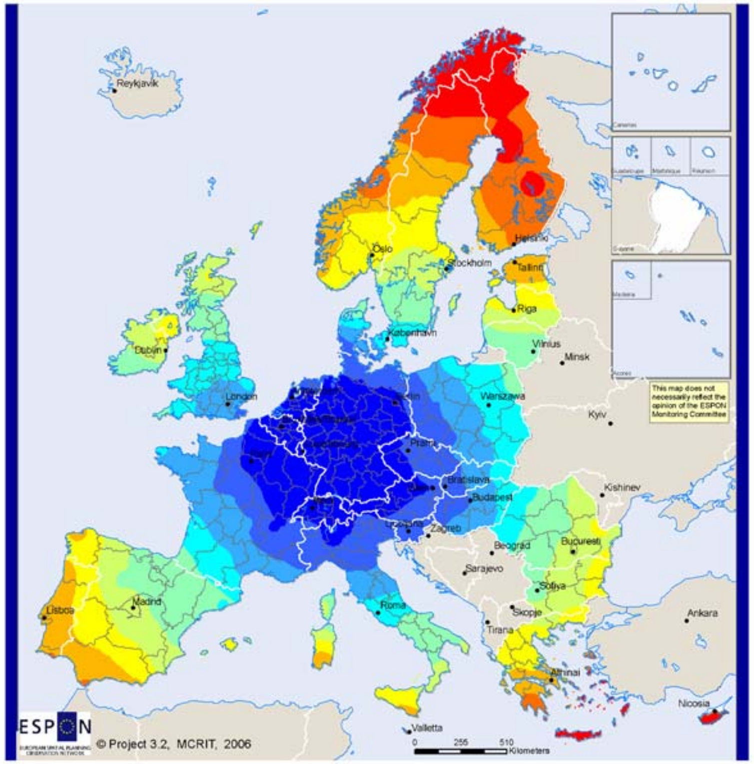
Accessibility as cost, Baseline:

- Accessibility to the whole ESPON space is highest in the Pentagon (i.e. average travel cost is lower).
- The barrier effect of mountain ranges like the Alps and the Pyrenees is notable, but the completion of road and rail tunnels helps to diminish this effect as it can be seen in Catalonia or in Lombardy.
- The disparities between West and East are still important but the introduction of new links in the Czech Republic, Slovakia and Hungary increases the accessibility quite significantly, thus breaking the former West/East border.

Accessible GDP at less than 10 hours, Baseline:

- The accessible GDP follows a pattern similar to the accessibility as cost however some important differences arise because the GDP distribution plays an important role in the indicator.
- The barrier effect of mountains disappears almost completely.
- Poland, Czech Republic, Slovakia and Hungary benefit from a good geographical position and are able to access a big market. This effect is greatly increased due to the new road and rail links.

Multimodal accessibility 2030 baseline as mean travel cost



© Eurographics Association for the administrative boundaries

Origin of data: Based on output of KTEN, 2006

Source: MCRIT

Legend

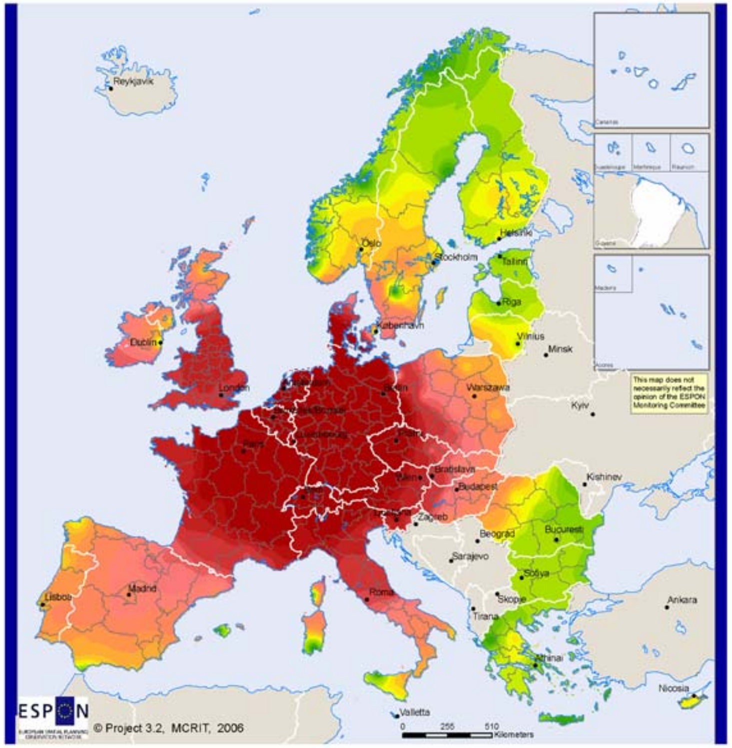
- 514 - 547
- 548 - 581
- 582 - 620
- 621 - 665
- 666 - 743
- 744 - 793
- 794 - 860
- 861 - 933
- 934 - 1.016
- 1.017 - 1.938
- No data

Multimodal accessibility measured as mean cost (€) of travel from the NUTS 2 capital to all other NUTS 2 capitals

$$\frac{\sum_i Cost_{NUTS2_{i \to d}}}{n}$$

Higher values indicate worse accessibility

GDP accessibility at less than 10 hours. Baseline 2030



© Eurographics Association for the administrative boundaries

Origin of data: Based on output of KTEN, 2006

Source: MCRIT

Legend

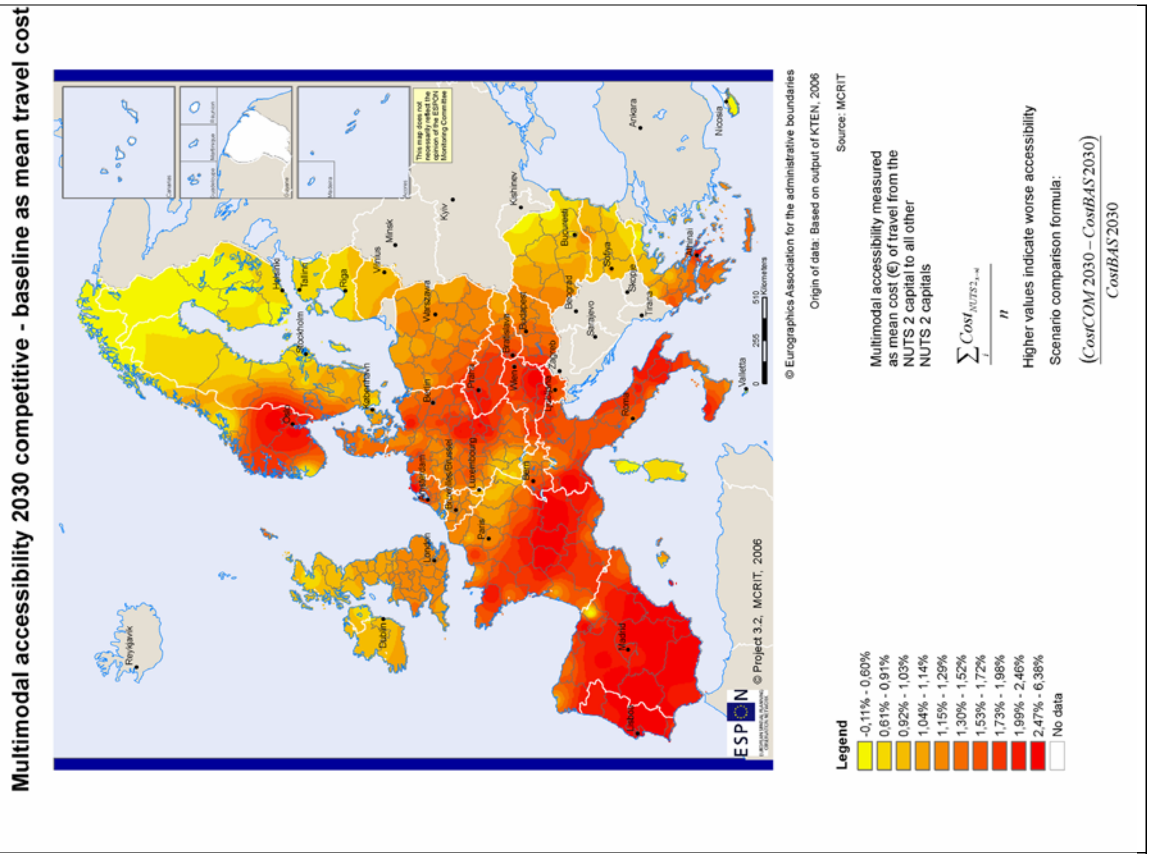
- 0,05 - 14.153,27
- 14.153,28 - 28.306,49
- 28.306,50 - 42.459,72
- 42.459,73 - 70.766,16
- 70.766,17 - 113.225,83
- 113.225,84 - 141.532,28
- 141.532,29 - 183.991,95
- 183.991,96 - 240.604,84
- 240.604,85 - 311.370,96
- 311.370,97 - 396.290,30
- 396.290,31 - 523.669,31
- 523.669,32 - 693.507,99
- 693.508,00 - 905.806,34
- 905.806,35 - 1.089.798,24
- 1.089.798,25 - 1.302.096,59
- 1.302.096,60 - 1.457.782,05
- 1.457.782,06 - 1.924.838,42
- 1.924.838,43 - 2.321.128,68
- 2.321.128,69 - 2.816.491,49
- 2.816.491,50 - 3.609.072
- No data

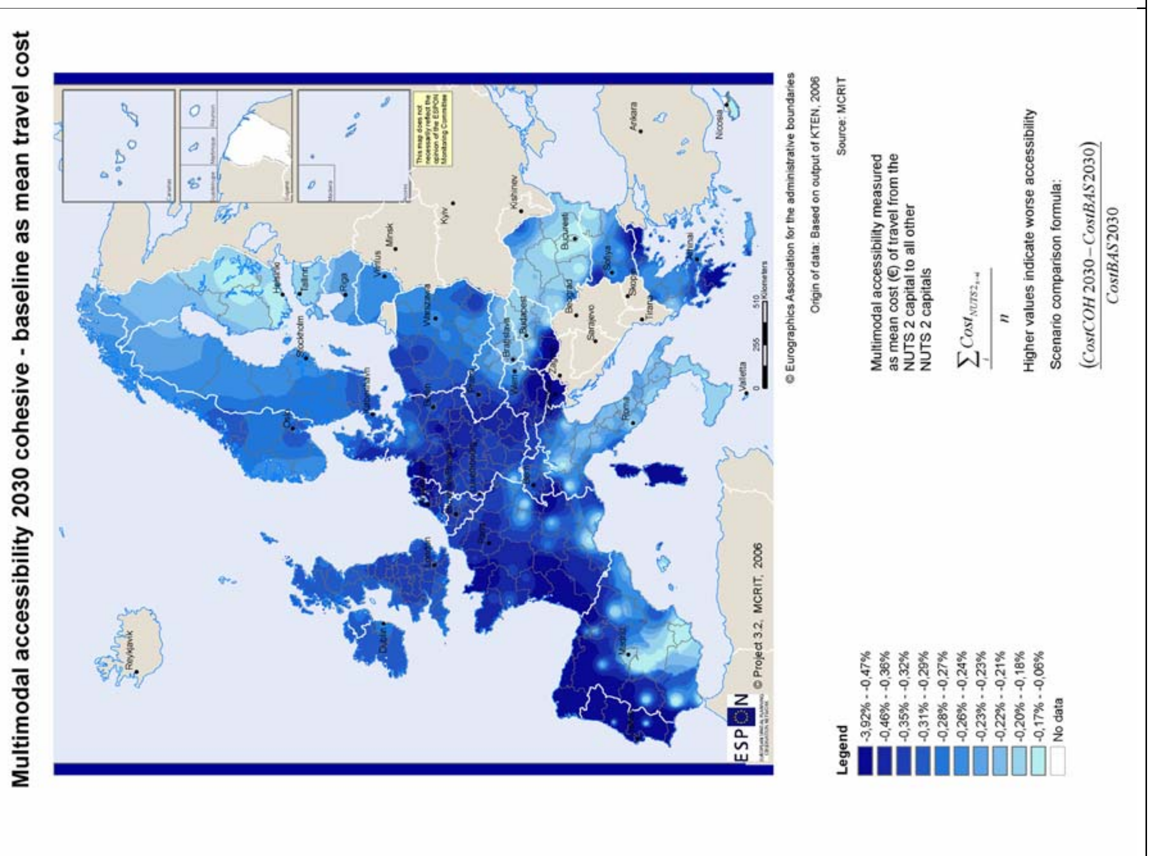
Accessibility as cost, Cohesive:

- Travel cost decreases in the whole territory when comparing Cohesive and Baseline scenarios, due to the higher degree of investment.
- The accessibility improvement is most important in Portugal, Western Spain, French Atlantic coast, the northern Balkans border and the Greece-Bulgaria border.
- The Pentagon area also benefits notably from the investments in the periphery.

Accessibility as cost, Competitive:

- The competitive scenario has a lower general accessibility, as investment is concentrated in selected zones of the territory.
- Peripheral zones like southern Italy, most of Spain, Portugal and Western France are the most harmed.
- The border between EU-15 and the new members suffers an important loss of accessibility, especially in Czech Republic and Eastern Austria, while the effect is less important in the farthest countries, Romania and Bulgaria.


Multimodal accessibility 2030 competitive - baseline as mean travel cost
Legend
-0,11% - 0,60%
0,61% - 0,91%
0,92% - 1,03%
1,04% - 1,14%
1,15% - 1,29%
1,30% - 1,52%
1,53% - 1,72%
1,73% - 1,98%
1,99% - 2,46%
2,47% - 6,38%
No data
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT
© Project 3.2, MCRIT, 2006
Multimodal accessibility measured as mean cost (€) of travel from the NUTS 2 capital to all other NUTS 2 capitals
Higher values indicate worse accessibility
Scenario comparison formula:
(CostCOM 2030 − CostBAS2030) / CostBAS2030

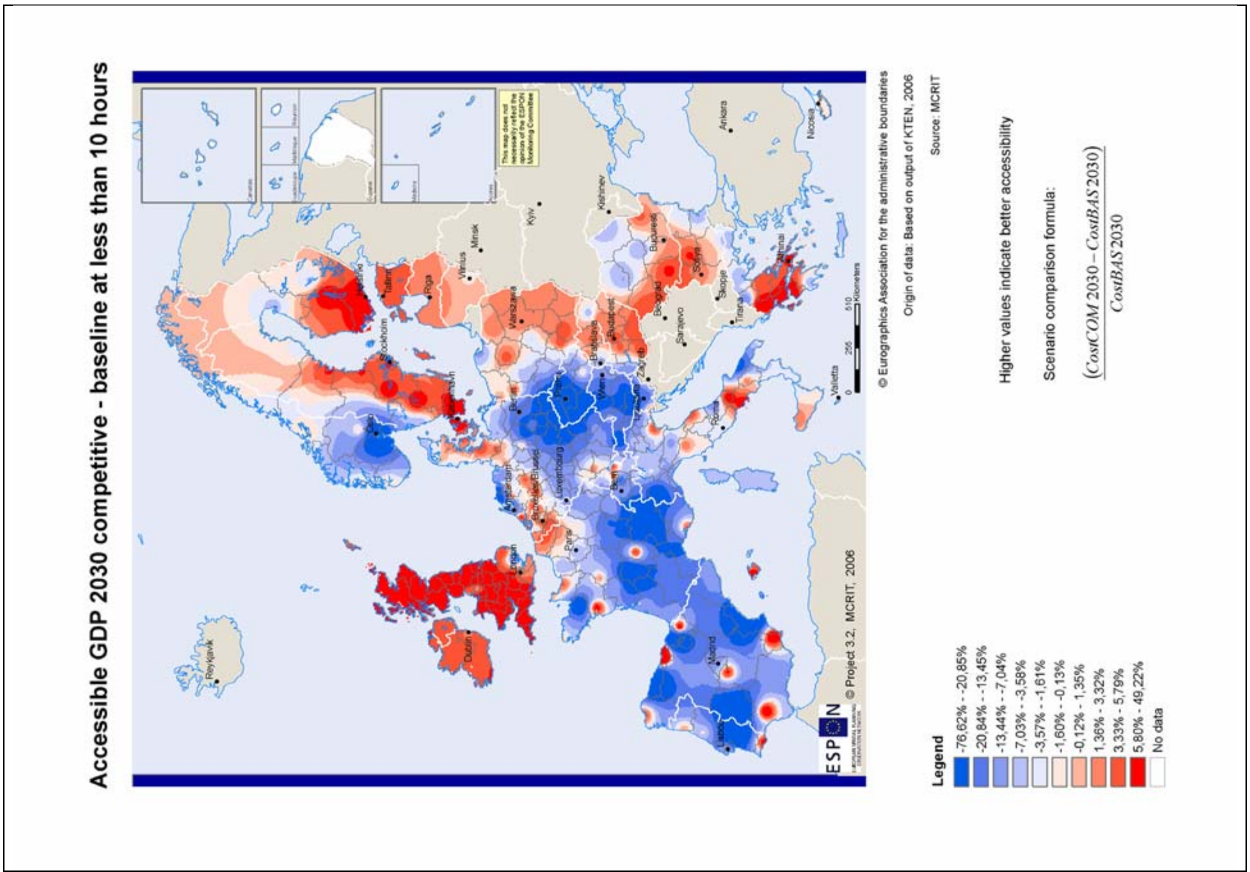

Multimodal accessibility 2030 cohesive - baseline as mean travel cost
Legend
-3,92% - -0,47%
-0,46% - -0,36%
-0,35% - -0,32%
-0,31% - -0,29%
-0,28% - -0,27%
-0,26% - -0,24%
-0,23% - -0,23%
-0,22% - -0,21%
-0,20% - -0,18%
-0,17% - -0,06%
No data
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT
© Project 3.2, MCRIT, 2006
Multimodal accessibility measured as mean cost (€) of travel from the NUTS 2 capital to all other NUTS 2 capitals
Higher values indicate worse accessibility
Scenario comparison formula:
(CostCOH 2030 − CostBAS2030) / CostBAS2030

Accessible GDP at less than 10 hours, Cohesive:

- The accessible GDP increases, when comparing to the baseline scenario, mainly in two zones, Portugal/Spain/Southern France, and in the axe Eastern Germany/Czech Republic/Hungary/West Bulgaria/Greece.
- There is a minor improvement in northern Scandinavia as well as Southern Ireland.
- The accessible GDP losses are found in Italy, Eastern Romania, Poland, the Baltic states, United Kingdom and Southern Scandinavia.

Accessible GDP at less than 10 hours, Competitive:

- In the Competitive scenario we see a major increase of accessible GDP in the eastern corridor, from Southern Finland, through the Baltic states, Poland Hungary, Romania until Bulgaria.
- The second important increase is located in the British isles and the eastern coast of Sweden.
- Many urban zones have an increase of accessible GDP due to both an improvement of accessibility as well as the regional increase of GDP in neighbouring regions as predicted by MASST model.
- Many rural regions of Spain and France, Northern Italy, Austria and most of Germany experience a reduction in accessible GDP.
- The Pentagon does not vary in average, accessible GDP increases in the north while it decreases in the south.
- The improvements are in general localised in certain zones according to the selection criteria of infrastructure projects.


Accessible GDP 2030 competitive - baseline at less than 10 hours
Legend
-76,62% - -20,85%
-20,84% - -13,45%
-13,44% - -7,04%
-7,03% - -3,58%
-3,57% - -1,61%
-1,60% - -0,13%
-0,12% - 1,35%
1,36% - 3,32%
3,33% - 5,79%
5,80% - 49,22%
No data
© Project 3.2, MCRIT, 2006
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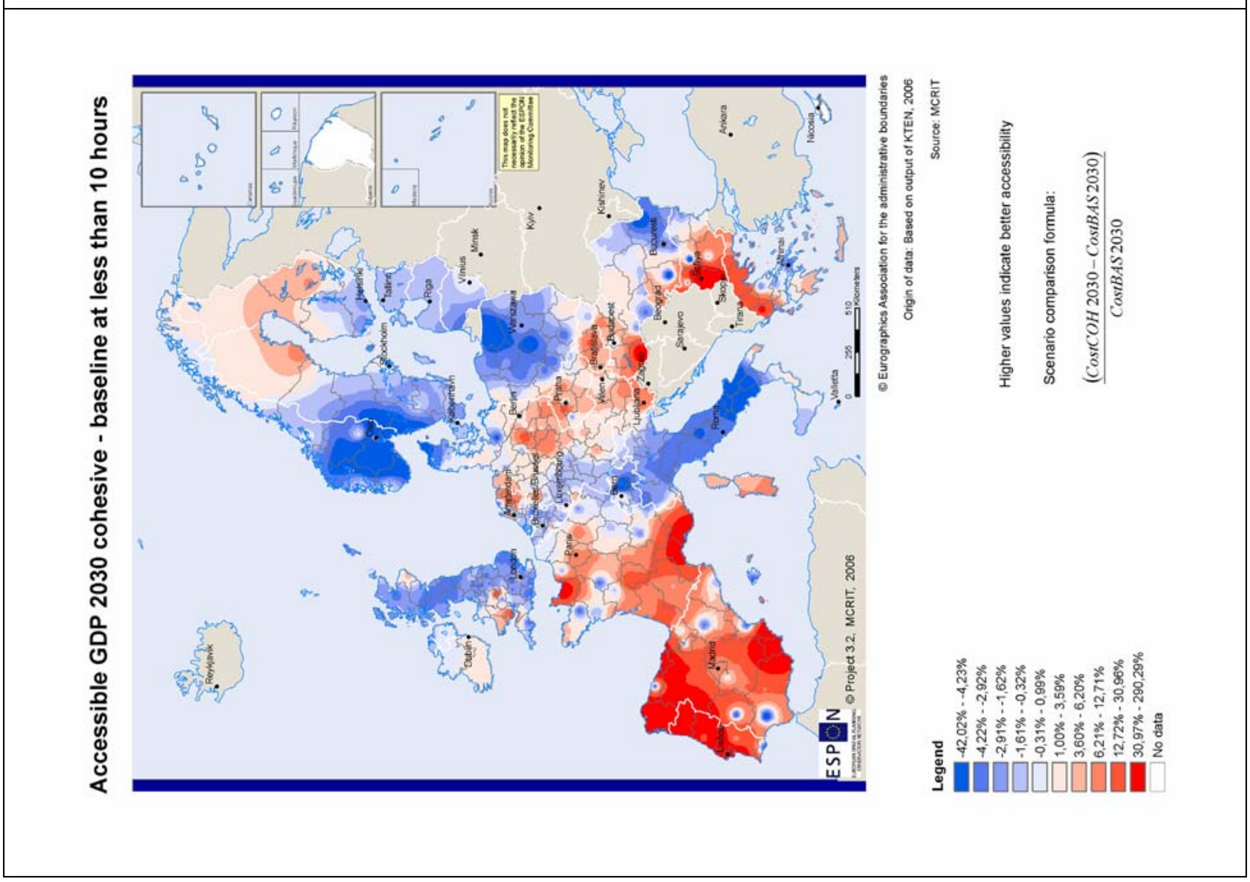
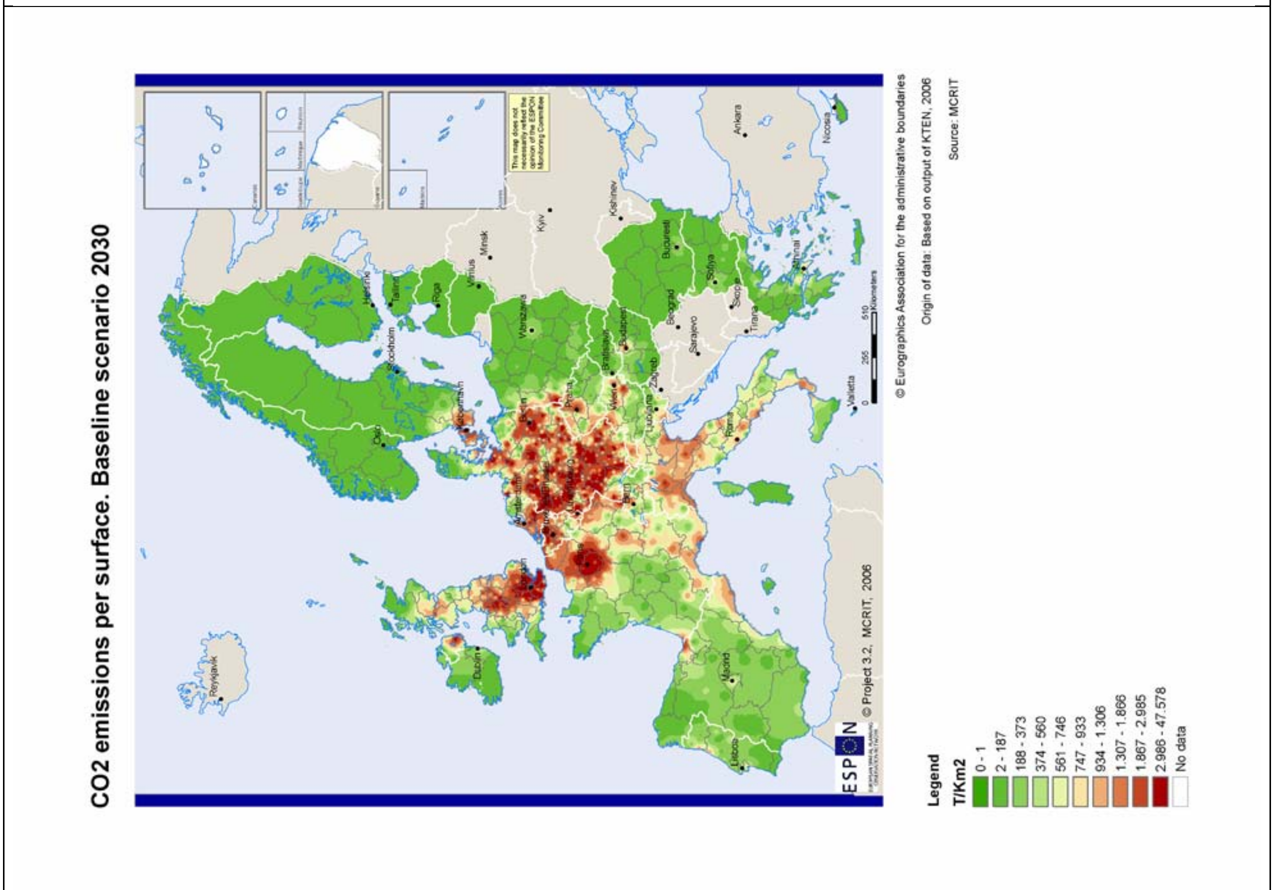
Origin of data: Based on output of KTEN, 2006
Source: MCRIT
Higher values indicate better accessibility
Scenario comparison formula:
$\frac{(CostCOM\,2030 - CostBAS\,2030)}{CostBAS\,2030}$


Accessible GDP 2030 cohesive - baseline at less than 10 hours
Legend
-42,02% - -4,23%
-4,22% - -2,92%
-2,91% - -1,62%
-1,61% - -0,32%
-0,31% - 0,99%
1,00% - 3,59%
3,60% - 6,20%
6,21% - 12,71%
12,72% - 30,96%
30,97% - 290,29%
No data
© Project 3.2, MCRIT, 2006
© EuroGraphics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT
Higher values indicate better accessibility
Scenario comparison formula:
$\frac{(CostCOH\,2030 - CostBAS\,2030)}{CostBAS\,2030}$

3.8.3 CO_2 emissions

CO_2 emissions, Baseline:

- This maps show the surface density of CO_2 emission due to interurban road traffic. The distribution pattern of emissions matches to a great extent with the distribution of traffics.
- The highest CO_2 concentrations correspond to the Pentagon, Île-de-France, southern half of United Kingdom and most of Germany. This pattern has not changed very much from the present situation.
- The corridor that links western Mediterranean with Northern Europe has an important absolute growth of emissions showing the relevancy increasing of the corridor.
- Northern Romania, central regions of Poland and some zones in the Baltic states have a reduction of emissions mainly due to depopulation, which leads to a decrease in traffics.


CO2 emissions per surface. Baseline scenario 2030
Legend
T/Km2
0 - 1
2 - 187
188 - 373
374 - 560
561 - 746
747 - 933
934 - 1.306
1.307 - 1.866
1.867 - 2.985
2.986 - 47.578
No data
© Project 3.2, MCRIT, 2006
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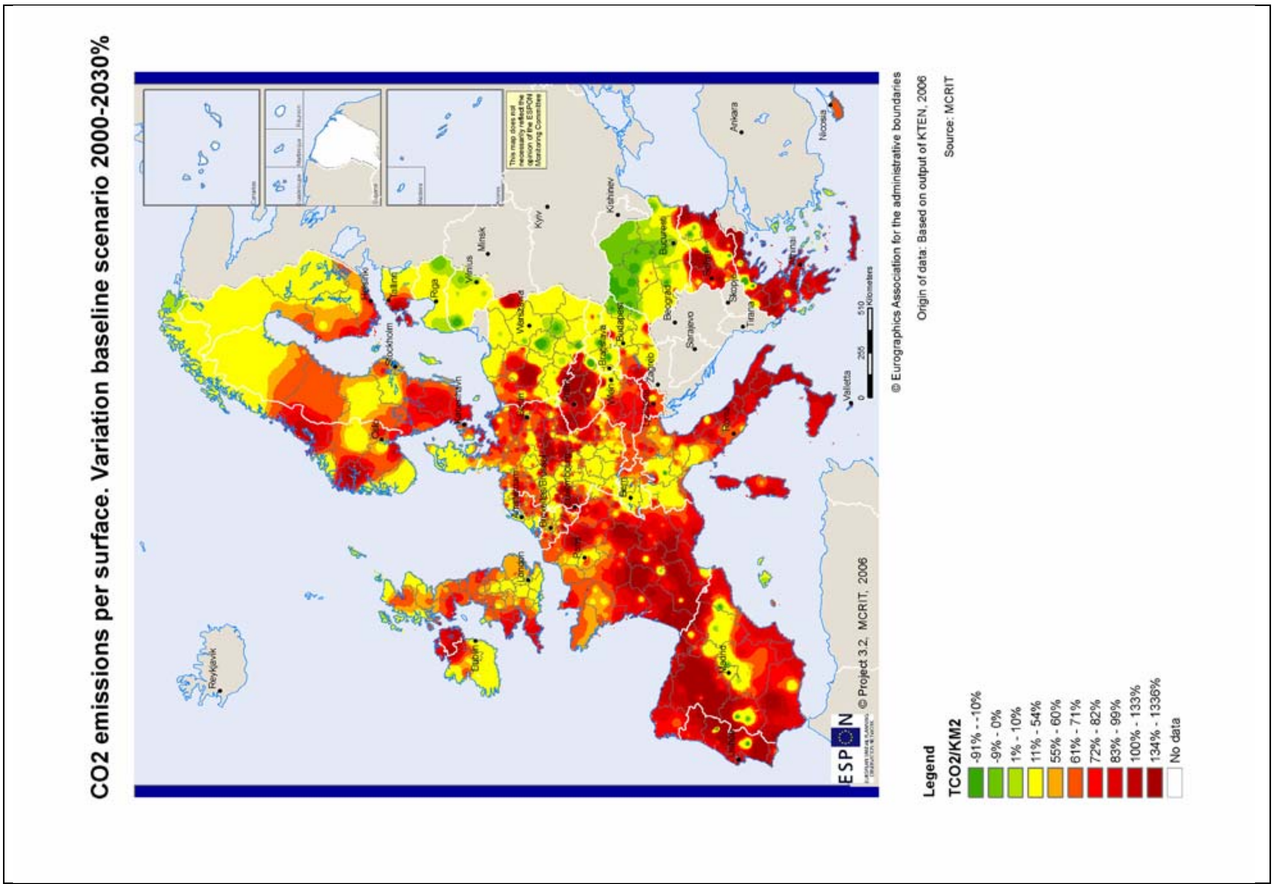
Origin of data: Based on output of KTEN, 2006
Source: MCRIT

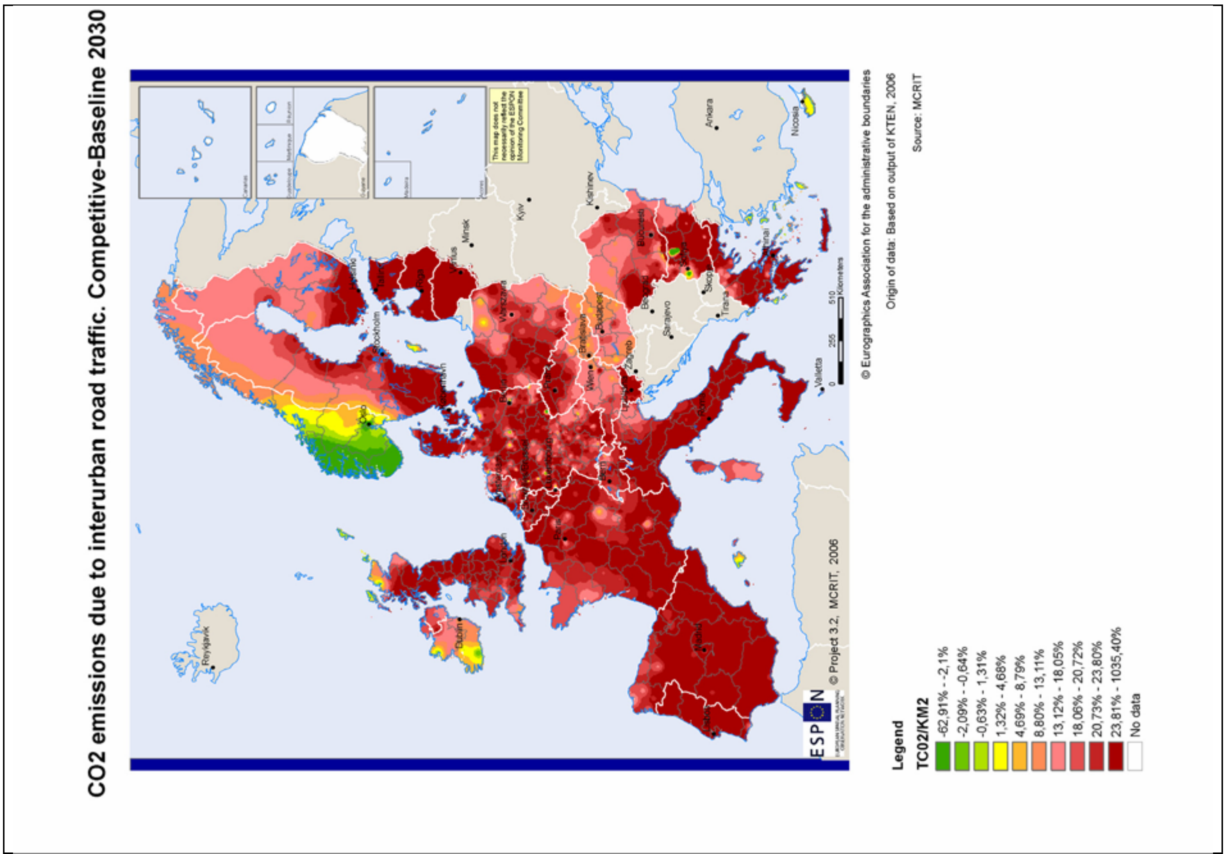

CO2 emissions per surface. Variation baseline scenario 2000-2030%
Legend
TCO2/KM2
-91% - -10%
-9% - 0%
1% - 10%
11% - 54%
55% - 60%
61% - 71%
72% - 82%
83% - 99%
100% - 133%
134% - 1336%
No data
© Project 3.2, MCRIT, 2006
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT

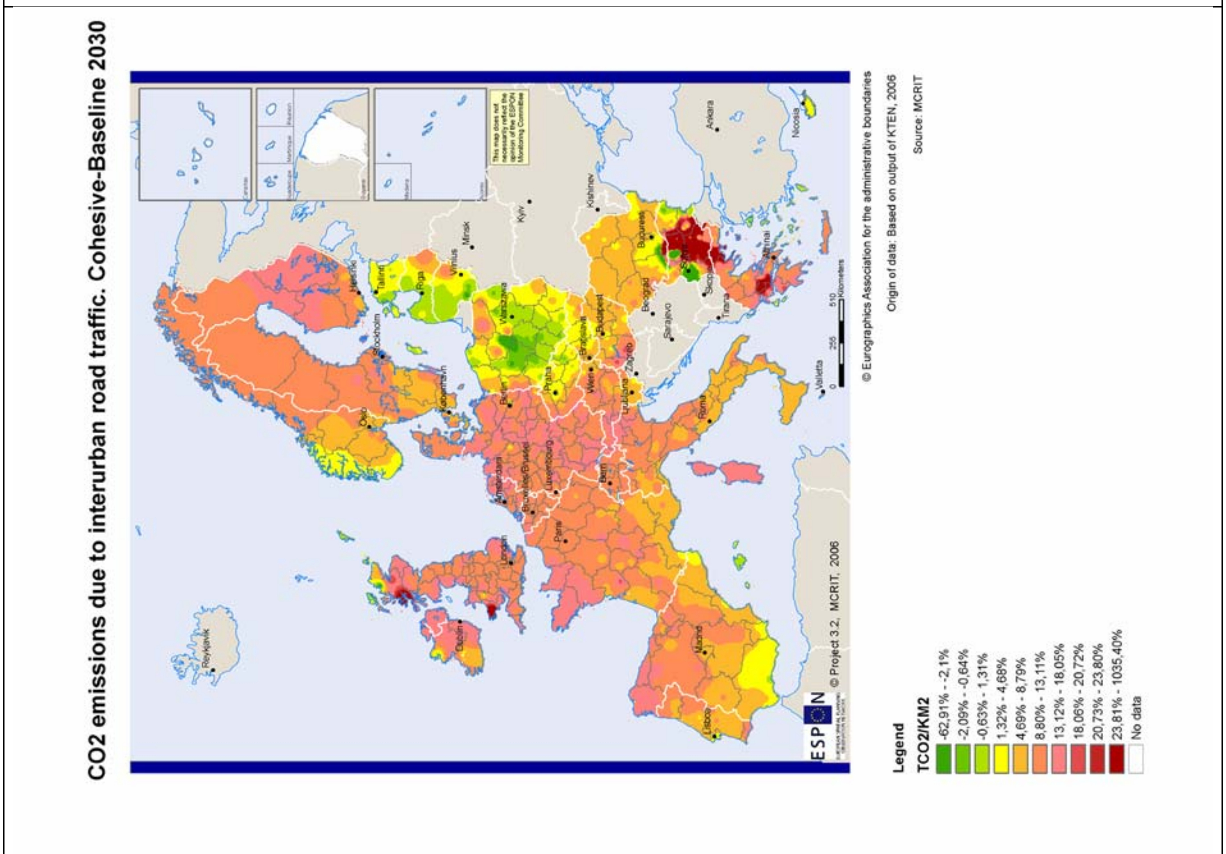
CO_2 emissions, Cohesive:

- Emissions in the cohesive scenario are in general higher than in the baseline. This happens because of the higher interrelation between peripheral regions.
- The West Mediterranean Arch grows less than northern Europe, because it concentrates less crossing traffic. The same happens with the Eastern countries.
- Central Poland shows a little reduction in CO_2 emissions, though it is very small.
- The map shows an important increase of emissions in Bulgaria, but they are accompanied by localised losses. This is due to the opening of new corridors that induce a change in the traffic from one region to its neighbour. In average the growth is not that important.

CO_2 emissions, Competitive:

- The competitive scenario has an overall growth in emissions because of two main factors, the dynamisation of economies and the predominance of road over rail.
- The growth is less important in Scandinavia (except the Eastern coast of Sweden and the South of Finland).
- Central eastern Europe (Slovakia, Hungary, Eastern Austria and Northern Romania) has far less growth of emissions. This is due to the lack of infrastructures in the competitive scenario.


CO2 emissions due to interurban road traffic. Competitive-Baseline 2030
Legend
TC02/KM2
-62,91% - -2,1%
-2,09% - -0,64%
-0,63% - 1,31%
1,32% - 4,68%
4,69% - 8,79%
8,80% - 13,11%
13,12% - 18,05%
18,06% - 20,72%
20,73% - 23,80%
23,81% - 1035,40%
No data
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT
© Project 3.2, MCRIT, 2006


CO2 emissions due to interurban road traffic. Cohesive-Baseline 2030
Legend
TC02/KM2
-62,91% - -2,1%
-2,09% - -0,64%
-0,63% - 1,31%
1,32% - 4,68%
4,69% - 8,79%
8,80% - 13,11%
13,12% - 18,05%
18,06% - 20,72%
20,73% - 23,80%
23,81% - 1035,40%
No data
© Eurographics Association for the administrative boundaries
Origin of data: Based on output of KTEN, 2006
Source: MCRIT
© Project 3.2, MCRIT, 2006

4 ETCI - European Territorial Cohesion Index

Introduction

The main aim of the research on a European Territorial Cohesion Index was to **develop a technical tool for evaluation of the scenario**. The introduction of the bad defined expression 'territorial cohesion' has introduced a confusion because the intention of the researchers engaged in this project has neither been to propose any kind of global synthesis of previous ESPON results (as it was done in ESPON 3.1 RCE - Regional Classification of Europe), nor to propose any kind of criteria for the allocation of structural funds during the period 2007-2013.

The initial idea was simply that each scenario should be evaluated in a quantitative way with a synthetic index which should take into account the three fundamental objectives of the European Spatial Development Perspective: economic competitiveness, social cohesion and sustainable development. This synthetic index should have be better than GDP/capita (which only takes into account the economic dimension) but remain very simple because, in the framework of ESPON 3.2, it was necessary to estimate trends both in past and future (1980-2030).

The **first round of research** (presented in the first and second interim reports of ESPON 3.2) has consisted in exploring the literature on composite index (like UNDP Human Development Index) in order to realise a state of the art on the different possible ways to combine innovative methods of spatial analysis like maps of discontinuities or discriminant analysis. In this step of exploration we focused mainly on technical questions and used existing data (in particular data from statistical appendix of second report on economic and social cohesion) in order to support research but without in depth analysis of the quality of information. This first round of research has produced interesting results from a methodological point of view, but also has demonstrated that the construction of synthetic indexes introduces an obvious contradiction between political significance and scientific quality, and that it was possible to introduce strong manipulation in the results. In deed, even if initially ETCI was only conceived as a synthetic tool for the evaluation of prospective scenario, the growing importance of the concept of 'Territorial Cohesion' in European debates has introduced suspicion on the potential use of this index for operational policies. We have underlined the danger of political manipulation of synthetic indexes as different formula of ETCI can produce different pictures of European territory. For example, the construction of 2 different indexes (one more based on Lisbon strategy, another more based on ESDP objectives) has provided the distribution of lagging regions in Europe. If these fictive indexes had been used for the allocation of structural funds, the first one would have concentrated the funds on new member countries and the second on southern regions.

Finally, this first round of research led to the conclusion that the initial objective of building a global synthetic index taking into account all the dimensions of European official documents was currently very complex because of the contradiction between some of these objectives, and because the decision of the definition of the nature of the indicators taken into account to build an operational ETCI should in definitive belong to policy makers.

Considering these difficulties, it was decided in the **second round of research** (ESPON 3.2 second and third interim reports) to postpone the research on statistical and cartographic tools and to renounce to the purely deductive strategy that consists in basing the construction of the index on theoretical concepts before considering methodological tools and empirical applications. ESPON 3.2 researches on Territorial Impact Assessment adopted this kind of deductive strategy, focusing its works on the best theoretical way to evaluate quantitatively territorial cohesion. But, as the initial aim of ETCI was to evaluate effectively the scenarios and not to propose a theoretical concept impossible to apply empirically in the framework of the project, it was decided on our part to adopt a more inductive strategy, focusing on the availability and quality of data which could be used for the development of an index taking into account various dimensions of ESDP objectives, and trying to define the concept of territorial cohesion basing us on third Cohesion report and other recent political document (Treaty establishing a Constitution for Europe and the conclusions of Rotterdam informal meeting of spatial planning Ministers of November 2004, etc.).

The analysis of the data situation in regard to political expectations on territorial cohesion led to the conclusion that it was not currently possible to build any relevant index of territorial cohesion in the framework of ESPON and Eurostat databases. Indeed, only the economic dimensions appear to be well documented, but very few information is available at regional level for the evaluation of environmental sustainability, and practically nothing can be found for social cohesion. This situation produces a vicious circle where availability of statistical data limits the possibilities of political action, except in the field of Lisbon Strategy in a narrow economic sense. This pessimistic conclusion about data available was confirmed by the analysis of ESPON core indicators in various Lead Partners meetings and led us to explore other ways to complete the ESPON database by new measures of social cohesion. An attempt was done in the second interim report on the question of Health, but the researches have been mostly focusing on questions of mortality, population ageing and accessibility to economic services of general interest.

So after a first part where we will come back on the first round of research, we will discuss in the second part why the extension of the use of demographic variables to other dimensions than the one which has been yet analysed by ESPON 1.1.4 ('Demographic Trends') can be currently considered as one of the most promising way to secure a social dimension. The construction of an **Index of Sustainable Demographic Development** combining life expectancy at birth and median age permits to reflect indirectly the social situation (as life expectancy is an indirect social indicator) and the dynamics and potentialities of territories (as median age is in Europe an indirect migratory dynamics indicator). It also permits to respond to the growing policy preoccupations at European level about the problematic of population ageing that have been underlined in many recent official documents.

In the third part we will explore another possible way to study the question of territorial cohesion with the problem of local **access to economic services of general interest**, in order to establish ground basis for the measure of territorial cohesion in the future ESPON II. The case study of accessibility to maternities in the Grande Région (border region between Belgium, France, Germany and Luxemburg) permits to vary the scale and to give an example of another approach of territorial cohesion matters, at more local level and in the particular cross-border context.

4.1 The roots of ETCI and the current impossibility of presenting a unique synthetic index

The ETCI task relied on several achievements made in the ESPON framework, about the concept of territorial cohesion and the ways to measure it. Those works can be considered as first stones on which the ETCI work was built.

The first attempts have been made during the preparation of ESPON, i.e. in the SPESP. The SPESP strand 1.3, 'indicators for social integration and exclusion', has given a first list of indicators to measure *social integration*. The strand 1.4, 'spatial integration', gave some insights in the understanding of *spatial integration*: the authors underline the various facets of the concept which can be related to 'mechanic integration' (similarity, homogeneity, discontinuities) and 'organic integration' (flow, accessibility, barriers). It was also underlined by the SPESP that it is dangerous to separate the analysis of social and spatial integration which are both parts of the more general concept of territorial cohesion.

The ESPON project 3.1 has summarised the previous terminological and methodological work and has gone one step further for making the concept operational through the so-called Hypercube. At a first level, this Hypercube distinguish four fundamental dimensions: cohesion, territory, scale and time. At a second level, each dimension comes in different elements: the 'cohesion' is composed of potential, position and integration; the 'territory' of society and space; the scale from various levels from World to local; the time from short term to long term. The Hypercube is actually a very good scope, not only for defining the *territorial cohesion*, but also to link the concept with its policy implications.

4.1.1 Political requests and review of literature

In the first draft of the treaty establishing a constitution for Europe (early 2004), the expression 'territorial cohesion' comes several times. But it stays vague. It is the most often associated with 'economic and social cohesion', so the reader cannot easily infer what is precisely *territorial*. The ETCI background turns to a lot of other sources, political like the spring reports or conceptual/statistical like the work done so far in ESPON. Considering this, the work done in the first steps of the project consisted on identifying the main sources and on establishing the bases of the work.

4.1.1.1 Human Development Index: an international reference

The first reference in the field of aggregated indicators is the *Human Development Index* (HDI), made by the United Nations in 1991. Its purpose was to measure human development combining three dimensions of development: economy, education and demography. The HDI is supposed to be a 'summary measure of human development' (UNPD, 2003) that allows a ranking of the world countries following their degree of achievement in human development. The notion of 'human development' that underpins the HDI is inferred from the first articles of the Universal Declaration of Human Rights. Three parameters have been kept in order to reflect the three dimensions of development mentioned above: a long and healthy life, measured by the life expectancy at birth; the knowledge, measured by a combination of the adult literacy rate and the gross enrolment ratio; decent standard of living, measured by the GDP/capita (in purchasing parity standard). Thus the political text (the Universal Declaration) guided the choice of the indicators.

The HDI had also to have a popularization property: the indicator had to be easily understood as by the policy makers as by the general public. It results on the one hand in an annual ranking of countries according to their level of human development, on the other in temporal evolution series.

From a methodological point of view, the HDI was presented as an evolutionary indicator, right from the first *Human Developments Report* (HDR), promised to successive improvements along the annual publications of the reports. Indeed, building the indicator raises questions in terms of data availability, normalisation/transformation into index, weighting between the three criteria, and about the possibility to add other dimensions. Mahbub ul Haq, the creator of the HDR, was aware of these limits. His colleague Amartya Sen, Nobel laureate in economics, reminds that 'the crudeness [of the HDI] had not escaped

Mahbub at all. He did not resist the argument that the HDI could not be but a very limited indicator of development. But after some initial hesitation, Mahbub persuaded himself that the dominance of GDP (an overused and oversold index that he wanted to supplant) would not be broken by any set of tables. People would look at them respectfully, he argued, but when it came to using a summary measure of development, they would still go back to the unadorned GDP, because it was crude but convenient' (Sen, 1999). A strong parallel can be drawn with the current situation of the European regional policy, to the extent that the GDP/capita remains the reference indicator in the political debates (Grasland, 2004).

Many articles were published after the creation of the HDI in 1990, assessing the HDI limits and proposing methodological changes and new complementary indicators (Human poverty index, Gender-related development index, Gender empowerment measure…).

Amongst the general qualities of the HDI, several authors acknowledge the indicator helped opening again the debate on measuring the development, even if methodological critics can be addressed to the indicator (Fukuda-Parr 2001, Sagar & Najam 1998, Streeten 1994). The discussions about development crossed the disciplinary boundaries, to the extent that the questions were no longer dealt by the only economists, and helped bringing together scientific concerns with political ones.

Nevertheless the HDI is subject to numerous criticisms. The first one is related to the availability, quality and comparability of data (Chamie 1994, Srinivasan 1994). For example, 40% of the countries (for a total of 171 countries) have no data on the gross elementary enrolment ratio (Loup & Naudet 2000). In this case the data necessary to build the HDI are estimated; in other cases, when the data exist but are of bad quality, the correcting procedures are highly problematic. The data concern questions the reliability of the HDI.

The transformation of variables is also subject to criticisms, particularly concerning the GDP/capita. In the first version of the HDI, the GDP/capita was transformed through a complex pseudo-logarithmic formula corresponding to a piecewise affine function, such as above a level of wages, the increase of GDP changed only in a tiny way the ranking of the standard of living component of the HDI. So the intervals between countries above 6000$/capita were cancelled. Sagar & Najam criticize this transformation with the example of Switzerland and Mexico as both countries appear in the Human Development Report of 1997: although the Switzerland level of GDP/capita is nine times higher than the Mexico level, the transformation leads to almost identical values (the GDP/capita in Switzerland is only 3% more than the Mexico one…) (Sagar & Najam 1998). The authors propose a uniform application of the logarithmic transformation to avoid such results. This has been inserted in the HDI calculation from 1999[14].

The way of aggregating the three dimensions of the HDI is also questioned. It is just an arithmetical mean. But the addition supposes that the three criteria can be perfectly substituted to each other, and that a weakness in one can be compensated by strength in another, which is a reductionist point of view as regards the usual meaning of 'human development' (Booysen 2002, Desai 1991). Some suggest using a log-additive function to avoid this problem (Desai 1991). Others propose to multiply the variables instead of adding them up, in order better to take into account the case when a variable is far lower than the two others (Sagam & Njar 1998).

Besides, some underline the limits of the composite index as regards the possibility to compare the levels of HDI through time. Each year, new countries are considered and this

[14] This change modified the ranking of countries, namely allowing the countries with a high level of GDP/inh but a poor education or health policy to gain several places (USA, oil monarchies, etc.). It is difficult not to wonder about the political pressures preceding this revision…

modifies the ranking; the same happens with the methodological changes. When the HDR is published, a retrospective ranking of countries is certainly provided following the latest method. But such evolutions cause significant changes. As Morse put it, after a comparison of the different methods used by the UN year by year for calculating the HDI, the results display a large volatility: differences following the minimum and maximum values considered for the index of life expectancy, differences if the index of wages is calculated with the Atkinson formula or the integral logarithmic formula… (Morse 2003). In fact the HDI would be nothing more than a statistical artefact according to some authors (Lüchters & Menckhoff 1996).

Last, the HDI is also criticized concerning the dimensions it does not take into account. For example the indicator does not hold any measure of the infra-national and inter-personal inequalities. Each of the three dimensions should ideally include such information (Hicks 1997). Others ask for taking into account the environmental and sustainable development dimensions in the HDI (Morse 2003, Neumayer 2001). These experts' discords often hide a balance of institutional powers between different world agencies, with the classical split noticeable at the European level between the socio-economic specialists (Eurostat) and the environment specialists (EEA).

As far as the last point is concerned, the literature related to the human development indicator differs from the one related to the sustainable development indicators (SDI): the former being more top-down oriented, from policy goals to their translation into indicators, the latter being more bottom-up and would run from data (Morse 2004). As our study of a composite index in the European framework was more HDI-like, we did not explore deeply the contribution of the SDI literature, although it is as dense as the HDI one. In this field the 'Dashboard of sustainability' needs to be quoted, as internet software allowing the user to combine several indicators upon request[15]. But the dashboard does not go into the regional divisions. We underlined another important difference with the work undertaken in the ETCI: the dashboard is interesting in terms of reviewing available data and handling the data, but it has absolutely no territorial dimension.

At this point, the general problem of the ETCI had become obvious: many of the limits pointed here about HDI would have concerned an eventual composite ETCI built with the same kind of method, and as 'Territorial cohesion' is a multisectoral concept, it requires combining different dimensions in a *territorial* framework, which should demand innovative methods. And to explore them we had first to face two crucial questions: the question of selection of indicators and methodology, and the question of availability of data.

4.1.1.2 The question of selection of indicators and methodology: 'spiritual exercises' on a reference database

To evaluate the advantages and inconvenients of the various concepts of methods which have been proposed for the elaboration of composite indexes, we have suggested in the first step to use one or two reference databases as a basis for systematic comparison of methodologies. We used the '*Statistical annex of the 2nd Cohesion Report*' as first reference database for those experiments. Indeed, it is a database which has yet been analysed in depth by many people and which is sufficiently old (1999) to avoid the political problems which would necessarily appear if we were working on up-to-date database.

[15] http://esl.jrc.it/envind/dashbrds.htm

4.1.1.2.1 The Statistical Dimension

From a statistical point of view, the building of an ETCI is a classical question of *data reduction* for which many solutions are proposed in the field of descriptive statistics. It is also a problem of *data transformation* because the policymaker can expect some properties from the final index. And we should not forget that there is also a problem of *data interpretation* because the results should be easy-to-use and in order to be used in an operational way. But we have to bear in mind that data reduction is necessarily connected with possible data manipulation and that a good statistician can easily orient the result in one or another direction…

As we could not ignore that an ETCI could be used in the future for the allocation of Structural Funds, we had to make very clear how it is built and how it could be oriented by policy-makers in one or another directions. If necessary, we could have built an 'ETCI Computation Machine' where policymakers could have change the sign and the weight of variables introduced in the computation of the final results and give immediately the resulting map and the amount of population or region eligible to Structural Funds eligible in each state… As a pedagogical example of data manipulation, we have applied a methodology derived from UN's HDI to the data of the 2nd Cohesion Report in order to obtain two different formula of ETCI, derived from two European political documents: ESDP and Lisbon (Figure 23).

In function of the methodology, the results were quite different: in the first case southern regions and eastern Germany appeared to be the less favoured regions, while in the second case central and eastern Europe countries appeared to be the areas the more in difficulty. Examples like this permit to show the limits of synthetic indexes, which are easy to manipulate. They brought us to the conclusion that the problem of the political choice of data and their scientific accuracy is currently impossible to surpass.

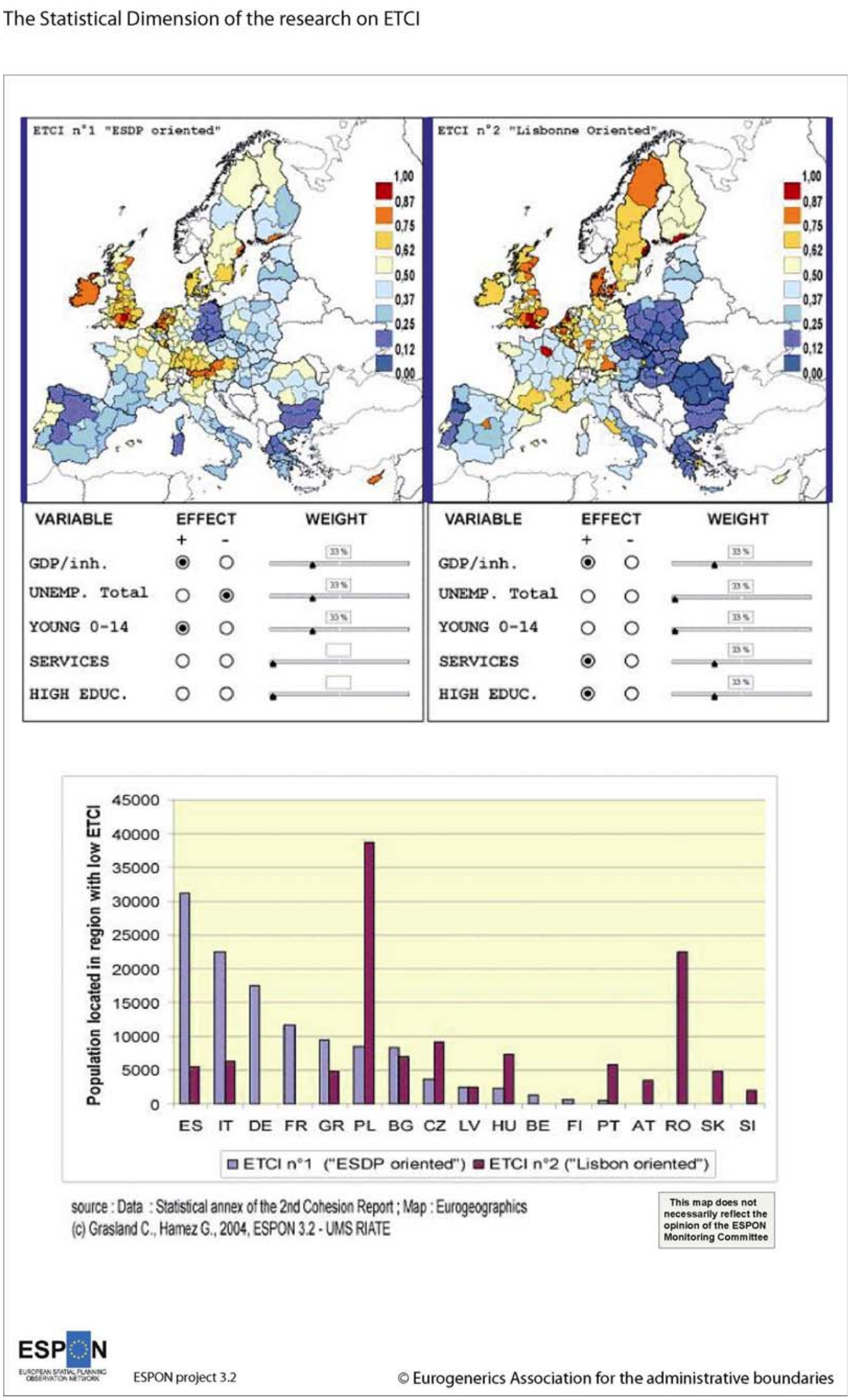


Figure 23 The Statistical Dimension of the research on ETCI

4.1.1.2.2 The Spatial Dimension

As our purpose was related to the construction of a European *Territorial* Cohesion Index, we also insist in the first round of research that we should not focus only on the statistical dimension but also introduce important considerations of spatial analysis. This was probably the most innovative part of the work to be done by ESPON as compared to other institutions like OECD or UN which has a good experiment in statistical methods but very few interest in the introduction of a spatial dimension in the measure of cohesion or development.

One of the more important dimensions of territorial cohesion concept is related to the spatial organisation of heterogeneity. The global level of heterogeneity (e.g. mean difference of development between two regions), has to be compare to the local level of heterogeneity (e.g. mean difference between contiguous regions) in order to propose a measure of spatial autocorrelation which is generally positive, which indicate that differences are lower between regions which are close than between regions which are distant. The evolution of spatial autocorrelation is a precious measure of the phenomena of local convergences between regions of different level. It is also possible to measure territorial autocorrelation which is based on the comparison of heterogeneity between regions of the same category (e.g. of the same state) and regions of different categories (e.g. regions of different states). Those measure are very helpful when one suspects the existence of 'path of convergences' or 'path of development' which are not necessarily related to group of neighbouring regions but to groups of regions of the same type (industrial, metropolitan, peripheral, …).

The cartography of heterogeneity is a very useful tool for the development of a policy of territorial cohesion. In previous research of the SPESP and the ESPON program, many proposals has been made for the cartography of discontinuities related to one single variable like absolute or relative difference of GDP/capita. But a territorial discontinuity can generally not be based on a single criterion and should be based on several criteria. Therefore, we have proposed to develop a multivariate analysis of territorial discontinuities which will examine each elementary discontinuity for all criteria before combining them together in global discontinuities which will have a qualitative and quantitative dimension[16].

As an example, *Figure 24* presents the values of discontinuities for our ETCI n°1 which is a combination of economic discontinuities (GDP/capita), social discontinuities (total unemployment rate) and demographic discontinuities (% of young). Each criterium contributes equally to the global value of discontinuity which can be the result of very different combinations. The homogeneous areas are easy to visualize (orange and yellow links between regions with low differences on all criteria) and are separated by territorial discontinuities (blue borders with a thickness proportional to the sum of absolute differences on each of the three criteria). The qualitative analysis can help to define the potential effects of each important discontinuity according to the level and the direction of differences on each criteria.

[16] It means that the global discontinuity will not be based on the differences related to a global synthetic variable but will be based on a synthesis of all local discontinuities. This is very important if we want to avoid the phenomena of "compensation" between criteria which would appear with the first solution.

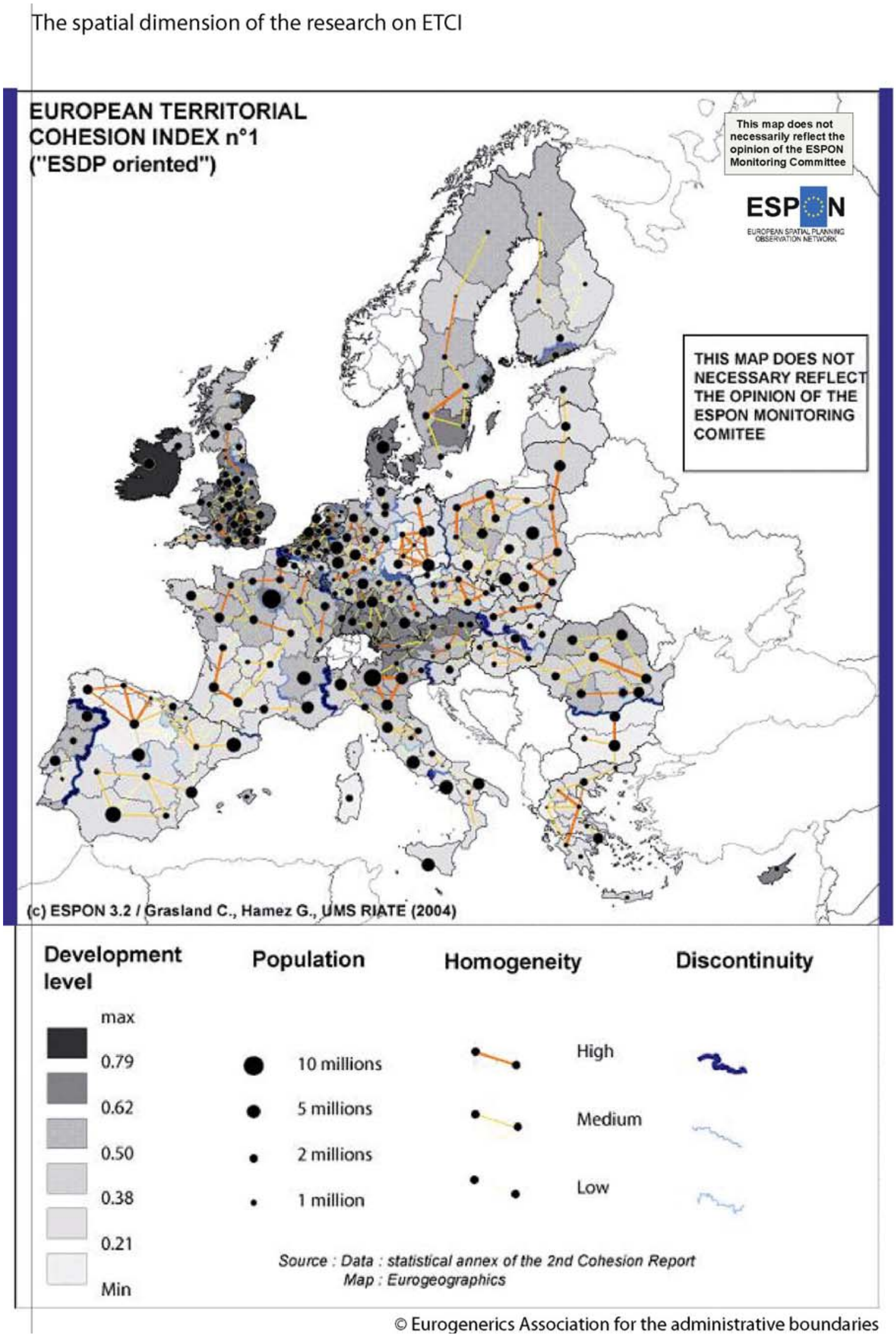


Figure 24 The spatial dimension of the research on ETCI

4.1.1.3 The vicious circle relating statistical information and political action

According to the previous state of the art, and even if we were aware of the limits of composite indexes, we had a good view on the possible theoretical statistical solutions for the elaboration of a composite index which could combine the three dimensions of ESDP (as the HDI combines the three dimensions of human development). We had also sufficient ideas on cartographic and spatial analysis tools which could be used for the exploitation of such an ETCI. But we had to go further in the work to enter the crucial problem of data availability on the three dimensions of ESDP. And we had to admit that it was not currently possible to find consistent data on each of the three dimensions, and that it was not possible to measure an ETCI for different periods of time at a regional level (minimum NUTS1).

4.1.1.3.1 Pessimistic results of the analysis of ESPON Core indicators (LP Meeting, Feb. 2005)

During the Lead Partner Meeting of 17-18 February 2005, the list of core indicators developed in ESPON framework by the TPGs was examined with scrutiny. This list of 103 indicators looked at first glance varied, but at second glance there was an important dimension missing: the social one. In fact only 4 of the 103 indicators can be considered as social:

- pupils by educational level (developed by the TPG 112 at NUTS3)
- educational level of population (developed by TPG 3.1 at NUTS3)
- unemployment rates (developed by TPG 3.1 at NUTS3)
- impact of accessibility changes on unemployment (developed by TPG211 at NUTS3)

There are other indicators indirectly related to the social dimension, for instance the diffusion of internet or cellular phones, or the proportion of households with personal computers (indicators developed by the TPG 122). Nevertheless these indicators are more 'mixed' than social and are highly dependant of the date of data collection (for example the diffusion of broadband access to Internet can double or triple in a couple of years).

What are missing are truly social indicators, for example:

- wages calculated not through the means but the quantiles (decomposing the wages following the 10% poorer, the 10% richer, etc.) in order to investigate inter-personal disparities;
- wage differences between males and females, following the means and the quantiles;
- share of 'low wages' in the total of workers;
- share of teen-agers leaving the educational system without any qualification.

These few examples intend to show that it is possible in the ESPON framework to explore the social dimension, but it has not been a primary focus so far and we had to work on ETCI without having relevant indicators taking into account the social dimension.

1.1.3.2 Should we reduce territorial cohesion to economic competitiveness?

This round of researches on available indicators led us to underline that the situation of the ESPON database (which is also the situation of EUROSTAT) has produced a vicious circle. As most available indicators are related to economic situation and competitiveness, most ESPON studies are related to these topics. Reversely, as very few information is available about social cohesion (and at a less degree about sustainable development), most ESPON studies ignore these crucial dimensions of ESDP. Therefore, if the results of the ESPON programme are used by policymakers, they will one more time reinforce the usual over domination of one dimension of ESDP (economic) and comfort the common feeling that the other dimensions (social & environmental) are not really important for the future.

The focus of the current European Commission on *Lisbon Strategy* can be interpreted as the consequence of an ideological choice, related to the domination of right oriented political forces in the European Parliament. But it is certainly also the result of a technical problem which is the lack of production of indicators of good quality, out of the economic dimension. This domination of economic dimension is also a consequence of the clear domination of economists in the expert panel which is usually consulted by the European Commission. Geographers, sociologists or demographers are less often consulted and their opinion is less frequently taken into account. The situation is not so critical for environmental dimension as for social dimension, because the EEA and JRC are able to deliver regular information of good quality which can support policy orientations like *Gothenburg Strategy*. In the current statistical situation of EU, even if a left policy oriented majority was elected at the European Parliament, this majority would face very difficult problems in the development of a *Social Agenda*, because relevant statistical information are not available and it is impossible to develop a policy without good indexes for ex-ante and ex-post evaluation.

So we arrived to the pessimistic conclusion that in the current statistical situation of the European Union in general (and the ESPON Programme in particular) it is impossible to build any relevant index of territorial cohesion at regional level which could combine the three dimensions of ESDP. It is certainly possible to build an index of economic competitiveness (Cf. work in progress of TPG ESPON 3.3 on Lisbon Strategy). It should be possible, even if difficult, to build an index of sustainable development (Cf. previous work of TPG ESPON 132 on ‘cultural heritage’, and foreseen work of TPG241 on ‘Environment’). But it is actually not possible to elaborate any good and complete index of social cohesion[17].

4.1.1.3.2 Breaking the vicious circle

To break this vicious circle, we have mentioned at the end of this first round of researches four options.

Option 1: Asking EUROSTAT or ESPON II to elaborate new data collection in the future

It is possible to address recommendation to EUROSTAT for the elaboration of target indexes of social cohesion… but these indexes will not be available before many years. If we want to break the vicious circle described above, we are have to imagine immediately innovative solutions for the estimation of indexes measuring the social cohesion at regional level.

During the 8th round of projects (ESPON II), it would be necessary to develop projects exploring the different possible social indicators.

Option 2: Using long term series available at national level for regional estimations

[17] This lack of information on the social dimension of ESDP has been pointed by two panel groups working on the core indicators of the ESPON database during the last LP meeting of February. The panel group also noticed that even when information is available (labour forces, economy, accessibility …) it is not possible to evaluate the dynamic dimension because on a total amount of 103 core indicators, only 2 are related to past evolution and 3 to prognosis on future trends.

The most interesting indicators of social cohesion are generally available at national level but not at regional level. It is for example the case of measure of social inequalities (e.g. distribution of incomes by deciles), measure of social well being (e.g. health expenditures per inhabitant), measures of gender differences (e.g. participation of women to political decision), etc. The double constraint in the ESPON program as regards the large geographical coverage (29 states) and a precise territorial resolution (NUTS2 or NUTS3) results in withdrawing all interesting indexes of social cohesion, because they are never available simultaneously at regional level for all states of the ESPON area. For the moment, to develop a research on social cohesion at regional level in whole ESPON area, a solution can be to develop such a 3-step approach:

(1) Start the analysis at national level in order to have a global view
(2) Try to obtain regional estimations based on statistical models
(3) Realise case studies on states where regional information is available in order to validate the regional estimations

This methodology is often the only possible one. In the second interim report, we proposed a study on health expenditure that permit to show that discontinuities on health expenditures per capita are often even more important than discontinuities in terms of GDP (*Figure 25*).

Compared discontinuities in terms of health expenditure and GDP per capita around 2000 in ESPON area

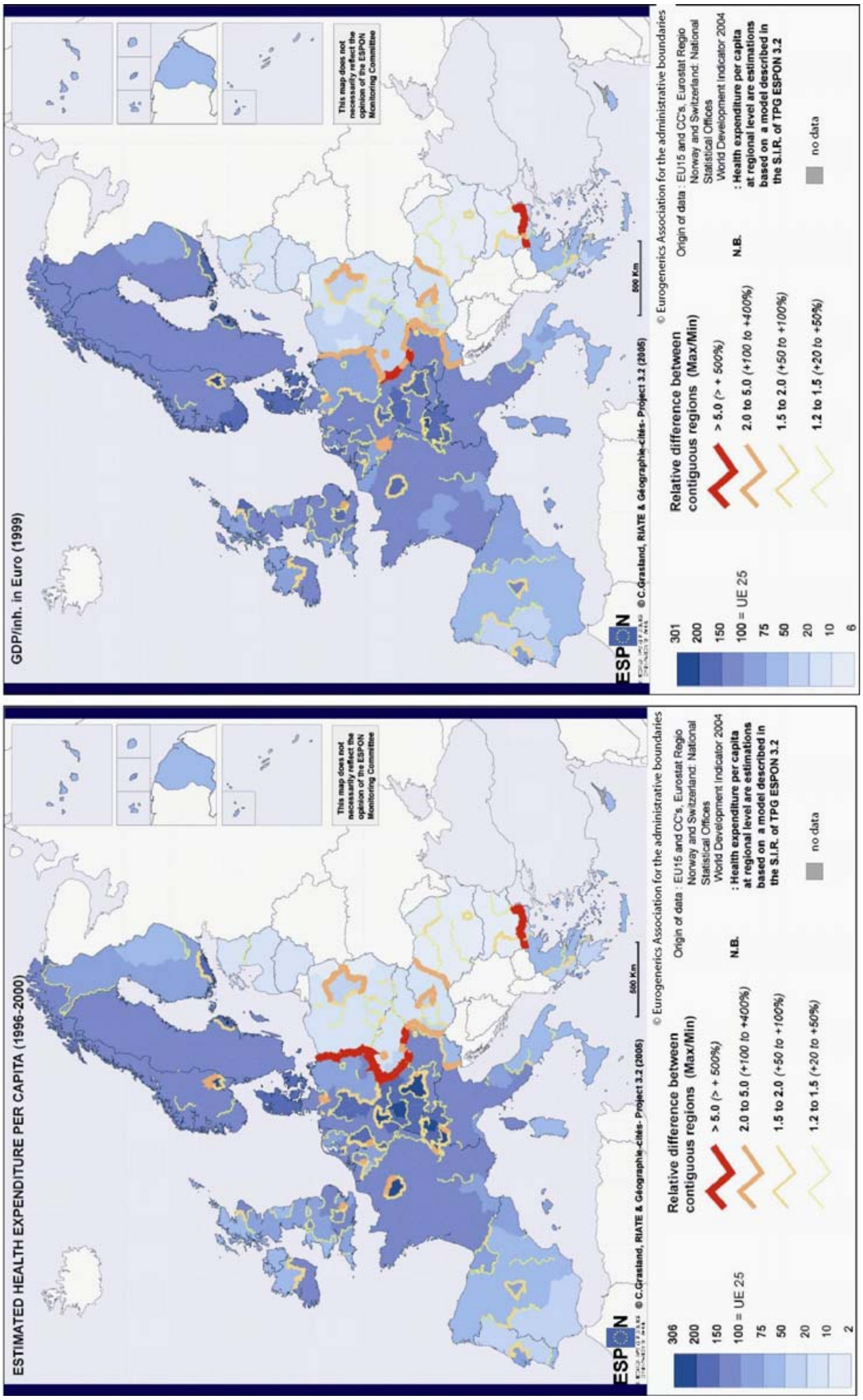


Figure 25 Compared discontinuities in terms of health expenditure and GDP per capita around 2000 in ESPON area

However, we had to underline in the mentioned report that such a methodology cannot be fully satisfactory as regional values are only estimations.

Option 3: Trying to estimate target phenomena with proxy variables available at NUTS2

In the Human Development Index, the 'long and healthy life' is measured by the life expectancy at birth. Of course, this is only a rough estimate of well-being, but, as we will see in the second part of the present report, the indicator has several interests. Combined with another demographic indicator (median age), we will propose an 'index of sustainable demographic development' (ISDD) able to measure the evolution of European disparities at various space and time scales.

Option 4: Case studies for validation of estimations and in depth analysis (accessibility, etc.)

This option consists in carrying through research on the social topics, combining analysis at the macro level with case studies. Such a work can be expected from the next ESPON project on the social dimension (8th round of projects), and has been developed during the second round of researches on ETCI with the example of accessibility to maternities in the Grande Région.

But before presenting the results of this study, we will present next the development of the 'option 3', about the interest of demographic criteria in order to measure territorial cohesion at various space and time scales.

4.2 Index of sustainable demographic development (ISDD): a complementary solution for quantitative evaluation of scenarios

4.2.1 The growing European political focus on the impact of demographic change on territories

ESPON project 1.1.4 on demography has focused on the evolution of labour force in Europe and the economic consequences of ageing and migration on the evolution of pensions (with the problem of increasing the period of work), but paid very few attention to social significance of demographic parameters like mortality. The report put in relief the demographic evolution in the light of the endogenous growth in order to stimulate competitiveness:

'This means that both the EU regional development policy as well as national policies must prioritise an economic and social policy (family policy) in order to stimulate a rise in TFR (Total Fertility Rate). This will be of utmost importance even in order to stimulate the preconditions for endogenous growth that probably will stimulate competitiveness at all levels. From a cohesion point of view this is of great importance if the risk for future concentration and social exclusion shall be avoided. As much of the social policy – including family policy – still is of national character, it is of utmost importance to coordinate these

means within the EU in order to increase TFR and stimulate natural population development'[18]

In fact, the focus of project 1.1.4 on the question of population ageing is the direct confirmation that European policies consider demographic factors mainly as an economic issue rather than as a global social one:

1) In the ESDP, demographic change was presented as a statement of fact:

'(240) Three trends will dominate population development in the EU in the next 20 to 30 years: decline in population; migratory movements; and shifts in age profile.
(241) Natural population growth in the EU has been very low for years and is showing a declining trend. Without considerable changes in the birth rates of the EU 15, a shift from population growth to population decline could begin to appear around 2020. Against this background, international and interregional migratory movements are of increasing importance for EU population developments and its sub-areas'[19]

And according to the ESDP, these trends have many spatial effects such as polarization:

'The new requirements are being fully met with far-reaching spatial consequences. 'Pensioner towns' are thus also increasingly developing in Europe (as has been the case in the USA for a long time) in regions which are scenic and have a more favourable climate.'[20]

2) The Third Report on economic and social Cohesion, following some remarks from the Second Report[21], points to this fact:

'Demographic ageing in Europe is a particular challenge. The regional variations in this respect are considerable reflecting trends in fertility and mortality, and in migration.'.[22]

So demography is apprehended at the same time as a challenge at the national and the regional level. It appears like a policy challenge:

'In particular, Member States, regions and citizens (…) will also have to tackle the particular challenges that derive from an ageing population, growing immigration, labour shortages in key sectors and social inclusion problems.'[23]

3) At the intergovernmental level, discussion around territorial cohesion at Rotterdam meeting in November 2004 took into account the demographic challenges:

'The Ministers took note of the demographic, economic, social and environmental challenges facing the recently enlarged EU territory, especially those emerging or intensifying since the adoption of the ESDP'[24]

The Discussion paper for this EU informal ministerial meeting focused on the territorial consequences of a sharp rise in old-age dependency rates at EU level:

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[18] Espon Project 1.1.4. "The Spatial effects of demographic trends and migration", p. 29.
[19] European Commission, 1999, *ESDP*, p. 57.
[20] *Ibid*., p. 59.
[21] European Commission, *Second Report on economic and social cohesion*, 2001, particularly pp. 41-47.
[22] European Commission, *Third Report on economic and social cohesion*, 2004, p. xxvi.
[23] European Commission, *Third Report on economic and social cohesion*, 2004, p. xxix.
[24] Dutch Presidency, 2004ba *EU informal ministerial on territorial cohesion Presidency conclusions*, Rotterdam, 29th of November 2004 (1.1).

'The total population aged 65+ in the EU-25 will be 40% higher in 2025 than in 2000. One consequence will be a sharp rise in old-age dependency rates at EU-wide level. Metropolitan areas and highly urbanised regions are likely to experience higher population growth in future while regions with very low population densities are likely to continue to lose population, threatening their vitality. This change creates challenges for territorial development related, for example, to the emergence of specific needs and locational choices of retired people. Entire regions are specialising in the settling of retired people. Their economic base is becoming a residential one, progressively changing their productive base. The decreasing proportion of the population of people of working age is likely to strengthen competition between regions to attract young qualified manpower. In addition, there is an increasing trend of cross-border retirement. The whole territory will be confronted by these challenges, to different degrees.'[25]

All these texts show the political attention paid to population ageing and related issues of dependency ratio, labour shortage and pensions. Here demography is not really seen in social features but essentially as a particular challenge (replacement of labour force, pensions, etc.). This dimension is essential, but demography can also be used as a precious measure tool of social cohesion. As we will see next, it can be an interesting alternative to the use of traditional indicators (GDP, unemployment rates…) that make international comparisons difficult.

4.2.2 Scientific interests and limits of demographic criteria for the measure of territorial cohesion

4.2.2.1 Demography: the most reliable international indicators at regional level

Demographic indicators have been historically the first variables subject to international harmonisation, during 19th century in Europe26. On this period, the normalisation of demographic variable in Europe and their availability at various time and spatial scales have provided the basis of major research in the field of social sciences27. The extraordinary quality of the statistical system of the 19th century in the field of demography can be simply illustrated by the fact that it has been possible to produce map of fertility covering all Europe from 1871 to 1960 at a regional level equivalent to our actual NUTS2 and NUTS3 units (Coale, Ansley and Cotts Watkins, 1986). And it is possible to produce all equivalent classical demographic indexes on very long time period.

During the period of the cold war, when Europe was divided between East and West, the only statistical solution for analysing the international and interregional differences of socialist and capitalist countries was precisely the use of demographic variables because all

[25] Dutch Presidency, 2004b, *Discussion paper for the EU informal ministerial meeting on territorial cohesion*, p. 3.

[26] In his major work sur *l'homme et le développement de ses facultés, essai d'une physique sociale* (1835), the Belgian mathematician Adolphe Quetelet presented his conception of the average man as the central value about which measurements of a human trait are grouped according to the normal curve. Quetelet organised the first international statistics conference in 1853 which was followed by the creation of international associations for the international harmonisation of statistics. The development of statistical methods was clearly linked to the development of harmonised collection of demographic data. For example, Galton's first insights about regression sprang from a two-dimensional diagram plotting the sizes of daughter peas against the sizes of mother peas. As described below, Galton used this representation of his data to illustrate basic foundations of what statisticians still call "regression" despite the fact that Galton's work was related to racial theories of the decline of societies.

[27] For example in sociology with the research of Emile Durkheim on *Suicide* or in Geography with the *Political Geography* of Friedrich Ratzel, both published in 1897.

economic and social criteria were based on statistical systems of data collection which were absolutely not comparable[28]. More generally, the majority of statistics produced by non democratic countries was suspected of manipulation. This was certainly also the case of demographic data (e.g. underestimation of infant mortality rate in Soviet Union) but in this particular case it was relatively easy to identify the manipulation because the demographic laws are relatively stable and some evolutions are simply impossible (Blum, Mespoulet, 2003).

After the fall of the iron curtain, the first regional atlas covering the whole future ESPON area was precisely the demographic atlas realised by the University of Brussels presenting the demographic situation of Europe in 1960, 1980 and 1988 at NUTS2/NUTS3 level and including the European part of Russia (Decroly, Vanlaer, Grimmeau, Roelandts, Vandermotten, 1991). Demographic data have provided the basis for the first research trying to compare the regional differences in all Europe, eastern and western, precisely because it was the only available and comparable information at regional level and in a long term perspective. That’s why the elaboration of the first numerical maps of European regions (including Eastern Europe) and new spatial analysis tools (multiscalar territorial analysis, cartography of discontinuities) were based on the use of demographic indicators (Grasland, 1991; Decroly, 1994).

It is not by chance that demographic variables have always been used for the development of new methods of statistics and spatial analysis. It is because they are the most reliable and the most frequently available at various scales.

4.2.2.2 Availability in social, spatial and time dimensions

The fact that demographic data have been harmonised historically very early is not their only advantages compared to other criteria. Indeed, the fact that demographic parameters are related to all individuals through census (age structure, household structure) and civil services (birth, death, marriage) means that they can be used at very different spatial scales and in very different social contexts.

If we consider for example life expectancy at birth, we can easily measure spatial variations at different scales, from Europe to local authorities and even in smaller spatial units like blocks or street inside an urban area. Of course, the precision of the estimation is lower when the spatial aggregate concerns a population of small size, but it is always possible to compute estimated values with confidence intervals and therefore to observe social inequalities in a very detailed way. An equivalent multiscalar approach is fully impossible for economic variables because (1) GDP is generally measured only at NUTS2 level – and sometimes it is just an estimation based on the disaggregation of national accounts (2) Incomes are theoretically available at household level but they are protected by secret in most statistical institutes and are provided only for large aggregates.

In political terms, demographic variables make possible the development of policy recommendations which could nicely distinguish between social intervention (in favour of less favoured social groups, whatever their location) and spatial intervention (in favour of regions which are less advantaged, all things being equal with social structure).

[28] For example, the notion of GDP/capita did not make sense in socialist countries where the contribution of services was underestimated. The division of activities in primary, secondary and tertiary sector was no more applicable in socialist countries because it was related to a capitalist view of the society established by an American, Colin Clark.

4.2.2.3 Interaction of demography with all dimensions of social life

Taking into account all these advantages, we can really ask: Why have spatial planners in general and the ESPON program in particular not made a more important use of demographic variables in their studies?

The answer to this question is that demographic indicators are very complex, very difficult to use and to interpret because they interact with all dimensions of social life and it is not generally possible to define clearly what are the causes and consequences of a demographic situation. As will be discussed in point 2.3.1 about life expectancy at birth, demographic indicators are 'social sponges' which absorb social, political, economical, cultural, ecological effects in such a complex combination that it is never easy to identify a major determination and therefore to propose simple interpretation of the message that they deliver.

Moreover, the demographic parameters are also difficult to analyse because they link past, present and future trends in a very complex way. A typical example of this is provided by the measure of fertility which is very different if we measure it for a cohort (women born the same year) or for a specific year (women having child during a given year). In the first case, we obtain a longitudinal index that can only be measured for women that have achieved their period of childbearing, and is generally relatively stable in its evolution. In the second case, we have a transversal index which is a synthetic measure based on the fiction of what would happen if a woman would have during her life the fertility rate by age of the target year: such a transversal index is much more chaotic in its evolution because it is submitted to exceptional events of the year, without considering the fact that previous or subsequent years can modify the final number of children of each generation of women.

In other words, many demographic indicators are *de facto* synthetic indexes and the problem is not to combine them with other economic, social or ecological variable but to interpret which message they can deliver on the other dimensions of social life.

4.2.3 Population ageing and index of sustainable demographic development

4.2.3.1 The interest of the combination of life expectancy at birth and median age in order to measure territorial cohesion and inequalities

4.2.3.1.1 Life expectancy: a good summary of social dimension [29]

Amongst all demographic indicators, life expectancy at birth is a classic one used to measure the level of development of societies at world scale. As mentioned in point 1.1.1, it is one of the three components (with GDP/capita and instruction indicators) of the Human Development Index used by the United Nations Development Program to compare UN member states. It was introduced in 1990 by Mahbub Ul Haq and Amartya Sen to compensate the weakness of GDP/capita, indicator of economic production that does not estimate well global wealth by not taking into account capital and savings, and that does not give any indication about dispersion of wealth, and so about social cohesion (Kervasdoué, 2005). Another difficulty with GDP/capita is that, even converted in pps (which currently is only available at national, but not at regional level), it can under-estimate the wealth of different societies according to the structure of their economy and the nature (formal or informal) of their production, and in function of the value given to their internal services (Todd, 1998). More generally, GDP has the paradoxical characteristic of positively taking into account destructions, in the sense that they generate monetary flows (the best example is the recent tsunami in South Asia): for the calculation of GDP,

[29] See Appendix II for a methodological discussion of the calculation of life expectancy.

cycles of destruction and reparation are more positive than prevention and preservation, which is a real problem in terms of environment (Viveret, 2003). All these discussions about GDP explain why, in complement of econometric approaches, it seemed to us that it was necessary to introduce life expectancy at birth as an alternative indicator of reference to measure territorial cohesion in ESPON area.

Indeed, as a value calculated from mortality by age tables at a given moment[30], it reflects large parts of the social situation in a given country or region: it is generally recognized as a good indicator of health system efficiency, and thus of the social care provided for the population (OECD, 2005). But more generally, much more than GDP, it also gives indications about 'quality of life' or 'well being' of the population. Measuring quality of life in a quantitative way is by definition always risky and subject to debates (Gadrey, 2004). But life expectancy remains one of the less subjective parameter if we want to intent it, not only basing us on the trivial assumption that to live well, someone first needs to live: scientific studies on 'healthy life expectancy'[31] show that the general increase of life expectancy in developed countries corresponds to a similar - and sometimes faster - increase of healthy life expectancy (cf. REVES[32] network or World Health Report 2004). And, as an indicator of mortality by age, life expectancy at birth is also much more than a health indicator concerning the old: it is also very sensible to premature deaths, and premature deaths generally express many aspects of general material and psychological conditions of life. This property of the indicator makes it very interesting to measure general social situation of different countries and regions. The correlation coefficients between life expectancy at birth and all social and economic development indicators are generally very strong at world scale. This is partly due to the huge differences between richer countries and less developed ones exposed to extreme situations (war, famine, epidemics, etc.). Within more developed countries, the differences of life expectancy at birth can seem to be limited in comparison with world-scale differences. However, they remain significant, in particular at regional level and between social groups. Many scientific studies show regularly that the inequalities of life expectancy between social classes remain very significant in many of the richer countries in the world (Hatersley, 1999; Geronimus, 2001; NSUK, 2005). This situation is due to the sensitivity of this indicator to the social situation: even in countries with elevated and relatively fast growing GDP, the fragility of parts of the population can limit the progress in global life expectancy and increase the social and regional variability of the indicator (Ireland, United States), while prosperous and cohesive societies will have comparable values for all social class or regions, with a higher total value (Sweden, Japan).

This emerging property results from the fact that many social parameters influence directly or indirectly life expectancy at birth in developed countries: bad hygienic conditions of parts of the population (infant mortality), psychological diseases (suicides or risk conducts - alcohol, drugs, fast driving, etc.), difficult conditions of work (accidents), bad quality of infrastructures (accidents due to bad equipment or non respect of security norms), violence and criminality (homicides) are diverse factors reflecting the level of well-being and harmony of a society that are captured by the value of life expectancy at birth. Indirectly, they give indications about the capacity of a society to take care and preserve its population and environment, just like it is correlated to its level of global wealth (i.e. ESDP central aspects). So, as we can see - and as underlined previously (1.1.3) -, the problem of life expectancy at birth is maybe to be a too synthetic indicator by summarizing so many parameters: the same evolution of life expectancy in two different regions can have different causes, just like there can be, inside a same society, compensation effects between different types of mortality evolutions (for example an increase of work accidents

[30] See Appendix II.1.

[31] Healthy life expectancy is generally defined as the number of years to be lived in good health based on the hypothesis of a stabilization of incapacity rates, internment rates and mortality by age: it correspond to life expectancy minus the number of years lived without incapacity and without internment.

[32] *Réseau pour l'Espérance de Vie En bonne Santé* (Healthy life expectancy network).

linked with a degradation of conditions of work compensated by a decrease of car accident linked with a specific repressive policy on fast driving) or between different evolutions of mortality between social groups (increase of life expectancy in a specific group, decrease on another).

However, this property is by definition common to every synthetic indicator. And as the goal of ETCI is precisely to be synthetic enough to offer a global measure of differences between regions on the level of the entire ESPON area, this aspect of life expectancy at birth is not a real handicap. And, just like all classic demographic indicators, its big advantage - in comparison with synthetic indexes built as a combination of various indicators - is its political transparency (free from suspicion of manipulation) and the availability of the data in all ESPON regions for a long term period. It is possible to manipulate GDP or unemployment rates, but this is much more difficult for mortality.

4.2.3.1.2 2.3.1.2. Median age: a major driving force for European societies

In the ESPON area, life expectancy at birth is now increasing everywhere and is expected to keep on increasing during the next decades. However, regional dynamics and starting points are not the same between different regions, and life expectancy value has not the same significance in function of the age structure of the populations considered. As mentioned in point 2.1, ESPON project 1.1.4 have already underlined how much population ageing is an essential parameter, conditioning many of the future evolutions of European Societies, and European official texts give an increasing importance to the issue of demography and population ageing[33]. In fact, ageing and the increase of the age dependency ratio appear to be a real potential bottleneck for the development of many European regions in the next decades. Currently, projections about evolution of age structure of population are predicting an increase of the difference between 'young' metropolitan and 'old' rural regions, and more generally between, on the one hand, the north-western and, on the other hand, the southern and eastern parts of Europe. More generally, scientific works describe a 'second demographic transition', insisting on the multiple quantitative and qualitative effects of population ageing (Van de Kaa, 1987; Cliquet, 1991), and some more precisely on territorial cohesion and its link with polycentrism (Champion, 2001). All these aspects led us to introduce the parameter of median age[34] together with life expectancy at birth to measure cohesion between territories. The combination of these two variables has already been used in recent scientific works to show that average remaining lifetime can increase at the same time as a population's age (Sanderson, Scherbov, 2005). And as the regional differences of age of the population will be increasing in the future in Europe, the question of solidarity between generations (pensions) will also be a question of solidarity between regions, and the age parameter will be each time more important in terms of territorial cohesion.

4.2.3.1.3 Combination Life Expectancy - Median age: index of sustainable demographic development (ISDD)

Both dimensions of the demographic profile of European societies put forward here (life expectancy at birth and median age) can be combined, in order to define bold trajectories in time of different countries and regions. This combination produces a bi-dimensional index of sustainable demographic development (ISDD) that permits to evaluate and compare the diversity of situations and evolutions across ESPON area.

[33] See also Appendix I.
[34] See Appendix II.2.

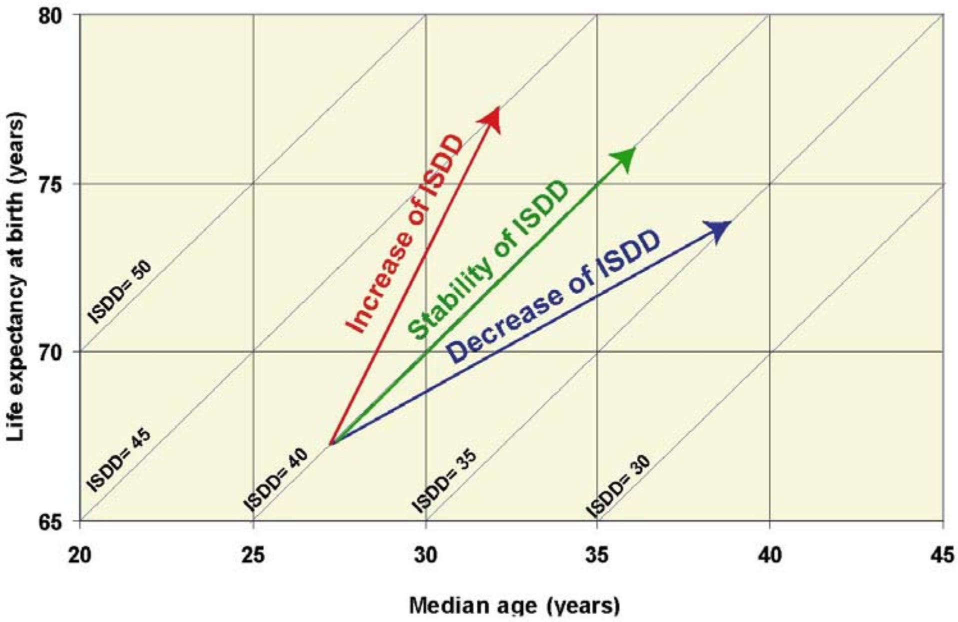


Figure 26 Typical demographic trajectories

Both median age and life expectancy have been increasing during the last 20 years and are expected to keep on increasing everywhere in ESPON area during the next decades. However, the dynamics are not the same everywhere. In *Figure 26* three typical trajectories of this bi-dimensional index are represented. The first one (red) represents the type of trajectory of spatial units with faster increase of life expectancy than median age, and thus an increasing ISDD; In the second configuration (green), there is an equal increase of both indicators, and so a stable ISDD; third trajectory (blue) shows a slower increase of life expectancy at birth than median age. At first glance, the first type of curve can be considered as the more positive, corresponding to a limited population ageing combined to a high life expectancy reflecting a high level of human well-being. On the contrary, the third one seems to correspond to the less advantageous situation, with an ageing population and a low life expectancy.

It is also possible to convert this bi-dimensional index into a uni-dimensional one by subtracting median age from life expectancy at birth, in order to obtain an indication about 'mean remaining lifetime' of the population. The values given by such a subtraction are not properly the averages of remaining lifetime of living populations at time *t* in the studied areas (which is only possible to calculate for extinct generations), neither life expectancy at median age (conceptually possible to calculate but technically not realizable because of lack of data)[35]. However, in ESPON area, the correlations of such an indicator with life expectancy at median age and mean life expectancy of the living population are respectively equal to + 0.99 and + 0.73 at nuts2 level, and the mean differences between those indicators are only equal to 1,5 and 2,2 years (less than 5 % deviation), so ISDD can be considered as a good proxy of remaining lifetime of the population in contemporary Europe (*Tables 23 & 24*).

[35] See Appendix II.1. and II.3.

	Life Expectancy at Median Age (LEMA)	Mean Life Expectancy (MLE)	Life Expectancy at birth – Median Age (ISDD)	ISDD-LEMA	ISDD-MLE
ESPON29	40.5	41.2	39.0	-1.5	-2.2
Brazil	47.0	36.7	42.6	-4.4	5.9
Cameroon	42.2	29.4	32.4	-9.7	3.0
China	44.7	37.9	40.7	-4.0	2.8
India	45.3	33.8	36.9	-8.3	3.1
Japan	41.3	44.6	40.1	-1.2	-4.6
USA	43.1	41.3	41.3	-1.8	0.0

Table 23 Difference between indexes of « remaining lifetime » and ISDD in various regions of the world in 2000

	LEMA	MLE	ISDD
LEMA	+ 1.00	+ 0.68	+ 0.99
MLE	+ 0.68	+ 1.00	+ 0.73
ISDD	+ 0.99	+ 0.73	+ 1.00

Table 24 Correlation between indexes of « remaining lifetime » and ISDD in ESPON area in 2000 (nuts 2)

However, the fact that the correlations are less significant and the differences are more important between different kinds of remaining lifetime indexes in other regions of the world (particularly in those where mortality before median age is important) shows the limits of ISDD as a universal remaining lifetime index.

Considering this, the uni-dimensional version of the indicator must be used carefully: its value doesn't have an exact and universal signification, it is just an indication about the age structure and mortality dynamics of a given population in order to make comparisons between spatial units and between periods[36]. Another limit of the uni-dimensional version of the index is that it can take the same value in very different situations[37], even if in the ESPON area this problem is much less important than at world scale. All these limitations of the uni-dimensional ISDD have invited us to use it only at European level, and to focus more on its bi-dimensional version to measure territorial cohesion in the ESPON area and make comparisons in time (past, present, future) and space (state, regional and local level).

4.2.3.2 Demographic trajectories of European states as compared to the world

All data used here at state level are derived from the 2004 revised United Nations Population Prospect (UNPP) data base[38]. Data taken into account here to represent future values of the index are those corresponding to the UNPP medium hypothesis. *Figure 27* gives a general reference permitting to observe the evolution of the values during the

[36] See Appendix II.3.
[37] For example spatial unit with a life expectancy of 80 and a median age of 50 will have the same ISDD than another one with a life expectancy of 50 and a median age of 20.
[38] In partnership with project 3.4.1. – "Europe in the world".

world's demographic transition (fast increasing ISDD until 1980) and the parallel increase of its two components after 1980, with a stability of ISDD around 38 years.

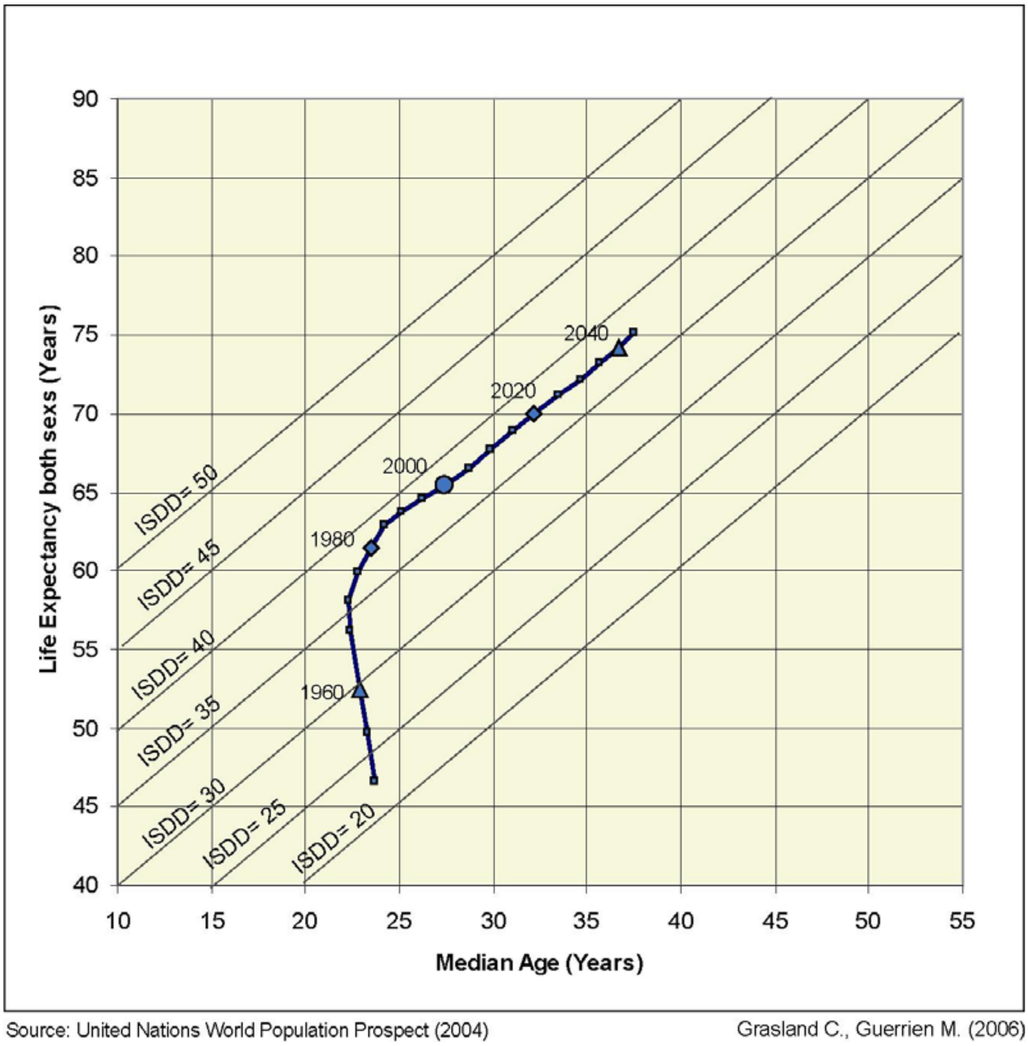


Figure 27 World demographic trajectory (3 UNPP hypothesis)

This general stabilization of the world's ISDD during the 1980-2050 period corresponds to very diverse local situations. On *Figure 28*, we can see that the ESPON area is facing a slow decrease of ISDD since the 1980's and especially after 2000 due to its fast median age increase not compensated by the amelioration of its life expectancy at birth. Japan presents the same kind of trend, but with a higher life expectancy and much faster population ageing, while the United States are characterized by a slow increase of both indicators. The most spectacular evolution is China's, whose broken trajectory after 1970 reflects the huge demographic challenge the 'People's Republic' will have to face in the next decades.

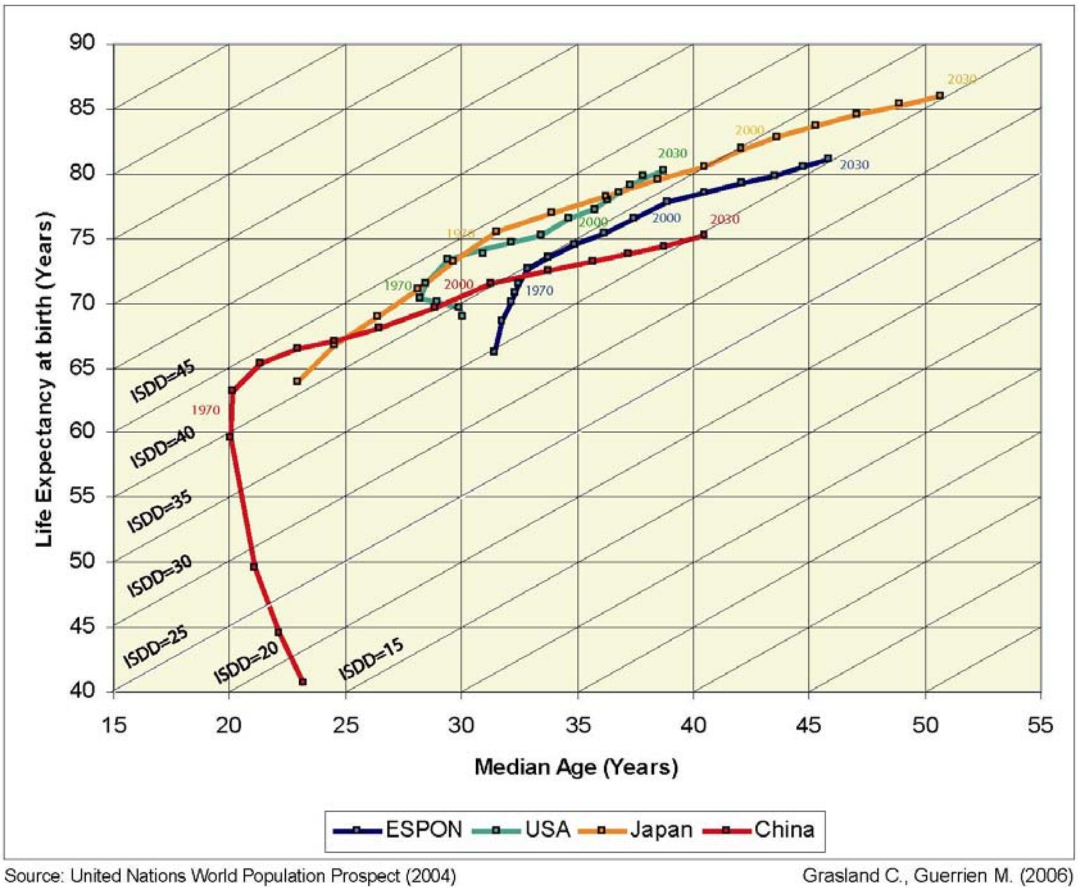


Figure 28 ESPON area's trajectory compared to United States, Japan and China's

If we compare the ESPON area to its eastern and southern neighbourhood, the differences of trajectories are even more spectacular (*Figure 29*). The former Soviet Union countries' chaotic trajectory shows how much the index is influenced by social crisis, with the break of the curve from the 1970's to the 1990's. In the case of the Southern Mediterranean countries (including Turkey), the concave trajectory shows the progressive change of demographic regime between 1950 and 2030, with an inflexion point at the end of 20th century before an evolution parallel to the world's average, but with a much higher ISDD value due to its current extremely young population[39]. In fact, the comparison between the trajectories of the ESPON area and the Southern Mediterranean countries illustrates nicely the debate about current and future enlargement of the EU, neighbourhood policy and the opening/closing of borders: the huge differences between northern and southern countries across Mediterranean Sea shows at the same time the opposition and the complementarity of their demographic characteristics.

[39] In an anthropological point of view, these trajectories suggest that demographic behaviours reflect social and cultural structures, but they also condition them in a way: the irregular trajectory of the former Soviet Union and the fast change of South Mediterranean countries can be associated to the tumultuous social and political situations during the last period in those regions, as well as a cause of social political instability (South Mediterranea) than as a consequence (Soviet Union). On the contrary, the peaceful and "conservative" characteristics of Europe might be put in relation with its regular trajectory and its population ageing.

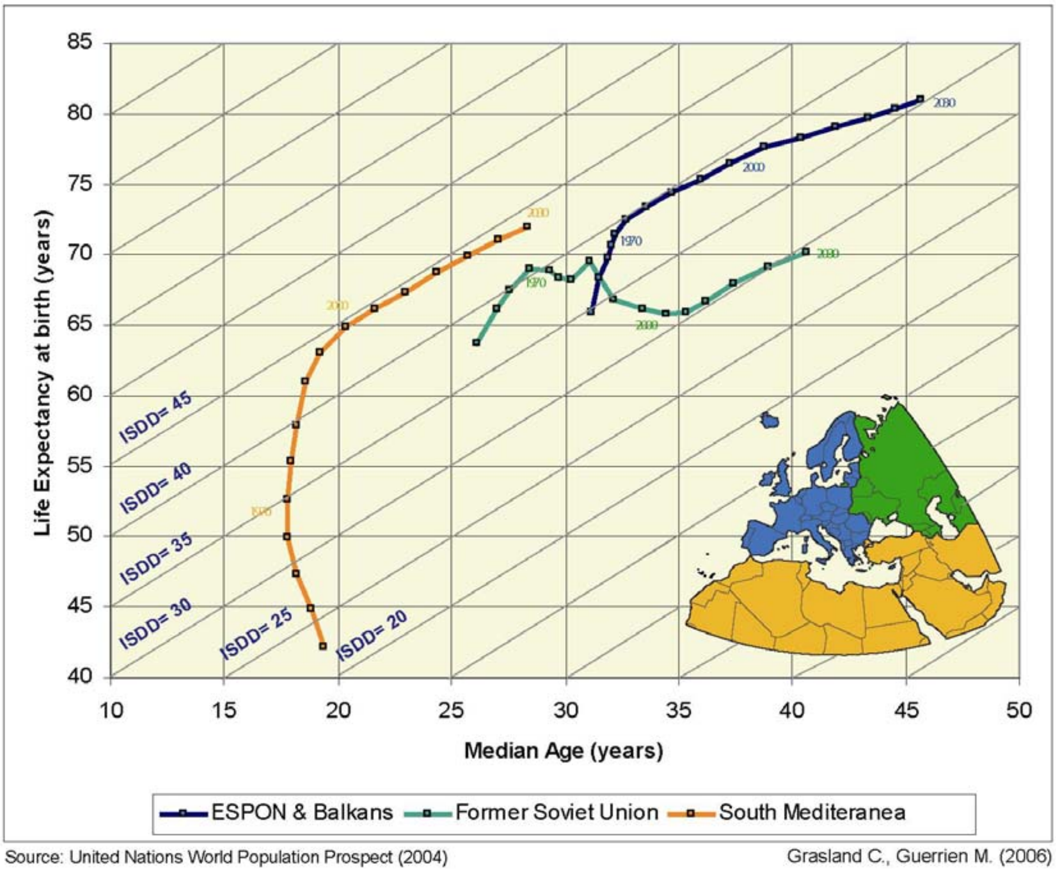
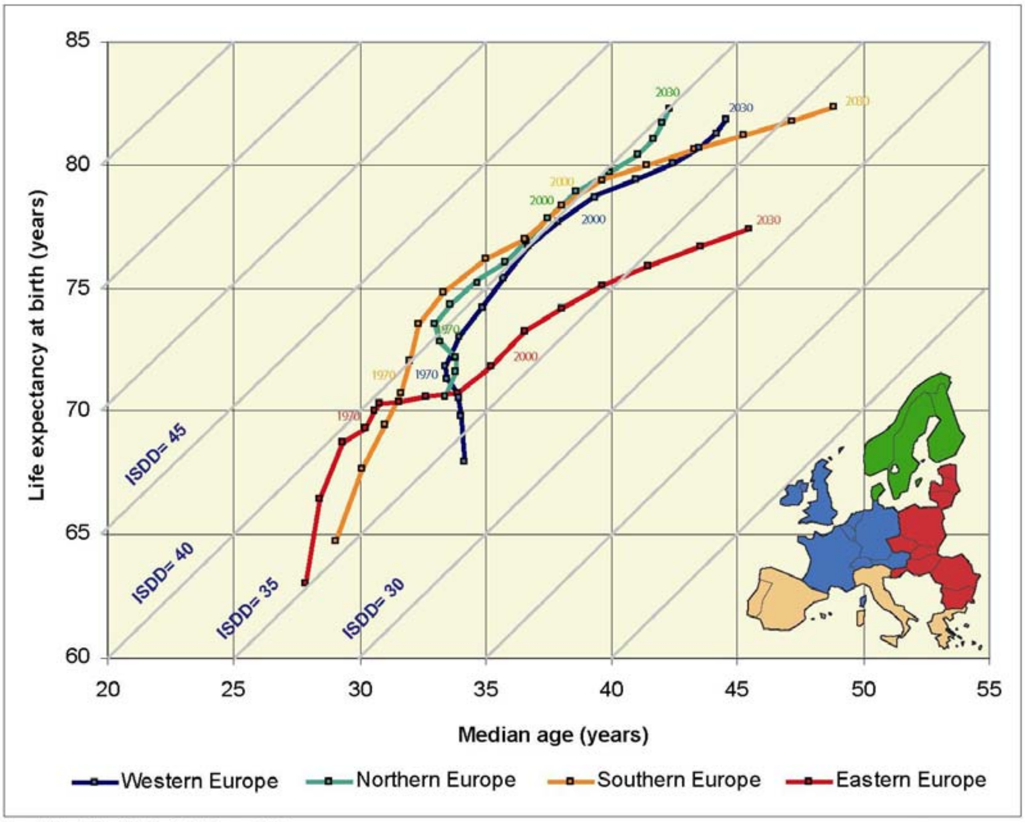


Figure 29 ESPON area[40] and neighbourhoods trajectories

Inside the ESPON area, we also observe different kind of trajectories. Observing each country's profile one by one between 1950 and 2030[41], and considering social and spatial proximities to aggregate them, we can define 4 big regions inside ESPON area. Northern Europe is characterized by a more stable ISDD, due to its slower increase of median age. Western and - even more - southern Europe will face a slow decrease between 2000 and 2030 because of its relatively fast population ageing. But the most challenging demographic situation is observed in Eastern Europe, characterized by a fast population ageing not compensated sufficiently by the increase of life expectancy during the next period. Just like in the case of the former Soviet Union, we can observe on this curve the effects of the economical and political crisis of the socialist system in the 1980's and 1990's: it has produced a stagnation of life expectancy at birth, an exceptional phenomenon in Europe during the period 1950-2030.

[40] ESPON29 + Iceland and Balkans.
[41] See Appendix IV.



Source United Nations World Population Prospect, 2004 Grasland C., Guerrien M. 2006

Figure 30 ESPON 4 big regions trajectories

4.2.3.3 ISDD at regional scale: nuts2 homogeneities and discontinuities

At regional level, we don't have data equivalent to the UNPP state database for past, present and future. Regional data for Life Expectancy and Median Age are available in 1980 and 1988 (Decroly & Vanlaer, 1991) but for the moment, around 2000, ESPON and EUROSTAT databases don't give the values of these demographic indicators. So we had to calculate each NUTS2 life expectancy at birth and median age in 2000, and to use various statistical methods in order to propose estimations of 2015 and 2030 values of these indicators according to the hypothesis of the 3 scenarios of ESPON 3.2 ('baseline', 'cohesive' and 'competitive').

For 2000, the availability of data concerning age pyramids and mortality rates for almost all nuts2 regions has permit to calculate the values for the 2 indicators, using Michel Poulain's regression method for life expectancy at birth (1990) and a simple linear interpolation for median age[42]. For 2015 and 2030, different methods of estimation were used for each indicator.

4.2.3.3.1 *Scenarios of variation of median age*

For median age, we have considered 2015 and 2030 UNPP national values for each country (medium hypothesis), and disaggregated them taking into account the part of each region in national growth during the period 1980-2000. For the baseline scenario, estimations are strictly based on 2000-2015-2030 UNPP predictions about national trends and on the hypothesis of the extension of 1980-2000 regional trends. They permit to see what will be the evolution for these regions if there is no major change in terms of migrations and fertility. But for cohesive and competitive scenarios, extrapolations have been made taking into account divergence and convergence hypothesis. In deed, cohesive scenario is based on the hypothesis of a bit higher fertility and a lower immigration (external and internal) than in the baseline scenario, while competitive scenario is based on the opposite assumption (low fertility and higher level of migration). So, even if those tendencies approximately compensate themselves at global European scale, the impact inside European territories will not be the same at all in function of the scenario considered. In the case of cohesion scenario, the main hypothesis is that regions with a high 1980-2000 increase of median age (regions in difficulty, losing their youth) will face a relatively slower ageing (due to higher fertility and less emigration), while attractive regions with a low 1980-2000 median age growth will face a relatively faster ageing (due to a lower immigration). On the contrary, in the case of competitive scenario, the hypothesis is that regions in difficulty will face an even faster ageing while attractive regions populations will remain relatively young[43].

Using this method, the results show that the global population ageing process between 2000 and 2030 has not the same territorial impact in function of the scenarios (*Figures 31 & 32*). However, as median age is narrowly related to age structure, the differences cannot be very important in such a short period of 3 decades (*Table 25*). So the smoothed maps representing the values of the indicator in 2030 for the 3 scenarios (*Figure 31*) are not very different from one to another. The global tendency is a faster population ageing in different regions of Southern and Eastern Europe, and increasing disparities between metropolitan regions and more rural ones. This tendency is very strong in competitive scenario, as it's based on the hypothesis of a high attractiveness of richest and more dynamic regions (Pentagon and Northern Europe), and on the contrary a low attractiveness of peripheral and rural areas. In cohesive scenario, the hypothesis of a more important redistribution and solidarity between regions and countries leads to less disparities at European scale, concentration of young people and immigrants being less important and equalization of accessibility to services permitting to maintain active populations in less favoured areas.

The maps of discontinuities give the same global image (*Figure 32*) but the methodology, instead of smoothing them, put forward the differences between contiguous regions and doesn't take into account the size of population of the regions. The discontinuities are logically more important in competitive scenario than in baseline and cohesive scenario. The interesting point is that the major discontinuities are intra-national ones (Germany, Poland, Spain, Bulgaria), and that many countries are characterized by a high heterogeneity in terms of population ageing – phenomenon difficult to see in the smoothed maps.

[42] See Appendix II.2.
[43] See Appendix III.1 for details of the methodology.

MEDIAN AGE	2000	2030 - baseline	2030 – cohesive	2030-competitive
Weighted average	38,22	46,52	46,99	46,03
Weighted std deviation	2,59	4,70	4.32	6.01
Variation coefficient	6,8 %	10,1 %	9,2 %	13,1 %

Table 25 Regional variations of median age in ESPON area (nuts2)

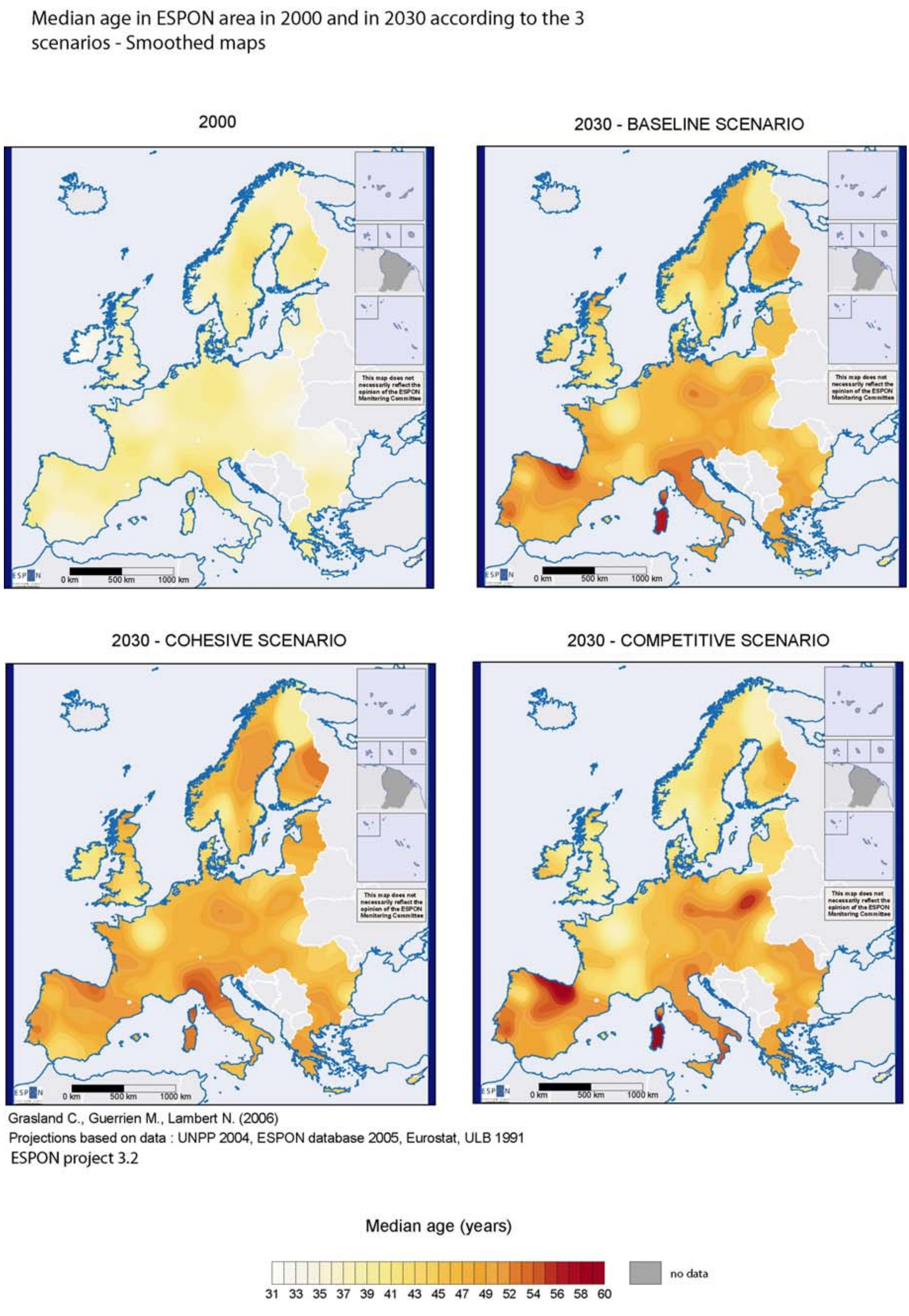


Figure 31 Median age in ESPON area in 2000 and in 2030 according to the 3 scenarios - Smoothed maps

Median age in ESPON area in 2000 and in 2030 according to the 3 scenarios – Maps of discontinuities

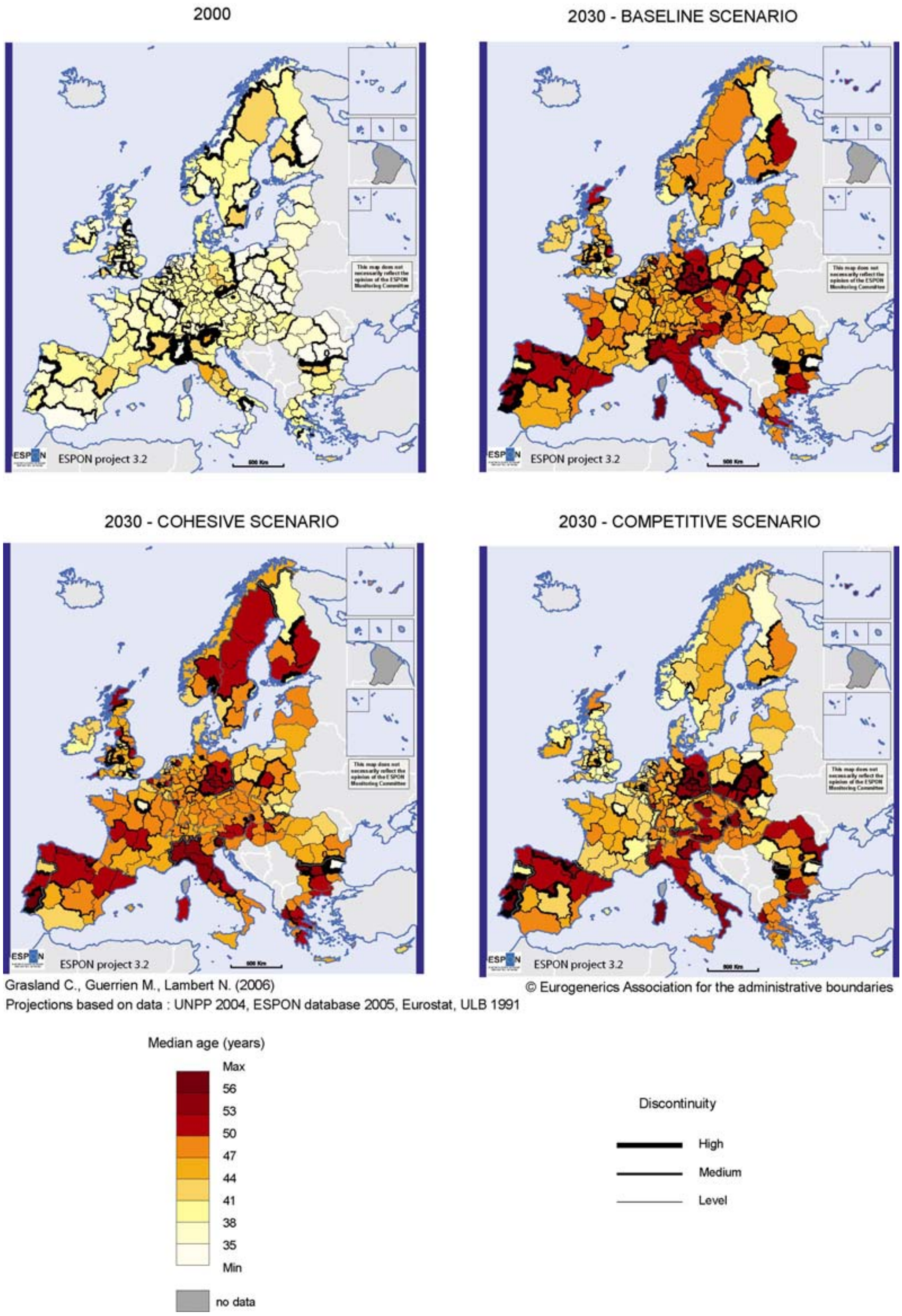


Figure 32 Median age in ESPON area in 2000 and in 2030 according to the 3 scenarios – Maps of discontinuities

4.2.3.3.2 *Scenarios of variation of life expectancy at birth*

For life expectancy at birth, it's not possible to apply exactly the same statistical method than for median age. In deed, while median age is a longitudinal parameter which is changing very slowly through time (whatever the level of mortality, fertility and even external migration, the age structure remains relatively easy to predict for the near future), life expectancy at birth is a transversal parameter able to be subject to sensible variations on short term[44]. So it is not appropriate in its case to take into account 1980-2000 tendencies as it can give in certain regions wrong results because of the long-term extrapolation of data concerning a specific period independently of 'catching-up' or 'specific crisis' effects.

To estimate 2015 and 2030 life expectancy's values for each scenario, we considered 2000, 2015 and 2030 UNPP national predictions and 2000 regional values in order to apply a β-convergence model combining assumptions of convergence/divergence at inter-national and intra-national levels. The baseline scenario is based on the hypothesis of a constant dispersion of life expectancy's values at inter-national and intra-national levels: the hypothesis is that life expectancy will keep on increasing everywhere approximately at the same rhythm, and that inequalities between territories will remain the same. In the case of cohesive scenario, the hypothesis is that both intra-national and inter-national disparities will be reduced, due to the effect of a strong cohesion policy in direction to the regions and country in difficulty, with weak health and protection systems. On the contrary, in the case of competitive scenario, the central hypothesis is that inequalities between countries will be accentuated and there will be no reduction of intra-national disparities, the concentration of wealth in the more developed regions and countries helping them to increase even more their standards of living, health care, etc., and so on their life expectancy, while the effect of the weaker cohesion policy is a slower increase (and in some cases a stagnation or a reduction) of life expectancy at birth (increase in the more fragile parts of the population of diseases, accidents, dangerous behaviours, addictions, homicides, suicides, etc.) [45].

Using this β-convergence statistical model, the results show that the general increase of life expectancy between 2000 and 2030 is very unequally distributed in function of the scenarios (*Figures 33 & 34*). The smoothed maps and the maps of discontinuities both show that the difference between western and eastern regions remains significant in the 3 scenarios, but that they are more obvious in the competitive, while they tend to be attenuated in the cohesive. In the first case, it results from the hypothesis that competitive policies lead to less solidarity between territories, for example in terms of health security systems, and produce a more important territorial polarization (higher concentration of populations with high standards of living - and so on life expectancy - in the dynamic areas). In the second case, on the contrary, it results from a more important social harmonization and less territorial polarization. This growing homogeneity in cohesive scenario and growing heterogeneity in competitive one is expressed by the variation coefficients values, respectively 1,6 and 5,5 % (table 26).

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[44] See Appendix III.2.

[45] For example if there was a "catching-up" of a particular region in a given country between 1980 and 2000 - with the faster relative increase but still the lower value of the country -, and if the trends are prolonged for several decades, this region will get the higher life expectancy in the estimations, even if it does not correspond to any logic.

LIFE EXPECTANCY AT BIRTH	2000	2030 – baseline	2030 - cohesive	2030-competitive
Weighted average	76,90	81,34	81,30	81,36
Weighted std deviation	2,60	2,21	1,33	4,47
Variation coefficient	3,4 %	2,7 %	1,6 %	5,5 %

Table 26 Regional variations of life expectancy at birth in ESPON area (nuts2)

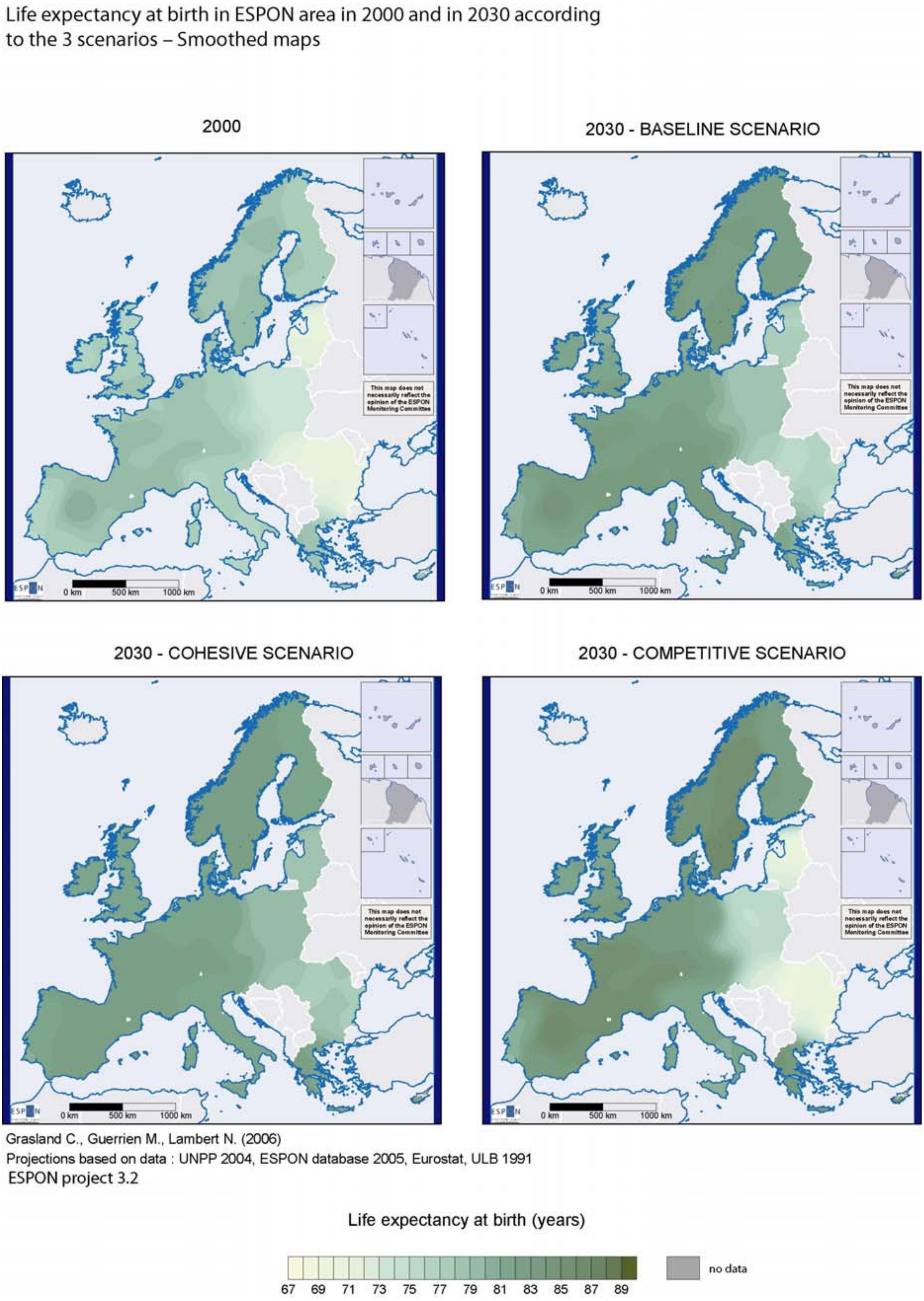


Figure 33 Life expectancy at birth in ESPON area in 2000 and in 2030 according to the 3 scenarios – Smoothed maps

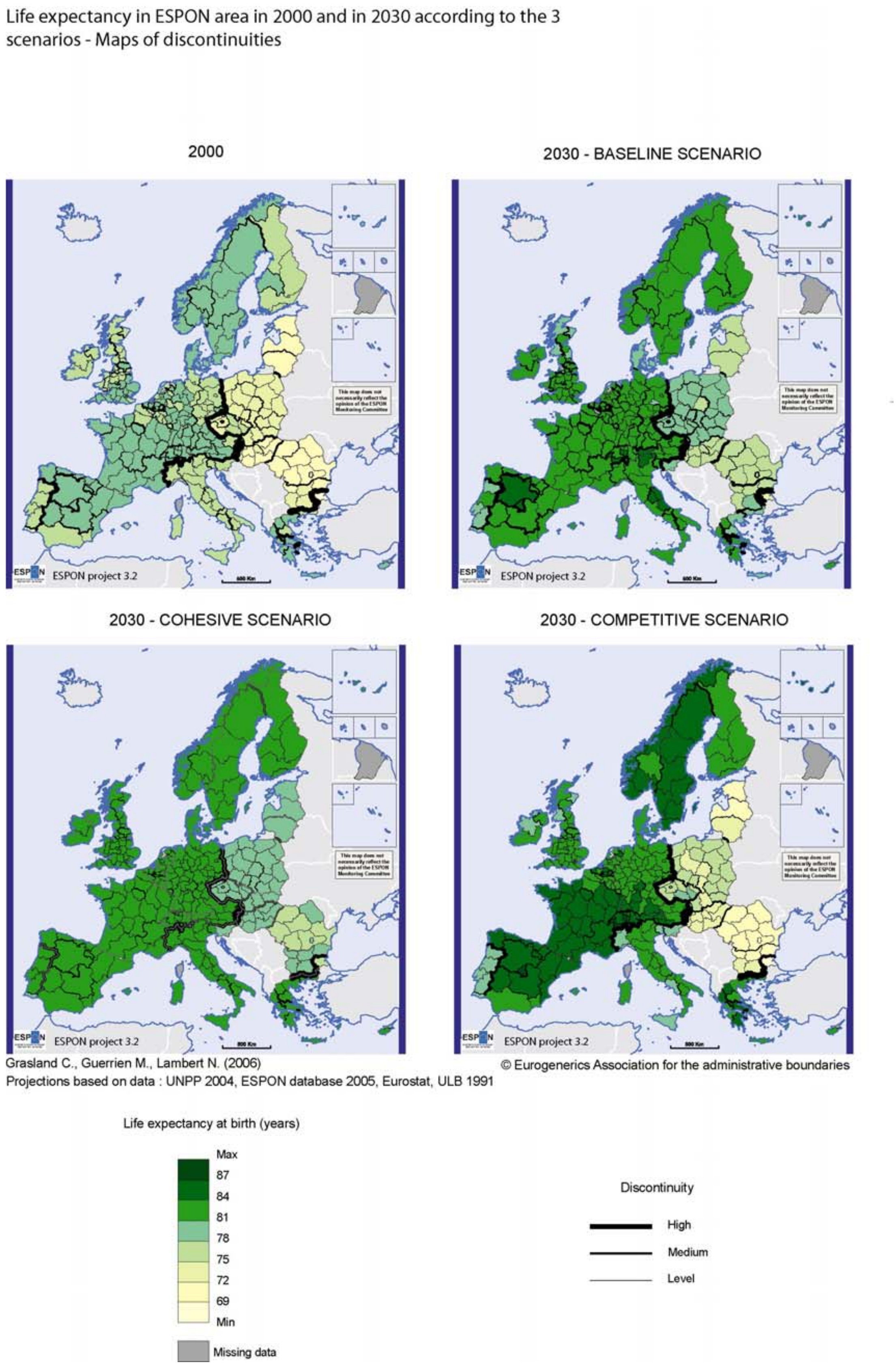


Figure 34 Median age in ESPON area in 2000 and in 2030 according to the 3 scenarios - Maps of discontinuities

4.2.3.3.3 Scenarios of variation of ISDD

As ISDD is a combination of life expectancy at birth (positive component) and median age (negative component), and as we have observed that both indicators evolutions were linked to the potential attractiveness of the territories and tend to be similar in certain aspects (regions where median age is increasing faster tend to be the same that those which life expectancy at birth's increasing is slower, and *vice-versa*), there is no surprise in observing that ISDD maps reproduce and accentuate the polarizations described above (East/West Europe, metropolitan regions/rural areas, etc.). *Table 27* shows that the variation coefficients are more important for this indicator for the 3 scenarios, and particularly according to the competitive one. The smoothed map of ISDD in 2030 according to this scenario (*Figure 35*) show very clearly the growing opposition between the north-western and the northern Europe that manage to keep a relatively high ISDD (high migratory attractiveness and high life expectancy) and the southern and, moreover, eastern part of the ESPON area that have a fast decreasing ISDD (population ageing faster than the increase of life expectancy because of youth emigration and bad social situation). The smoothed map according to cohesive scenario presents the same tendency but much more attenuated. On the map of discontinuities, the East/West fracture appears even more clearly, but other discontinuities are detectable, like discontinuities between big metropolitan areas and their surroundings, and various discontinuities in Eastern Europe that must be taken cautiously because of the particular demographic unstability during the last period in the former-socialist countries that may have influenced the regional projections.

To resume, the global tendency put forward by all these maps is that between 2000 and 2030:

1) Attraction of national youth and international immigrants (with higher fertility) in metropolitan regions contains the increase of median age in the urban areas and in northern and western Europe, and accelerates it in more rural regions and in eastern Europe. This phenomenon is sometimes reinforced by migration of old people from metropolitan to rural and tourism regions (Casado Diaz, Kaiser, Warnes, 2004).

2) Higher incomes and better accessibility to health and social services for people living in metropolitan areas and in northern and western Europe accelerates the increase of their life expectancy at birth, and on the contrary relative impoverishment and less accessibility to services in rural areas and eastern Europe limits it.

3) These tendencies are particularly important in competitive scenario, but more limited in the cohesive where the strong cohesion policy manages to limit the territorial polarization and contains this evolution.

ISDD	2000	2030 – baseline	2030 – cohesive	2030 - competitive
Weighted average	38,68	34,82	34,31	35,33
Weighted std deviation	2,85	4,99	4,53	8,15
Variation coefficient	7,4 %	14,3 %	13,2 %	23,1 %

Table 27 Regional variations of ISDD in ESPON area (nuts2)

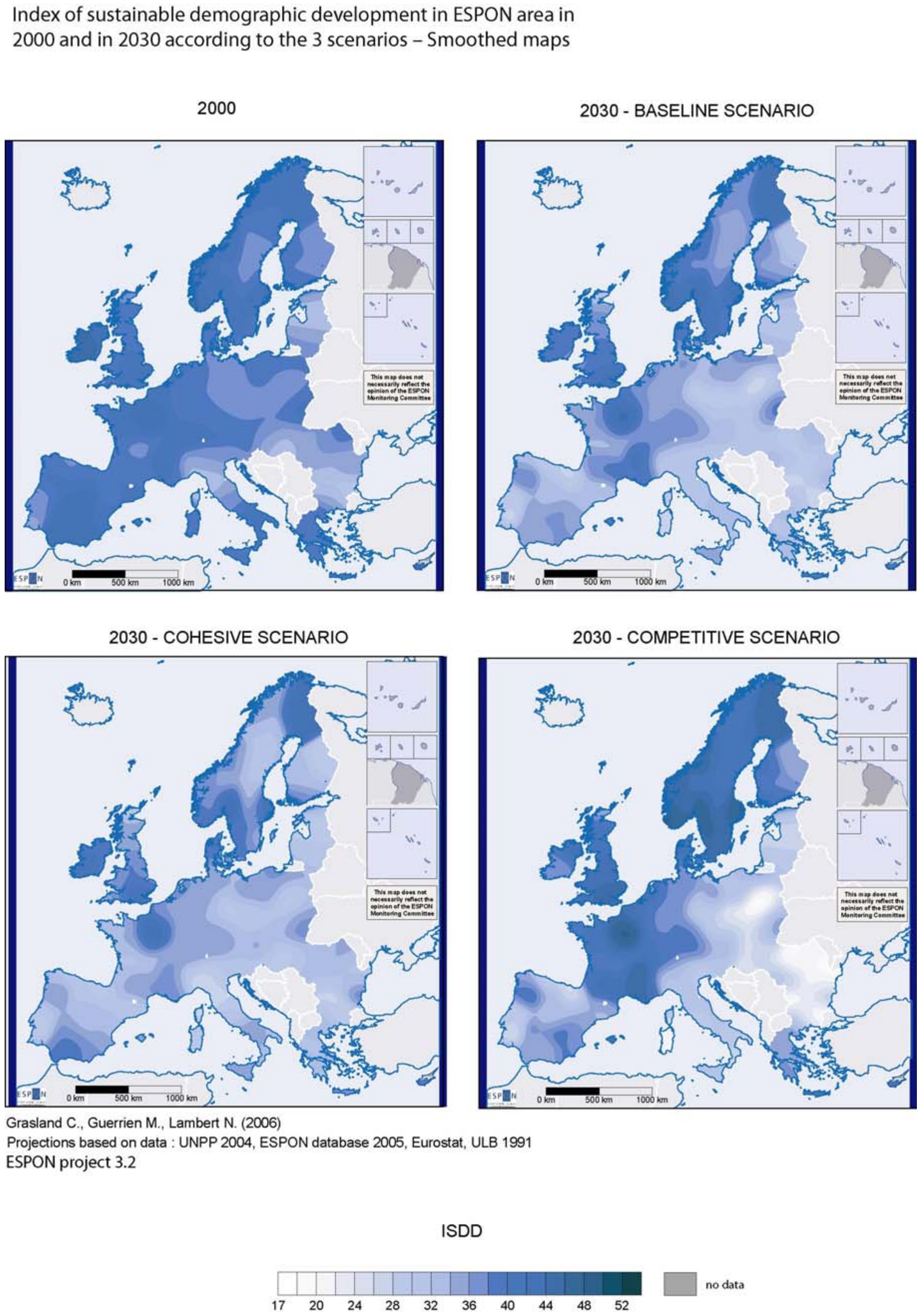


Figure 35 Index of sustainable demographic development in ESPON area in 2000 and in 2030 according to the 3 scenarios – Smoothed maps

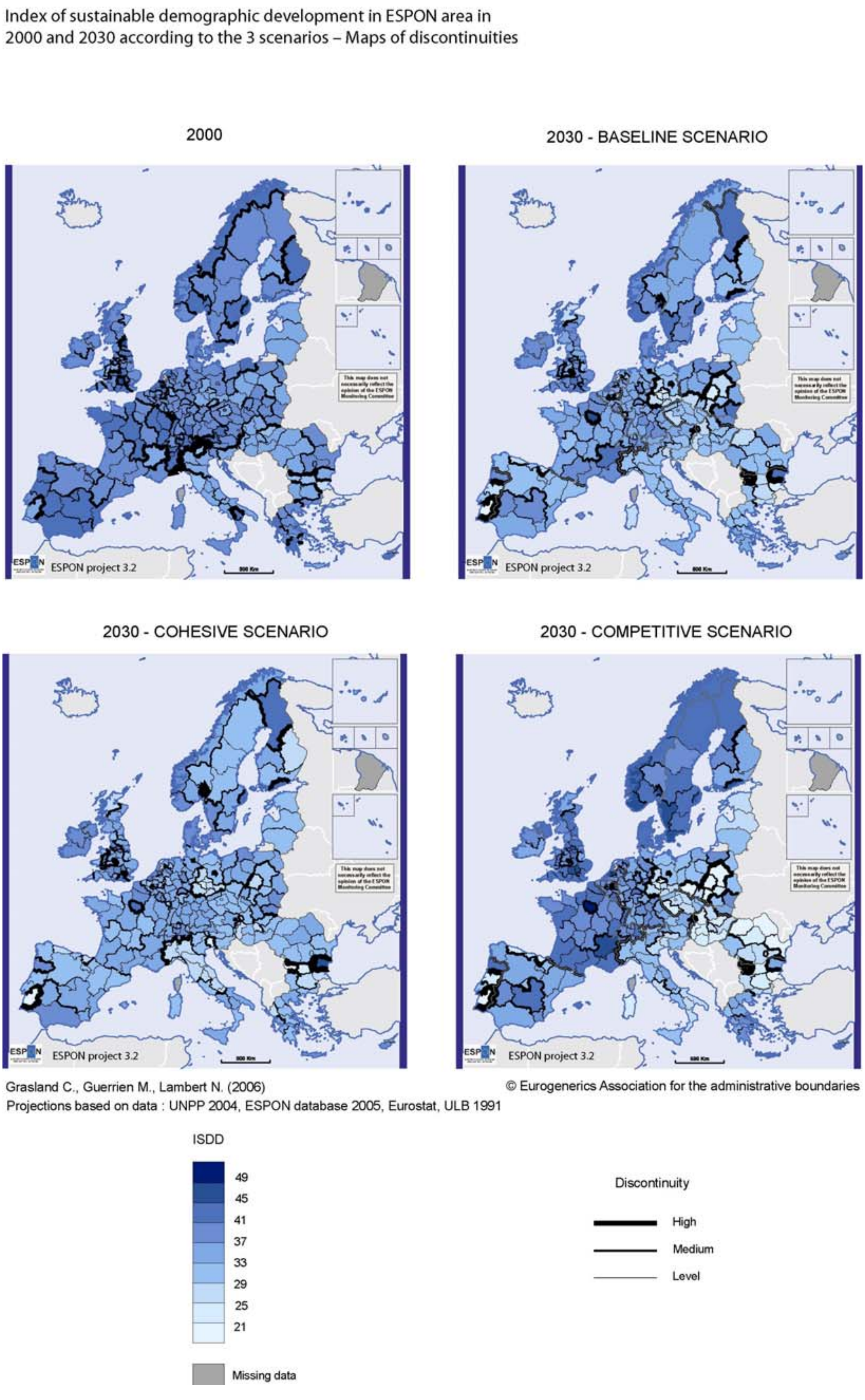


Figure 36 Index of sustainable demographic development in ESPON area in 2000 and 2030 according to the 3 scenarios – Maps of discontinuities

	Median age 2030			Life expectancy at birth 2030			ISDD 2030		
	baseline	competitive	cohesive	baseline	competitive	cohesive	baseline	Competitive	cohesive
Former communist countries	47.4	48.8	47.5	78.2	74.8	79.4	30.8	26.1	31.9
UE 15 + Switzld, Norway, Cyprus and Malta	46.2	45.1	46.8	82.4	83.5	81.9	36.1	38.3	35.1

	Median age 2030			Life expectancy at birth 2030			ISDD 2030		
	baseline	competitive	cohesive	baseline	competitive	cohesive	baseline	Competitive	cohesive
Very low urban influence	47.5	47.3	47.9	81.3	81.0	81.2	33.8	33.7	33.3
Low urban influence	46.3	45.7	46.8	81.3	81.5	81.3	35.0	35.8	34.5
Medium urban influence	44.5	42.7	45.8	81.8	83.4	81.9	37.4	40.7	36.1
High urban influence	42.4	41.0	43.6	81.0	81.9	81.5	38.6	40.9	37.9
Very high urban influence	37.5	36.7	37.5	81.5	82.8	81.7	44.0	44.3	46.0

Table 28 Compared ISDD in 2030 according to the 3 scenarios: former communist/capitalist countries and urban/rural areas[46]

[46] Defined at nuts2 level with population density and CORINE landcover parameters (ESPON database 2006).

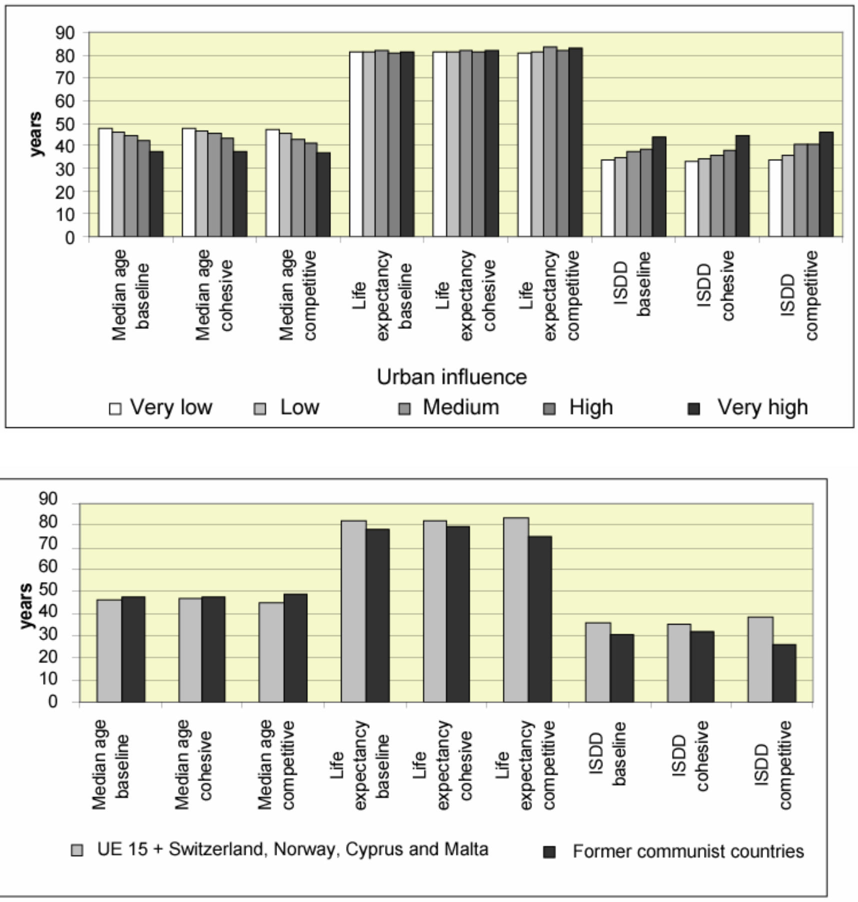


Figure 37 Compared ISDD in 2030 according to the 3 scenarios: former communist-capitalist countries and urban-rural areas[47]

[47] Defined at nuts2 level with population density and CORINE landcover parameters (ESPON database 2006).

APPENDIXES

I: SELECTED POLITICAL DOCUMENTS RELATED TO DEMOGRAPHY

II: DEFINITION AND PROPERTIES OF ISDD

III: ESTIMATION OF 2015 AND 2030's ISDD VALUES

IV: ISDD STATE GRAPHICS (ESPON + Croatia, Turkey and Ukraine)

V: BIBLIOGRAPHY

APPENDIX I: SELECTED POLITICAL DOCUMENTS RELATED TO DEMOGRAPHY

- *Third report on economic and social cohesion: 'A new partnership for cohesion. Convergence, competitiveness, cooperation' - 2004*

'Population of working age will begin falling over the present decade in all four southern Member States, Germany and most of the accession countries. In the next decade, the fall will spread to all countries, apart from Ireland, Luxembourg and Cyprus. On the latest projections, the number of people aged to 15 to 64 is projected to be 4% smaller in the EU15 in 2025 than in 2000 and in the accession countries, 10% smaller.
The decline will be accompanied by substantial growth in the number of people of 65 and over. By 2025, there will be 40 % more people than now beyond retirement age in both the present EU15 and the accession countries, implying a ratio of under three people of working-age for everyone aged 65 and over as opposed to a ratio of over four to one at present. Other things being equal, the ageing of population will lead to a gradual contradiction of the EU's force and is likely to have implications for growth potential.'

p. x (*executive summary*)

'Liberalising the markets for transports, telecommunications and energy has led to increased efficiency and lower prices. It has also, however, involved a threat to particular social groups or regions of being excluded from access to essential services. Public service obligations have, therefore, been established to ensure that everyone can obtain essential services – or 'services of general economic interest' – of reasonable quality and at affordable prices, as required by the EU Treaty (Article 16). Community funds have been made available to help ensure that these obligations are respected across the EU.'

p. xvi (*executive summary*)

'Demographic ageing in Europe is a particular challenge. The regional variations in this respect are considerable reflecting trends in fertility and mortality, and immigration. Addressing the problems is not simply a question of coping with a rise in the dependent population. It also requires ensuring that national and regional development strategies are adapted to demographic circumstances and are able, in particular, to promote active ageing policies and to exploit the often underused potential of the older population.'

p. xxvi (*conclusions: a proposal for a reformed cohesion policy*)

'In particular, Member States, regions and citizens will have to adapt to a world experiencing rapid economic and social change and restructuring, trade globalisation and a move towards a knowledge-based economy and society. They will also have to tackle the particular challenges that derive from an ageing population, growing immigration, labour shortages in key sectors and social inclusion problems.'

p. xxix (*conclusions: a proposal for a reformed cohesion policy*)

- *Second report on economic and social cohesion 'Unity, solidarity, diversity for Europe, its people and its territory' - 2001*

'Population in the EU is ageing rapidly. With low birth rates, the proportion of young people under 15 has declined for a number of years and is projected to continue to do so in the future, falling from 17% in 1998 to 14.5% in 2025. By contrast, the proportion of those aged 65 and over is rising significantly and is set to increase even faster after 2010 as the baby-boom generation begins to reach this age. Accordingly, the proportion is projected to increase from around 16% of total population in 1998 to 22% by 2025. Moreover, with this, the relative number of people of 80 and older is rising faster still.

These trends will have important consequences for social welfare and taxation systems across the EU. In particular, the prospect is for a growing number of people above retirement age who will need to be supported by those in employment. All Member States will experience an increase in the old-age dependency rate (the number aged 65 and over relative to those of working-age, taken here as 15 to 64), but the extent of this is likely to vary significantly between them. The most marked increases are expected to be in Italy, Sweden, Finland and Germany and the smallest in Ireland, Portugal and Luxembourg.'

p. 42 (*Factors determining real convergence*)

- *First Cohesion Report - 1996*

'Years of work on indicators to measure the quality of life in the broader sense, and the more recent reflections in the Union on the 'greening' of national accounts, have identified the limitations of conventional income measures such as GDP, even if as yet there is no operationally viable alternative. Overcoming these limitations would allow due account to be taken of environmental effects, and more broadly of the sustainability of economic development.'

p. 6 (*executive summary*)

- *European Spatial Development Perspective (ESDP) - 1999*

'(240) Three trends will dominate population development in the EU in the next 20 to 30 years:
- decline in population
- migratory movements
- shifs in age profile.

(241) Natural population growth in the EU has been very low for years and is showing a declining trend. Without considerable changes in the birth rates of the EU fifteen, a shift

from population growth to population decline could begin to appear around 2020. Against this background, international and interregional migratory movements are of increasing importance for EU population development and its sub-areas.'

p. 57 (*Part B-1.2. Demographic trends*)

- *Report on Territorial Cohesion, European Parliament - 2005*

'De nouveaux critères et indicateurs territoriaux, à côté du PIB, devraient être créés pour mesurer le développement d'une région et les obstacles à ce développement, tels les handicaps territoriaux spécifiques, l'indice de décentrement et d'accessibilité, la dotation en infrastructures et en transport, le niveau d'activité en recherche et innovation, en éducation et formation, le niveau de diversification de la productivité dans la zone.'

p. 9

- *EU informal ministerial meeting on territorial cohesion Presidency conclusions in Luxembourg, 20/21.05.2005*

'They [The Ministers] noted that the proposals of the European commission to strengthen the Lisbon Strategy ('Working Together for Growth and Jobs. A New Start for the Lisbon Strategy') endorsed by the European Spring Council incorporate a territorial dimension in four ways: a) innovation poles linking regional centres, universities and business; b) national Lisbon action plans; c) attractiveness of areas to business and daily life; and d) the requirement to involve regional and local actors (multi-scale approach). They expressed the view that further consideration of the territorial dimension in EU policies could add value to the implementation of the Lisbon Strategy'

Presidency Conclusions (2.3)

- *EU informal ministerial meeting on territorial cohesion Presidency conclusions Rotterdam, 29.11.2004*

'The Ministers took note of the demographic, economic, social and environmental challenges facing the recently enlarged EU territory, especially those emerging or intensifying since the adoption of the ESDP, including the effects of climate change, global competitiveness and high energy prices. They stressed, once again, the importance of territorial cohesion, both in strengthening competitiveness and reducing disparities within the cohesion framework, and the key role that cities play in this concern.'

Presidency Conclusions (1.1)

'The Ministers recognised that territorial cohesion adds to the concept of economic and social cohesion by translating the fundamental EU goal of balanced and sustainable development into a territorial setting. They recognised that is both a multi-sectoral and a multi-level concept that can be implemented at regional/national, transnational and European levels. They acknowledged that it adds an integrated and long-term approach to the process of exploiting territorial potentials'

Presidency Conclusions (2.1)

'They recognized the important role of ESPON in enabling a coherent approach to the development of the EU territory. They considered the continual observation of European territorial trends and developments a highly important instrument of support in pursuing territorial cohesion'

Presidency Conclusions (4.3)

‘Although migration patterns offer various challenges for Europe, falling population is a feature of many regions of the EU. This is due particularly to natural demographic factors. Population of working age in the enlarged EU is likely to begin falling earlier than the total, while a large and continuous increase in the proportion of the population aged 65 and over will occur. The total population aged 65+ in the EU-25 will be 40% higher in 2025 than in 2000. One consequence will be a sharp rise in old-age dependency rates at EU-wide level. Metropolitan areas and highly urbanised regions are likely to experience higher population growth in future while regions with very low population densities are likely to continue to lose population, threatening their vitality. This change creates challenges for territorial development related, for example, to the emergence of specific needs and locational choices of retired people. Entire regions are specialising in the settling of retired people. Their economic base is becoming a residential one, progressively changing their productive base. The decreasing proportion of the population of people of working age is likely to strengthen competition between regions to attract young qualified manpower. In addition, there is an increasing trend of cross-border retirement. The whole territory will be confronted by these challenges, to different degrees.’

Discussion paper for the EU informal ministerial meeting on territorial cohesion, p. 3

‘The report proposes that future cohesion policy should focus on investment in a limited number of Community priorities, reflecting the Lisbon agenda, encapsulated in these key themes: innovation and the knowledge economy; environment and risk prevention; accessibility and services of general economic interest. All of these themes are fundamental to the balanced and sustainable development of the EU territory and its is essential that they are addressed in an integrated, coherent way. The priority themes will be addressed under three objectives: convergence, regional competitiveness and employment, and territorial co-operation.’

Discussion paper for the EU informal ministerial meeting on territorial cohesion, pp. 7-8

APPENDIX II: DEFINITION AND PROPERTIES OF THE INDEX OF SUSTAINABLE DEMOGRAPHIC DEVELOPMENT

1. Life expectancy at birth

Life expectancy at age x of an extinct generation ($LEEG(x)$) is very easy to calculate: it is the arithmetic average of remaining duration of life at age x of a population born in an area A at time t. If a_i is the age of death of individual i and n the total population of P,

$$LEEG(x) = (\sum a_i - x) / n$$

So life expectancy at birth of an extinct generation is simply $LEEG(0) = \sum a_i / n$.

However, life expectancy is generally calculated for living population, which age of death is obviously unknown. This makes its calculation more complex. To calculate life expectancy at a present time, a life table of crude death rates by age must be used. This table permits to calculate probability of surviving at each age [48]. If probability of surviving from age x to age $x + n$ is denoted nP_x, the life expectancy at age x, denoted $LE(x)$, is calculated by adding up the probabilities at every age[49]:

$$LE(x) = \sum t\, P_x {}_{t=1}^{\infty}$$

Life expectancy at birth $LE(0)$ is then obtained integrating all the probabilities of surviving at every age (from 0 to the maximum age). We must note here that the calcultaion doesn’t take into account changes of life expectancy in the future. So life expectancy is usually calculated with no allowance for expected future changes. This means that life expectancy as it is calculated here is not generally appropriate for calculating how long any given individual of a particular age is expected to live, as it assume that current death rates will be "frozen" and not change in the future. This property is essential to understand the difficulty to measure real ‘remaining life’ of a given population (see paragraph 3).

2. Median age

Median age of a population P is the age value that parts it in 2 groups of equal size: a median age of m_p means that half of the population is younger than m_p and the other half is older. It is a good indicator of population ageing, easily deductible from pyramid of ages (size of population by age). However, data about age structure of the population is generally only available by age groups of 5 years, which make only possible to identify median age group (the age group [x ; x + 5 [where parts of the population aged less than x and aged more than x + 5 are both inferior to 50 %). To estimate precise median age values at state and regional level, we have considered here that the trend inside median age group is linear. If a_p is the proportion of population P younger than x and b_p is the proportion of population P older than x + 5,

$$m_p = x + 5 \,.\, [\ (1/2 - a_p) / (b_p - a_p)\ ]$$

Mean age – calculated as the arithmetic average of the living population at time t - is another good and simple indicator of population ageing. However, its deduction from pyramid of ages is generally more complicated because of the age groups aggregations usually realized on their top[50]. And the differences between median age and mean age are

[48] For example, if one observed a group of people who were alive at their 60th birthday, and 5 % of them were dead by their 61st birthday, then the crude death rate at age 60 would be 5 %.

[49] Because the age is rounded down to the last birthday, on average, it can be expected that people live half a year beyond their final birthday, and half a year is added to calculate total life expectancy.

[50] « 65 years and more » or « 80 years and more » age group.

so limited in ESPON area that this technical problem led us to choose the first indicator to measure population ageing and build 'remaining life' index.

3. ISDD

The uni-dimensional version of the index of sustainable demographic development of a population *P* is calculated as the simple subtraction of the median age to the life expectancy at birth of this population:

$$ISDD_p = LE(0)_P - m_P$$

Considering the properties of its two components, this uni-dimensional index compares data about different generations: median age at date *t* is an instantaneous value concerning all the living generations on *t*, whereas life expectancy at birth at date *t* only reflects mortality by age on *t*. So life expectancy at birth on *t* gives more information about mean duration of life of disappearing generations[51] than about life's duration of baby that were born on *t*. For example, it is probable that the lifetime of the children that were born in 2000 in Europe will be superior to life expectancy at birth in 2000 in Europe (because of health progress and increase of security), but it is impossible to calculate precisely this mean lifetime before the extinction of this generation. The fact that life expectancy 'at birth' at date *t* is paradoxically calculated with the deaths at this date, while median age takes into account all the living population on *t*, is a limit for the use of the uni-dimensional ISDD as a 'remaining life' index: in theory, it could for example have negative values (median age superior to life expectancy at birth), even if this kind of situation is practically impossible.

Anyway, the aim of ISDD is not to be a 'remaining life' index and furnish a value of 'mean remaining duration of life' (*MRDL*) of the population. Such a value of *MRDL* could be calculated, as the weight average of life expectancies by age. For $x = 0, 1, \ldots, p$,

$$MRDL = (\Sigma\, n_x \,.\, LE(x)) / N$$

p = age of the older individual
n_x = number of individual aged x
$LE(x)$ = life expectancy at age x
N = total population

However, the lack of data about mortality by age at ESPON regional levels makes impossible the calculation of life expectancies by age. And the *MRDL* value would anyway remain only an indicator, always because of the impossibility of measuring the duration of life of a population before its extinction. Life expectancy at median age ($LE(m_P) = \sum t\, P_{mp}$) could be another solution, but it presents the same limits (lack of data, and indicative value without real significance in itself), and it doesn't take into account people that has died before median age: life expectancy at median age is always superior to the uni-dimensional 'remaining life' index proposed here ($LE(m_P) > LE(0) - m_p$), but it 'forgets' very premature deaths, that are also an important information.

Considering all this, the advantage of the ISDD is its simplicity of calculation and interpretation as an indicator of 'remaining life', and the possibility of representation in its both dimensions. Just like any synthetic index, the values of its uni-dimensional version have not a real significance by themselves, but their main interest is to permit comparisons between different periods and areas.

[51] For example in 2000 generations that were born t the beginning of XX[th] century.

APPENDIX III: ESTIMATION OF 2015 AND 2030's ISDD VALUES

1. Estimation of Median age's values in 2015 and 2030.

Estimation of median age of population of European regions in 2015 and 2030 is relatively simple as it is a longitudinal parameter which is strongly related to age structure and is changing very slowly through time. Whatever the level of mortality, fertility and even external migration, the age structure remains relatively easy to predict, at less for the near future.

Here, for baseline scenario, we have calculated estimated values of median age for 2015 and 2030 considering 2015 and 2030 UNPP national value for each country (medium hypothesis), and disaggregating them taking in account the estimations for 1980 and 2000 to estimate the part of each region in national growth:

$$x_R(t_2) = x_R(t_1) \cdot [[1 + ((x_R(t_1) / x_R(t_0))^{1/(t1 - t0)} - 1)/(x_C(t_1)/x_C(t_0))^{1/(t1 - t0)} - 1)) \cdot x_C(t_2)/x_C(t_1)]^{1/(t2 - t1)}]^{t2 - t1}$$

where $x_R(t_i)$ is the value of x in the region R at time ti
$x_C(t_i)$ is the value of x in the country C at time ti

(Here x = median age; t_0 = 1980, t_1 = 2000, t_2 = 2015 or 2030)

So the estimations of median age in the baseline scenario for 2015 and 2030 are simply based on 2 main hypotheses:

1° The extension of 1980-2000 regional trends

2° The validation of 2000-2015-2030 UNPP's projections about national trends.

These estimations correspond to the hypothesis of the prolongation of current trends in terms of population ageing, and permit to see what will be the evolution for these regions if there is no major change in terms of migrations and fertility.

For cohesive and competitive scenario, a simple statistical model of convergence/divergence was used, with the following assumptions:

1° Cohesive scenario is based on the hypothesis of a lower general annual immigration rates in whole ESPON area during 2000-2030 than during 1980-2000 period. So the general population ageing process is faster than in the baseline scenario. Cohesive scenario is also based on the hypothesis of a general increase of life expectancy higher than in baseline scenario. Between European regions, this scenario considers that the relative increase (average annual growth) of median age and life expectancy at birth will be faster in the regions with low median age in 1980 and 2000, and that it will be lower in the 1980-2000 fast ageing regions ('convergence' hypothesis).

2° Competitive scenario is based on the hypothesis of a higher general annual immigration rates in whole ESPON area during 2000-2030 than during 1980-2000 period. So the general population ageing process is lower than in the baseline scenario. Competitive scenario is also based on the hypothesis of a general increase of life expectancy lower than in baseline scenario. Between European regions, this scenario considers that the relative increase (average annual growth) of median age and life expectancy at birth will be lower in the regions with low median age in 1980 and 2000, and that it will be higher in the 1980-2000 fast ageing regions ('divergence' hypothesis).

2. Estimation of Life Expectancy's values in 2015 and 2030.

2.1 Difficulties of prediction of life expectancy

The situation is much more difficult to project for life expectancy at birth than for median age, because life expectancy is a transversal parameter able to be subject to strong variations on short term. A new disease, a war, an economic crisis can increase very strongly the number of death during a short period and therefore introduce a strong decrease of life expectancy during this period. Good examples are provided by Russia after the fall of the Iron curtain of by Southern Africa after the explosion of AIDS during the 1990s (*Figure 38*).

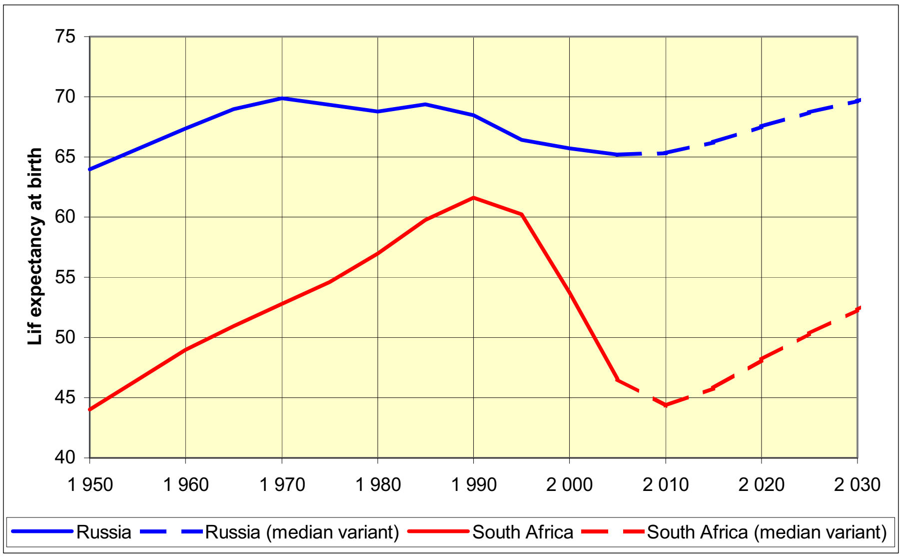


Figure 38 Uncertainty for the estimation of Life expectancy : The example of Russia and Southern Africa

- In the case of southern Africa, it is obvious that the effect of AIDS was fully impossible to predict before the beginning of the 1990's. A prospective scenario elaborated in 1980 would have proposed an estimation of life expectancy in 2005 equal to 67 years when it was finally only 47 : 20 years of difference !
- In the case of Russia, situation is a bit different as the reason of the diminution of life expectancy are not the spread of a new epidemy (impossible to predict) but a progressive degradation of economic and social situation. A prospective scenario elaborated in 1980 would have notice a beginning of degradation of the situation as life expectancy stopped to increase in 1970 and experiment a period of slow decrease. In this case, different prospective scenario would have been possible. An extrapolation based on recent period (1970-1980) would have predicted rather correctly the decline of life expectancy to 65 years in 2005 when an extrapolation based a longer period (1950-1980) would have estimated that the decline of 1970-1980 was an accident and proposed an estimation of 75 years of life expectancy in 2005, which would have been false. In both case, what was not predictable was the small improvement of life expectancy in 1980-1985, neither the brutal decline in 1990-2000 during the collapse of Soviet Union and the turn to market economy.

If we transpose these examples of Russia and Southern Africa to our actual situation of elaboration of scenario in 2005 for the years 2015 and 2030, we can conclude that the risk of error is very high as we can not exclude the arrival in Europe of 'Wild cards' as spread of a new disease or the shock of a world global economic crisis. What is therefore at stake is not an attempt to predict future situation of life expectancy but rather to elaborate typical scenarios of evolution under the assumption that wild cards are excluded and that differences are only related to the effects of specific parameters introduce in our model in order to evaluate the potential effects of increasing liberalisation or increasing social and territorial cohesion.

2.2. Estimation of Life expectancy in baseline scenario.

As we are not able to predict external shocks that can modify the global evolution of life expectancy in the ESPON29 territory, we consider initially the medium variant of United Nation as reference for all the scenarios. Estimations of life expectancy are available for our ESPON countries in 2015 and 2030 and our baseline scenario is simply based on the assumption that the prediction of UN will be globally correct at national levels. The only difficulty in this case is to estimate regional values of life expectancy derived from regional values in 2000 and national values in 2000, 2015 and 2030. With the assumption that regional differences inside each state are the same during all the period, the problem is easy to solve and is a typical application of space-time (ST) estimation methods proposed in LTDB.

The only problem that can appears when we combine regional and national values of different sources is a contradiction between the national estimation of life expectancy in 2000 according to Eurostat and United Nations. As the methods employed for the estimation of life expectancy are not the same, we have a high probability to observe differences and we are oblige to choose one of the alternative sources as reference and to modify the other one. In present case, we considered that the value of life expectancy elaborated by UN was better than the one that we derived from Eurostat because UN can rely on mortality tables (probability of death by age) when our regional estimations are based on an indirect method of standardisation (comparison of observed and expected death according to age structure) which is less accurate and is more likely to introduce errors. In conclusion, the equation for the estimation of baseline is defined by equation (1)

$$X_{i,t+n} = X_{i,t}^{Eurostat} \times \left(\frac{X_{State(i),t}^{UNPP}}{X_{State(i),t}^{Eurostat}} \right) \times \left(\frac{X_{State(i),t+n}^{UNPP}}{X_{State(i),t}^{UNPP}} \right) \quad (1)$$

An example of estimation is provided in *Table 29* for Hungary where the equation is simplified as the correction of differences between Eurostat and UNPP values of life expectancy for whole Hungary in 2000 has yet been made.

	2000	2005	2010	2015	2025	2030
Hungary	71.7	73.2	74.3	75.3	76.1	76.9
HU01	72.0	*73.5*	*74.6*	*75.6*	*76.4*	*77.2*
HU02	71.7	*73.2*	*74.3*	*75.3*	*76.1*	*76.9*
HU03	72.0	*73.5*	*74.6*	*75.6*	*76.4*	*77.2*
HU04	71.5	*73.0*	*74.1*	*75.1*	*75.9*	*76.7*
HU05	71.4	*72.9*	*74.0*	*74.9*	*75.8*	*76.5*
HU06	71.5	*73.0*	*74.1*	*75.0*	*75.9*	*76.7*
HU07	71.6	*73.1*	*74.2*	*75.1*	*76.0*	*76.8*

(yellow)	National estimation of United Nations (*UNPP, The 2004 Revision*)
(light orange)	Regional values of life expectancy (*Eurostat*)
(orange)	Verification of the coherence of both estimations
(light green)	Estimations of baseline scenario

Table 29 Example of computation of life expectancy in baseline scenario

What is important to observe is the properties of the baseline scenario in terms of evolution of estimation of regional differences:

1. *The past trends (1980-2000) are not taken into account for the evolution of future situations.*

2. *The internal regional differences inside each state are frozen in the situation of 2000.*

3. *The international differences between states rely on the assumptions of median variant of United Nation which is generally rather optimistic and politically correct.*

2.3 Estimation of Life expectancy in Competitive and Cohesive scenarios

For the estimation of liberal and cohesive scenarios, we propose a model with three parameters which can be fixed to different values according to assumptions which are made on the territorial effect of changing policies inside the ESPON territory:

2.3.1 Assumption on convergence at international level

We can firstly ask if differences of life expectancy between states (considered as a whole) are likely to increase of decrease during the period 2000-2015 and 2015-2030. What is at stake here is firstly the question of global harmonisation of social security system, welfare, redistribution of economic resources, parity of access to medical infrastructure and other services of general interest in a European context. But it is also the potential effect of social polarisation at international level with concentration of richest old people in states where condition of living are better and concentration of poorest people in states where the social infrastructure are less developed. It is of course impossible to detail all parameters than can influence the evolution of life expectancy but we can propose two opposite scenarios according to the fact that differences of life expectancy are globally increasing of decreasing between states through a model of beta-convergence following equation (2)

$$\left(\frac{X_{i,t+n}}{X_{i,t}}\right)=\left(\frac{X_{ESPON29,t+n}}{X_{ESPON29,t}}\right)\times\left(\frac{X_{State(i),t}}{X_{ESPON29,t}}\right)^{n\ \beta_{International}} \quad (2)$$

With a positive value of the parameter $\beta_{International}$ we assume a divergence process at international level which means that states with higher life expectancy than ESPON average in 2000 will experiment higher growth of life expectancy in the future than states with lower life expectancy than ESPON average. With a negative value, we assume on a contrary a convergence process and a global reduction of differences in the levels of life expectancy of ESPON states.

The empirical evaluation of this parameter for the past period 1980-2000 provide interesting insights for the choice of empirical parameters to be applied for the future period. The empirical value of $\beta_{International}$ can be estimated through the following linear equation (3)

$$\log\left(\frac{X_{i,t+n}}{X_{i,t}}\right)=a+b.\log\left(\frac{X_{State(i),t}}{X_{ESPON29,t}}\right) \quad (3)$$

The results of the model are a general increase of life expectancy (+0.2% per year) associated with a small trend to divergence at international level (+0.5% per year). But the explanatory power is very poor (r-square=0.03) and the analysis of residuals reveals that the model linking growth rate of life expectancy and international situation as compared to ESPON average is not a linear one. We can indeed observe in *Figure 39* that the regions which has benefit from the most positive evolution of life expectancy where located in countries which had a life expectancy equal to ESPON average in 1980. The less favourable evolutions were the one of regions located in countries with either much higher or much lower life expectancy than ESPON average.

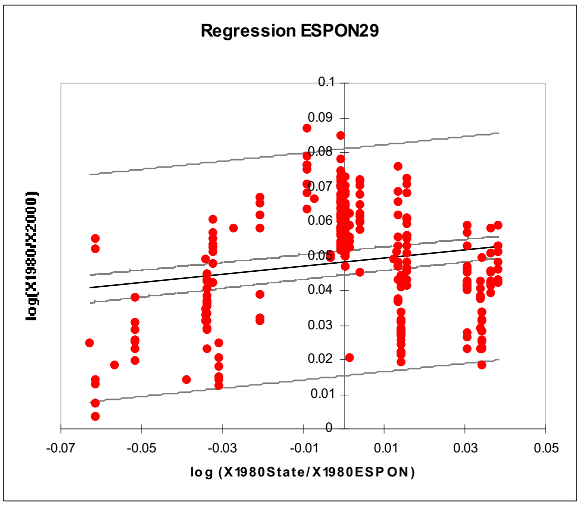


Figure 39 International beta-convergence of life expectancy in ESPON 29 (1980-2000)

This result is primarily difficult to interpret. It could suggest that the evolution of life expectancy through time is non-linear and follows a logistic curve with maximum growth when countries arrived at the level of 70-75 years old and slower progress for countries having life expectancy of less than 70 years or more than 75 years. But another interpretation is possible if we notice that in 1980 the level of life expectancy is strongly correlated with the political situations of states according to socialist and capitalist system. We propose therefore to analyse separately the evolution of countries according to their political situation in 1980 in order to examine what was their situation in terms of convergence or divergence during the following period 1980-2000.

In the case of the 19 countries with market economy in 1980 (EU15+CH+NO+MT+CY), we observe a very clear trend to convergence of levels of life expectancy (beta = -2.1% per year), in a global context of increase (+0.3% per year). The global pattern of trajectories observed in this western countries can be summarised by *Figure 40* where are presented the mean trajectory and the standard deviations as regard to initial situation in 1980. The fit of the model is much better (r-square = 22%) than in previous situation where socialist and capitalist countries was mixed.

In the case of the 10 former socialist countries, we observe exactly the reverse evolution with a global trend to divergence (beta=+2.1% per year) which produce increasing difference between the countries of this group as presented in *Figure 41*. Considered as a whole, the regions of the former socialist countries as experimented an average growth of life expectancy which was more or less equal to the one of old member states. But this growth was very different according to initial situation of countries. The region which started with a relatively high level of life expectancy (Slovenia) has made rapid progress when regions with relatively low level of life expectancy in 1980 (Romania) has experimented lowest rate of increase.

As the period 1980-2000 is characterised by a strong process of liberalisation of economy in east-central Europe ('*Shock Therapy*') and by a strong policy of regional cohesion in European Union (*Development of structural funds policy*), we can suggest to use the value of the beta parameters observed in each part of Europe as reference for the estimation of future trends according to liberalisation scenario and cohesive scenario:

- For cohesive scenario, we have therefore considered that a convergence of levels of life expectancy will be observed with a rate of -2% per year, comparable to what was observed in western Europe during the period 1980-2000.
- For competitive scenario, we have consider that a divergence of levels of life expectancy will be observed with a rate of +2% per year, comparable to what was observed in east-central Europe during the period 1980-2000 of transition from socialist to market economy.

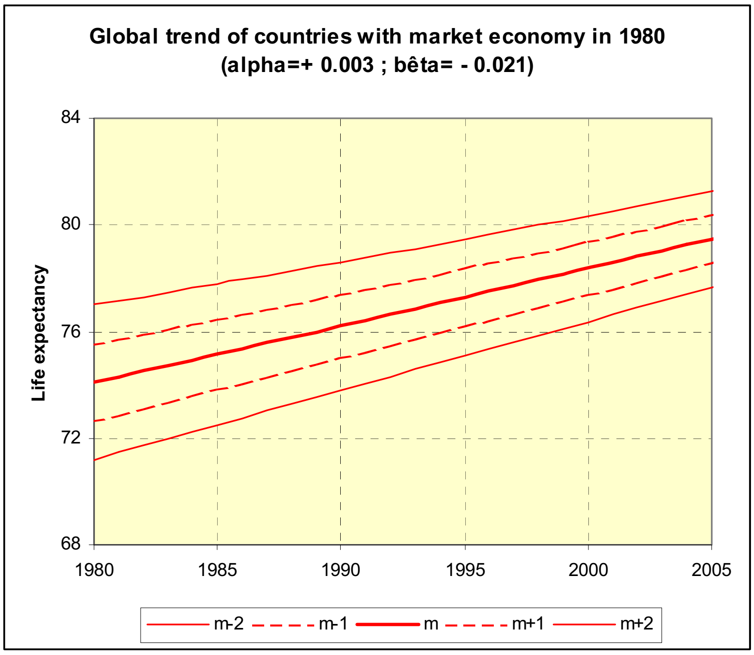


Figure 40 Evolution of life expectancy in ESPON countries with market economy in 1980

Figure 41 Evolution of life expectancy in ESPON countries with socialist economy in 1980

2.3.2 Assumption on convergence at intra-national level

Having solved the question of evolution of international differences, we have now to examine which assumptions can be made on the evolution of internal regional differences inside the boundaries of each ESPON state. What we try to evaluate is therefore the degree of intra-national convergence, out of the trends that can be observed at international level, according to equation (4) :

$$\left(\frac{X_{i,t+n}}{X_{i,t}}\right) / \left(\frac{X_{State(i),t+n}}{X_{State(i),t}}\right) = \left(\frac{X_{i,t}}{X_{State(i),t}}\right)^{n\,\beta_{Intranational}} \qquad (4)$$

They are different way to solve mathematically this equation. The most simple is to start from previous equation (3) and to add a parameter of intranational convergence to the previous parameter of international convergence according to equation (5)

$$\log\left(\frac{X_{i,t+n}}{X_{i,t}}\right) = a + b.\log\left(\frac{X_{State(i),t}}{X_{ESPON29,t}}\right) + c.\log\left(\frac{X_{i,t}}{X_{State(i),t}}\right) \qquad (5)$$

For this model, we are obliged to exclude countries with only one region (LU, EE, DK, …) where they are of course no internal differences. We are also obliged to exclude Poland and Slovakia because, due to changing territorial division, it is impossible to estimate correctly internal differences in the same basis in 1980 and 2000. The panel of regions is therefore reduced to 247 regions instead of 274 in previous case.

The model indicate the existence of a very strong intra-national convergence with $\beta_{Intranational}$ equal to 3% per year on the period 1980-2000. It means that, whatever the increase or decrease of differences between states, we have observed in a majority of state a strong reduction of internal differences, an equalisation of the levels of life expectancy observed in the different region of the same state. But we have to take into account the fact that internal convergence is not necessary the same in each state. Experiments revealed that Nordic countries with important welfare state has experiment higher level of convergence (-3.3% in Sweden and -3.4% in Norway) when United Kingdom in the Thatcher's period had a lowest level of convergence (-1.9% per year). Situation was intermediate in France (-2.6% and Germany -2.5%).
This results suggest that internal homogenisation of ESPON countries in terms of life expectancy is a global trend but that can be accelerated or limited according to the type of policy developed at national level. This suggest the following choice for the elaboration of scenarios :

- For cohesive scenario, a high level of internal convergence remain observed in each state, with a level comparable to the one observed in the period 1980-2000 (-3% per year).

- For liberal scenario, we assume that they are neither convergence or divergence inside the state and that internal differences are stable, according to their level of 2000.

3.3 Combination of intranational and international parameters

The combination of both parameters of international and intranational evolution in the same model can be visualize on *Figure 42* where we present the typical evolutions of regions belonging to a state A (located under the average of ESPON in 2000) and regions belonging to a state B (located above the average of ESPON in 2000).

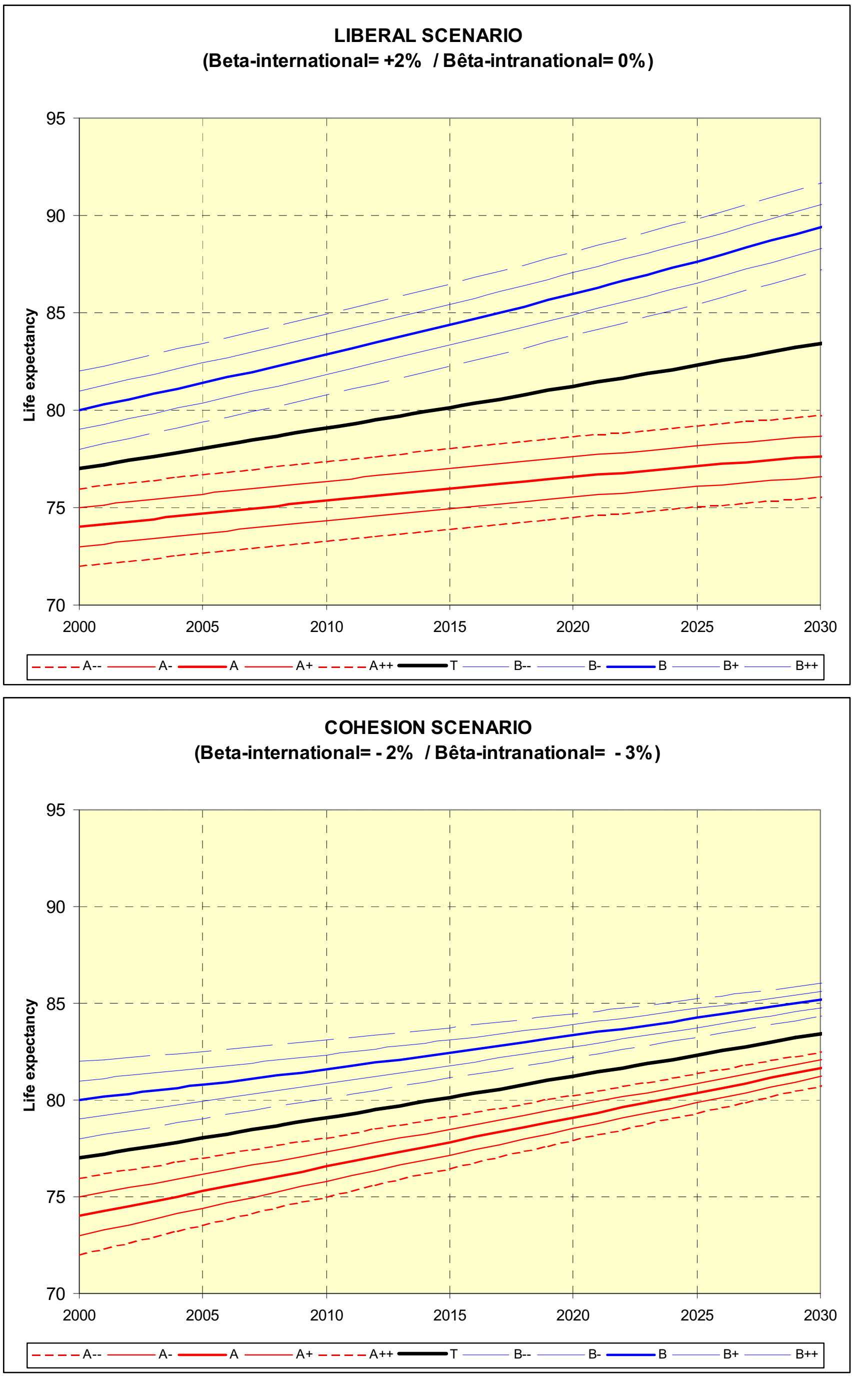
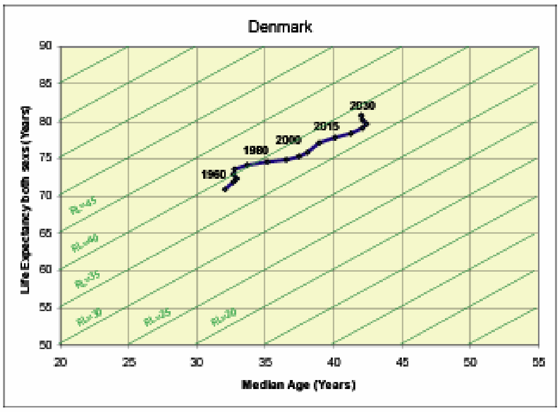
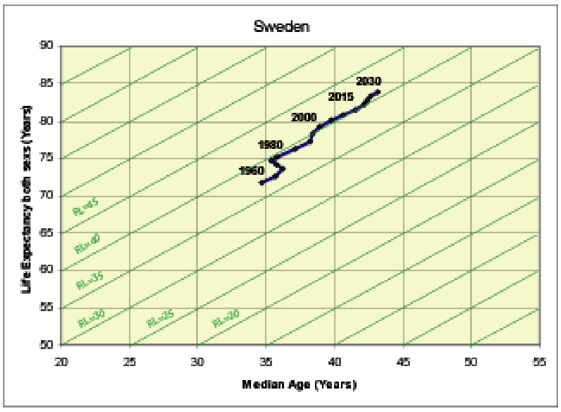
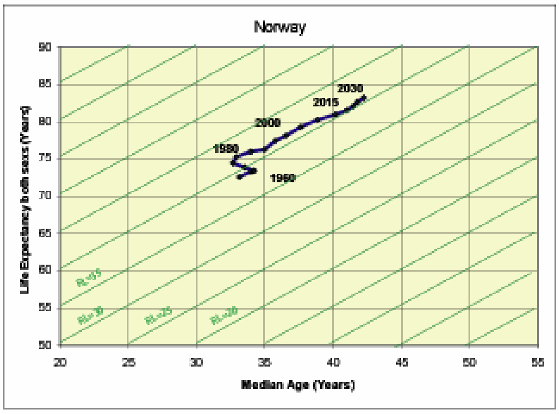


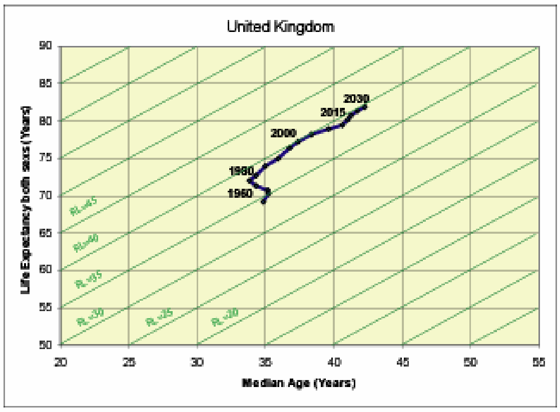
Figure 42 Evolution of life expectancy in liberal and cohesive scenarios

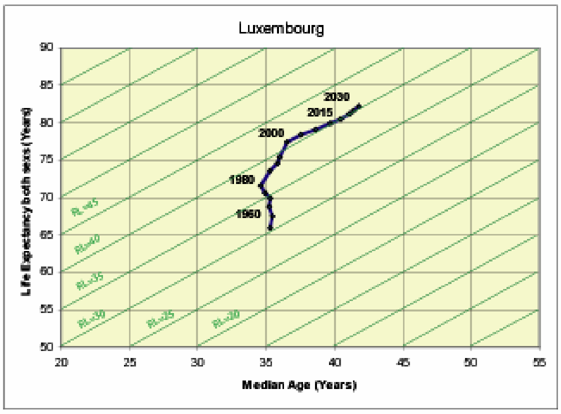
APPENDIX IV: ISDD STATE GRAPHICS (ESPON + Croatia, Turkey and Ukraine)

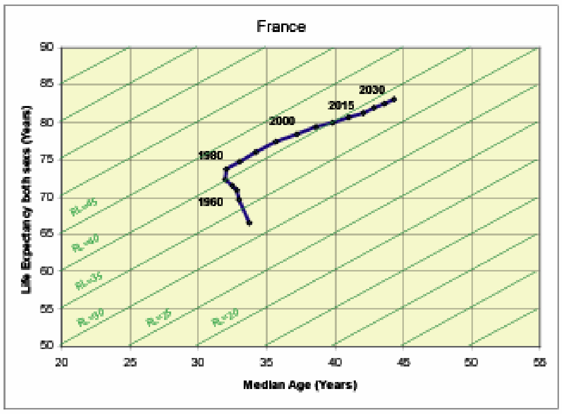


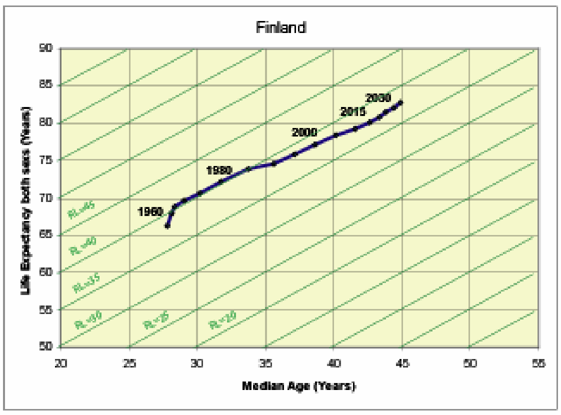


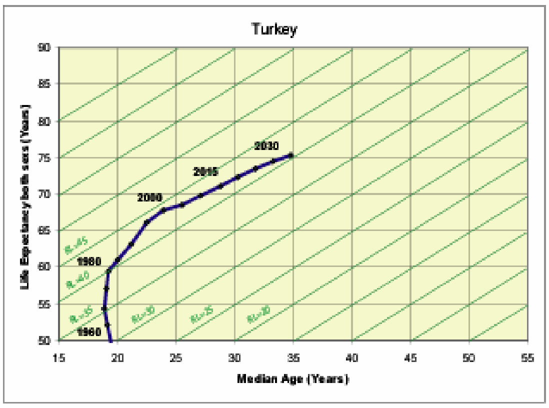


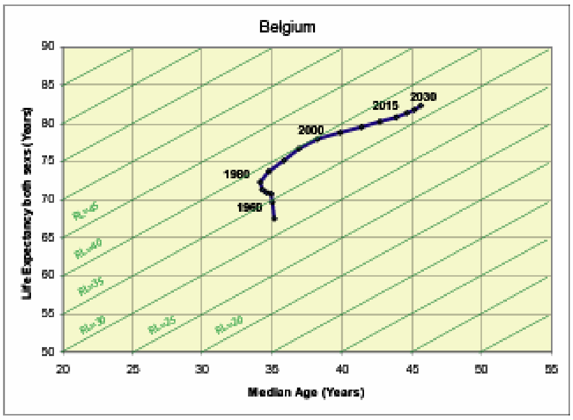











Belgium
Life Expectancy both sexs (Years)
Median Age (Years)
1960
1980
2000
2015
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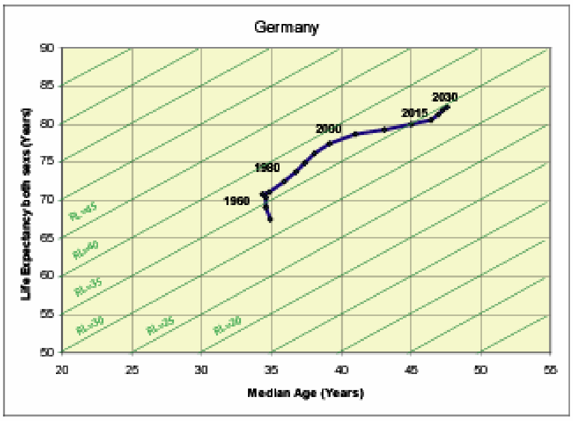
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Life Expectancy both sexs (Years)
Median Age (Years)
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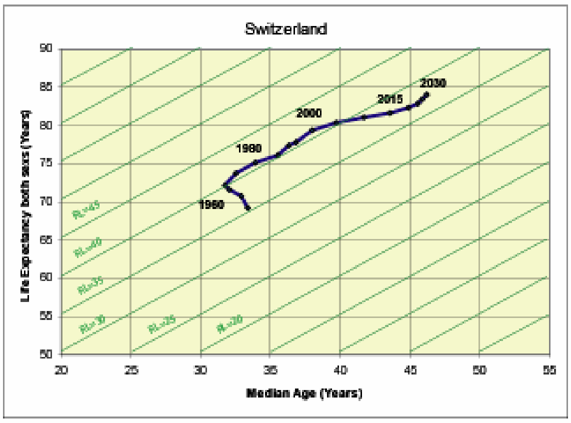
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Life Expectancy both sexs (Years)
Median Age (Years)
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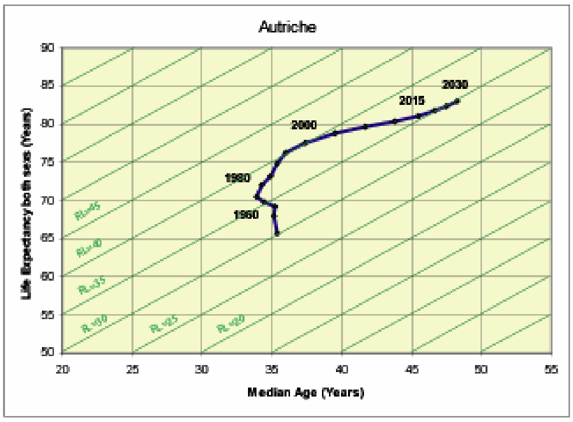
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Life Expectancy both sexs (Years)
Median Age (Years)
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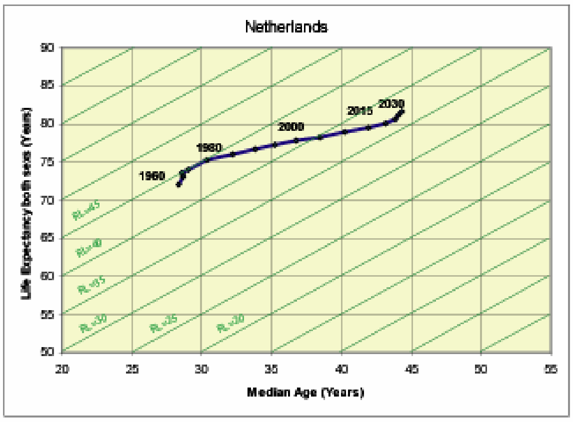
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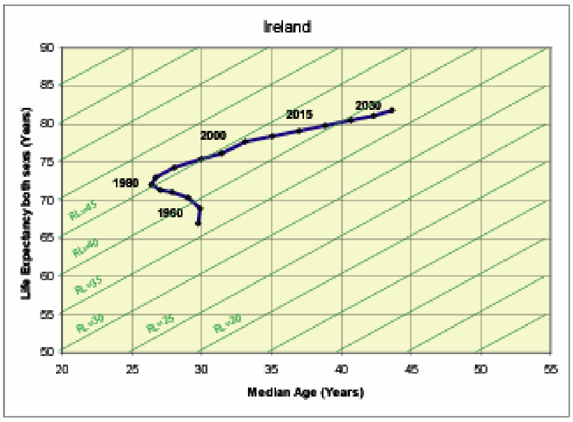
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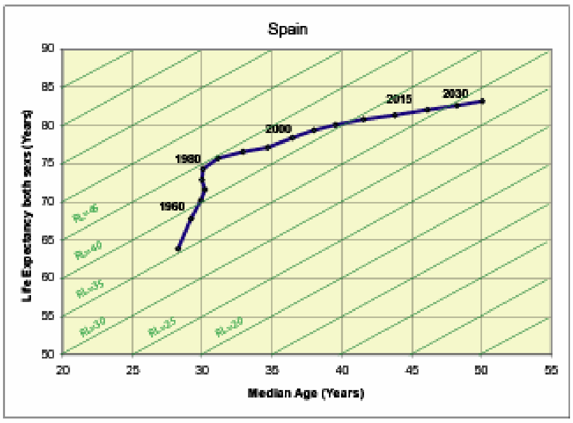
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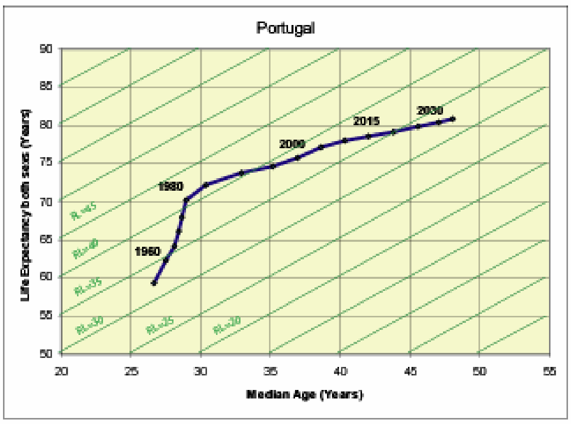
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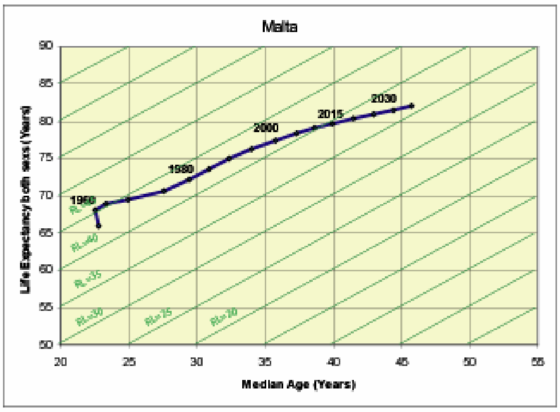
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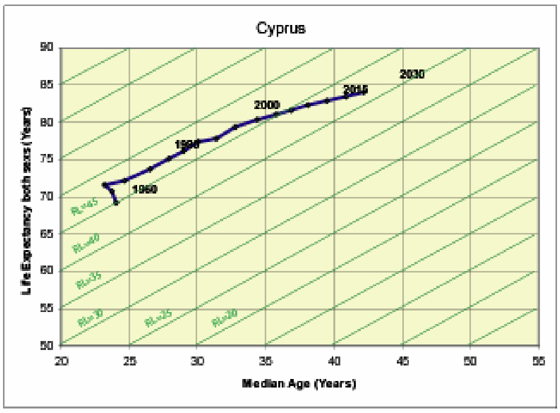
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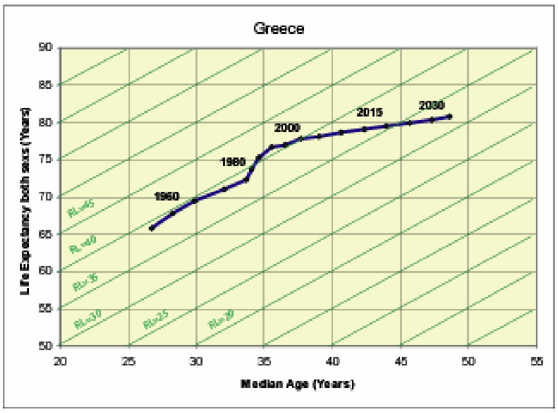
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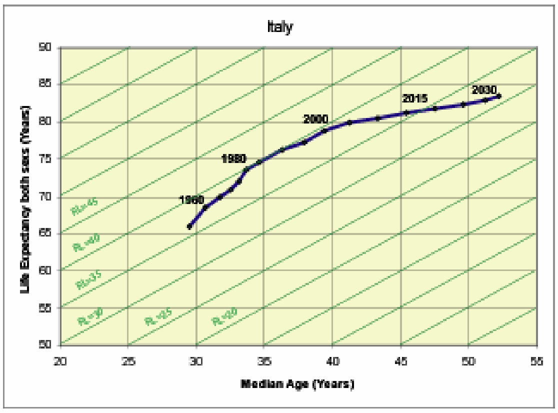
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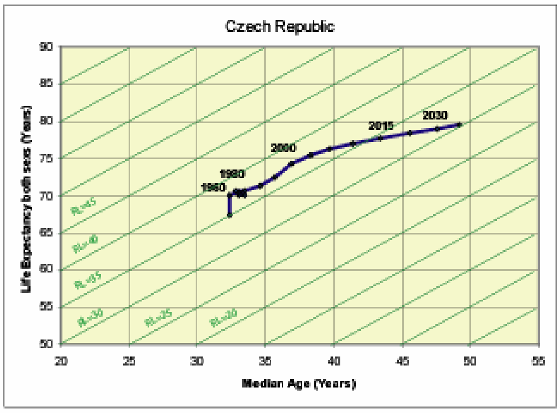
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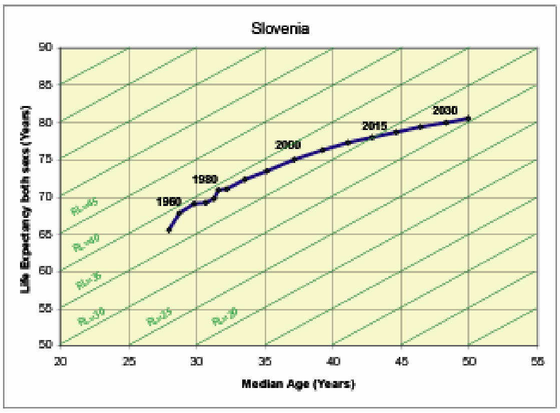
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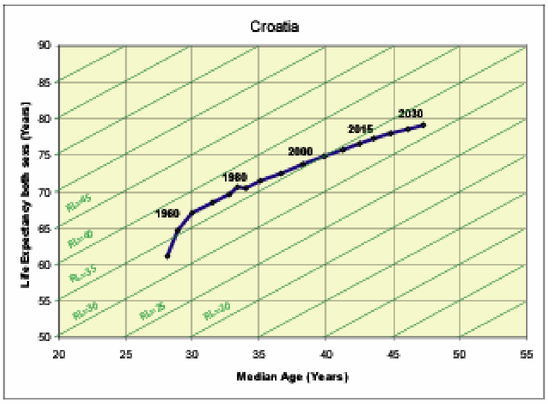
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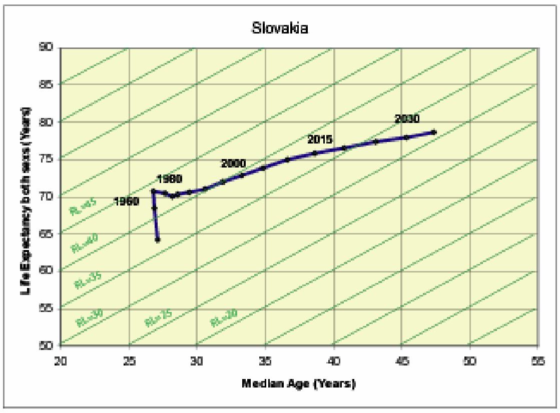
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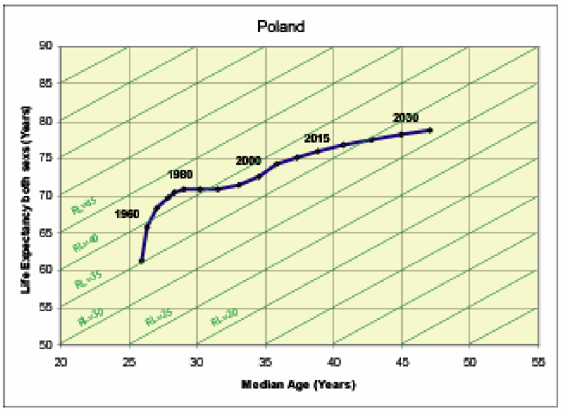
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1960
1980
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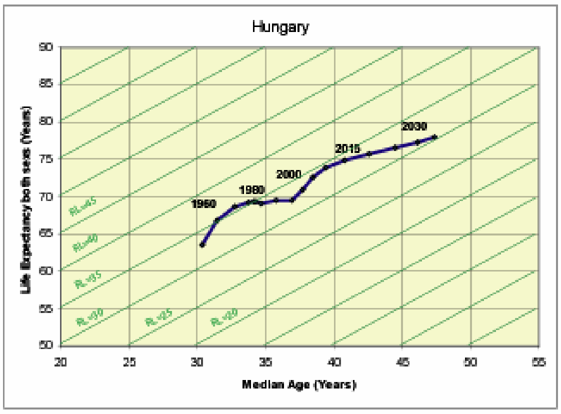
2015
2030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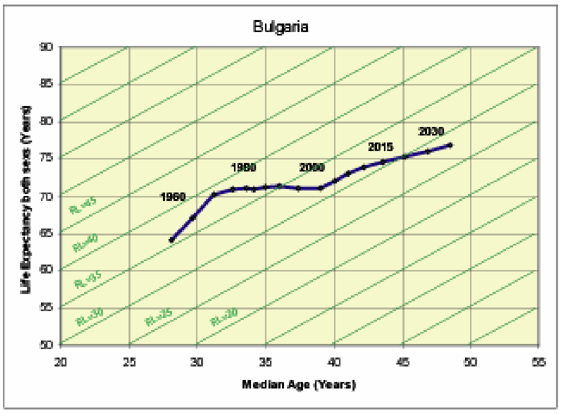
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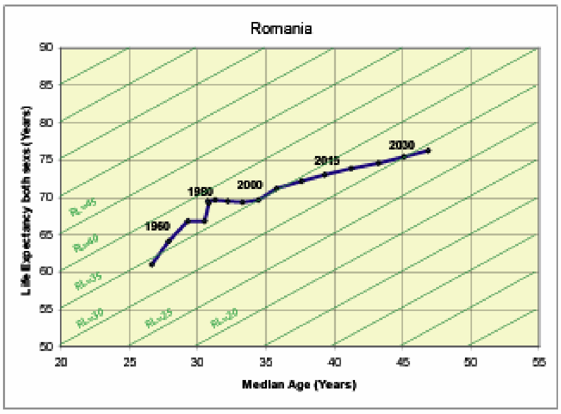
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Median Age (Years)
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20 25 30 35 40 45 50 55
1960
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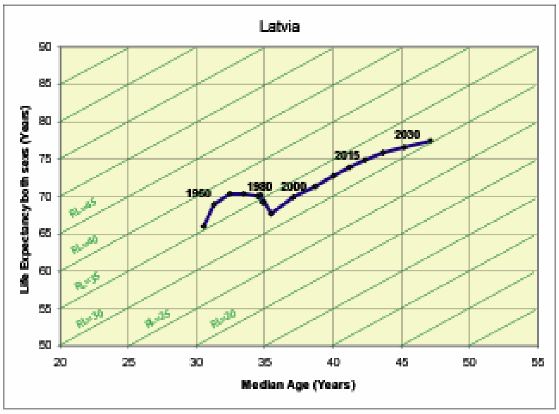
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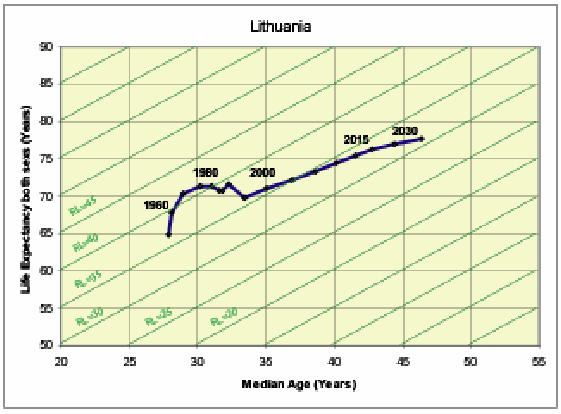
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Median Age (Years)
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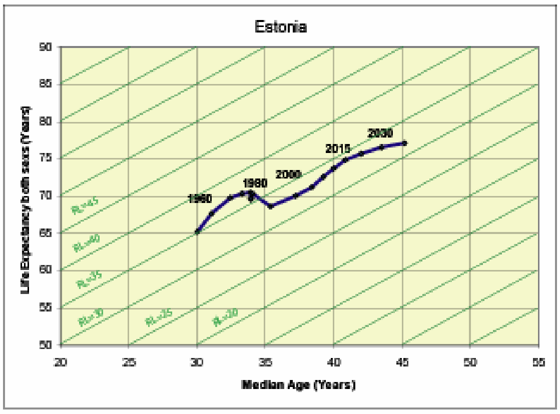
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Life Expectancy both sexs (Years)
Median Age (Years)
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20 25 30 35 40 45 50 55
1960
1980
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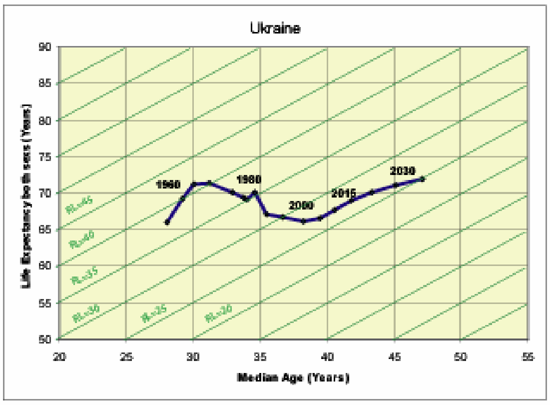
Ukraine
Life Expectancy both sexs (Years)
Median Age (Years)
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20 25 30 35 40 45 50 55
1960
1980
2000
2015
2030

APPENDIX V: BIBLIOGRAPHY

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5 Measuring territorial cohesion at the local scale

5.1 Introduction

Our scenarios provide a general vision of possible evolutions of the European policies and territory, with a territorialisation at the meso-scale represented by the Interreg 3B areas. As the scenarios had to cover the entire ESPON space, it was obviously not possible to provide sound prospective images for the micro-scale, i.e. the national to local levels.

However, three different attempts were made at providing such 'downscaling' for selected case study regions and using different methodologies. These attempts are presented in this chapter.

5.2 ISDD at local scale: the examples of urban areas and cross-border regions

The interest of ISDD is not limited to international, national or regional level: it's possible to use it at more local scales. In the framework of ESPON 3.2., the studies mainly concern regional level, but it would be probably useful in future projects to be able to measure territorial cohesion at more local level, because of the important social economical heterogeneity inside many nuts2 regions.

For example, a study in the region of 'Ile de France' (*Figure 43*) confirms a number of assumptions about the interest of ISDD. Within the area composed of Paris and its neighbourhood, we can observe in the baseline scenario (prolongation of actual trends) the opposition in terms of life expectancy between the wealthy towns of the south-west and the poorer cities of the north and the east. The radio-concentric geographical polarization observed on the maps of *Figure 43* corresponds to the classical social economical one put forward by many researches on Ile-de-France. This north-east/south-west opposition is particularly important in the case of the competitive scenario, which is based on a *β*-divergence assumption (hypothesis of increasing fragmentation within metropolitan areas, with the reinforcement of the social polarization in urban spaces). In the cohesive scenario, this polarization is less important, because of the more developed social policies.

Such a phenomenon is the same that what is observed at nuts2 level. But the interesting point here is about population ageing. In deed, while at European scale the nuts2 with the youngest population in the scenarios were also the nuts2 with the highest life expectancy at birth (metropolitan regions of western Europe), we can observe that the repartition at urban scale is not the same: in *Figure 43*, we can note that the cities with the highest life expectancy at birth are many time cities with quite high median age, and vice-versa. This explains that there is not so much polarization in terms of ISDD, life expectancy at birth and median age values tending to compensate. Such a phenomenon results partly from 'mechanical' effects (when people live longer, it influences the age structure and so on the median age) but it's not enough to fully explain it. In deed, the differences of median age are very important in 2000 and in 2030 according to the 3 scenarios (sometimes more than 10 years). In fact, they are linked to the different proportions of immigrants and different levels of fertility between the different parts of the region, which are very linked to the huge social and economical heterogeneity.

The heterogeneity in terms of life expectancy and median age within a nuts2 unit like Ile-de-France, and more generally the differences of correlations between ISDD components in function of the scale considered (negative at nuts2, positive at intra-urban level) illustrates all the difficulty to determinate the appropriate scale to measure European territorial cohesion. The future researches on indicators able to be used in order to measure territorial cohesion will need to take into account this difficulty, that puts forward the current impossibility to propose a unique and trans-European and ‘trans-scale’ European Territorial Cohesion Index (in function of the scale elected to observe a given phenomenon, heterogeneity or homogeneity situations can be observed in the same territory).

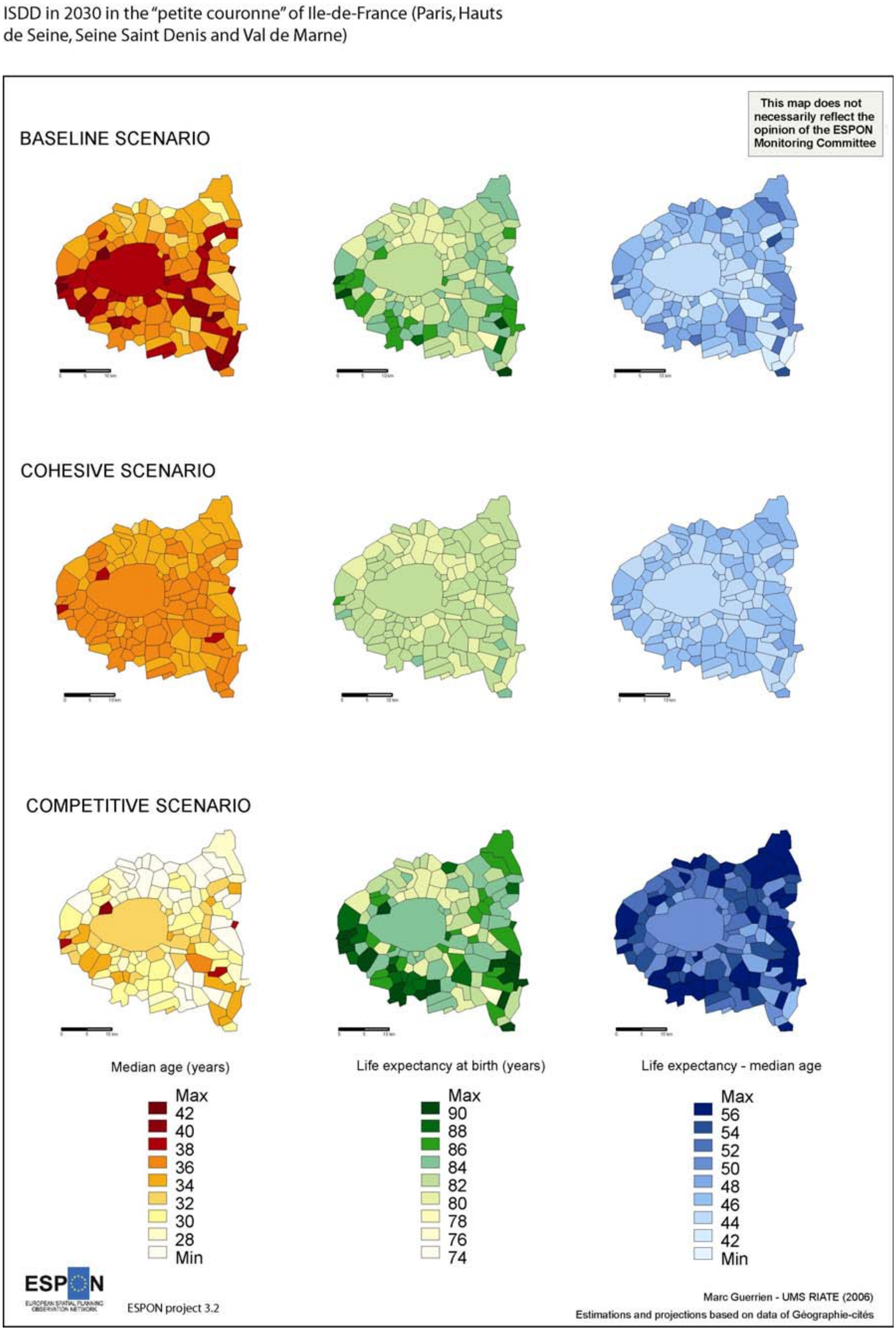

Figure 43 ISDD in 2030 in the 'petite couronne' of Ile-de-France (Paris, Hauts de Seine, Seine Saint Denis and Val de Marne)

Another possible interesting scale of application of ISDD could be in cross-border areas, in order to distinguish the importance of intra-regional and international differences. However, with such a scale, it remains quite difficult to propose estimations in function of each scenario. In a metropolitan region like Paris, which population is very mobile and where there are many migration flows, it's quite reasonable to formulate various hypothesis of convergence and divergence of median age and life expectancy in function of the different scenarios. However, if we take as a local example a cross-border area like the Grande Région in order to measure territorial cohesion, we must note that fertility parameters, and so on median age, remain dependant of national belonging of the region. *Figure 44* shows clearly than in such a cross-border region the main factor of explication of differences of population ageing remain the national belonging (elevated median age Saar in Germany, lower median age in Lorraine, France, or Luxemburg) and it's difficult to pretend that the prevalence of the hypothesis of the cohesive scenario would produce more or less homogeneity in terms of median age. We can only imagine that in a competitive policy configuration the disparities in terms of life expectancy would be accentuated as compare to the 2000 situation, while in the case of the cohesive scenario it would be attenuated, but the huge difference in terms of population ageing between Saar and its western neighbours will in every configuration conditions strongly the differences of ISDD.

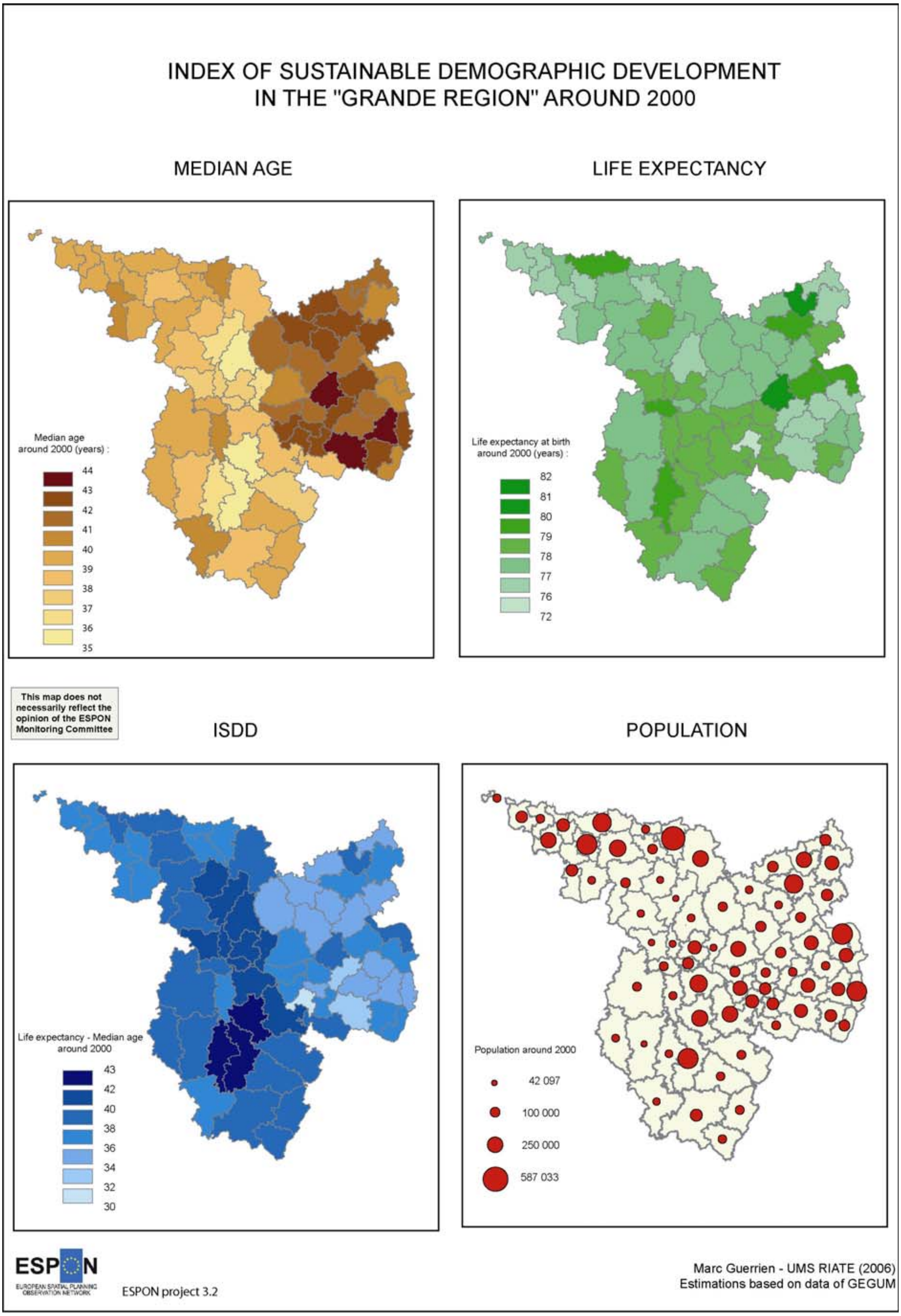

Figure 44 ISDD around 2000 in the 'Grande Région'

This example shows that the question of territorial cohesion in a cross-border area like the Grande Region is very linked to the question of spatial integration at international level. If we compare the analysis at different scale (international, inter-regional, intra-urban, intra-regional), the conclusion is that the interpretation of the significance of ISDD can differ, and it puts forward its limits as a multi-scale indicators in order to measure territorial cohesion. So such an indicator must be used cautiously, taking into account systematically the social and economical situation in the areas concerned. However, it is currently one of the most promising option in order to establish scientifically correct comparisons at different space and time scale in all ESPON area.

5.3 The example of maternity hospitals accessibility in the Grande Région

The concept of territorial cohesion relates to the notion of regional disparities, an issue that has been previously examined using the demographic indicator of 'remaining life' that complement the traditional economic variables that are normally employed studies. However, the concept also deals with the question of accessibility to 'essential services and basic facilities' if one follows the latest European political documents like the 3rd Report on Cohesion. Addressing this topic requires a new kind of methodology adapted to the new geographical scale considered.

The elaboration of an indicator of accessibility to basic services tackles complementary aspects of the social dimension as it is studied in the TPG1.4.2[52]. The scale is not the same: when the TPG1.4.2 analyses the social services and services of general economic interest, the coverage extends to EU29 and the lowest geographical level of these studies is the NUTS3 level and more often only the NUTS2 level. At this scale, access to services is defined in a macro-economic way as the access to social transfers. In contrast, we consider that the access to basic services raises truly territorial questions since this is the access the inhabitants may have or not to the service providers. These questions can only be sorted at the local scale. So our study must be seen first as a contribution to the definition of the concept of 'territorial cohesion' and secondly as a preparatory work for further local/social studies in ESPON2. Moreover, the value of such a study lies in the opportunity to ask questions that are meaningful to the everyday life of EU inhabitants, which could help widen the diffusion of the ESPON programme beyond the usual stakeholders' arena[53].

5.3.1 Accessibility to Basic Services: Challenges for a Reproducible Method in the ESPON Space, at Local Level

As far as accessibility to basic services is concerned, the reliability of results is a matter of scale. The more precise level of analysis adopted in ESPON projects, such as NUTS3, appears inappropriate: the mean size of NUTS3 units is approximately 50 km from one side to the other, while the question of access to services concerns smaller distances. For instance, within the same NUTS3, the distance to the nearest hospital may vary from 0 to 40 km, and this situation cannot be summarized without considering the internal structure of the NUTS3. Such differences within a given NUTS3 have been demonstrated in a Belgian preliminary study of hospitals with emergency services that showed that the mortality rates significantly increase when the distance to the hospital exceeds six kilometres[54].

This situation raises three challenges:

1. Which territorial local units must be considered? The LAU2 is not harmonised across the 29 ESPON countries (for instance, the French LAU2 are five times smaller than those in Belgium), and this situation cannot always be solved by a combination of LAU1 and 2 (eight EU countries, including France and Belgium, have no LAU1 partition). This work has benefited from the TPG 3.4.3 inputs on the Modifiable Area Unit Problem.

[52] Project ESPON1.4.2, *Preparatory Study on Social Aspects of EU Territorial Development*, 2006
[53] The TPG 1.4.2 final report ends with 19 ideas of potential projects. The territorial framework of all these potential future projects stays at the NUTS2/3 level. We can regret that the 1.4.2 consortium did not question the social dimension at the local level and did not ask for testing further research at this level.
[54] Research done by Alice Romainville (IGEAT / ULB), as a part of the "Demography" volume of the Belgium National Atlas.

2. Which data can be used? The current ESPON database does not comprise data at lower levels than NUTS3. One of the only databases existing at LAU has been made out for the purpose of the 'Mountain study' (a project undertaken for the European Commission by a consortium led by Nordregio, and completed later to cover the entire ESPON space). This database has been tested in the context of the specific needs of our research. As a result, there are important data deficiencies at such a level (for example the data on deaths and births in Rheinland-Pfalz and Saarland were not available in the database although presented as complete).
3. Which method must be set out? The method must be sufficiently robust to be used when data are scarce. Our aim is to create a method that is *reproducible*, one that is applicable to any regions since a *limited range of data is required*.

Particular attention also has to be paid to the situation along national borders. Since the basic facilities and essential services are framed within national contexts, borders are important discontinuity lines in terms of provision and organisation of services. Recently, several, mainly bottom-up cross border initiatives took place to better coordinate services such health. The evaluation of these services is not easy since it is frequently observed that each border is typical and that the situation cannot be explored except by monographs. Our intention here is to adopt a more top-down approach through a reproducible method whatever the border context is.

The ETCI initiative cannot answer all these challenges, but can prepare the future studies about territorial cohesion at this scale in the perspective of ESPON2 by proposing a methodology and testing it. We have applied the method in the so-called 'Grande Région' or 'Gross Region' which has been chosen for three reasons:

1. This trans-national area comprises four countries (Belgium, France, Germany, Luxembourg), so it is an interesting region to compare the availability and to initiate the work of harmonisation[55];
2. The density of borders provides an interesting opportunity to examine the eventual complementarities among countries. Moreover, since there is a political will in the *Grande Région* to foster the cooperation among regional authorities, it makes sense to define influence areas of services across the border.
3. The borders between Luxembourg and neighbouring countries are major economic discontinuities in Western Europe[56]. The disparities of GDP per capita levels in absolute terms are extreme. Important flows of workers which converge towards Luxembourg lead to a greater potential attractiveness of public services.

[55] Our participation in previous and ongoing Interreg projects in the Region was the opportunity to gain some knowledge on the territorial trends in this transnational area.
de Ruffray S., Meddahi D., Moron E., 2004, /Contribution à la situation économique de la Grande Région, /Report and atlas made for the Conseil Economique et Social de la Grande Région
de Ruffray S., Meddahi D., Moron E., Smits F., 2005, /A method to delimit cross border labour market: The example of the "Great Region"/, Paper presented at the 14th European Colloquium on Theorical and Quantitative Geography, Tomar, 9 th -13 th September 2005
[56] See the Annex A of the ESPON3.1 Third Interim Report, "Multiscalar Territorial analysis", http://www.espon.eu/mmp/online/website/content/projects/260/714/file_1250/3.ir_3.1-full.pdf

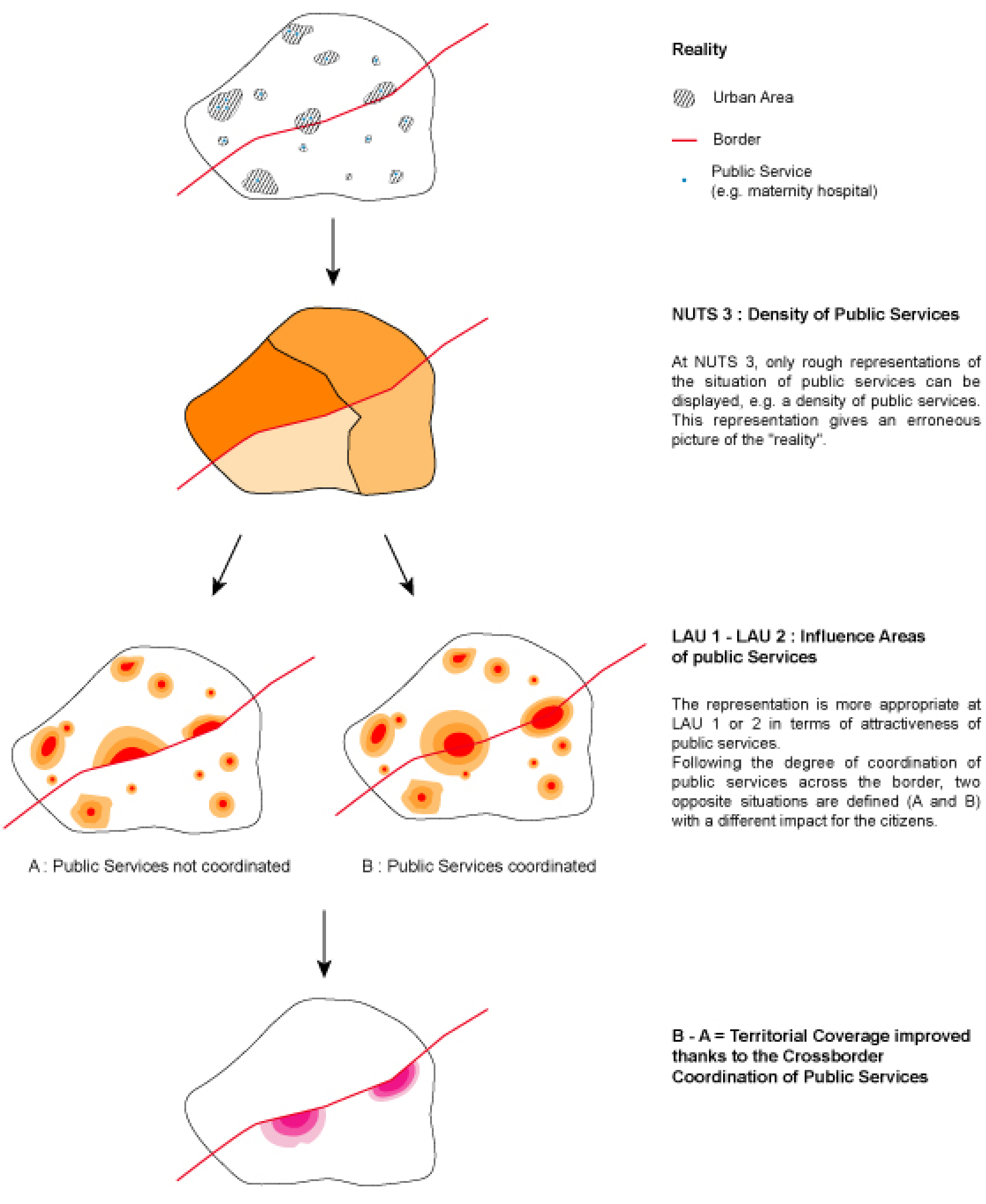

Figure 45 The relevance of LAU 1/2 levels to represent the accessibility to public services

5.3.2 Empirical Test: the Accessibility to Maternity Hospitals in the Grande Region

Maternity hospitals were selected from those 'basic facilities and essential services' for this empirical test. Given the high diversity in fecundity rates between the countries, especially between Germany and its neighbours, it is interesting to focus on maternity hospitals in order to assess our results according to the different national trends.

The situation along national borders with respect to the definition of cross border cooperation sectors is interesting to study. Indeed, public services and neighbourhood facilities are always listed in the national contexts. The borders are lines of strong discontinuity in terms of localization and organization of the services.

Cross border relates to the notion of a thorough coordination of health services, not limited as it is today to parsimonious projects between isolated health providers[57]. This requires the harmonisation of health coverage systems.

The achievement of the study required the choice of a mixture of LAU1, LAU2 and sometimes other units. Belgium and Saarland have the larger LAU2 in the Region, and do not have any LAU1 units. So the territorial template cannot be more precise than this level. The corresponding units in size are in France, the 'cantons' (aggregation of French LAU2), in Luxembourg the 'cantons' (LAU1) and in Rheinland-Pfalz the 'Verwaltungsgemeinschaften' (LAU1).

Our methodology consists in taking into account the maternity hospitals of the Region, and to combine the capacity (number of beds in each maternity hospital) and the demand (number of births in each LAU) with the accessibility to each maternity hospitals. In total there are 146 maternity hospitals in the Grande Région. The empirical test concerns only the maternity hospitals located near the borders, because our aim is not to give an exhaustive view of reality, but to convey the added value of the method.

5.3.2.1 Spatial, Conceptual and Mathematical Choices to Make a Reproducible Method in the European Space

The conceptual, methodological and mathematical foundations take into account the complexity of basic services' accessibility. The point is to display contrasting territorial situations since they require different recommendations in terms of spatial planning. Moreover, the attempt to make the work reproducible in the ESPON29 framework is an added value of the method.

5.3.2.1.1 Conceptual Foundations

The idea is that there are no strict limits between the influence areas of maternity hospitals. On the contrary, the LAU can be attracted at the same time by several maternity hospitals.
Three main parameters form the conceptual foundations of the delimitation method, designing graduated limits around the maternity hospitals.

They take into account:

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[57] For the moment, health cross border cooperation usually deals only with emergency services and social protection of borderers. There are numerous other projects on benchmarking, but no global view.
See the research-action Interreg IIIA project "Offre de soins et mobilité à l'intérieur de l'espace transfrontalier Lorraine - Grand-Duché de Luxembourg - Province de Luxembourg", 2004, http://www.santetransfrontaliere.org/luxlorsan/main.htm
Mission Opérationnelle Transfrontalière , 2001, An assessment of cross border cooperation between hospitals, France - Belgium - Luxembourg - Germany - Italy - Spain - Great Britain - Switzerland http://www.espaces-transfrontaliers.org/en/studies/santeanglais.pdf
Mission Opérationnelle Transfrontalière, 2004, La coopération transfrontalière sanitaire. *Les Cahiers de la MOT,* 4, http://www.espaces-transfrontaliers.org/document/cahier_Mot_4.pdf

- The accessibility in terms of the required time to reach the maternity hospital from each LAU: A threshold of 30 minutes has been empirically decided: when the distance between a LAU and a maternity hospital exceeds 30 minutes, we consider that it cannot be attracted by the maternity hospital and its value is zero. Taking into account various legal speed limits, time is measured for a car travel in optimum conditions without any stop constraint. This parameter brings a time-distance constraint to the maternity hospital area delimitation[58].
- The capacity that represents the ability of the maternity hospital to attract the women of the LAU is based on both the number of beds (and their *occupation in time*) offered and the number of births in LAU where the maternity hospital is located.
- The demand that represents the lack of beds of the LAU is based on both the number of beds offered and the number of births in LAU.

5.3.2.1.2 Mathematical Foundations

The method is based on an application of fuzzy sets theory and possibility theory. These theories are adapted to study and formalise spaces which are not strictly delimited, or which are only poorly delimited. For each LAU, a membership value to an influence area is obtained, and for each maternity hospital a membership profile is built. Hence, it is possible to establish the large and small influence areas to which a LAU contributes.
An influence area is a geographical space defined by such characteristics as accessibility, capacity, and demand which differentially affect it. The membership to an influence area may be very high for some places, much less important for another or non existent for others. The influence area is imprecise since each spatial unit contributes to it at various levels.
Normalization and combinations rely on the operators that are taken from possibility theory and from fuzzy set theory which are detailed in the second part.

5.3.2.2 Strengths and Weaknesses of the Grande Région LAU: the Inhabitants' Inequity in the Access to Maternity Hospitals

5.3.2.2.1 The Representations of the 'Accessibility to Basic Services'

The accessibility to maternity hospitals has different meanings. First, these meanings and the related policy messages are presented. Then, their territorial impacts are displayed through the use of mathematical operators (fuzzy logic).

Three Different Policy Meanings

In the most obvious way, the accessibility to a basic service can be understood as the time-distance between the inhabitants' place and the closer basic service provider, with eventual additional criteria on the supply and the demand (see above). In other terms, each LAU is supposed to be attracted only by one service provider. The focus is put on the dominant service provider whose influence area extends on a fix number of LAU, without taking into account the potential overlaps between influence areas. **In policy terms, this approach considers the minimum offer of service.**

This first display of accessibility to services does not take into account the inhabitants' possibility of choice, an important consideration in terms of territorial weakness or strength. For example, the situation of a LAU located very close to a service provider, but far away from any other, is less robust than the situation of a LAU surrounded by several service

[58] The network is made of the different strands

providers: the eventual closing of a service provider is far more detrimental in the former case than in the latter. Hence, in a second approach, the two or more proximate service providers must be taken into account. **In policy terms, this means considering the territorial weaknesses and strengths through the overlaps between the service areas**.

In contrast, it is interesting from a policy point of view to focus on the exclusive service areas. So **a third approach needs to highlight the territorial weaknesses in terms of unique membership to a service provider**.

The fuzzy logic operators are used to display the territorial impacts of these policy meanings.

Three Representations of the Accessibility to the Maternity Hospitals

Since the three following representations describe the current situation, the national boundaries are meant to be closed to cross-border flows of women.

The first approach is related to the dominant maternity hospital in terms of closeness to the LAU. The map draws attention to this dominant maternity hospital, where the women have the highest possibility to go. This representation illustrates two relationships: the higher values correspond to well serviced areas and the lower values to derelict areas. For example, some LAU located in the Walloon region north of the Meuse French département or in the East of the Moselle département raise concern because of their distance from any maternity hospital.
Figure 46 represents the choice of the higher membership value to a maternity hospital for all the LAU. The best operator is the Zadeh[59] t-conorm, which combines the membership values of any LAU to any maternity hospital. The Zadeh t-conorm is part of the triangular conorm (or t-conorm) which is one of the major function families. The t-conorm is adapted to the definition of operations which are close to the union operation sets. The parameters are combined in an additional way.

The second approach is shown on the figure 47 through the overlap between the influence areas of maternity hospitals. It corresponds to the choice of the second higher membership value. The weaker LAU which depends on only one maternity hospital appears in beige with a zero membership value.
The approach ignores the places located at the fringes of the study area which can be connected to maternity hospitals located outside of the study areas limits. Nevertheless we notice an important contrast between some Walloon areas which are poorly serviced and some LAU whose membership value is higher and which represents privileged areas where the inhabitants can choose between at least two nearby maternity hospitals.

[59] T-conorm of Zadeh : max(x,y)

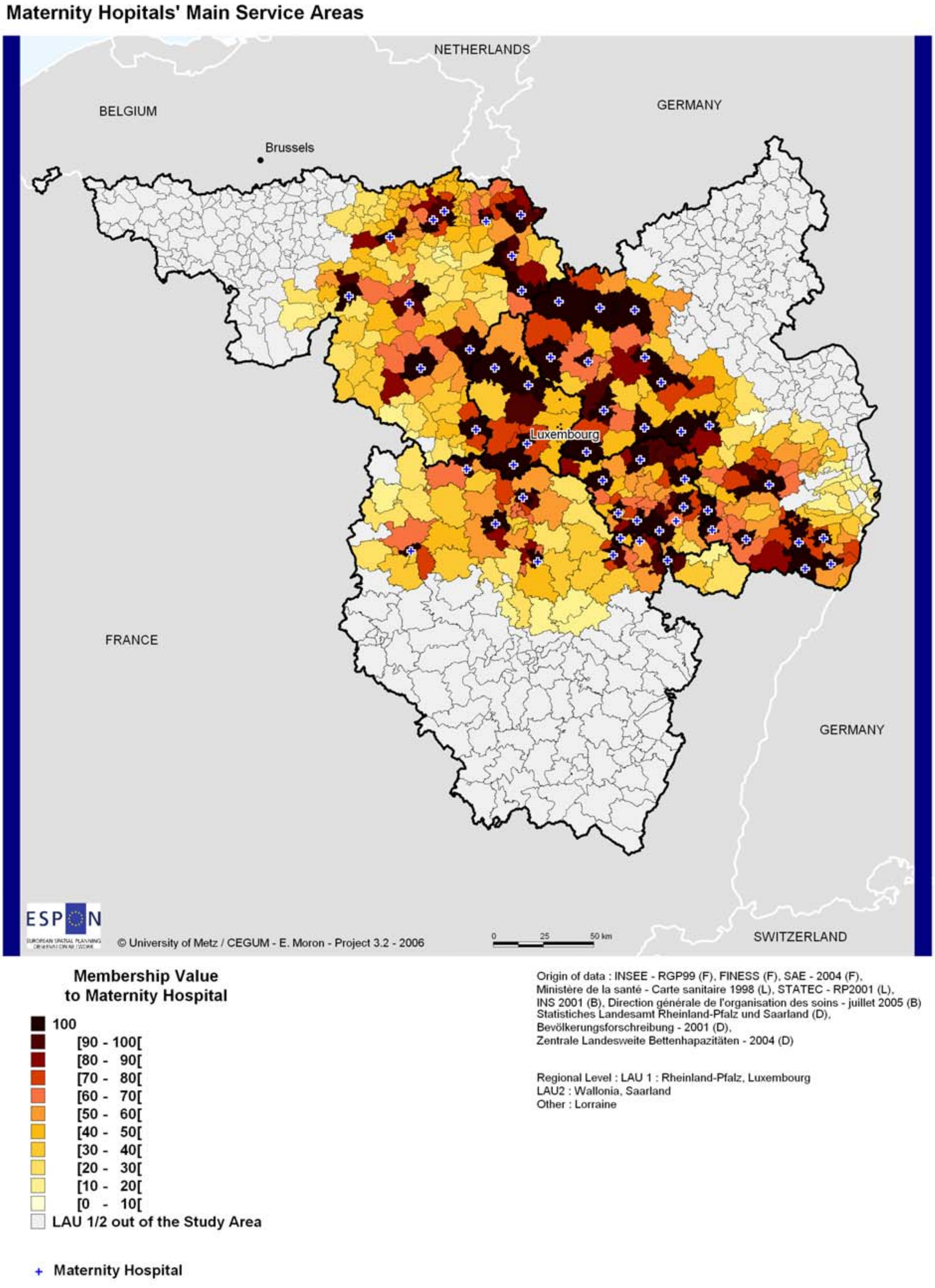


Figure 46 Maternity Hospitals Predominant Service Areas

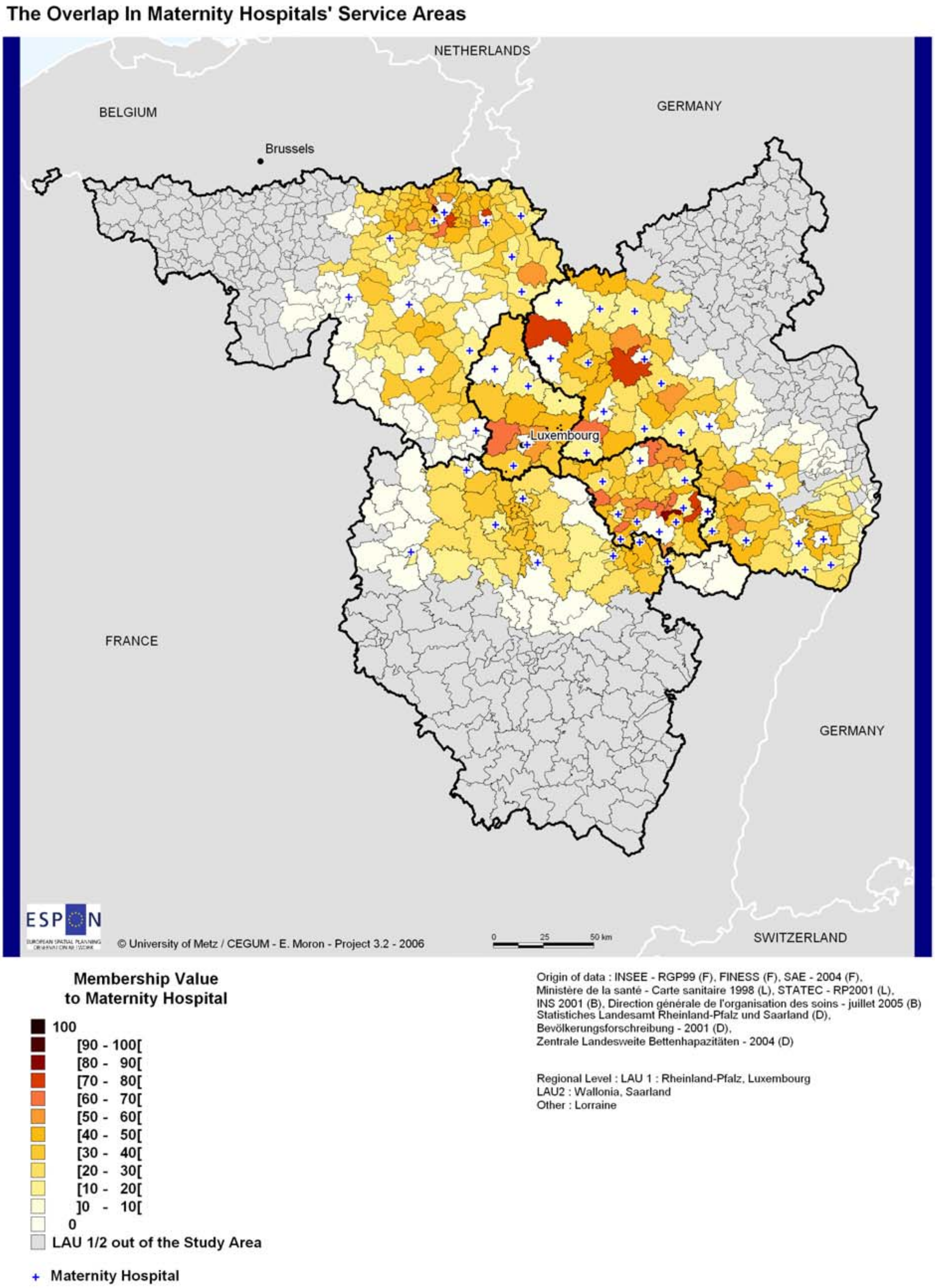


Figure 47 The Overlaps between Maternity Hospitals Service Areas

The third approach draws attention to the most important maternity hospitals (whose membership value stays at 100) which have an significant number of beds. Some, namely in Metz or Saarbrucken, also implicitly correspond to maternity hospitals that provide more specialised services like neonatology. The LAU in red on the map, which belong to classes whose the membership value is high, may have two opposite meanings: some exclusively belong to a maternity hospital (see in the Meuse French département) while others strongly belong to several maternity hospitals (see around Luxembourg). The definition of these interstitial areas is essential for the policy makers in terms of service redistribution.

Figure 47 represents the choice of the lowest membership value for any LAU (except 0, taking into account the threshold of 30 minutes).The operator is the Zadeh[60] t-norm which combines in a different way the LAU membership values. This t-norm corresponds to the triangular conorms, one of the families of functions. This function allows the selection of the highest intersection value between two components and tends to eliminate the smallest membership value.

Following a biological metaphor, the first approach focuses on the dominant gene while the second displays a recessive gene, such as the service 'hidden' areas. They prove complementary sides of the same territorial reality.

5.3.2.2.2 Towards a typology of the accessibility to maternity hospitals

A classification based on all the membership values leads to a global vision of the three spatial approaches described above, where each LAU is described following its membership to one or more maternity hospitals areas. Not taken into account are the LAU located 30 minutes farther away from the maternity hospitals, the distinction between the five classes reveals the spatial complexity of the accessibility to basic services at the Grande Région level.

[60] T-norm of Zadeh : min(x,y)

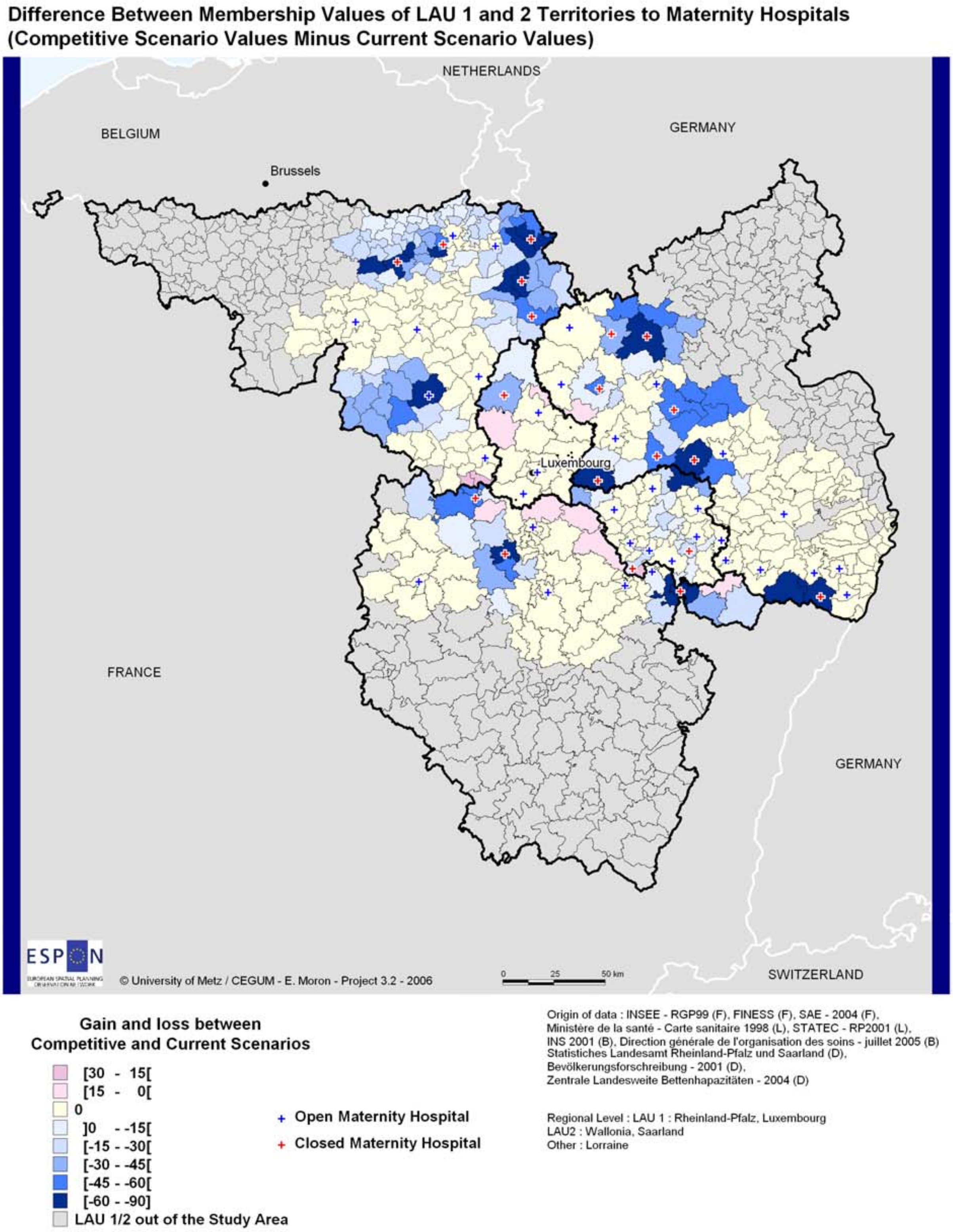


Figure 48 Difference Between Membership Values of LAU 1 and 2 to Maternity Hospitals (Competitive Scenario Values Minus Current Scenario Values)

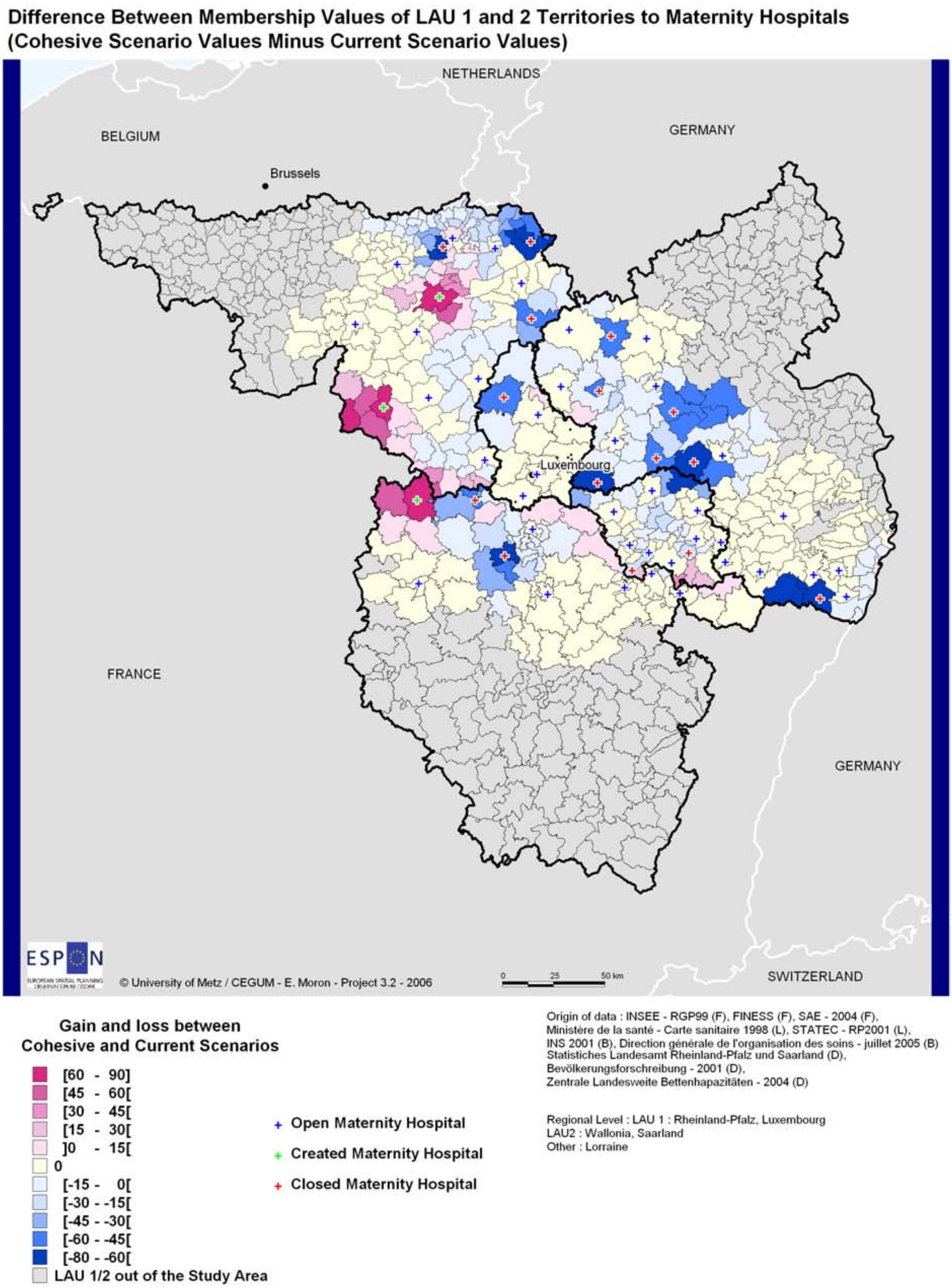


Figure 49 Difference Between Membership Values of LAU 1 and 2 to Maternity Hospitals (Cohesive Scenario Values Minus Current Scenario Values)

In figure 49, the LAU in light blue are in a situation of unique membership to a maternity hospital and deserve the policy maker's full attention. A better cooperation between the social security systems could improve the situation of the ones located close to the national boundaries, for example at the East of the Moselle French département or at the North of the Meuse département. Other LAU are in a more dramatic situation, namely in the Walloon core.
The LAU with maternity hospitals are generally represented in dark blue, signifying a high unique membership. This corresponds to different situations; either the inhabitants cannot choose their maternity hospital, or their maternity hospital is particularly attractive (in terms of specialised services like neonatology).

The overlap areas are ranked in three classes displaying more and more privileged situations, shown in colours ranging from the green class for the mean multi-membership to the red class for the high multi-membership. In the latter, the inhabitants can actually choose between several close maternity hospitals.

Although the method is developed on the basis of a set of limited and elementary data, it displays the rich diversity of possible situations regarding the accessibility to maternity hospitals. Its interest also lies in relation to the 3.2 prospective scenarios work. The representation of the alternative locations of maternity hospitals (with respect to the policy options that were defined in the scenarios) leads to the computation of inhabitants' accessibility gains and losses.

5.3.3 An Application on ESPON 3.2 Prospective Scenarios

The methodology is applied to the competitive and cohesive scenarios. The contrasted policies developed in the scenarios have divergent impacts on the basic and essential services. It is possible to represent the impact for the inhabitants by applying the previously developed method.

A strict application of the method in the scenarios would require the calculation of the number of births or women of a reproductive age by LAU in 2030. This calculation would be different according to the three scenarios because the expected dynamism of the metropolitan, urban and rural zones is not the same. For example, the competitive scenario foresees a metropolitan reinforcement and a rural decline contrary to the cohesive scenario. That would also involve a new calculation of time-distance between each LAU and maternity hospitals while following the foreseeable evolutions of the road network. It was not possible here to work out such forecasting models in a project that was intended to demonstrate the importance of studies at the local scale. However, interesting results are found with respect to the current situation of the births by LAU. The localization of maternity hospitals is changed according to the type of policies, whether competitive or cohesive.
We will present the hypothesis of each scenario before analyzing the differences of gains and/or losses for the citizens.

5.3.3.1 The Selected Hypotheses in the Competitive and Cohesive Scenarios

5.3.3.1.1 Competitive Scenario

The competitive scenario hypotheses suggest a further privatisation and liberalisation of public services along with a focus of public expenditures that are not related to health, but rather to Lisbon-oriented topics of R&D and education, ICT. If there is less public intervention in general, border inhabitants may benefit from the abolition of barriers to cross-border cooperation. These hypotheses lead to two location principles that govern maternity hospitals (1) smaller hospitals whose profitability is not ensured (less than 30 beds) are closed, except when no other hospital remains in the neighbourhood to provide a minimum service level, and (2) women can go to a maternity hospital on the other side of the border.

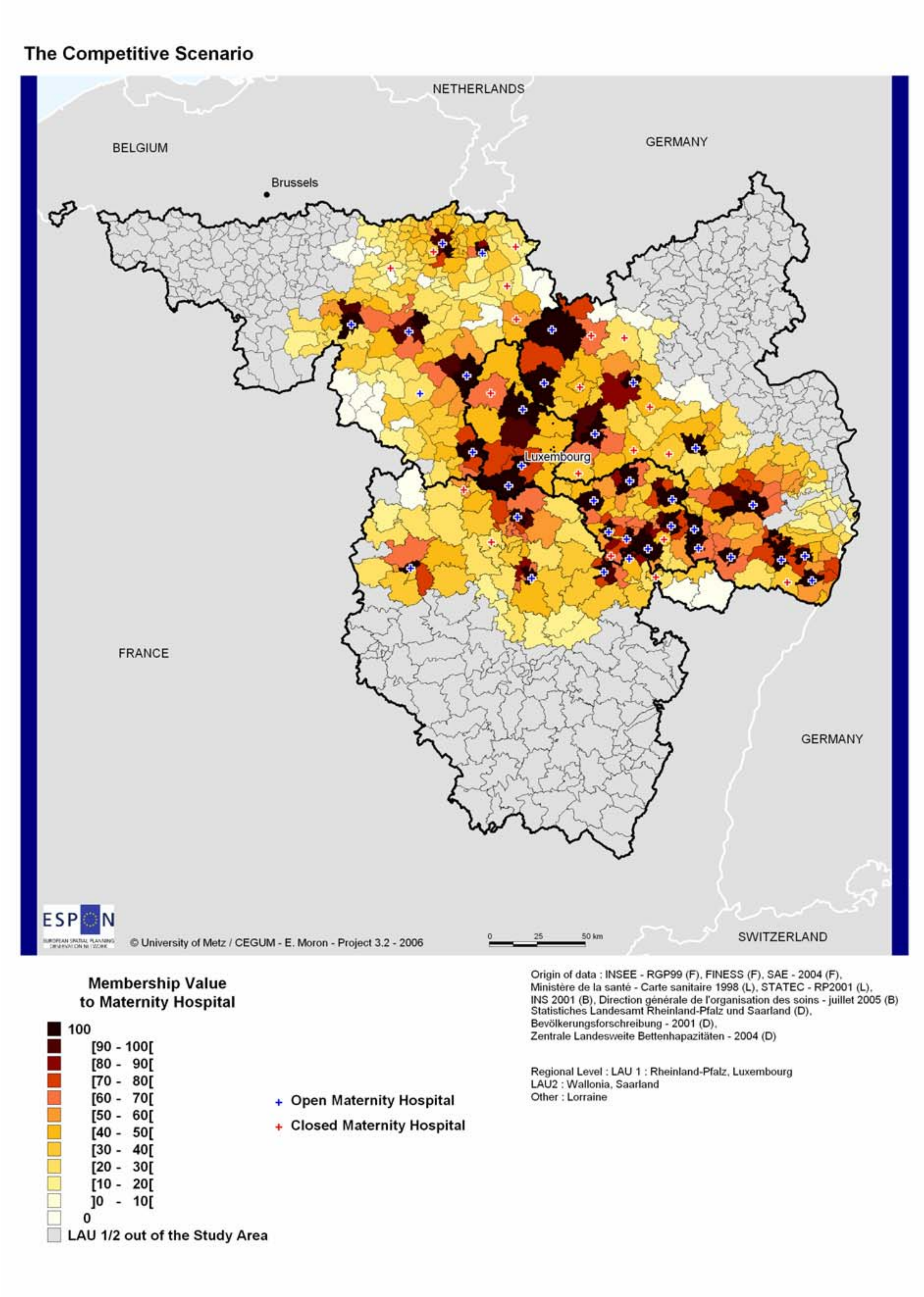


Figure 50 The Competitive Scenario

The development of the most competitive sectors causes an increasing duality between spaces. The metropolises and dynamic areas still grow. The rural spaces, in peripheral situation, such as Lorraine, enter a spiral of decline.

The map is deeply changed, displaying new derelict areas with lower membership values. Accessibility in border areas is not deeply modified because of new opportunities for cooperation despite the closing of some maternity hospitals.

5.3.3.1.2 Cohesive Scenario

The policy orientation of the cohesive scenario directs the allocation of significant funding to basic infrastructures and services, harmonization of the taxation and social security systems and improvements to the accessibility of rural areas. Particular actions are implemented to restart fecundity, in particular in terms of childcare. Accessibility to small and average cities is reinforced by the improvement of the system of transport and connection with the principal axes. Three hypotheses in the design of the network of maternity hospitals were considered: (1) hospitals cluster to take advantage of the better and more diversified services of large units; (2) new maternity hospitals are more likely to be established in deprived areas, and (3) women who live near national borders will use maternity hospitals on either side.

On the map, the overall configuration is not deeply altered, but the fragility of some areas is restricted through keeping accessibility to the services, particularly in the border areas.

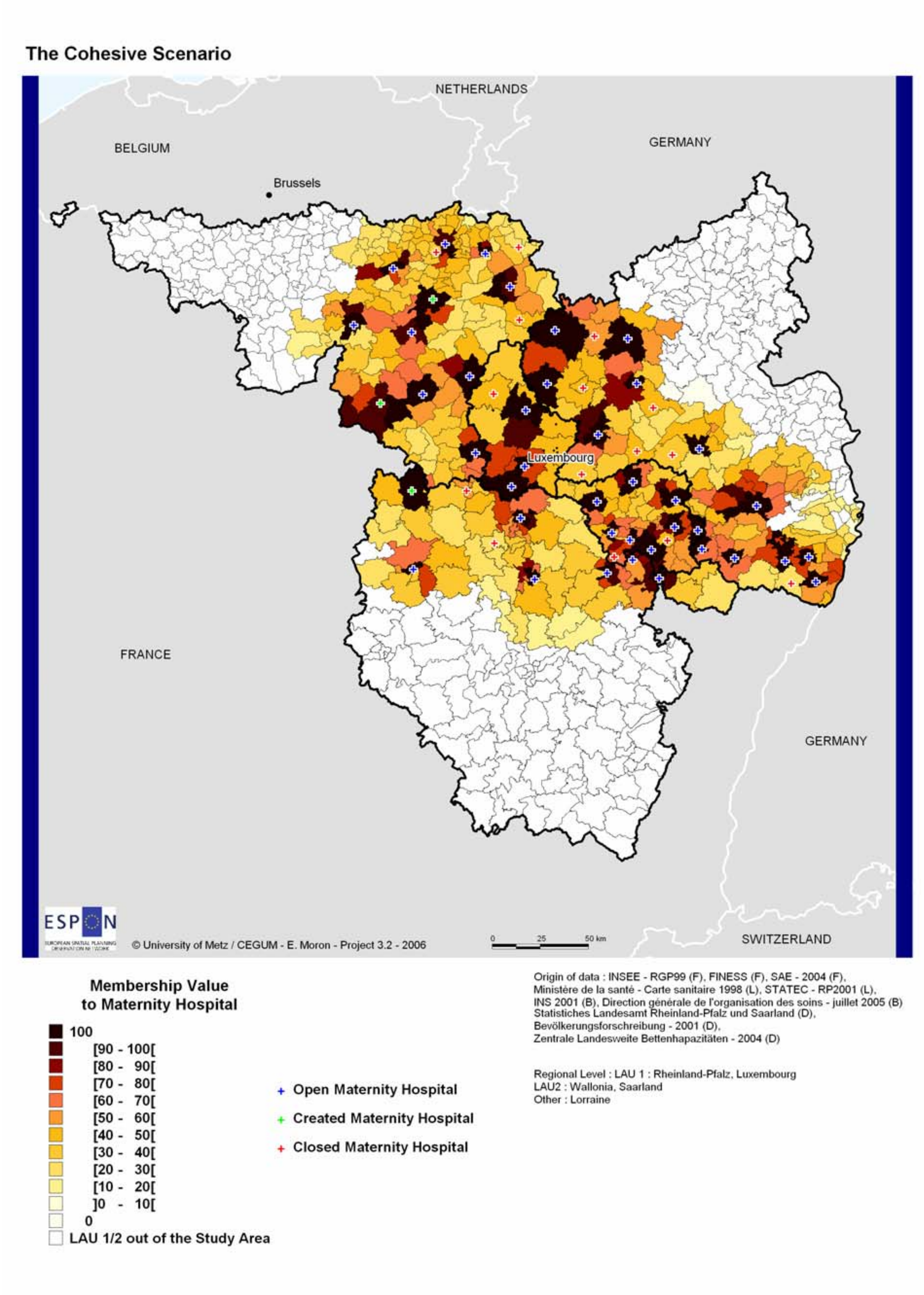


Figure 51 The Cohesive Scenario

5.3.3.2 Differences between the Scenarios

Figure 52 presents differences between the LAU membership values in the current situation and in the cohesive scenario. The most striking element is the gain in accessibility from the creation of new maternity hospitals in the Walloon and French rural territories, while there appears to be some loss in the German urban territories. The dark blue colours illustrate the LAU where a maternity hospital has been closed, a situation which is not necessarily dramatic if closure has lead to create larger units in the vicinity. A new balance is created through a transfer from the over-serviced to the derelict zones. Such a movement is an expression of solidarity among the territories, providing an illustration of what could be the 'territorial cohesion'.

Figure 53 displays the difference between the LAU membership values in the current situation and in the competitive scenario in terms of gains and losses in accessibility. A general loss in accessibility has occurred in the significant number of LAU which are shown in light blue. However, the darker blue pattern of the LAU which have lost a maternity hospital (red crosses) does not signify a catastrophic situation because other hospitals remain in the vicinity (a condition for the closing). Little gains in accessibility are observed close to the borders, reflecting the possibility to access a maternity hospital on the other side of the border. Nevertheless, this general restructuring raises concerns about the impact on the environment of the study population.

The two maps show situations which have advantages and drawbacks whatever the selected scenario. The competitive scenario could be applied in some areas, while the cohesive scenario seems to be crucial for demographic purpose in the rural areas.
This method illustrates the interest to apply different scenarios at a local scale.

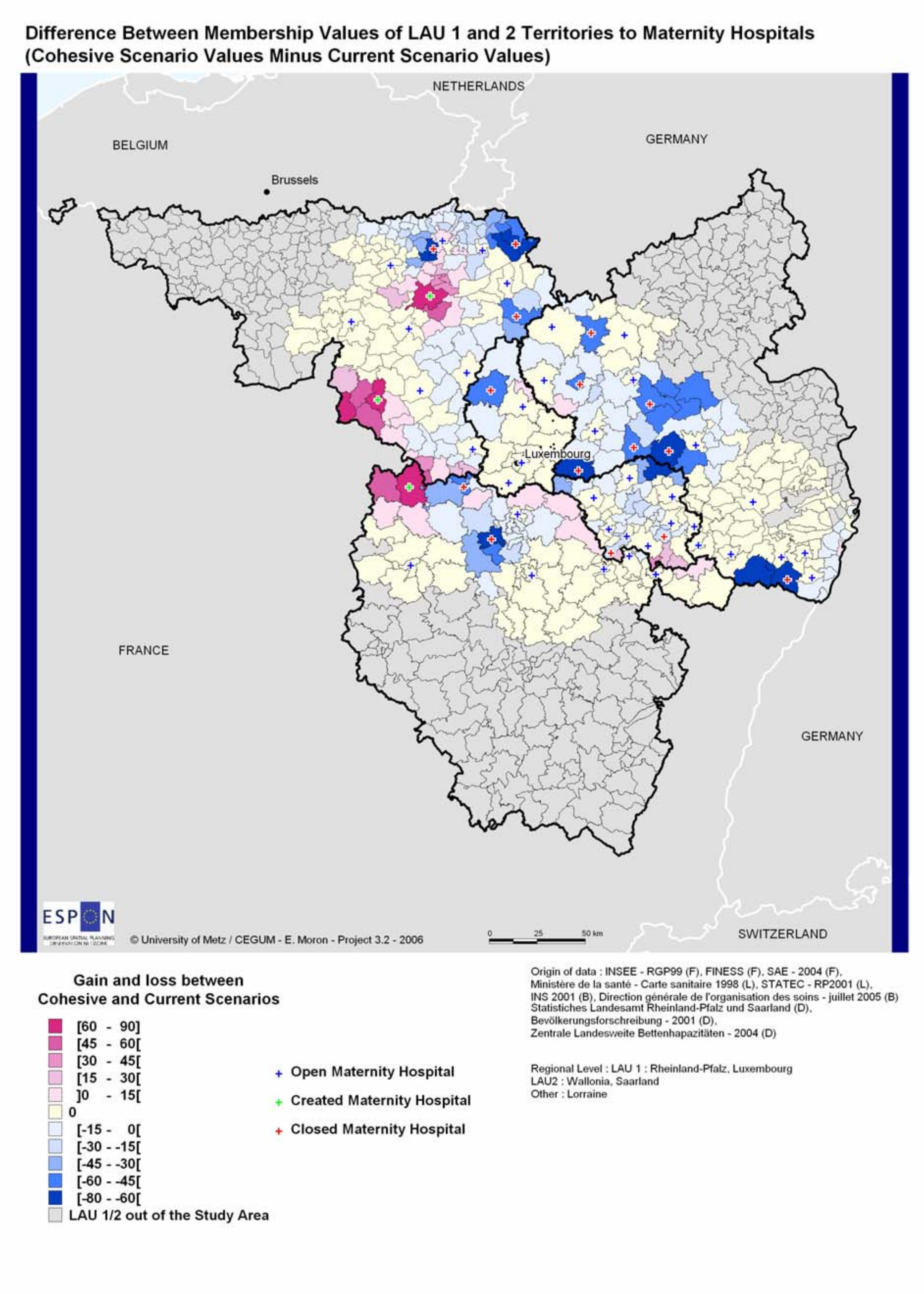


Figure 52 Difference Between Membership Values of LAU 1 and 2 to Maternity Hospitals (Cohesive Scenario Values Minus Current Scenario Values)

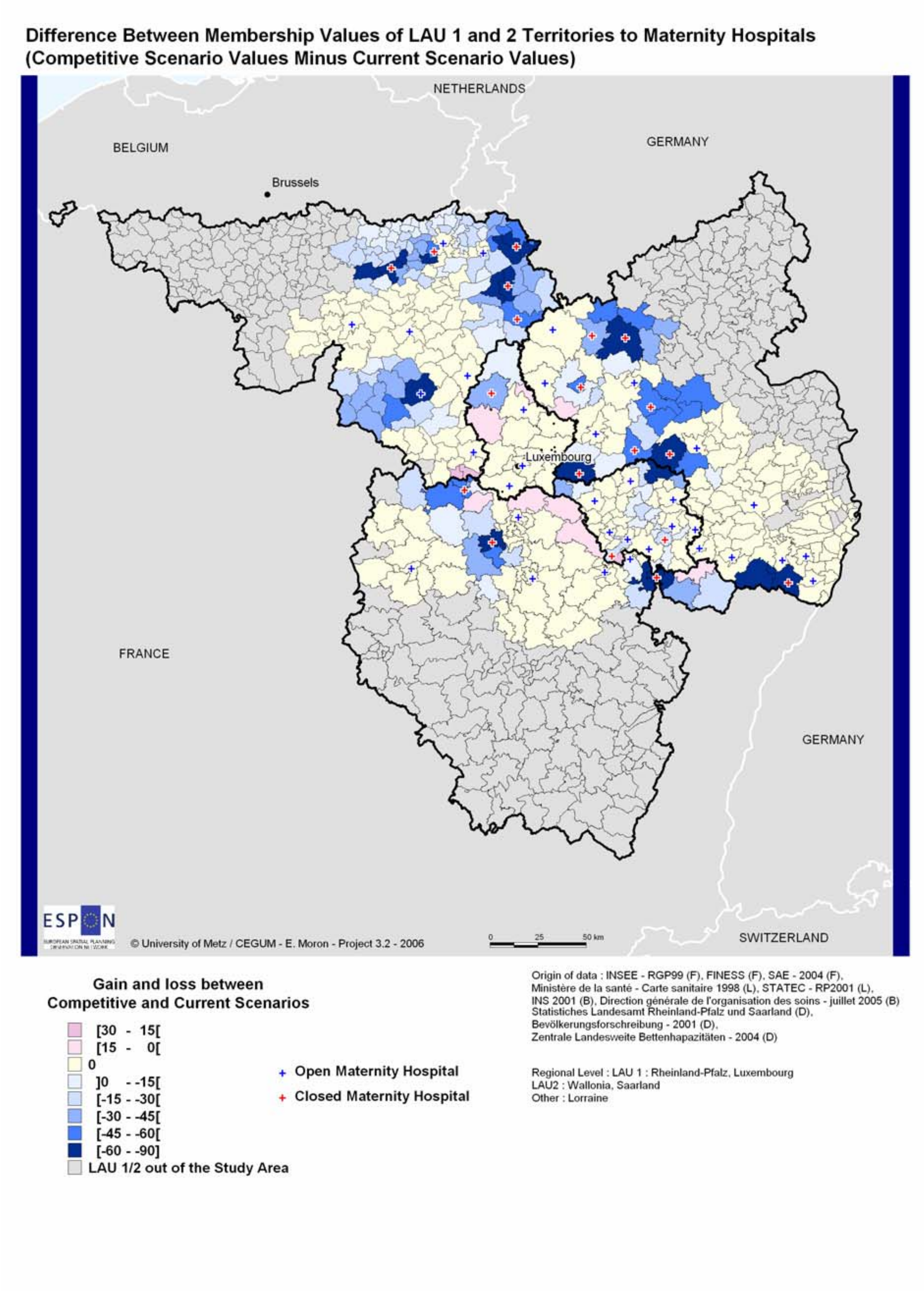


Figure 53 Difference Between Membership Values of LAU 1 and 2 to Maternity Hospitals (Competitive Scenario Values Minus Current Scenario Values)

Conclusions from the Empirical Test

Since accessibility to basic facilities and essential services are an inherent component of territorial cohesion, and the achievement of reliable results at the LAU level across the ESPON area is difficult, the proposed method raises several interesting points. First, it is based on a very small range of data: the number of births in the LAU, the number of beds in each maternity hospital provided by the national health services and the accessibility between maternity hospitals and LAUs. This ensures that the results will be reproducible. Secondly, the fuzzy operators look interesting in terms of the political meaning of 'accessibility to essential services'. On one hand, the choice of operators determines different visions of accessibility, particularly when the inhabitants belong to the influence areas of several services. On the other hand, influence areas have no strict delimitations in reality, and fuzzy operators allows this reality to be taken into account.

If territorial cohesion continues to be advanced as a crucial political consideration in the European Union, further local studies such as this one must be launched. Too often ignored in the past by the ESPON program, social matters can only be tackled at this scale. Moreover, in the context of doubtful current expectations regarding the European construction, policy makers and scientists endorse the responsibility of bringing concrete answers to the daily concerns of inhabitants about the meaning of the European integration for them. The choice here of the maternity hospitals as a type of basic service must be considered as a first step of a more global study taking into account various services, namely school or transport matters to mention only the most important ones. The development of a method which integrates accessibility options to these different services would allow scientists to provide a more innovative picture of the territory, centred on the concerns of inhabitants. Will this challenge give rise to a policy command in ESPON2?

APPENDIX: Delimitation of influence areas around maternity hospitals

Calculation of the influence areas

The maternity hospitals' influence areas are defined according to three different parameters:

1. *The accessibility*, in terms of the required time (under 30 minutes only) to reach the maternity hospital from each LAU. This parameter brings a time-distance constraint to the maternity hospital area delimitation. The more travel time to reach a maternity hospital, the less chance that the LAU will belong to its influence area. Taking into account various legal speed limits, time is measured for a car travelling in optimum conditions without any stop constraint.
2. *The capacity*, in terms of the ability of a maternity hospital to attract the women from other LAU. It depends on the number of beds and the number of births, per year.
3. *The demand*, in terms of the need of maternity beds of the LAU. This is based on both the number of beds offered and the number of births in the LAU

With respect to accessibility, we consider the network of highways, multi-lane roads, national roads, regional and main intra-regional roads. Time-distance is calculated on the basis of the LAU centroids. This raises the methodological problem that maternity hospitals are not generally located at the centroid. But this problem is reduced by having designed our LAU template in order to harmonize them as much as possible on the basis of size (the median size of the LAU is 70 km²).

The capacity is calculated for each maternity hospital. For i = 0, 1, …, n,

$$C_i = (NB_i *365/6 - NN_i)$$

C_i = capacity of the maternity hospital
NB_i = number of beds for the maternity hospital
365 = number of days per year
6 = mean length of a stay in maternity hospital (days)
NN_i = number of births in the LAU where the maternity hospital is located

The demand is calculated for each LAU. For j = 0, 1, …, p,

$$D_j = (NB_j *365/6 - NN_j)$$

D_j = demand of the LAU
NB_j = number of beds for the LAU
365 = number of days per year
6 = mean length of a stay in maternity hospital (days)
NN_j = number of births in the LAU

D_j is equivalent to C_i if i=j, or n other terms if the maternity hospital is located in the LAU.

These three parameters are combined and normalised to represent the accessibility to the maternity hospitals according to the capacity and the demand. The result is the accessibility to the maternity hospital according to capacity and demand.

For the maternity hospital i, with i = 0, 1, …, n, and for the LAU j, with j = 0, 1, …, p,

$$AM_j = (C_i - D_j)/ A_j$$

AM_j = accessibility to the maternity hospital according to capacity and demand of each LAU
C_i = capacity of each maternity hospital
D_j = capacity of each LAU
A_j = accessibility for each LAU to reach maternity hospital

The normalised value is the result of :

$$AM_j = ((AM_j *100)/ \max (AM_j))$$

The combined value of accessibility and attractiveness of each maternity hospital increases from 0 (no accessibility) to 100 (the best accessibility).
The value 0 corresponds to:

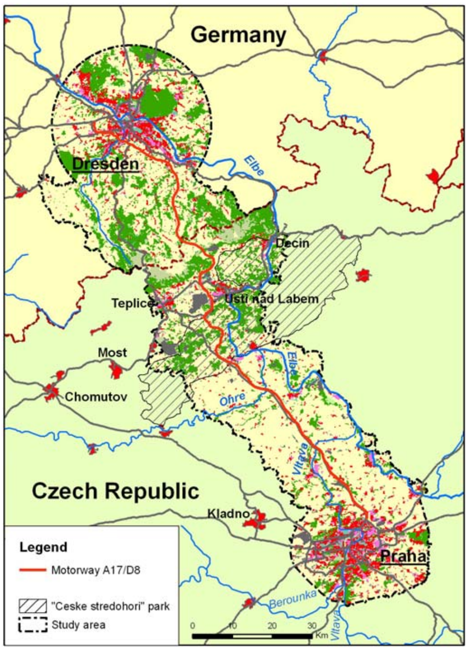
- a LAU having a maternity (thus not potentially attracted by the considered maternity hospital);
- or a LAU located sixty minutes away from the considered maternity hospital;
- or a LAU without births.

The value 100 corresponds to the LAU where the considered maternity hospital is located.
Between 0 and 100, a high value means that the LAU is located close to the maternity hospital and/or there is a high need in the LAU (a lot of births).

5.4 Effects of socio-economic scenarios on land-use dynamics: downscaling and linking integrated policy scenarios and MASST outputs with the MOLAND Model

The ultimate effects of policies and correlated programmes of implementation are often reflected in the actual physical variations occurring on land use patterns. The purpose of this brief note is to evaluate how the integrated policy scenarios elaborated in the ESPON programme's project 3.2 'Spatial scenarios in relation to the ESDP and EU Cohesion Policy' can be downscaled and translated into land-use dynamics of a specific region. The results herein presented are of preliminary nature and aim to demonstrate the feasibility of the approach.

The exercise has been carried out for the study area including the cities of Dresden and Prague and the transport corridor between two cities defined by the motorway D8 on the Czech side and A17 on the German side[61].



The simulation of the land use spatial pattern has been performed by using the MOLAND Regional Growth model developed at the EC/JRC[62]. The MOLAND model is based on 'cellular automata' (CA) approach and allows to integrate spatial aspects of land use patterns with socio-economic (including transport plans), institutional and environmental features of territorial development. The MOLAND model simulates land use dynamics on the basis of digital map compiled at scale 1:25,000 and is calibrated with historical land use information.

The input parameters for the modelling exercise were derived from the predicted trends for population and economy generated by the MASST model for the period 2002-2015 and the overall integrated storylines. The population is projected to decline in the whole area, with higher decrease in Czech Republic, and more moderately in the Saxonian part of the study area. The economy is expected to have a positive growth, with a peak of 4.5-5.5% GDP for Prague and about 1.7-2.6% in the most remote and less populated Severozapad region. The main trends of the Baseline scenario can be shaped by means of implying different priorities in the policy on European level (table 30). This scenario model provides an administrative breakdown to NUTS2 level.

[61] J.I. Barredo, L. Petrov, V. Sagris, C. Lavalle, E. Genovese (2005) Towards an integrated scenario approach for spatial planning and natural hazards mitigation. EUR 21900 EN. Available on http://moland.jrc.it

[62] C. Lavalle, J.I. Barredo, N. McCormick, G. Engelen, R. White, I. Uljee. The MOLAND model for urban and regional growth forecast - A tool for the definition of sustainable development paths. European Commission, DG-Joint Research Centre, Ispra, Italy, 2004, 22 pp. EUR 21480 EN. Available on http://moland.jrc.it

	Cohesive scenario		Competitive scenario	
	Population decrease	GDP growth	Population decrease	GDP growth
CZ01 Praha	Higher decrease	Lower	Slower decrease	Highest
CZ02 Strední Cechy	Slower decrease	Higher	Higher decrease	Lower
CZ04 Severozápad	Slower decrease	Higher	Higher decrease	Lower
DED1 Chemnitz	Slower decrease	Higher	Higher decrease	Lower
DED2 **Dresden,** rural municipalities	Higher decrease	Higher	Slower decrease	Lower
DED21 **Dresden,** Kreisfreie Stadt	Higher decrease	Higher	Slower decrease	Lower

Table 30 The relative changes in population and GDP for Cohesive and Competitive scenarios with respect to the Baseline scenario

These parameters were translated into the MOLAND model to drive the evolution of land use classes. Two specific classes are herein examined: areas dedicated to residential settlements and areas dedicated to industrial, commercial and service activities.
Residential areas are further spitted in four sub-classes, depending on settlements' density. The sub-classes are defined as: (1) continuous dense; (2) continuous medium dense; (3) discontinuous and (4) discontinuous sparse urban fabric. The developments of these land use classes are coupled with general economic and population growth figures. Figure 54 shows the growth of residential areas by regions for (A) Baseline, (B) Cohesive and (C) Competitive scenarios of ESPON / MASST for the administrative units under study. Figure 55 presents the land use maps for years 1998 and 2015 for the three scenarios for the area surrounding Prague. The differences in the land use patterns simulated for the three scenarios, as compared with the actual situation in year 1998 is shown in figure 56.

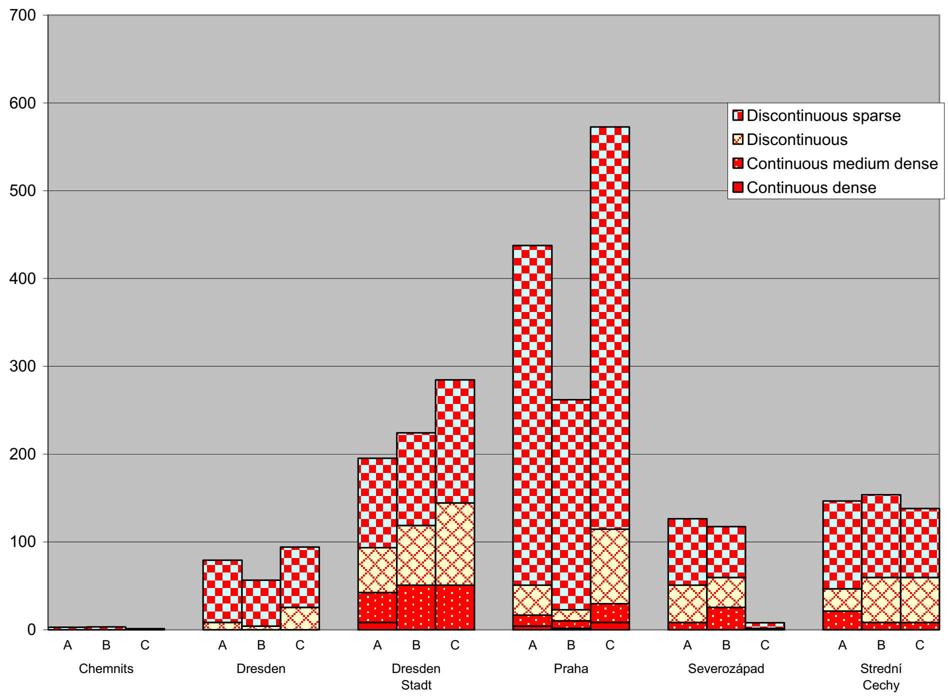


Figure 54 Growth of residential areas by regions for (A) Baseline, (B) Cohesive and (C) Competitive scenarios. Numbers correspond to the numbers of new cells (200x200 meters or 4 ha).

The analysis of the output maps allows formulating some qualitative and quantitative considerations on spatial patterns of land uses. In the administrative units of Saxony the majority of settlements is represented by sparse residential settlements (sub-class (4)), therefore rather scattered on the territory. Nevertheless these areas accommodate considerable amount of inhabitants, especially in the densely populated municipalities of Dresden district. In the Czech rural areas, the settlements are mostly represented by class (3) -discontinuous urban fabric- so they are more 'spatially' compact, but accommodate fewer residents. These trends are reconstructed by assuming that residential classes observed in the land-use map for year 1998 are slowly decreasing over the simulation period. Additional data, such as zoning maps, land suitabilities and others, could be considered to evaluate the impact of local and regional land use policies, for ex., to reduce sprawl and/or increase accessibility.

The simulation for industrial, commercial and service areas is based on GDP figures as output from MASST, represented in figure 57.

It is interesting to note that the economic growth for the city of Prague is predicted to double in the Competitive scenario, as opposed to the moderate growth expected for Dresden.
In the MOLAND model there are several land use classes which correspond to economic activities, namely (1) industrial sites, (2) commercial areas and (3) public and private services. The trends observed in the GDP projections are proportionally allocated to the abovementioned activities, on the basis of statistical data (EUROSTAT gross value added (GVA) for economic sectors for year 2002). The spatial density of economic activities –i.e. the amount of activity units corresponding to one modelled cell- plays a crucial role in coupling regional economic performance and demand for land use. This value is initially read in and calculated from the actual data for 1998 (initial land use and economic activities) for each economic sector in each region. Subsequently, the value is dynamically updated bearing in mind regional economic potentials as well as transitional potentials and possible densification of activity at cell level.
Figure 58 Illustrates variations of land use patterns in the three simulated scenarios, with reference to the actual situation in year 1998 for city of Prague and surroundings.
Figures 59 and 60 show the development of commercial areas respectively around Prague and Dresden. The areas coded in blue represent the location of new commercial settlements as results of the considered economic scenario.

Conclusions

The presented approach allows downscaling of wider socio-economic scenarios to specific geographical area. Although the methodology is not intended as a tool for detailed spatial planning, it provides relevant information on land use pattern within specific administrative areas. For example, the development of residential settlements can be quantified and characterised or the growth of industrial and other economic activities can be evaluated in the light of their accessibility and impact on future infrastructure.

The outputs herein presented are extremely preliminary due to the limited nature of the exercise. More efforts should have been dedicated to the collection and ingestion in the MOLAND model of data on planning practices (e.g. zoning and legislation) and on the analysis of sectoral economic activities. Therefore a number of assumptions based on the historical trends have been made. Nevertheless, the results are extremely positive and promising in view of a further step of quantification of the ESPON 3.2 scenarios.

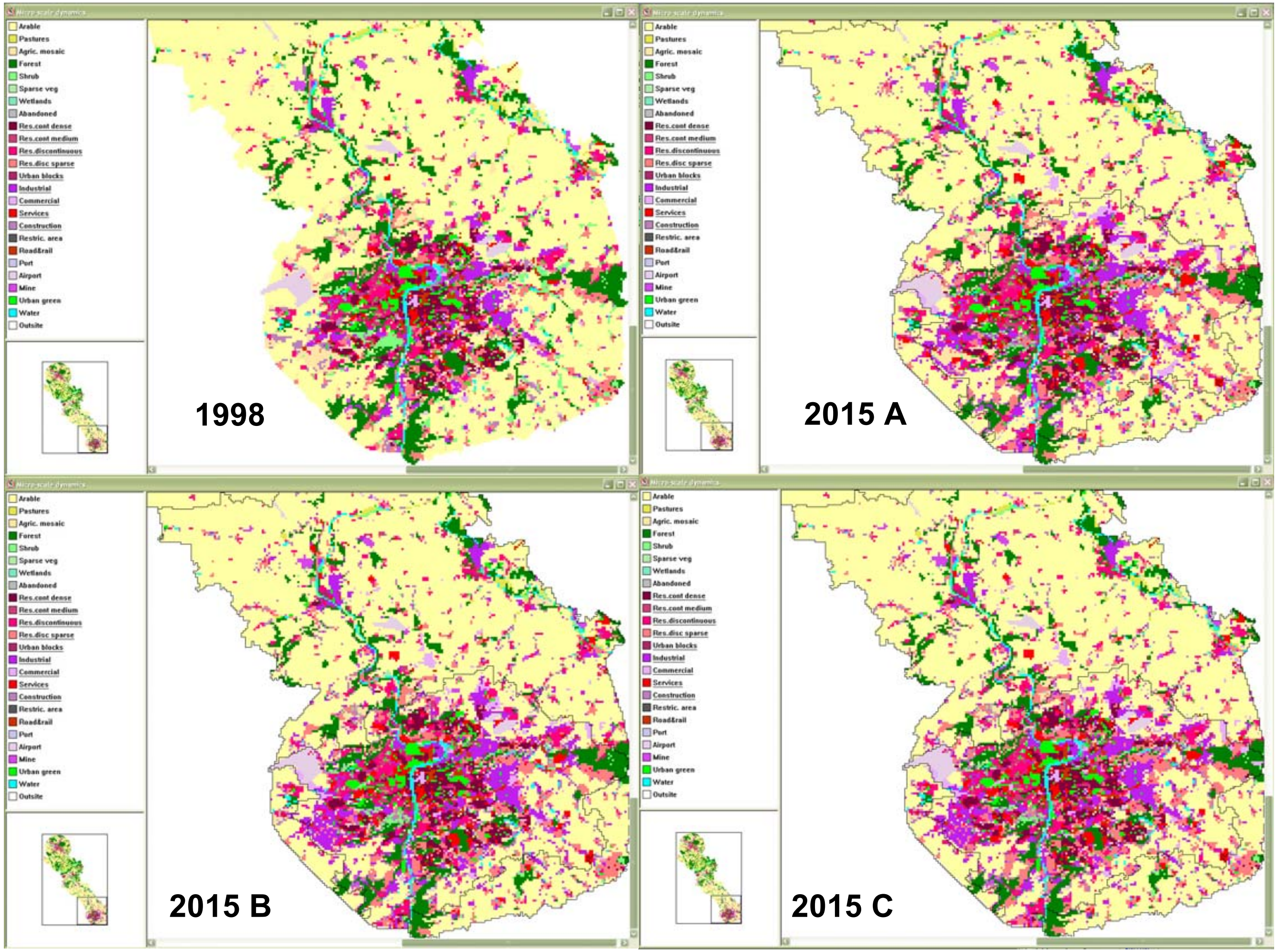


Figure 55 Land use development around Prague. A Basesine scenario; B Cohesive scenario; C competitive scenario

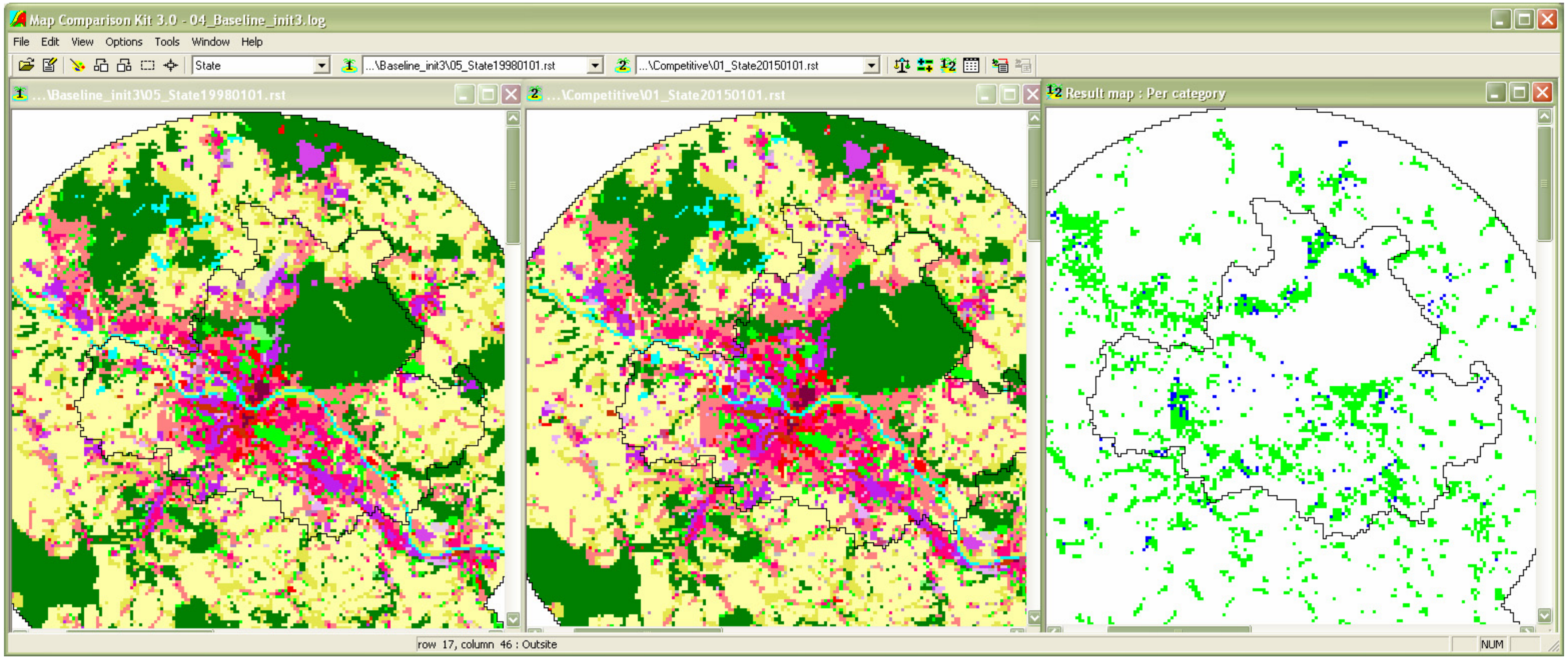
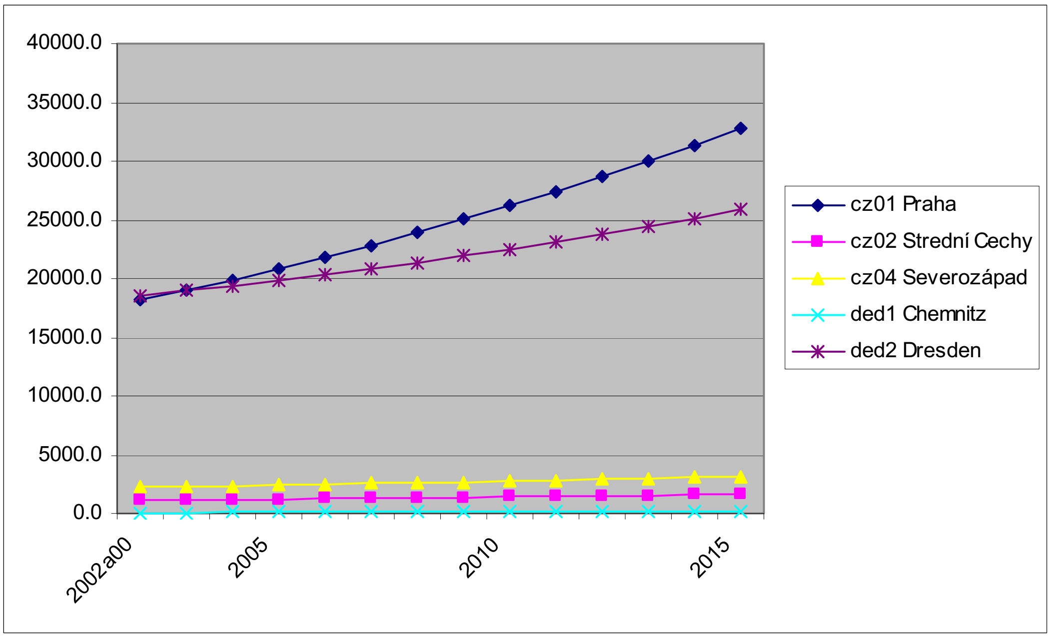


Figure 56 Development of low density residential areas around Dresden from 1998 to 2015 (Competitive scenario)

Left: land use map in year 1998; Centre: land use map for year 2015; Right: comparison of land uses: green – the class is presented on both maps; blue – the class is present only for year 2015 (i.e. new development).

GDP- Cohesive scenario



GDP – Competitive scenario

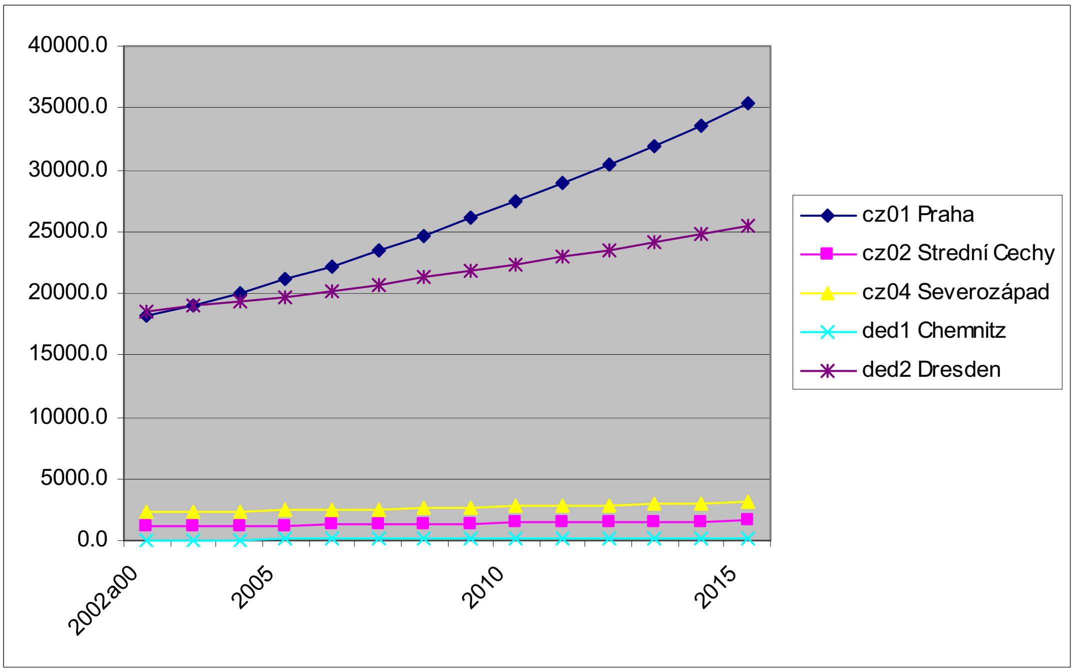


Figure 57 GDP growth projected by MASST model for study area

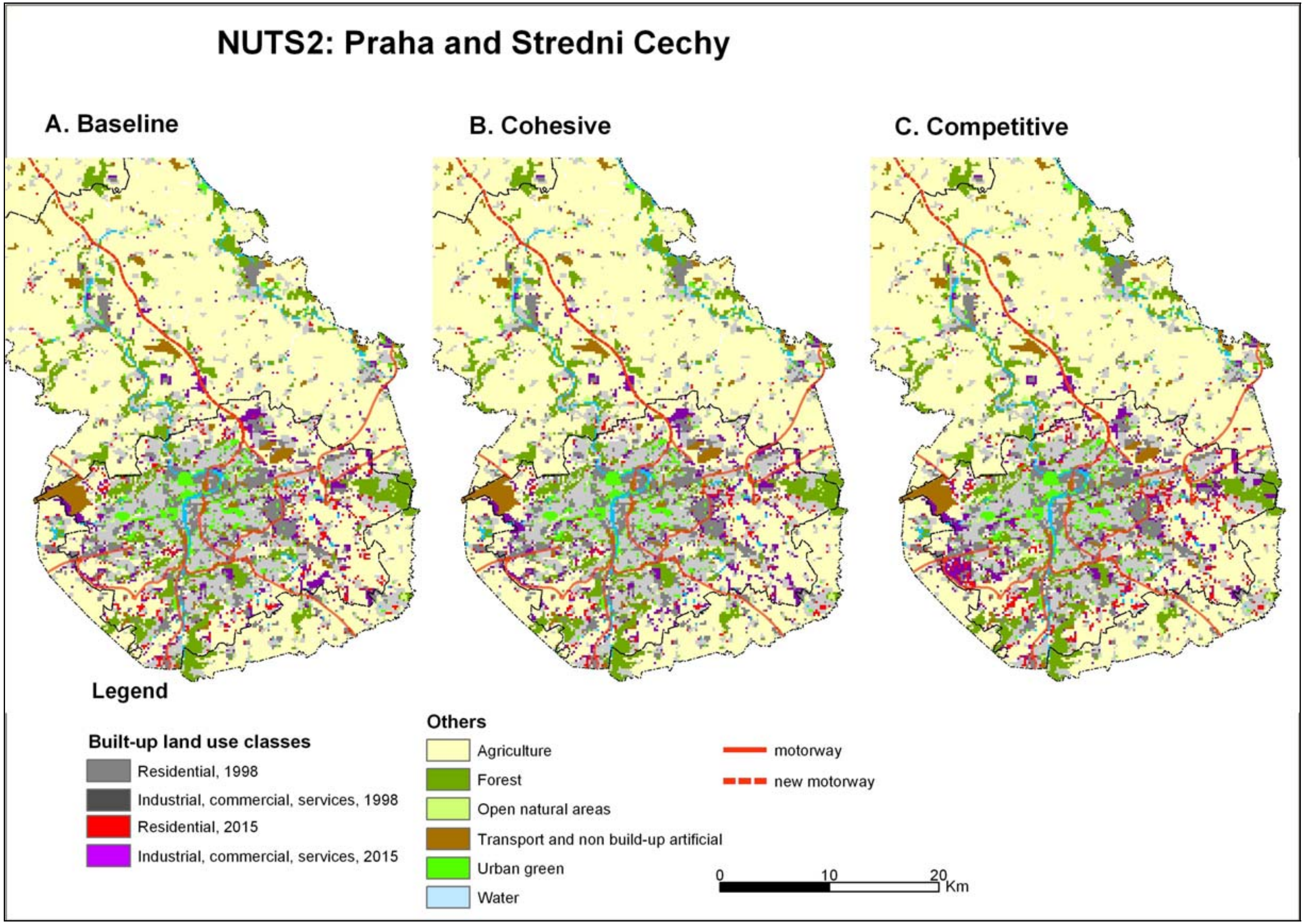


Figure 58 Variations of land use patterns in the three simulated scenarios, with reference to the actual situation in year 1998

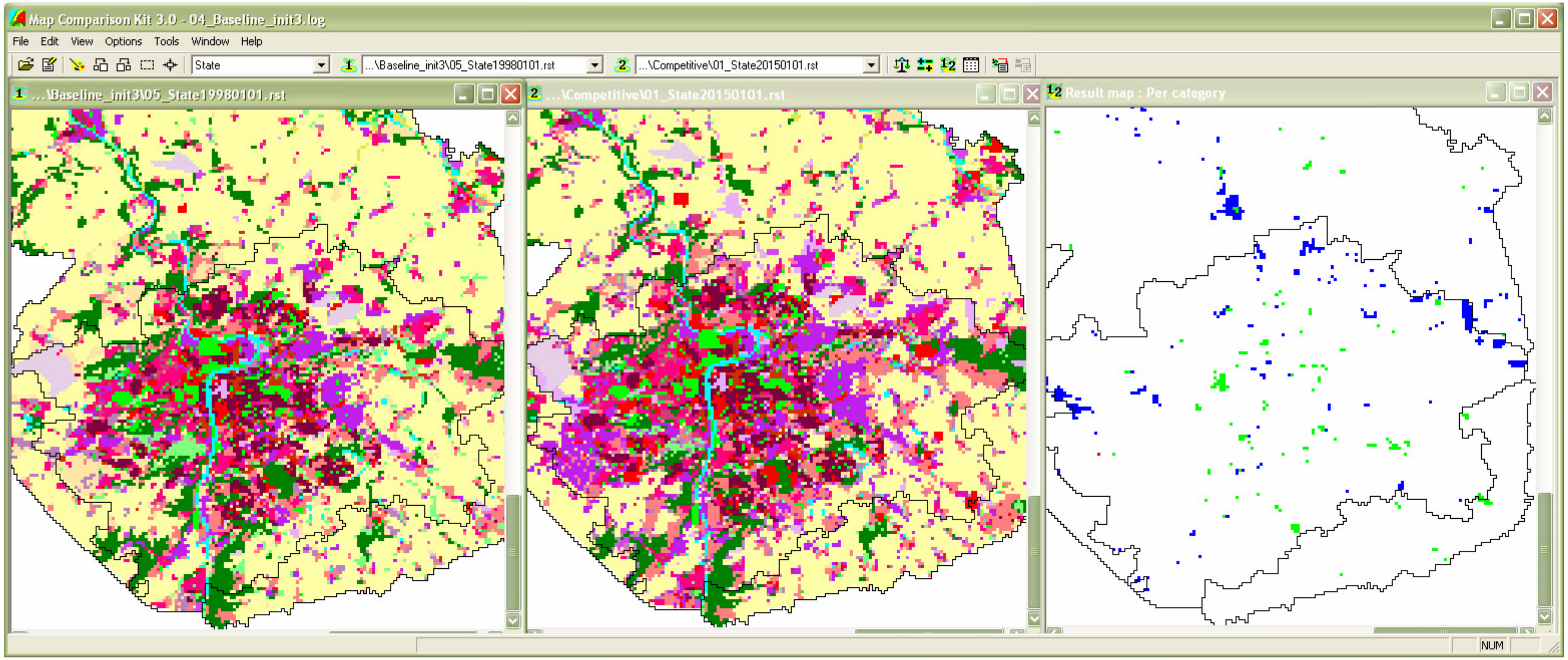


Figure 59 Development of Commercial areas around Prague from 1998 to 2015 (Competitive scenario)

Left: land use map in year 1998; Centre: land use map for year 2015; Right: comparison of land uses: green – the class is presented on both maps; blue – the class is present only for year 2015 (i.e. new development).

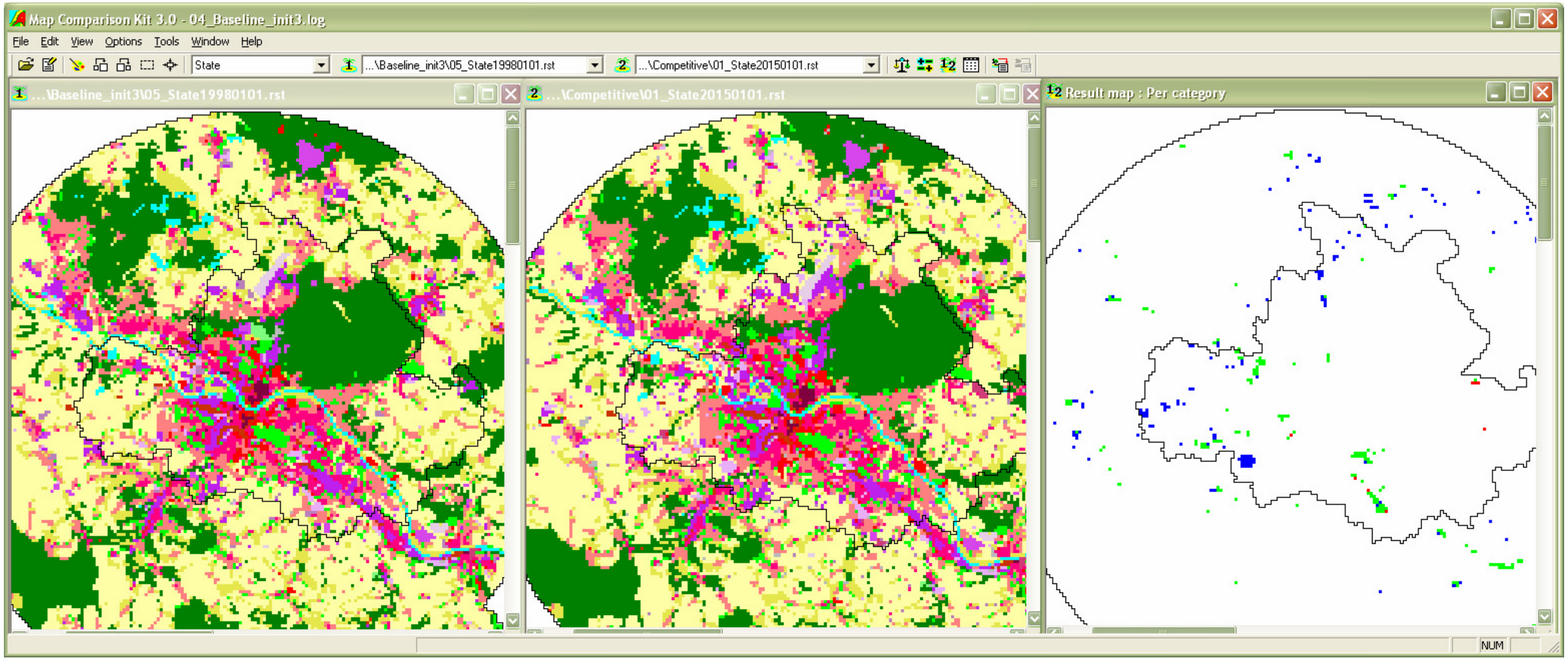


Figure 60 Development of Commercial sites around Dresden from 1998 to 2015 (Competitive scenario)

Left: land use map in year 1998; Centre: land use map for year 2015; Right: comparison of land uses: green – the class is presented on both maps; blue – the class is present only for year 2015 (i.e. new development).

6 Wild Cards

The aim of the ESPON 3.2 project is to develop a number of scenarios for the future of Europe. The aim here is essentially to analyse the impacts that these scenarios would have on the territorial structure of Europe. Thus, as the ESPON 3.2 project deals with the conception of strategic policy scenarios for the future development of the European territory, Wild Card analysis can be useful in studying the internal impacts of the scenarios to specific external shocks. Moreover, as the scenarios were initially constructed as separate thematic scenarios, the WC’s, as they are applied to the policy scenarios, may help our understanding of how the various parts interact, as well as investigating the coherence of their argumentation.

6.1.1 Introduction to Wild Cards Analysis

Wild Card (WC) usage has been extensively developed in the corporate business world, particularly by companies dealing with strategic commodities in global markets (i.e. the nexus between warfare, oil, and energy usage). The purpose of WC’s is usually to test the *reactiveness* of a given system - usually a large organisation - to unforeseen but high impact events. Such an approach is seen as highly useful to the organisations involved in ‘turbulent and unforgiving environments’ (Mendonca *et al.*, 2003). WC analysis is generally seen as a means to ‘ignite a strategic conversation’ in the context of any given organisation (Van der Heijeden in Mendonca *et al.*, 2003).

In the literature, WC’s are defined as, ‘future developments or events with a relatively low probably of occurrence but a likely high impact on the conduct of business’ (BIPE Conseil *et al.*, 1992). In that sense, the array of WC’s can be as broad as the human imagination itself, though their main characteristics are that they are ***improbable*** (but not entirely impossible) and with potentially ***wide-ranging impacts***. Consequently, ‘wild cards change our frame of reference, our mental map of the world’ (Steinmüller, 2004).

If the construction of WC’s is for the most part an imaginative process, being able to do this in a systematic manner exponentially increases the explanatory power of the exercise. In that sense, when elaborating a WC, it is necessary to consider its main features. The main characteristics of the WC concern its process, its plausibility, its topic, and the nature of its impact.

- Process: <u>Sudden event or long-term process?</u>

The literature identifies three main causal origins for WC’s:
1. They are the result of a sudden random, unforeseeable, event
2. They encapsulate the sudden realisation of the importance of a long-lasting process, a *creeping crisis*, with climate change perhaps being the most striking contemporary example, or,
3. They are connected with the realisation of the emergence of a future potential problem.

- <u>Plausibility: between imagination and likelihood</u>

The degree of plausibility of a WC is mainly identified by the relationship between imagination and the likelihood of the event, ranging from ‘unimaginable surprises’ to 'certain surprises', displaying an increasing likelihood that the event will occur *at some time* in the future (Mendonca *et al.*, 2003).

1. ***'Certain surprises'*** can, for instance, include earthquakes or other natural disasters: everybody intuitively knows that they are going to happen (i.e. in San Francisco, California), there is then a certain predictability in respect of pervious historical patterns of activity, but the issue of *exactly when* and *where* is simply not foreseeable.
2. The category of ***'imaginable and probable surprises'*** could entail for instance, the re-emergence of political troubles in Russia, with Russia becoming increasingly authoritarian once again and undertaking to 'renationalise' many of the industrial sectors that were privatised during the Yeltsin years.
3. Concerning ***'imaginable but improbable surprises'***, one such example could be gauged in relation to the political inability of the global community to solve the problem of oil dependence. As such, when oil does effectively 'run dry' there is a refocusing on the bicycle in respect of personal mobility issues.
4. Finally, as it seems difficult to imagine the unimaginable, we will leave the potential content of the ***'unimaginable surprises'*** category to the reader.

- Topic or subject:

Five distinct topic areas are usually cited in the literature on Wild Cards (Mendonca et al., 2003; Steinmüller, 2004): military/political, technological, economic, socio-cultural, and environmental/biological (i.e. the *PESTE* framework).

- Impact:

An assessment of a WC's impact is directly linked with our ability to assess the response of the scenarios to the WC itself, particularly in respect of their stability and sensitivity (Mendonca *et al.*, 2003). As Wild Cards are often described as *breaks in the development trend*, describing the type of break thus becomes essential (positive, negative, abrupt, smooth…) (Mendonca et al., 2003).

6.1.2 Wild Cards and ESPON 3.2 Scenarios

In the framework of this project, WC's serve as a sounding board for the developed scenarios. The general aim is to test, qualitatively, the reaction of each scenario to a panel of unexpected and potentially high-impact future developments, as well as to assess their quantitative impact essentially using the MASST model. The WC's are designed to test the individual scenarios' ability to deal with the impact of the issue, phenomenon, or occurrence in question, with a particular focus on the likely *territorial* impacts.

The WC analysis does not occur during the scenario-construction phase, as it can only be performed *after* the four different scenarios are completed. However, it should be fully integrated into the overall scenario process, as a reflexive exercise. Moreover, as the scenarios that have been developed in ESPON 3.2 have been built along multiple themes and as their individual impacts are difficult to gauge, the assessment of the response of the scenarios to the selected WC may improve the understanding of how their individual parts fits together.

By means of this exercise, our intention is to emphasise the potential strengths and weaknesses of each scenario, when facing a particular and/or disturbing event. The WC analysis will thus enable us to define new 'final images' in the scenarios that are not the result of policy developments but of an unexpected event. It would then be interesting to describe how far these new final images differ from the expected pictures.

The expected outcome of the WC analysis concerns the ability to pinpoint the importance that an external event may have on the development of Europe, and the internal disparities between its regions.

The WC analysis will be designed with a view to the construction of a new and original perspective on each of our scenarios, by challenging their reasoning and by introducing an unknown and unexpected element into scenario development. The WC analysis aims to foster discussion around the question: 'What if this happens…?' This reflexive exercise is both a valuable one for the researchers involved in the ESPON 3.2 process as well as, potentially, for future readers, essentially acting as an eye-opener or by counteracting certain pitfalls (lack of imagination, wishful thinking/hyper-worst-case thinking) (Steinmüller, 2003).

6.1.3 Further Development of Wild Card Choices

After the July TPG the focus/scope of the 'Wild Cards' was narrowed down to a number of 'core' issues which generally reflected the basic messages identified in summing up the results of the ESPON 3.2 project. These messages relate in particular to the themes of ***energy policy***, ***climate change***, ***the nativity/demography/immigration 'nexus'***, and to the nature of ***economic exchange under globalisation.*** As such then, these issues will be used to identify, frame, and produce the 'Wild Cards' in the final stage of the project. The 'Wild Cards' will have a territorial focus, noting in particular their impacts on various types of regions, as well as their broad geographical impact. In a methodological sense, during each 'Wild Card' usage *a ceteris paribus* assumption, in respect of other factors, is used.

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7 Visualisation and Communication

7.1 Introduction

Scenarios are not only useful for the policy makers involved in the elaboration process as mind games and for internal discussion, but also, and mainly, as communication tools. They allow to raise awareness about fundamental driving forces and to explain policy options more vividly. The spatial scenarios developed in this project target a wide audience, from the spatial development community at European level to regional territorial policy makers and, albeit to a more limited extent, the general public.

But in order to communicate you also need to present and visualise in a form easily understandable by your audience. Quite some effort has, therefore, gone into the reflection on how to best visualise scenario results and the important policy questions and messages. The most prominent results of this effort are the K&C tool and the mapping of the scenarios.

7.2 General Communication Efforts

In the light of this very wide-ranging potential audience, the communication of the work in progress and the results will have to be very diversified and targeted. In light of the limited resources, however, several elements have been privileged (in addition to the obvious communication to the ESPON Monitoring Committee and the general ESPON community at ESPON seminars):

1. Transnational and national events targeting the national and regional territorial development community

National events should be based on the demand of national contacts and aim at informing the national or regional policy makers and other stakeholders about the ESPON scenarios and to discuss the national relevance of the project's findings. Such events have already taken place in Belgium, France, Austria, the Netherlands and Spain and future events are planned in Poland and the Netherlands. Both at Monitoring Committee meetings and at a meeting of the SUD committee representatives have been encouraged to envisage the organisation of such an event in their country. More events are expected to take place after the publication of this report.

The scenarios are also of special interest for the transnational territorial development stakeholders. Many of them are active in Interreg programmes, notably around spatial visions. Members of the team have been called upon to present specific thematic aspects of the work at meetings of such spatial vision groups. In the context of INTERACT seminars, the work is also presented as a whole to the representatives of the different Interreg IIIB regions.

2. Presentations in events of the scientific community

All members of the team are encouraged to present our work either at scientific conferences or in scientific publications and this has been done at several occasions and will continue in the same manner in the future.

3. A final ESPON publication on scenarios

At the end of the project, which coincides with the end of the first phase of the ESPON programme, the integrated scenarios will be presented in a special ESPON publication. This will be limited to about 50 pages and present the scenarios in a very synthetic, readable and easily understandable manner in order to serve as a basis for further communication activities, mainly in the context of ESPON 2013.
The presentation will include more vivid descriptions of example areas in order to show the effects of the scenarios in concrete places.

4. Integration of project 3.2 into the general ESPON communication strategy

Several general ESPON communication activities are foreseen in the future, notably at the beginning of ESPON 2013. It was decided together with the coordination unit that project 3.2 be part of some of the events, as has already been the case for the DG Regio Open Days. For the future, such participation of researchers from the project will obviously depend on their availability after project termination.

7.3 Visualising the future: the scenario maps

The ESPON Monitoring Committee has strongly insisted on the necessity to accompany the scenarios with appropriate maps. In light of the history of scenario mapping in the EU policy context (notably the experience of the ESDP), this is quite a challenging task, as maps link more abstract scenario texts to very concrete territories. This is even more the case in the case of scenarios such as ours where the space and thematic scope covered is so large that it is nearly impossible to evaluate the detailed territorial evolutions at NUTS 3 or even NUTS 2 level.

7.3.1 Mapping quantitative projections

Quantitative projections are an important support to the scenarios. The team has spent quite some time searching for the best compromise between displaying as much information as possible and not giving the illusion of precise predictions. The most prominent example has been a quite intense discussion concerning the visualisation of the MASST results (see chapter 2 in this volume). As models are by definitions only approximations of reality, it was decided that for the actual visualisation within the scenarios, smoothed maps should be used in order to make it obvious that we are dealing with uncertainty. However, these smoothed maps have the disadvantage of distorting the actual quantitative results of the scenarios. We, therefore, present the original, NUTS 2 maps in the scientific section on the MASST.

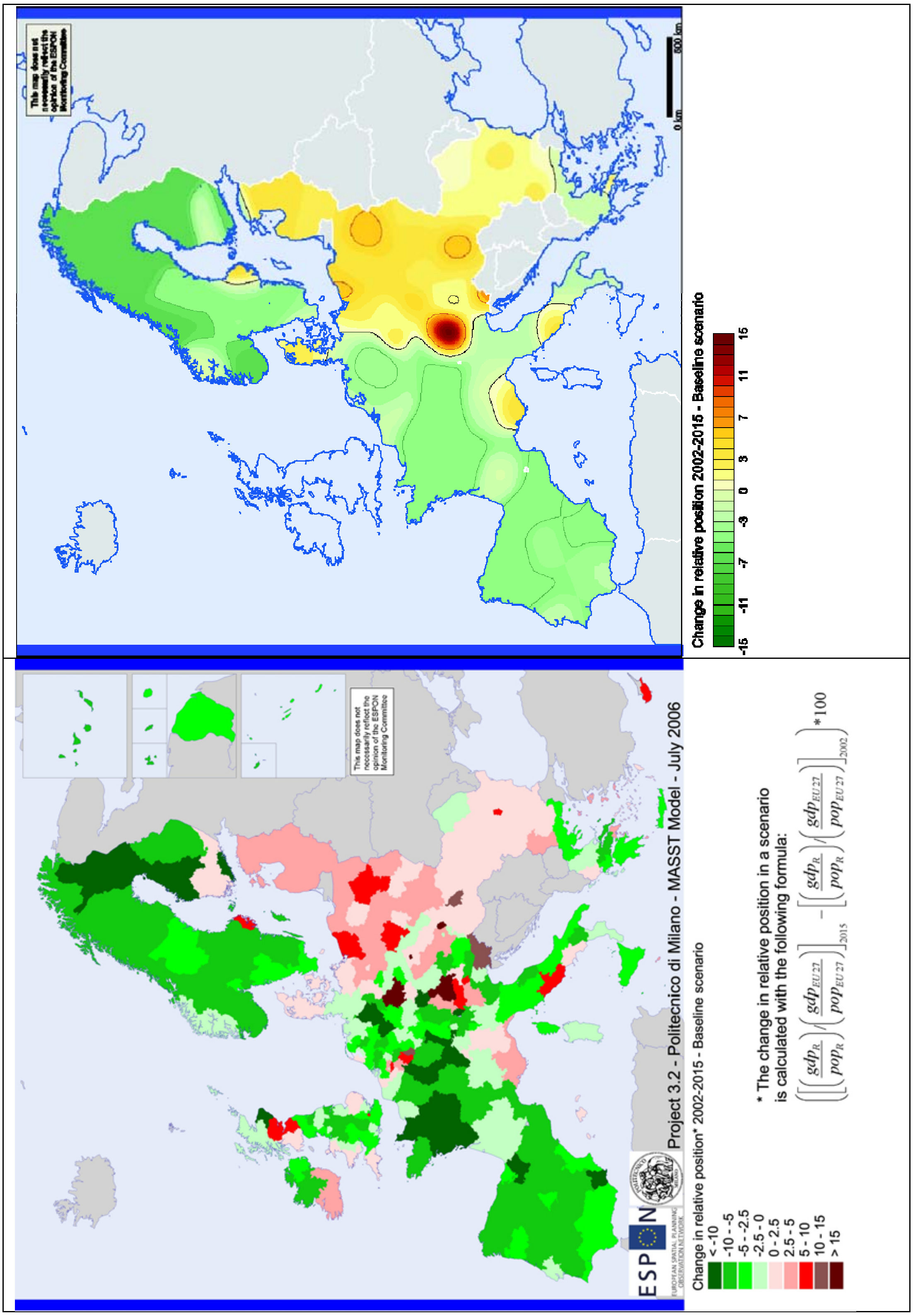

Figure 61 Unsmoothed and smoothed map on the basis of the same MASST output

7.3.2 Visualising complexity: Combining different driving forces and different points in time

Another approach used by the project, notably in its contribution to the ESPON Atlas, was the combination of different maps representing different aspects of the territorial evolution. This approach allows to use only quantitative data, but this obviously limits the scope of what can be displayed. See figure 62.

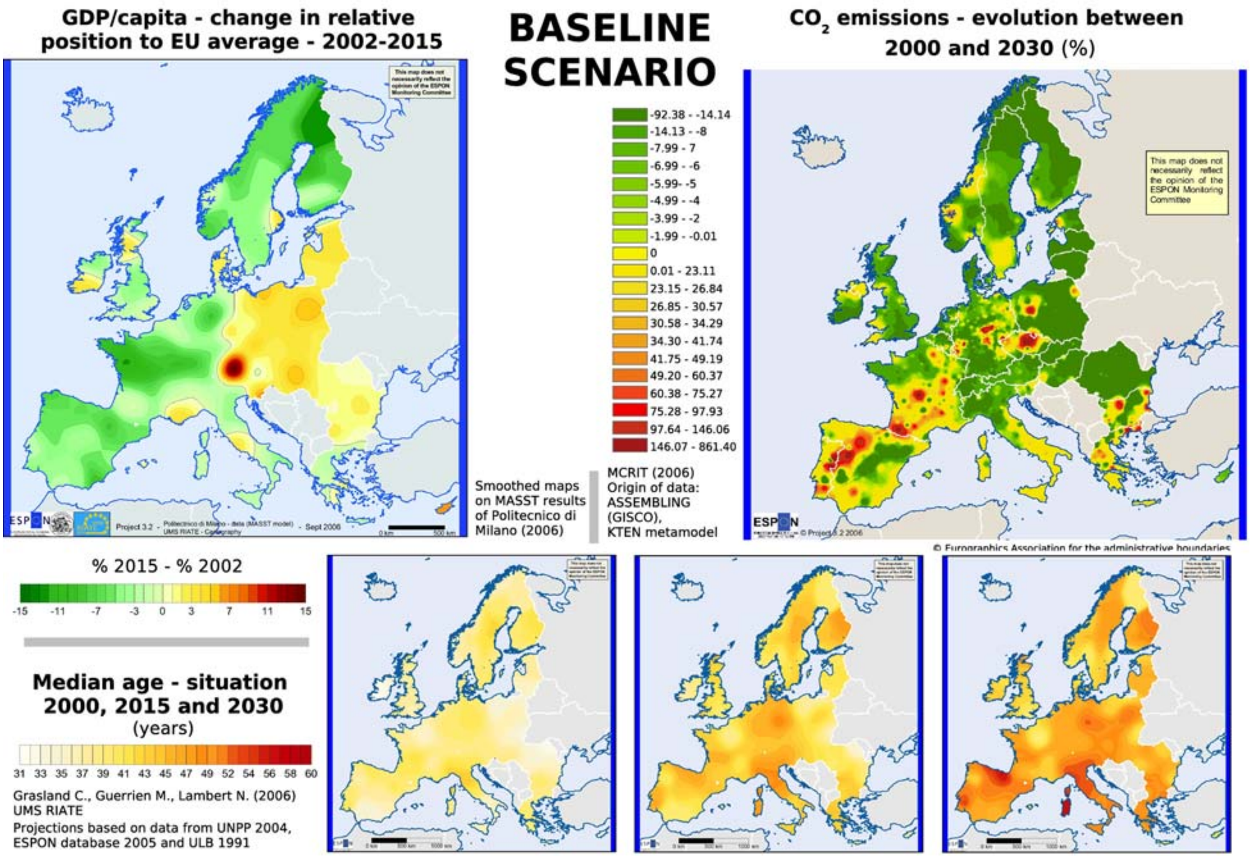

Figure 62 Combining different model results for scenario visualisation

Similarly, it was thought that for most of the scenario maps, it is not the individual map which is important, but rather its position in a comparative series of different points in time and/or different scenarios. One example of such an approach are the maps resulting from the demographic models, showing the indicator for sustainable demographic development, developed more in detail in chapter 4. The juxtaposition of the different points in time allow an easy vision of the main important evolutions, instead of focusing on individual points of the map.

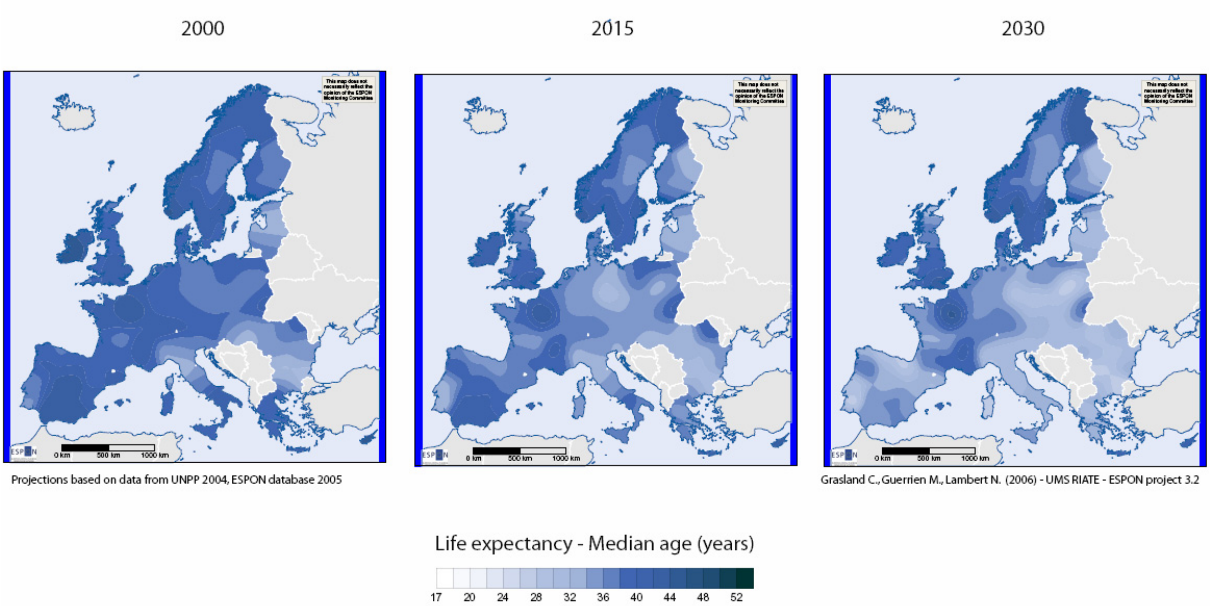

Figure 63 Indicator of sustainable demographic development, baseline scenario 2000-2015-2030

To take this even further, the team has developed a dynamic, interactive web-based map visualisation tool which allows to view different scenario maps in a continuous slide show either by time or by scenario, thus again focusing the attention on the main elements of change. This tool is part of the K&C web site discussed in the next section, and is available at http://www.mcrit.com/scenarios/ESPON32/index.htm.

7.3.3 The art of synthesis: schematic scenario maps

Finally, as the major cartographic outcome of this project, throughout a long iterative process, schematic scenario maps have been elaborated. Starting from the brainstorming results presented in the Third Interim Report and based on the final versions of the integrated scenarios, a working group met several times to come to grips with the difficulty of displaying the highly complex territorial evolutions over 25 years in legible maps. Several criteria were used to guide the process:

1. The maps should focus on the major policy issues at stake. Elements that are linked to policies should either not be shown or be more discrete.
2. The maps should show the European picture, without losing some macro-regional specificities. They should not attempt to go into local details, but rather show the general structure of the European territory.
3. The maps should focus on the differences between scenarios, but at the same time be autonomous, i.e. one should be able to look at one map and understand it without having to see the others. This meant that only those elements clearly different between the scenarios should be included.
4. The maps depict the static image of Europe in 2030. They do not try to show the actual driving forces and evolutions leading to this image.
5. The maps should not give the illusion of quantitative precision. It should be immediately visible that these maps are sketches or images, not scientific maps.
6. Empty spots in the map are allowed, i.e. if an area does not present any particular policy challenge, can stay white.
7. The maps should be lisible on an A4 page.

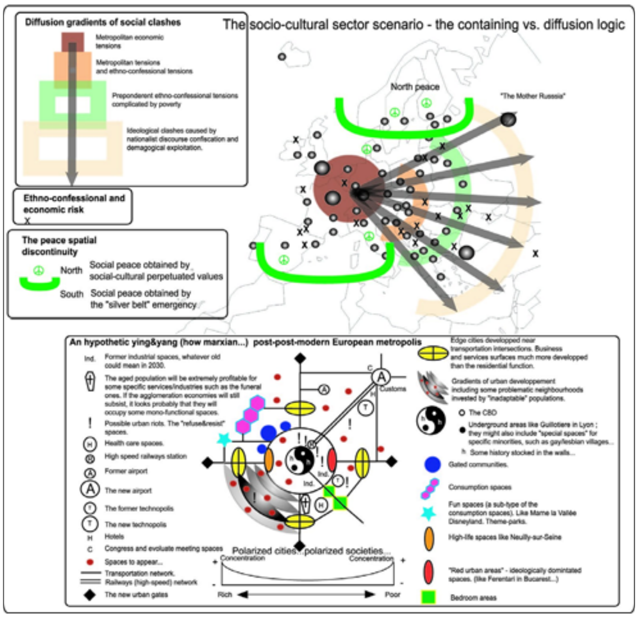

Figure 64 Examples of conceptual schematic maps elaborated during initial brainstorming period

The final results (presented here in the form of one the last drafts, see figure 65) of this effort were maps which correspond to the above criteria and which should serve as a support for the presentation and discussion of the scenarios. Obviously, these maps cannot replace the more complex textual explanations, but are only a visual complement to reinforce certain messages.

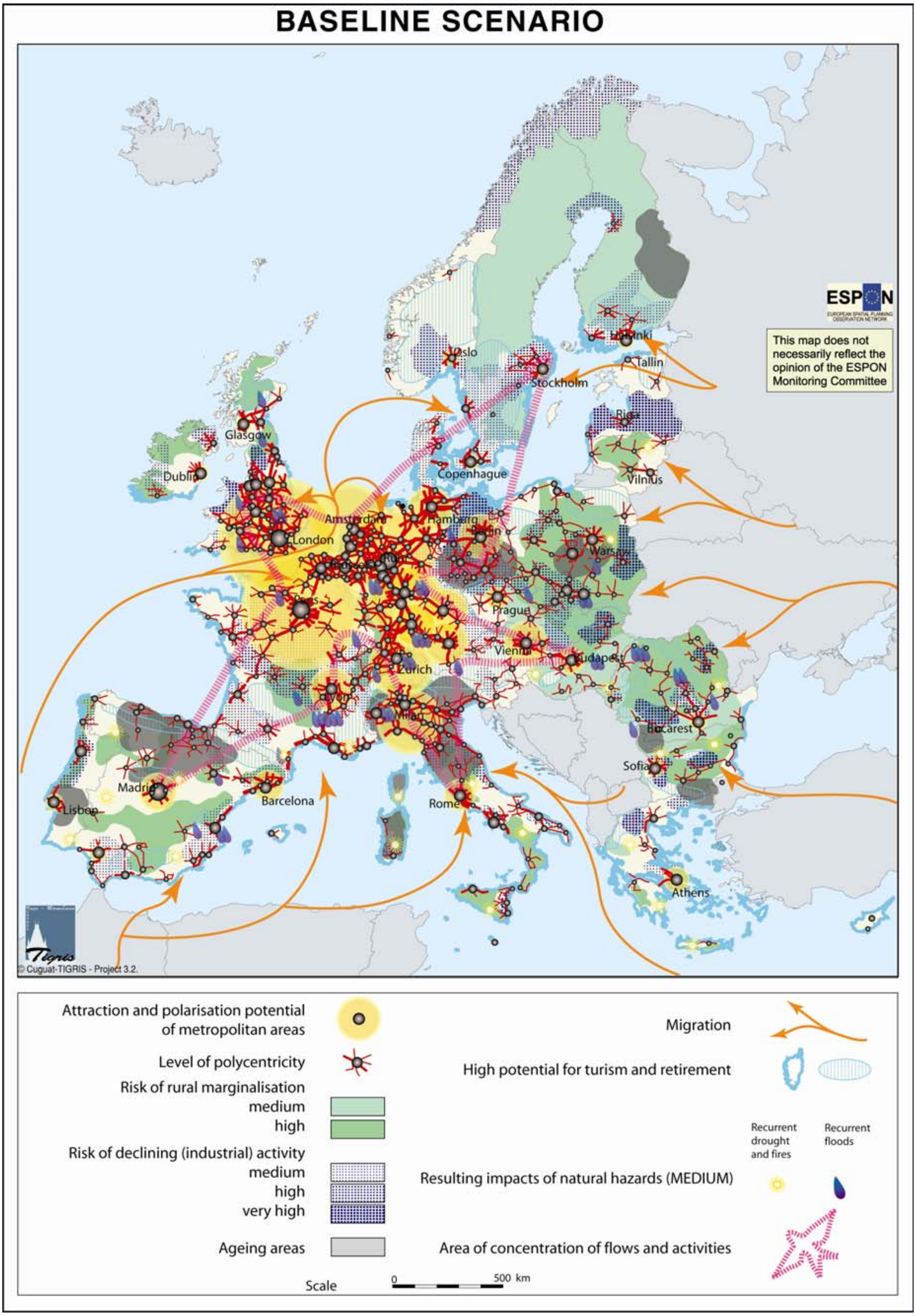

Figure 65 Almost final draft of the synthetic schematic map of the baseline scenario image 2030

7.4 The Knowledge and Communication Tool (K&C): experiments in the communication of visions and issues and in the dynamic visualisation of scenarios

It is said that we can not discover Europe, but invent it: Europe is a vision waiting to be somehow realized! In the ESPON 3.2 project different type of languages were used to express alternative visions for Europe to be realized in the 2015-2030 horizon. From fictional texts fantasying possible futures to tables and matrices containing figures related to new regional migrants or tons of CO2 emissions per square kilometer expected by 2030, from raster or thematic maps to interactive multimedia animations, from hand-made sketches to policy-oriented texts, and policy-oriented maps. The project was a laboratory where all kind of languages, scientific and artistic, were used, according to different purposes. A political vision, any scenario, needs a combination of all these languages to be expressed.

If something is common to all languages used in ESPON 3.2 is the need to represent dynamic evolutions, changes over time, rhythms. It is not a picture, or a photography of a particular moment, but the choreography of many interdependent factors what matters, and the patters behind. It is not just space but also *time*, what matters when imagining futures ahead. At the end, the *topos* of any non-utopian vision is made of space (where?) and time (when?). Including time evolutions in spatial analysis is the paramount challenge of ESPON3.2.

K+C website (now located at www.mcrit.com/scenarios) was designed to face this main question: how to visualise spatial dynamics in a scientifically sound and politically relevant way?. Complementary to this, K+C was also planned as a repository of reference materials used during the process of developing the project; in this respect, K+C has been designed a virtual laboratory.

K+C takes the outcomes of the SPESP group of infography as starting point, and goes an step ahead introducing dynamic and interactive visualisation for both scientific and artistic maps and images.

7.5 What's K+C website?

K +C is a library of scientific and artistic resources, useful to inspire European policy-makers and policy-analysts to imagine alternative futures for Europe. It contains all kind of interesting material produced during the ESPON 3.2 project, from prospective maps to databases, to multimedia animations, and references of regional and national prospective studies used as reference.

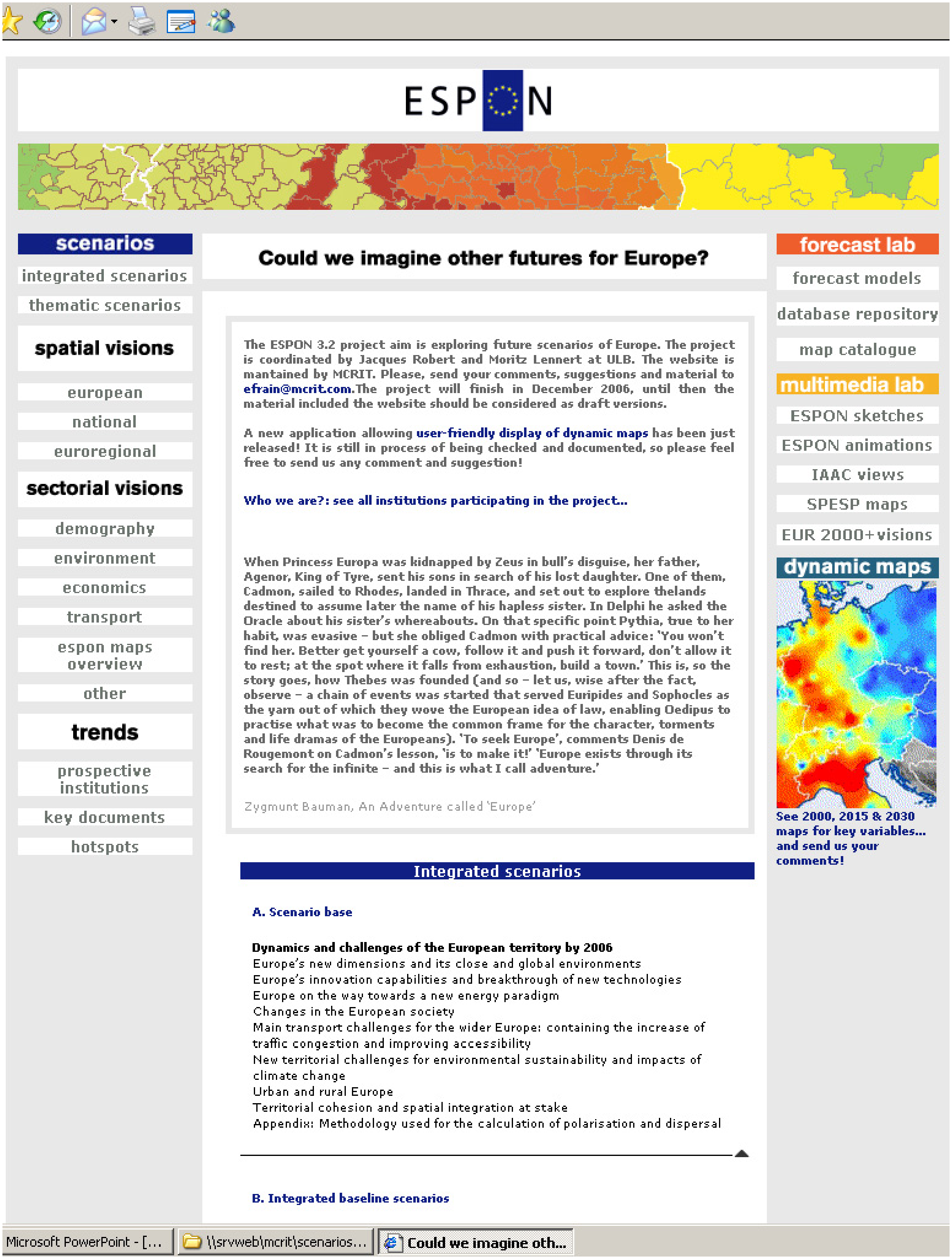

Figure 66 K+C website at www.mcrit.com/scenarios

All together, K&C website paramount aim is moving people to be more active and creative, and better informed, when imagining European futures.

It has two main components:

7.5.1 Knowledge resources

It contains materials used during the elaboration of the project:

- Reference prospective studies
- A selection of existing trends

As well as materials produced by the project:

- Texts and latest version of documents
- Database repositories: modelling results
- Map catalogue

This component aimed to be useful as a working laboratory for ESPON 3.2 partners during developing the project, and for the ESPON Community. Once the project be over, most of these materials will be checked and updated when useful, or removed otherwise.

7.5.2 Communication resources

These resources are the core of K + C website. The goal was to explore alternative technologies and design methods to represent dyamic changes.

- Interactive animations and sketches
- A user-friendly tool for dynamic map retrieval and visualisation programmed to present scenarios in a friendly understandable manner.

It also includes meaningful images produced in the last decades (from Europe 2000, Europe 2000+, ESDP, SPESP, ESPON...), as well as by the partners of ESPON3.2. In order to visualise the political-aims of each scenario, several infographic developments have been produced in the ESPON 3.2. From different options, the experience of Europe 2000 and Europe 2000 + was considered of great interest, in line with the previously SPESP approach mentioned. The political maps being designed are based on overimposing political symbols representing political aims to a geographic reference background that removes unncessary precision but still contains basic information concerning territorial dynamics, comming from the forecast models.

7.6 The need for dynamic visualisation of fuzzy maps on K+C

In future-oriented studies the minimum number of maps needed to explore a single variable (say CO2 emissions due to transport activities) is astonishing. Fourteen maps would be needed at least, in the context of ESPON 3.2, since there are three time horizons (2000, 2015, 2030) and three reference scenarios (baseline, pro-competition, pro-cohesion), and the variable has to be also anlysed in relative terms (its growth in relation to the previous time horizon, or in relation to other scenarios). Because the definition of the scenarios does not allow for revolutionary changes to happen within the time horizons, comparing absolute values often brings less interesting information that the relative ones.

When data needs to be displayed at different geographic levels (like CO2 that can be represented from raster cells of 1 km square to NUTS V, NUTS III or NUTS II), then the amount of interesting maps become enormous, not to speak about combining different thematic maps.

Software tools able carry on sophisticated statistical analysis to explore data without looking at maps is even more risky, time consuming and tedious process, in the ESPON3.2 context. There is no other solution that starting from analysing a minimum set of maps that contains maximum information (the fourteen maps mentioned for the ESPON 3.2), checking if they validate our hypothesis, or not, and establishing a dialogue with the map leading to change its design, the mathematic model producing the data mapped, or reformulating our hypothesis. In this respect, final maps have to reflect a sort of agreement between the analyst subjective intuitions and the model more objective outcomes. Mutual respect between the map and the map-maker is essential.

7.6.1 Dynamic visualisation of maps

Because ESPON 3.2 deals with the future of Europe, dynamic maps showing the evolution of a given variable are indispensable.

To allow for a dynamic visualisation, a new innovative web-based tool was developed in K+C to allow for a fast retrieval of the fourteen maps per variable, comparing map evolution through time periods or through scenarios in the same period.

The tool programmed in K+C for this purpose allows to display predesigned maps one by one or to display them dynamically at different speeds.

The user first to select an indicator from a list, then choose if it has to be displayed in absolute values or relative to the baseline scenario values, then decide the order or visualisation, if across scenarios (baseline, cohesion, competitive) or along time (2000, 2015, 2030). All legends are provided in a separate file.

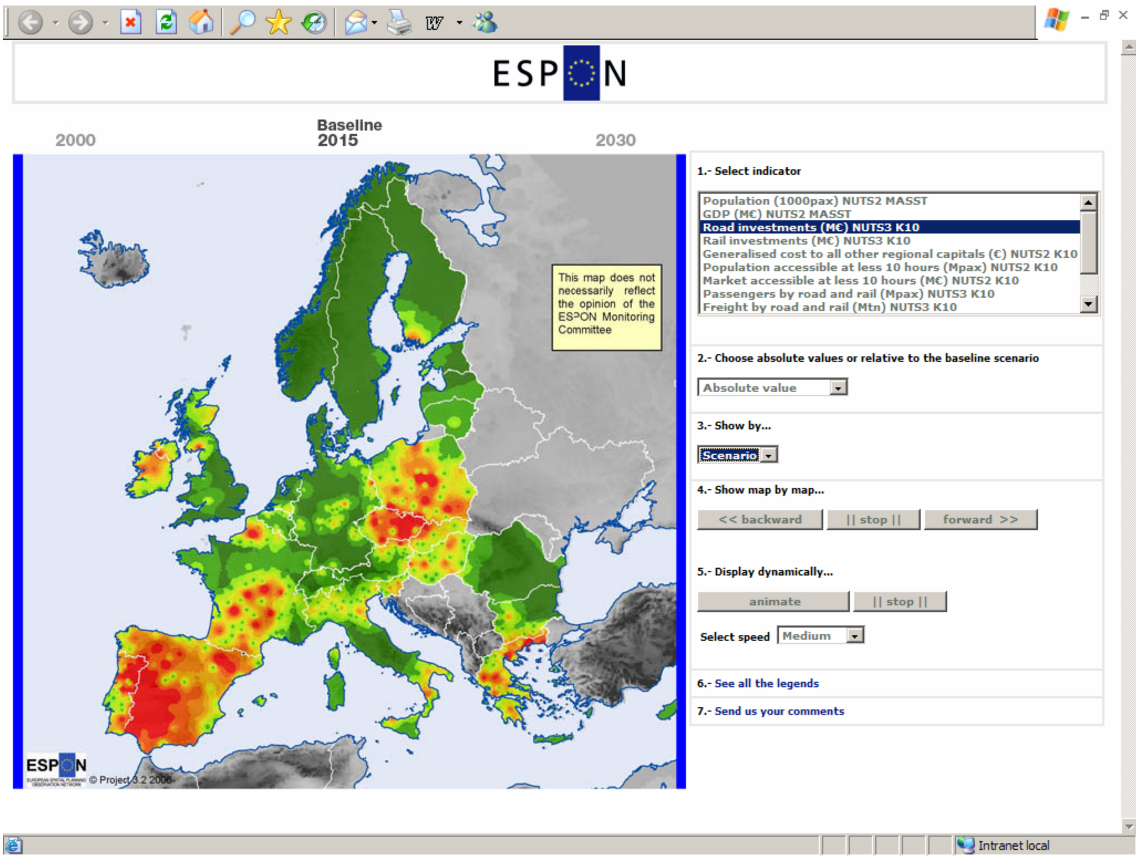

Figure 67 User-interface for dynamic visualisation of maps at www.mcrit.com/scenarios

The tool was designed in dynamic HTML and standard Java script, available in any Internet browser.

7.6.2 Fuzzy maps

All ESPON 3.2 maps were designed following consistent colour layouts and thresholds values in order to facilitate their comparison. Usually data is mapped changing the graphic attributes of the geographic elements where they are attached, for instance the GDP regional growth in 2015 can be mapped giving colours to NUTS II surfaces; maps designed this way have to classify regions into separate groups by using always arbitrary thresholds, in order to give one colour to each group. This may induce readers to read these groups or categories as actual classifications. When the goal of the map is just displaying the geographic pattern of a given variable, through time or through the territory, fuzzy maps are highly convenient since they avoid to classify entities, and focus the reading in the whole map.

On the other hand, for indicators such as emissions due to transport activities, fuzzy maps provide a more accurate visualisation of the source data, originally calculated for each transportation link, that provincial or regional aggregates.

One may argue that because of these reasons fuzzy maps are more useful in the case of studies such as ESPON, and therefore they were adopted as usual way to present results in ESPON 3.2.

7.7 Multimedia animations of Europe on K+C

A number of web-based multimedia animations have also been designed. They do not pretend neither to inform nor to educate, but just to move readers' awareness. The animations where designed in Macromedia Flash.

7.7.1 Animation of alternative views of Europe

- Europe as a city of cities
- Europe as network of networks (competitive globalization)
- Europe as country of countries (nationalistic cohesion)
- Back to nature (romantic environmentalism)
- Welcome to a digital Europe (innovative competitiveness)
- Europe as fortress (Europe just for Europeans)

Figure 68 Animations at www.mcrit.com/scenarios

7.7.2 Animation of key background questions:

- The world is changing as still you don't know...
- Do we understand Europe turbulent dynamics?
- Could we design alternative futures of Europe?
- Europe needs a single center?
- How we keep our cultural identity in a world of traffics?
- Could we control natural hazards?
- How many maps we need to represent Europe?

7.7.3 Animation of cross-border development strategies. Emerging new europes.

- Ryaneurope
- Novaistria
- Constant recombinations
- Agrospace

7.7.4 Animation of Europe 2000+ strategic maps:

- Western Mediterranean
- Central Mediterranean
- Atlantic Arc – Trend scenario
- Atlantic Arc – Prospective scenario

7.7.5 Animations of European from territorial patterns:

- Digits
- Cels
- Zones
- Nodes
- Bordes
- Flows
- Policies
- Landscapes

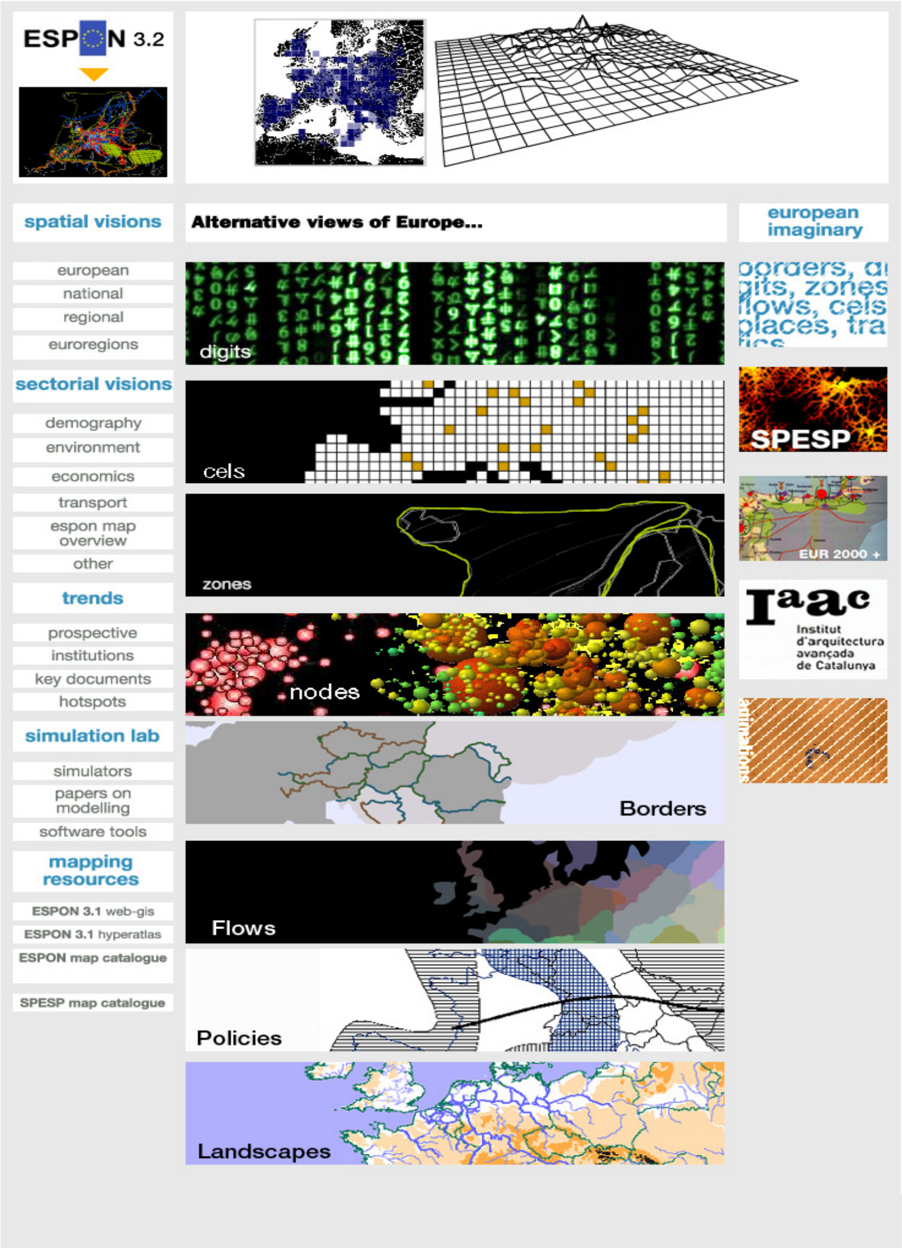

Figure 69 Animations at www.mcrit.com/scenarios

7.8 Final considerations: Give me the maps!

All considered, any method of representation involves a combination of scientific, artistic and political languages, each one better adapted to a different purpose: while scientists generate more and more rational questions, artists provide intuitive answers to rather unknown questions and politicians take decisions based on moral arguments.

Language...	**Purpose...**	**Domain...**	**Outcome...**
Scientific	Rational: As it is...	Reality	Previsions-measures
Artistic	Esthetic: As it could be...	Imaginary	Prospections-expressions
Political/Religious	Ethic: As it should be...	Symbolic	Norms

Confusion concerning to whom we are communicating, taking what role, and using which kind of language, is the primary source of misunderstanding. The merit of cleaver images is, then, to focus in meaningful questions, expressing relevant tensions and removing political conflicts when not necessary. We can consider as a reasonable goal knowing (and even controlling) the fundamental tension in any map; the goal is producing good enough maps to be scientifically reliable and politically relevant, able to move readers emotions and thoughts towards meaningful questions. This was the skill of ancient map makers, long before computers and satellites and Google-Earth was available to everybody.

Europe is an imaginary entity not attached to a well defined geography. This is way some maps, images and mind-catching illustrations have become political icons in Europe, from the *Iron Curtain* to the satellite image of the light from cities produced by NASA, the map of road traffic map firts produced by CEDRE, now by United Nations, or the once famous *Blue Banana*. These and other well-known images and illustrations have served as powerful tools for both shaping attitudes and moving opinions. Maps make explicit future opportunities and also old conflicts, agreements as well as disagreements, and therefore it is not surprising at all that the Spatial Development Committee failed to agree in which maps to include in the final European Spatial Development Prospective (ESDP) policy-document, for similar reasons that the Parliament of Europe failed to write a short text of European history, just a few pages to add to all national histories. While drafting histories and drawing maps, there are always important discussions going-on in parallel, concerning the CAP or the Structural Funds future allocation, for instance, and it is therefore understandable that policy-analysts and policy-makers become extremely sensitive to maps, images and mind-catching illustrations that may influence these discussions in unpredictable ways. This is why King Lear by saying *Give me the maps!*, opened up the Pandora Box, and the drama started.

8 Validation

Elaborating regionalised territorial scenarios for the whole of Europe is a very complex exercise and demands a lot of thematic and geographical expertise. It is impossible to concentrate all this expertise into one single project team. At the same time, in the ESPON context scenarios are only useful if they correspond to the actual needs of policy makers. In order to ensure that the scenarios correspond to the latest scientific knowledge, to the actual realities of different European (macro-)regions and to the needs of policy makers, the team embedded ifferent processes of validation into the scenario building.

8.1 The ESPON Monitoring Committee

While the intervention of external experts was to be sought at key stages of the development of scenarios, the role of the ESPON Monitoring Committee (MC) was, as the main stakeholder, intended from the start to be the most important source of validation in the process. Indeed their input has provided a fundamental and on-going guide in the actual development of scenarios and decisions about what should constitute their focus. Their input to the scenario building process was also appropriate as the MC are themselves senior officials from EU member states, as well as internationally renowned experts in subjects related to spatial development and planning. In the early stages, and then at key phases of the project, the MC members have acted essentially as experts to provide direction when important decisions have had to be made regarding for example the themes prioritised for attention. This was a constant process with discussions taking place at almost every MC meeting since the beginning of the project. MC members have also taken part in the discussions during the ESPON seminars, notably the regional validation session at the Manchester seminar and the discussion of the draft integrated scenarios in Salzburg.

In order to make the scenarios even more stakeholder-based, however, more intensive session, with more time, involving the MC would have been a plus to the project. However, given the functioning of the ESPON and of the MC, this was not possible.

8.2 Other ESPON expertise

To complement the advisory role played by the MC, the TPG has also sought specific regional expertise from a variety of sources. The sources targeted have varied in their productiveness. ESPON contact points have been approached, but their responses have been very limited. ESPON seminar participants have, by contrast, been utilized more effectively, perhaps because as a `captive audience' their attention was focused if for a short time on the scenarios and their application to individuals' regions and spheres of knowledge. Most productive in this context have been the general workshop on the thematic scenarios during the Luxembourg seminar in May 2005 and the four regional workshops held at the Manchester seminar in November 2005, as well as the workshops on the draft integrated scenarios in Salzburg. These both produced significant inputs and gave the scenario building process a transparency which has also been positive in terms of validation.

8.3 External validation

To complement the validation internal to ESPON, the team went through two more formal (albeit limited) external validation processes at two different stages of the project.

The first concerned the thematic scenarios in order to validate the scientific base of the assumption made in these scenarios. Experts were sought out according to their knowledge in a particular field and the scenarios sent to them together with a validation sheet. The return rate, however, was not as good as hoped for, due, amongst other elements, to the fact that these experts provided their help for no charge.

Those who did respond, however, provided valuable input which helped to strengthen the scenarios. In those cases where the 'official' expert did not respond, the respective teams tried to find other sources of validation, sometimes just calling or emailing other researchers.

The second external validation process concerned the regionalisation of the integrated scenarios. The team used the INTERREG IIIB regions as a basis for this regionalisation. For each region a TPG member from that region was chosen to provide the regionalisation. In those cases where more expertise was necessary, but also for those territories not covered (the island and ultraperipheral regions) an attempt was made to find outside support. In this case, the experts read a summary of the scenarios and their territorialisation applied to their respective region and sent in their comments. Three such experts provided their insights, a fourth unfortunately was not able to submit his comments on time.

Some indirect or informal validation also took place through the presentation of the scenarios at two Interract seminars and at several regional events (Belgium, France, Austria, Spain, Netherlands). At all of these events, feedback from the audience was encouraged and often proved helpful.