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The dynamics of regional inequalities☆,☆☆

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ABSTRACT

This paper analyses the link between regional inequalities and GDP per capita at the country-level. Our starting hypothesis is that the evolution of regional inequalities should follow a bell-shaped curve as national GDP per capita rises since growth by its very nature is unlikely to appear everywhere at the same time, as has been argued by a number of authors, from Kuznets [Kuznets, S., (1955), Economic growth and income inequality, American Economic Review 45(1), 1–28] to Lucas [Lucas, R.E., (2000), “Some macroeconomics for the 21st century”, Journal of Economic Perspectives 14 (1), 159–168]. We test this hypothesis econometrically using semi-parametric estimation techniques and regional data for a panel of European countries. Our results provide strong support for such a bell-shaped curve and are robust to changing the regional administrative units and the time period, as well as controlling for other possible determinants of regional inequalities. We also find support for this hypothesis when considering non-European countries.

1. Introduction

Economists have increasingly paid attention to the role played by knowledge and spillovers in explaining countries' growth differentials and diffusion both across countries and regions; see, for instance, Jones (2004) and Klenow and Rodriguez-Clare (2005). Accordingly, knowledge spillovers should give rise to substantial scale effects in productivity stemming from their non-rival nature.[1] However, although knowledge and technological progress are in this regard seen as the main engines of economic growth in the long run, the latter may inevitably increase rather than decrease regional inequalities, and these two elements are very unlikely to be evenly spread both across time and space. As a consequence, economic growth may foster divergence rather than convergence across spatial units, suggesting that convergence may evolve non-linearly. Indeed, when considering the theoretical literature on growth and convergence, a wide array of arguments arise advocating either for the long term reduction or for the persistence and self-reinforcing nature of economic inequalities across countries and regions; see, for instance, Galor (1996), Pritchett (1997), and Lucas (2000). Elements such as spillover effects and nonlinearities have also been considered in empirical studies providing evidence for the non-linear nature of the growth and convergence processes; see, for instance, Durlauf and Johnson (1995), Quah (1996b, 1997), Liu and Stengos (1999) and Canova (2004).

Interestingly, the idea that regional inequalities are likely to evolve in a non-linear way can be traced back as early as the 1950s. The evolution of regional inequalities was then usually linked to national economic development paths and the process of industrialisation. As a matter of fact, it was Kuznets (1955) in his analysis of income disparities who suggested the existence of a “*long swing*” in regional income inequalities, where there is first a rise and then a subsequent fall of income differentials caused by the industrialisation process accompanying national development and the decline of agriculture. Several authors have built on this idea in a regional context suggesting the existence of a bell-shaped curve of spatial development where inequalities should first increase as developed areas benefit from external economies, location of decision-makers, political power, and capital and labour mobility; see for instance Myrdal (1957),

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[1] See, in particular, Romer (1990), Kremer (1993) and Tamura (1996) among others.

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Hirschman (1958), Williamson (1965) and, more recently, Ottaviano and Thisse (2003).[2]

While a non-linear relationship between regional inequality and national income per capita clearly has important implications for economic theory and policy, there is to the best of our knowledge no explicit econometric study that has set out to investigate its existence, although a number of works have been suggestive of its possibility. In the current paper we explicitly test this hypothesis using data for EU countries. The EU economy arguably makes for a particularly suitable case study given the sizeable disparities in economic development both across regions and countries compared to, for instance, the US. Our starting hypothesis is that, while the mechanisms described in the aforementioned studies essentially concerned countries engaged in deep structural changes that goes along with industrialisation, there are reasons to believe that regional inequalities may also be significantly affected by other types of structural changes and may also concern industrialised countries. The EU, in particular, has faced a number of such changes over the past two decades in the context of the EU integration process and successive enlargements of the EU. One may thus exploit the fact that EU countries have very different relative GDP per capita, hence allowing one to observe regional inequality across a wide range of relative national economic development levels. To investigate this we use data on GDP per capita for European regions between 1975 and 2000. We show, using a flexible semi-parametric estimator, that the relationship between the relative national GDP per head and regional inequalities follows a bell-shaped curve, suggesting that growth first increases regional inequalities but then tends to lower them as the relative national GDP per capita continues to rise. This result is robust to considering other OECD countries, alternative geographical units, and after controlling for other potential determinants of regional inequalities such as the degree of international openness, industrial specialization, regional aid, and the level of fiscal decentralisation. Our paper is thus, to the best of our knowledge, the first study to provide robust evidence of the bell-shaped relationship between regional inequalities and national GDP per capita.

The remainder of the paper is organized as follows. In Section 2 we review the existing empirical literature concerning the link between national development and regional inequalities. We also present a simple theoretical model to illustrate the main mechanisms at hand. Sections 3 and 4 present some preliminary evidence and our main econometric results. Section 5 summarizes our findings and discusses some policy implications.

2. Revisiting the link between national development and regional inequalities

2.1. Related empirical literature

A number of stylised facts tend to support the possibility of a bell-shaped evolution of regional inequalities. Following Kuznets (1955), Williamson (1965) provides an extensive analysis of the topic by considering in detail the spillovers mechanism driving the evolution of regional inequalities according to the stages of development of a nation during industrialisation. According to Williamson (1965), spillovers may occur through a number of channels such as migration, capital flows, government policy and interregional trade. Using evidence based on descriptive statistics for a number of countries between the end of the XIXth century and World War II, he finds some supportive evidence for a non-linear relationship between regional inequalities and national development. His conclusions derive from two main empirical facts: first, regional disparities are greater in less developed countries and smaller in the more developed ones and, second, over time, regional disparities increase in the less developed countries and decrease in the more developed. Accordingly, regional income inequalities can be considered as a by-product of the development process and industrialisation and any attempts at lowering them may eventually hamper this process. Kim and Margo (2003) also show that in the US the rise of industrialisation during the second half of the nineteenth century has increased regional income disparities, where manufacturing was concentrated in the north and specialisation in agricultural activities occurred in the south. By the second half of the twentieth century, however, regional industrial structures converged through a dispersal of agriculture and the rise of services activities across the US States.

The more recent European experience is also quite revealing as regard to the dynamics of regional inequalities depending on national catching-up processes. In particular, the poorest EU member states, i.e., both the former Cohesion country group (i.e. Greece, Ireland, Portugal and Spain) and the new member states that have entered the EU in 2004, have generally experienced a fast catching-up process over the past two decades with important implications in terms of the evolutions of their regional inequalities. For instance, in the European context, Quah (1996a) observes that the two countries that have reached the highest rates of economic growth during the 1980s and 1990s, Spain and Portugal, are those that have experienced the most striking rise in regional imbalances. In another contribution, Quah (1996b) considers the case of three EU cohesion countries, Spain, Portugal, and Greece, and shows that, while the first two have experienced strong growth rates and growing regional imbalances during the 1980–89 period, Greece has experienced only modest growth rates accompanied by decreasing income inequalities across its regions.[3] Petrakos and Saratsis (2000) also find similar evidence for Greece, discovering that, during the 1980s, the most developed regions in Greece have faced growing difficulties due to tighter foreign competition implied by the European integration process, while less developed regions were less affected. The same authors also argue that this may be one of the reasons explaining why regional inequalities have tended to decrease in this country during the 1980s. In other recent contributions, Davies and Hallet (2002) together with Petrakos et al. (2003) also provide some descriptive evidence for growing regional income imbalances for the poorest EU countries. Similar evolutions have also been found for a number of new EU member states, as evidenced in a recent report by the European Commission (2004). This report in particular shows that regional inequalities have tended to rise in countries such as the Czech Republic, Hungary, Poland, and the Slovak Republic since 1995 as a consequence of a fast national catching-up in GDP per capita.

2.2. A simple model of growth, catching-up and technological diffusion

In order to illustrate the interaction between national GDP per capita and regional inequalities, we present a simple theoretical framework which borrows directly from Lucas' (2000) model, where spillovers are assumed to be the main vehicle of economic development. While Lucas' model was intended to examine the link between cross-country inequalities and economic progress, it can easily, however, be used to illustrate how growth transition dynamics can influence the evolution of regional inequalities within countries. These growth transition dynamics are induced after a given technological shock (or innovation) takes place entailing an acceleration of growth at the national level. The model makes the hypothesis that one region initially benefits from this shock and then describes how regional inequalities evolve as cross-regional spillovers take place.

[2] The evidence concerning the non-linear relationship between urbanization and development is also a well documented fact in urban economics, see, for instance, the seminal work of Alonso (1969).

[3] The group of Cohesion countries here refers to the countries entitled to the so-called EU Cohesion fund including, for the period considered here, Ireland, Greece, Portugal and Spain.

Let us consider a country composed of n regions. Initially all regions are assumed to have a constant level of income per capita represented by y_0. We assume that an innovation takes place in one region at date $t=0$. We call this region the leading region. The innovation pushes productivity levels up and results in higher income levels in this region at a date $t+1$. Growth is, therefore, at least initially, localized. Subsequently, the leading region experiences a constant growth rate represented by the term α. The other regions, which we call the follower regions, will start growing at a date $s>0$. We assume in addition that each follower region starts growing at a different date and this will, in turn, affect their catch-up rate. In making this assumption, we are thus assuming that follower regions differ in their technological capability that allows them to adopt the innovation that has taken place in the leading region. The model then implies a distribution of starting dates characterising regional differences in technological capability. We can thus index regions by the date at which they start growing, such that $y(s,t)$ will be the income per capita level of a region s which starts growing at a date $t=s$.

According to the hypothesis above, the level of income of the leading region at any date t can be written as $y(0,t)$:

$$y(0,t) = y_0(1+\alpha)^t \tag{1}$$

where α is the constant growth rate of the leading region.

When the follower regions start growing at a date $t>0$, they do so according to the following expression:

$$\frac{y(s,t+1)}{y(s,t)} = (1+\alpha)\ \left(\frac{y(0,t)}{y(s,t)}\right)^{\beta} \tag{2}$$

where β is a catch-up rate that we assume to be constant for all the follower regions. This term represents the spillover effect described earlier and the speed at which the innovation of the leading region is transmitted to the follower regions. The growth rate of the follower regions will thus be equal to the steady state growth rate α plus a term that is proportional to the income gap (which can be interpreted as the technological distance with respect to the leading region) between the follower and the leader. The influence of the income gap depends in turn on the catch-up rate β. This catch-up rate is particularly important as it determines the speed (in number of years) at which follower regions' incomes catch up with the leading region's income. According to Eq. (2), the later a follower region starts growing, the higher will be its initial growth rate. The model therefore assumes that there is a growth bonus for late entrants. According to Eq. (2), the growth rate of the follower regions will decrease as these regions' income rises and catches-up to the leading region's income level. According to Eqs. (1) and (2), however, the income of the follower region never surpasses that of the leading region.

In this model, the leading region will always benefit from higher income per capita such that, starting from a situation where all regions have the same level of income per capita and thus where there is no inequality across regions, inequality will inevitably rise once the leading region starts growing. The evolution of regional inequalities essentially depends on the relative weights (i.e., both their number and their relative size in the national economy) of the regions that are in a growth regime compared to those that are in a stagnation regime. One can therefore say that Eqs. (1) and (2) describe the possible income paths of regions and consider that regional inequalities are governed by the probability for growth to arise in any of these regions. The relative weights in the national economy of the regions that are in a growth or stagnation regime can therefore be thought of as being determined by the probability of a region to being in a growth regime.

Following Lucas (2000), the probability for a region to be in a growth or a stagnation regime can be related to the average (country)-level of income. The hypothesis used by Lucas is that a region is more likely to shift from a stagnation to a growth regime the higher is the country-level of knowledge (and thus the higher the average level of income per capita) which allows lagging regions to get access to growth-enhancing innovations.

The development path of a set of regions belonging to the same country can thus be described according to a hazard rate model where the conditional probability for a region to experience the onset of growth is given by a hazard rate $\lambda(t)$, which, in turn, is determined by the country-average level of income $x(t)$. In order to specify such a hazard rate, one needs to define first the (unconditional) probability that any region starts growing at a date t. We call this probability $F(t)$ which can be derived from hazard rate models and is given by the following expression:

$$F(t) = \lambda(t)\left[1 - \sum_{s<t} F(s)\right]. \tag{3}$$

The national average level of income can in turn be constructed as a weighted sum of the level of income of each region-type where the weights are given by the probabilities to be in a growth or in a stagnation regime as follows:

$$x(t) = \sum_{s\leq t} F(s)\, y(s,t) + \left[1 - \sum_{s\leq t} F(s)\right] y_0. \tag{4}$$

With Eqs. (3) and (4) at hand we can thus define the hazard rate in which the national income per capita value given by Eq. (4) determines the proportion of regions that begin to grow at a given date t. The hazard rate is assumed to be a function of the initial level of income per capita (y_0) and the average level of income per capita (x_t).

$$\lambda(t) = \lambda_m \exp(-\delta(x(t)-y_0)) + \lambda_M[1 - \exp(-\delta(x(t)-y_0))] \tag{5}$$

assuming that δ, λ_m, $\lambda_M>0$ and $\lambda_m<\lambda_M$.

Following Eq. (5), the hazard rate $\lambda(t)$ is a weighted average of the two (constant and exogenously given) hazard rates λ_m and λ_M, where the weight applied to the high hazard rate (λ_M) is assumed to be an increasing function of the national average income level. Put differently, the hazard rate will get closer to λ_M, which is the upper-bound limit for $\lambda(t)$, when the average level of income $x(t)$ rises. The influence of the national average income level is determined by a parameter δ which is exogenously given. Accordingly, when all regions are in a stagnation regime, then the expressions (1)–(4) give $x(t)=y_0$ and $\lambda(0)=\lambda_m$. The level of regional inequality is then equal to zero. Once the leading region starts growing, it will do so according to Eq. (1) and, as time passes by, i.e., as $t\to\infty$, $x(t)\to\infty$ and $\lambda(t)\to\lambda_M$, the probability for a region to start growing will tend towards its maximum value λ_M. The model therefore is organised around two hypothesis: on the one hand follower regions grow according to a catching-up process as described by Eq. (2); on the other hand the probability that a region starts growing at a date t conditional on stagnation until t depends on the average level of national income, according to the hazard rate given in Eq. (5).

The extent of regional inequalities can be, as in Lucas (2000), described by the standard deviation of the log of the relative income per capita across regions, which is given by $\sigma(t)$ defined as in the expression below:

$$\sigma(t)^2 = \sum_{s\leq t} F(s)\left[\ln\left(\frac{y(s,t)}{x(t)}\right)\right]^2 + \left[1 - \sum_{s\leq t} F(s)\right]\left[\ln\left(\frac{y_0}{x(t)}\right)\right]^2 \tag{4}$$

and can be seen as the weighted value of the standard deviation of regional GDP per capita.

Fig. 1 depicts the relationship between the average level of income (or national average of income per capita) and $\sigma(t)$ for a given set of

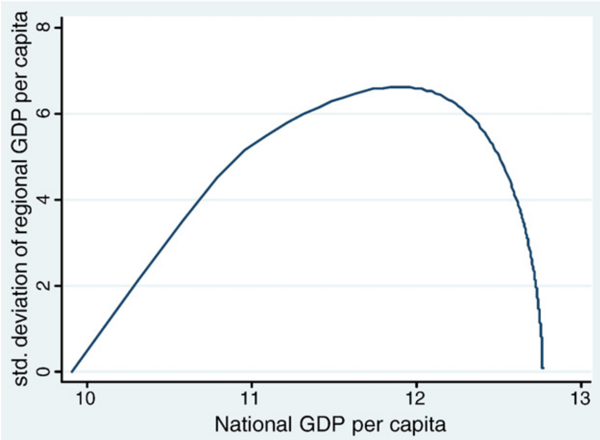

Fig. 1. Theoretical analysis of the relationship between National GDP per capita and regional inequalities. Parameter values for Fig. 1: $\alpha=0.02$, $y_0=10{,}000$, $t=300$, $\lambda_M=0.001$, $\lambda_M=0.03$, $\lambda_m=0.02$, $\beta=0.025$.

parameters values. Accordingly, the relationship between the level of regional inequalities and the per capita national income level is non-monotonic and follows a bell-shaped curve. Regional inequalities initially rise while the forces for divergence dominate until, after a certain threshold, regional inequalities start falling. This outcome illustrates the role played by technological diffusion between regions: the larger the country-wide stock of knowledge or, equivalently, the higher the level of average income per capita, the higher will be the probability of any region to benefit from technological spillovers. One must note, however, that the diffusion of growth described by Eq. (2) constitutes very much a black box. The model thus does not rule out the fact that other mechanisms could also explain the acceleration of growth at country-level, as well as growth transmission across regions such as through technological change and human capital externalities, as in Tamura (1996), through trade integration and specialisation, as in Puga (1999), and through institutions and the removal of barriers to technology adoption such as regulatory, or legal constraints, as argued by Parente and Prescott (1994). We must point out that the identification of such alternative explanations goes beyond the scope of the present study, however. Rather here we try to assess whether the relationship depicted by Fig. 1 holds for different samples of European countries, regardless through which channel the spill-overs occur. In our context this entails observing the evolution of regional inequalities and the relative level of national economic development of countries/regions together across time. This is equivalent to considering that any point on the curve plotted in Fig. 1 corresponds to the relative values of income per capita and level of regional inequalities of a given country at any date t.

Lucas' (2000) model is particularly useful to show in a simple manner the way regional inequalities evolve when national growth is rapid and when all regions are not all equally equipped to benefit from this growth acceleration. The latter in turn is more likely in regions located in relatively poor countries engaged in fast catching-up process. Note in particular that Lucas' model does not specifically refer to relative rather than absolute level of income per capita. In fact Lucas' model, like Williamson's hypothesis, describe the consequences of industrialisation processes where growth is depicted over very long (more than a century for Lucas) time spans and where industrialisation is proxied by the country-level of income per capita. While Williamson and Lucas were interested by the consequences of the industrialisation process, we instead consider a period during which EU economic growth was high by historical standards and coincided with the EU integration process, including EMU and the accession of lagging new EU member states. EMU and successive enlargements of the EU can be seen as exogenous shocks entailing deep structural changes which, like technical progress favouring industrialisation, may have favoured some regions more than others. These changes have, in particular, translated into greater openness to foreign trade, greater mobility of capital (e.g., FDI) and fast decline in agriculture among other. In terms of the model presented here, we thus consider the consequences of these different important changes in the EU to be equivalent to productivity shocks (in the international trade theory sense) that may have affected both α, the growth rate of the leading region, and β, the catch-up rate representing cross-regional spillovers.

3. Data and preliminary evidence

3.1. Data and measure of regional inequalities

We use data on gross value added per capita by NUTS2 regions taken from the Cambridge Econometrics database based on Eurostat data in order to compute our regional inequality measure, which is represented by the standard deviation of the log of regional GDP per capita by country.[4] Despite the fact that most studies on EU regions use this regional breakdown, an issue with the NUTS2 regions is that they are not necessarily economically homogeneous. The consequence is that the geographical definition of regions in terms of NUTS2 may sometimes be artificial in order to comply with European statistical standards. Thus we will also use alternative datasets and definitions of spatial units in order to check the robustness of our results in Section 4.3. Table A1 in the Appendix provides further details on the number of regions covered by country. All in all the Cambridge dataset allows one to work with a sample of 12 European countries including Austria, Belgium, Finland, France, Germany, Greece, Italy, the Netherlands, Portugal, Spain, Sweden and the United Kingdom. This data set also includes information for some of the member states that entered the EU in 2004, such as Bulgaria, the Czech Republic, Estonia, Hungary, Lithuania, Latvia, Poland, Romania, and the Slovak Republic, although it must be noted that the geographical breakdown for these countries does not always match the one used for the old member states (i.e., the NUTS2 classification).

The level of national development is represented by the log of GDP per capita expressed in purchasing power standards (PPS) with one unit of PPS representing approximately one euro. Our measure of regional inequalities is the standard deviation of the logarithm of GDP per capita following the model presented in Section 2. A number of alternative indicators could also have been chosen, such as the Gini index or the coefficient of variation. These alternative measures produced results that were in line with the ones presented here.[5] In addition, our GDP per capita variable is measured relative to the EU average. While the model described in Section 2.2 makes use of the absolute level of GDP per capita, the use of the relative rather than absolute level of GDP is preferred since what we are not interested in the impact of industrialisation but rather in the influence of national catching-up on regional inequalities. One should also note in this regard that Lucas' version of the model described in Section 2 deals with the evolution of regional inequality for an individual country rather than a set of countries, so that normalizing allows us to abstract

[4] Note that we systematically checked the results obtained using the Cambridge Econometrics data by using the region database which is less complete. The results obtained were nearly identical to the ones presented here. Table A1 in the Appendix provides further details concerning the countries considered and the number of observations available for the different datasets used in the paper. We also excluded the Alentejo region for Portugal Groningen region for the Netherlands which suffered from clear breaks in their series of GDP per head.

[5] Note also that, in order to check whether the standard deviation of regional GDP per capita was influenced by the number of regions by country, we computed the correlation between these two variables for the EU15 and it was equal to −0.33 One can therefore assume that the number of regions does not influence our measure of regional inequalities.

Table 1
Relative level of national GDP per capita and regional inequalities in cohesion countries.

	Relative level of GDP per capita					Relative level of regional inequalities (standard deviation of the log regional GDP per capita)				
	1975–1979	1980–1984	1985–1989	1990–1994	1995–2000	1975–1979	1980–1984	1985–1989	1990–1994	1995–2000
Austria	1.02	1.07	1.05	1.08	1.09	1.11	1.15	1.23	1.27	1.19
Belgium	1.03	1.06	1.05	1.09	1.11	1.15	1.24	1.24	1.26	1.24
Germany	1.13	1.16	1.15	1.17	1.14	0.81	0.90	0.92	0.92	0.92
Spain	0.76	0.72	0.73	0.77	0.79	0.91	0.85	1.00	1.05	1.07
Finland	0.92	1.00	1.03	0.9	0.99	0.98	0.93	0.97	0.93	1.06
France	1.08	1.10	1.08	1.06	1.00	1.10	1.07	1.12	1.20	1.15
Greece	0.70	0.67	0.61	0.61	0.66	0.98	0.62	0.57	0.61	0.76
Italy	0.96	1.01	1.03	1.02	1.02	1.38	1.35	1.34	1.36	1.42
Netherlands	1.09	1.05	1.03	1.03	1.12	0.95	1.06	0.79	0.60	0.62
Portugal	0.53	0.56	0.57	0.66	0.73	1.32	1.26	1.15	1.12	0.95
Sweden	1.16	1.15	1.15	1.02	1.01	0.59	0.64	0.70	0.79	0.75
UK	1.00	0.97	1.01	0.97	1.00	0.79	0.82	0.84	0.87	0.87

Notes: figures are relative to the EU15 countries, GDP per capita is measured at PPS.
Regional inequalities are measured using the standard deviation of the logarithm of regional GDP per capita. Regional inequalities for Portugal are not available for 1975 and 1976. Values for country groups are in weighted (population) average.
Regional inequalities computed excluding Alentejo region for Portugal. Regional inequalities computed excluding Groningen region for the Netherlands. Regional inequalities computed excluding the new Länder for Germany.

from general developments within our sample of countries and focus on country specific relationships instead. Finally, our normalization allows also us to reduce both serial correlation and the effect of potential outliers, see Canova (2004). In the sequel, therefore, values of national GDP per capita and regional inequalities will always be considered relative to the EU average or to any other relevant country group.

3.2. Preliminary evidence

Before turning to the econometric testing of the bell-shaped hypothesis of regional development, we provide some descriptive statistics regarding the evolution of regional GDP per capita inequalities and their possibly link with national GDP per capita levels. According to the existing evidence for Europe briefly reviewed in Section 2.1, the poorest EU15 members in the early 1980s (i.e., Spain, Portugal, Greece, and Ireland) have experienced fast catching-up over the past two decades or so and this has translated into rising regional inequalities. Here we provide a first description of the evolution of regional inequalities in these countries during the period 1975–2000 (except for Ireland for which regional data were not available at the NUTS2 for the period considered) as well as for the other EU15 countries. We will also later consider the new EU member states. Table 1 displays the relative level of national GDP and the standard deviation of regional GDP per capita for the EU15 countries by 5 year intervals. This unearths some interesting patterns for a number of countries. For instance, in the case of a country like Spain, both the relative level of national GDP per capita in relation to the EU15 average and the level of regional inequality decreased between the periods 1975–1979 and 1980–1984. During the following periods, however, the level of regional inequalities has increased following the catching-up process of the national level of GDP per capita. A similar pattern is also observed for Greece. From the beginning of the period considered until the 1985–1989 period Greece's GDP per capita level declined compared to the EU15 average only to catch up again during the period 1995–2000 and a similar evolution is also observed in terms of the relative level of regional inequalities. For Portugal, in contrast, regional inequalities tended to decline during most of the period, although it must be said that the standard deviation of regional GDP per capita displays very high variability, as evidenced in Table 2, and that in examining annual data one can see that for some periods regional inequality increases were also experienced during periods of catch up.

An alternative manner to describe the relationship between the relative level of national GDP per capita and regional inequalities is via scatter plots for each country, as is done in Fig. 2. These plots show that non-linearity in line with our starting hypothesis can readily be observed in countries such as Austria, Belgium, Germany, (although here regional inequalities tend to always increase as the national GDP increases), France, the Netherlands, Sweden, and the UK. In some other countries the raw data do not seem to provide such support, such as Finland and Italy, possibly because of the high variability of the regional inequality index. The case of Greece does not show any pattern in line with our starting hypothesis. It must be noted, however, that Greece experienced a notable decline in its relative GDP per capita (as compared to the EU average) since the early 1980s and that, as stated earlier, the most recent economic recovery has also translated into a relative increase in regional inequalities, as evidenced in Table 1. In the case of Portugal the data tend to provide evidence for a non-linear relationship, although the high volatility of the level of regional inequalities in this country makes it somewhat difficult to visualise any clear pattern.

The descriptive statistics concerning the countries that joined the EU in 2004, i.e., the so-called new member states countries (NMS), tend to be particularly illustrative of the rise in regional inequalities

Table 2
Summary statistics for the EU15 countries, 1975–2000.

	Relative level of GDP per capita		Relative level of regional inequalities	
	Mean	Standard deviation	Mean	Standard deviation
Austria	1.11	0.02	1.19	0.05
Belgium	1.11	0.03	1.18	0.05
Germany (western only)	1.20	0.02	0.92	0.04
Spain	0.79	0.03	1.04	0.06
Finland	1.01	0.05	1.12	0.06
France	1.11	0.05	0.75	0.06
Greece	0.68	0.04	0.80	0.09
Italy	1.05	0.02	1.31	0.09
Netherlands	1.11	0.04	1.01	0.09
Portugal	0.64	0.07	1.17	0.20
Sweden	1.14	0.08	0.77	0.08
UK	1.04	0.02	0.75	0.03

Notes: figures are computed relative to the EU25 average. Regional inequalities computed excluding Groningen region for the Netherlands. Regional inequalities computed excluding Alentejo region for Portugal.

that accompanies the national catching-up process. Since the short-time span available for these countries does not allow us to depict the same plot as Fig. 2 which concerned the EU15 countries, we instead in Table 3 provide detailed statistics for the NMS and shows that these countries display, on average, higher regional inequalities than the EU15 countries, including the Cohesion countries. In

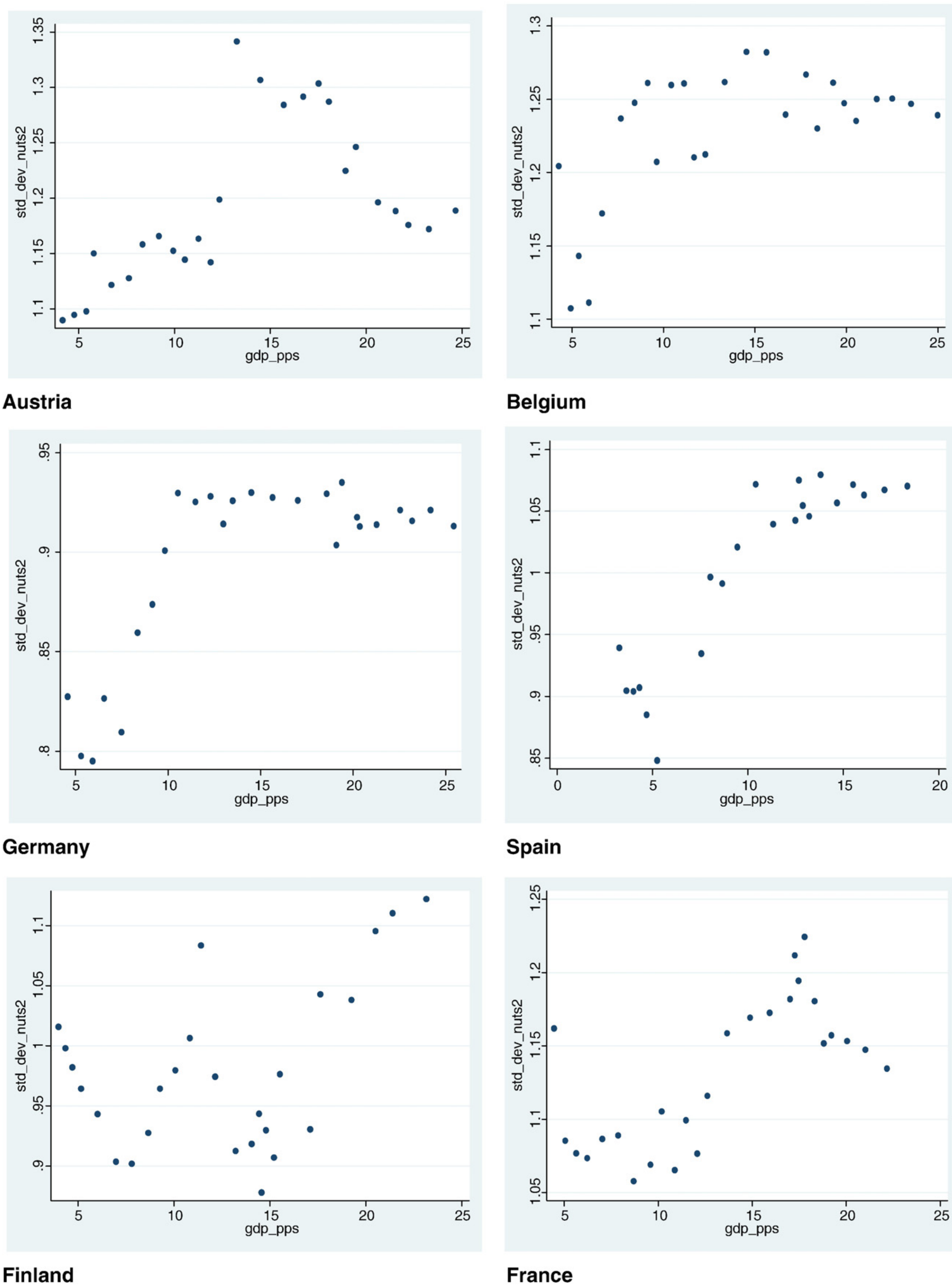

Fig. 2. Scatter plot of standard deviation of EU15 NUTS2 regions GDP per capita versus country-level GDP per capita, 1975–2000.

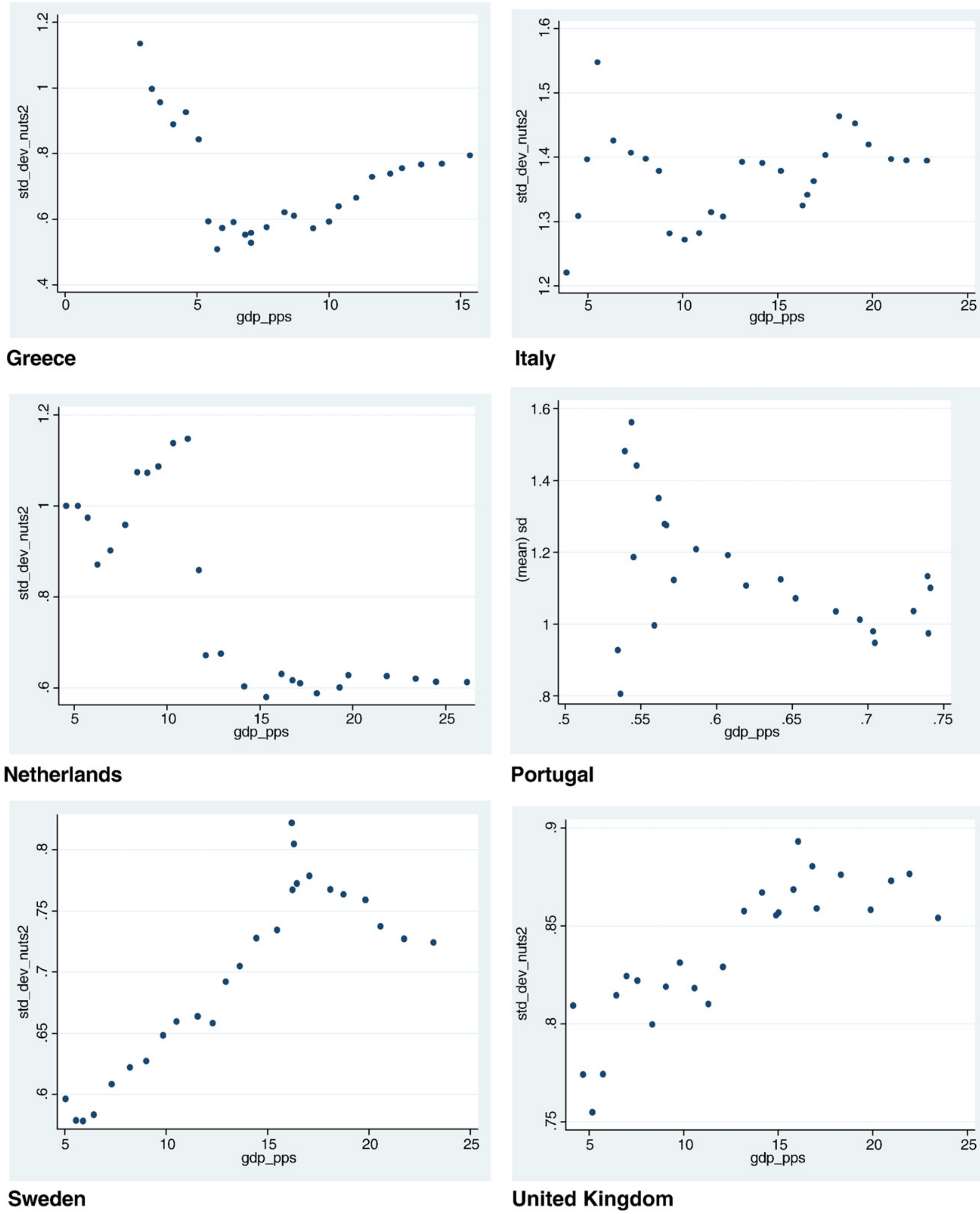

Fig. 2 (*continued*).

addition, the NMS have almost invariably all experienced a continuous increase in the level of regional inequalities during the period 1995–2000 compared to the EU15, except for Bulgaria, Poland, and Slovenia. Part of this evolution is probably due to the transition from a planned to a market-oriented economy. It follows that a large part of the rise in regional imbalances is likely to be due to the rapid catching-up process experienced by these countries during the past decade, as argued by Petrakos et al. (2000). However, one must note that not all the NMS have been catching-up during the 1995–2000 period. Rather some countries, such as Bulgaria, the Czech Republic and Romania, have even seen their GDP per capita compared to the EU15 average decline during these years. On

Table 3
Relative level of national GDP and regional inequalities in new member states and candidate countries.*

	Relative level of GDP per capita (EU25 = 100)		Relative level of regional inequalities	
	1995	2000	1995	2000
Average	0.43	0.45	1.10	1.22
Bulgaria	0.31	0.27	0.96	0.90
Czech Rep.	0.70	0.65	0.95	0.99
Estonia	0.34	0.42	1.52	1.54
Hungary	0.49	0.53	1.09	1.22
Lithuania	0.34	0.38	0.65	0.96
Latvia	0.30	0.35	1.46	2.21
Poland	0.41	0.46	1.43	1.35
Romania	0.30	0.25	0.83	1.06
Slovenia	0.68	0.73	0.60	0.58
Slovakia	0.44	0.48	1.53	1.38

*Figures are relative to the EU25 countries weighted average, weights given by population.
GDP per capita is measured at PPS and regional inequalities are measured using the standard deviation of the logarithm of the regional GDP per capita.

average, these countries have also experienced a less pronounced rise in regional inequalities.[6]

3.3. National development and regional inequalities in the long run: how illustrative is the EU case?

As mentioned earlier, while the bell-shaped curve of spatial development in principle describes long run dynamics, existing evidence reported in the empirical literature, as well as the preliminary results just described here, tend to provide a somewhat similar picture for the EU despite the fact that these evolutions are only observed for periods of, at most, 25 years. Our underlying hypothesis is that this period can be considered as a snapshot of a much longer historical process. Two questions need to be clarified in order to check whether this hypothesis is indeed reasonable. First, is the period considered here, i.e. 1975–2000, a time of especially pronounced economic growth for the EU countries? Second, why should the changes in regional inequalities described in the model of Section 2.2 be observed in this particular period rather than in a more distant future?

In order to reply to the first question, ideally, one would avail of much longer historical data on regional inequalities in order to see whether periods of fast economic growth are accompanied by significant changes in economic inequalities, as would be more in line with the model of Section 2.2. Since long term data of such nature are not available, one indirect alternative approach is to check where our sample period stands relative to national growth patterns. In order to do this, we have complemented our analysis by considering statistics on GDP per capita growth since the early XIX century using the Angus Maddison database for the EU25 countries. These complementary data are included in Table 4 which provides information on national GDP per capita growth averages since the early XIX century and up to 2000.[7] Interestingly, this data reveals that for half of the countries–especially the poorest ones, such as all the NMS (except the Czech Republic), but also for relatively rich countries such as the UK, Sweden and Finland–the periods considered in the econometric exercise are historically high growth periods. For the old Cohesion country group, the period 1995–2000 is also a period of historically high growth rates, although not as high as during the period 1950–1973.

The second question mentioned above, i.e., why the changes in regional inequalities should be observed during these periods of high EU national growth rather than at different points in time, is probably the more challenging one with respect to linking our empirical findings to the model presented in Section 2. Indeed the model of Section 2 says nothing about the exact timing of observing a rise in regional inequalities. It remains to be seen therefore whether the period of fast economic growth for most EU countries would justify observing simultaneous significant changes in regional inequalities. The hypothesis illustrated by the model is that national growth is essentially due to productivity changes accompanied by radical changes in economic structures. Here, however, we do not observe such technological and structural changes since we only consider national GDP per head as the main variable explaining regional inequality dynamics. Furthermore, because the model assumes that technological and structural changes do not appear in all regions at the same time, regional inequalities should inevitably rise, at least at the beginning of periods of high national growth. Therefore, the main thing to know is whether the period considered here (i.e., 1975–2000) was a period of particularly pronounced structural changes for the EU and if this was likely to translate into rising economic inequalities. A number of stylised facts suggests indeed that this is the case. These facts refer in particular to the acceleration of the economic integration process since the mid-1980s with the EU Single Market Program, the advent of the euro in the late 1990s and to the accession of the lagging EU member States in the mid-1980s and early 2000s. These changes usually (although not only) related to an increase in trade integration in the EU, can be considered as exogenous (to the regions) shocks affecting both national GDP growth and, by the same token, regional inequalities. We consider these elements in more details in what follows.

Firstly, a number of authors including, in particular, Gianetti (2002), have related the rise of European regional inequalities in the 1990s to the

Table 4
A historical perspective on national growth patterns in the EU25: average GDP per capita growth in % by periods of time since 1820.

	1820–1850	1850–1870	1870–1890	1890–1913	1950–1973	1973–1990	1990–1995	1995–2000
Austria	0.010	0.006	0.014	0.015	0.049	0.024	0.013	0.028
Belgium	0.011	0.019	0.012	0.009	0.035	0.021	0.012	0.024
Bulgaria	N/A	N/A	0.015	0.013	0.052	0.003	−0.011	0.003
Czech Rep.**	0.008	0.004	0.013	0.014	0.031	0.011	−0.010	0.016
Estonia	N/A	N/A	N/A	N/A	N/A	0.013	−0.046	0.065
Finland	0.005	0.011	0.010	0.019	0.043	0.025	−0.014	0.044
France	0.011	0.008	0.012	0.017	0.040	0.019	0.008	0.025
Germany	0.009	0.013	0.014	0.018	0.050	0.017	0.017	0.019
Greece	0.008	0.004	0.015	0.013	0.062	0.016	0.006	0.032
Hungary	N/A	N/A	0.015	0.016	0.036	0.008	−0.022	0.043
Italy	0.006	0.005	0.005	0.019	0.049	0.025	0.011	0.018
Latvia	N/A	N/A	N/A	N/A	N/A	0.014	−0.106	0.064
Lithuania	N/A	N/A	N/A	N/A	N/A	0.008	−0.099	0.043
Netherlands	0.009	0.008	0.009	0.009	0.034	0.016	0.014	0.031
Poland	N/A	N/A	0.015	0.013	0.035	−0.003	0.019	0.051
Portugal	0.000	0.003	0.007	0.004	0.054	0.025	0.014	0.035
Romania	N/A	N/A	0.015	0.015	0.048	0.001	−0.020	−0.011
Slovakia**	0.008	0.004	0.013	0.014	0.031	0.011	−0.021	0.035
Slovenia	N/A	N/A	N/A	N/A	N/A	N/A	−0.007	0.042
Spain	0.002	0.006	0.015	0.010	0.056	0.027	0.013	0.040
Sweden	0.002	0.013	0.011	0.017	0.031	0.016	0.001	0.031
United Kingdom	0.010	0.016	0.011	0.009	0.024	0.019	0.013	0.028

*Sources: Angus Maddison database, The World Economy, Historical Statistics, OECD, 2003 and authors' computations. Average growth rates of GDP per capita in PPP, g_t, are computed between two periods T and T', $T' < T$ such that $g_t = (y_T / y_{T'})^{1/(T-T')} - 1$ where y_T is the GDP per capita of a given country at date T.
**Figures are for Czechoslovakia up to 1990.

[6] This can be seen also by splitting the sample of new EU member states considered here into two sub-samples: those that have experienced a rise in their GDP per capita relative to the UE15 and those who did not. Non-reported results show that the non catching-up countries have on average (using population figures as weights) seen the standard deviation of their regional GDP per capita to increase by around 21% while the catching-up countries have more than doubled this figure with a rise equal to 43%.

[7] Note, however, that the two world war periods were excluded given the abnormal evolution of national GDP per capita during these periods.

setting-up of the Single Market Program and the rise in trade integration that followed. According to Gianetti (2002), economic integration would have intensified international knowledge spillovers (compared to within-country spillovers), which would have favoured country rather than region-level convergence in the EU during the implementation of the Single Market Program.[8] Accordingly, despite the fact that increased economic integration tends to lower the barriers to technological spillovers, the diffusion of knowledge and innovation in the EU still have strong country specific components. More specifically, when considering the Gianetti (2002) and Bottazzi and Peri (2003) results together, these tend to suggest that while not all regions may have benefited equally from the increased economic integration process, the evolution in regional economic inequalities in the EU has also had a strong national component.

Secondly, while the previous arguments may hold for all EU countries, the countries that have acceded to the EU during the period 1975–2000 do present specific features that make them particularly interesting case-studies for analysing the dynamics of regional inequalities.[9] More specifically, countries such as Greece, (who acceded in 1981), Spain and Portugal (1986), and, more recently, the ten new member states from Central and Eastern Europe (who acceded in 2004), in general were lagging well behind in term of economic development compared to the incumbent member states. In particular, these countries were characterised by a large agriculture sector, a large presence of public-owned enterprises, and high regulatory burden. EU accession therefore translated into deep structural changes. One may want to note that while the NMS acceded only in 2004, the effects of the EU membership and the structural reforms would have accompanied their accession and have led to deep economic restructuring and fast catching-up much earlier; see in particular, European Commission (2000, 2004). In general though, countries that entered the EU from a relatively low level of economic development have faced deep structural changes and fast economic catching-up that are also unlikely to have affected their regions equally. This is precisely also the reason why European Cohesion Policy had been developed at the time, with the objective of rendering the integration and accession process as smooth as possible for lagging EU regions see European Commission (1990). This policy was also continued after the accession of the NMS in 2004 with the same reasoning.

The arguments exposed above therefore suggest that the period and sample of countries considered here is potentially illustrative of the regional dynamics described by the model of Section 2 because, on the one hand, we consider a period of relatively fast economic growth and, on the other hand, because this period coincided with fast structural changes and the catching-up process of countries lagging behind. The mechanisms described in the model can thus be used also to analyse the evolution of regional inequalities for countries that have already been industrialised but that may have faced important shocks potentially affecting they regional inequalities. It follows that, while the absolute value of country-level of income per capita needs to be used to measure the degree of industrialisation, the relative level of income per capita is more suitable when considering the consequences of other types of shocks and, structural changes which take place over shorter time spans.

The preliminary evidence presented in Section 3.1 is suggestive of the fact that, during the period considered here, significant changes in regional inequalities have also taken place, but faces some limitations. First of all, the patterns may not necessarily reflect some underlying common economic phenomenon but could just be the result of country specific factors and common time specific factors. Secondly, as mentioned earlier, there may be other factors that affect both GDP per capita and regional inequality taking place that could produce the patterns observed. For instance, pro-active regional policy and implicit income redistribution schemes may be the driving cause behind the descending part of any bell-shaped curve observed. As a matter of fact, as mentioned earlier, evidence for Europe suggests that these policy-related factors may play an important role in smoothing income inequalities in countries such as Germany or France; see, for instance, European Commission (2000) and OECD (2004). In order to ensure that this is not the case one needs to thus control for other such factors via econometric analysis, as is done in the following section.

Table 5
Parametric estimations of the relationship between regional inequalities and national GDP per head.

	EU15	EU25	EU15	EU25
Inequality (−1)	–	–	0.835	0.553
			(0.952)	(2.531)
GDP per capita	−0.322**	−0.491**	−0.345	−0.067
	(0.166)	(0.110)	(0.318)	(0.902)
(GDP per capita)^2	0.175	−0.084	0.050	−0.085
	(0.278)	(0.165)	(0.846)	(0.450)
R^2	0.76	0.54	–	–
# Countries	13	23	12	23
# Years (mean)	26	6	26	6
# Obs	312	132	312	132

Note: (1) Results for the EU15 concern 1975–2000 and for the EU25 1995–2000. (2) All regressions in the first two columns include time and country dummies. (3) Regressions in the last two columns were estimated using the bias corrected LSDV estimator by Kiviet (1995) using the XTLSDVC STATA command, and standard errors are bootstrapped using 100 replications. Standard errors are given in parentheses.

4. Econometric analysis

4.1. Econometric methodology

Following our underlying hypotheses, the relative level of economic development, here denoted as X, of a country should explain where this country lies in terms of regional inequalities, represented by Y, with poorer countries experiencing growing regional imbalances as they catch up with richer countries. One way to test econometrically the relationship between Y and X is to run a simple parametric OLS estimation including both country and time dummies to control for country specific time invariant unobservables and time specific factors common to all countries in the sample. We do so using data for the EU15 regions over the 1975–2000 period, where we include both the level of national GDP per capita and its square term in order to capture any non-linearity in its relationship with Y. The results of the OLS estimates are given in the first Column of Table 5. As can be seen, our results suggest that national prosperity acts to decrease regional inequalities while the square value of this variable is insignificant.[10] However, a simple Ramsey RESET tests suggest that the specified functional form may not be correct. We thus also experimented with other higher order terms of the national GDP per capita but were unable to obtain a RESET test statistic that did not suggest misspecification.[11] Column 2 of Table 5 displays the results of our estimations using the EU25 sample of countries. Results are very similar to the ones concerning the EU15 with a negative and significant coefficient on the GDP per capita variable, but no significant coefficient on its square term. We also experimented with a dynamic parametric specification. More specifically we used

[8] It is also worth noting, that recent papers looking more specifically at knowledge spillovers in the EU find, however, that R&D spillovers in the EU are subject to strong distance-decay effects with a significant influence exerted by national borders, see Bottazzi and Peri (2003).

[9] We do not consider the cases of Sweden, Austria and Finland since these countries have acceded the EU in 1995 given their relatively high development level at that time.

[10] A joint significance test of the GDP per capita and squared GDP per capita terms was insignificant in all cases.

[11] The result of the RESET test when including the level of national GDP only displays an F-value equal to 10.84 and is significant at 1%. When including this variable and its squared term the F-test value is 8.18 and is also significant at 1%.

the bias corrected LSDV estimator proposed by Bruno (2005). Accordingly, GMM systems estimator is used to estimate the residuals of a consistent estimator. These residuals are then used to correct the biased LSDV coefficients using the Kiviet's (1995) bias correction method. Standard errors are bootstrapped using 100 replications. Results of this exercise for the EU15 and EU25 sample are given in the last two columns of Table 5. As can be seen, the insignificance of the lagged dependent variable provides no support for a dynamic specification. Moreover, the inclusion of the lagged dependent variable renders both GDP per capita variables insignificant.

One problem, of course, with simply using higher order terms to estimate a possibly non-linear relationship is that even these place fairly strong restrictions on the possible link between the dependent variable and the explanatory variable of interest that may not reflect the true underlying relationship. Moreover, a more flexible approach to tackle non-linearity issues in growth and convergence studies is to use semi-parametric methods, as suggested by Durlauf (2001). This way one can investigate the possible non-linearity of the relationship between regional inequality and national development, while also allowing for the (linear) effect of other conditioning variables. We follow the semi-parametric methodology proposed by Robinson (1988) using the Kernel regression estimator.[12] Accordingly, one can consider the following equation to be estimated:

$$Y = \alpha + g(X) + \delta Z + u \tag{5}$$

where Z is a set of explanatory variables that are assumed to have a linear effect on Y, $g(.)$ is a smooth and continuous, possibly non-linear, unknown function of X, and u is a random error term. Robinson's methodology proceeds in two steps. First, an estimator of δ, $\hat{\delta}$, can be obtained by using OLS on:

$$Y - E(Y|X) \ = \hat{\delta}\ [Z - E(Z|X)\ ] \ + \ v \tag{6}$$

where v satisfies $E(v|X,Z) = 0$ and $E(Y|X)$ and $E(Z|X)$ are estimated using the Nadaraya–Watson non-parametric estimator. For instance, the estimation of $E(Y|X)$, $\hat{m}_Y(X)$, can be written as[13]

$$\hat{m}_Y(X) = {}_i\frac{\sum_{i=1}^{n} K_h(x - X_i)Y_i}{\sum_{i=1}^{n} K_h(x - X_i)} \tag{7}$$

such that $i = 1 \ldots n$ is the n number of observations, $K_h()$ is the shape function, commonly referred to as the kernel, that is a continuous, bounded and real function that integrates to one and acts as a weighting function of observations around X and depends on the choice of bandwidth h. More specifically, this technique corresponds to estimating the regression function at a particular point by locally fitting constants to the data via weighted least squares, where those observations closer to the chosen point have more influence on the regression estimate than those further away, as determined by the choice of h and K. An additional appeal of this sort of technique is that it avoids any parametric assumptions regarding $E(Y|X)$ and thus about its functional form or error structure. In a second step, the function g from Eq. (5) can be estimated by carrying out a non-parametric regression of $(Y - Z)$ on X such that $\hat{\delta}$ is the OLS estimator of:

$$Y - \hat{m}_{\tilde{y}}(X) = \delta(Z - \hat{m}_Z(X)) + \varepsilon \tag{8}$$

where ε is a random error term. Intuitively, $\hat{g}(X)$ is the estimate of $g(X)$ after the independent effect(s) of Z on Y has been removed.[14] Given that the estimate of $\hat{g}(X)$ is at least in part based on non-parametric estimation techniques, one cannot subject it to the standard statistical type tests, e.g., t-test. One can, however, relatively easily calculate upper and lower pointwise confidence bands as suggested by Härdle (1990).[15] For all our estimations we use a Gaussian kernel for K_h and the optimal bandwidth h suggested by Fox (1990). One should note that the size of the estimated error variance, $\hat{\sigma}^2(X)$, at any point of X will depend proportionally on the marginal distribution of X. In other words, the accuracy of the estimate of $g(X)$ at X is positively related to the density of other observations around that point. In order to visualize this effect we, as suggested by Härdle (1990), calculate the pointwise confidence bands at points chosen according to the distribution of X. Specifically, we chose points so that one per cent of the observations lie between them.[16] In terms of explanatory control variables to be included when estimating Eq. (5) we first utilised time and country specific dummies. The former allows for year specific effects that are common to all countries, while the latter controls for unspecified time invariant country specific effects that could bias results. In a latter stage we also include other potentially important explanatory variables.

Before proceeding to describe our results it is important to point out intuitively the advantages in our context of using our semi-parametric estimator compared to the parametric estimators used before, and why this estimator can produce very different, but much more accurate, results in terms of any non-linearity in the relationship in question. First, in any parametric estimation the potential non-linearity must be imposed a priori by, for example, choosing higher order terms or spline functions. For instance, first and second order terms only allow for concave or convex relationships. Additionally, this relationship would have to hold over the entire data range. Under the semi-parametric estimator we use, in contrast, the slope (i.e., the shape) is allowed to vary across all values of the explanatory variable of interest and is estimated at each point. Moreover, the estimator purges any non-linear correlation between the explanatory variable of interest and all other control variables as well (as is implied by Eq. (8)). It is not surprising then that parametric and non-parametric estimators can provide very different conclusions regarding the non-linearity, see, for example, Banerjee and Duflo (2003).

4.2. Results for the EU

Our semi-parametric kernel regression estimate of $g(X)$ along with pointwise confidence bands are shown for various samples and specification in Figs. 3–12. Before commenting on these, it is important to point out that, in contrast to the horizontal range which corresponds to the true range of values for X, one cannot read too much into the vertical scale of the figures, as the range is derived from predicted values where there is an issue of non-identification of the unrestricted intercept term, and thus does not completely overlap with actual observed inequality values. Another disadvantage of the semi-parametric estimator is that there is no obvious way to calculate the equivalent of an r-squared as for many parametric methodologies, because, as can be seen from Eq. (8), not only is non-linearity allowed for between the dependent variable and the main explanatory variable of interest, but also between the main variable of interest and all other explanatory variables. Nevertheless, we

[12] See Blundell and Duncan (1998) for details and a helpful discussion of the implementation of this method.

[13] See Nadaraya (1965) and Watson (1964).

[14] One should note that this, as can be seen in Eq. (8), also entails controlling for non-linear effects between Z and X.

[15] It is worth noting that the confidence band proposed by Härdle (1990) ignores the possible approximation error bias. Including this would complicate the expression considerably since the bias is a complicated function of the first and second derivatives of $g(X)$. This bias tends to be highest at sudden peaks of the data and at the necessarily truncated left and right boundaries of the data. However, if h is chosen proportional to $1/n(1/5)$ times a sequence that tends slowly to zero then the bias vanishes asymptotically for the interior points, see Härdle (1990) and Wand and Jones (1995).

[16] For the endpoints we chose the 1 and 99 percentiles of the distribution.

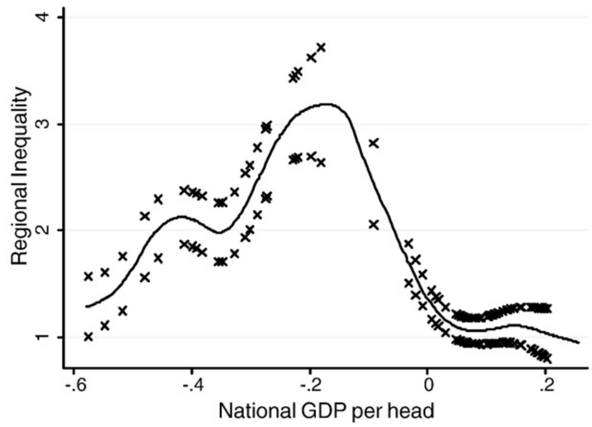

Fig. 3. Results for EU15 1975–2000. GF measure: 0.72.

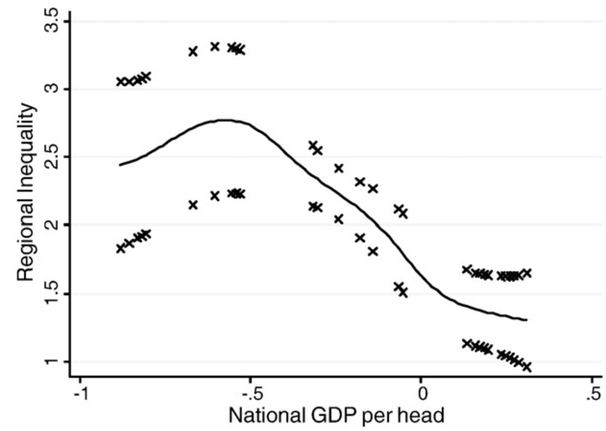

Fig. 6. Results for EU25 1995–2000 (inequality measure based on NUTS2 regions). GF measure: 0.87.

have calculated a proxy indicator for the 'success' of our estimator given by the squared correlation between the predictions produced by the semi-parametric estimator and those of the actual values of regional inequality after purging (linearly) the effects of all other explanatory variables. The resultant measure (for convenience sake noted as GF) ranges, as does the standard *r*-squared, from 0 to 1, where higher values imply a better 'success' and is reported below each estimated figure.

Fig. 3 shows the semi-parametric estimates for the EU15 countries over the 1975–2000 period. The distance between the confidence interval points and their vertical distance from the estimated figure suggests that our estimates are made with some precision. Even at the end points, where estimates normally tend to be relatively poorer because the neighbourhood around points is necessarily truncated, we obtain fairly accurate estimates. Our measures of the goodness of fit also suggest a relatively (to values of regional inequality purged linearly of country and time effects) high fit. Most importantly, in terms of the shape of the relationship between regional inequalities and national GDP per capita, one discovers a clear bell-shaped

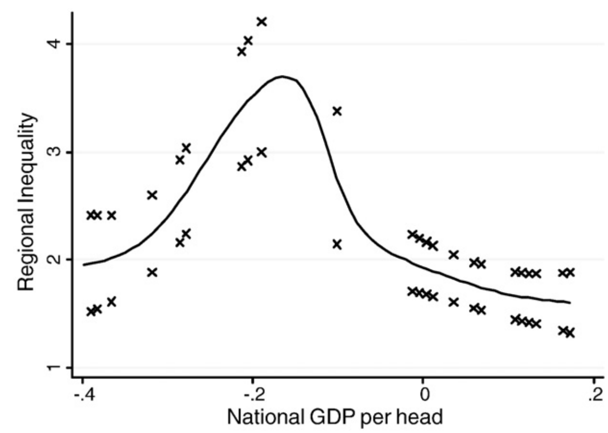

Fig. 7. Results for EU15, 1995–2000. GF measure: 0.72.

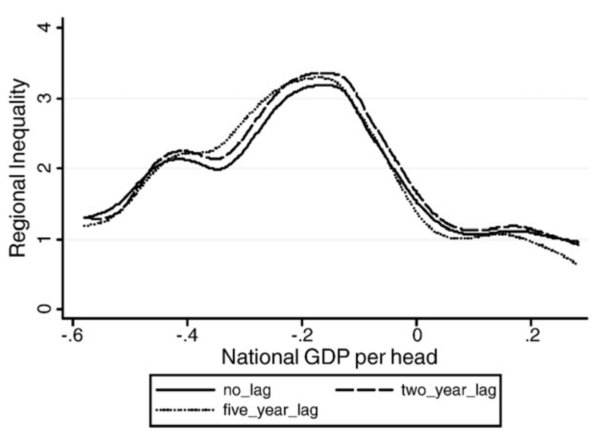

Fig. 4. Results for EU15 1975–2000 — using lagged GDP values. GF measure: 0.72 (no lag), 0.66 (2 year lag), and 0.65 (5 year lag).

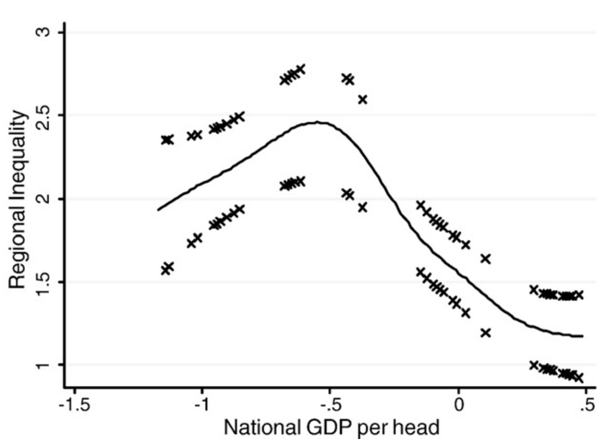

Fig. 5. Results for EU25 1995–2000. GF measure: 0.63.

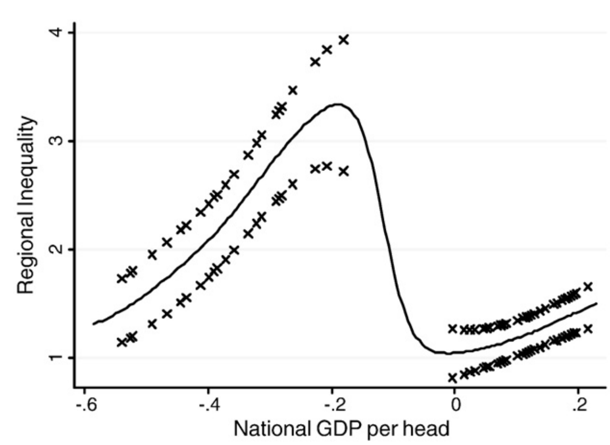

Fig. 8. Results based on functional urban areas 1977–1996. GF measure: 0.85.

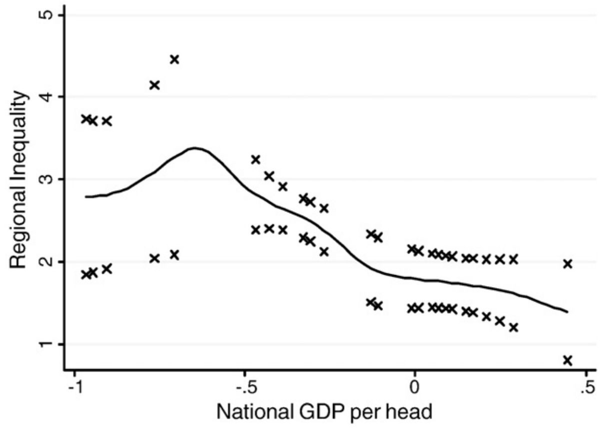

Fig. 9. Results based on OECD territorial statistics, 1977–1996. GF measure: 0.88.

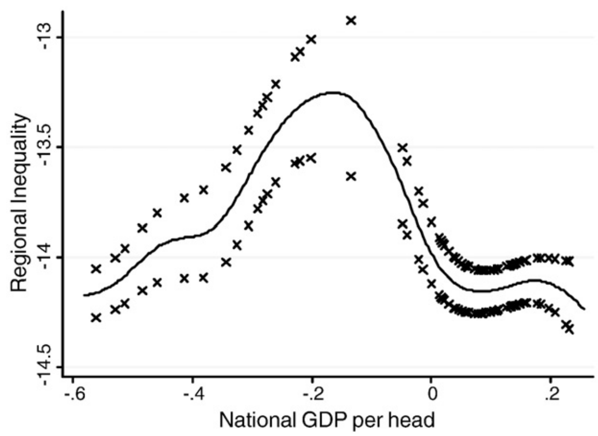

Fig. 10. Results for EU15, 1976–2000 (controlling for fiscal decentralisation, regional aid, and openness). GF measure: 0.70.

relationship, which plateaus out at high levels of GDP per capita. In other words, at low levels of relative (country) GDP per capita, regional inequalities tend to rise, but, after reaching a peak, this trend is reversed and regional inequalities fall. In this regard we also tested whether we could reject linearity of the relationship between *X* and *Y* by employing the test proposed by Li and Wang (1998), but could decisively reject the null hypothesis of a linear relationship.[17]

There are a number of reasons to suspect that our estimations are potentially biased. First, there is a direct link between the regional GDP series used to compute our inequality measure and the national GDP per head used as the main explanatory variable, as suggested in the model described in Section 2. Second, economic theory and empirical evidence suggest that regional economic inequalities may directly affect regional economic performance through agglomeration economies, see Fujita and Thisse (2002) for a theoretical review and Ciccone and Hall (1996) and Ciccone (2002) for empirical evidence, although one must note that the relationship between regional agglomeration of economic activities and national economic performance is not really the focus of the present study. Nevertheless, there could effectively be some correlation between the two variables due to the influence of some unobserved factors which are not controlled for in our empirical specification.

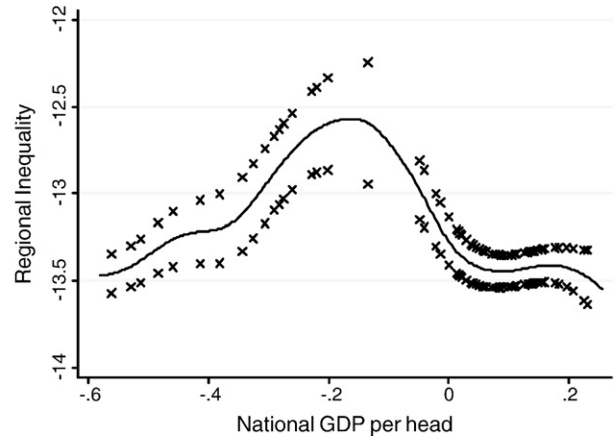

Fig. 11. Results for EU15, 1976–2000 (controlling for fiscal decentralisation, regional aid, and real openness). GF measure: 0.72.

One way to handle the potential endogeneity of the relative level of national GDP per head is to use past levels of logged GDP per head as is usually done in the convergence literature; see Barro and Sala-i-Martin (2004, ch.11). Fig. 4 plots our semi-parametric estimations using the actual value of the relative GDP per capita as explanatory variable, as in Fig. 3, together with the 2-year lagged and the 5-year lagged values of the same variable. For visual convenience we only report the estimations without the confidence bands. According to these results, the bell-shaped link evidenced earlier still holds, and the fit only falls marginally. Furthermore, the small bumps observed in Fig. 3 both on the right and left hand-side of the sample estimates are smoothed and this is especially true when using the 5-year lagged series of GDP per head. Also, the goodness of fit measure only falls marginally. In what follows we thus will use the lagged 2-year level of relative national GDP per head as the main explanatory variable given that using the 5 year lagged values reduced our sample size considerably, especially when considering alternative datasets.

It is interesting to examine also whether the bell-shaped curve holds for the new member states that entered the EU in 2004. Unfortunately the small sample of new EU entrants, ten countries over 5 years, is not enough to produce any separate estimates for these countries alone. Instead we consider them with the rest of the EU in our EU25 sample. The results of this exercise are shown in Fig. 5. Accordingly, there is further support for our starting hypothesis, particularly since the data now cover a much wider range of GDP per

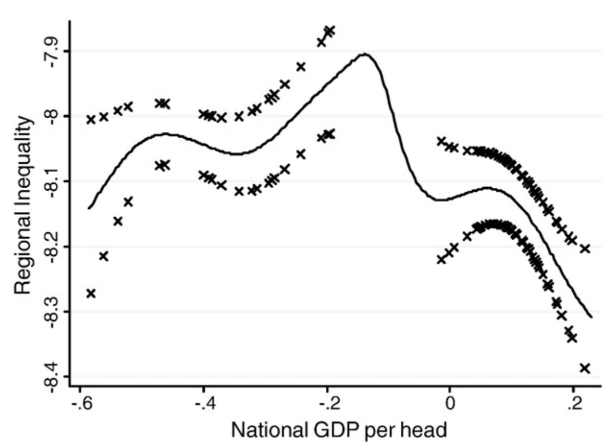

Fig. 12. Results for EU15, 1980–2000 (controlling for fiscal decentralisation, regional aid, real openness and industrial dissimilarity). GF measure: 0.80.

[17] The test statistic generated by bootstrapped replications at 5 and 1% critical value was 162.93 and 53.83, respectively. We also employed this test for all subsequent semi-parametric estimations and in all cases were able to decisively reject linearity.

capita levels. One should note that the regional data used for the new member states are not always based on the same spatial disaggregation, however. In fact, the NUTS2 level which was used for the EU15 countries sample is only available for Poland, the Czech Republic, Hungary and Slovakia.[18] In order to see whether this influences our results we estimated our equation including only the new member states for which NUTS2 regional data were available. Results displayed in Fig. 6 are indeed broadly in line with those presented in Fig. 5, although the confidence band is somewhat broader in the earlier range due to the loss of sample size. We also ran our estimations for the EU15 sample during the years 1995–2000 in order to check whether the change in the time period considered could be influencing the findings. The results of these estimations are displayed in Fig. 7 and show that the bell-shaped curve found earlier still holds. Importantly, both Figs. 5 and 6 indicate that the initial rise in regional inequalities accompanying national catching-up is less pronounced in absolute terms than the decline that follows as catching-up proceeds.

4.3. Results using alternative datasets: functional urban areas and OECD data

In order to check the robustness of our results we also used two alternative datasets. The first is a database compiled at the London School of Economics on European functional urban areas (FURs). Following Magrini (1999, 2004), if we are to evaluate growth and convergence dynamics across regions correctly, the spatial units used should abstract from commuting patterns. The FURs are precisely defined on the basis of core cities identified by concentration of employment and surrounding areas on the basis of commuting data. They are broadly similar in concept to the (Standard) Metropolitan Statistical Areas used in the US; see Cheshire and Hay (1989) and Cheshire and Magrini (2000) for more details. It is, however, also worth pointing out that the FUR areas do not cover the whole territory of the countries they belong to. We use data on the FURs for seven EU countries for the period 1977–1996.[19]

The second dataset comes from the territorial statistics of the OECD collected through the national statistical offices of OECD member countries and Eurostat. These national censuses and surveys are undertaken in different time periods and years of observation may vary between countries. The appeal of this database is that it covers non-European countries such as Australia, Canada, the US, Mexico, Norway, and Japan in addition to the EU counties used earlier. In order to ensure comparability across time for all countries, these territorial Statistics are organised in four waves: Wave 1 (about 1980), Wave 2 (about 1990), Wave 3 (about 1995), and Wave 4 (about 2000). GDP figures are expressed in constant US dollars and data are collected at the level of 300 regions of the OECD area. Initially data on Island, Ireland and Luxembourg were available with the OECD database but consisted of very few regions. These countries were thus not considered in the analysis. Moreover, in the case of Germany, the OECD database includes Eastern German Länder after 1990, which greatly influences the level of regional inequalities. Only data before 1990 were thus used for this country.

Fig. 7 displays our semi-parametric estimates using the functional urban areas. As can be seen these data are probably least supportive of a bell-shaped relationship since while low relative levels of GDP per capita are associated with rising inequalities and after a certain turning point there is a clear fall in regional inequality, regional inequalities marginally rise with very high levels of relative GDP per capita. The small sample size of the FUR data calls for caution when interpreting the corresponding results. Regional inequalities would then also rise for relatively high levels of national GDP per capita indicating that some regional divergence may occur for the corresponding countries, although the slope of the curve tends to be much lower for relatively rich compared to relatively poor countries. This result is not totally contradictory to our starting hypothesis given that the FUR data do not cover the whole set of EU regions. With the FUR data we compare the level of income of a limited number of metropolitan areas for each of the countries included in the sample. Given that these areas play a major role in fostering growth and technological diffusion, one may well expect this to be true across all countries and not only for the poorest ones. This would suggest that metropolitan areas are more likely to play a greater role in fostering the catching-up of the poorest countries compared to the wealthier ones, although caution must be taken when interpreting these results given the small sample size available.

The results using OECD territorial statistics are depicted in Fig. 9. As with our regional databases there is a clear bell-shaped relationship, although this is not as pronounced as with most of our European data. In addition, as can be seen from the wide confidence bands, point estimates appear to be less precise, especially for relatively low levels of GDP per head, which may well be due to the small number of observations available.

4.4. Controlling for additional explanatory variables

The preceding analysis assumed that, apart from country and time specific effects, regional inequalities were influenced by the relative level of GDP per capita only. This assumption is rather restrictive and our results can potentially suffer from the omission of other (possibly) important determinants of regional inequalities. We thus check whether the general relationship between regional inequalities and GDP per capita holds when including additional explanatory variables. In this regard, we would ideally like to include all potential determinants as suggested by the existing empirical growth and trade literature. In practice, however, regional data on these aspects are rarely available and/or of poor quality and we thus chose to focus on a limited number of variables using the European NUTS2 regional breakdown for which data were most complete.[20]

The first additional explanatory variable considered is a measure of national trade openness. The inclusion of this can be seen as important given the fact that the model presented in Section 2 assumes that spillovers occur only at a national level, excluding international and, in particular, technological spillovers related to trade intensity which have been found to be important in the literature; see Coe and Helpman (1995) and Gianetti for evidence concerning the European case. The empirical literature on trade and growth generally uses the ratio of total trade (import + export) to GDP in order to measure trade openness; see Frankel and Rose (2002). Recently, however, Alcalá and Ciccone (2004) have criticized the use of this index given that trade tends to raise the relative price of non-tradable goods. In order to circumvent this issue they propose instead two alternative indices: the *real openness index*, which is the sum of imports *plus* exports expressed in common currency (here the euro) relative to the GDP expressed in PPP terms and the *tradable GDP openness* which is defined as the sum of nominal exports and imports divided by the nominal value of GDP in the tradable sector. In our estimations we use the traditional openness indicators as well as the two alternative indicators proposed by Alcalá and Ciccone (2004). The expected sign for this variable is positive if we assume that not all

[18] For the other countries the NUTS3 level was used instead given that NUTS2 data were not available.

[19] The data are in GDP per capita in US $ expressed in PPP terms, see the Table A1 in the Appendix for more details.

[20] Additional explanatory variables such as labour mobility and differences in regional educational level were also initially considered but were dismissed given that they are only available on regional basis for few countries and only for very short time spans. Table A2 in the Appendix provides further details on data sources and definitions of all the variables used.

Table 6
Krugman specialisation index for the EU15, 1980–2000.

	1980	1990	2000	% Change between 1980 and 2000
Austria	0.23	0.21	0.19	−0.18
Belgium	0.26	0.25	0.29	0.11
Germany	0.23	0.20	0.24	0.05
Denmark	0.23	0.23	0.23	0.01
Spain	0.39	0.35	0.31	−0.21
Finland	0.33	0.26	0.25	−0.26
France	0.23	0.19	0.17	−0.27
Greece	0.47	0.42	0.34	−0.28
Italy	0.33	0.28	0.25	−0.25
Netherlands	0.18	0.17	0.14	−0.20
Sweden	0.16	0.17	0.21	0.27
UK	0.20	0.18	0.19	−0.05
EU15 average	0.27	0.24	0.23	−0.14

Sources: Cambridge Econometrics and authors' computations. See Table A2 for a definition of the Krugman index and the sectoral breakdown used.

regions benefit equally from greater trade openness such that regional inequalities may rise.

The second variable to be considered is a measure of regional industrial specialisation. Here we use the country/year average of the so-called Krugman specialization index. When considering two different regions j and k, the Krugman index corresponds to the expression: $K_{j,k,t} = 0.5\sum_s |x_{s,j,t} - x_{s,k,t}|$ where $x_{s,j,t}$ is the share of sector s in total employment of region j at a given year t. Since absolute values of the differences in sectoral employment shares are taken, the indicator value varies between 0 and 1 and will be low when two regions j and k have similar industrial structures (i.e., a similar distribution of employment shares across industries), and high otherwise. Once $K_{i,j,t}$ is calculated for all regions in a given country/year, then we can compute the average value of $K_{i,j,t}$ for each country/year as indicated in Table A2 in the Appendix. The Krugman Specialisation Index (Table 6) depicts the structure of the economy in the respective country in relation to the structure of the average of the rest of the EU. The use of this index was made popular after the study by Kenen (1969), who first advocated that sectoral specialization may play an important role in determining regional economic fluctuations and growth patterns, see also Clark and van Wincoop (2001) and Midelfart Knarvik and Overman (2002) for further discussion. The idea is that two regions with dissimilar industrial structures should also have differing growth experiences. Also, regions highly specialized in agriculture and/or traditional manufacturing activities should be less prone to adopt new technologies during periods of innovation-led economic growth and should grow less than more technologically advanced regions. For instance, Gianetti (2002) shows that European regions with similar technological capabilities (directly linked to the specialization of regions in traditional sectors) have converged substantially, while the others have displayed some tendency to diverge over the period considered. The expected sign on this variable is thus positive if countries where regions have similar industrial structures, i.e., lower average value of $K_{j,k}$, also tends to display lower regional imbalances. Table 5 provides the values of the Krugman index for the EU15 during the period 1980–2000, which is the longest time span for which regional employment data are available for five sectors of the economy: agriculture, construction, energy and manufacturing, market services, and non-market services. This table shows that, on average between 1980 and 2000, regional industrial structures within countries have tended to converge in the EU as the average value of the Krugman index decreased from 0.27 to 0.23 (representing a 14% decrease). This regional convergence in industrial structure is experienced in some of the least developed EU15 member states, such as Spain and Portugal, where detailed statistics show that these evolutions have been driven by the decline of the agriculture sector and also in other countries, such as Finland and France, where this decline is mainly driven by the rise of the service versus the manufacturing sector. However in some cases (i.e., Belgium, Germany, and the Netherlands) the index has tended to increase during the same period.

The third variable to be considered is a measure of fiscal decentralisation, which also may have been a cause of growing economic divergence in the EU. Evidence in this direction has recently been provided by Rodríguez-Pose (1996) and Rodríguez-Pose and Gill (2003), for instance.[21] These studies relate to the well-known Oates theorem on fiscal decentralisation according to which differences in preferences about public goods across regions will require decentralized provision of such goods in order to improve regional economic performance; see Carrion i Silvestre et al. (2004). In contrast, other authors have found rather contradictory results finding little evidence for a significant effect of fiscal decentralisation on regional growth; see, for instance, Xie et al. (1999) and Davoodi and Zou (1998). The question of the relationship between fiscal decentralisation and regional inequalities thus appears to be an empirical one. In order to control for the possible influence of fiscal regional decentralisation we use the indicator developed by the World Bank, which is based on data from the IMF's Government Finance Statistics. This indicator is the share of sub-national public expenditures as a percentage of national GDP. It is worth noting that this indicator accounts for regional as well as local public spending.

The final additional explanatory variable is a measure of the impact of EU regional policy. The main objective of this EU policy has been to boost convergence and reduce regional economic development disparities in EU regions and countries. Especially since the end of the 1980s, European structural funds have largely benefited those EU regions with a GDP per capita lower than 75% of the EU average (the so-called Objective 1 regions).[22] These regions, in turn, are mainly concentrated in the member states with the lowest GDP per capita. Over the period 1989–1999 these funds have represented, on average, around 2% of the GDP of the Cohesion countries group (including Spain, Portugal, Greece and Ireland) against 0.12% for the rest of the EU.[23] Despite their importance, the evidence on the effective impact of EU structural funds remains inconclusive with a number of authors suggesting that, at best, their impact was negligible, see Boldrin and Canova (2001) and Beugelsdijk and Eijffinger (2003). De la Fuente (2002), however, finds a positive and significant impact of structural funds on the economic development of Spanish regions. In order to control for the possible influence of EU regional policy we use as a control variable the level of Structural Funds as a percentage of national GDP. The expected sign for this variable is negative if structural funds allocation was successful in reducing regional inequalities.

As an initial step we would first like to verify that the impact of these additional explanatory variables on regional inequalities coincides with a priori expectations and thus whether they are likely to serve as good proxies for their intended purpose. One option would be simply to estimate their effect with standard OLS including relative GDP per capita as in Table 4. However, clearly our semi-parametric results suggest that the relationship between GDP per capita and

[21] Stansel (2005) provides similar evidence for the US.

[22] Another important component of EU cohesion policy is the Cohesion fund. While this fund may also have an impact on regional inequalities, this impact is less clear-cut given that it is attributed on a national basis (the criterion being that the EU country must have a GDP per head below 90% of the EU average) in order to boost growth mainly through public investment in transport and energy infrastructure and also for the environment.

[23] Sources: Annual reports of the EU Court of Auditors for data from 1976-1996 and EU Commission's Annual report on allocated expenditure from 1997 on.

regional inequalities is of a non-linear nature, not even necessarily well captured by higher order terms as evidenced earlier. One method to take account of this while still obtaining estimates of other explanatory variables assumed to have a linear impact is to follow the method proposed by Yatchew (1997). Accordingly, we assume a partial linear model as in Eq. (5), sort the data according to values of X (i.e., the level of national GDP per head) and first difference Y and all other linear determinants given by Z (i.e., all the other explanatory variables). This allows the direct effect of $g(X)$ and the indirect effect of Z on X to be purged from Eq. (5) so that one can get estimates of δ using OLS on the first differenced data. The results of these estimations are given in Table 5. Column (1) shows that the estimated signs on the structural funds and fiscal decentralisation proxies coincide overall with a priori expectations in that the latter is positive and significant and the former negative and significant. In contrary, the openness variable is insignificant. In columns (2) and (3) we re-estimated our model using the tradable openness as well as the real openness measures, as defined earlier. While the tradable openness variable is still insignificant, as shown in column (2), the real openness proxy in column (3) displays the expected positive and significant coefficient. We thus kept the real openness variable to estimate the full model in column (4), where we also included the dissimilarity variable. This latter variable turns out to be insignificant, however. Moreover, the Structural Funds variable now is insignificant, which may be because the time period considered for this regression is shorter given the lower data availability on the dissimilarity variable; see Table A2 in the Appendix for more details on data availability.

In Figs. 10–12 we thus proceeded and re-estimated our semi-parametric specification for the EU15 sample including these additional control variables for various combinations. One should note that the results obtained in these figures must be compared to Fig. 3 where we only included the relative level of national GDP per capita as explanatory variable. Accordingly, regardless of what fiscal decentralisation or openness variable we use, the estimated shape of the regional inequality–national development link remains bell-shaped. In Fig. 12 we also included our dissimilarity index, although one must note that this meant reducing our sample period to start from the 1980s given data limitation, as mentioned earlier. Nevertheless, one still observes the outlines of a bell-shaped curve.

Table 7
Parametric estimations of partial non-linear model, EU15 1975–2000.

	(1)	(2)	(3)	(4)
Structural funds	−0.04*	−0.04*	−0.043**	−0.015
	(0.02)	(0.02)	(0.021)	(0.024)
Fiscal decent. % GDP	0.010**	0.012**	0.010**	0.022***
	(0.004)	(0.005)	(0.004)	(0.005)
Openness	0.224	–	–	–
	(0.157)			
Tradable openness		−0.161		
		(0.745)		
Real openness	–	–	0.502***	0.612***
			(0.185)	(0.204)
Dissimilarity	–	–	–	−0.157
				(0.584)
R^2	0.73	0.73	0.74	0.78
# Obs	264	264	264	180

Notes: (1) data were sorted according to the relative GDP per capita range and then all variables first differenced (2) country dummies included, but time dummies excluded because these were in all cases jointly insignificant; standard errors in parentheses; (3) ***, ** and * indicate 1, 5 and 10% significance levels respectively, all regressions include a constant term.

5. Summary and conclusion

In this paper we examined the link between national GDP per capita and regional inequalities for a number of European countries and found evidence of a bell-shaped relationship between these two variables. These results are in line with earlier theoretical work by Lucas (2000) and also the empirical analysis by Williamson (1965). While Williamson (1965) and Lucas (2000) analyse the consequence of industrialisation, measured indirectly by the absolute level of income per capita, we believe that their arguments can also be used to measure the consequences of other (than industrialisation) types of structural changes affecting both national growth and regional inequalities. Indeed there is no reason to believe that the changes in regional inequalities described by these authors should stop once all countries become industrialised, i.e. once they have reached a certain absolute level of income per capita. One could perfectly assume that other types of shocks entailing deep structural changes could also significantly affect productivity and growth and have similar impact on regional inequalities. What remains equally important compared to these previous studies, however, is the fact that regional inequalities are likely to be much more affected in countries engaged into especially deep structural changes and starting from relatively low levels of GDP per capita as these countries are more likely to experience fast catching-up processes. This does not preclude that regional inequalities may also rises in relatively rich countries facing similar types of shocks. Our hypothesis in this regard is that regional inequalities would tend to rise relatively less in these countries compared to poorer countries given that in relatively poorer countries regions are likely to be more equally equipped to face these shocks as suggested in particular by Gianetti (2002) in the case of the EU integration process.

Our econometric results suggest that the large differences across relative national GDP per capita levels across the EU and the fast catching-up process experienced by some of these countries, in particular the countries that have entered the EU in 2004, make the EU a good case study of the dynamics of regional inequalities as national catching-up proceeds. To date the existing empirical literature has failed to identify convincing empirical regularities regarding the dynamics of regional inequalities and, in particular, its non-linear nature. These issues in particular call for the use of non-parametric techniques as suggested by Durlauf and Johnson (1995). Using semi-parametric estimation techniques (Table 7) we show that regional inequalities tend to rise on average as the relative level of national GDP per capita rises but then tend to decline once a certain relative level of national GDP per capita is reached. Our results would thus tend to suggest that arguments similar to the ones used by Williamson (1965) in the context of the industrialisation process of developing countries to explain the bell-shaped curve of regional inequalities can also be used to explain the change in regional inequalities experienced by countries engaged into other types of structural changes such as the ones entailed by the EU integration process and the successive enlargements of the European Union.

Arguably our findings have important policy implications. For example, in terms of EU Cohesion policy, which has been aimed at boosting convergence and catching-up of lagging EU regions, the evidence presented here implies that some degree of regional inequality may be unavoidable, at least at the initial stages of national catching-up processes. As argued in this paper, the main reason for this is that growth, because of its very nature, is unlikely to appear everywhere at the same time. Thus, one may argue that regional policy and public investment should aim at boosting national growth in order to guarantee greater national prosperity at the expense of temporarily rising regional inequality, especially in the least developed countries such as some of the new EU member states, where nearly all regions, included the most developed ones, lie well below EU GDP per capita levels. Accordingly, the cost of re-shifting funds towards the most dynamic regions could be mitigated by national-level interpersonal income redistribution mechanisms in these countries.

Appendix A

Table A1
Number of regions and dataset used.

Country	Eurostat/Cambridge Econometrics database (NUTS2 regions)	Functional urban areas	OECD territorial statistics
Australia	–	–	8
Austria	9	–	9
Belgium	11	4	3
Bulgaria***	28	–	–
Canada	–	–	12
Czech Republic	8	–	8
Denmark	–	–	3
Estonia***	5	–	–
Finland	5	–	6
France	22	22	23
Germany	31 (42*)	28	11
Greece	13	–	4
Hungary	7	–	7
Italy	21	17	20
Japan	–	–	10
Latvia***	5	–	–
Lithuania***	10	–	–
Mexico	–	–	32
Netherlands	12	4	4
Norway	–	–	7
Poland	16	–	16
Portugal	7	–	7
Romania***	41	–	–
Slovak Republic	4	–	4
Slovenia***	12	–	–
Spain	18	16	18
Sweden	8	–	8
United Kingdom	37	24	–
United States	–	–	51
Total # of observations	312**	180	72

*Including new Landers.
**132 for EU25.
***NUTS3 regions.

Table A2
Statistical sources of explanatory variables used in Section 4.3*.

Indicator	Definition	Source	Time period covered
Traditional openness index	$(\text{export}_{i,t} + \text{import}_{i,t}) / \text{GDP}_{i,t}$	Ameco database, European Commission, Directorate General for Economic and Financial Affairs	1975–2000
Real openness index	$(\text{export}_{i,t} + \text{import}_{i,t}) / \text{GDP}^{p}{}_{i,t}$ where $\text{GDP}^{p}{}_{i,t}$ is the GDP expressed in purchasing power standard	Ameco database, European Commission, Directorate General for Economic and Financial Affairs	1975–2000
Tradable openness index	$(\text{export}_{i,t} + \text{import}_{i,t}) / \text{GDP}^{t}{}_{i,t}$ where $\text{GDP}^{t}{}_{i,t}$ is the GDP of the tradable sectors	Ameco database, European Commission, Directorate General for Economic and Financial Affairs	1975–2000
Industrial dissimilarity index	$K_{i,t} = \frac{1}{0.5\ N_i(N_i - 1))} \sum_{j,j \neq k}^{N_i} \sum_{k,k \neq j}^{N_i} K_{j,k}$ where N_i is the number of regions located in country i and $K_{j,k,t} = 0.5 \sum_s \lvert x_{s,j,t} - x_{s,k,t} \rvert$ where $x_{s,j}$ = share of sector s in total employment of region j	Cambridge Econometrics sectors s concern agriculture, construction, energy and manufacturing, market services and non-market services	1980–2000
Fiscal decentralization index	Sum of local and regional total expenditures, excluding current and capital transfers to other levels of government, divided by National GDP	World Bank	1975–2000
EU regional aid	Total EU payment for regional development from the European Regional development Fund (ERDF), the European Agricultural Guidance and Guarantee Fund (EAGGF), and the European Social Fund (ESF) in % of national GDP	European Commission, Directorate General for Economic and Financial Affairs	1975–2000

*Indicator subscripts indicate country i and year t. Monetary variables are expressed in current euros.

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