# Does the EU convergence machine still work ?

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## Introduction

From the very beginning, convergence has been one of the explicit goals of the EU. The 1957 Treaty of Rome states that European leaders were "[…] *anxious to strengthen the unity of their economies and to ensure their harmonious development by reducing the differences existing between the various regions and by mitigating the backwardness of the less favoured*". The passage reflects the importance of convergence of income levels, in particular for the legitimacy of the European integration process. The prospect of catching up with EU living standards has undeniably been one of the major attractions of EU membership for potential candidates, while socio-economic underperformance in some countries or regions may undermine support for the European project in current member states. Indeed, Europeans' views on EU membership and on the EU's future deteriorated in the aftermath of the crisis, notably in those member states most affected by it (EC, 2014). Moreover, regions that have experienced relative economic decline or seen lower employment rates are more likely to vote for anti-EU parties (Dijkstra *et al.*, 2019).

This article sheds light on whether the EU "convergence machine" (Gill and Raiser, 2012; Bodewig and Ridao-Cano, 2018) still works. To be more precise, we assess the achievements of the EU with respect to income convergence, expressed in terms of GDP per capita, at both the national and regional level. Income (or real) convergence typically refers to the process of poorer countries/regions catching up towards the income levels of richer countries/regions. Convergence can also be explored along a variety of other dimensions. In the run-up to the EMU, the emphasis was mostly on nominal convergence, as the Maastricht Treaty established criteria for adoption of the euro in the form of nominal variables such as inflation, interest and exchange rates, fiscal deficits and debts. Moreover, economies are said to display cyclical convergence when they are in the same phase of the business cycle at the same time and hence move in synchronisation (Franks *et al.*, 2018). In this article, we disregard those other convergence dimensions.

There is an extensive empirical literature on convergence in the EU. Whereas various studies have considered convergence within a subset of EU member states – most often the euro area or Central and Eastern European countries – our own analysis extends to all EU member states, still including the United Kingdom. Another aspect that sets this article apart from most other studies is that convergence is examined at both the national and regional level, and that we attempt to draw connections between developments at those two levels. Moreover, we adopt a longer-term perspective than is usual, as far as European Commission data allow it. Convergence among the older EU15 member states is thus analysed from 1960 onwards, while for the countries that have

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joined the EU since 2004, data beginning in 1995 are used. At the regional level, we employ data on about 200 EU28 large regions from 1996 onwards. Finally, our research also adjusts the boundaries of regions to take better account of the commuting zones of important metropoles, as one of our objectives is to examine the impact of agglomeration economies, in particular through the growth premium for regions which include a national capital or another metropolitan area.

The remainder of the article is structured as follows. Section 1 briefly reviews the main theoretical concepts that form the basis of our empirical analysis. Section 2 focuses on the convergence process among EU member states, while Section 3 investigates the extent of convergence at the regional level.

## 1. Main theoretical concepts

There are many different concepts of (real) convergence, but beta and sigma convergence are the most frequently analysed. Beta convergence implies that lower-income countries or regions tend to grow faster than richer ones. It is a necessary, though not sufficient, condition for sigma convergence, which is in turn defined as a decrease in the dispersion of per capita incomes across countries or regions over time.

The idea of beta convergence follows directly from the neoclassical growth theory (Solow, 1956; Swan, 1956) and hinges on the assumption of diminishing returns on (physical) capital. Poor, capital-scarce economies tend to attract larger capital inflows, as they exhibit higher returns on this production factor, thereby growing faster and catching up with the real per capita levels of richer economies. In other words, neoclassical models assume that countries grow at different rates because they have different stocks of capital and are therefore at different points on their growth paths. An economy grows faster the further it is below its so-called "steady state", where it eventually continues to grow at a constant, long-run rate[1].

Convergence tends to be a slow process however, as Barro and Sala-i-Martin (1992) were among the first to demonstrate empirically. A so-called "iron law of convergence" seems to apply, according to which the gaps in real GDP per capita between economies diminish at a rate of about 2 % per year. This implies that it takes around 35 years for half of the initial income gap to disappear, while the time needed to close three-quarters of the gap between economies' incomes is no less than 70 years. The time required for substantial convergence to materialise is thus typically in the order of several generations.

When all economies are assumed to converge towards the same steady state, beta convergence is said to be unconditional or absolute. The concept of conditional convergence, on the other hand, takes into account the fact that economies differ in a variety of structural or institutional characteristics. Under such circumstances, countries or regions may still converge, but not towards the same steady states. In other words, beta convergence then only holds when a certain set of economy-specific features are kept fixed. One implication of conditional convergence is that economies with similar features are likely to display similar growth trajectories, which is referred to as "club convergence".

Standard neoclassical growth theory predicts that integration, by lifting barriers to the movement of goods, services, capital and workers and, hence, by its effect on capital accumulation, leads to income convergence. However, and especially at subnational levels, opposing agglomeration forces may be at work. Availability of a large pool of potential customers and easy access to intermediate goods and services can be a factor driving concentration of economic activity. As such effects tend to boost growth in certain regions at the expense of others, convergence

1 This long run, steady state growth rate depends on the rate of technological progress, which neoclassical models assume to be exogenously determined. A new wave of growth models sought to endogenise technological progress, either by introducing it in its own right or by allowing for increasing returns on capital (e.g. Romer, 1986; Lucas, 1988). According to these so-called "endogenous growth models", economies with greater access to knowledge may always grow faster and divergence may occur.

does not necessarily occur[1]. The concentration of activities in urban regions, to the detriment of more rural areas, is a well-known example of these effects. The EU's cohesion policy was set up precisely with these concerns in mind.

## 2. Convergence at the national level

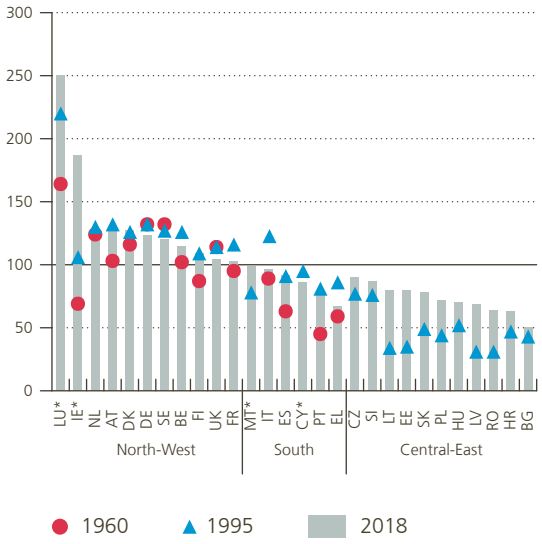
### 2.1 A cursory look at cross-country convergence

The following sections analyse the extent of convergence and the speed at which it has been taking place across countries within the EU. Chart 1 shows EU member states' GDP[2] per capita (in purchasing power standards or PPS[3]) in 1960 (where available), 1995 and 2018[4], illustrating that large differences in per capita incomes still exist between EU countries. Since GDP data for certain small countries – i.e. Luxembourg, Ireland, Cyprus and Malta – are biased by the presence of large multinational corporate structures and/or an outsized financial sector, we leave these countries out of the remainder of our analysis[5].

Chart 1

**Large differences in per capita incomes persist across EU member states…**

(GDP per capita in PPS, EU15 average = 100 for 1960 and EU28 average = 100 for 1995 and 2018)




Source: EC (Ameco).

* The GDP per capita figures of LU, IE, MT and CY have to be treated with caution, given the presence of large multinational corporate structures and/or an outsized financial sector.

1 See, among others, Martín *et al.* (2001) and Alcidi (2019).

2 GDP data include the (short-term) effect of structural and investment funds at the national level and at the regional level.

3 Price levels differ across countries; prices are usually higher in richer than in poorer countries. In order to better compare incomes, these are converted using purchasing power standards or PPS. PPS is an artificial currency unit used by Eurostat; one PPS can buy the same amount of goods and services in each EU country.

4 Data for member states that joined the EU since 2004 are only available as from 1995; for the "older" EU member states – i.e. those that joined the EU before 2004 – data are available as from 1960.

5 Because they are well-known concepts, we continue to use "EU15" to refer to our sample of "old" member states (i.e. the countries that joined the EU before 2004) and "EU28" for the entire sample of EU countries, even though the respective samples include 13 and 24 countries only.

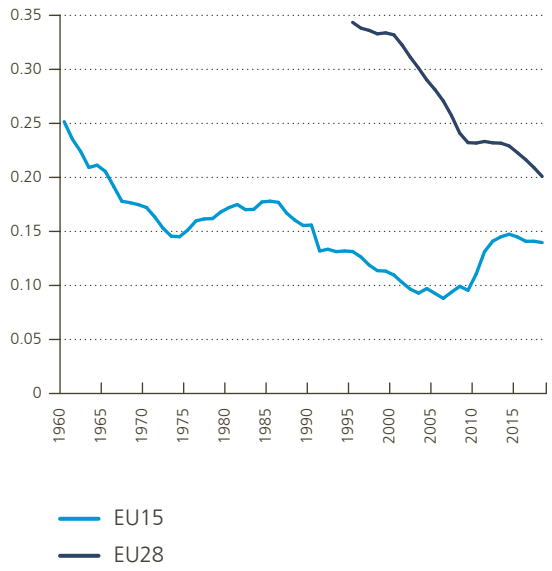
In 2018, incomes in the North-Western European countries were all above the EU average. This contrasts with incomes in Southern and Central-Eastern Europe (CEE), which were all below the EU average. The per capita income in the EU's poorest member state, Bulgaria, still amounted to only half of the EU average in 2018, similar to its situation in 1995. In that respect, Bulgaria differs from most other CEE countries, where per capita incomes have moved up compared to the EU28 average over the past two decades. On the other hand, most countries in the (initially) richer North-West and South of Europe have only just maintained their relative income positions or experienced a deterioration. This is a first indication that, between 1995 and 2018, broad convergence took place between the EU28 countries.

A similar trend can be observed in Chart 2, which plots the coefficient of variation of EU per capita incomes – a measure of sigma convergence – over time. Between 1995 and 2018, cross-country differences in EU28 incomes have been declining and sigma convergence has thus taken place. From 1960 to just before the global financial crisis, sigma convergence can also be observed among EU15 countries, though periods of faster convergence alternated with periods of stagnation or even divergence. In the aftermath of the global financial and European sovereign debt crises, per capita incomes in crisis-hit Southern European countries drifted apart from those in North-Western Europe. Hence, in 2014 the dispersion of incomes among EU15 countries was back at its 1990 level, before gradually diminishing again.

Chart 2

**… but the dispersion in per capita incomes has generally decreased over time**

(population-weighted coefficient of variation * of EU countries' GDP per capita in PPS)




Source: EC (Ameco).
* Standard deviation divided by the mean.

## 2.2 Unconditional beta convergence

In this section, we start by investigating the existence of beta convergence among EU countries, a concept that, as explained in section 1, captures the extent to which initially poorer EU countries have caught up with richer ones. We first examine the existence of unconditional or absolute beta convergence, irrespective of countries' structural differences. In the next section, we will look into conditional convergence, which allows us to delve deeper into the main drivers of cross-country growth differences among EU member states.

The existence of absolute beta convergence can be verified with a simple linear regression in which the explained variable is the average annual growth rate of GDP per capita over a certain period of time – as is common in the literature, we consider five-year periods – and the only explanatory variable is the initial level of GDP per capita. The equation, which we estimate using ordinary least squares (OLS), thus becomes:

$$\frac{1}{5} ln\left(\frac{Y_{i,t+5}}{Y_{i,t}}\right) = \alpha + \beta lnY_{i,t} + \varepsilon_{i,t}$$

where $\frac{1}{5} ln\left(\frac{Y_{i,t+5}}{Y_{i,t}}\right)$ is the average annual growth rate of per capita GDP in country i between the years $t$ and $t+5$ and $(ln)\, Y_{i,t}$ is the (natural logarithm of) initial per capita income in country $i$. A negative coefficient for the latter variable indicates absolute beta convergence, as it implies that a lower initial income tends to go hand in hand with stronger growth in the following period. A positive coefficient would point to divergence. Chart 3 shows the result of such a regression exercise, repeated for 5-year rolling windows since 1960 (i.e. 1960-1965 income growth regressed on 1960 income, 1961-1966 income growth regressed on 1961 income, etc.) for the EU15 countries (left-hand panel) and since 1995 for the EU28 countries (right-hand panel). The results confirm that convergence in the EU has not been a smooth process. The 1960s to the mid-1970s marked a period of significant convergence between EU15 countries, as illustrated by a strongly negative beta. This period covers part of the "Golden Age" for Western Europe, which extended from the end of the Second World War to the early 1970s and was characterised by historically high economic growth rates, strong productivity growth and low unemployment. The establishment of the predecessors of the EU – the European Coal and Steel Community in 1951 and the European Economic Community in 1957 – contributed to this development by boosting intra-European trade, allowing for a more efficient allocation of resources and widespread technology transfers. The oil crisis and the collapse of the Bretton Woods system at the beginning of the 1970s put an end to this period of strong convergence.

Subsequently, convergence picked up again from the mid-1980s, more or less until the global financial crisis in 2008. First of all, the signing of the European Single Act in 1986, which led to the creation of the European Single Market in 1993, supported convergence by reducing obstacles to the free movement of people, goods, services and capital. The accession of some relatively poorer countries to the EU (in particular, Spain and Portugal in 1986) also gave a renewed boost to the convergence process[1]. It was only during the early 1990s that convergence was weaker. These were turbulent years; the iron curtain came down, the Soviet empire imploded and the Gulf War erupted. The industrial world entered a recession, triggered by rising oil prices and rising real interest rates in Europe due to the re-unification of Germany. The Bundesbank responded to the expansionary fiscal policy in Germany by increasing its interest rate. In autumn 1992 and summer 1993, the recession culminated in Europe with the Exchange Rate Mechanism (ERM) crisis.

The global financial and European sovereign debt crises marked a period of divergence. The strong financial integration in the run-up to the crisis, with capital flowing abundantly from the richer "core" to the countries in the "periphery", supported growth in the latter countries and, therefore, convergence, but this later proved to be unsustainable. Investment was channelled primarily to the non-tradable sector – in some cases the counterpart of housing market bubbles – and was accompanied by competitiveness losses, worsening the prospects for more durable growth based on exports (Coutinho and Turrini, 2019). Over the last few years, the beta coefficient has again entered negative territory however, suggesting that convergence among the EU15, driven by higher growth in some Southern European countries, may have resumed.

When the CEE countries are added to the sample (right-hand panel), negative betas and, thus, absolute convergence can be observed for the entire period from 1995 onward. It is only during the 1990s – a period of transition and low growth for countries in the region – that the model provides a weaker fit and convergence was less pronounced. Convergence reached its fastest rate on the eve of the global financial crisis, which in

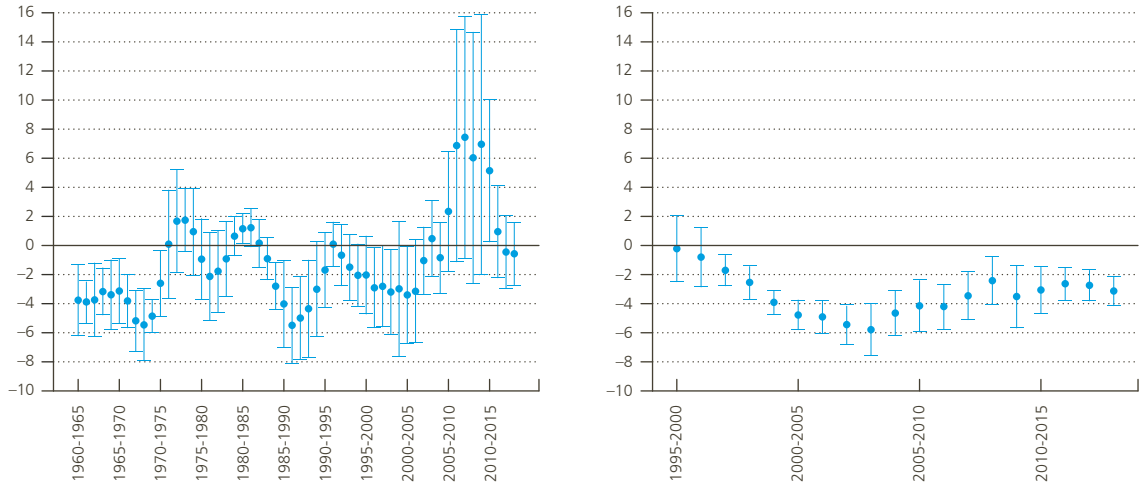
1 Nominal convergence in the run-up to the introduction of the euro in 1999 initially also seemed to go hand in hand with real convergence. In fact, Diaz del Hoyo *et al.* (2017) point out that so-called "Maastricht" convergence may have facilitated real convergence by providing stable macroeconomic conditions and by anchoring expectations.

turn marked a period of weaker (but still statistically significant) convergence for the EU28. In the last couple of years, the convergence machine seems to have regained some speed, although it is still too early to tell whether the fast pace of the early 2000s can be matched. The chart illustrates that Central-Eastern Europe has played a prominent role in the EU convergence process during the last two decades. The transition from centrally planned to market-based economies led to a significant reallocation of resources, stimulating catch-up growth. This process was supported by the region's rapid integration with the rest of Europe, a process that started with the signing of the first Association Agreements in 1994 and eventually culminated in EU accession for most countries in 2004, for Bulgaria and Romania in 2007, and for Croatia in 2013. Moreover, several of these countries have also joined the euro area in the meantime. The integration process further boosted trade linkages with the rest of Europe and spurred capital and labour mobility and innovation.

Chart 3

**Convergence has not been a smooth process**

(unconditional beta coefficients in % and their 95 % confidence intervals, estimated from rolling OLS regressions for 5-year-ahead growth in GDP per capita in PPS)




Source: EC (Ameco).

Charts 4 and 5 offer an alternative way of visualising the convergence process, at the same time allowing us to identify individual countries' trajectories vis-à-vis the EU average in GDP per capita terms. The panels in these charts correspond with the different sub-periods identified in Chart 3, for the EU15 and EU28 country samples respectively. The panels plot EU countries' change in GDP per capita over the sub-period considered against their initial income levels, both relative to the EU average. As such, the charts illustrate whether and to what extent initially poorer countries grew faster than their richer counterparts: if the (regression) line of best linear fit has a negative slope, this again signifies convergence, whereas a positive slope points to divergence. The charts furthermore indicate which countries grew faster or slower than their initial incomes would suggest: countries above (below) the fitted line grew faster (slower) than expected.

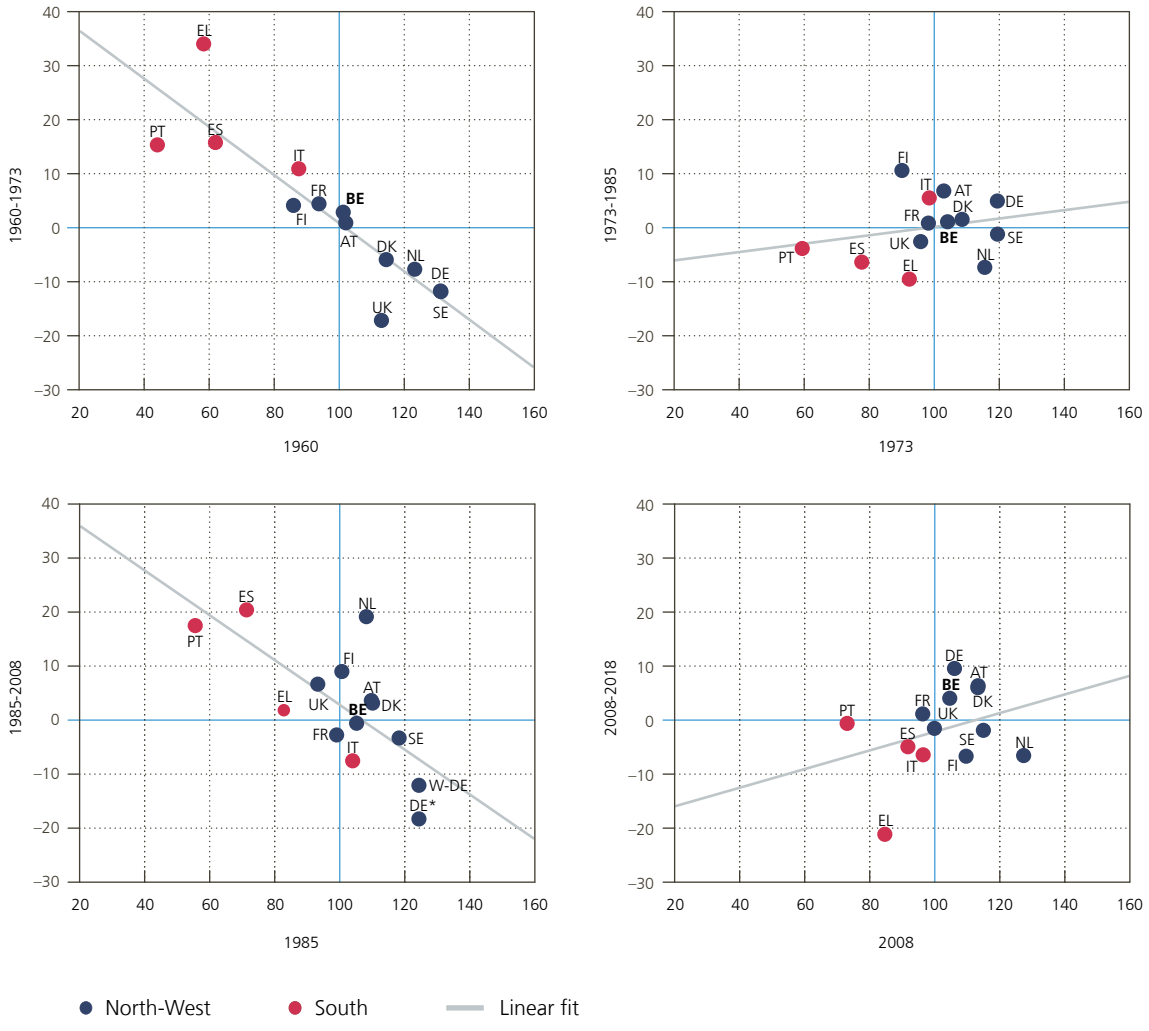
As highlighted before, within the EU15, periods of convergence alternated with periods of divergence (Chart 4). The strong convergence observed from the 1960s to the mid-1970s was driven by Southern European countries catching up with the countries in the North-West; Spain, Italy, Greece and Portugal all recorded below-EU average income levels at the beginning of the period but grew, on average, substantially faster than their richer counterparts. The next convergence period, from the mid-1980s until the crisis, was supported by strong growth in Spain and Portugal; Greece did not succeed in keeping pace with them, while Italy even witnessed below-average growth and saw its relative position deteriorate. As the last panel of Chart 4 illustrates, the global financial and

European sovereign debt crises had exactly this effect on all countries in the South, particularly in Greece, where per capita incomes declined by more than 20 percentage points relative to the EU average over the period 2008-2018.

## Chart 4

**Strong convergence among "old" member states during the first decades of EU integration has (temporarily?) come to a halt**

(change in GDP per capita in PPS over the sub-period considered versus initial GDP per capita in PPS, both relative to the EU15 average)




Source: EC (Ameco).

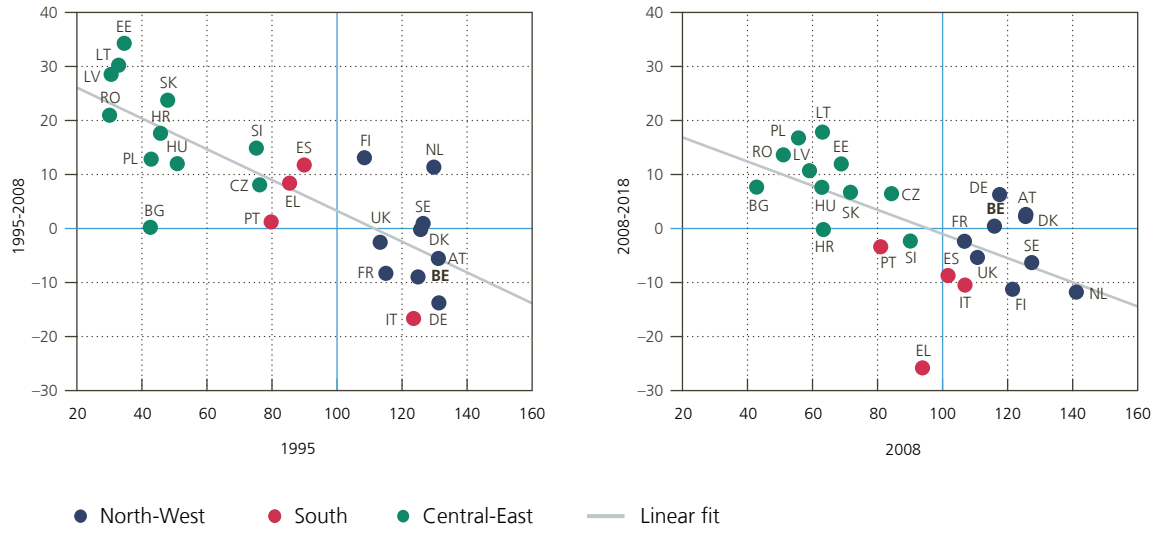
* The position of Germany (DE) in the lower-left panel is influenced by the reunification of the country; from 1991 onwards, data for Germany include data from both the Western and Eastern parts of the country (whereas for the years before, only West Germany is included). The addition of data from a relatively poorer area pushes the position of Germany downward. For the sake of clarity, the data point for West Germany (W-DE) is also included.

Chart 5 again introduces the CEE member states to the sample. Most countries from this region are situated in the upper left part of the chart, for both sub-periods considered: most of these initially poorer countries managed to grow substantially faster than the EU average, especially in the decade leading up to the crisis. The Baltic countries and Romania in particular registered very strong growth and therefore managed to significantly improve their positions relative to the EU28 average. Between 1995 and 2018, the latter countries managed to more than double their per capita incomes compared to the EU average (cf. Chart 1).

Chart 5

**Accession of Central-Eastern European countries gave a new boost to convergence**

(change in GDP per capita in PPS over the sub-period considered versus initial GDP per capita in PPS, both relative to the EU28 average)




Source: EC (Ameco).

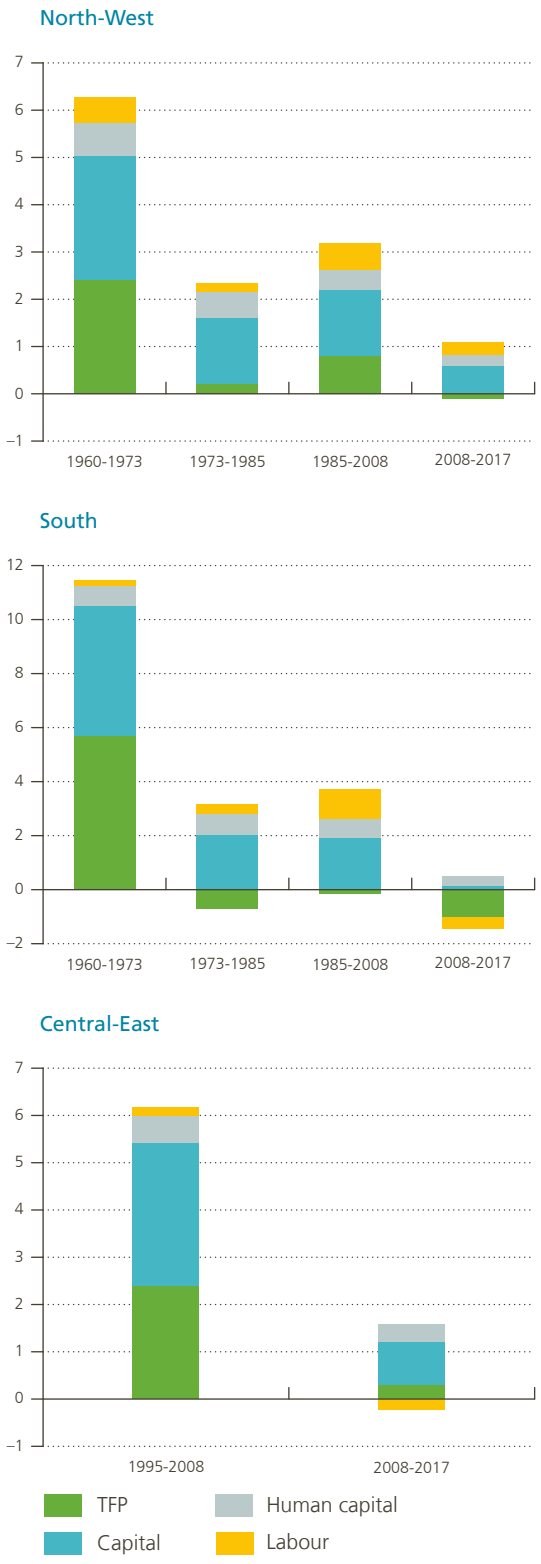
One way of distinguishing between the various drivers of economic growth for the different sub-periods identified above is through a growth accounting exercise (Chart 6). During the so-called "Golden Age", economic growth in the North-Western and Southern European countries was driven mainly by total factor productivity (TFP) and an accumulation of capital. Growth touched historic highs, with economies in North-Western Europe advancing by more than 6 % on average annually (in real terms) and by more than 10 % in Southern Europe. Similar growth rates were never attained again and the contribution of productivity gains diminished strongly in subsequent periods. In the South, productivity losses even became a drag on growth in all subsequent periods, especially so in the aftermath of the global financial and European sovereign debt crises. The crises also induced large South-North migration flows – especially in the segment of the young and educated –, with the resulting declines in human capital and labour further negatively affecting growth.

As for Central-Eastern Europe, the 1995-2008 period was characterised by strong annual growth of more than 6 % on average, boosted by increases in both capital and productivity. Capital and financial sector liberalisation, the gradual adoption of the EU acquis in view of accession, and large-scale privatisations in the transition from centrally planned to market economies attracted large capital inflows from other European countries. Furthermore, TFP dynamics in CEE countries were especially strong in the period preceding the crisis, reflecting in part the beneficial consequences of these countries' integration into the EU and the gains from a reallocation of resources during transition. Growth has, however, slowed sharply since the crisis. Investments were scaled down and emigration translated into a negative contribution of labour dynamics to growth. As this concerned mainly the young and higher educated, emigration, in turn, also adversely affected human capital.

## Chart 6

**The drivers of growth in the EU have changed over time**

(contributions to average annual growth rates of real GDP, percentage points)




Source: Penn World Table 9.1.

## 2.3 Conditional beta convergence

We now go one step further than our simple convergence tests above, taking into account the fact that growth rates differ across countries not only as a result of different initial income levels, but also because of other factors. We therefore add a vector of control variables $X_{i,t}$, that may also affect countries' steady states, to our equation:

$$\frac{1}{5} ln\left(\frac{Y_{i,t+5}}{Y_{i,t}}\right) = \alpha + \beta lnY_{i,t} + \gamma X_{i,t} + \varepsilon_{i,t}$$

As explained above, by allowing for countries to move towards different steady states, this equation thus enables us to study the extent of *conditional* convergence among EU member states. However, we do not attempt to pin-point the exact drivers of growth in the EU in an exhaustive way ( as there is already a vast body of research on that subject), or to establish causality. Instead, we consider a small set of key variables distilled from the most relevant literature[1].

### *Explanatory variables*

Next to the initial level of GDP per capita, we introduce population growth as an independent variable in the equation. On the one hand, to the extent that population growth implies a dilution of the capital stock per capita, it negatively affects economic growth. Population growth through migration flows, on the other hand, may also affect growth by impacting human capital. The sign of this variable's coefficient is therefore ambiguous. The ratio of investment to GDP is expected to enter the equation with a positive sign, reflecting the fact that higher investment is associated with faster capital accumulation and, therefore, higher growth. The build-up of human capital per worker is approximated by an index based on the average years of schooling and an assumed rate of return for education. We expect this factor to make a positive contribution to growth. Trade openness, as measured by the ratio of exports plus imports to GDP, is introduced to the equation with an expected positive sign, as trade is known to enhance the allocation of resources and the diffusion of technology and knowledge, thus benefiting growth. Finally, inflation and government consumption are included as measures of macroeconomic (in)stability, both with an expected negative sign. With regard to the former, both the average annual rate as well as the standard deviation of inflation are included in the regression, reflecting the importance of both low and stable inflation for economic activity to flourish. Public consumption, for its part, is assumed to proxy for expenditures that do not directly affect productivity but entail distortions to private decisions (Barro, 2003). Annex 1 provides more details on the variables used in the regression.

We include period dummies to control for possible common shocks affecting all countries, and geographical dummies (for Southern and Central-Eastern Europe; with North-Western Europe being the base category)[2] to control for shocks and hard-to-model structural characteristics common to specific regional blocs.

### *Regression results*

The regression is again estimated using simple (pooled) OLS. Following standard practice in the estimation of growth regressions with panel data, annual observations are converted into averages (or changes) over non-overlapping, five-year sub-periods, to reduce the effects of short-term disturbances on the results. To maximise the number of observations for this particular regression exercise, we employ an unbalanced sample, including observations since 1960 for the EU15 member states, and since 1995 for the other EU28 countries. The regression results are displayed in Table 1.

1 See, among many others, Coutinho and Turrini (2019), Barro (2003), Kaitila (2005) and Savelin and Żuk (2018). We refrain from assessing the (long-term) impact of the EU's structural and investment funds on economic growth and convergence. This is the subject of an extensive literature with largely inconclusive results (see, e.g., the meta studies by Dall'Erba and Fang, 2017, and Darvas *et al*., 2019).

2 Geographical dummies can be seen as an alternative to including country-specific fixed effects which would, instead, absorb all (time-invariant) between-country variations and may introduce bias into the estimation (see Temple, 1999).

Table 1

**Cross-country regression results**

(panel OLS regression, 5-year non-overlapping periods,1960-2018 for EU15, 1995-2018 for the other member states)

| | No control variables | With control variables |
|---|---|---|
| Dependent variable | | |
| Average GDP per capita growth | | |
| Independent variables | | |
| Initial GDP per capita | –2.700*** | –4.507*** |
| Dummy for Southern countries | | –0.436 |
| Dummy for CEE countries | | –1.134* |
| Population growth | | –0.339** |
| Investment ratio | | 0.070 |
| Human capital | | 0.723 |
| Trade openness | | 0.007* |
| Government consumption ratio | | –0.070* |
| Inflation | | –0.116** |
| Inflation volatility | | –0.002 |
| Constant | 30.407*** | 45.122*** |
| Period dummies | No | Yes |
| Number of observations | 211 | 209 |
| Number of countries | 24 | 24 |
| R-squared | 0.618 | 0.922 |
| Adjusted R-squared | 0.616 | 0.913 |

Sources: EC (Ameco), Penn World Table 9.1 and World Bank.
Note: Standard errors (not shown) are clustered at the country level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Our estimations confirm the existence of absolute beta convergence for our sample of EU countries between 1960 and 2018: running the regression with no control variables yields a negative beta coefficient of –2.7. Running the regression with the above-described control variables yields a more negative beta coefficient of –4.5. In other words, over the longer term and considering all member states, convergence in the EU has been quite strong. In fact, a beta coefficient of –4.5 implies that a 1 % decrease in initial per capita GDP would raise a country's average growth rate over the next five years by 4.5 basis points annually. Beta estimates can also be used to project the time that countries would need to move closer to their steady states. More specifically, at a convergence rate of 4.5 %, it would take countries about 15 years to eliminate half of the gap towards their long-run steady states. All the other independent variables enter the equation with the expected sign (with population growth negatively affecting growth), even though they are not all statistically significant at the conventional 5 % or 10 % level[1].

In order to illustrate how the regression variables have affected growth in the EU, we plot them against "residual" growth of GDP per capita (correcting for the influence of all other variables included in the regression) in Chart 7. For each country, the latest observation (the variable's average over 2015-2018) is marked in colour. The chart illustrates the positive correlation of growth with investment, human capital and trade openness, and the negative association with government consumption. Moreover, the chart enables us to assess how the

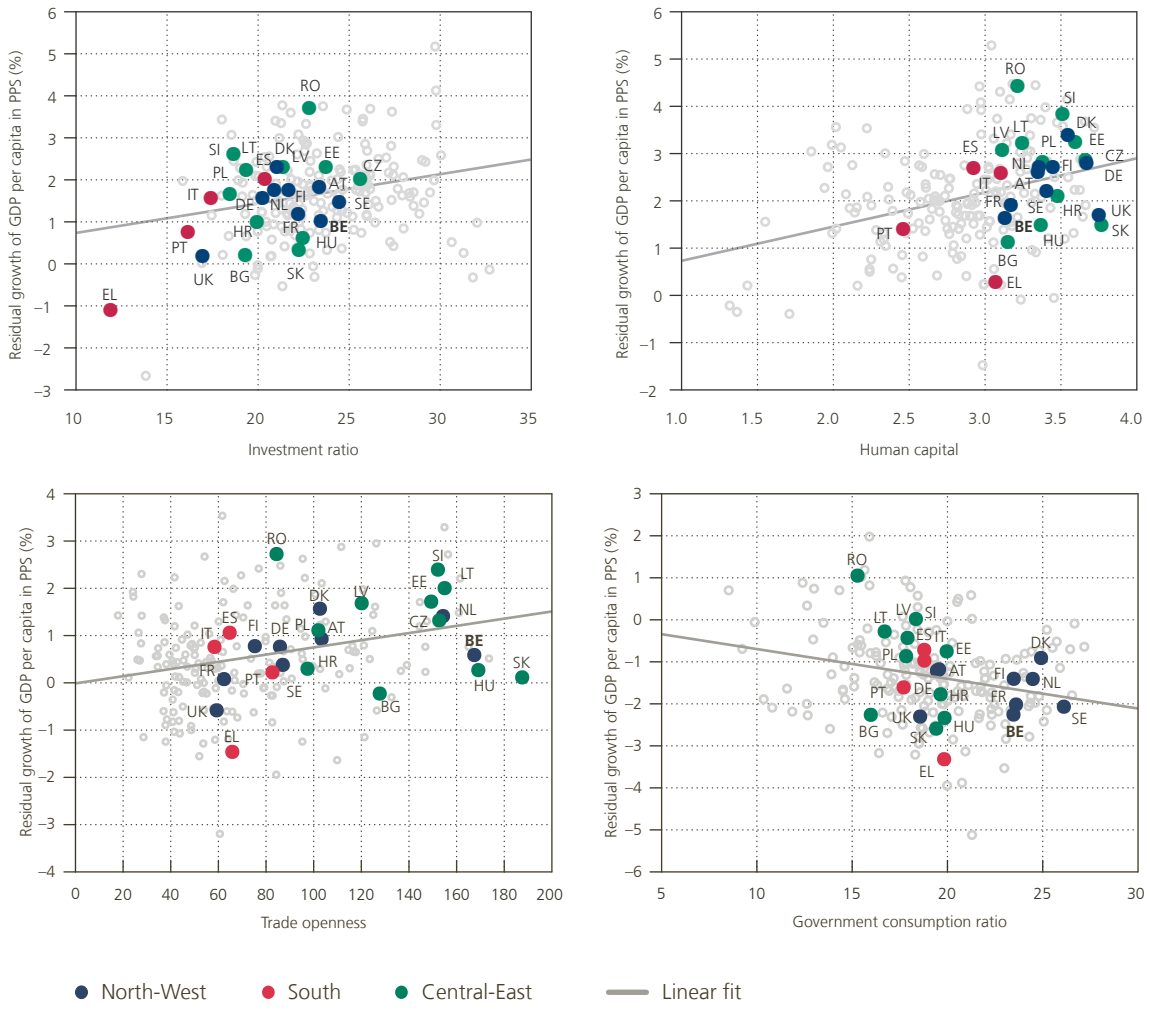
1 The coefficients of investment and of human capital are only statistically significant at the 15 % level.

different countries perform with regard to the variables concerned. In particular, during the latest observation period (2015-2018), Southern European countries performed quite poorly on the variables that positively affected growth. CEE countries have relatively high values for human capital and trade openness, while North-Western European countries tend to have relatively high government consumption ratios.

## Chart 7

**Investment, human capital and trade openness are positively associated with growth in the EU, while government consumption shows a negative correlation**

(partial residual plots with average country values for 2015-2018 marked in colour)*




Sources: EC (Ameco), Penn World Table 9.1.

* The charts plot the residuals from the panel regression model (with control variables) plus the contribution of the variable of interest on the y-axis against the variable of interest on the x-axis. The slope of the trend line therefore corresponds with the regression coefficient of the independent variable in question (shown in Table 1).

## 3. Convergence at the regional level

In this section, we pursue three objectives. First, we verify whether there is also convergence of GDP per capita[1] levels between the regions across the EU28[2]. Second, we classify regions into different categories according to their economic performance, including the Belgian regions. Third, we examine the role played by capital cities and other important metropoles in terms of convergence and growth. To this end, we selected the 24 capitals as well as 75 metropolitan areas, according to the EU-OECD definition[3], with a population of more than 500 000. In particular, we are interested in the incremental effect on income growth when a region includes, respectively, such a metropolitan area, a "large" metropolitan area with a population of more than 1.5 million, or a capital (irrespective of its population size). The motivation for considering metropoles comes from the literature on agglomeration economies, which advances the idea that productivity and growth benefit from the concentration of economic activity through increasing returns to scale and positive externalities such as lower transportation costs, knowledge spill-overs, and a better matching on the labour market (Krugman, 1991a and 1991b).

Before examining (sigma and beta) convergence, we first elaborate on our data and methodology.

### 3.1 Data and methodology

Our research uses the novel regional database Ardeco, made available online in December 2019 by the European Commission[4]. This provides us with regional-level data starting in 1996 for all the 24 countries considered.

We use a concept of large regions developed by the OECD (Territorial Level 2, henceforth TL2) and also commonly employed by the IMF (see IMF, 2019 and Ebeke *et al.*, 2020). The European literature, however, typically uses the Eurostat NUTS classification (Nomenclature of Territorial Units for Statistics): NUTS1 for major socio-economic regions; NUTS2 for the reference regions for the application of EU regional policies (regions eligible for cohesion funds); and NUTS3 for small regions (Eurostat, 2018). For example, in the case of Belgium, NUTS3 corresponds to districts ("*arrondissements*"), NUTS2 to "provinces" and NUTS1 to "regions". The OECD typology builds on the NUTS nomenclature in order to distinguish only two categories: large and small regions (the latter referred to as Territorial Level 3, TL3). For the EU member states, TL2 regions correspond to NUTS2 regions except for Germany, the UK and Belgium, where NUTS1 aggregates are considered instead: Länder in Germany, regions/nations in the UK and regions in Belgium. Compared to NUTS2, the TL2 typology places more emphasis on administrative regions (where policy decisions are taken) than on the homogeneity of the sample in terms of population. As illustrated in the left-hand map in Chart 8, other TL2 regions include those that people generally have in mind such as the regions in Italy, the former regions in France, the autonomous communities in Spain, the provinces in the Netherlands and the voivodeships in Poland.

In this article, we take the TL2 regions as our starting point, because the use of administrative regions makes more sense in terms of economic policy, because we are more interested in large regions than small ones, and because smaller entities are more subject to methodological issues, in particular the issue of spatial dependence, as economic growth in one region may affect the growth of neighbouring regions. This spill-over effect is found to be most significant within a travel time of 150 minutes (EC, 2017 and Annoni *et al.*, 2019). In the remainder of our analysis, we disregard the effects of spatial dependence.

1 In this section, we also use income convergence as synonymous with GDP per capita convergence or real convergence.

2 As in the previous section, EU28 actually stands for the 24 EU countries considered, as Ireland, Luxembourg, Cyprus and Malta were excluded from our research. Here we also exclude regions located outside Europe (the Territoires d'Outre-Mer for France; the Canary Islands, Ceuta and Melilla for Spain; and the Azores and Madeira for Portugal), as well as one tiny region inside Europe (Åland in Finland). In addition, we drop the Dutch province of Groningen because the volatility in its GDP per capita mainly reflects fluctuations in the price of gas, the extraction of which has constituted a significant share of economic activity.

3 See the common EU-OECD definition of Functional Urban Areas (FUAs) (Dijkstra *et al.*, 2019; OECD, 2019; EC, 2016, 2019). Basically, FUAs are cities and their commuting zones. Metropolitan areas are FUAs with a population of more than 500 000.

4 While country data are based on the Ameco database released with the Autumn 2019 EC forecasts, the regional figures extracted from Ardeco in December 2019 were based on a previous vintage of EC forecasts (Spring 2019). This implies that revisions in national accounts that have been implemented in the autumn of 2019 in some countries, including Belgium, have not been taken into account in our regional analysis.

Table 2

**Twenty TL2 regions with the highest GDP per capita (PPS) in 2018 ***

| | Name of the Region | GDP per capita | Area (km²) | Ranking area ** | GDP per capita after correction | Ranking in GDP per capita after correction |
|---|---|---|---|---|---|---|
| 1 | Hamburg | 60 762 | 755 | 6 | 45 895 | 12 |
| **2** | **Brussels** | **60 442** | 162 | 1 | **49 340** | **6** |
| 3 | Prague | 58 795 | 496 | 4 | 42 468 | 18 |
| 4 | London | 58 674 | 1 572 | 9 | 50 013 | 4 |
| 5 | Bratislava | 55 813 | 2 053 | 12 | 55 813 | 1 |
| 6 | Ile de France | 54 683 | 12 070 | 76 | 54 683 | 2 |
| 7 | North-Holland | 52 537 | 3 403 | 23 | 49 699 | 5 |
| 8 | Stockholm | 51 108 | 7 153 | 42 | 51 108 | 3 |
| 9 | Copenhagen | 50 647 | 2 559 | 16 | 47 837 | 8 |
| 10 | Utrecht | 48 102 | 1 449 | 8 | 48 102 | 7 |
| 11 | Warsaw | 47 677 | 6 104 | 39 | 47 677 | 9 |
| 12 | Bremen | 47 156 | 420 | 3 | 37 178 | 31 |
| 13 | Salzburg | 47 072 | 7 154 | 43 | 47 072 | 10 |
| 14 | Vienna | 46 766 | 415 | 2 | 42 058 | 21 |
| 15 | Budapest | 45 558 | 525 | 5 | 33 629 | 48 |
| 16 | Bucharest-Ilfov | 45 072 | 1 804 | 10 | 45 072 | 13 |
| 17 | Helsinki | 44 153 | 9 568 | 63 | 44 153 | 14 |
| 18 | Bavaria | 43 733 | 70 543 | 196 | 43 733 | 15 |
| 19 | Bolzano | 43 689 | 7 398 | 46 | 43 689 | 16 |
| 20 | Baden-Württemberg | 42 618 | 35 745 | 180 | 42 194 | 20 |

Sources: EC (Ardeco), own calculations.

* Grey rows show TL2 regions that were corrected to incorporate their commuting areas.

** Ranking area: position in the ranking of TL2 regions by area (from the smallest to the largest).

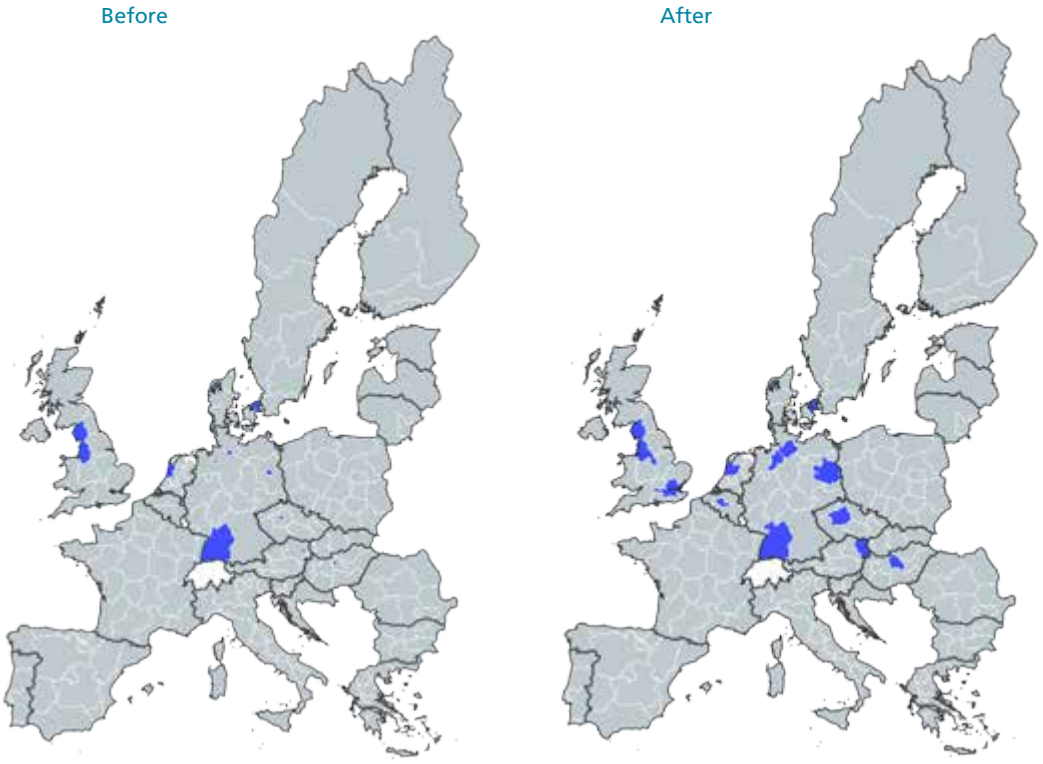
Ranking the TL2 regions by GDP per capita (Table 2), we observe that the richest regions often include the national capital or a large metropole. They are sometimes also very small in terms of area. Notably, the Brussels-Capital Region is by far the smallest of the 204 TL2 regions. A small size and a high income (GDP per capita) often go hand in hand. Indeed, regional GDP per capita is a ratio between total production in the region and the number of people living there. The smaller the geographical unit, the more likely a substantial fraction of local GDP is attributable to commuters (Monfort, 2008). Commuters contribute to the GDP of a small capital region like Brussels but they do not belong to the population of that region. Brussels' high GDP per capita – the highest in the EU28 in 1996 and the second highest in 2018 – is therefore partly an artefact of its very narrow geographical definition. As one of our main purposes is to compare the performance of capital regions or metropolitan regions with other regions, and since the administrative definition of regions varies from country to country in terms of size, we have expanded several TL2 regions to encompass the commuting zones of their metropole(s) in order to diminish the bias from inter-regional commuting. While Lazio largely covers Rome and Ile-de-France largely covers the Parisian basin, the TL2 regions of some other capitals and metropoles do not in fact cover their commuting areas sufficiently.

In practice, according to our analysis of the 24 capitals and 75 metropoles (see Annex 2), twelve capital or metropole regions are found to extend beyond one TL2 region. They are coloured in blue in the left-hand map of Chart 8, while their extended TL2 region is represented in the right-hand map. They include the six capital

NUTS2 regions often corrected in the literature (Annoni *et al.*, 2019 ; Iammarino *et al.*, 2018) : Amsterdam, Berlin, Brussels, London, Prague and Vienna. The other TL2 regions that are expanded to include commuting flows comprise two other capital regions (Budapest and Copenhagen), two Länder cities (Hamburg and Bremen) and two other regions where a metropole is situated close to the border with other TL2 regions (North of England because of Manchester, and Baden-Württemberg because of Mannheim).

Chart 8

**Twelve of the 204 large regions were expanded to cover the whole commuting zone of their metropole(s)**




Sources : Eurostat, OECD.

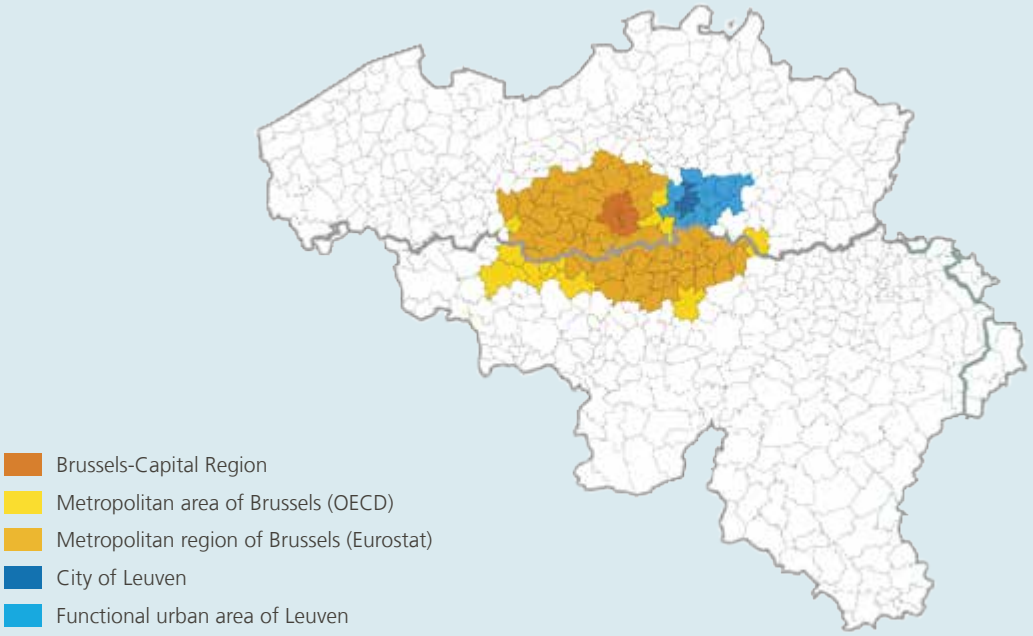
In three cases, the extension of the TL2 regions involves merging two regions, so that we end up with 201 "TL2-corrected" regions. In the nine other cases, the expansion implies a reduction in the size of neighbouring TL2 regions (see Annex 3 for more details on the corrections). The correction applied to Brussels and its effect on the GDP per capita of each Belgian region is illustrated in Box 1. Based on the TL2-corrected definition, the ranking of regions according to their GDP per capita changes significantly (Table 2). In particular, metropolitan regions whose TL2 is expanded, such as Hamburg, Brussels and Prague, see significant drops in their income ranking. As a result, Bratislava now has the highest GDP per capita at over 55 000 euros (in PPS), significantly less than Hamburg's figure of almost 60 800 euros before corrections. Conversely, some areas adjacent to a corrected metropole (such as Lower Saxony) enjoy a higher GDP per capita than before the correction.

BOX 1

# The correction for Brussels as an important metropolitan area and its consequences

Belgium has two metropolitan areas according to the EU-OECD definition: Brussels and Antwerp. Wallonia has no metropolitan areas, as Charleroi and Liège and their respective commuting zones have a population of less than 500 000.

**Brussels: from metropolitan area to metropolitan region**



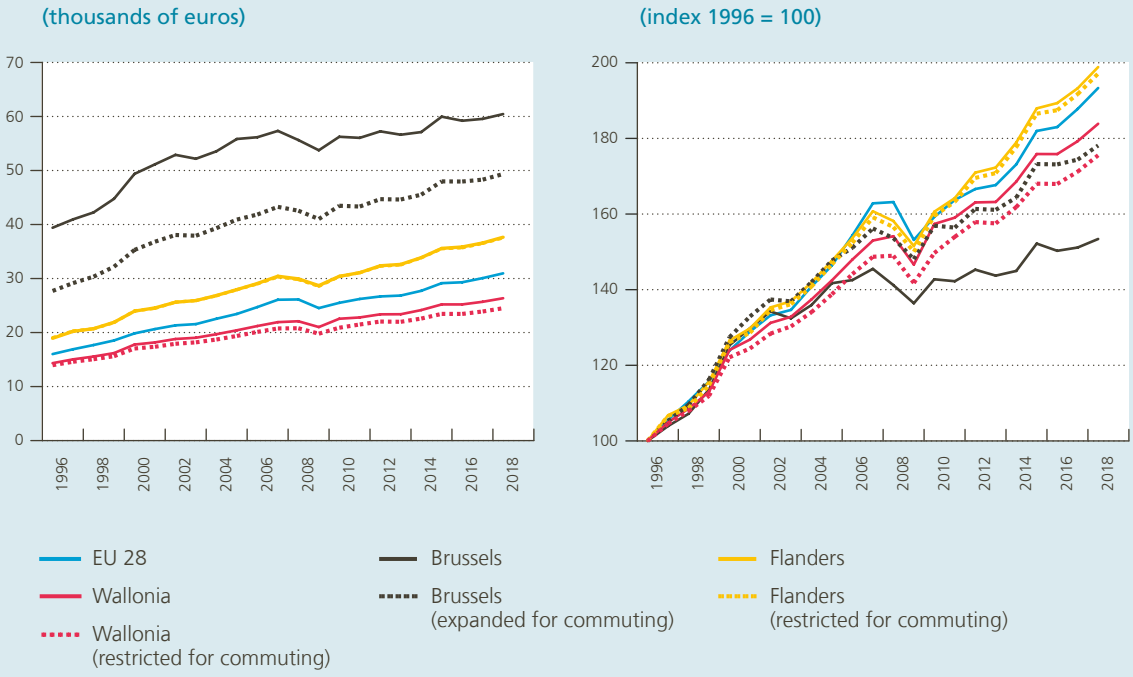

Sources: Eurostat, OECD.

The Brussels-Capital Region (in dark orange) consists of 19 municipalities. It is the smallest TL2 region in our sample. According to the EU-OECD definition of *metropolitan areas* which is based on municipalities (yellow), the commuting zone of Brussels extends far into both the Flemish and the Walloon Region. In Wallonia, for example, it would include Ath and other municipalities in the province of Hainaut as well as Gembloux (province of Namur). Conversely, Leuven and its surrounding municipalities (blue) are not included in the Brussels metropolitan area, since Leuven is considered to form a functional urban area (FUA) on its own.

Eurostat (2018b) defines *metropolitan regions* as NUTS3 (or an aggregation of NUTS3) regions in which at least 50 % of the population lives in a metropole. The metropolitan region of Brussels (light orange) includes the districts of Nivelles (equal to the province of Walloon Brabant in Wallonia), Aalst and Halle-Vilvoorde (both in Flanders).

As (GDP and other) statistics are only available at the NUTS3 level (and not at the municipality level), we use the Eurostat definition of metropolitan regions for the remainder of our analysis.

**Impact of the expanded definition of Brussels on the GDP per capita of the Belgian regions**




Source: EC (Ardeco).

Before the expansion, the Brussels-Capital Region has the highest GDP per capita (in PPS) among the three Belgian Regions over the whole period. The GDP per capita of the Flemish Region is higher than that of Wallonia, which is actually below the EU28 average. Wallonia's GDP per capita is also negatively affected by the commuters working in the neighbouring Grand Duchy of Luxembourg. Our expansion of Brussels to attenuate the commuting bias, however, dramatically reduces its GDP per capita, though that figure remains well above the national average. It also reduces the GDP per capita of Wallonia somewhat, as its richest province, Walloon Brabant, is excluded. There is hardly any impact on the GDP per capita of the restricted Flemish Region (without Aalst and Halle-Vilvoorde).

Looking at economic growth since 1996, the most remarkable feature before the correction is the much lower growth rate of the Brussels-Capital Region compared to the other regions. The Flemish Region has the fastest-growing GDP per capita, even slightly outpacing the EU28 average. Economic growth has been lower in Wallonia than in Belgium as a whole. When the Brussels Region is expanded, its economic performance is significantly enhanced, while that of Wallonia, without dynamic Walloon Brabant, worsens. Meanwhile, growth in the Flemish region is little affected by excluding Aalst and Halle-Vilvoorde.

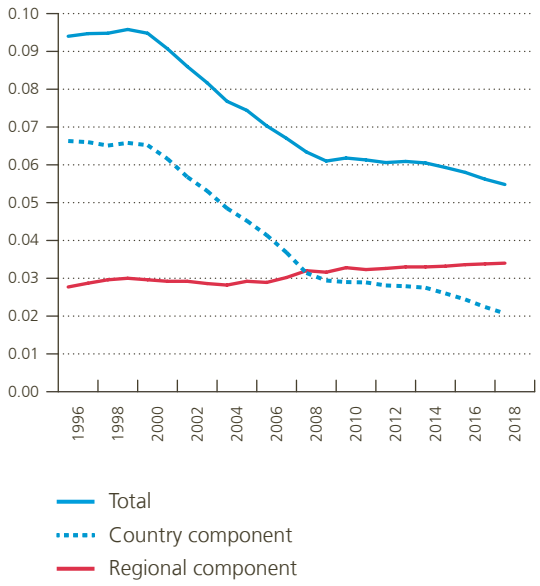
## 3.2 Dispersion

For the analysis of sigma convergence at the regional level, we favour the Theil index instead of the (population-weighted) coefficient of variation, as it allows us to decompose the overall regional income dispersion into a country component and a regional component, the latter showing the intra-regional disparities within each country (Monfort, 2008).

### Chart 9

**Dispersion of regional incomes across the EU has decreased due to the decline in dispersion between countries**

(population-weighted Theil index of GDP per capita in PPS and its decomposition into country and regional components, EU28 TL2-corrected regions)




Source: EC (Ardeco).

Disparities in GDP per capita have declined across the EU28 regions over the last two decades. This sigma convergence was especially marked in the early 2000s. As happened at the national level, sigma convergence was interrupted during the global financial and European sovereign debt crises, before receiving a new, though more modest, impetus in recent years.

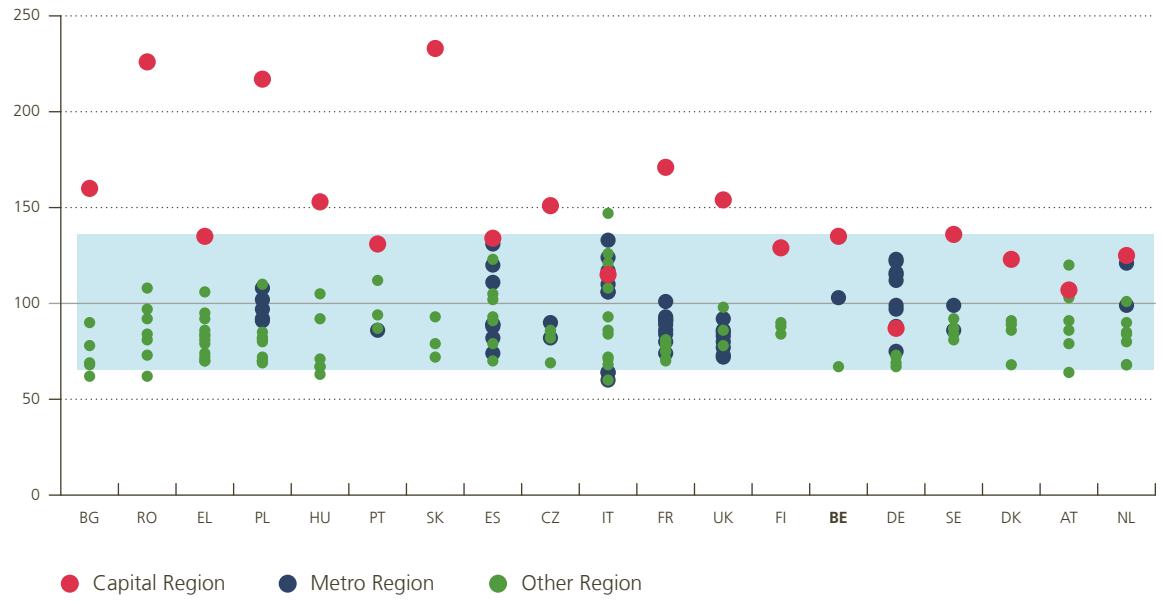
The decline in the Theil index of incomes is fully explained by the country component. As illustrated in the previous section, the dispersion between countries has indeed diminished, while the dispersion within countries has increased somewhat over the 1996-2018 period as a whole.

While a full analysis of regional disparities within individual countries is beyond the scope of this article, in Chart 10 we illustrate the dispersion of GDP per capita for countries with at least three ("TL2-corrected") regions[1].

Chart 10

**Regional disparities remain substantial within most EU countries***

(GDP per capita in PPS, national average = 100, 2018e, TL2-corrected regions)




Source: EC (Ardeco).

* Countries are ranked from the lowest to the highest level of national GDP per capita. The blue-shaded band indicates the income range between the poorest and richest Belgian region.

In 2018, regional income disparities were still substantial in most EU28 countries, be they poor (on the left) or rich (on the right). Typically, the region with the highest GDP per capita is the capital region, the three exceptions being Rome, Vienna and Berlin. In the case of the German capital, its GDP per capita is actually below the country average. In most cases, the capital's income level far exceeds that of the other regions of the country.

In general, the GDP per capita of the other (non-capital) metropolitan regions lies above the respective national averages. The main exceptions are found in France, the UK, the Southern regions in Spain and Italy, and the North of Portugal (Porto).

The income differences between Belgium's poorest and richest region after being adjusted to attenuate the commuting bias (Wallonia and Brussels, respectively), are considerable but, when expressed relative to the national average, they are not exceptional compared to other EU countries.

1 In Annex 4, we provide a similar chart without corrections for the commuting zones of the 12 metropolitan regions. The main conclusions hold.

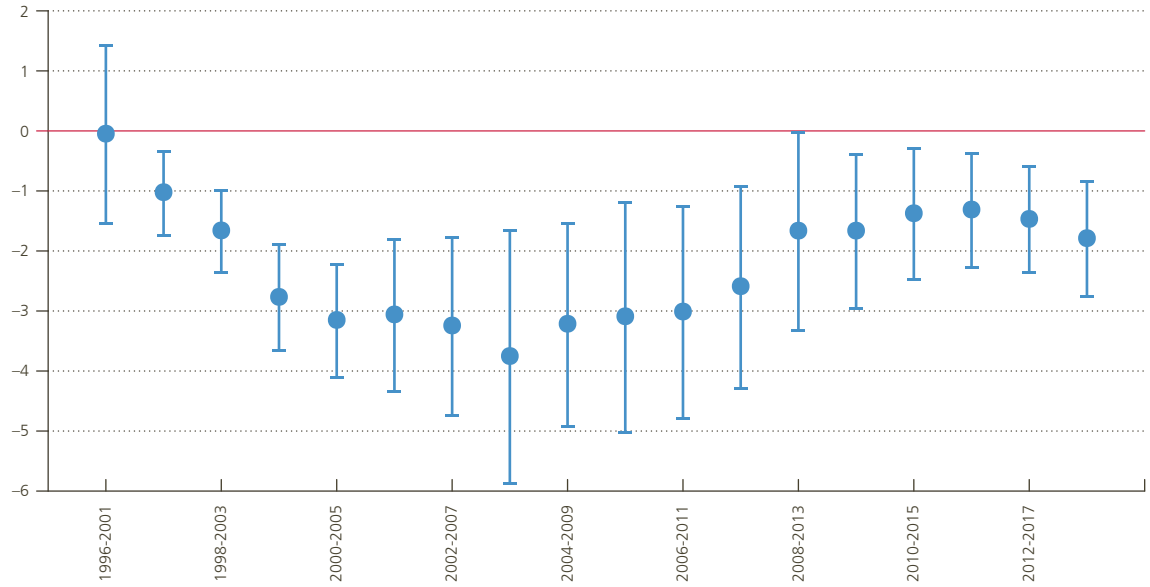
## 3.3 Unconditional beta convergence

As in the section on national convergence, we start the analysis of unconditional beta convergence at the regional level with a chart of beta coefficients estimated from 5-year rolling regressions. The results from this exercise show that there has been significant convergence among the EU28 regions since 1997. As was the case for national convergence, regional convergence was fastest before 2008. Convergence slowed down between 2008 and 2015, before the first tentative signs of a new acceleration reappeared.

Chart 11

**Regions have converged most of the time across the EU28**

(unconditional beta coefficients in % and their 95 % confidence intervals, estimated from rolling OLS regressions for 5-year-ahead growth in GDP per capita in PPS, TL2-corrected regions)




Source : EC (Ardeco).

Also taken together over the whole 1996-2018 period, we find a significant negative beta coefficient, evidence of long-term unconditional beta convergence. As in section 3, we can illustrate this by means of a scatter plot of initial (1996) GDP per capita versus the (1996-2018) change in GDP per capita (both relative to the EU28 average). Regions that were initially poorer than the EU average (GDP per capita below 100) typically grew faster than the EU average (positive values on the y-axis), while richer regions tended to grow more slowly. This relation is captured by the negative slope of the regression line in Chart 12.

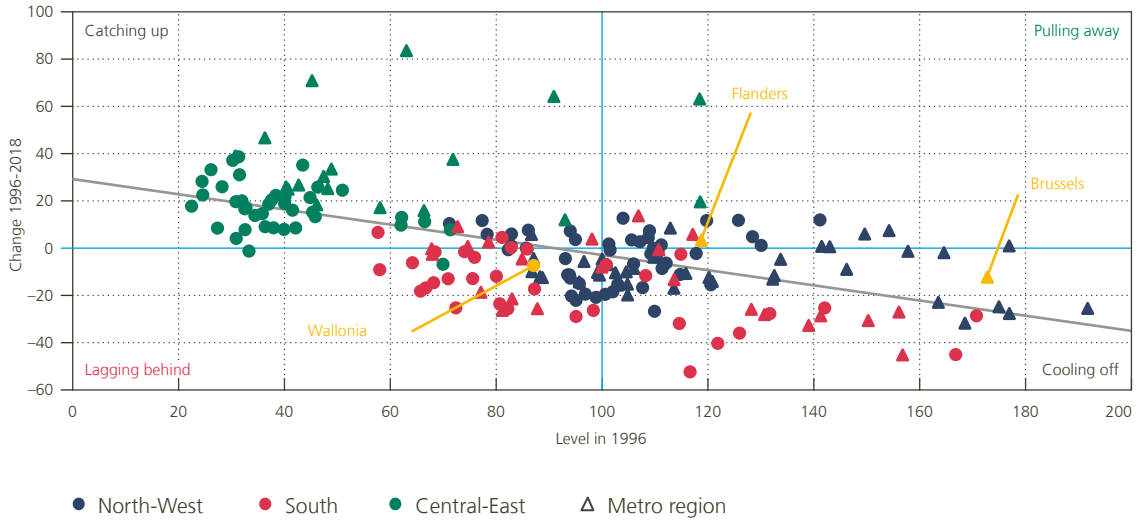
Regions in the upper-left quadrant are "*catching up*" : starting from a worse than average position, they grew faster than the EU average ; regions in the upper-right quadrant are "*pulling away*" : starting from a better-than-average position, they still grew more rapidly than the EU average over the period ; regions in the lower-left quadrant are "*lagging behind*" : poorer than the EU average initially, and growing more slowly than the EU did ; and finally, regions in the lower-right quadrant are "*cooling off*" : richer than the EU average initially, and growing more slowly. Within the catching-up and cooling-off categories, a further distinction can be made according to whether a region is above the regression line, i.e. performing better than what one could expect based on its initial income, or below the regression line, i.e. performing worse than expected. All in all, we thus classify regions along six categories (Chart 13).

The relative position of the regions within the quadrants depends on the period considered and on the definition of the regions. Here, we present the results for our TL2-corrected regions over the whole 1996-2018 period. The results for the TL2 regions (without corrections) are shown in Annex 4.

Chart 12

**Unconditional beta convergence across EU28 regions over the long term**

(change in GDP per capita in PPS over 1996-2018 versus GDP per capita in PPS in 1996, both relative to the EU28 average, TL2-corrected regions)




Source: EC (Ardeco).

Most regions in CEE countries (in green) are classified as catching up with the EU. As highlighted before, they are an important driver of overall EU28 convergence. Often these regions, notably all metropolitan regions (green triangles in Chart 12), are above the regression line, i.e. they recorded higher growth than was expected based on their initial level of income. Bratislava and Prague stand out in particular as they were pulling away fast. The regions catching up less than expected (upper-left quadrant, below the regression line) comprise several non-metropolitan regions (green dots) in Bulgaria, Hungary and Poland (located mostly on the eastern periphery of the EU; see Chart 13).

Southern European regions (in red) are mainly found in the two lower quadrants as their GDP per capita has failed to keep pace with average EU growth. Those lagging behind include the *Mezzogiorno* (Southern Italy) and all Greek regions except Attica (the capital region around Athens). Among the regions cooling off, we find regions in the North and centre of Italy as well as Attica. In most cases, these regions are also below the regression line, meaning that the growth of their GDP per capita has fallen short of expectations on the basis of their initial income level. Spanish regions are found in all quadrants.

North-Western European regions (in blue) are mainly found on the right-hand side of the chart as their level of income was above the EU average in 1996. Among the exceptions are the Länder of Eastern Germany, which are catching up more than expected, and lagging regions in Northern England and various parts of France.

Looking at the three Belgian regions, Flanders (here without Aalst and Halle-Vilvoorde to adjust for the commuting bias of Brussels) is one of just 23 regions that are pulling away. Starting with GDP per capita 19 % above the

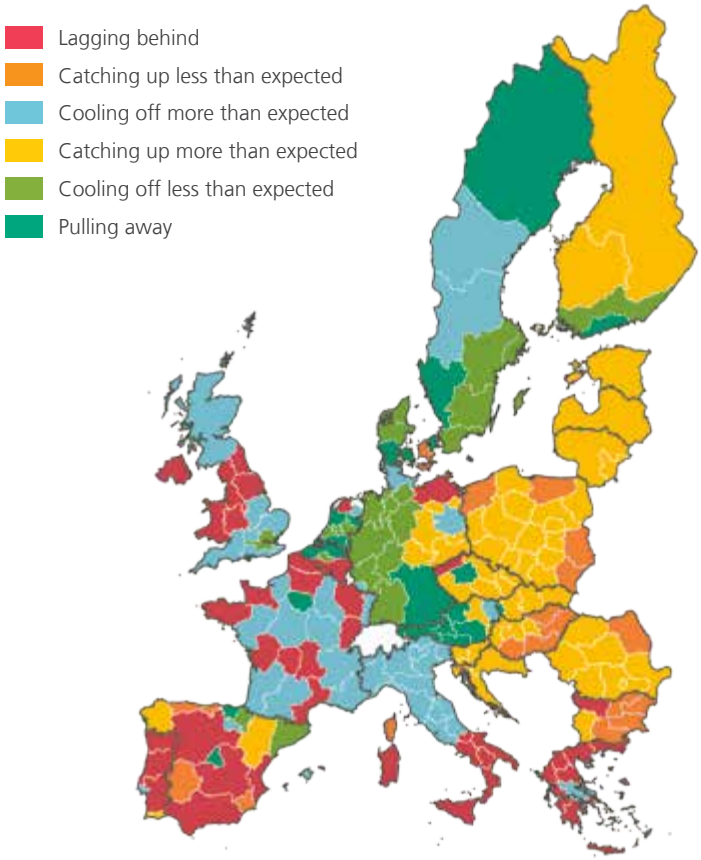
EU average in 1996, its income growth over 1996-2018 was slightly higher than the EU average (3 percentage points in total). Nevertheless, its performance stands out as EU average growth is boosted by the strong performance of regions that are catching up (mainly in the CEE countries). The regions that compare closest to Flanders (in terms of their relative position in Chart 12) include the capital region of Madrid and a number of regions in Western Austria. Only the regions of Salzburg, Copenhagen and North Holland (Amsterdam) clearly outperformed Flanders, with both higher initial incomes and faster growth. Bayern and other capital regions like Paris and Helsinki also belong to the pulling-away category.

Brussels (expanded to its commuting zone) belongs to the regions which are cooling off. Starting from a particularly high-income level in 1996 (173 % of the EU average), Brussels could not keep pace with the EU (growing by 12 percentage points less than the EU over the 1996-2018 period). However, this performance was still better than expected on the basis of its initial level of GDP per capita. Other regions in similar positions (above the regression line) include most Western German Länder, the central provinces of the Netherlands, Northern Denmark, South-Eastern Sweden, Catalonia, Navarra, and (expanded) London.

Wallonia (here without Walloon Brabant to neutralise the commuting bias of Brussels) is lagging behind according to our classification. Starting with a GDP per capita of about 87 % of the EU average, its per capita growth increased by 7 percentage points less than the EU as a whole over the 1996-2018 period. This performance is quite

Chart 13

**In most EU countries, regions show heterogenous patterns of economic development**




Source : EC (Ardeco).

similar to that of the metropolitan regions of Valencia, Wales and Nord-Pas-de-Calais. Several French regions with an initial level of GDP per capita between 90 and 100 % of the EU figure in 1996 have fallen even further behind than Wallonia over the period considered. Relative to the EU, Picardie, Franche-Comté, Lorraine and Auvergne all lost around 20 percentage points, while Lower Normandy, Brittany, Limousin, Poitou-Charentes and Languedoc-Roussillon all lost more than 10 percentage points. Besides Wales, lagging regions in the UK comprise former mining or industrial regions in Northern England and the West Midlands, as well as Northern Ireland.

The map (Chart 13) clearly illustrates regions' heterogenous patterns of economic development, even within countries (but without showing the quantitative differences in initial incomes and growth as displayed in Chart 12). Notably, except for the Paris region, the relative position of all other continental French regions has deteriorated significantly, and they are either lagging behind or cooling off more than expected. Similarly, all UK regions have grown less rapidly than the EU but London has been more resilient. This may have contributed to a "geography of discontent" (Dijkstra *et al.*, 2019) and played a role in the results of the Brexit referendum of June 2016. Spain and Germany in particular display great diversity in terms of regional economic development.

## 3.4 Conditional beta convergence

### *Explanatory variables*

As in the section on national convergence, we extend our regional analysis by including control variables in the regression, thereby moving towards a study of conditional convergence among EU regions, allowing for the possibility that regions tend towards different steady states. Again, we employ only a limited set of key variables commonly used in the empirical literature[1]. We do not aim to come up with an exhaustive empirical model of growth at the EU regional level or to identify causal relationships.

Some of the independent variables that we consider here are similar to those we use in the national convergence regressions: population growth (whose expected sign is ambiguous), the ratio of investment to GDP (with an expected positive sign), and geographical dummies[2] (South, CEE; with North-Western Europe being the base category) to control for possible common shocks and hard-to-model structural characteristics common to these areas. Due to data constraints, however, we use a different measure of human capital in this section, based on the concept of educational attainment, defined as the share of the population aged 25-64 having at least an upper secondary school diploma (with an expected positive sign).

In addition, we consider variables specific to the regional level[3]. First, we add population density. This variable has the advantage of being a continuous measure, contrary to dummies for rural, intermediate and urban regions. Second, we include (time-invariant) dummy variables to indicate whether a region contains a metropolitan area (with a population of more than 500 000), a large metropolitan area (population of more than 1.5 million) or the national capital city (all with expected positive signs). Indeed, capitals and other large cities are often thought to operate as hubs of knowledge, innovation and skilled workers, and to generate agglomeration economies. For example, the concentration of people and firms makes it easier to attract business services and major universities. Complex economic activities also tend to concentrate in large cities (Balland *et al.*, 2020).

1 Annex 5 provides more details on the variables used in the regressions. As in the national-level analysis we abstract from the (long-term) influence of the EU's structural and investment funds.

2 We refrain from introducing country-fixed effects in our regional-level models, as this would fundamentally change the interpretation of the beta coefficient in the regression, to the speed of regional convergence within the country rather than the speed of regional convergence across the EU.

3 Two other variables – the initial share of agriculture in total employment and a dummy for the presence of a large port - were tested but found to add little information beyond the controls already included in the regression. This could be due to the fact that it is mainly in non-metropolitan Southern and CEE regions that agriculture accounts for a relatively large proportion of employment, and that among the 26 regions we identified as having a large port, 22 are already classified as metropolitan regions.

Table 3

**Summary statistics of the regression variables, by category of the TL2-corrected regions**

| | Lagging behind | Catching up (less than expected) | Cooling off (more than expected) | Catching up (more than expected) | Cooling off (less than expected) | Pulling away | EU total or average |
|---|---|---|---|---|---|---|---|
| GDP per capita PPS, 1996 (in % of EU average) | 83 | 48 | 121 | 55 | 136 | 124 | 100 |
| Change in GDP per capita PPS, 1996-2018 (in % of EU average) | –13 | 8 | –21 | 23 | –9 | 9 | 0 |
| GDP per capita PPS, 2018 (in % of EU average) | 70 | 56 | 100 | 78 | 127 | 133 | 100 |
| **Control variables** (1996-2018 average) | | | | | | | |
| Population growth (in %) | 0.1 | –0.2 | 0.4 | –0.2 | 0.5 | 0.5 | 0.2 |
| Population density (inhabitants per km²) | 146 | 78 | 182 | 138 | 351 | 284 | 182 |
| Investment (in % of GDP) | 21.6 | 21.6 | 21.6 | 23.3 | 20.8 | 23.2 | 22.1 |
| Higher secondary/tertiary education (in % of population aged 25-64) | 59 | 69 | 66 | 83 | 77 | 78 | 72 |
| **Dummy variables** (number of regions) | | | | | | | |
| Metropolitan region | 16 | 2 | 21 | 19 | 13 | 11 | 82 |
| Large metropolitan region | 7 | 0 | 9 | 5 | 9 | 6 | 36 |
| Capital region | 1 | 0 | 4 | 9 | 3 | 7 | 24 |
| North-West | 19 | 2 | 22 | 8 | 19 | 19 | 89 |
| South | 26 | 4 | 18 | 3 | 2 | 2 | 55 |
| Central-East | 2 | 13 | 0 | 40 | 0 | 2 | 57 |
| **Total number of regions** | **47** | **19** | **40** | **51** | **21** | **23** | **201** |

Sources: EC (Ardeco), Eurostat.

Summary statistics of these variables for the six categories of regions we identified earlier reveal some interesting patterns.

Over the 1996-2018 period as a whole, the population has declined in regions which are catching up. In most cases, this concerned CEE regions and was accompanied by above-average GDP growth, resulting in very strong GDP *per capita* growth. Despite emigration, these regions managed to achieve a substantial expansion of activity, thanks mainly to investment and technological progress. On average, limited demographic growth in regions that are lagging behind is due to a decline in the population of some Southern regions, though that decline is less severe than in CEE regions, especially in the aftermath of the global financial and European sovereign debt crises. Other regions saw a combination of both high population growth and GDP growth. This has been the case especially for capital regions all around the continent, such as Warsaw, Bratislava, Madrid, Helsinki and Stockholm. In Belgium, all regions recorded positive population growth[1].

On average over the period, population density was in fact much higher in richer regions (cooling off or pulling away) than in poorer regions (catching up or lagging behind). Among the latter, those that have caught up at a faster pace are those that had a higher population density. Also, 19 metropolitan regions, mainly in CEE, caught up more than expected (on the basis of their initial level of income).

1 In the (expanded) Brussels Region, population grew on average faster than in the other two Belgian regions. (Restricted) Flanders also enjoyed above-EU average growth rates for both population and GDP. (Restricted) Wallonia recorded higher than average population growth but below par GDP growth. Both dimensions therefore contributed to its classification as a region which is lagging behind.

Regions that have pulled away or caught up more than expected have the highest educational attainment and investment ratios. Conversely, the regions lagging behind have a significantly lower share of their working-age population with at least an upper secondary school diploma.

### *Cross-sectional regression results*

Our estimations confirm the existence of *unconditional* beta convergence for our sample of EU regions between 1996 and 2018: running a cross-sectional regression with no control variables yields a negative beta coefficient of –1.9. The relationship between initial income and subsequent growth over the whole period is highly significant and, according to the R-squared statistic, the initial level of income appears to explain more than half of the variation in growth rates between regions.

Table 4

**Cross-sectional regression results**

(OLS regression, EU28 over 1996-2018, TL2-corrected regions)

| | No control variables | With control variables |
|---|---|---|
| Dependent variable | | |
| Average GDP per capita growth (in PPS) | | |
| Independent variables | | |
| Initial GDP per capita | –1.929*** | –1.756*** |
| Dummy for Southern regions | | –0.298 |
| Dummy for CEE regions | | 0.518 |
| Population growth | | 0.236 |
| Population density | | 0.021 |
| Investment ratio | | 0.025* |
| Human capital | | 0.016 |
| Metropolitan region | | 0.191 |
| Large metropolitan region | | 0.006 |
| Capital region | | 0.678** |
| Constant | 21.430*** | 17.878*** |
| Number of observations/regions | 201 | 201 |
| Number of countries | 24 | 24 |
| R-squared | 0.527 | 0.768 |
| Adjusted R-squared | 0.525 | 0.756 |

Sources: EC (Ardeco), Eurostat.
Note: Standard errors (not shown) are clustered at the country level, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

When the control variables are added to the model, the beta coefficient remains highly significant while the explanatory power of the model improves, as evidenced by the higher value for the adjusted R-squared. The geographical dummies take their expected sign but are found to be not statistically significant. This suggests that much of the observed geographical difference in average growth can be explained by (a combination of) the other control variables. The investment to GDP ratio and human capital both enter the equation with a positive sign (and the former is statistically significant), even though these variables' economic significance is much more modest than that of the initial income level; a one percentage point increase in the investment ratio (human capital) boosts average growth by a mere 2.5 (1.6) basis points per year.

Moreover, our regression points to faster growth in metropolitan regions (though the metropolitan dummy is apparently not statistically significant) and, even more so, in capital regions, suggesting an important role for agglomeration effects. There seems to be an effective premium for regions that include their nation's capital (cf. Alcidi *et al.*, 2018). All other things being equal, capital regions' average annual growth over 1996-2018 is almost 0.7 percentage points higher than growth in other regions. To some extent, the growth advantage of capital regions may relate to the fact that, in CEE, several new countries were created just before our estimation period (the three Baltics, the two Balkan countries and Slovakia), providing a new role for cities transitioning from a regional capital to a national capital. The pre-eminence of a capital premium over a metropolitan premium may be partly due to statistical bias (company headquarters tend to be located in capital cities rather than in other cities and the split of their value added may be imperfect). Nevertheless, genuine economic factors are also at play. More often than not, capital cities are the country's financial centre, the main exceptions being Berlin (vs Frankfurt) and Rome (vs Milan). As evidenced by Coyle and Sensier (2019) for London, an important factor for the better performance of national capital regions compared to other regions may in some cases be the concentration of public investment in the capital.

It is interesting to investigate to what extent the control variables explain the differences between actual income growth and income growth predicted on the basis of initial income only. We illustrate this for the case of Belgium (Box 2).

BOX 2

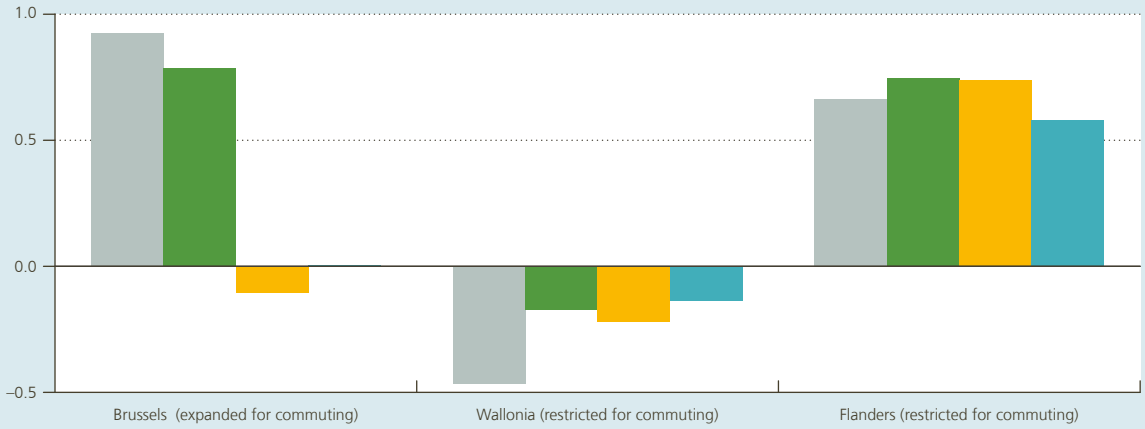
# To what extent do the control variables explain the growth performance of the Belgian regions?

In the chart below, the grey bars correspond, for each Belgian region, after being adjusted for the commuting bias of Brussels, to the difference between the actual income growth achieved over 1996-2018 and the figure that is predicted on the sole basis of initial GDP per capita in 1996.

In the case of Brussels (expanded to adjust for commuting), actual income growth is higher than expected on the basis of its initial income level. As the blue bar is close to zero, this positive differential can be fully explained by the added control variables. Above all, Brussels benefits from being the capital region, as reflected by the substantial difference between the grey and yellow bars. To some extent, Brussels also benefits from the educational attainment of a significant share of its working-age population (difference between the grey and green bars).

**Controlling for educational attainment and metropoles / capitals reduces the difference between actual and predicted income growth**

(residuals from various model specifications over 1996-2018)




Sources: EC (Ardeco), Eurostat.

Without Walloon Brabant (to neutralise the commuting bias of Brussels), Wallonia has witnessed lower average income growth since 1996 than expected on the basis of its initial level of GDP per capita (negative value for the grey bar). Our model explains a substantial part of this differential, as indicated

by the difference between the grey and blue bars. First, Wallonia's growth suffers from the absence of a metropole with a population of more than 500 000 within its borders. Second, a relatively large percentage of its working-age population has a low educational attainment.

In the case of Flanders (without the districts of Aalst and Halle-Vilvoorde to neutralise the commuting bias of Brussels), income growth is higher than expected on the basis of its initial level of GDP per capita (positive value for the grey bar). However, the blue bar is nearly as high as the grey bar, meaning that adding our control variables does not help to explain the region's relative over-performance. Flanders benefits from the presence of a metropole (Antwerp); a relatively large percentage of educated working-age population and a relatively high population density. Further analysis is needed to uncover the key factors at play.

The impact of the proximity of Brussels as both a metropole and a capital region on the economic growth of Flanders and Wallonia has not been analysed.

### *Panel regression results*

For completeness, we have also performed panel regressions as we did for national-level convergence (cf. the specifications outlined in sections 2.2 and 2.3). Again, annual observations are converted into averages over non-overlapping five-year sub-periods.

Our panel estimations confirm the existence of unconditional beta convergence for the EU regions: running the regression with no control variables yields a negative beta coefficient of –2.5 (Table 5).

In this panel regression set-up, the geographical dummy for CEE regions remains significant, even when we add the other control variables. The growth premium for regions including the national capital is confirmed and, in this panel specification, the dummy for metropolitan regions takes a higher positive value and becomes statistically significant (at the 10 % level). The statistical and economic significance of the investment ratio is also higher than in the cross-sectional regression, while educational attainment becomes less significant.

Table 5

**Panel regression results**

(panel OLS regression, 5-year non-overlapping periods,1996-2018 for EU28, TL2-corrected regions)

| | No control variables | With control variables |
|---|---|---|
| Dependent variable | | |
| Average GDP per capita growth (in PPS) | | |
| Independent variables | | |
| Initial GDP per capita | –2.454*** | –1.668*** |
| Dummy for Southern regions | | –0.560 |
| Dummy for CEE regions | | 1.274*** |
| Population growth | | –0.318 |
| Population density | | 0.064 |
| Investment ratio | | 0.052*** |
| Human capital | | 0.011 |
| Metropolitan region | | 0.295* |
| Large metropolitan region | | 0.147 |
| Capital region | | 0.710** |
| Constant | 27.267*** | 16.566*** |
| Period dummies | No | Yes |
| Number of observations | 1 005 | 804 |
| Number of regions | 201 | 201 |
| Number of countries | 24 | 24 |
| R-squared | 0.264 | 0.585 |
| Adjusted R-squared | 0.263 | 0.578 |

Sources: EC (Ardeco), Eurostat.

Notes: Standard errors (not shown) are clustered at the country level, * p < 0.10, ** p < 0.05, *** p < 0.01.
The model with the full set of control variables is not estimated for the sub-period 1996-2000 as data for the human capital variable are only available from 2000 onwards.

## Conclusion

This article finds evidence of relatively strong convergence of incomes (GDP per capita) across countries and large regions in the EU over the long term (since 1960 for EU15 countries and 1996 for EU28 countries/regions). The catching up of initially poorer Central-Eastern European countries has contributed to sustained convergence since the mid-1990s.

However, the convergence process has not always been smooth. While the EU "convergence machine" has worked most of the time and for most regions, sometimes and for some places it has faltered. Convergence has been strongest during high-growth periods, during the early stages of EU integration among the old member states, and just before and following the accession of the Central-Eastern European countries. Crisis periods were marked by slowing convergence (in the EU28) or even divergence (in the EU15). The global financial crisis and ensuing European sovereign debt crisis in particular heralded a period of severe economic underperformance in much of Southern Europe, undermining overall convergence. There are some tentative signs of renewed, post-crisis income convergence but it is too early to tell whether and when the convergence machine will regain speed, especially in light of the current Covid-19 crisis.

EU-wide convergence of regional incomes since 1996 has benefited from the convergence of incomes between countries, even though within-country income disparities remain substantial and have even increased slightly over time. Capital regions have grown faster on average, thereby contributing to regional convergence across EU countries but also to within-country disparities. Agglomeration effects, such as a concentration of higher-productivity activities and innovation in particular places, have likely played a role here. Our analysis, however, suggests that such effects are less significant for metropolitan regions than for capital regions.

### *What does this mean in terms of policy implications?*

First, convergence in the run-up to the global financial crisis and the European sovereign debt crisis proved to be unsustainable, pointing to the importance of avoiding excessive imbalances and ensuing boom and bust cycles. Completion of the EU integration process and further improvements in the design of the European project, including the completion of the Banking Union and the Capital Markets Union, may also be needed.

Second, investing in physical and human capital can improve growth performance at both the national and regional level.

Third, the observation that, in most EU countries, regions display heterogeneous patterns of development suggests a need for place-sensitive regional policies, tailor-made to the specific situation of each region. Indeed, optimal policy instruments arguably differ for regions that are lagging behind or catching up. They may also differ between capital, metropolitan and non-metropolitan regions, as well as urban versus rural regions. To this end, there is a role for policies at different levels of power. Next to national and regional authorities, the EU can play a role by boosting the efficiency of its cohesion policy.

Convergence was recognised as one of the main objectives when the EU was created. In order for the European project to be successful and gain the support of its citizens, no country or region should be left behind.

# Annex 1

## Variables used in the cross-country regression

| | Description | Source |
|---|---|---|
| Dependent variable | | |
| Average GDP per capita growth | Average annual growth, over a 5-year period, of GDP per capita, in purchasing power standards (PPS), in % | EC (Ameco) |
| Independent variables | | |
| Initial GDP per capita | (Natural) logarithm of GDP per capita at the start of the 5-year period, in PPS | EC (Ameco) |
| Population growth | Average annual population growth, over a 5-year period, in % | EC (Ameco) |
| Investment ratio | Investment as a percentage of GDP, average over a 5-year period | EC (Ameco) |
| Human capital | Index of human capital per worker, based on the average years of schooling, linearly interpolated from Barro and Lee (2013) and on an assumed rate of return for primary, secondary, and tertiary education, as in Caselli (2005), average over a 5-year period | Penn World Table 9.1 |
| Trade openness | Exports plus imports, as a percentage of GDP, average over a 5-year period | EC (Ameco) |
| Government consumption ratio | Government consumption as a percentage of GDP, average over a 5-year period | EC (Ameco) |
| Inflation | Annual percentage change in average CPI, average over a 5-year period | World Bank – World Development Indicators |
| Inflation volatility | Standard deviation of the annual percentage change in average CPI, average over a 5-year period | World Bank – World Development Indicators |

## Annex 2 – Identification of the twelve TL2 metropolitan regions to be expanded

On the basis of the (EU-)OECD definition, we identify, in addition to the 24 national capitals, 75 metropolitan *areas* in which the (core) city/cities and commuting zones delimited accurately in terms of municipalities have a population of more than 500 000. These metropolitan areas are listed in the table below. Those in bold are capitals. The metropolitan areas with a population above 1.5 million are "large metropoles". These are those listed above Helsinki in the table, plus Sofia and Bucharest.

Regional statistics are hard to find at the municipal level. At best, we can find figures for NUTS3 regions. Therefore, we have matched each metropolitan *area* to its corresponding metropolitan *regions,* defined by Eurostat as NUTS3 regions (or aggregates thereof) in which 50 % or more of the population lives in a metropole. Their population is indicated in column 3.

For these metropoles, we can also identify the TL2 region(s) where their core cities are located (column 4). Those in grey encompass more than one TL2 region and were therefore expanded, though not necessarily to the whole of the associated TL2 region(s) but to one or more of their TL3 regions.

**List of the 24 capitals and 75 selected metropolitan areas**

(population in thousands, ranked in descending order of the 2016 OECD figure)

| Metropolitan area | Population in 2016 according to | | Corresponding TL2 region | Commuting area |
|---|---|---|---|---|
| | OECD (metro area) | Eurostat (metro region) | | |
| **Paris** | **12 007** | **12 135** | **Ile de France** | |
| **London** | **11 984** | **14 073** | **London** | **South-East; East of England** |
| **Madrid** | **6 633** | **6 446** | **Communidad de Madrid** | |
| **Berlin** | **5 142** | **5 176** | **Berlin Land** | **Brandeburg** |
| Milan | **5 101** | 4 310 | Lombardy | |
| Rome | 4 414 | 4 347 | Lazio | |
| Barcelona | 3 970 | 5 454 | Cataluña | |
| **Athens** | **3 563** | **3 600** | **Attica** | |
| Naples | 3 418 | 3 111 | Campania | |
| Manchester | 3 320 | 3 661 | North-West | East-Midlands |
| Hamburg | 3 234 | 3 263 | Land of Hamburg | Lower Saxony; Schleswig-Holstein |
| **Warsaw** | **3 133** | **2 998** | **Warsaw** | |
| West Midlands urban area | 2 968 | 2 518 | Midlands | |
| **Budapest** | **2 966** | **2 997** | **Budapest** | **Pest** |
| Munich | 2 849 | 2 864 | Bavaria | |
| **Lisbon** | **2 818** | **2 817** | **Lisbon** | |
| **Vienna** | **2 794** | **2 793** | **Vienna** | **Lower Austria; Burgerland** |
| Stuttgart | 2 736 | 2 747 | Baden-Württemberg | |
| **Amsterdam** | **2 717** | **3 205** | **North Holland** | **Flevoland** |
| Frankfurt am Main | 2 647 | 2 661 | Hesse | |
| **Brussels** | **2 629** | **2 498** | **Brussels** | **Flanders; Wallonia** |
| Leeds | 2 598 | 1 728 | Yorkshire & the Humber | |
| Katowice | 2 541 | 2 743 | Silesia | |

## List of the 24 capitals and 75 selected metropolitan areas (continued 1)

(population in thousands, ranked in descending order of the 2016 OECD figure)

| Metropolitan area | Population in 2016 according to | | Corresponding TL2 region | Commuting area |
|---|---|---|---|---|
| | OECD (metro area) | Eurostat (metro region) | | |
| **Stockholm** | **2 269** | **2 250** | **Stockholm** | |
| **Prague** | **2 178** | **2 606** | **Prague** | **Stredni cesky** |
| **Copenhagen** | **2 055** | **2 005** | **Capital region** | **Sjaelland** |
| Cologne | 1 975 | 1 981 | North Rhine Westphalia | |
| Lyon | 1 951 | 1 844 | Rhône-Alpes | |
| Glasgow | 1 818 | 1 844 | Scotland | |
| Turin | 1 769 | 2 280 | Piedmont | |
| Marseille | 1 751 | 3 082 | PACA | |
| Valencia | 1 709 | 2 518 | Communidad de Valencia | |
| Rotterdam | 1 680 | 1 819 | South Holland | |
| Dusseldorf | 1 547 | 1 545 | North Rhine Westphalia | |
| Seville | 1 533 | 1 941 | Andalucia | |
| **Helsinki** | **1 472** | **1 629** | **Helsinki** | |
| Krakow | 1 408 | 1 481 | Lesser Poland | |
| Lille | 1 345 | 2 603 | Nord-Pas-de-Calais | |
| Dresden | 1 344 | 1 342 | Saxony | |
| Toulouse | 1 328 | 1 356 | Midi-Pyrénées | |
| Nuremberg | 1 324 | 1 329 | Bavaria | |
| Hanover | 1 299 | 1 304 | Lower Saxony | |
| Porto | 1 272 | 1 721 | North | |
| Bremen | 1 255 | 1 264 | Bremen Land | Lower Saxony |
| Liverpool | 1 202 | 2 031 | North-West | |
| Mannheim-Ludwigshafen | 1 174 | 1 175 | Baden-Württemberg | Rhineland Palatinate; Hesse |
| Bordeaux | 1 170 | 1 576 | Aquitaine | |
| Newcastle | 1 167 | 1 166 | North-East | |
| Gdansk | 1 154 | 1 318 | Pomerania | |
| Antwerp | 1 098 | 1 037 | Flanders | |
| The Hague | 1 070 | 1 075 | South Holland | |
| Thessaloniki | 1 055 | 1 109 | Central Macedonia | |
| Bilbao | 1 037 | 1 134 | Basque country | |
| Palermo | 1 033 | 1 270 | Sicily | |
| Leipzig | 1 017 | 1 022 | Saxony | |
| Gothenburg | 1 007 | 1 660 | Western Sweden | |
| Braunschweig / Salzgitter / Wolfsburg | 995 | 996 | Lower Saxony | |
| Poznan | 983 | 1 180 | Greater Poland | |
| Bristol | 944 | 1 131 | South-West | |
| **Riga** | **938** | **1 006** | **Latvia** | |
| Lodz | 916 | 1 085 | Lodz | |
| Bonn | 914 | 918 | North Rhine Westphalia | |
| Nantes | 907 | 1 389 | Pays de la Loire | |
| Leicester | 881 | 1 413 | East-Midlands | |

**List of the 24 capitals and 75 selected metropolitan areas** (continued 2)

(population in thousands, ranked in descending order of the 2016 OECD figure)

| Metropolitan area | Population in 2016 according to | | Corresponding TL2 region | Commuting area |
|---|---|---|---|---|
| | OECD (metro area) | Eurostat (metro region) | | |
| Utrecht | 875 | 1 279 | Utrecht | |
| Malaga | 849 | 1 643 | Andalucia | |
| Nice | 818 | 1 084 | PACA | |
| Saarbrucken | 802 | 804 | Sarre | |
| Cardiff | 780 | 1 130 | Wales | |
| Strasbourg | 775 | 1 123 | Alsace | |
| Florence | 772 | 1 014 | Tuscany | |
| Saragossa | 750 | 961 | Aragon | |
| Bari | 750 | 1 262 | Puglia | |
| Bologna | 745 | 1 008 | Emilia-Romagna | |
| Brno | 723 | 1 177 | Jihovýchod | |
| Rennes | 718 | 1 056 | Brittany | |
| Ostrava | 717 | 1 211 | Moravskoslezsko | |
| Genoa | 713 | 852 | Liguria | |
| Rouen | 694 | 1 255 | Upper Normandy | |
| Montpellier | 672 | 1 138 | Languedoc-Roussillon | |
| **Vilnius** | **672** | **805** | **Sostinės regionas** | |
| Catania | 659 | 1 114 | Sicily | |
| Malmo | 658 | 1 314 | Southern-Sweden | |
| Grenoble | 658 | 1 255 | Rhône-Alpes | |
| **Bratislava** | **642** | **638** | **Bratislava** | |
| Murcia | 616 | 1 469 | Region of Murcia | |
| Oviedo / Gijon | 605 | 1 037 | Asturias | |
| Coventry | 598 | 912 | Midlands | |
| **Tallinn** | **576** | **579** | **Estonia** | |
| Venice | 562 | 855 | Venice | |
| Granada | 556 | 917 | Andalucia | |
| Vigo | 540 | 944 | Galicia | |
| **Ljubljana** | **537** | **538** | **Western Slovenia** | |
| Padua | 534 | 937 | Venice | |
| Verona | 514 | 922 | Venice | |
| **Sofia** | **n.d.** | **1 682** | **South-West** | |
| **Bucharest** | **n.d.** | **2 288** | **Bucharest-Ilfov** | |
| **Grad Zagred** | **n.d.** | **1 245** | **Continental Croatia** | |

Sources: Eurostat, OECD.

## Annex 3

### Corrections made to TL2 regions in order to better reflect the commuting zones of metropoles

(switch to TL2-corrected regions)

| Name of the metropole | TL2 of the core | TL2 of the commuting area | Action |
|---|---|---|---|
| London | London | South-East | add Surrey, Berkshire, Kent Thames gateway and West Kent |
| | | East of England | add Hertfordshire, Southend-on-Sea, Thurrock, Heart of Essex, West Essex and Essex Thames gateway |
| Berlin | Berlin (Land) | Brandenburg | add Potsdam, Barnim, Dahme-Spreewald, Havelland, Markish-Oderland, Oberhavel, Oder-Spree, Potsdam-Mittelmark and Tetlow-Fläming |
| Manchester | North-West | East-Midlands | add South and West Derbyshire |
| Hamburg | Hamburg (Land) | Lower Saxony | add Harburg and Stade |
| | | Schleswig-Holstein | add Herzogtum Lauenburg, Pinneberg, Segeberg and Stormarn |
| Budapest | Budapest | Pest | merger |
| Vienna | Vienna | Lower Austria | add Weinviertel and Wiener Umland (Nordteil and Südteil) |
| | | Burgerland | add Nordburgenland |
| Amsterdam | North-Holland | Flevoland | merger |
| Brussels | Brussels-Capital | Flanders | add Halle-Vilvoorde and Aalst |
| | | Wallonia | add Walloon Brabant |
| Prague | Prague | Stredni cesky | merger |
| Copenhagen | Hovenstaden | Sjaelland | add Østsjælland |
| Bremen | Bremen (Land) | Lower Saxony | add Diepholz, Rottenburg, Osterholz, Verden and Delmenhorst |
| Mannheim-Ludwigshafen | Baden-Württemberg | Rhineland Palatinate | add Ludwigshafen am Rhein, Frankenthal, Neustadt an der Weinstraße, Speyer, Bad Dürkheim and Rhein-Pfalz-Kreis |
| | | Hesse | add Bergstraße |

Sources: Eurostat, OECD.

## Annex 4 – Robustness: What if our analysis is based on the (non-corrected) TL2 regions?

Using TL2 regions instead of TL2-corrected regions affects mainly Chart 10 on regional disparities and Chart 12 showing the unconditional beta convergence across the EU28 regions over the long term.

### *1. Regional disparities*

As the GDP per capita changes for the corrected regions – both the metropolitan/capital regions that have been expanded and their surrounding regions that have been restricted –, the chart on regional disparities is slightly modified. In particular, the GDP per capita of the regions for which the commuting zone is included is much higher for the (uncorrected) TL2 regions than for the TL2-corrected regions. This is the case for Brussels, whose value jumps from 135 to 170, but this is also notable for Hamburg and other capital regions, notably North Holland (Amsterdam), Vienna, Prague, Budapest and London.

Among the regions with the smallest GDP per capita according to the TL2-corrected definition, Wallonia benefits from the presence of Walloon Brabant to climb from 67 to 72 percent of the national average when we consider the TL2 definition.

However, the main messages hold true when taking the TL2 regions at face value: regional disparities matter, capital regions are usually those with the highest GDP per capita in their country, and regional disparities are not exceptionally large in Belgium relative to the other EU countries.

**Chart**

**Regional disparities**

(GDP per capita in PPS, national average = 100, 2018e, TL2 regions)


Source: EC (Ardeco).

### *2. Unconditional beta convergence across EU28 regions over the long term*

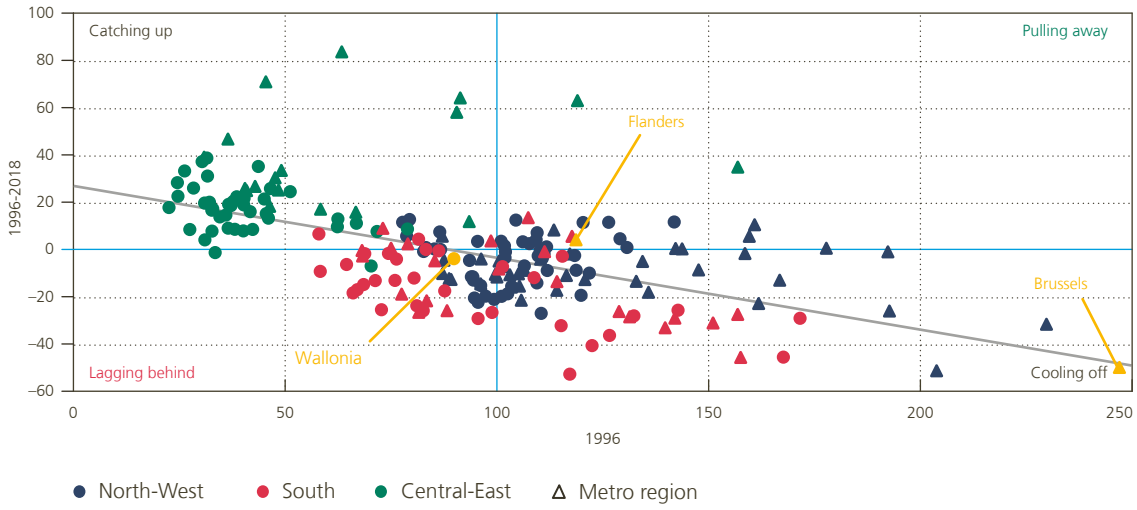
Also here the main conclusions are robust to keeping with the TL2 regions without corrections: there is a negative relationship between the level of GDP per capita in 1996 and its subsequent change over the 1996-2018 period. In most cases, the regions are classified in the same quadrant as when the TL2-corrected regions are used.

The Belgian regions too remain in their respective quadrants. Without corrections, the Brussels-Capital Region (19 municipalities) stands out as the region with the highest GDP per capita in 1996. It is thus no surprise to find it cooling off since then. Starting from an (artificially high) of almost 2.5 times the EU average, its GDP per capita lost 50 percentage points relative to the EU average over 1996-2018, which ranks as the third highest (relative) decline of all 204 TL2 regions. Brussels is now even slightly below the regression line (instead of above it, when corrections for commuting zones are made). While without correction for the commuting bias of Brussels the position of Flanders is hardly affected, that of Wallonia improves when the relatively rich and dynamic Walloon Brabant is not excluded. Starting with a higher initial income (89.8 percent of the EU average), it lost only 3.9 percentage points relative to the EU over the 1996-2018 period.

**Chart**

**Unconditional beta convergence across EU28 regions over the long term**

(change in GDP per capita in PPS over 1996-2018 versus GDP per capita in PPS in 1996, both relative to the EU28 average, TL2 regions)




Source: EC (Ardeco).

# Annex 5

## Variables used in the (cross-sectional) regression at the regional level

| | Description | Source |
|---|---|---|
| Dependent variable | | |
| Average GDP per capita growth | Average annual growth, over the whole period, of GDP per capita, in purchasing power standards (PPS) | EC (Ardeco) |
| Independent variables | | |
| Initial GDP per capita | (Natural) logarithm of GDP per capita at the start of the period, in PPS | EC (Ardeco) |
| Initial population density | Population divided by the number of square kilometres | EC (Ardeco) for the population and Eurostat (2016 definition) for the area |
| Population growth | Average annual population growth, over the whole period, in % | EC (Ardeco) |
| Investment ratio | Investment as a percentage of GDP, both at current prices, averaged over five years at the start of the period | EC (Ardeco) |
| Human capital: educational attainment | Share of the population in the 25-64 age group having at least an upper secondary school diploma at the start of the period (2000 being the first available year) | Eurostat based on Labour Force Survey, data available only at the NUTS2 level |
| Metropolitan region | Dummy for the presence of a metropole (population of more than 500 000) | Own construction based on OECD, Eurostat definitions |
| Large metropolitan region | Dummy for the presence of a metropole (population of more than 1.5 million) | |
| Capital region | Dummy for the presence of a (national) capital city | Own construction |
| Independent variables used in alternative model specifications (results not shown) | | |
| Importance of agriculture in the economy | Share of agriculture in total employment at the start of the period | EC (Ardeco) |
| Presence of a significant port | Dummy for the presence of a port where the gross weight of goods handled in 1997 exceeds 25 million tonnes | Eurostat |

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