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Regionalisation of demographic and economic projections

Trend and convergence scenarios from 2015 to 2060

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Abstract
Territorial cohesion or territorial disparities? Two alternative scenarios for regional growth.
Demographic and economic projections are essential tools in many domains of policy making. They allow policymakers anticipating future trends and explore alternative scenarios, and provide the basis to assess impacts of policies. This report regionalises recently published EU reference demographic and economic projections from country to NUTS3 level. Two alternative scenarios have been used to carry out the regionalisation: 'trend' and 'convergence'. In the trend scenario recent observed growth rates continue, whereas in the convergence scenario less developed regions grow faster than more developed ones. While the trend scenario accentuates current territorial disparities generating more concentration of production and population, the convergence scenario promotes a more balanced growth and therefore more territorial cohesion.

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Executive summary

Demographic and economic projections for territorial impact assessment

Policy making in various fields relies nowadays on projections. Projections provide a description of how the future will unfold regarding one or more domains of reality. They are usually based on models which simulate real-world phenomena and expectations regarding the future.

The European Commission periodically releases long-term demographic and economic projections for the European Union Member States like, for example, the ones presented in *The 2015 Ageing Report*, produced by the Directorate General for Economic and Financial Affairs (DG ECFIN) and Eurostat (ESTAT). These 'reference' projections are produced with country-level detail and have been used, for example, to assess the economic and budgetary impacts of the ageing population. While country-level detail is sufficient for several applications, a range of other applications might benefit from projections with an enhanced geographical detail. This is particularly the case for policies with a strong territorial dimension such as the Cohesion Policy, rural development, migration, transport, urban environment and investment policies in general.

Evaluating regional growth scenarios: trend and convergence

The purpose of the work described in this report was two-fold. In the first instance, to downscale the original country level projections and show regional detail. Secondly, to apply two different regional growth scenarios — 'trend' and 'convergence' — to regionalise the reference projections in order to evaluate territorial cohesion in Europe and support discussions around the future of the Cohesion Policy. The set of regionalised variables includes GDP, employment and population.

The two scenarios correspond to two rather distinct future trajectories of regional growth. The **trend scenario** assumes that past sector growth rates will be maintained over time. Gross Value Added (GVA) and Employment per sector in each region is projected based on recently observed growth rates, which shift gradually to the national mean by 2035, after which only national sector growth rates are used. The variables are then rescaled to fit the national totals from the reference projections. The regional population scenario is taken directly from ESTAT, which assumes that key demographic parameters (fertility, mortality and migration rates) will be identical across Europe in 2150. Under this scenario, GDP per capita and GDP per employed person (productivity) are a consequence of the projected population, GDP and employment levels. This is a conservative scenario as no significant structural changes to the regional economies occur. As such, it can be used as a baseline scenario to support territorial impact assessment in various policy domains.

The **convergence scenario** assumes that growth rates will converge in the future, leading to more similar regional levels of GDP per capita and productivity in the long-run — a well-known process referred to as β-convergence. Under β-convergence conditions, the levels of GDP per capita in a given year are negatively correlated with the subsequent growth rates. Two β-convergence functions were calibrated empirically and applied to determine future growth rates of GDP per capita and productivity. If GDP per capita grows faster than productivity, employment grows, if not it shrinks. In turn, regional population levels are influenced by employment. The latter relationship is constructed around the assumption that the relative levels of employment within a country influence a region's attractiveness to population, thus generating internal population flows. A simplified diagram of the convergence model is shown in Figure 1. Like in the trend scenario, all variables are rescaled to fit the national totals from the reference projections.

Two alternative pathways for EU regional development

Both scenarios are constrained by the reference projections at national level, hence differences between the scenarios are limited to within-country variations. Despite this constraint, results from the two regionalised projections show significant differences in terms of future regional distribution of GDP, employment and population.

In the **trend scenario**, the regions that are currently most developed benefit the most. This results in further geographical concentration of production, employment and population. On the other hand, the **convergence scenario** promotes a more balanced economic growth, with less developed regions growing faster, generating more employment and attracting more inhabitants than in the trend scenario. The scenarios thus generate two distinct pathways for regional development, one in which existing EU disparities are exacerbated (trend scenario), and another in which more regional cohesion is attained (convergence scenario).

Figure 2 shows GDP per capita relative to EU average in 2010 and in 2060 in the trend and convergence scenarios. While the trend scenario essentially preserves the current geographical distribution of GDP per capita, the convergence scenario attains a much more balanced geographical distribution within countries, as well as between countries. It is remarkable, for instance, that regions with GDP per capita below 50 % of the EU average completely disappear in the convergence scenario, and that many other regions get closer to the EU average. This effect is particularly pronounced in all Eastern countries.

Informing the Cohesion Policy

If the trend scenario's assumptions held, one would expect additional pressure on Cohesion Policy, which would have to support a growing number of regions classified as 'less developed' according to the current classification scheme based on the distance to the average EU GDP per capita. On the contrary, the convergence scenario significantly improves the current situation, with a net total of 51 upgraded regions in the period 2015-2060, and 30 more regions classified as 'more developed' as compared to the trend scenario in 2060.

Contributing to further deepen the knowledge for territorial impact assessment

The work presented in this report aims at providing scientific support to the development of the Cohesion Policy and other policies with strong territorial dimension. It contributes to the knowledge base of the pilot **Knowledge Centre for Territorial Policies** that is being set up by the Directorates General Joint Research Centre (DG JRC) and Regional and Urban Policy (DG REGIO) of the European Commission.

The regionalised projections are being integrated in the Land Use-based Integrated Sustainability Assessment modelling platform — **LUISA** — for applications such as urban, transport and energy modelling, and the assessment of territorial cohesion. Future work involves the construction of a larger, integrated regional model, with an enhanced migration mechanism, the inclusion of determinants of growth, as well as a module to estimate demand for residential, industrial and commercial land uses, thereby establishing a more operational linkage with the dynamic spatial allocation module of LUISA.

Further specific work will continue exploring alternative options to regionalise EU reference projections, in particular by relaxing the national constraints. This will be particularly useful in order to test different convergence hypotheses. The relaxation of national constraints to simulate convergence scenarios will require the testing of conditional convergence schemes, where other growth factors and determinants are taken into account. In what concerns the trend scenario, the main focus will lie on the investigation of the impact of model structure on the herein achieved results.

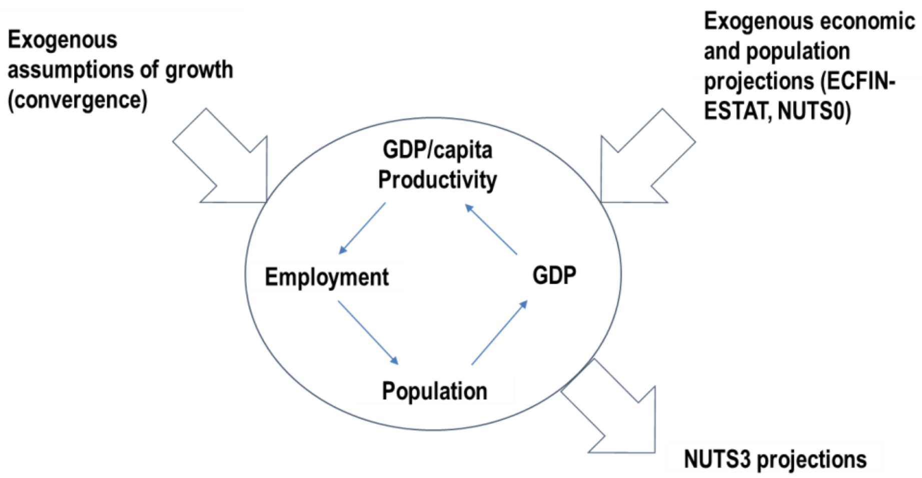

Figure 1. Simplified diagram of the convergence model.

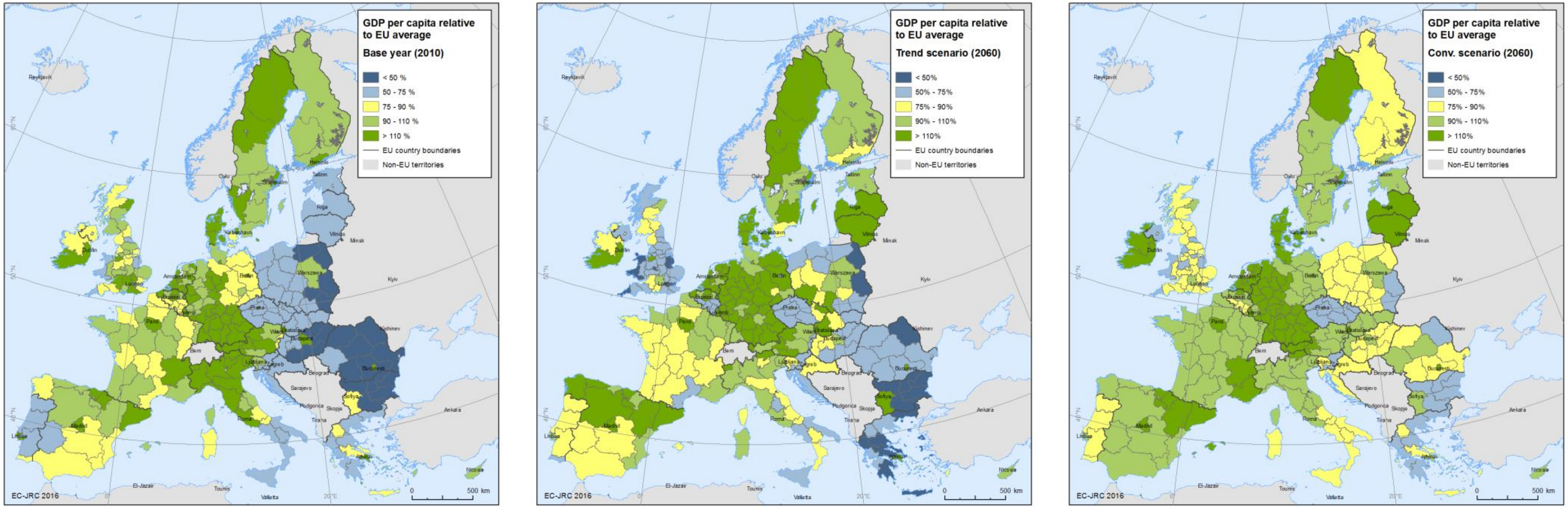

Figure 2. GDP per capita (PPS) relative to EU average in 2011 (left), and in 2060 in the trend scenario (centre) and in the convergence scenario (right), per NUTS2.

1. Introduction

1.1 Demographic and economic projections

Policy making at the European Commission in various fields relies nowadays on projections. Projections provide a description of how the future will unfold regarding one or more domains of reality, and are usually based on models which simulate real-world phenomena and expectations regarding the future.

Demographic and economic projections are especially important. In simple terms, demographic projections address the size and characteristics of population in the future, while economic projections address the economic growth and employment levels. In turn, demographic and economic projections are used as input to various analyses or models which can produce projections for other domains and which depend on the demographic and/or economic development. Indeed, demographic and economic projections are the basis or the starting point for modelling and projecting in all other domains that concern directly or depend on human activity. For example, future greenhouse gas emissions depend as much on technological options and advancements as on the size of population and economic output of specific economic sectors and activities. In turn, climate models use information on future greenhouse gases emissions to make predictions regarding future climate (e.g. temperature and precipitation). Finally, future precipitation and temperature levels may influence risk of droughts or floods which may affect the local population and economy. This illustrates that modelling sequences can be quite long and complex; that the very ultimate outputs are dependent on the models and assumptions used to project population and economy; and that often there are feedback mechanisms and interactions which can only be tackled in fully integrated modelling frameworks.

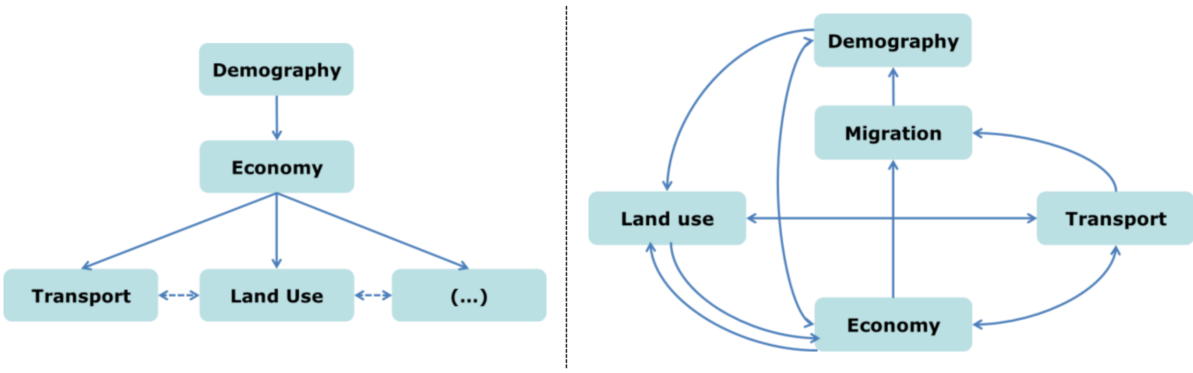

Figure 3. Two stylised model integration architectures as conceptualisations of reality.

Figure 3 illustrates that different architectures for modelling chains can be constructed to describe and model reality. The left part of Figure 3 represents a top-down, linear, sequential and compartmentalised approach which does not include feedback mechanisms. This is the most common architecture in current modelling integration practice. The right part of Figure 3 represents a nonlinear, recursive and integrated architecture. This is much more challenging to implement due to three main reasons: (1) difficulties in representing and modelling reciprocities between sectors; (2) difficulties in reconciling expert knowledge from various domains; (3) integration between models is technically challenging.

Demographic and economic projections can be either short or long term, and address anything from a single region or province to much larger geographical domains such as countries, continents or the entire world. Projections addressing large geographical domains may have different levels of spatial resolution, from macro world regions, to countries or even sub-national regions.

Services of the European Commission release periodically demographic and economic projections. Short-term economic projections are released twice a year, while long-term demographic and economic projections are released every 2 to 3 years. These projections typically cover the entire extent of the European Union with national detail (or sub-national detail in the case of some releases of demographic projections). Long-term demographic projections are produced by Eurostat, while long-term economic projections are produced by DG ECFIN together with the Economic Policy Committee at the request of the ECOFIN Council. These two sets of projections are tied because GDP depends on labour input which in turn depends on demographic developments. These projections have been used in the past, among other applications, to:

- Assess the economic and budgetary implications of ageing in Europe (EC, 2012; EC, 2015a);
- Create a EU reference scenario of greenhouse gas emissions in Europe from transport, energy and other sectors (EC, 2014a);
- Create an EU reference scenario of territorial impacts (land uses, population and accessibility) (Lavalle et al., 2016; Baranzelli et al., 2014).

1.2 Background and objectives of the work

DG REGIO manages the EU European Regional Development Fund and the Cohesion Fund, which together with the European Social Fund forms Regional or Cohesion Policy. Cohesion policy aims at kick-starting growth, employment, competitiveness and development on a sustainable basis with the ultimate goal of promoting economic, social and territorial cohesion within the European Union (EC, 2014b). For that reason, REGIO is particularly interested in demographic and economic data that describe the past and current situation in order to measure the social and economic performance of regions and therefore assess the results of the Regional Policy. But it also needs projections in order to foresee where action and of which type could be required in the future.

Because REGIO's domain of action is regions and urban areas, historical and projected data should be available at the highest spatial (i.e. regional) disaggregation possible. Currently, the European statistical system is organised to produce statistics for the NUTS zoning system, which can be described as a hierarchical system of territorial units for statistical purposes. The NUTS0 level corresponds to countries (28 countries in the EU currently), NUTS2 corresponds to regions within country (272 units) and NUTS3 corresponds to provinces or districts within regions (1 315 units). This system is also compatible with the LAU zoning system, referring to local administrative units, typically municipalities, communes or parishes (the lowest LAU level is composed of approximately 130 000 units). Each NUTS3 is composed of one or more LAU units, and each LAU unit belongs to a single NUTS3. The main population-related variables are available at the LAU level for the whole of the EU. An increasing number of countries disseminate population data at even lower aggregation levels, namely census tracts or high resolution grids (< 1 km x 1 km). Economic data are available at the sub-national level, i.e. NUTS2 and/or NUTS3. Projections for both demography and economy, however, are often only available at country level (NUTS0), and thus are a major limitation for foresight studies at the sub-national level.

The work herein presented was a joint collaboration between DG REGIO and DG JRC who envisaged a limited set of demographic and economic *regional* projections linked to the reference projections from Eurostat and ECFIN. The set of scenarios include (1) a 'central' or 'trend' scenario where recent observed growth rates continue, and which can be used as a baseline for territorial impact assessments at the European Commission, and (2) a 'convergence' scenario whereby territorial cohesion is materialised through the continuation of long-run catching-up processes by lagging regions — a process also referred as β-convergence in economic literature (Sala-i-Martin, 1996; Monfort, 2008).

The regionalisation relied on a historical series of the main socioeconomic variables. Data were initially gathered from the Eurostat online database and then gap-filled in order to achieve a complete and consistent historical series per NUTS3 covering the period 2000-2011. The final, concrete goal was to come up with two NUTS3-based projections, trend and convergence, covering the period 2015-2060 for three key socioeconomic variables: population, GDP and employment.

Down the line, it is also expected that achieved results and methods can be used to feed a broader discussion on the future of Cohesion policy, namely by:

- Envisaging possible trajectories of regional development;
- Supporting a debate on the desirable future spatial distribution of population, employment and economic activities.

From a methodological point of view, this work is also an opportunity to gradually shift from the modelling paradigm represented in Figure 3 (left), to a more recursive approach (right) where reciprocities between demography and economy are better represented, particularly by establishing economy as a driving force for migration. Current practice in demographic projections by Eurostat simply assumes that net migration tends to zero in the very long term (EC, 2015a). This work is also a step towards a greater integration of demographic, economic and land use dynamics within the LUISA modelling platform, which aims at providing integrated territorial impact assessments (Lavalle et al., 2016). LUISA projects sub-regional changes in land use and activities, and is thus highly sensitive to regional demographic and economic projections.

1.3 Scope and limitations of the results

The results presented in this report are highly experimental and exploratory in nature. The regional variability obtained in the various scenarios is derived from stylised 'what-if' assumptions regarding the vision of future regional development: in the case of the 'trend' scenario, past sector growth rates continue, resulting in less economic and territorial cohesion; in the case of the 'convergence' scenario, β-convergence occurs resulting in more economic and territorial cohesion. The results obtained cannot therefore be attributed any degree of likelihood or uncertainty. Instead, they intend solely to (1) demonstrate that there are ample pathways for regional development, and (2) grasp the consequences of those pathways for cohesion. In both scenarios, the results are, however, constrained by the national totals from the Eurostat and ECFIN projections, thus limiting the overall difference between scenarios.

The 'regionalisation' methodologies will be maintained and improved by JRC and REGIO, resulting in possible further revisions and/or updates of the scenarios and results. The data underlying these (or future) regionalisation exercises will initially support internal activities and discussions within the Commission and will eventually be disseminated for wider public use.

1.4 Structure of the report

Chapter 2 of this report describes the methodology used to construct the historical database and the projections for the two scenarios, trend and convergence. Details on the scenarios' assumptions are also described in the same chapter. Chapter 3 documents the results of the regionalised projections in the form of summary graphs and maps. Although NUTS3 is the base calculation unit, the NUTS2 regions were chosen as reporting units due to their higher policy relevance. Results will be analysed at different scales: EU, country and regional levels, with focus on three types of regions: 'more developed', 'transition' and 'less developed'. Chapter 4 wraps-up the main conclusions and limitations of the work done and points towards future work.

2. Methodology

2.1 Overview

The term 'regionalisation' is used in this report to refer to the process of obtaining regional figures of demography and economy from reference projections available at the national level. In the case of this work specifically, the target spatial units are NUTS3 regions. The regionalisation is technically achieved by 'disaggregating' a given total figure per country amongst the NUTS3 regions which compose it. This process is also commonly referred to as 'downscaling'.

The disaggregation or downscaling is necessarily governed by different assumptions or calculation rules ([1]). A simple calculation rule would be, for example, to keep observed regional shares constant through time. Such an assumption however would be meaningless from a Regional Policy perspective as it simply replicates the status quo of a given observed moment in time by keeping the regional variability constant, thus ignoring ongoing or expected processes of divergence/convergence of regions.

In the exercise carried out, two different scenarios have been designed, the 'trend' and the 'convergence'. The trend scenario assumes that past sector growth rates continue over time. It is essentially a business-as-usual approach without any changes to the course of recently observed trends. For that reason it could be used as a baseline scenario for territorial impact assessments. On the other hand, the convergence scenario assumes that growth rates will continue to converge in the future, leading to more similar levels of wealth per capita and productivity — a well-known and widely described process usually referred to as β-convergence (Sala-i-Martin, 1996, Monfort, 2008, Montresor et al., 2011).

The regionalisation exercise relied on two main data inputs:

- Historical database containing basic demographic and economic variables at NUTS3 covering the period 2000-2011 (based on Eurostat data) and;
- Reference projections at national level from Eurostat ('Europop 2013' demographic projections) and ECFIN (macroeconomic projections). The demographic projections from Eurostat were also available at NUTS3 level, and these were used in the trend scenario exclusively.

Section 2.2 provides additional detail on these two data inputs. The scenarios define the calculation rules for the disaggregation from national (NUTS0) to regional level (NUTS3). The outputs are a set of variables available for the period 2015-2060, in 5-year intervals: total population, GDP, employment, GDP per capita (GDP/population) and productivity (GDP/employment). A simple diagram representing the regionalisation workflow is shown in Figure 4.

([1]) More precisely, a calculation rule for a disaggregation embodies necessarily one or more assumptions regarding the regional distribution of a given national total figure.

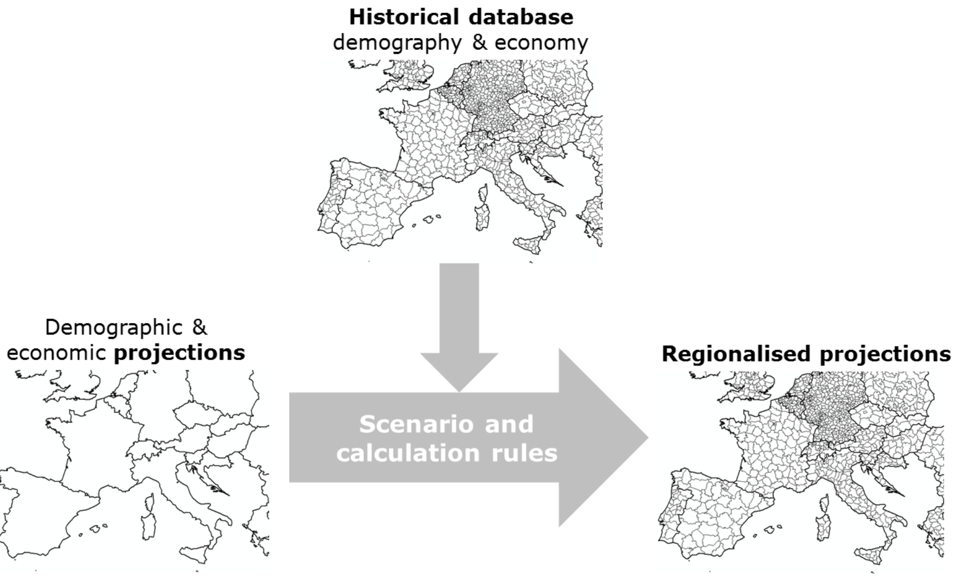

Figure 4. Regionalisation workflow.

The general workflow behind the regionalisation consists of the following steps:

1. Build a historical data series of GVA (or GDP or employment or population) at NUTS3 level, 2000-2011;
2. Extrapolate GVA (or GDP or employment or population] at NUTS3 level for the years 2015-2060 (in 5-year intervals) using a scenario-specific mechanism:
    - In the trend scenario observed regional- and sector-specific growth rates in the period 2000-2011 are applied. Population is taken directly from Eurostat's projections at NUTS3 level;
    - In the convergence scenario growth rates for GDP per capita and for productivity converge over time using a β-convergence function. Population changes as function of total employment;
3. Total GVA (or GDP or employment or population) obtained in the previous step for each region is rescaled in order to respect the country totals from the reference projections.

Two additional remarks regarding the regional projections of GVA:

1. The rescaling step involves the transformation from GVA to GDP, as the reference macroeconomic projections address GDP only. Given the very high correlation between total GVA and GDP (≈ 1) ([2]), this straightforward conversion is considered admissible.
2. The regional projections of GDP are expressed in both constant EUR and PPS of 2005. Constant prices in EUR remove the effect of price inflation over time, while prices in PPS correct of the purchasing power differences geographically across Europe. PPS is an artificial currency used in Europe for statistical and analytical

([2]) GDP = GVA + taxes on products — subsidies on products.

purposes. In theory one unit of PPS can buy the same amount of goods and services across all regions within Europe. For this reason, PPS units are especially convenient for comparing GDP per capita between countries. The conversion from Euros to PPS is done by dividing Euros by a correction factor called purchasing power parities (PPPs). PPPs reflect price differences across countries, and are derived from the comparison of prices of products in different countries ([3]). The PPP value for the EU-28 in 2005 is 1. If a given country has a PPP of 1.15 in the same year, it means that prices are on average 15 % higher than the EU-28 average. Series of past PPPs are calculated and provided by Eurostat. The extrapolation of PPPs into the future was required in order to convert projected GDP in constant EUR to PPS. The extrapolation was based on a long time series of PPP (1995-2013) that shows high linearity for all countries (high r-square).

2.2 Main data inputs

2.2.1 Historical database

The regionalisation exercise relied on a historical data series of the main demographic and economic variables. The data were initially extracted from Eurostat's online database ([4]). The first task consisted of filling the gaps in the database in order to make it complete. The methods used to fill the gaps were interpolations and extrapolations whenever required, and/or resort to alternative data sources, namely online databases from national statistical offices. The most incomplete datasets were Gross Value Added per sector, followed by Employment per sector. GVA and GDP figures were transformed to constant prices (chain linked volumes, 2005) using sector specific deflators also available from Eurostat. The table below summarises the content and characteristics of the compiled historical database.

Table 1. Contents and characteristics of the demographic and economic historical database.

Variable	Unit	Sectors (NACE rev.2)	System of accounts	Temporal span	Regional breakdown
GVA	Million Euro in current prices and constant prices (2005)	6 sectors (A, B-E, F, G-J, K-N, O-U)	ESA95	2000-2011	NUTS3
Employment	No of employed persons (thousands)	6 sectors (A, B-E, F, G-J, K-N, O-U)	ESA95	2000-2011	NUTS3
GDP	Million Euro in current prices and constant prices (2005)	Not applicable	ESA95	2000-2011	NUTS3
Population	No. of residents	Not applicable	Not applicable	2000-2013	NUTS3

([3]) For definitions of PPS and PPP, consult the OECD Glossary of Statistical Terms, https://stats.oecd.org/glossary.

([4]) Extraction date: January 2015.

2.2.2 Reference projections

Although various sources of long-term projections are currently available from international organisations, the Europop 2013 demographic projections from Eurostat and the macroeconomic projections from ECFIN have been used as the reference projections in the regionalisation exercise in order to keep full consistency with the official data and assumptions currently in use at the EC. Both projections have been published in the EC's *The 2015 Ageing Report* (EC, 2015a) and can also been found online ([5]).

When they were first released in March 2014, Europop 2013 projections had a spatial breakdown of NUTS0 and covered all the EU-28 countries plus Iceland, Norway and Switzerland. During 2015 Eurostat released a regionalised version of the same projections down to the NUTS2 and NUTS3 levels. These projections also include gender and age breakdowns. The main underlying assumptions regard fertility and mortality rates, life expectancy and net migration. These key demographic determinants were assumed to converge over the very long run. According to the authors,

> *setting the year of convergence very far into the future has the advantage of taking due account of recent trends and developments in the beginning of the period, while at the same time assuming a degree of convergence over the very long-term in terms of demographic drivers* (EC, 2015a).

The macroeconomic projections relied on Europop 2013, and were produced and released with a NUTS0 breakdown. The main projected variables include GDP, employment, productivity and labour force. The economic structure, or sector composition of national economies, is not projected. Assumptions concerning, for example, participation rate (which determined labour input) and productivity growth have been used to generate the macroeconomic projections. The link between the Eurostat's demographic and ECFIN's economic projections is strong:

> *To project GDP growth over the long-term, a production function framework is used. In this framework, demographic projections are crucial for the projection exercise of economic and budgetary developments over the long-term. Indeed, the assumptions used for the population projections have a profound impact on projections for the labour force and thus for economic growth. In addition to assumptions for the population projections, it is necessary to make some specific statistical assumptions regarding long-run developments in each of the growth components. This framework enables looking at the drivers of labour productivity growth (namely total factor productivity and the capital stock per worker)* (EC, 2015b).

Both sets of projections cover the period 2015-2060. Figure 5 shows that European GDP is projected to almost double in the period 2015-2060, with a compound annual growth rate of 1.45 %. However, as Figure 6 shows, growth rates vary significantly between countries, but remain highly positive in all cases. Projected EU population and

([5]) http://ec.europa.eu/economy_finance/publications/european_economy/2015/ee3_en.htm employment do not to show dramatic changes until 2060 (Figure 5). The main trends regarding population and employment are summarised below:

> *The overall size of the population is projected to be slightly larger by 2060 but much older than it is now. The EU population is projected to increase (from 507 million in 2013) up to 2050 by almost 5 %, when it will peak (at 526 million) and will thereafter decline slowly (to 523 million in 2060). This increase would however not be the case without the projected inward migration flows to the EU. There are wide differences in population trends until 2060 across Member States* (Figure 7)*. While the EU population as a whole would be larger in 2060 compared to 2013, decreases of the total population are projected for about half of the EU Member States (BG, DE, EE, EL, ES, HR, LV, LT, HU, PL, PT, RO, SI and SK). For the other Member States (BE, CZ, DK, IE, FR, IT, CY, LU, MT, NL, AT, FI, SE and UK) an increase is projected.*
>
> *[…]*
>
> *The projections show that employment (aged 20-64) will peak at 215 million in 2022, and after that fall to 202 million in 2060. This implies a decline of about 9 million workers over the period 2013 to 2060. The negative prospects stemming from the rapid ageing of the population, will only be partly offset by the increase in (female and older workers) participation rates migration inflows and the assumed decline in structural unemployment, leading to a reduction in the number of people employed during the period 2023 to 2060 (13 million).* (EC, 2015a)

Given the projected GDP growth and relative steadiness of total population and employment, GDP per capita and productivity will grow at a pace similar to GDP.

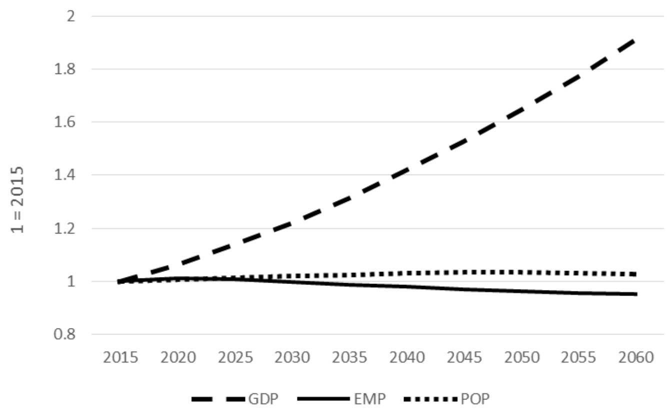

Figure 5. Overall trends for GDP, employment and population in the EU, 2015-2060.

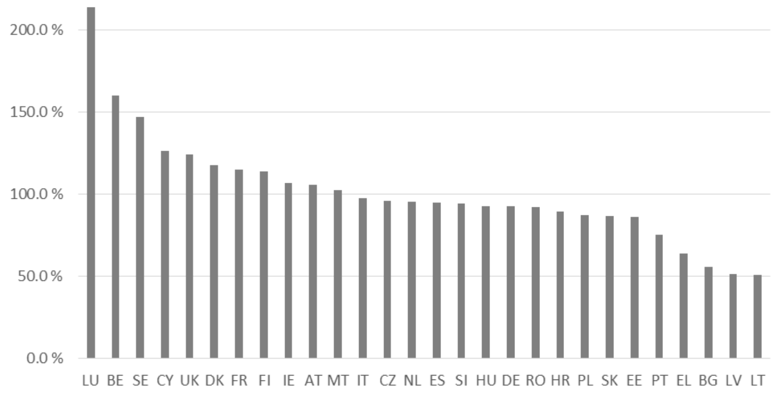

Figure 6. Growth in GDP per country, 2015-2060.

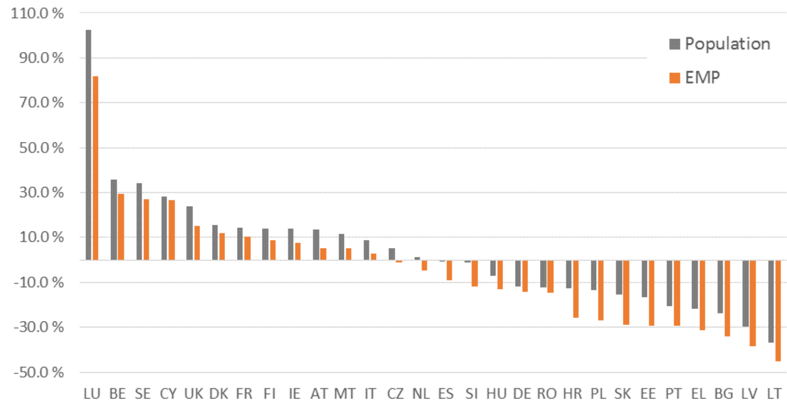

Figure 7. Growth in Population and Employment per country, 2015-2060.

2.3 Scenarios

2.3.1 Trend scenario

The trend scenario is essentially a business-as-usual situation whereby past regional and sector growth rates continue over time. The downscaling of each variable is operated independently which means that they do not influence each other. The resulting GDP per head and productivity, as well as the employment to population ratio, are therefore a consequence, not a driver, of the downscaling under this scenario's conditions.

Total population per NUTS3 was taken directly from Eurostat ([6]). By using regionalised population data from Eurostat we ensure the highest possible compatibility with the assumptions used at the Commission — a key requirement for the trend scenario. In order to downscale GDP and employment following a trend logic, three possible approaches were considered:

a) Past regional sector growth rates continue;

b) Past national sector growth rates continue;

([6]) Extraction date: January 2016.

c) A combination of the two above, whereby past regional sector growth rates converge linearly to national sector growth rates in a given moment in time.

Option a) assumes that regional sector growth rates observed in the period 2000-2011 continue over the subsequent period of nearly 50 years. This can be considered farfetched and would strongly exacerbate regional disparities. Option b), on the contrary, assumes that regional sector growth rates in the future will be the same as the national sector growth rates in the observation period, thus keeping regional variance stable over time. However, there are no reasons to assume that regional sector growth rates will suddenly switch to the national sector growth rates. This leads to option c) which combines the two previous approaches. Option c) assumes that sectors in regions will experience growth rates similar to previous years but only at the beginning of the projection. This assumption weakens with time due to increased uncertainty regarding future growth rates. Such uncertainty is addressed by assuming that regional sector growth rates gradually shift to the observed national sector growth rates in the period 2000-2011. In this exercise, from 2035 onwards each sector grows at the same pace in all regions within each country, thus keeping regional variance stable from that point in time. It must be noted that option c) is as speculative as any 'what-if' assumption, but it has been preferred because it follows a trend logic without generating too extreme outcomes.

In practice, option c) is governed by a simple weight matrix which defines the relative weights to be applied to regional and national sector growth rates (Table 2). Future growth rate g' for a time interval Δt in region r and sector s is determined by equation 1,

$$g'_{\Delta t,r,s} = (g_{r,s} * regw_{\Delta t}) + (g_{c,s} * natw_{\Delta t}), \text{ with } natw_{\Delta t} = 1 - regw_{\Delta t} \qquad \text{eq. 1}$$

where g refers to observed compound growth rates in the period 2000-2011, regw is the regional weight, natw is the national weight, and the subscripts r and c refer to region and country, respectively. Equation 2 shows how regional sector GVA is projected.

$$GVA_{t+n,r,s} = GVA_{t,r,s} * (1 + g'_{\Delta t,r,s})^n, \text{ with } t+n \in \Delta t \qquad \text{eq. 2}$$

where t refers to the base year 2011 and n is a number of additional years in the future. After obtaining GVA for each region and sector for t+n, the values are rescaled so to match national GDP totals from the reference projections (equation 3).

$$GDP_{t+n,r} = GDP_{t+n,c} * (\Sigma_s GVA_{t+n,r,s} / \Sigma_r \Sigma_s GVA_{t+n,r,s}), \text{ with } r \in c \qquad \text{eq. 3}$$

The same procedure (equations 1 to 3) is applied to regionalise employment in the trend scenario.

Table 2. System of weights for regional and national growth rates in the trend scenario.

	Δt=2011-20	Δt=2020-25	Δt=2025-30	Δt=2030-35	Δt=2035-60
Regional weights (regw)	1	0.75	0.5	0.25	0
National weights (natw = 1 - regw)	0	0.25	0.5	0.75	1

Figures 8 and 9 show the distribution of average annual factor growth rates per sector at country and NUTS3 levels in the period 2000-2011 for GVA and employment, respectively. There is high variability in the distribution of sector growth rates particularly at NUTS3 level for both GVA and employment. These growth rates drive the trend scenario, leading to different regional growth paths until 2035.

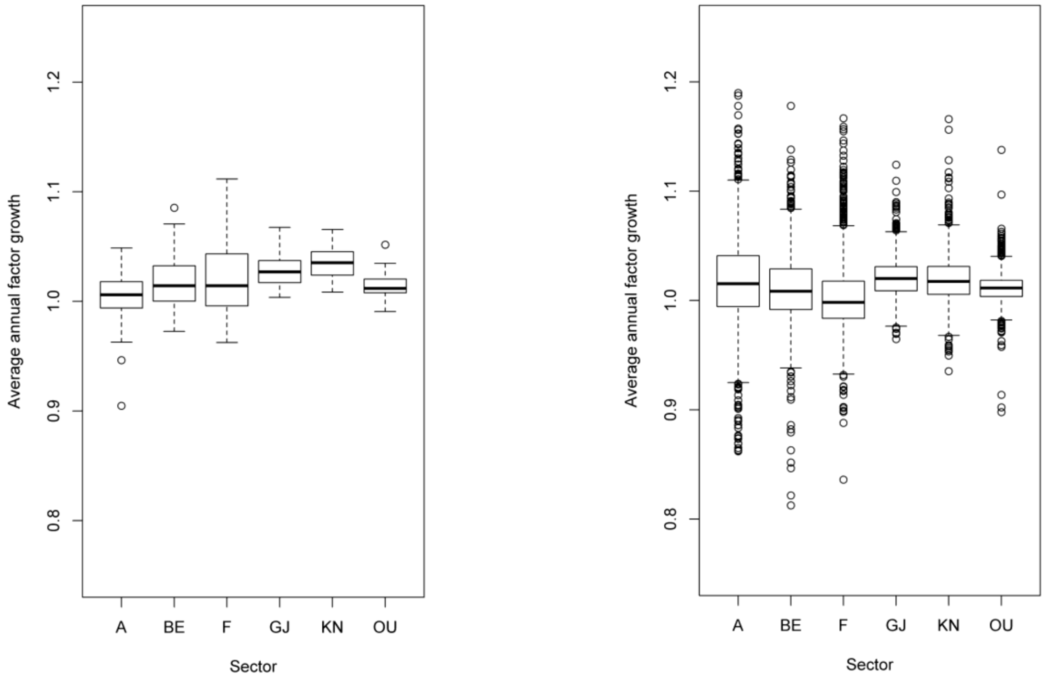

Figure 8. Distribution of GVA average annual factor growth rates at country (left) and NUTS3 (right) levels in the period 2000-2011.

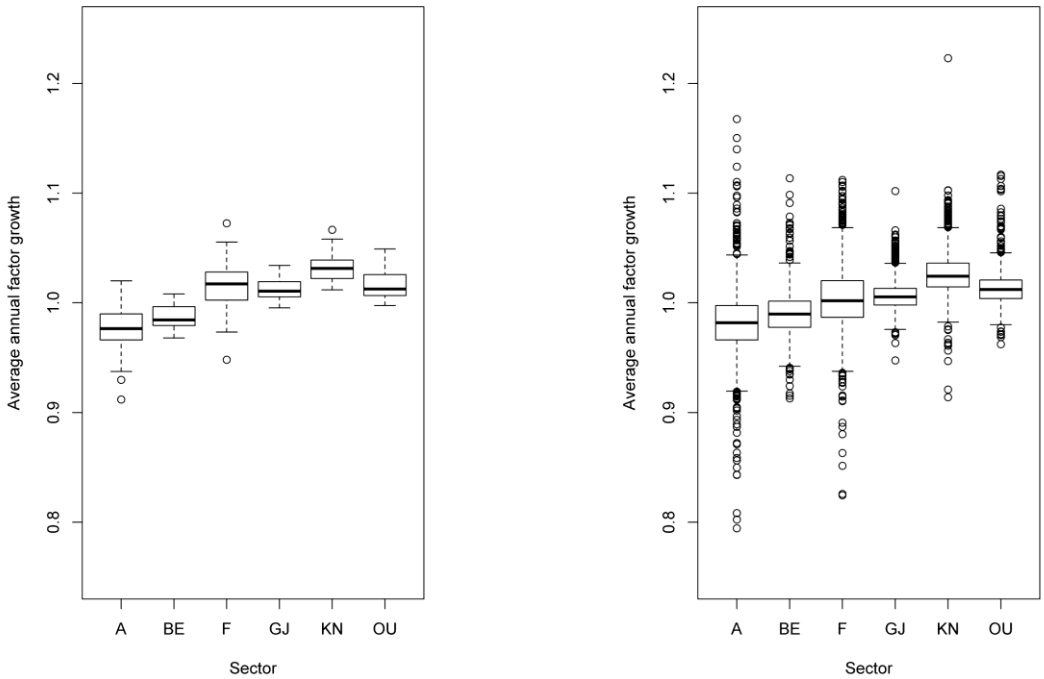

Figure 9. Distribution of employment average annual factor growth rates at country (left) and NUTS3 (right) levels in the period 2000-2011.

2.3.2 Convergence scenario

The convergence scenario assumes that levels of GDP per capita (GDPcap) and productivity (GDP per employed person or worker, P) converge over time. In practice, this means that:

- Lower income regions (lower GDPcap) experience higher GDPcap growth than higher income regions and;
- Less productive regions (lower GDP per worker) experience higher productivity growth than more productive regions.

The behaviour whereby lagging economies grow at faster paces than wealthier ones has been observed and documented in Europe (Monfort, 2008; Montresor et al., 2011; Forgó and Jevcák, 2015) and elsewhere, and may occur both between countries, between regions, or even within an economy (Sala-i-Martin, 1996). In economic growth literature, this is often referred as β-convergence, a concept introduced by Barro and Sala-i-Martin (1992), and is directly related to the so-called 'catch-up' effect (Abromovitz, 1986). One reason to expect catch-up is, according to the *The Economist* economics glossary, 'that workers in poor countries have little access to capital, so their productivity is often low. Increasing the amount of capital at their disposal by only a small amount can produce huge gains in productivity. Countries with lots of capital, and as a result higher levels of productivity, would enjoy a much smaller gain from a similar increase in capital' ([7]). Convergence of productivity levels in Europe has also been studied and observed by various authors (see, for example, studies by Montresor et al, 2015; Moura e Sa Cardoso and Ravishankar, 2015).

However, the pace of convergence is not constant. In fact, there could be periods of fast convergence, slow convergence and even divergence (Korotayev and Zinkina, 2014; Korotayev et al., 2015). Moreover, different types of β-convergence have been identified: absolute or unconditional, conditional and club convergence. When all economies are assumed to converge towards the same steady-state (in terms of GDP per capita and growth rate), β-convergence is said to be absolute or unconditional. Conditional convergence emphasises that growth is determined in great part by intrinsic and structural characteristics of the economies and the countries' institutions, which vary even in the long run. As a result, economies converge to different steady states. According to Abramovitz (1986), the ability to absorb new technology, attract capital and participate in the global markets are key conditions to trigger catch-up processes of economies. The degree to which economies fulfil these conditions may determine the speed of convergence towards their steady-state. Finally, we may refer to club convergence when groups of economies converge to similar steady-states because they portray structural similarities. In this sense, club convergence can be seen as a form of conditional convergence. In recent years there has been considerable debate about the extent and speed of convergence in reality. Thorough reviews of the debate have been published, for example, by Islam (2003) and Eckey and Türck (2006).

([7]) Extracted from the definition of the catch-up effect, from *The Economist* (http://www.economist.com/economics-a-to-z/, consulted in March 2016).

β-convergence functions capture the pace of converge, and can be estimated by regressing growth rates of GDPcap or productivity against initial levels of GDPcap or productivity (Monfort 2008). For the purpose of this work, equations 4 and 5 have been used to calculate projected annual growth rates of GDPcap and productivity, respectively:

$$1/n \log(GDPcap_{t+n}/GDPcap_{t}) = \alpha + \beta * \log(GDPcap_{t}) \qquad \text{eq. 4}$$

$$1/n \log(P_{t+n}/P_{t}) = \alpha + \beta * \log(P_{t}) \qquad \text{eq. 5}$$

In the equations above, t is a given initial year, n is the subsequent number of years, P stands for productivity, and α and β are the coefficients. The equations have been estimated by the ordinary least squares (OLS) method using EU country data for the period 1995-2013. Therefore, in these equations, growth of GDPcap is a function of the initial levels of GDPcap in 1995, whereas growth in productivity is a function of the initial productivity levels in 1995. The estimated β coefficients for both equations are negative, as expected in a β-convergence situation. The results are documented in Figure 10, showing a good fit.

The convergence scenario, thus, assumes that the β-convergence observed in the period 1995-2013 ([8]) amongst EU countries continues throughout the projection period. The equations reflect as well a situation of unconditional convergence, as no other growth determinants are factored in. The option for unconditional convergence functions was found appropriate given the imposed national constraints, as many of the conditions for convergence are relevant only at country level anyway.

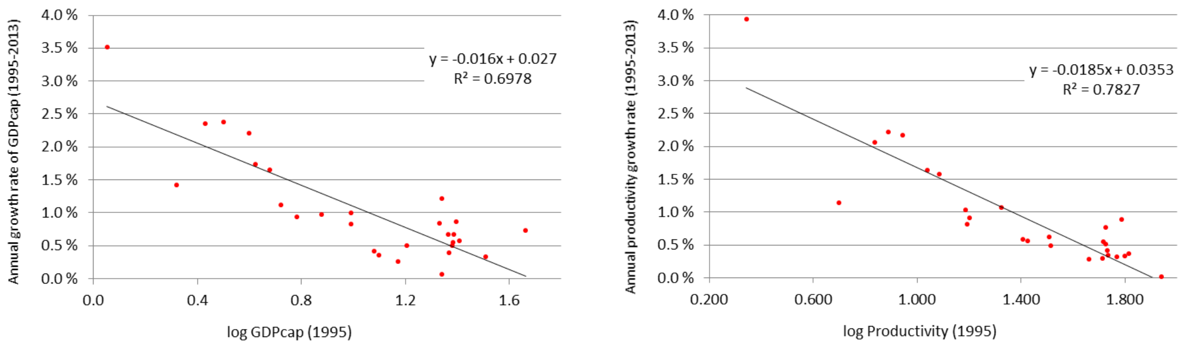

Figure 10. Convergence functions for GDP per capita and productivity growth.

It is further assumed that employment grows as a function of the ratio between GDPcap growth and productivity growth, as in equation 6, where E′ denotes projected employment before rescaling.

$$E'_{t+n,r} = E_{t,r} * [(GDPcap_{t+n,r} / GDPcap_{t,r}) / (P_{t+n,r} / P_{t,r})] \qquad \text{eq. 6}$$

([8]) The longest available country-level data series to assess convergence.

If population did not change, then the ratio between GDPcap growth and productivity growth would be identical to employment growth (9). Therefore, population change is the only source of variation in eq. 6. If GDPcap growth is faster than productivity growth, employment change will be faster than population change. However, if population change is negative, employment change can be negative (just not as negative). If productivity growth is faster than GDPcap, employment change will be slower than population change. However, if population growth is positive, employment change can still be positive (just not as big).

The relationship established in equation 6 is supported by empirical data. Figure 11 shows a scatter plot built upon historical NUTS3 level data, with employment growth factor on the yy axis (10) and the ratio between GDPcap and productivity growth factors on the xx axis (11). The figure shows clearly that impacts in employment are proportional to the ratio between GDPcap growth and productivity growth. When GDPcap grows faster than productivity, the impact on employment is positive. A possible explanation is that higher increases in GDPcap generate extra demand in the economy which eventually translates into additional employment. Conversely, when productivity grows faster than GDPcap employment decreases. This could be linked to two possible reasons. Regions with economic recession have less demand than the current capacity of the economy, which eventually translates into reduced employment. Another reason could be economic restructuring, specialisation, automation and innovation processes, which often could be associated with decreases in employment.

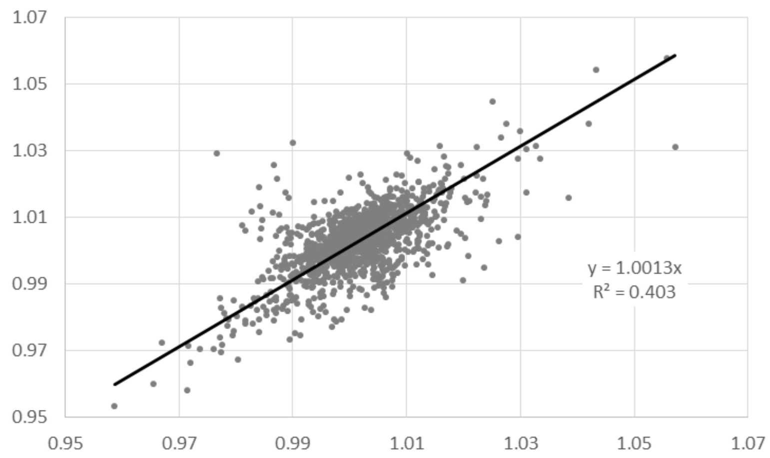

Figure 11. Relationship between employment growth factor (yy) and the ratio between GDPcap and productivity growth factors (xx).

In fact the convergence scenario could lead to loss of employment and population even in some lagging-behind regions, depending on their level of productivity and GDP per capita. Regions where productivity is lagging behind considerably may converge more

---

(9) $(GDPcap_{t+n,r} / GDPcap_{t,r}) / (P_{t+n,r} / P_{t,r}) =$
$[(GDP_{t+n,r} / Pop_{t,r}) / (GDP_{t,r} / Pop_{t,r})] / [(GDP_{t+n,r} / EMP_{t+n,r}) / (GDP_{t,r} / EMP_{t,r})] =$
$[(GDP_{t+n,r} / GDP_{t,r})] / [(GDP_{t+n,r} / GDP_{t,r}) / (EMP_{t+n,r} / EMP_{t,r})] =$
$1 / (EMP_{t+n,r} / EMP_{t,r}) = EMP_{t+n,r} / EMP_{t,r}$

(10) Calculated as $E_{t=2011}/E_{t=2000}$.

(11) Calculated as $[(GDPcap_{t=2011}/GDPcap_{t=2000}) / (P_{t=2011}/P_{t=2000})]^{(1/(2011-2000))}$.

quickly in terms of productivity than in terms of GDPcap, leading to employment decrease. This could reflect a process of, for example, jobs shifting from subsistence agriculture to more productive sectors inside and/or outside the region.

Regional population is a function of total employment in regions. The higher the employment in regions the more attractive is the region to population. The mechanism is defined in eq. 7 allowing, in practice, migration of population driven by job opportunities:

$$Pop'_{t+n,r} = E_{t+n,r} / R'_{t+n,r} \qquad \text{eq. 7}$$

where Pop' stands for population (before rescaling), E is employment and R' is the ratio between employees and population (E/P), and r is a NUTS3 region. At this point, the actual ratio between employees and population in each region in t+n ('true' R) is unknown, so R' is an approximation of R by assuming it follows the national trend as determined by the reference projections (eq. 8):

$$R'_{t+n,r} = (E_{t,r} / Pop_{t,r}) * [(E_{t+n,c} / Pop_{t+n,c}) / (E_{t,c} / Pop_{t,c})], \text{ with } r \in c \qquad \text{eq. 8}$$

Employment and population for t+n in country c is given by the reference projections at national level (Eurostat) described in Section 2.2.2. Structural differences in R across regions within a country are kept constant throughout the simulation, i.e. variance of R is kept constant (see Figure 12). Figure 13 shows the statistical distribution of R in Europe per NUTS3 in 2010, with a median of ≈ 0.42. A R value of 0.42 signifies that there are circa 2.4 inhabitants for each employed person. Regions scoring abnormally high R ratios (e.g. R > 0.6) are likely regions which receive large influxes of workers residing in neighbouring regions. Regions with very low R could be associated with high unemployment rates and/or low active population and/or low participation rate or regions with high level of commuting to jobs in a neighbouring region.

After determining GDPcap', E and Pop, GDP' can be found using equation 9.

$$GDP'_{t+n,r} = GDPcap'_{t+n,r} * Pop_{t+n,r} \qquad \text{eq. 9}$$

The convergence scenario is implemented in an integrated system coded in 'R' language where all variables are tied influencing each other dynamically in time. In other words, it is a recursive model because the modelled values of one year (t) influence the model behaviour in a subsequent year (t+n). Figure 14 exhibits a detailed diagram of the workflow. The workflow can also be summarised along the following lines:

1. GDPcap for t+n in region r is calculated as a function of GDPcap in t in the same region (exogenous convergence assumption, see Figure 10);
2. Productivity for t+n in region r is calculated as a function of productivity in t in the same region (exogenous convergence assumption, see Figure 10);
3. The number of employees E' for t+n is calculated using the ratio between GDPcap growth and productivity growth as a factor for employment growth (see equation 6);

4. The future regional ratios of employment to population ($R'_{t+n,r}$) are determined by applying the change in R at country level from the reference projections (see equation 8);
5. Population P' for t+n is determined (see equation 7);
6. GDP' for t+n is calculated (see equation 9);
7. Final GDPcap and productivity for t+n are determined, and then used in the next iteration.

Variables E', Pop' and GDP' are rescaled in steps 3, 5 and 6 respectively, so that the sum of the regionalised values match the national totals projected in the reference projections. Therefore, E', Pop' and GDP' become E, Pop and GDP in each region and in each time step. Equation 10 shows how population is rescaled. Similar equations are used for Employment and GDP.

$Pop_{t+n,r} = Pop'_{t+n,r} * (Pop_{t+n,c} / \Sigma_r Pop'_{t+n,r})$, with $r \in c$ eq. 10

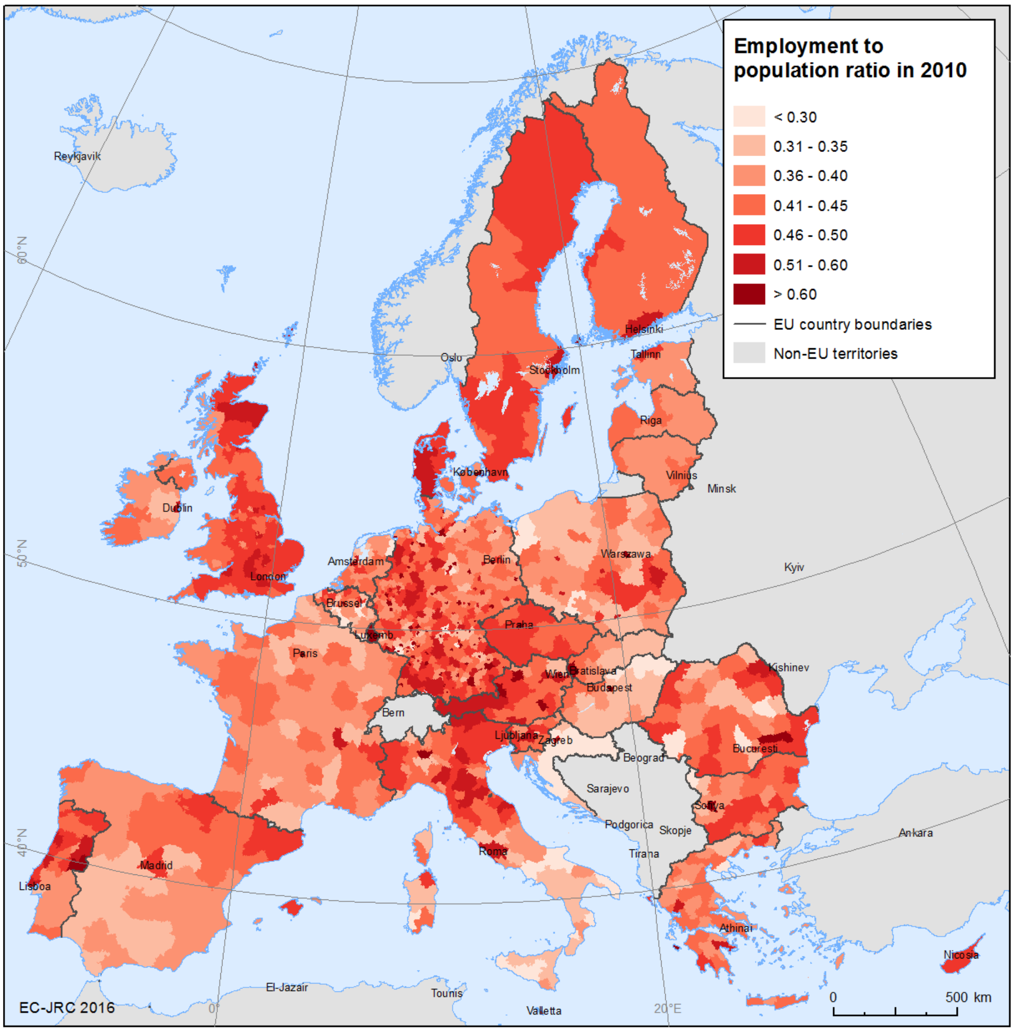

Figure 12. Geographical distribution of the employment to population ratio in Europe per NUTS3, 2010.

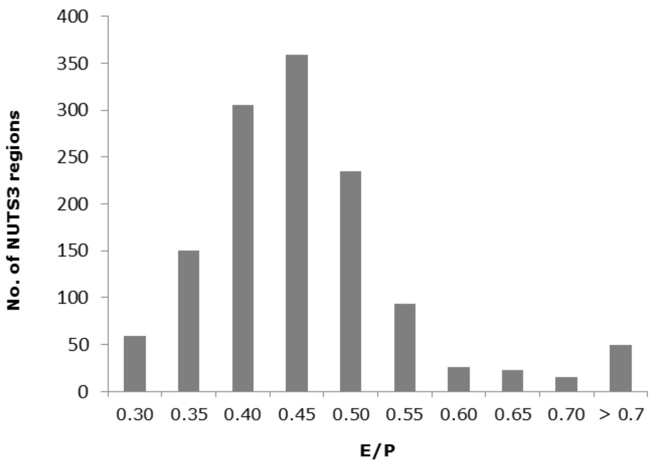

Figure 13. Frequency distribution of the employment to population ratio in NUTS3 regions in Europe, 2010.

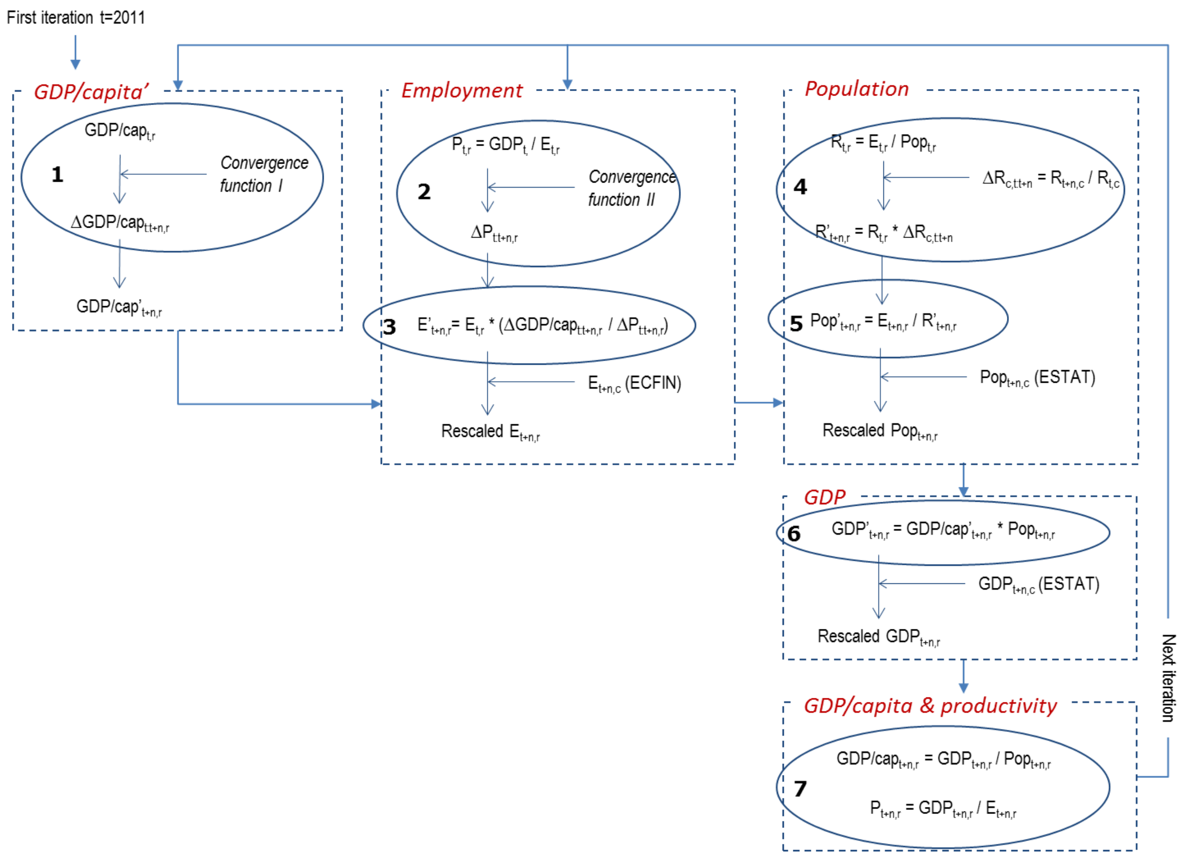

Figure 14. Detailed diagram of the regionalisation model.

3. Results

The five output variables of the regionalisation exercise are GDP, employment, population, GDP per capita and productivity (GDP per employed person). These variables were regionalised to the NUTS3 level (1 315 units) for the period 2015-2060, in 5-year time steps. The results have then been aggregated and reported at the NUTS2 level, the most relevant regional level for EU policies. Eligibility to Structural Funds is defined at the NUTS2 level, and many NUTS2 regions enjoy significant political power in certain Member States.

This chapter is structured in three main sections: 3.1) EU outlook, 3.2) Country focus and 3.3) Regional focus. Section 3.1 shows the results of the two scenarios for the entire EU, and per three main regional typologies:

- Type 1, or 'more developed' regions:
  - NUTS2 regions with GDPcap above 90 % of the EU average;
- Type 2, or 'transition' regions:
  - NUTS2 regions with GPDcap between 75 % to 90 % of the EU average;
- Type 3, or 'less developed' regions:
  - NUTS2 regions with GDPcap below 75 % of the EU average.

The above classification defines the eligibility of NUTS2 regions for Structural Funds ([12]). Less developed regions are eligible for the largest share of funds in order to kick-off growth and promote economic, social and territorial cohesion. Transition regions are eligible for a smaller share of funds. The most developed are eligible for the smallest share. For the purpose of this report, the classification of regions was based on their GDP per capita in PPS in the years 2009, 2010 and 2011 ([13]).

The results obtained allow us to assess possible implications of the two regionalisation scenarios for future eligibility by counting the foreseen number of regions classified under each typology in each scenario. Finally, the overall state of EU's territorial cohesion is assessed by measuring projected disparity levels of GDP per capita under the trend and convergence scenarios. To a large extent, however, the effect of the scenarios' assumptions on the three types of regions is limited by the imposed national constraints ([14]). In the 'Country focus' section we therefore analyse growth in the three regional typologies for three specific countries individually, Italy, Spain and Germany. By focusing on specific countries, the rescaling effect is removed and the observed regional growth differences are only due to the scenario specifications. Finally, in the 'Regional

([12]) Structural Funds include the European Social Fund (ESF) and the European Regional Development Fund (ERDF). Eligibility to the Cohesion Fund (CF), which is also part of the Regional Policy, is determined per country: member States whose Gross National Income per inhabitant is less than 90 % of the EU average.

([13]) The average GDP per capita in PPS observed in each region in the 3 years (2009, 2010 and 2011) was used in order to avoid possible misclassification resulting from atypical jumps or falls in single-year records.

([14]) The 'imposed national constraints' refer to the rescaling of the regional values to match the national totals from the reference projections. See Section 2.3 for details.

focus' section, maps of regional GDP, employment and population growth are shown for both scenarios. These maps allow us to visualise the resulting spatial patterns of growth and the main differences between scenarios.

In all maps and plots, GDP in PPS has been preferred over GDP in constant prices because it removes the effect of different price levels between countries.

3.1 EU outlook

Figure 15 shows absolute levels of GDP, population, employment, GDP per capita and productivity for the trend and convergence scenarios. At a first glance, differences between the scenarios may not look very significant when the variables are aggregated per the three regional typologies and shown as absolute levels. This is due to two main reasons. First, the number of more developed regions is larger than the number of transition and less developed regions put together. According to the classification used, based on GDP per capita in 2010, there were 143 more developed regions, while transition and less developed accounted for 56 and 73 regions, respectively. Therefore, the difference between total GDP, employment and population will remain high. Second, although the transition and less developed regions are favoured by higher growth rates in the convergence scenario, the convergence effect is not strong enough and is limited by the imposed national constraints. Nevertheless, a more pronounced catch-up effect is visible in the convergence scenario for all variables, and particularly for productivity, which almost converges by 2060.

Table 3 confirms that, under the convergence scenario, transition and less developed regions in 2010 account for a higher share of the total GDP, employment and population in 2060 than what the trend scenario would warrant. The total GDP of these regions accounts for about 28 % of the total EU GDP in 2010. While this share would remain essentially unchanged by 2060 if the trend scenario held, it would instead rise to approximately 37 % under the convergence scenario. Total employment and population are set to decrease in the 2015-2060 period in less developed regions in both scenarios due to the reference projections which project particularly acute decreases in population and employment in less developed countries (see Figure 7, Section 2.2.2). However, the decrease is much less pronounced in the convergence scenario. It is as well interesting to note that trend scenario promotes a further concentration of population in more developed regions (share of 58 % in 2010 to 64 % in 2060), whereas in the convergence scenario the more developed regions keep a relatively constant share of population throughout the projection time-span.

The left pane of Figure 16 shows the evolution of the ratio between GDP per capita in less developed regions and GDP per capita in more developed regions. A value of 0.5 means that the GDP per capita in less developed regions is 50 % of the GDP per capita in more developed regions. Consequently, a value of 1 would mean equal GDP per capita, hence full convergence. The right pane shows the ratio between productivity in less developed regions and productivity in more developed regions. GDP per capita and productivity tend to catch-up with time in both scenarios, but the effect is considerably more marked in the convergence scenario. By 2060, less developed regions achieve more than 70 % the GDP per capita of more developed regions, and about 95 % of the productivity of more developed regions.

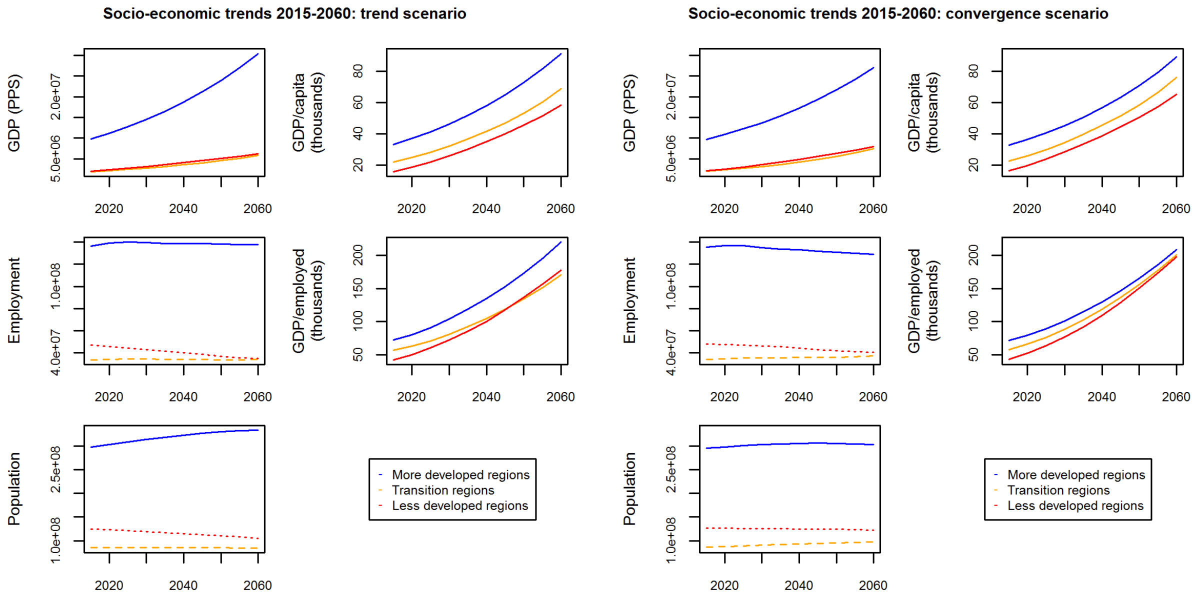

Figure 15. EU outlook in absolute levels for trend (left) and convergence scenarios (right).

Table 3. Share of GDP, employment and population levels in 2015 and 2060 in trend and convergence scenarios per regional typology.

	2010	**2060**	
		Trend	**Convergence**
GDP (PPS)			
More developed	71 %	72 %	64 %
Transition	14 %	14 %	18 %
Less developed	14 %	15 %	19 %
Employment			
More developed	62 %	67 %	63 %
Transition	16 %	16 %	18 %
Less developed	22 %	17 %	19 %
Population			
More developed	58 %	64 %	58 %
Transition	17 %	16 %	19 %
Less developed	25 %	20 %	23 %

Differences between scenarios are more easily visualised in Figures 17 and 18, where projected variables are indexed to the year 2015. Figure 17 shows one set of plots per scenario, while Figure 18 shows one set of plots per regional typology. The main conclusion from these figures is that transition and less developed regions perform better in the convergence scenario, while more developed regions perform better in the trend scenario. Employment and population growth is particularly different between scenarios. While in the trend scenario employment and population in transition and less developed regions are set to decrease sharply, in the convergence scenario employment and population decrease considerably less, or even increase in the case of transition regions. Conversely, the expected population growth in the more developed regions is much toned down in the convergence scenario.

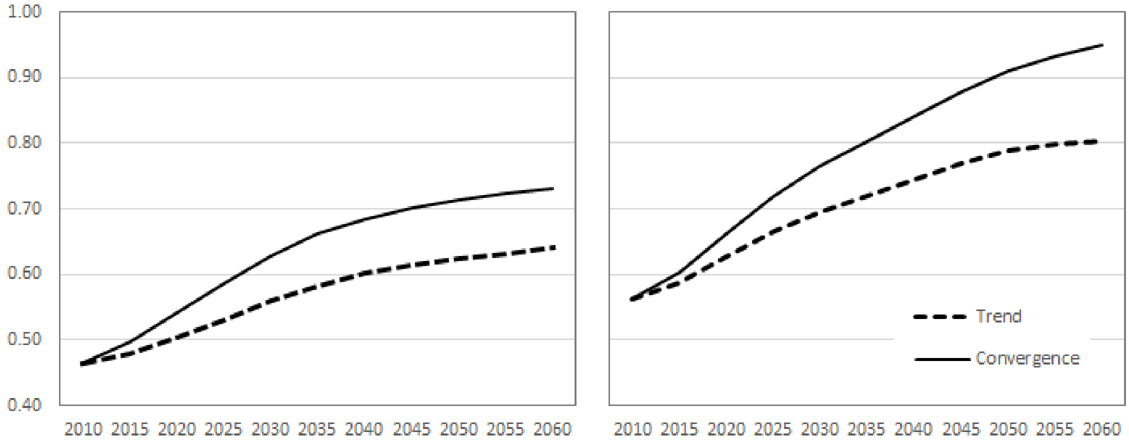

Figure 16. Ratio between GDPcap in less developed regions and GDPcap in more developed regions (left), and ratio between productivity in less developed regions and productivity in more developed regions (right).

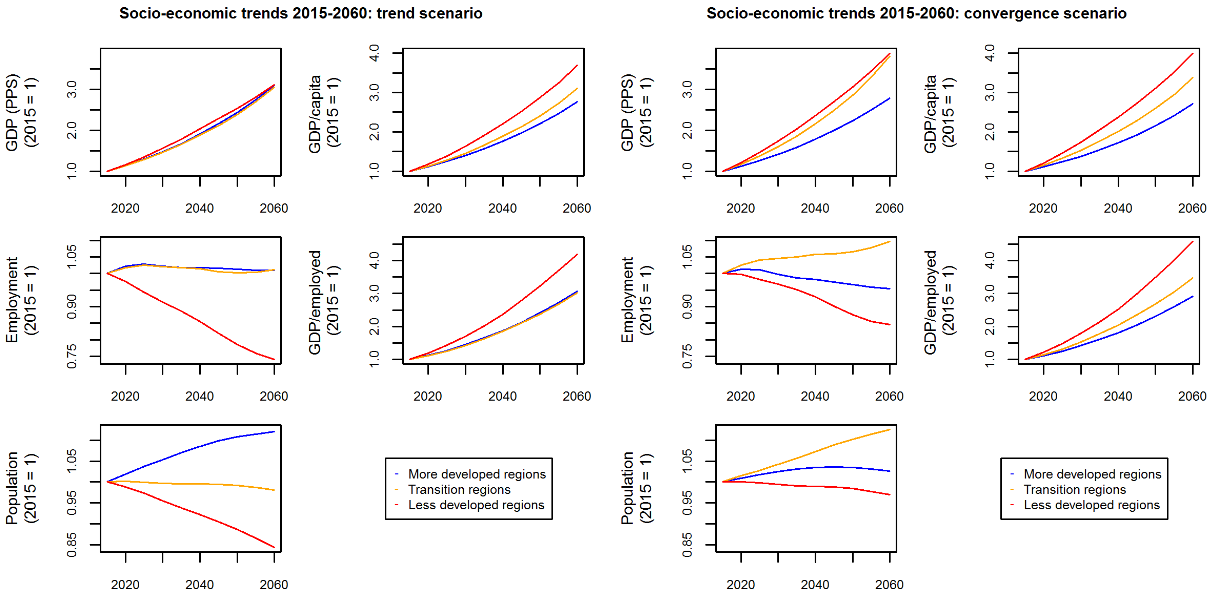

Figure 17. EU outlook in indexed values for trend (left) and convergence scenarios (right).

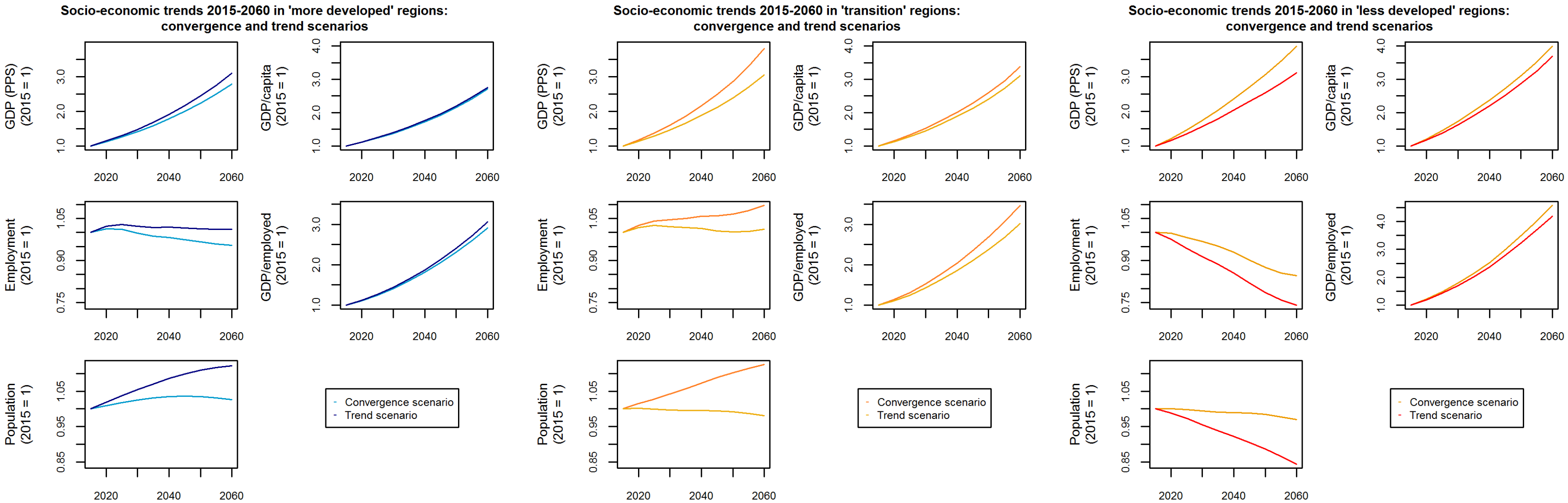

Figure 18. Outlook in indexed values for trend and convergence scenarios for more developed regions (left), transition regions (centre) and less developed regions (right).

3.1.1 Sigma-convergence under the two scenarios

According to Sala-i-Martin (1996), sigma-convergence exists when the dispersion of per capita income across economies tends to fall over time, leading to a reduction of disparities among regions. The occurrence beta-convergence, although necessary, may not be sufficient for sigma-convergence: 'Intuitively, this is either because economies can converge towards one another but random shocks push them apart or because, in the case of conditional beta-convergence, economies can converge towards different steady-states' (Monfort, 2008).

One straightforward way to assess sigma-convergence is to calculate the coefficient of variation (CV) over time for a set of regions. The coefficient of variation is defined as the ratio of the standard deviation to the mean. It is a relative measure, easy to calculate and interpret. The higher its value, the higher the dispersion of the distribution, meaning, in this particular case, the higher the regional disparities. Other indices of sigma-convergence exist, such as the Gini coefficient, the Atkinson index, the Theil index, or the Mean Logarithmic Deviation. Monfort (2008) has reviewed and used these indices to analyse sigma-convergence among Europe's regions in the period 1995-2005. In a more recent study, Dao et al. (2013) have chosen the coefficient of variation of GDP per capita in PPS to measure sigma-convergence in Europe in the period 2002-2008. The coefficient of variation is sensitive to the GDP units used. It is generally lower when calculated based on GDP per capita in PPS, since the price level differences between countries are removed. Results shown by Dao et al. (2013) also show that the coefficient of variation is sensitive to the spatial unit of analysis.

In this report we calculated the CV of GDP per capita based on NUTS2 regions for both scenarios. Figure 19 shows the evolution of the index during the projection period. In case the trend assumptions hold in the long run, the CV remains relatively stable in the first 10 to 20 years, but then increases, thus signalling further regional disparities. The convergence scenario shows a steady downward trend of the CV, revealing sigma-convergence, or territorial cohesion as a consequence of the assumed unconditional beta-convergence.

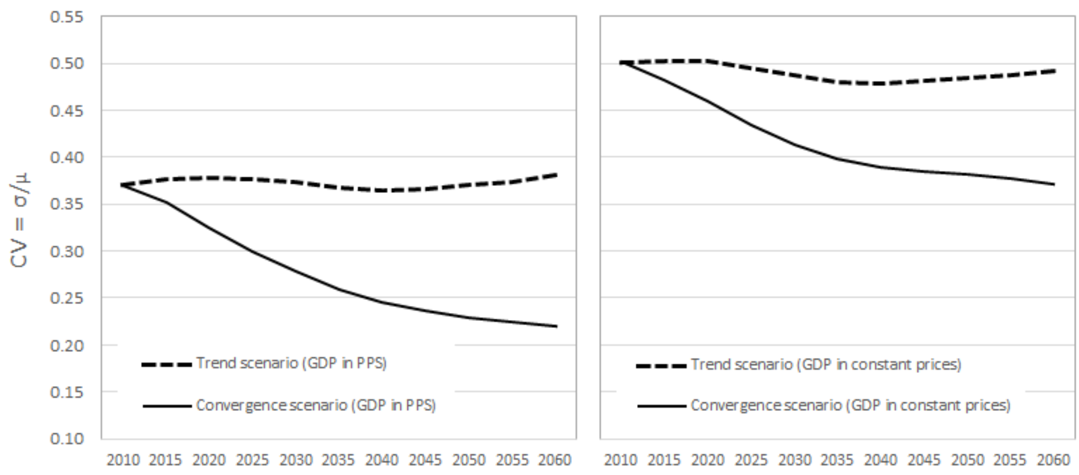

Figure 19. Evolution of the coefficient of variation in the trend and convergence scenarios (PPS to the left and constant prices to the right).

3.1.2 Consequences for eligibility

As a result of the different regional growth and development trajectories, regional eligibility for EU funds changes across time. The most visible effect of the trend scenario is the increase in the number of regions classified as less developed which is compensated by a decrease of both transition and more developed regions in the long run. A total of 61 NUTS2 regions are 'relegated' to lower levels of development (i.e. lower GDP per capita relative to EU average), while 42 NUTS2 regions are 'promoted' to higher levels. This overall deterioration does not hold in the convergence scenario, where 76 regions are projected to 'jump' to higher levels, against only 25 NUTS2 regions being relegated to lower levels. In fact, the number of less developed regions decreases pronouncedly throughout the projection time span. In relation to the trend scenario, the EU-28 under the convergence scenario would have 30 more 'more developed' regions, 26 more 'transition' regions and 56 less 'less developed' regions by 2060 (see Figure 20 and Tables 4 and 5).

The long-term objective of the Cohesion Policy is to achieve higher levels of cohesion, meaning a more balanced regional distribution of wealth, and less pressure on Cohesion Policy itself, a situation which would be clearly achieved under the convergence assumptions. On the other hand, the scenario which assumes a continuation of the most recent regional and sector trends implies a slight but continuous worsening of regional disparities in Europe, and consequently an ever growing number of lagging regions in need of Cohesion Policy.

Because eligibility is based on GDP per capita in PPS relative to the EU average, it must be noted that the herein presented estimates are not independent from the way PPS adjustments are projected. As mentioned earlier in this report (see Section 2.1), purchasing power parities, which are used to convert EUR currency to PPS terms, have been linearly extrapolated based on the observed trends from a long time series (1995-2013).

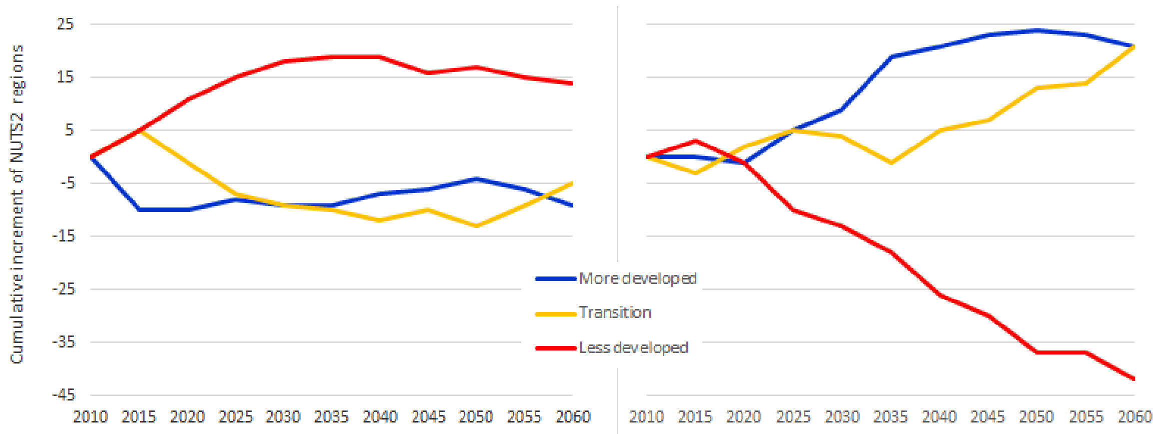

Figure 20. Cumulative change in number of regions per typology in trend (left) and convergence scenarios (right).

Table 4. Transition between regional typologies in the trend scenario.

		2060			
		More developed	**Transition**	**Less developed**	Total
2010 (15)	**More developed**	108	22	13	143
	Transition	17	13	26	56
	Less developed	9	16	48	73
	Total	134	51	87	272

Table 5. Transition between regional typologies in the convergence scenario.

		2060			
		More developed	**Transition**	**Less developed**	Total
2010[13]	**More developed**	122	21	0	143
	Transition	30	22	4	56
	Less developed	12	34	27	73
	Total	164	77	31	272

3.2 Country focus

Both trend and convergence scenarios are constrained by the reference projections at country level. The results shown in the section above for the three regional typologies are thus limited by this constraint. For example, if countries composed mostly of lagging regions are set to diverge in terms of population growth, then it impacts negatively the overall performance of less developed regions when looking at the EU as a whole in both scenarios. That is in fact the case, as many of the less developed countries in Europe are projected modest or even negative population growth rates in the coming decades (see Figure 7, Section 2.2.2), with obvious impacts on total employment and GDP.

In order to actually assess the impact of the different scenario assumptions one has to look within individual countries. In this section we have selected three countries, and analysed regional growth for both scenarios. Italy, Spain and Germany are large

(15) Classification of regions for year 2010 was based on the average GDP per capita in PPS in the years 2009, 2010 and 2011.

countries in the EU context, with a wide range of regional typologies ([16]), and thus have been selected for further study.

Figures 21, 22 and 23 show growth trends for Italy, Spain and Germany, respectively. Differences in the regional distribution of GDP, employment and population are only attributed to the scenario assumptions, as the total levels per country are equal in both scenarios. It is now even more evident that the different assumptions used for future regional development impact substantially the within-country variability of the projected variables. That is particularly the case of employment and population, whose growth rates are very low in the less developed regions in the trend scenario, but much higher in the convergence scenario, while the exact opposite occurs to the more developed regions. Transition regions also tend to benefit under the convergence assumptions. The case of Italy is notable, as the expected regional development model (i.e. the one represented by the trend scenario) is completely inverted in the convergence scenario — an outcome which is even more evident in the maps presented in the next section.

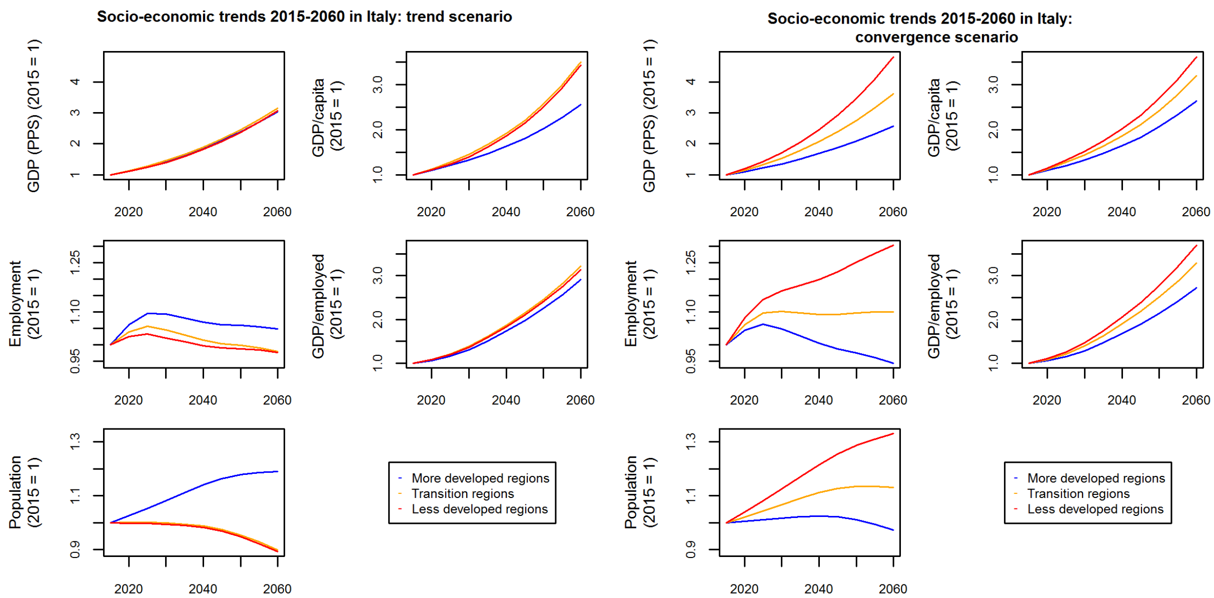

Figure 21. Outlook for Italy in indexed levels for trend (left) and convergence scenarios (right).

([16]) All three typologies are represented in Italy and Spain, and typologies 1 and 2 are represented in Germany.

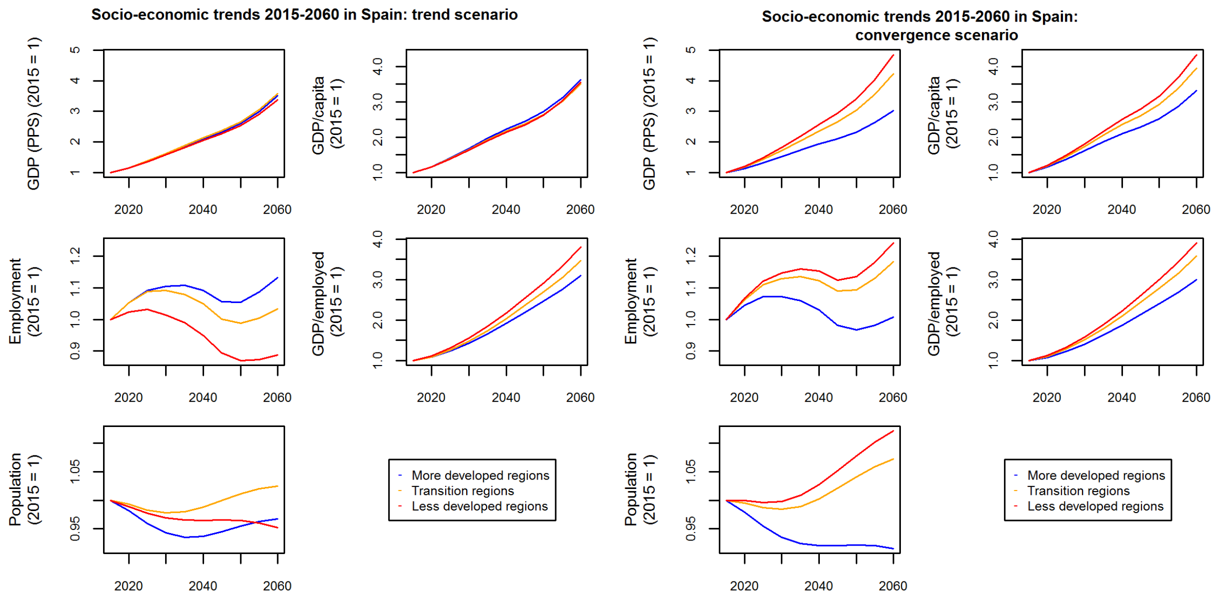

Figure 22. Outlook for Spain in indexed levels for trend (left) and convergence scenarios (right).

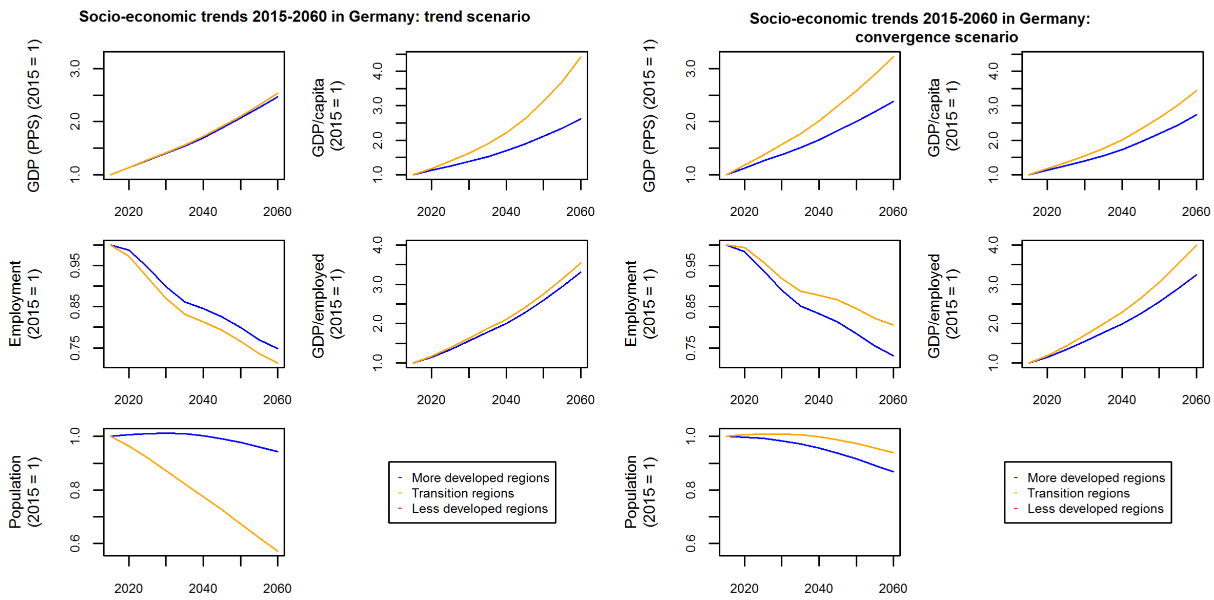

Figure 23. Outlook for Germany in indexed levels for trend (left) and convergence scenarios (right).

3.3 Regional focus

In the previous sections we looked at aggregations of regions according to the classification method used to determine eligibility to EU's structural funds: more developed regions, transition regions and less developed, or lagging regions. In this section we present maps of regional GDP, employment and population growth at the NUTS2 level, thus allowing an assessment of the outcome of the two scenarios with higher geographical resolution.

Figure 24 shows NUTS2 maps of projected average annual growth rates of GDP in the trend and convergence scenario, plus a map identifying the scenario which delivers the highest growth rates in each region. Figures 25 and 26 show growth rates and differences between the two scenarios for employment and population, respectively. For countries with one single NUTS2 region, though, no differences can be visualised between scenarios. That is the case of Estonia, Cyprus, Latvia, Lithuania, Luxembourg and Malta.

Figure 27 is perhaps the best summary of the outcomes of this project. It shows GDP per capita relative to EU average in 2011 and in 2060 in the trend and convergence scenarios. While the trend scenario essentially preserves the previous geographical structure of regional distribution of GDP per capita, the convergence scenario attains a much more balanced geographical distribution within countries, and even between countries. It is remarkable, for instance, that regions with GDP per capita below 50 % of the EU average completely disappear in the convergence scenario, and that many other regions get closer to the EU average. This effect is particularly pronounced in all Eastern countries.

As mentioned in Section 2.3.2, although the convergence scenario favours growth in transition and less developed regions, it could as well lead to loss of employment and population in certain less developed regions depending on their specific levels of GDPcap and productivity. Such employment losses could be related to fast productivity catch-up due to economic restructuring and/or migration of workforce to more productive sectors outside the region. This effect was mostly expected in regions with a high agricultural share of employment.

To check this hypothesis, regional employment growth rate relative to national employment growth rate (over the projection time span) was first calculated in order to remove the effect of the national constraints. Then, the transition or less developed regions with an employment growth rate below the national mean have been identified, i.e. a total of 23 out of 129. It was then found that nearly 75 % of those regions had a high share of agricultural employment compared to the national average in 2010, thus validating the expected effect of the convergence scenario. Most of these regions are located in Greece, Poland and Romania, but may occur as well in Czech Republic, Croatia, Hungary, Portugal and the United Kingdom.

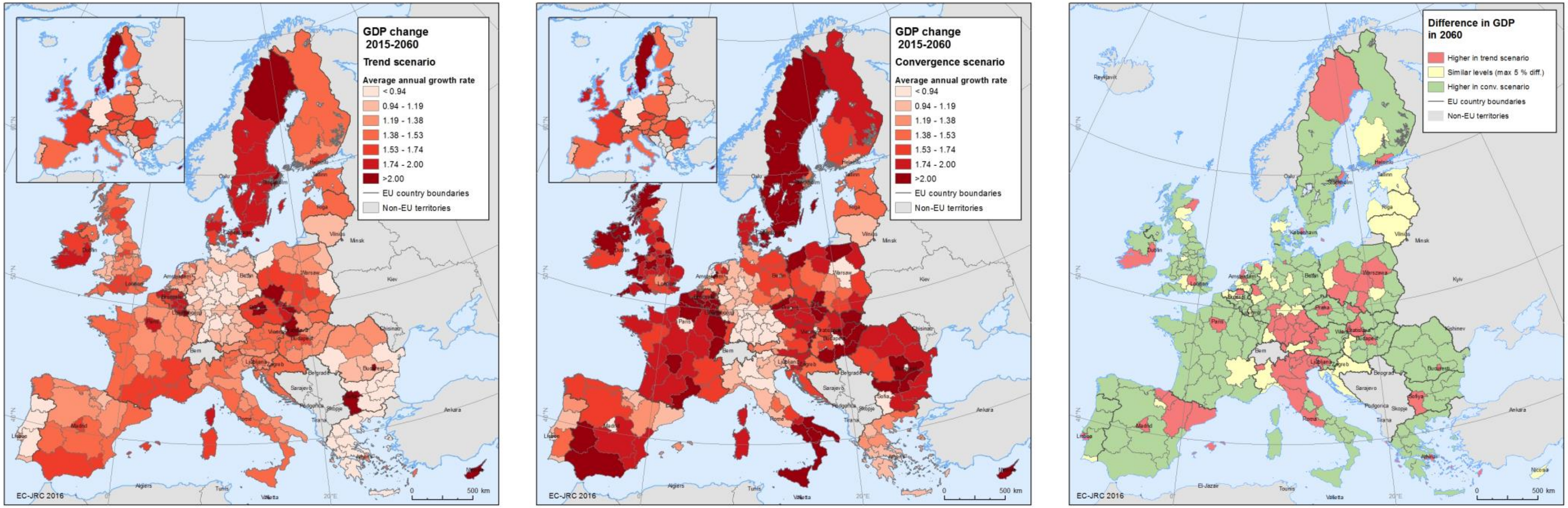

Figure 24. Geographical distribution of GDP growth rates per NUTS2 for trend and convergence scenarios.

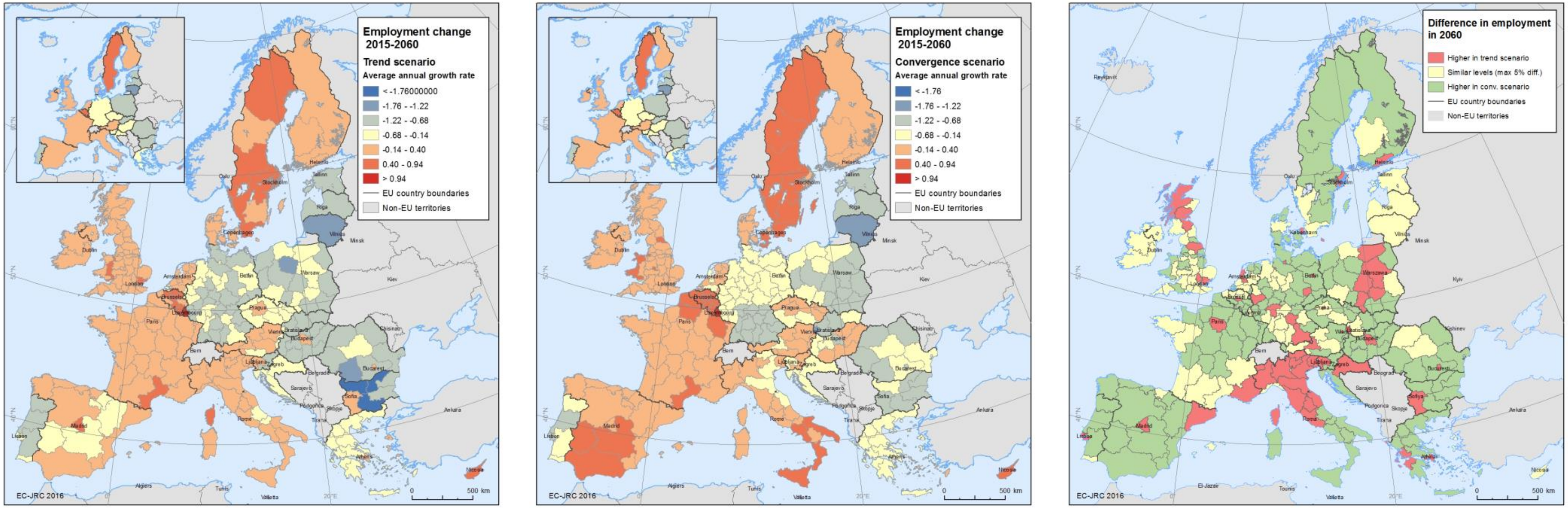

Figure 25. Geographical distribution of employment growth rates per NUTS2 for trend and convergence scenarios.

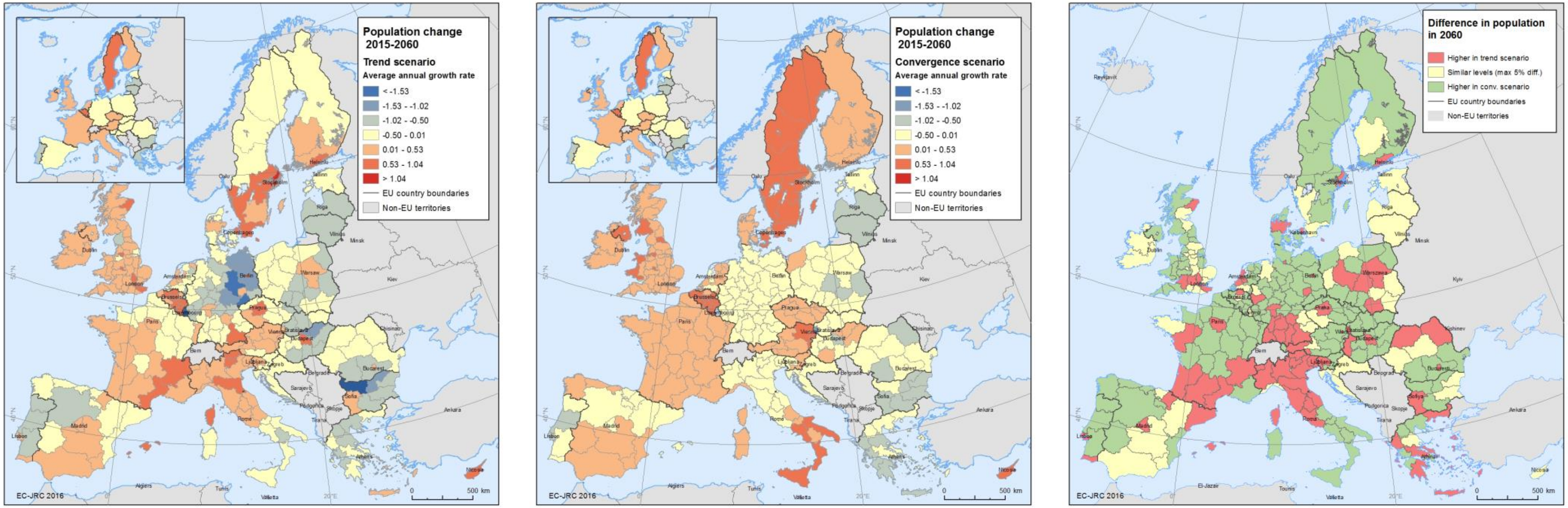

Figure 26. Geographical distribution of population growth rates per NUTS2 for trend and convergence scenarios.

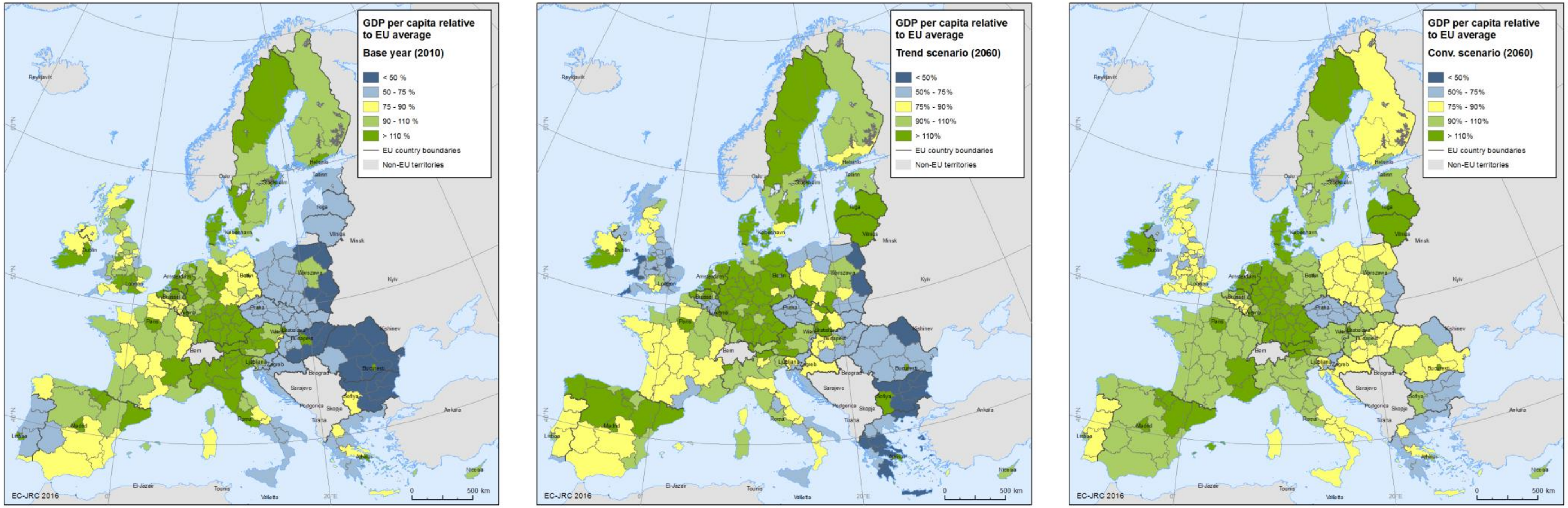

Figure 27. GDP per capita (PPS) relative to EU average in 2011 (left), and in 2060 in the trend scenario (centre) and in the convergence scenario (right), per NUTS2.

4. Discussion and way forward

4.1 Wrapping-up: context, objectives and key findings

Reference EU demographic and macroeconomic projections have been published recently in *The 2015 Ageing Report* of the European Commission. These projections were originally used to assess the economic and budgetary impacts of the ageing population (EC, 2015a), and were produced with country level detail, which was sufficient for its original purpose. As explained in the introduction to this report, these projections can and should also be used by other services of the Commission, but their geographical resolution is limited for certain applications.

The purpose of the work described in this report was two-fold. In a first instance, we wanted to produce a 'regionalised' version of the reference projections by downscaling the original country level projections down to regional detail, namely NUTS3. Second, we wanted to regionalise the projections using two different regional growth scenarios — trend and convergence — so to envisage two rather distinct future trajectories of regional growth, and evaluate the impacts of the assumed scenarios in terms of future territorial cohesion in Europe. The trend scenario assumes that recently observed regional sector growth rates continue, which means that no major structural changes or regional growth shifts are projected. The convergence scenario, instead, assumes that less developed regions grow faster than more developed ones, leading to convergence of the lagging regions towards the EU average.

In both scenarios, the projected GDP, employment and population levels match those from the EU reference projections at national level thus preserving full compatibility. The differences between scenarios are therefore limited to within country variations. Despite this constraint, results from the two regionalised projections show significant differences in terms of future regional distribution of GDP, employment and population. The trend scenario generates further geographical concentration of production, employment and population. Regions which are currently the most developed benefit the most. On the other hand, the convergence scenario promotes a more balanced economic growth, with consequences as well in employment and population distribution within countries. The two scenarios generate in fact two distinct pathways of regional development, one in which disparities rise (trend scenario), and another in which regional disparities shrink (convergence scenario). If the trend scenario assumptions held, one would expect additional demand for cohesion policies to support a growing number of regions classified as 'less developed' according to the current classification scheme based on distance to average EU GDP per capita in PPS. On the contrary, the convergence scenario improves significantly the current situation, with a net of 51 upgraded regions in the period 2015-2060, and 30 more regions classified as 'more developed' in relation to the trend scenario in 2060 (see Section 3.1.2).

4.2 Limitations

The work described in this report encompasses three main limitations:

1. Imposed national constraints from the reference projections limit scenario variability;
2. Different mechanisms used to generate the trend and the convergence scenarios poses issues to the comparability of the two scenarios;
3. Projections are derived from a deterministic, assumption-based system, not suited for policy evaluation.

The first limitation from the list has already been mentioned earlier: the projections are constrained by the national levels from the reference projections. This option has the advantage of ensuring full compatibility between the reference projections and their regionalised versions. However, the imposed constraint limits the extent of variance between scenarios, which would be richer had those constraints been removed. For the convergence scenario specifically, this also implies that migration is 'internal', i.e. migration within countries. International migration is therefore addressed only by the reference projections at country level.

Another limitation is related to the fact that trend and convergence scenarios have been generated using different mechanisms. In the trend scenario GDP and employment are projected independently, and each according their recent trends, while population is taken directly from ESTAT at the NUTS3 level. In this setup, the variables do not interact with each other, and the resulting GDP per capita, productivity and employment to population ratio are a consequence of the projected levels of GDP, employment and population. Conversely, in the convergence scenario, GDP per capita and productivity levels are set to converge first by means of aprioristic convergence functions, impacting in sequence on employment, population and finally GDP through a series of equations. In addition, the levels obtained at each year influence the growth rates of GDP per capita and productivity of the subsequent years (Section 2.3.2). As such, differences between scenarios cannot be attributed exclusively to the different regional growth assumptions used, but also to differences in model structure.

The extent to which model structure influenced the obtained results has not been assessed by the time of the writing of this report. One possible way to investigate this is to replace the convergence functions of the model represented in Figure 14 (see Section 2.3.2) by regional growth rates for GDP per capita and productivity obtained from observed trends (2000-2011). This would generate a trend scenario using the same mechanism used to generate the convergence scenario. Comparing then the two trend scenarios would shed light on the impact of the model structure on the herein reported differences between trend and convergence scenario.

Finally, it must be emphasised that the results obtained have been achieved using a 'what-if' approach supported by assumptions on future regional growth, and implemented through a deterministic system of equations. This must not be confused with approaches which model the effects of specific policies on a given baseline scenario, such as computable general equilibrium (CGE) models. As such, the results obtained do not reflect the expected effects of specific policies, but simple show two alternative regional growth scenarios regardless of any current or future policy. Bearing this in mind, the approach used allowed us to answer one particular question: what are the consequences for territorial cohesion in Europe if current trends continue to hold in the long run? However, questions like 'what should be done to curb current trends and avoid further regional disparities?' or 'what would be the effect of policy "A", or "'B"?' are out of the scope of this work.

The operationalisation of the trend and convergence assumptions is also influenced by some constraints and options. One example is the regional and sector growth rates used in the trend scenario which are based on a somewhat limited observation period (2000-2011) due to lack of more recent regional data. Besides, statistical artefacts in the historical data (e.g. related to how data is reported and collected) could bias observed growth rates, thus influencing the trend scenario. Another example concerns the convergence functions which, despite being applied to regions, are based on observed convergence between countries in Europe. The option for unconditional convergence functions instead of conditional convergence functions was found appropriate given the imposed national constraints, as many of the conditions for convergence are related to country level factors.

4.3 Way forward

The regionalised trend projections are likely to remain an appealing product for policies with a strong territorial dimension, such as the Cohesion Policy, rural development, migration, transport and urban environment. On the other hand, convergence projections could attract interest as exploratory tools for policy domains dealing with economic, social and territorial cohesion related issues.

Future work will continue exploring alternative options to regionalise EU reference projections, in particular by relaxing the national constraints, while maintaining compliance EU-level projected volumes. This will be particularly useful in order to test different convergence hypotheses. The removal of national constraints to simulate convergence scenarios will require the testing of conditional convergence schemes, where other growth factors and determinants are taken into account. In what concerns the trend scenario, the main focus will lie on the investigation of the impact of model structure on the herein achieved results.

On a more ambitious tone, the long-term plan includes the construction of a larger, integrated regional model as a major component of the LUISA modelling platform. The tool built to generate the convergence scenario (see Figure 14, Section 2.3.2) shall be the basis of the future regional model. Figure 28 sketches its structure and main components. In this tentative scheme, 'growth assumptions' refer to either trend or convergence trajectories, while 'determinants of growth' can be any other well-established factors which influence regional growth (e.g. human capital). The Cohesion Policy signal can be included by importing estimated impact coefficients from exogenous evaluations tools such as the RHOMOLO model (Brandsma and Kancs, 2015).

The new tool would, in addition, have a simple, constrained demographic module, with mortality and fertility rates derived from the Eurostat reference demographic projections, plus a more elaborate net migration model based on a gravity approach, and be sensitive to economic incentives (e.g. employment opportunities, wage differences).

Demand for residential, industrial and commercial land uses would be computed endogenously. Demand for residential land use is currently being modelled as a function of total population and households, whereas demand for industrial and commercial land uses is modelled as a function of economic output per sector (GVA). In both cases, future expected land use intensities are applied to convert activity levels (population, households, or sector GVA) into land demand in hectares (Batista e Silva et al., 2014; Baranzelli et al., 2014). Demand for land uses is a key input to model future land use changes at local level.

A mechanism for spatial spill overs of population could be constructed to allow estimated regional population to flow to other, neighbouring regions whenever there is too limited additional space for residences. As such, final estimated population levels would be the result of a combination of demographic, economic and geographical conditions. Land demand would finally be passed to the dynamic spatial allocation module of the LUISA modelling platform in order to simulate local-level population and land use changes (Lavalle et al., 2016). Finally, feedbacks between the allocation module and the regional module could be implemented by establishing a response mechanism between future urban structure, regional growth (Ahrend and Schuman, 2014) and innovation (Carlino et al., 2007).

The above mentioned work will contribute to the purposes of the pilot Knowledge Centre for Territorial Policies which is currently being set up by JRC and REGIO.

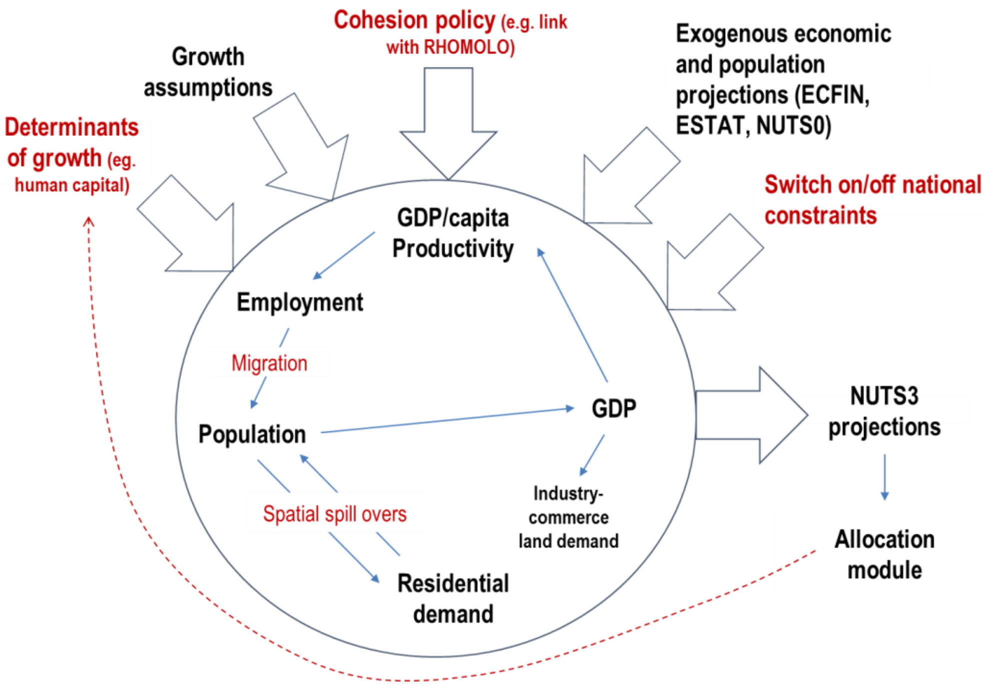

Figure 28. Simplified diagram of the expanded regionalisation model (in red the areas which will require further empirical study and/or technical and methodological development).

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List of abbreviations

CV	Coefficient of Variation
DG	Directorate General
EC	European Commission
ECFIN	Directorate General for Economic and Financial Affairs
ECOFIN	Economic and Financial Affairs Council
ESA	European system of national and regional accounts
EU	European Union
EUR	Euros
GDP	Gross Domestic Product
GVA	Gross Value Added
JRC	Directorate General Joint Research Centre
LAU	Local Administrative Units
LUISA	Land use-based integrated sustainability assessment modelling platform
NACE	Statistical Classification of Economic Activities in EU
NUTS	Nomenclature of territorial units for statistics
OLS	Ordinary Least Squares
PPP	Purchasing Power Parities
PPS	Purchasing Power Standard
REGIO	Directorate General for Regional and Urban Policy

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