Economic Integration and Regional Development: Are European Regions Converging?

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Abstract:

The paper analyses regional growth and convergence in the European Union over the period 1977-2002. We find no significant reduction in regional income disparity over the past two decades. Regional income differentials remain substantially above the average level of disparity within the member countries. Our econometric analysis finds evidence for conditional beta convergence. The estimates suggest that structural variables like the labour participation and the employment share in the electronics sector influence regional growth. They also point to the important role that national determinants of growth have for the growth performance of European regions. On the other hand, the analysis finds no evidence that the deepening of economic integration, i.e. the European Single market, has led to a general increase in the speed of regional convergence.

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1. Introduction

In the current process of Eastern enlargement ten new members states will join the European Union in 2004. On average, these countries have lower per capita income levels than the current EU member states. Regional income inequalities within the European Union will further increase. Allready now, average growth and income levels differ substantially across EU regions. While purchasing power adjusted per capita output in the ten richest regions at NUTS 2 levels is at least 42% above the EU average in 2002, per capita output of the ten poorest regions is at leat 41% below the EU average.

Although the European Commission considers the development of economically lagging regions and the reduction of regional disparities as priorities for her economic policy, the regional income distribution is also rather unequal by international standards. In 2002, the regional income variation in the EU (measured by the coefficient of variation of gross value-added per capita in purchasing power standards for NUTS 2 regions) was 0.30. At the same time, income variation between the 50 US states, in current dollar, was roughly half this size, 0.16.

The pronounced regional income disparities in Western Europe raise several questions. Does economic integration imply economic growth and convergence or not? What are the conditions for lagging regions to catch-up on advanced ones? Has regional policy been successful in reducing regional disparity? Analysing regional economic growth and convergence over the last 25 years, this paper addresses the first two questions. We consider regions as small open economies and stress a number of mechanisms for convergence or divergence that were developed in economic growth theory. The paper then presents stylised facts on regional growth and convergence in the European Union and estimates unconditional and conditional convergence equations for a subset of European regions.

We investigate the development of regional per capita gross value-added and find a reduction in regional disparities over the sample period. Our empirical findings reject unconditional convergence. However, we find evidence for conditional convergence, i.e. poorer regions conditionally grow faster than richer ones. Our results further suggest that structural factors, e.g. the rate of labour participation or the share of the electronics sector in total employment, play a role in determining the growth performance of regions. The estimates also stress the substantial impact of determinants of national average growth on regional economic performance. On the other hand, we fail to show a general positive impact of deeper economic integration in Europe on the speed of convergence towards the steady state. The results are

comparable to the estimates of Badinger et al. (2002), Cuadrado-Roura and Parellada (2002), and Tondl (2001).

The remainder is organised as follows. Section two presents a theoretical framework for convergence in open economies. In section three, we present stylised facts on regional growth and convergence in the European Union. Section four describes the data set, and section five reports estimates for unconditional and conditional convergence. Section six summarizes the results.

2. A Theoretical Framework for Convergence in Open Economies

The analysis of income or productivity convergence between economies distinguishes two aspects. Firstly, how does the distribution of income or productivity evolve over time? This is the concept of sigma-convergence. *Sigma-convergence* labels a decrease over time in income or productivity dispersion between economies. Appropriate measures of such dispersion are the coefficient of variation or the average distance from the sample mean. Sigma-convergence is thus a useful concept whenever one is interested in the evolution of the per capita income or the productivity disparities within a sample of economies.

The second approach, beta-convergence, examines the mobility within the sample income or productivity distribution. It is the appropriate concept whenever one is interested in the extent and in the speed of catching-up in per capita income or productivity of an economy relative to the sample average. Beta-convergence comes in two different varieties. *Unconditional beta-convergence* states that initially poorer economies exhibit higher per capita growth than richer ones. Poorer economies will grow faster until they have caught up on the rich countries or regions. Unconditional beta-convergence postulates a universal trend towards income or productivity convergence between economies. In equation form, the hypothesis of unconditional convergence implies that, in 2.1, $(\beta\text{-}1) < 0$ (see, e.g., Barro and Sala-i-Martin 1992 and 1995, Sala-i-Martin 1996).

$$(2.1) \qquad y_{it} - y_{i,t-1} = \alpha + (\beta - 1) y_{i,t-1} + u_{it}$$

The empirical rejection of the hypothesis of unconditional convergence in international cross-country growth comparisons has led to conditioning the convergence hypothesis. *Conditional beta-convergence* is present if an economy grows faster the further it is away from its own steady state of capital per worker and from its own long-run equilibrium growth path. For cross-country or regional comparisons, conditional beta-convergence implies that convergence in income or production levels and in per capita growth rates only occurs between such economies that are sufficiently homogenous with regard to important growth-determining socio-economic or political variables. To put it in another way, conditioning the convergence hypothesis means to control a priori for a number of variables that are possibly influential in explaining the cross-country or regional differences in empirically observed growth rates. Conditional convergence thus conditions on a number of explanatory variables x (equation 2.2) that may be responsible for the observable cross-country divergence in per cap-

ita growth rates and in standards of living. Conditional convergence is then compatible with an absolute divergence in per capita growth rates and productivity levels across economies. If the factors that determine the steady state differ between economies, the long-run growth rates and income levels will differ too (Straubhaar 1998, 14). Therefore, the hypothesis of conditional convergence can be formulated as follows: Do economies converge in their standards of living and in their growth rates, and how fast do they converge, if differences in growth-determining factors are controlled for?

$$(2.2) \qquad y_{it} - y_{i,t-1} = \alpha + (\beta - 1) y_{i,t-1} + \gamma x_{it} + u_{it}$$

Why should poorer economies conditionally growth faster than richer ones, and why should economies thus conditionally converge in per capita income or productivity terms? Growth theory and empirical studies on economic convergence stress three possible convergence mechanisms in open economies: capital mobility, technology diffusion, and labour mobility. Capital mobility as convergence mechanism is suggested by neoclassical growth theory. If production is characterised by constant returns to scale and a decreasing marginal productivity of capital, the return to capital should be higher the lower the initial stock of capital per worker. The internationally mobile capital will flow from economies where per worker capital stocks are high to economies with low capital endowment. As labour productivity is a positive function of the capital intensity, the neoclassical model with decreasing marginal returns to capital predicts a higher per capita growth performance in lagging economies. With above-average growth rates, poorer economies will finally catch up in income or productivity levels (Barro and Sala-i-Martin 1992 and 1995, Sala-i-Martin 1996, Sell 1998, Straubhaar 1998).

The emphasis that neoclassical growth theory places on the equalisation of per worker capital stocks as convergence mechanism disregards differences in the efficiency with which capital inputs are used. This is the place for technology diffusion to promote convergence. Neoclassical theory supposes technology to spread out internationally. There are a number of factors that are necessary for a successful adoption of innovations. These factors include an educated labour force or the institutional capability to adapt to new production methods. If lagging economies dispose of these complementary factors, they should be able to adopt the leader's technology. Productivity increases in lagging economies outpace the rate of technology growth in the leader economy if the pace of technology adoption exceeds the rate of innovation in the advanced countries or regions. As a result, growth of per capita production in

technologically lagging economies exceeds the rate of per capita growth in the advanced countries or regions. The further an economy is away from the technology frontier, the larger is the scope for technological catch-up (Barro and Sala-i-Martin 1995 and 1997, Sala-i-Martin 1996, Howitt 2000).

Labour migration is a third mechanism that could lead to convergence. Gaps in per capita production reflect both differences in productivity and in labour market performance. One could expect that large differentials in labour incomes and in employment conditions promote substantial migration from low-income and high-unemployment economies to high-income and low-unemployment countries or regions. From this perspective, labour mobility can be considered a substitute for capital mobility (Faini 2003).

In a world of unrestrained factor mobility and perfect technology diffusion, the convergence mechanisms should lead to instantaneous equalisation in productivity levels and in per capita growth rates (Obstfeld and Rogoff 1996, Rebelo 1992). Empirical studies, however, conclude that even with factor mobility and technology diffusion, the speed of convergence is rather limited. Open-economy models of economic convergence need to explain these two results. To this end, they introduce either adjustment costs or restrictions to factor mobility and technology diffusion. With adjustment costs, investment or migration decisions are the outcome of inter-temporal optimisation. As a result, capital and labour flows react to cross-country or regional differences in marginal returns only to the extent that these differences are assumed to persist for a certain time, the latter being a function of the adjustment costs (see Barro and Sala-i-Martin 1995, Herz and Röger 1995, and Shioji 2001). Credit constraint models, on the other hand, assume that only part of the investment in lagging economies can be financed by borrowing on international capital markets (e.g. Barro et al. 1995, Cohen and Sachs 1986). Part of the capital stock increase has to be financed out of domestic savings. As the build-up of the capital stock through domestic savings takes time, the capital stock per efficient labour in lagging open economies does not instantaneously jump to its long-run equilibrium.

Equivalently, it is plausible to consider migration as a costly and time-consuming process. Restrictions to capital and labour mobility amount to the same effect. Legal barriers, country risks and socio-linguistic frontiers also reduce the sensitivity of capital and labour flows to differences in capital or labour marginal productivity. Finally, technology diffusion is rather limited too (Barro and Sala-i-Martin 1997, Howitt 2000). The successful adoption of advanced technology requires complementary factors like an educated labour force. Addition-

ally, intellectual property rights normally protect the commercial exploitation of innovations, and patents expire only after several years.[1]

Divergence of growth rates, per capita income or productivity levels is an alternative to the convergence hypothesis. The theoretical backing is provided by endogenous growth theory. Contrary to the neoclassical model, endogenous growth theory attempts to explain technological progress, the key determinant of long-term growth, as determined within the model. Additionally, it replaces the neo-classical assumption of a decreasing marginal productivity of capital by the assumption of constant or even increasing marginal returns. Endogenous growth theory thus predicts growth rate divergence to be the dominant phenomenon. Capital mobility is no longer expected to foster convergence. Non-decreasing marginal returns to capital, a better infrastructure and a better human capital endowment in advanced economies imply that capital flows from poor to rich countries and not, as under the convergence scenario, the other way around (Lucas 1990). In a similar way, migration from capital poor to capital rich economies may actually increase divergence. Imagine a production function with physical capital, human capital, and labour as factor inputs. Arguably, human capital cannot be separated from the employees. If migration is biased towards high-skilled labour, the loss of human capital in poor regions (*brain drain*) more than compensates for the increase in the average stock of physical capital per worker. Finally, there is also little empirical evidence for decreasing returns to *human capital* as a complementary convergence mechanism limiting the incentives for skilled employees to move to prospering regions.

Economic theory does not provide a clear-cut answer as to whether per capita growth rates in open economies tend to converge, or whether capital and labour mobility tend to reinforce existing differences. The different growth theories make differing predictions.[2] Whether conditional or unconditional convergence occurs, or whether divergence is the dominant picture remains an empirical question.

[1] The crucial role of technology differences and technology transfer has spurred the argument that in order to explain regional economic growth performances one should focus on the role of multinational corporations and on the distribution in space of their production chains.

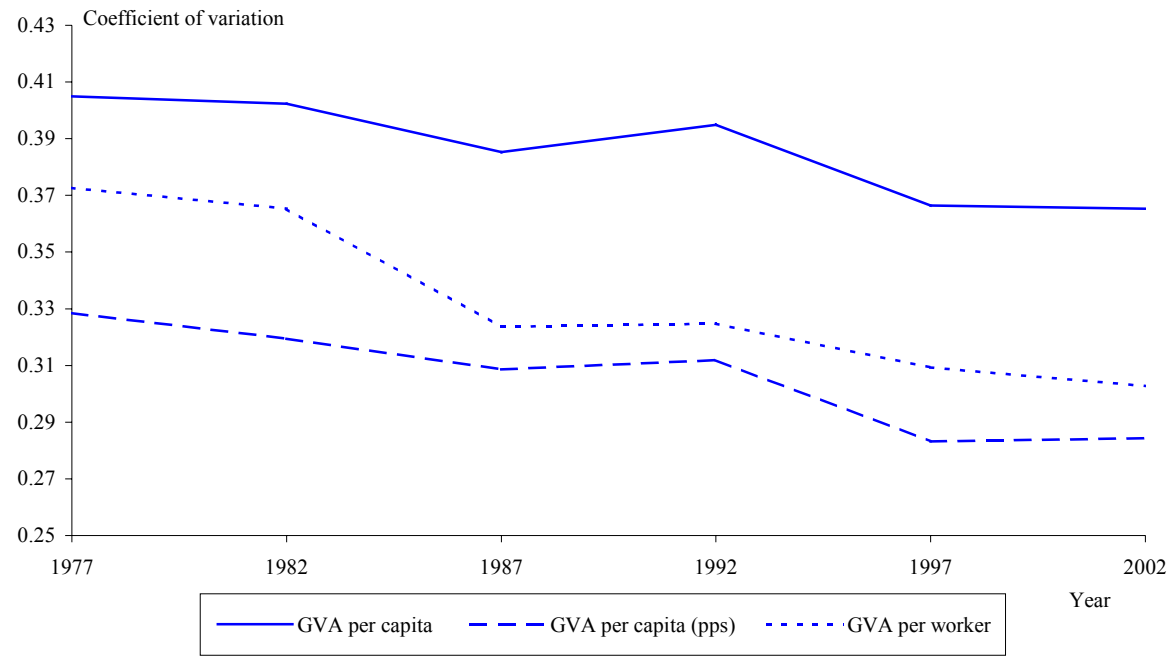
[2] Occasionally, the convergence hypothesis is interpreted as testing exogenous versus endogenous growth theories. It is however rather a test for the presence of diminishing marginal returns to capital. A model with a production function that combines AK and Cobb-Douglass technology can also generate convergence (see Barro and Sala-i-Martin 1995, chapter 4). Convergence may even be derived from a purely AK model (Sala-i-Martin 1996). The conditions for convergence to hold in the latter case however lack empirical support. In an open-economy framework they are not convincing for theoretical reasons neither.

3. Patterns of Regional Growth in the European Union

The preceding section sketched out the theory of productivity and income convergence in open economies. In this chapter, we present some empirical evidence for the European Union (EU). Thereby, we consider a sample of 208 regions at the territorial level of NUTS 2, where each region is weighted equally. We exclude Luxembourg and the French oversee territories and departments. Data for East Germany are only available from 1992 on. Therefore, East German regions are only included in figures for the post-1991 period. The figures presented in this section give a first account of the evolution of regional income and productivity dispersion and illustrate the hypothesis of unconditional convergence.

Sigma convergence can be detected by plotting the evolution of measures of cross-sample dispersion in gross value-added (GVA) per capita and per employee. Figure 3.1 graphs the coefficient of variation for the sample of 208 regions over the period 1977-2002.

Figure 3.1: Sample coefficient of variation, 1977-2002



The figure shows a slight decrease in regional dispersion over the past 25 years. Except for the end of the 1980s, when they marginally increased again, the coefficients of variation have decreased a bit or remained stable. The reduction of disparities is "strongest" for GVA per worker, but only marginal for per capita incomes. Additionally, the figure illustrates that pur-

chasing power adjusted income data exhibit less regional dispersion than non-adjusted income statistics.[3]

Figure 3.1 also shows that per capita dispersion is more pronounced than regional dispersion in gross value added per worker, i.e. in labour productivity. In other words, the income differentials between regions exceed the prevailing differentials in labour productivity. The difference between income and productivity dispersion points to the role of regional labour market performance and demography. However, the figure also suggests that most of regional income dispersion can still be attributed to differences in average labour productivity.

Figures 3.2 and 3.3 illustrate the hypothesis of sample convergence. They plot the average annual percentage growth of GVA per capita and per worker over the sample period against the logarithm of their respective initial values. Growth rates as well as levels of GVA are expressed as regional deviation from the EU-15 average, and gross value-added is measured in real euro of 1995. Observations in the second and the fourth quadrants are compatible with regional convergence in per capital production or labour productivity. Observations in the second quadrant combine a below-average starting point with an above-average growth performance. The fourth quadrant, on the other hand, includes those regions that start at higher levels but exhibit lower growth. With regions concentrated in these two sectors, the distributions of per capita and per worker GVA move towards their sample mean.

Figures 3.2 and 3.3 do not indicate a distinct negative relationship between the starting levels of GVA per capita and per worker, on the one hand, and the subsequent average growth rates on the other hand. For GVA per capita, the regions are distributed over all four quadrants. The same holds for per worker GVA. However, in the latter case the indications for sample convergence are slightly stronger. Some sample convergence for GVA per worker, on the one hand, and the absence of convergence in GVA per capita terms, on the other hand, may, once again, be interpreted as evidence for regional differences in labour market performance.

[3] The relative deviation from the sample mean, a second measure of the evolution of sample dispersion, yields qualitatively similar results.

Figure 3.2: Average growth and initial levels of regional gross value-added per capita, 1977-2002 (in real euro)

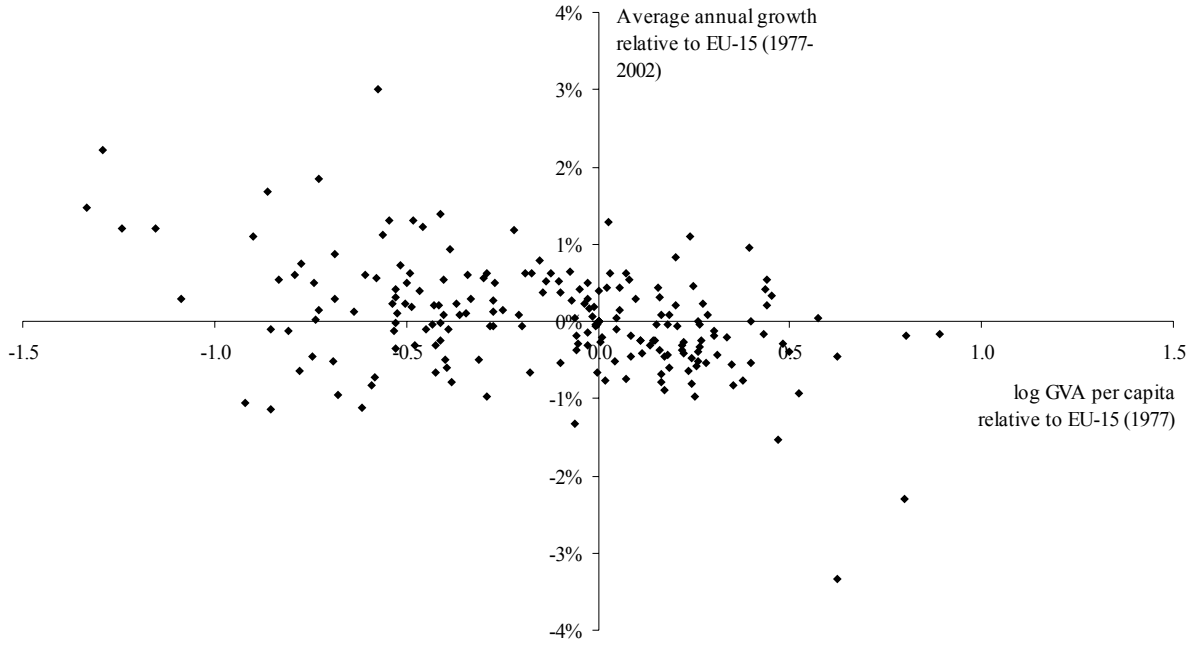
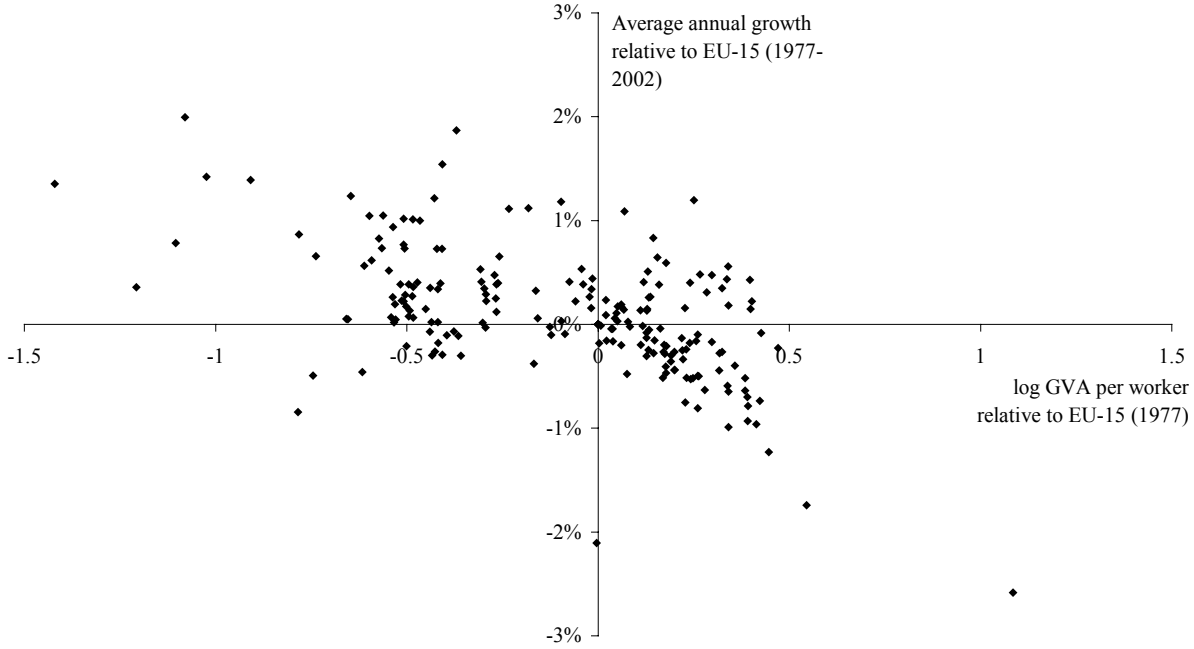


Figure 3.3: Average growth and initial levels of regional GVA per worker, 1977-2002 (in real euro)



The figures become more supportive for sample convergence if we rely on income data that adjust for regional purchasing power differentials. Initial levels and subsequent growth rates are plotted in 3.4 and 3.5. Once again, we measure levels and growth rates relative to the EU-15 average, this time however not in real euro but in purchasing power standards (PPS). Now, more observations are either located in quadrant two or quadrant four, the two quadrants

compatible with convergence towards the sample mean.[4] As in figures 3.2 and 3.3, the indication of convergence is stronger for GVA per worker than for GVA per capita.

Figure 3.4: Average growth and initial levels of regional gross value-added per capita, 1977-2002 (in PPS)

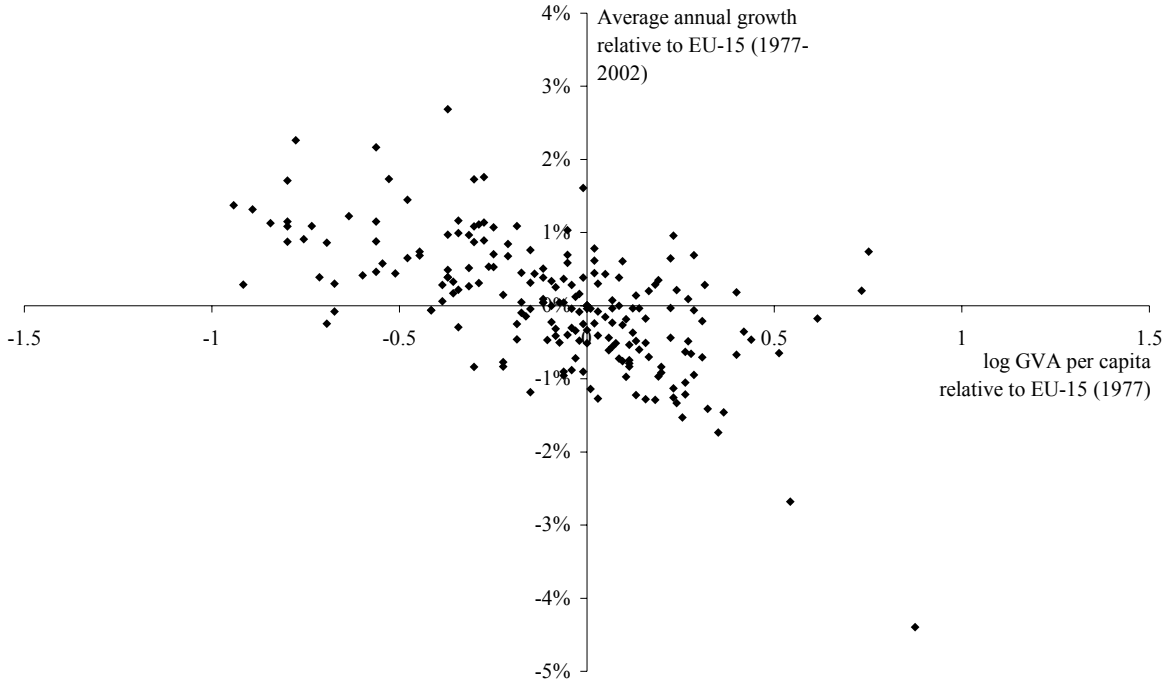
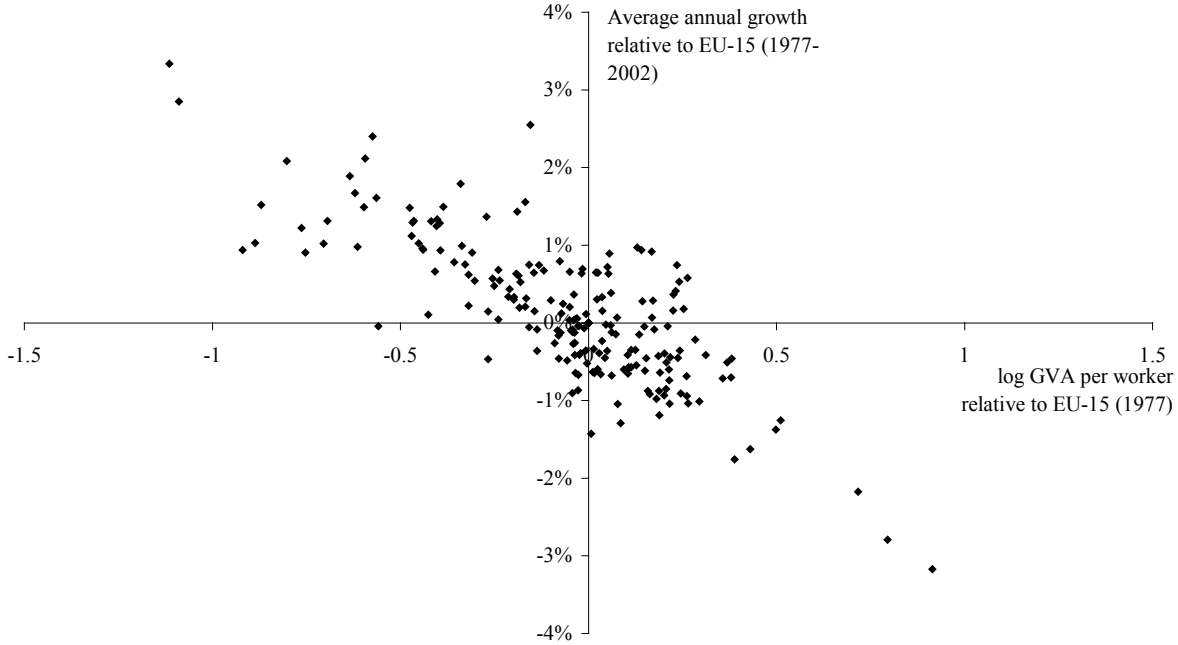


Figure 3.5: Average growth and initial levels of regional gross value-added per worker, 1977-2002 (in PPS)



[4] Although referred to as convergence towards the sample mean, the convergence pattern in the above figures does not exclude leapfrogging, i.e. one region taking over another. A region with modestly below-average initial income but high growth rates may well get ahead of other regions with minor growth performances.

Because looking at a long sample period can mask changes across time in the pattern of convergence or divergence, we split the sample in two sub-periods, ranging from 1977 to 1992 and 1992 to 2002, and investigate whether the pattern in figure 3.2 is constant over time or not.

Figure 3.6: Average growth and initial levels of regional gross value-added per capita, 1977-1992 (in real euro)

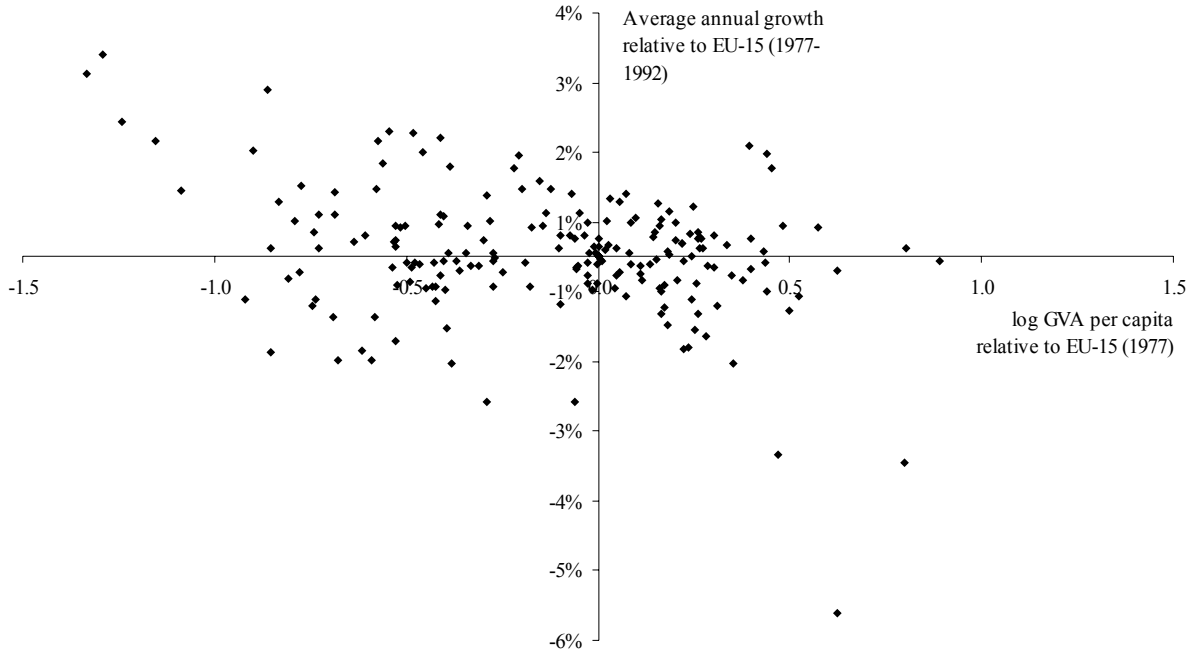
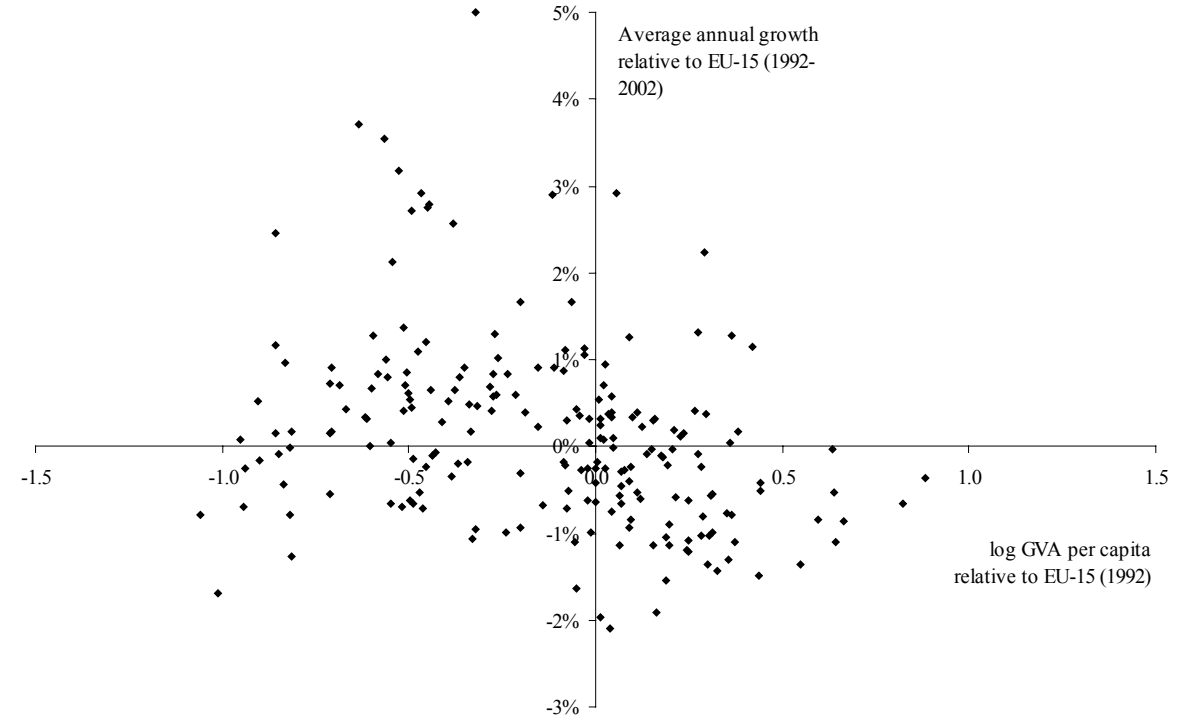


Figure 3.7: Average growth and initial levels of regional gross value-added per capita, 1992-2002 (in real euro)



Figures 3.6 and 3.7 portray the resulting plots for per capita GVA in real euro. They show that the distribution of regions over the four quadrants is similar in both periods. Economically this indicates the lack of convergence towards the sample mean in both sub-periods. The respective graphs for GVA per worker look similar (not reported here). Again, the pattern does not change much between the two sub-periods that we consider.

Figure 3.8: Average growth and initial levels of regional gross value-added per capita, 1977-1992 (in PPS)

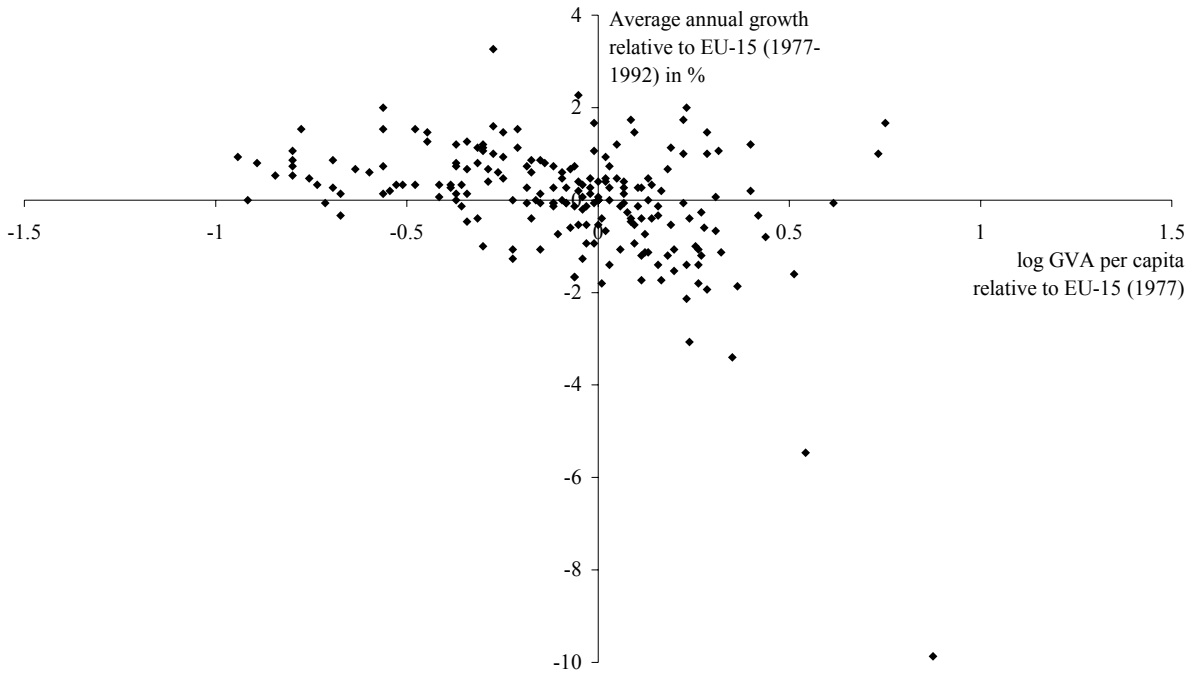
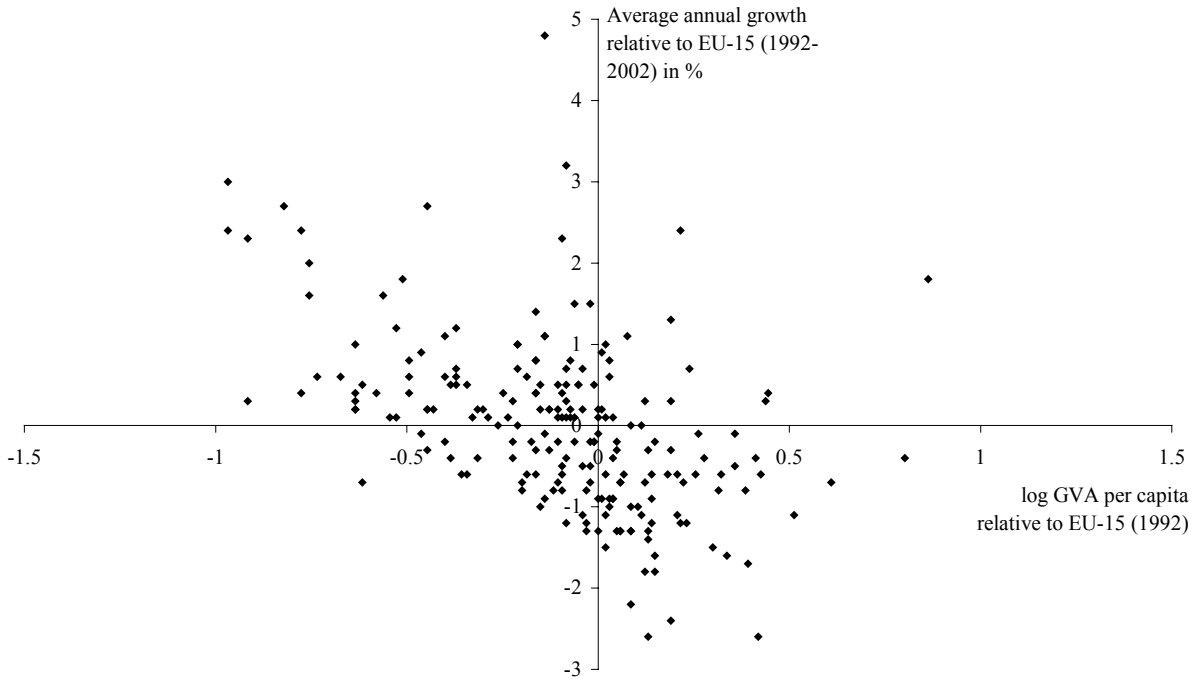


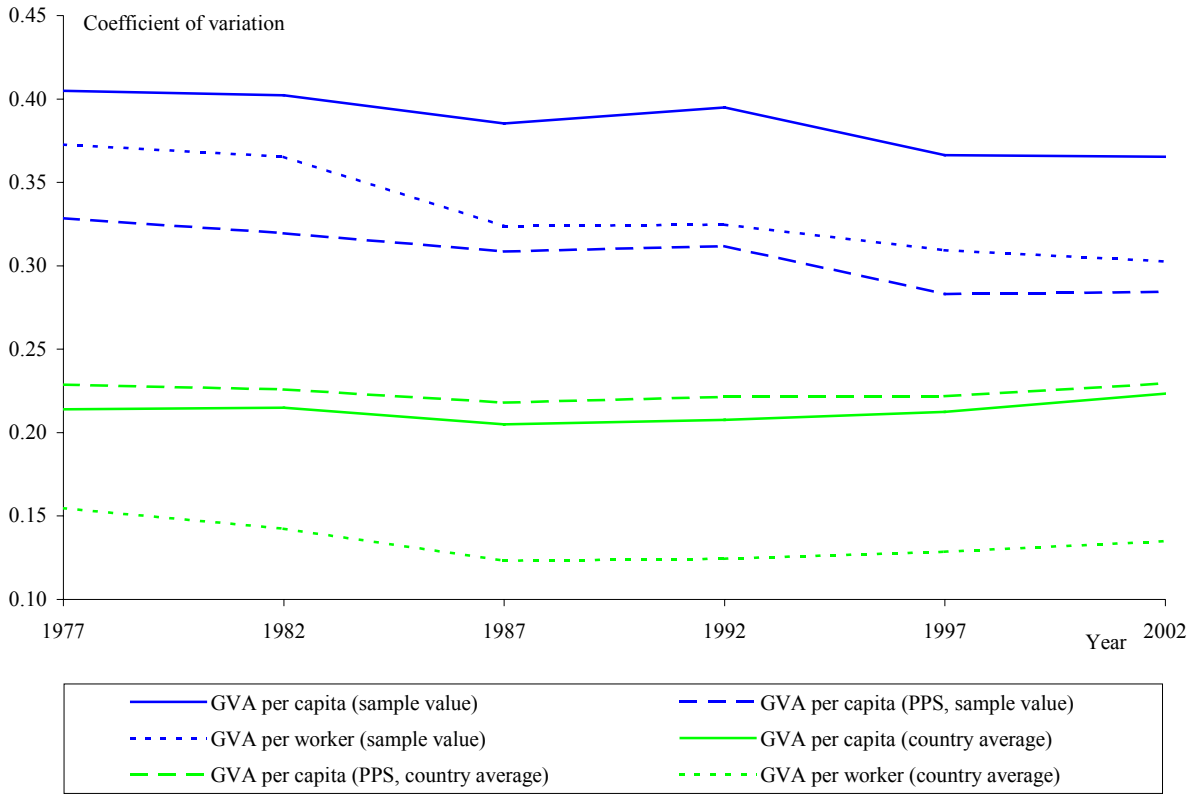
Figure 3.9: Average growth and initial levels of regional gross value-added per capita, 1992-2002 (in PPS)



For GVA per capita in purchasing power parities, we obtain a similar picture. The figures 3.6 to 3.9 are thus compatible with figure 3.1, which shows only a marginal reduction of per capita income dispersion over the sample period, whether per capita GDP is measured in euro or in purchasing power parities.

Another interesting point emerges when we compare the evolution of *inter-country* regional dispersion with the evolution of regional differences *within* the three countries. The respective series are given in figure 3.10. Here, "sample value" abbreviates the coefficient of variation of GVA per capita and of GVA per worker in the sample of 208 regions, where each region is weighted equally. The "country average", on the other hand, is the average country coefficient of regional variation. The series is calculated as the sum of the country-specific coefficients of variation divided by fourteen, the number of countries in the sample.

Figure 3.10: Inter- and intra-country coefficients of variation, 1977-2002

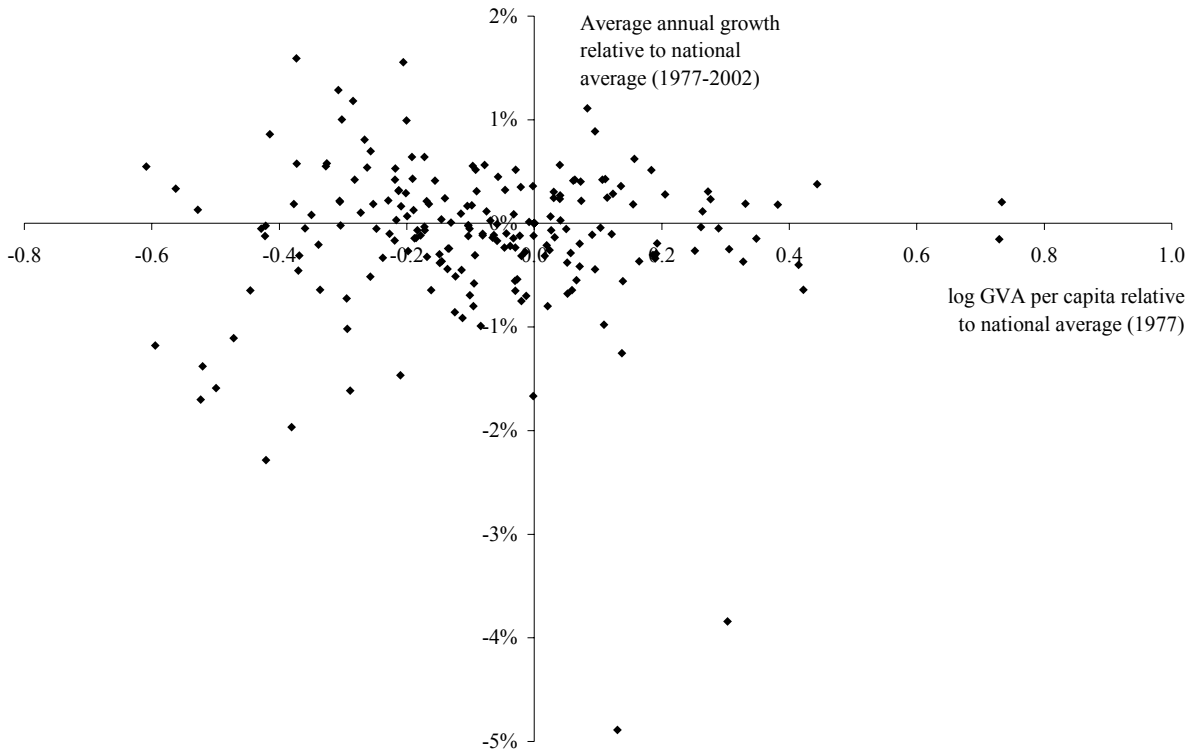


The figure 3.10 reveals that the sample average dispersion of per capita GVA and labour productivity exceeds the average dispersion within each country by far. As regional dispersion between countries has only slightly diminished over the sample period, the overall sample dispersion has but marginally approached the lower levels of average regional disparity *within* the countries. The gap between inter-country and intra-country disparities is still considerable.

A sample dispersion that is more pronounced than the average dispersion within the countries indicates the existence of country specific differences in regional GVA. A reduction of cross-country dispersion, on the other hand, could be attributed to a reduction of cross-country differences in the growth-determining factors and to the increased economic openness. As argued by convergence theory, openness and integration allow factor mobility and technology diffusion to promote convergence across and not only within countries. In this context, it is however striking that economic integration has not yet led to a pronounced reduction in regional disparities between the EU members.

A second noteworthy feature is the fact that regional dispersion in GVA per employee is significantly smaller than the dispersion in per capita terms. Again, this points to regional differences in labour market performance and in demography. If capital mobility and technology diffusion promote convergence, they should promote convergence in GVA per worker, i.e. labour productivity.

Figure 3.11: Relative average growth and initial levels of gross value-added per capita, 1977-2002 (in real euro)



To complement our set of stylised facts, let us look on figure 3.11. The latter plots relative per capita GVA growth against the relative level of per capita GVA in 1977. The term "relative" means that the regional data have been normalized by the respective country averages. Relative GVA growth of a French region, e.g., is its growth rate divided by the average growth performance of France. Equivalently, the relative level of per capita GVA is the regional level

divided by the French average value. This averaging allows dealing with national distortions. It is a simple method to compare cross-nationally the variation in regional growth rates in a determined national context (see Rodriguez-Pose 1999, 10).

The results from the nationally weighted per capita GVA in figure 3.11 are similar to our previous plot 3.2. There is no obvious pattern for poorer regions within a country to grow at above-average rates and for richer regions to grow at below-average rates only. For GVA per worker and for purchasing power adjusted data, the observations are slightly more concentrated in quadrants two and four. However, this concentration is even less pronounced than in figures 3.3 to 3.5. Once country differentials in growth rates and in income levels are accounted for, there is no indication of unconditional regional convergence. This observation coincides with figure 3.10, which reveals that sigma-convergence within the sample of EU NUTS 2 regions has been very limited over the period 1977-2002 has been limited. It further suggests that, to the extent that regional dispersion diminished, this convergence can be attributed to reductions in regional dispersion between countries. Within countries, figure 3.10 does not show any reduction in average regional disparity of per capita GVA over the past 25 years.

The overall picture from this section can be summarized as follows. Firstly, regional disparities between the European Union NUTS 2 have only marginally diminished over the period 1977-2002, thus narrowing but slightly the gap to the lower levels of regional dispersion *within* countries. A finding of disparity reduction *between* member states is compatible with economic integration, factor mobility and technology diffusion, e.g. via FDI, to promote convergence not only within but also between countries. However, sigma-convergence is far weaker than optimistic theories of regional convergence would suggest.

Secondly, the regional disparities between the EU countries are still much larger than the average disparities within the member states. Once again, it is striking that European economic integration has not yet led to a pronounced reduction in income and productivity differentials between countries, and that the wedge between intra-country and inter-country disparity remains substantial.

Thirdly, to the extent that our sample exhibits marginal sigma-convergence the latter seems to result from convergence between countries rather than from regional convergence within the member states. Once we normalize regional growth performances and the initial per capita levels of GVA by their respective country averages, the picture of convergence towards the mean vanishes. Whether this persistence of income level and growth differentials can be attributed to structural determinants of long-run growth is the topic of section five.

4. Data and Estimation Method

The empirical analysis builds on data from the Cambridge Econometrics regional database. The latter provides a comprehensive set of regional data on real gross value-added (GVA) per capita and per worker, on private sector investment, and on the economy's sectoral structure. The data are annual data and cover the period from 1975 to 2002 (and forecasts until 2006). GVA equals GDP net of taxes on and subsidies for production. We consider GVA to be the best available measure of aggregate production. The structural parameter variables are the rate of labour participation and the sector structure of employment.

Our data enclose 194 NUTS 2 regions of the present EU-15. The French overseas departments and territories, East Germany and Luxemburg are excluded because of the particular character of these regions, and because of problems in data availability.

To estimate unconditional and conditional convergence equations in section five, we use a random sample that includes 100 regions over the period 1977-2002. The regions are weighted equally. The data are in five-year intervals, i.e. we use values from 1977, 1982, 1987, 1992, 1997 and 2002.

The paper relies on the GMM-system method developed by Arellano and Bover (1995), and Blundell and Bond (1998). GMM-system estimates the equation in first differences and in level form (see Blundell et al. 2000, Bond 2002, and Hsiao 2003 for a detailed description). Bond et al. (2001) introduced the estimator in empirical growth research. GMM-system is particularly useful in the context of growth for two reasons. Firstly, it explicitly takes into account the dynamic structure of growth regressions. Growth regressions usually include lagged values of per capita income as one of the explanatory variables. This makes them dynamic empirical models.

Secondly, most of the explanatory variables may themselves be influenced by per capita growth, the dependent variable. GMM allows for the explanatory variables not to be strictly exogenous but predetermined. It does so by using lagged values of the explanatory variables, in levels and in first differences, as instruments for the regressors. In the context of growth regressions the weaker assumption of predetermined variables seems to be more appropriate than the assumption of strictly exogenous explanatory variables. For our purpose GMM is thus superior to Ordinary Least Squares. OLS requires the regressors to be strictly

exogenous. Furthermore, pooled OLS estimation does not account for the dynamic structure of growth regressions, and for the error correlation that results.[5]

Section five only reports the results from two-step GMM system estimation. The results from one-step estimation are left out. The reason is that two-step GMM gives efficient estimates in the presence of heteroskedastic error terms, whereas one-step estimation does not. The differences between one-step and two-step results are however small.

[5] See Bond et al. (2001) for an in-dept analysis of the behaviour of different panel estimators in the context of empirical growth studies.

5. Empirical Results from Growth Regressions

This section presents panel estimates of growth regressions for the EU-15 NUTS 2 regions over the period 1977-2002. The objective is to investigate, firstly, whether the data indicate a tendency for poorer regions to growth faster than richer ones, and, secondly, whether we can isolate structural parameters determining a region's long-run growth performance. The question of *unconditional convergence*, the convergence of regions towards common income levels and growth rates, is addressed by estimating the equation:

$$(5.1) \quad y_{it} = \alpha + \beta y_{i,t-1} + u_{it}$$

Estimations of unconditional convergence generally use the log of GVA per capita in period t as the dependent variable, and the lagged value of log GVA per capita as explanatory variable. This section however partially uses the variables in deviations from the sample mean. Each of the tables contains two columns. The first column presents the two-step GMM results that were obtained from using the data in differences from their respective sample value at period t. The use of data in differences eliminates the need to introduce time dummies that elsewhere allow the sample average growth rate to vary between periods of time, e.g. due to period specific technology shocks. In equation 5.1, y_{it} is thus the log of region i's per capita GVA at time t minus the logarithm of the sample average value of GVA per capita at the same period of time.

The second column equally uses the data in differences from their sample average. Additionally, it normalizes regional growth rates and regional per capita GVA levels by the respective national average values at time t. The per capita income of a French region, i.e., is thus divided by average GVA per capita in France before taking the logarithm and subtracting the sample average. Weighting regional growth and income levels by their national averages allows comparing across countries regional growth rates and income levels that are strongly affected by the regions' national context. The convergence hypothesis behind the values in column two is thus stronger as the sample convergence hypothesis for the estimates in column one. It states that if lagging regions were catching-up on advanced regions, one should expect regional convergence to occur within every country, and not only between countries (Rodriguez-Pose 1999, 6).

An important question is whether one should rely on GVA in real euro or in purchasing power standards. Data are available for both. GVA in real euro is measured as GVA in

euro of 1995 and adjusts for inflation during the sample period. Data in purchasing power standards additionally correct for regional differentials in purchasing power. From the policy perspective of regional cohesion, one should clearly focus on purchasing power adjusted numbers. From an economic theory perspective this is however not obvious. It rather depends on which convergence mechanism one thinks about. For labour mobility, the appropriate concept is convergence in purchasing power adjusted income. A combination of higher average euro wages with higher living expenses should eliminate the incentive to migrate. Concerning capital mobility and investment, on the other hand, we find GVA in euro to be the appropriate concept. Returns to capital are compared across regions in euro terms. If capital income can be transferred across regions and countries, one should invest in those places were the highest return (in euro) could be achieved. Therefore, this section concentrates on convergence in per capita GVA measured in real euro.

The hypothesis of unconditional convergence in 5.1 predicts the beta-coefficient to be smaller than one. With beta smaller than one, poorer economies grow faster than richer ones. However, the estimates for equation 5.1 do not support the hypothesis of unconditional convergence. The beta coefficient in column 1 of table 5.1 is close to one, and the tests for the validity of the specification are rejected at the 1% significance level.[6] Column two, which passes the test, reports a beta that is larger then one. Hence it does not predict unconditional convergence but divergence to occur.

The interaction term *y_1 (Single market)* allows the beta coefficient to vary between the sub-periods 1977-1992 and 1993-2002. The variable is defined as y_{it} times a dummy that is equal to one if the region has been inside the European Single market at time t, and equal to zero otherwise. The idea behind introducing this interaction term is that the deepening of European economic integration has increased the openness of regions (see Blanchard and Giavazzi 2002) and hence the scope for regional convergence at least between European countries. However, the estimates in table 5.1 do not support the idea of faster unconditional convergence during the 1990s. The interaction term is positive in value and statistically insignificant at common significance levels.

[6] The Sargan test is for the null hypothesis of instrument validity. The AR (1) and AR (2) statistic is for the null of no first- and no second-order autocorrelation in the residuals, respectively. GMM system estimation does not require the absence of first-order but only the absence of second-order residual autocorrelation to produce valid estimates.

Table 5.1: Unconditional convergence, 1977-2002

	1	2
Constant	-0.001 (0.829)	-0.003 (0.346)
y_1	0.968 (0.000)***	1.018 (0.000)***
y_1 (Single market)	0.013 (0.388)	0.027 (0.150)
Sargan test	0.003***	0.203
AR (1)	0.000***	0.000***
AR (2)	0.000***	0.612
Observations	500	500

Heteroskedasticity consistent p-values in parenthesis (null of statistical insignificance)
Statistical significance: *** significant at 1% level ** significant at 5% level * significant at 10% level

Under unconditional convergence, all additional regressors that control for differences in long-run growth should be insignificant. In the case of *conditional convergence*, on the other hand, additional long-run growth determinants matter. Conditional convergence thus only implies that economies converge towards their own steady-state growth path. Its empirical specification is given in equation 5.2:

$$(5.2) \quad y_{it} = \alpha + \beta y_{i,t-1} + \gamma_1 \ln\left(\frac{L}{N}\right) + \gamma_2 agrar + \gamma_3 electronics + \gamma_4 services + \gamma_5 \Delta y_{ct} + u_{it}$$

The structural parameters that are introduced to proxy for regional differences in steady-state growth paths and income levels include the labour participation rate and the sector structure of employment. The labour participation rate (L/N), the ratio of regional employment to regional population, is introduced in logarithms. Its influence on per capita growth is supposed to be positive.[7] The share of agriculture in total regional employment,

[7] The rate of labour participation could affect per capita growth via the following mechanism: Suppose the intercept term, α, captures the technology that is available to all regions. The extent to which technological advances are exploited and translated into per capita growth then depends on the participation rate. The general form of the convergence equation in logarithms is $y_{it} = (1-\beta) y_{it}^{*} + \beta y_{i,t-1}$. We can rewrite this as

agrar, is expected to negatively affect the regions long-run growth path. The share of the electronics sector in total regional employment, *electronics*, is considered as a proxy for the regions average level of technology, and should thus positively affect regional income growth. Finally, *services* is the employment share of market services. We also expect it to positively correlate with regional income growth, although the argument is more ambiguous.

A topic that has attracted much attention in recent empirical growth studies is the spatial correlation of regional growth rates (see, e.g., Badinger et al. 2002, Fingleton 2003, and Tondl 2001). Spatial correlation in the error terms causes inference based on t and F statistics to be misleading (see Rodriguez-Pose 1999, 9). There are sophisticated methods of filtering the data before using them in regression analysis, such as the distance weighting of the observations. This section relies on a simpler method and introduces countrywide growth rates as an explanatory variable. In equation 5.2, the national average growth rates are introduced as Δy_{ct}, where c stands for country and y_{ct} is the logarithm of country average per capita GVA in period t. When estimating equation 5.2 with nationally weighted income data, we already control for the correlation of growth rates within countries. The introduction of the average national growth rates as an explanatory variable then becomes superfluous.

Table 5.2 reports the estimates for equation 5.2. Again, all variables are used as deviations from the sample mean. Additionally, column two relies on nationally weighted per capita income data. With the variables in deviations from the sample mean at time t, the coefficient on labour participation implies that, for column one, a region that has a participation rate one percent above the sample average should on average exhibit a growth rate of 0.1 percentage points above the average. Equally, once we control for country differentials in per capita income (column two), an employment share in agriculture that is ten percentage points (1/10) above the sample average reduces a regions' relative growth rate by 0.02 percentage points. With data in deviations from the sample mean, we only look at deviations from the sample mean at period t, but do not compare levels across different periods of time.

$\ln\left(\frac{Y}{N}\right)_{it} = (1-\beta)\ln\left(\frac{Y}{L}\cdot\frac{L}{N}\right)^{*}_{it} + \beta\left(\frac{Y}{N}\right)_{i,t-1}$, where L is the labour force and N the region's population size. Technological progress affects production per worker. Decomposing the equilibrium growth rate, we obtain $\ln\left(\frac{Y}{N}\right)_{it} = (1-\beta)\ln\left(\frac{Y}{L}\right)^{*}_{it} + (1-\beta)\ln\left(\frac{L}{N}\right)_{it} + \beta\left(\frac{Y}{N}\right)_{i,t-1}$. The participation rate thus controls for regional differences in the propagation of technological progress into per capita income growth. As it is defined, an increase in activity among a region's population causes its participation rate to rise. However, it may also increase following net inflows of labour from other regions (commuting).

Table 5.2 : Conditional convergence, 1977-2002

	1	2
Constant	-0.002	-0.006
	(0.613)	(0.140)
y_1	0.933	0.909
	(0.000)***	(0.000)***
y_1(Single market)	0.015	0.057
	(0.191)	(0.007)***
Dy (national)	0.725	
	(0.000)***	
ln(empl/pop)	0.089	0.089
	(0.014)**	(0.049)**
Agriculture	-0.151	-0.197
	(0.137)	(0.067)*
Electronics sector	0.362	-0.202
	(0.578)	(0.793)
Market services	-0.150	-0.284
	(0.213)	(0.055)*
Sargan test	0.880	0.572
AR (1)	0.000**	0.000**
AR (2)	0.388	0.637
Observations	500	500

Heteroskedasticity consistent p-values in parenthesis (null of statistical insignificance)
Statistical significance: *** significant at 1% ** significant at 5% level * significant at 10% level

The empirical model for conditional convergence passes the two-step GMM specification tests. The beta coefficient is only slightly smaller than one. This indicates slow conditional convergence. Average national growth rates (column 1) are shown to have an important influence on regional growth performances. Most of the structural parameters are statistically significant at conventional significance levels in at least on of the specifications. Labour participation has a positive effect on income growth.[8] For employment in agriculture, the coefficient

[8] The elasticity of per capita income to an increase in labour participation is equal to one. Therefore, it follows from the previous footnote that, in the conventional convergence equation, the coefficient on labour participation should be equal to one minus the beta coefficient. For the estimates in table 5.2, this is the case (1 - 0.9 = 0.1).

is negative but small in absolute value. The interaction term *y_1 (Single market)* indicates no positive effect of economic integration on conditional regional convergence once country differentials in growth have been accounted for.

The results in table 5.2 point to the importance of national growth rates in determining regional per capita growth. They further report a beta coefficient that is fairly high and implies very slow conditional convergence only. The conditional convergence implied is even slower than the annual rate of convergence of 2% in Barro and Sala-i-Martin (1995). It is by far smaller than the EU-15 results of Badinger et al. (2002), and Tondl (2001), and the results in Bond et al. (2001) who use a sample of OECD country data. The economic implication of the results in 5.2 is that conditional on the structural characteristics included, regions only converge very slowly in their growth rates and income levels.

However, the estimates in table 5.2 have neglected the possibility with panel data to introduce individual specific effects. The latter can account for regional differences in growth determining variables that are constant over the sample period. The advantage of individual effects is that they reduce the bias from omitted or unobservable variables, e.g. the level of human capital or technology. On the other hand, with T=5 the estimates of individual effects are supposedly very imprecise.

Introducing individual specific effects considerably reduces the beta coefficient. This implies faster convergence. However, convergence now is not conditional convergence towards a steady state growth rate that is determined by a series of observed structural parameters. It is rather convergence towards a regional specific rate of income growth. As, at the margin, each region is different, so are regional steady state growth paths. The introduction of individual effects does cast a different light on the empirical evaluation of different growth theories. For the analysis of regional economic convergence, the estimated beta coefficient is however of limited use. In this context, the value of individual specific effects lies in the extent to which they reduce the omitted variable bias in the estimates. The results in table 5.3 confirm the positive effects of national income growth and of labour participation on regional growth performances. They also reject the idea that the speed of conditional beta-convergence may have increased during the 1990s. Concerning the economy's sector structure, the estimates however find the employment share in electronics to be the only parameter with a statistically significant and positive influence on relative regional growth. Following table 5.3, an employment share in electronics of 10 percentage points above the sample average would imply additional growth of about 0.3 percentage points.

Table 5.3: Conditional convergence including individual specific effects, 1977-2002

	1	2
Constant	-0.112 (0.000)***	-0.057 (0.000)***
y_1	0.568 (0.000)***	0.711 (0.000)***
y_1(Single market)	0.002 (0.868)	0.038 (0.012)**
Dy (national)	0.471 (0.000)***	
ln(empl/pop)	0.464 (0.000)***	0.104 (0.109)
Agriculture	-0.004 (0.987)	0.109 (0.417)
Electronics sector	3.493 (0.003)***	2.769 (0.006)***
Market services	-0.302 (0.424)	-0.108 (0.744)
Sargan test	0.996	1.000
AR (1)	0.000**	0.000**
AR (2)	0.141	0.267
Observations	500	500

Heteroskedasticity consistent p-values in parenthesis (null of statistical insignificance)
Statistical significance: *** significant at 1% ** significant at 5% level * significant at 10% level

However, the above estimates potentially suffer from a serious problem. The deviation of growth rates and employment shares from the sample mean normally gives numerically very small values. Little numerical variation will lead to imprecise estimates. Although a specification in deviations from the mean is economically plausible, it should be complemented by an estimation of data in levels. With data in levels, we suppose different *levels* of the sectoral employment shares or of labour participation to affect regional growth performances (as opposed to differences from the sample mean). The estimates of a specification with individual effects are given in table 5.4. Again, column one is for absolute values, whereas the second column reports estimates for nationally weighted growth and income levels.

Table 5.4: Conditional convergence including individual specific effects, variables in absolute levels, 1977-2002

	1	2
Constant	1.984	0.099
	(0.000)***	(0.561)
y_1	0.792	0.725
	(0.000)***	(0.000)***
y_1(Single market)	0.001	0.038
	(0.218)	(0.024)**
Dy (national)	2.850	
	(0.000)***	
ln(empl/pop)	0.370	0.141
	(0.000)***	(0.054)*
Agriculture	-0.133	-0.044
	(0.569)	(0.849)
Electronics sector	3.321	1.799
	(0.022)**	(0.165)
Market services	0.651	-0.073
	(0.160)	(0.763)
Sargan test	0.992	0.997
AR (1)	0.000**	0.000**
AR (2)	0.233	0.458
Observations	500	500

Heteroskedasticity consistent p-values in parenthesis (null of statistical insignificance)
Statistical significance: *** significant at 1% ** significant at 5% level * significant at 10% level

The estimates show the expected signs. The coefficient on labour participation is statistically significant at conventional levels in both columns. Furthermore, column one reports a statistically significant coefficient for the employment share in electronics, our technology proxy. A one percent increase in labour participation rates should raise per capita income growth by 0.35 percentage points in column 1, or by 0.14 percentage points in column 2. A ten percentage-point higher employment share in electronics, in column 1, is associated with 0.33 percentage-points higher income growth. The important impact of national growth determinants on regional performances is confirmed. The employment share in agriculture and in market

services, on the other hand, are not attributed a significant impact on regional growth within the EU.

The estimates for structural economic parameters in column two are statistically insignificant at conventional significance levels. However, as mentioned above, the normalization of per capita income and growth by national levels is also likely to result in very small numerical variation in the dependent variable and in regional per capita GVA.

Qualitatively, the estimates in table 5.4 are similar to the results in 5.3. For the methodological reasons mentioned above (numerical variation in the data), we tend to prefer specification one in table 5.4. The estimates of the beta coefficient are close to the findings of Badinger et al. (2002), Badinger and Tondl (1999), and Tondl (2001). They also find a significant influence of economic structure on regional growth performances. Contrary to Badinger and Tondl (1999), our results however fail to confirm a negative impact of employment in agriculture on regional growth.

Without individual effects, the estimation with data in levels (table 5.4) gives a beta-coefficient of about 0.9. This amounts to an annual speed of conditional convergence of 2%, the stylised finding of many cross-section growth regressions. Our results thus also replicate the difference between panel and cross-section results reported elsewhere (e.g. Badinger et al. 2002, Bond et al. 1999).

To conclude, we briefly summarize the results from this section. Table 5.1 reveals no tendency for unconditional convergence among EU regions. Once we account for national differences in growth and income levels, lagging regions are not shown to catch up on the sample means, but rather to loose track with the advanced regions. From tables 5.2 to 5.4 we conclude that average national growth rates play a major role in determining regional growth performances. We also find the rate of labour participation to have a positive impact on income growth. With regard to the economy's sector structure, table 5.2 indicates a negative but small impact of the employment share in agriculture on growth. The estimates from table 5.3 and 5.4, including individual effects, find a positive effect on regional growth of employment in electronics. The results confirm the evidence for conditional convergence.[9]

[9] With regard to the different predictions of neoclassical versus endogenous growth theory one may look at a possible correlation between income levels and error terms. The neoclassical assumption of decreasing returns to capital implies a negative impact of past levels of capital per worker on present growth performance relative to other countries or regions. The smaller beta, the bigger is this negative influence. The assumption of non-decreasing returns in endogenous growth models, on the other hand, denies any negative influence on past levels on present growth. In a specification with beta smaller then one, endogenous growth theory would expect the estimated representative region to systematically under-predict the growth performance of richer regions, and to systematically over-predict a poor economy's prospectus. Thus if already high income or productivity levels do not slow down a regions relative growth performance, we would expect the error terms to be positively correlated with the levels of per capita GVA. This is, however, not the case. We do not find any statistically signifi-

Finally, we briefly mention a result that relates to the potential sources of divergence or convergence. Convergence via capital mobility would imply a negative relation between initial productivity levels and subsequent per worker investment. However, over the period 1977-2002 we find no pronounced negative correlation between initial GVA per worker and subsequent average investment per employee. This suggests that there is no unconditional convergence in capital endowment. The correlation is rather a positive one. This coincides with our findings of no unconditional but only conditional regional convergence within the European Union.[10]

Straubhaar (1998) criticizes that estimates from convergence equations have only very limited value for economic policy. Unconditional convergence appears as a rather mechanic process. From an economic policy perspective, value can only be derived from the coefficient estimates for the additional explanatory variables in specifications of conditional convergence. In general, these estimates are however very sensitive to the explanatory variables included. Our analysis further suggests that the results may also depend on the data specification that one relies on. Nevertheless, the results presented in section 5 are qualitatively similar for both the variables expressed in absolute values and in deviations from the respective sample mean at period t. The finding that the rate of employment and the structure of economic activity play an important role in determining an economy's growth performance coincides with similar results from Southern Europe and the U.S. (see Badinger and Tondl 1999, Caselli and Coleman 1999). Our results do however not replicate the significantly negative impact on growth that these studies attribute to the sector share of agriculture.

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cant correlation between a region's per capita income and the respective residuals. We thus conclude that the growth regressions of the type presented in this section are a useful tool for the analysis of regional growth and conditional convergence in our sample of 100 EU NUTS 2 regions.

[10] It should be mentioned that our investment data are flawed in two respects. Firstly, they only contain private but no public sector investment. Secondly, the numbers are in euro of 1995 but not adjusted for regional differentials in price levels for investment goods.

6. Conclusions

This paper addresses the issue of regional economic growth and convergence in the European Union. Based on our framework of convergence in open economies, we look at the growth performance NUTS 2 regions over the period 1977-2002. For the group of about 200 regions regional dispersion has only marginally decreased over the sample period. For labour productivity, there is a certain tendency of lagging regions to exhibit above-average growth rates and thus of sample convergence. For per capita incomes, on the other hand, the paper finds no distinct tendency for poorer regions to grow at above-average rates. Furthermore, it seems that the slight reduction in regional disparities has been driven by a reduction of country income differentials. On average, we find no evidence for regional convergence within the EU member states. Regional average income levels within these countries rather seem to diverge slightly.

Our econometric analysis does not find evidence for unconditional convergence. However, controlling for a number of structural indicators we find evidence for conditional convergence. The beta parameter estimates from our panel for 1977-2002 are within the range of recent cross-section and panel estimates for the sample of EU-15 regions. The estimates suggest that the rate of labour participation and the sector structure of economic activity affect regional per capita income growth. The results also indicate the important role of countrywide economic growth performance for in the determination of regional growth performances. However, we find no empirical evidence that the deepening of economic integration in the 1990 has increased the speed of convergence.

Our results are in line with Badinger and Tondl (1999) who find a positive effect of labour participation on regional growth in Southern Europe, and with Caselli and Coleman (1999) who find structural economic change to be the most important determinant for income and growth convergence in the U.S. The present paper does however not replicate the finding of a negative effect of employment in agriculture on income growth. Instead, we find a significantly positive impact on income growth of employment in the electronics sector. We consider the latter to be a proxy for the rate of technological progress within a region.

The analysis suggests that regional policy should concentrate on the reduction of unemployment and on promoting the modernization of the economy's sector structure. In the context of our theoretical framework, institutional reforms that increase the mobility of labour and capital may also improve regional convergence. Regulations that increase adjustment

costs, on the other hand, risk to slow-down economic catch-up of poor regions by slowing down the speed of convergence, thus lowering the long-run regional output.

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Annex 1: Panel estimates without beta parameter heterogeneity

Table A 1.1: Estimates without individual specific effects, variables in absolute levels, 1977-2002

	1	2
Constant	0.714 (0.000)***	0.251 (0.006)***
y_1	0.945 (0.000)***	0.939 (0.000)***
Dy (national)	0.726 (0.000)***	
ln(empl/pop)	0.118 (0.002)***	0.136 (0.000)***
Agriculture	-0.182 (0.072)*	-0.170 (0.168)
Electronics sector	-0.393 (0.540)	-0.295 (0.705)
Market services	-0.093 (0.473)	-0.292 (0.045)**
Sargan test	0.614	0.352
AR (1)	0.000**	0.000**
AR (2)	0.298	0.750
Observations	500	500

Heteroskedasticity consistent p-values in parenthesis (null of statistical insignificance)
Statistical significance: *** significant at 1% ** significant at 5% level * significant at 10% level

Column one of table A 1.1 contains the estimates of equation 5.2 when all variables are expressed in absolute values. Column two, on the other hand, relies on nationally demeaned, i.e. nationally normalized, values of regional per capita GVA. Individual specific effects are not introduced.

Table A 1.2: Estimates with individual specific effects, variables in absolute levels, 1977-2002

	1	2
Constant	1.894	0.146
	(0.000)***	(0.340)
y_1	0.798	0.775
	(0.000)***	(0.000)***
Dy (national)	0.581	
	(0.000)***	
ln(empl/pop)	0.377	0.161
	(0.000)***	(0.029)**
Agriculture	-0.082	-0.053
	(0.656)	(0.800)
Electronics sector	3.408	1.557
	(0.003)***	(0.166)
Market services	0.740	-0.127
	(0.022)**	(0.564)
Sargan test	0.980	0.966
AR (1)	0.000**	0.000**
AR (2)	0.224	0.467
Observations	500	500

Heteroskedasticity consistent p-values in parenthesis (null of statistical insignificance)
Statistical significance: *** significant at 1% ** significant at 5% level * significant at 10% level

Table A 1.2 reports panel estimates where beta is assumed to be constant across regions and across time. This time, individual specific effects are included in order to control for unobserved determinants of regional growth. Column one contains the estimates of equation 5.2 when all variables are expressed in absolute values. Column two reports the estimates that result from nationally demeaned, i.e. nationally normalized, values of regional per capita GVA.

Table A 1.3: Estimates without individual specific effects, variables in deviations from sample mean, 1977-2002

	1	2
Constant	-0.003	-0.004
	(0.461)	(0.308)
y_1	0.930	0.962
	(0.000)***	(0.000)***
Dy (national)	0.723	
	(0.000)***	
ln(empl/pop)	0.081	0.072
	(0.022)**	(0.108)
Agriculture	-0.151	-0.155
	(0.120)	(0.133)
Electronics sector	0.431	-0.049
	(0.519)	(0.936)
Market services	-0.139	-0.270
	(0.260)	(0.072)*
Sargan test	0.681	0.378
AR (1)	0.000**	0.000**
AR (2)	0.370	0.555
Observations	500	500

Heteroskedasticity consistent p-values in parenthesis (null of statistical insignificance)
Statistical significance: *** significant at 1% ** significant at 5% level * significant at 10% level

Column one of table A 1.3 contains the estimates of equation 5.2 when all variables are expressed as deviations from their respective sample mean. Column two, on the other hand, reports the results for the specification where GVA per capita data have been nationally demeaned, i.e. nationally normalized. After nationally normalizing, per capita GVA is also expressed as deviation from its sample mean at each period t. Individual specific effects are not introduced.

Table A 1.4: Estimates with individual specific effects, variables in deviations from the sample mean, 1977-2002

	1	2
Constant	-0.089	-0.037
	(0.000)***	(0.000)***
y_1	0.558	0.762
	(0.000)***	(0.000)***
Dy (national)	0.470	
	(0.000)***	
ln(empl/pop)	0.477	0.126
	(0.000)***	(0.049)**
Agriculture	-0.032	0.098
	(0.877)	(0.484)
Electronics sector	3.340	2.327
	(0.002)***	(0.021)**
Market services	-0.347	-0.175
	(0.323)	(0.638)
Sargan test	0.962	0.991
AR (1)	0.000**	0.000**
AR (2)	0.155	0.257
Observations	500	500

Heteroskedasticity consistent p-values in parenthesis (null of statistical insignificance)
Statistical significance: *** significant at 1% ** significant at 5% level * significant at 10% level

Table A 1.4 reports panel estimates where beta is assumed to be constant across regions and across time. This time, individual specific effects are included in order to control for unobserved determinants of regional growth. Column one contains the estimates of equation 5.2 when all variables are expressed in deviations from their respective sample mean. Column two reports the estimates that result from nationally normalized values of regional per capita GVA. These nationally normalized GVA values then have are also expressed as deviations from the sample mean, i.e. from the sample mean of nationally normalized per capita GVA.