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Traditional convergence tests with Penn World Table 9.0[1]

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Tiivistelmä

Konvergoituvatko eri maiden tuottavuustasot? Lähentyvätkö kehittyvät maat kehittyneitä maita? Mitkä maaryhmät konvergoituvat? Tässä tutkimuksessa pyritään antamaan vastauksia edelle esitettyihin kysymyksiin tarkastelemalla työn tuottavuuden absoluuttista konvergenssia ja sigma-konvergenssia Penn World Table 9.0 aineistolla. Absoluuttisella konvergenssilla tarkoitetaan yksinkertaistaen sitä, että mitä alempi taso jollakin taloudellisella mittarilla on suhteessa muihin maihin, sitä suurempi on sen kasvuaste. Sigma-konvergenssilla tarkoitetaan sitä, että jonkin taloudellisen mittarin eri maiden tasojen hajonta pienenee jollakin aikavälillä. Tässä tutkimuksessa testataan konvergoituvatko tiettyjen maaryhmien tuottavuustasot. Nämä maaryhmät ovat seuraavat kansainväliset organisaatiot: OECD, EU ja APEC. Lisäksi testataan konvergoituvatko seuraavien maanosien maat keskenään: Afrikka, Aasia, Eurooppa ja Etelä-Amerikka. Tulosten mukaan konvergoitumista esiintyy seuraavissa maaryhmissä: OECD, EU, APEC, Eurooppa ja Aasia. Tulosten mukaan Afrikassa ja Etelä-Amerikassa konvergoituminen on kuitenkin epävarmaa tai jopa olematonta.

JEL koodit: O40, O47, O52, O53, O54, O55

Avainsanat: absoluuttinen konvergenssi, beeta-konvergenssi, sigma-konvergenssi, globalisaatio, työn tuottavuus, OECD, EU, APEC, Eurooppa, Afrikka, Aasia, Etelä-Amerikka

Abstract

Can we associate globalisation with converging productivity levels of different countries? Are the developing countries catching up? Which specific country groups converge? This paper provides answers to these questions by studying unconditional beta-convergence and sigma-convergence of labour productivity with the Penn World Table 9.0 dataset. Unconditional β-convergence exists if a smaller initial level of an economic measure is related with a larger growth rate of this measure, whereas unconditional σ-convergence exists if the standard deviation of the levels of an economic measure decreases over time. This paper tests the existence of convergence within specific country groups, which are the international organisations OECD, EU and APEC, and the continents Africa, Asia, Europe and South America. The tests support unconditional beta-convergence and sigma-convergence in the country groups of OECD, EU, APEC, Europe and Asia, whereas the convergence in Africa and South America is uncertain or non-existing.

JEL codes: O40, O47, O52, O53, O54, O55

Keywords: unconditional convergence, beta-convergence, sigma-convergence, globalisation, labour productivity, OECD, EU, APEC, Europe, Africa, Asia, South America

Contents

1 Introduction

A typical phrase concerning globalisation says that the world is getting smaller. By this we mean that the accessibility of the world has improved vastly, for example, due to information technology and reduction in travel time. However it is questionable whether at the same time there is an ongoing process which leads into smaller economic differences between countries due to, for instance, international economic competition, capital movement and diffusion of technology. That is, can we associate the ongoing globalisation with the converging economic characteristics of different countries.

Why should we be interested? Firstly, simply because we are interested in how countries develop economically, for instance, whether or not developing countries catch up the developed countries in living standards. Secondly, we are interested in whether there are some country groups or international organisations where the convergence process differs compared to the overall global economic convergence. Put differently, we are interested in whether membership to, for instance, OECD signals growth behaviour that is different compared to an outsider country.

Thirdly, and more importantly, the knowledge of economic convergence allows us to optimize our policy making according to this information. For instance, it is valuable for the developed European countries to know that the developing Eastern Europe converges economically towards them. One reason for this is that in the long run productivity largely determines wages and therefore the competitive advantage of the developing European countries likely decreases. Furthermore, the catching up wage levels leads to new emerging markets within the developing European countries and so forth. Overall, when deciding over long-term policy, such as investments, information over the development of the companion countries is crucial.

Traditionally the convergence literature, which springs from the seminal paper by Baumol (1986), tests the converging of economic performance indicators such as per capita GDP, labour productivity, total factor productivity and wages. A vast part of this literature concentrates on conditional convergence. These studies estimate a rate which measures

how fast economies return to their own steady states. However, when considering policy making, the true value is in knowing which economies converge towards each other, that is, unconditional convergence. Rodrik (2013) points out that convergence studies concentrate on conditional convergence since unconditional convergence is hard to find at country level. In this paper I however show that unconditional convergence exists in specific country groups. Furthermore I show that for some periods unconditional β-convergence exits for all countries provided in the dataset.[1]

Therefore, the interest of this paper is in two concepts of convergence, unconditional β-convergence and σ-convergence. Unconditional β-convergence exists when the relation between initial productivity levels and productivity growth rates is negative, that is, the smaller the initial productivity level the faster the growth rate. Unconditional σ-convergence exists if the standard deviation of the productivity levels decreases over time. The main objective of this paper is to test the existence of these two convergence concepts, that is, to study which country groups converge in productivity levels. In other words, I simply study in which country groups unconditional convergence and σ-convergence occurs and in which it does it not.

This study contributes in three different ways as follows. Firstly, convergence studies typically test unconditional convergence with a specific narrow sample.[2] Therefore, due to different sample periods, different data sources, different country coverage and different adopted tests the results are scattered and the comparability of these results is questionable. This paper provides estimates from the harmonized Penn World Table 9.0 (PWT9.0) dataset for the periods 1960-2014, 1970-2014, ... ,2000-2014, and for all the country groups that are traditionally tested. In this sense the unconditional convergence rate estimates provided in this study are more comparable than the earlier estimates.

[1]The overall number of countries in the dataset is 182 from which 169 countries are covered with data to calculate productivity for at least one of the periods considered. See appendix A.

[2]See Dobson et al. (2006) for a table of traditional convergence studies.

Secondly, this study tests for σ-convergence. As discussed later, a σ-convergence test is in a sense a more appropriate test for convergence compared to a β-convergence test. Therefore another contribution of the present study is that it provides results from 3 different σ-tests for the same periods and country groups that it provides the β-estimates. These three tests, provided by Carree and Klomp (1997) and Egger and Pfaffermayr (2009), test whether the standard deviation of the productivity levels decreases over time within a given country group.

Thirdly, this study tests whether three different GDP measures provided by the PWT9.0 dataset; living standards, productive capacity and national accounts GDP, lead to different convergence estimates. For instance, countries might converge in living standards GDP but not in productive capacity GDP. For more on the PWT9.0 dataset and different GDP measures see section 2 and (Feenstra et al., 2015).

The test results indicate that convergence occurs in the country groups; OECD, EU and APEC. Furthermore, also Europe and Asia as continents are converging indicating, for example, that the former Eastern Bloc countries are catching up. However, the convergence in terms of unconditional β-convergence and σ-convergence is much more uncertain or even non-existing in other continents considered, namely Africa and South America. These results reveal that indeed there are country groups that differ in the convergence process. Furthermore, for some periods I find support for β-convergence even in the World sample (all countries provided in the dataset). The σ-convergence test however suggest that the World has not been converging but rather diverging during the period 1960-2014. Interestingly I find some evidence that after the year 2000 also the World has started to σ-converge.

The paper is structured as follows. In section 2 I give a short discussion concerning the PWT9.0 dataset. A review of the different convergence concepts and a presentation of the different convergence tests utilized in this paper are given in section 3. Results are reported in section 4, whereas section 5 concludes.

2 Data

As Feenstra et al. (2015) note Penn World Tables have been standard data sources for across country real GDP measures. Since the work of Summers and Heston (1988) the dataset has advanced both in country coverage and in provided measures. Here my aim is to test cross-country convergence with the newly available Penn World Table 9.0 (PWT9.0) dataset.[3]

The main interest in economic convergence is on whether the real levels converge. The focus is therefore on GDP measures based on prices which are constant across countries and time. However construction of these real GDP series involves, for example, the estimation of the purchasing power parities (PPP), which increases the risk of measurement error. For this reason in this study the real national accounts GDP serves as a steady baseline while I study convergence also with the PPP fixed GDP measures. That is, I test labour productivity (GDP per employment) convergence with the traditional national accounts GDP based on national prices that are constant over time and with two PPP fixed GDP measures based on prices that are constant across countries and over time.[4] All three measures are from PWT9.0. The two PPP fixed GDP measures from PWT9.0 are the expenditure side GDP which represents the living standards of a country and the output-side GDP which represents the productive capacity of a country.

I present shortly the different measures of GDP. However for more on the data and the

[3] I first did the same regressions and tests as here with the PWT8.1 dataset. There are three main differences between PWT8.1 and PWT9.0. Firstly, the country coverage and the span are slightly improved in PWT9.0. Secondly the new PPP benchmark (ICP2011) has been utilized to improve harmonization. Thirdly, among "normal" revisions to the national accounts data PWT9.0 better account for the more comprehensive revisions set off by a growing number of countries that have shifted from the accounting rules of the SNA1993 to the SNA2008. Overall the results from PWT9.0 compared to the results from PWT8.1 differ mainly in favour of convergence.

[4] To calculate labour productivity I use employment rather than hours worked since this increases the number of observation notably.

differed GDP measures see Feenstra et al. (2015). The national accounts GDP is the real GDP at constant national prices obtained from national accounts data and the base is in 2011 USA dollars. By the living standards GDP I refer to the expenditure side GDP measure in Feenstra et al. (2015), whereas by the productive capacity GDP I refer to the output side GDP measure. Feenstra et al. (2015) convert GDP by final goods PPP exchange rate to produce the living standards GDP. Moreover they tread the trade balance as an income transfer to the representative consumer and therefore it too is deflated by the final goods PPP exchange rate. The productive capacity GDP differs from the living standards GDP since it is computed using PPPs specific to final goods, imports and exports. Another feature of the PWT9.0 dataset is that it provides living standards GDP and productive capacity GDP measures both in prices constant over country and in prices constant over time and country. Basically these differ only in that for the measures based on prices constant both in time and country the reference price vector is corrected from changing over time. For more information how this exactly is done see Feenstra et al. (2015). Here I use the PPP fixed GDP series that are based on prices that are constant over time and country as noted above.

The PWT9.0 dataset spans the period 1950–2014. However most of the countries are not covered this broadly. That is, for the year 1950 the dataset contains observations on productivity for 32 countries, whereas for the year 1960 it contains already observations for 82 countries. Then again for the founding OECD countries the full coverage starts from 1950 and for the EU-core countries from 1951. I start the analysis from the year 1960, rather than 1950. The overall number of countries in the dataset is 182 from which 169 countries are covered with data to calculate productivity for at least one of the periods considered. The country groups are listed in appendix A.

Often the interest in convergence papers is on a fixed time period, for example, Madsen and Timol (2011) study unconditional labour productivity convergence in OECD countries within the period 1870-2006. Here I however also test convergence within periods with different initial years. I do this to give further evidence on whether the convergence rate has changed during the 1960-2014 period. For example, it might be that for the first 40

years of the studied period productivity levels converge and after that the convergence shuts down. This case might result in non-rejection of the convergence hypothesis for the whole period when however sometime during the period converging has stopped. According to this reasoning I run the tests for the periods 1960-2014, 1970-2014, ... , 2000-2014. Another important reason to consider different periods is that the available observations increase the closer the initial year is to date.[5]

3 Tests for unconditional convergence

3.1 Convergence concepts reviewed

The convergence literature relates strongly with the growth literature. Traditionally the convergence literature tests the economic convergence implied by the neoclassical growth model by Solow (1956) and Swan (1956). Barro (2015) points out that the evolution of growth models can bee seen simply as extending the neoclassical growth model, mainly by endogenising the exogenous factors of the Solow-Swan framework. Rodrik (2013) states that actually the lack of empirical support for unconditional convergence led the (exogenous) growth theory into the endogenisation of the technological level and also into the study of conditional convergence.

The traditional concepts of convergence are absolute, conditional and club convergence.[6] Assuming economies are structurally similar, characterized by the same steady state. Then only the difference in the initial conditions of different economies affect convergence. In this case convergence is called absolute or unconditional convergence. The existence of unconditional convergence leads poor economies to catch up with the rich

[5]The obvious problem is that for some samples studied the number of available observations increases from the period 1960-2014 to the period 2000-2014. This hampers the comparability of the periods with different initial years. However I choose nevertheless to maximize the observations rather than to run the regressions for the same observations for all considered periods for a given sample.

[6]See also Quah (1993) for a slightly different defining of convergence.

ones.

Barro (1991), after showing that in a large sample of countries unconditional convergence is absent, controls for human capital and shows that there exists conditional convergence. Barro and Sala-i-Martin (1992) and Mankiw et al. (1992) further study the concept of conditional convergence. These papers state that countries converge towards their own steady-states, and therefore it is necessary to control for the differences in steady-states when studying convergence. Country specific steady-states however mean that poor countries do not neccesarily converge towards the rich countries. Islam (1995) further studies conditional convergence with a panel data approach.

Conditional convergence is compatible with differences among economies, in which case these differences spring from the structural differences of these economies. However systematic differences (non-convexities), for example, different available technology at different levels of economic development, might result in stages of growth or in other words multiple steady-state equilibria. Then clubs of converging countries can emerge as Durlauf and Johnson (1995) and Desdoigts (1999) propose, see also Baumol (1986).

When considering the three convergence concepts discussed shortly above we speaks of β-convergence. The interest is then mainly on whether the initial productivity level is negatively related to the growth rates of productivity in an unconditional, a conditional or a multiple regime (club convergence) setting.

Additionally there is the concepts of σ-convergence. Baumol (1986) in his article notes shortly that the dispersion of the cross-sectional productivity has decreased in the studied sample. Friedman (1992) argues that indeed this is a more relevant concept of convergence. This is because even if β-convergence exists it might be that the dispersion of the productivity levels across countries does not decrease over time. Indeed Friedman (1992) and Quah (1993) argue that β-convergence regression is tainted by regression fallacy, namely regression towards the mean. Friedman (1992) further argues that due to this fallacy a test of decreasing dispersion of the productivity levels over time is a more appropriate test for convergence. Lichtenberg (1994) is the first to propose a statistical test for σ-convergence.

Sala-i-Martin (1996) argues that both β-convergence and σ-convergence are interesting and give insight to different questions. That is, β-convergence studies the mobility within the distribution, whereas σ-convergence studies the evolution of the distribution. Sala-i-Martin (1996) also shows the relationship between σ-convergence and β-convergence, that is, β-convergence is a necessary but not a sufficient condition of σ-convergence, see also Lichtenberg (1994). In the next two sections I shortly present the β- and σ-tests I utilize in this paper.

3.2 β-convergence

To test the existence of unconditional convergence in the productivity levels I adopt the so called β-convergence test. For founding studies of β-convergence, see Baumol (1986) and Barro and Sala-i-Martin (1992). For a more resent study see, for instance, Madsen and Timol (2011). The test for unconditional β-convergence is a simple regression as follows:

$$\Delta \ln(\frac{Y}{L})_i^{t-t_0} = \alpha + \beta_1 \ln(\frac{Y}{L})_i^{t_0} + \epsilon_i \quad (1)$$

Or

$$\ln(\frac{Y}{L})_i^{t} = \alpha + \pi \ln(\frac{Y}{L})_i^{t_0} + \epsilon_i, \quad where \quad \pi = (1 + \beta_1) \quad (2)$$

Where $\ln(Y/L)_i^{t_0}$ is the initial log productivity level, $\ln(Y/L)_i^{t}$ is the log productivity level in the last period and $\Delta \ln(Y/L)_i^{t-t_0}$ is the (average) growth rate in between the initial year and the last year, ϵ_i is a stochastic error term. The null hypothesis of no β-convergence is rejected if the coefficient β is negative and statistically significant.

Furthermore Barro and Sala-i-Martin (1992) and Sala-i-Martin (1996) estimate a non-linear β-convergence regression to produce estimates that are directly comparable across samples with different initial years. The regression is as follows:

$$\frac{1}{T}\Delta \ln(\frac{Y}{L})_i^{t-t_0} = \alpha + (\frac{1 - e^{-\beta_3 T}}{T}) \ln(\frac{Y}{L})_i^{t_0} + \epsilon_i \quad (3)$$

The reasoning behind the non-linear version, as Barro and Sala-i-Martin (1992) and Sala-i-Martin (1996) state, is as follows. When convergence exists initially countries grow faster. The average growth rate of a long time period is then surely a combination of the more

fast growth in the earlier periods and also the slower growth in the later periods. In other words, as T gets larger the effect of the initial position on the average growth rate becomes smaller.

In Baumol (1986) the dependent variable in regressing (1) is the growth rate, whereas for example in Madsen and Timol (2011) the dependent variable is the average growth rate. In this paper the dependent variable in regression (1) is the average growth rate rather than the growth rate. However I prefer regression (3) since the estimation allows the direct comparison of the convergence rate estimates for samples with different time spans.

While the main interest is on regression (3), for robustness, I also run regression (1) transformed into a panel regression where the time dimension is formed from three- five- and ten-year intervals of the data. According to my knowledge, Islam (1995) is the first to study conditional convergence in a panel data setting. I do not add the fixed effects into the panel regression (1) since I study unconditional convergence. However I add time effects to adjust for over time changing world (club) average growth rates. For recent papers studing unconditional convergence in a panel data setting see Madsen and Timol (2011) and Rodrik (2013).

A short comment on interpreting the results, Madsen and Timol (2011) note that they interpret their results on a basis of a one-sided critical value since they test rather $\beta < 0$ than is β significantly different from zero. I agree that in their paper the one-sided test is justifiable since the focus is on OECD countries which are often found to converge. However in this paper interpretation is throughout done based on the two-sided critical values. That is I make no prior assumptions of the sign of β or of convergence.

3.3 σ-convergence

A σ-convergence test is a test whether the standard deviation of the productivity levels decreases over time. Here I shortly present a σ-convergence tests proposed by Lichtenberg (1994), an adjusted version of Lichtenberg's (1994) and an alternative likelihood-ratio test both proposed by Carree and Klomp (1997) and furthermore an alternative Wald test pro-

posed by Egger and Pfaffermayr (2009). The test statistic in Lichtenberg (1994) is:

$$T_1 = \frac{\hat{\sigma}_{t_0}^2}{\hat{\sigma}_t^2} \tag{4}$$

Where $\hat{\sigma}_{t_0}^2$ denotes the cross-country variance of productivity in the initial period and $\hat{\sigma}_t^2$ the variance in the last period. According to Lichtenberg (1994) the test statistic is asymptotically F distributed with $N-2$ degrees of freedom in both the nominator and the denominator.

Carree and Klomp (1997) argue that actually the test in Lichtenberg (1994) is F distributed with $N-1$ degrees of freedom instead of $N-2$. Moreover they show that $\hat{\sigma}_{t_0}^2$ and $\hat{\sigma}_t^2$ are not independently distributed when $\pi \neq 0$, implying that Lichtenberg's (1994) test is not F distributed and is biased towards finding no convergence, that is, a type II error. Therefore Carree and Klomp (1997) propose an adjusted version of the ratio of variances test which is standard normal distributed. They also derive an alternative likelihood-ratio based test. In their simulations they find that their likelihood-ratio test is more close to its asymptotic distribution even with small values of N. The test statistics are as follows:

$$T_2 = \frac{\sqrt{N}(\hat{\sigma}_{t_0}^2/\hat{\sigma}_t^2 - 1)}{2\sqrt{1-\hat{\pi}^2}} \tag{5}$$

$$T_3 = (N-2.5)\ln\left[1 + \frac{1}{4}\frac{(\hat{\sigma}_{t_0}^2 - \hat{\sigma}_t^2)^2}{\hat{\sigma}_{t_0}^2\hat{\sigma}_t^2 - \hat{\sigma}_{t_0,t}^2}\right] \tag{6}$$

Where $\hat{\sigma}_{t_0}^2$ denotes the cross-country variance of productivity in the initial period, $\hat{\sigma}_t^2$ the variance in the last period and $\hat{\pi}$ is the coefficient estimate of regression (2). The term $\hat{\sigma}_{t_0,t}^2$ is the covariance of productivities in the initial and last period. The test T_3 is asymptotically χ^2 distributed with 1 degree of freedom. Carree and Klomp (1997) point out that when considering the power of the tests, that is, the probability to correctly reject the null, the likelihood-ratio test and the adjusted ratio of variances test outperforms the test Lichtenberg (1994) proposes.

A more recent paper by Egger and Pfaffermayr (2009) propose a Wald test for testing σ-convergence. They note that when considering unconditional convergence their test

performs equally well in their simulations as the likelihood test Carree and Klomp (1997) propose. However when considering conditional σ-convergence, the test has some advantages over the likelihood-ratio test. Here I utilize the test to increase the robustness of the analysis. The test statistic for unconditional σ-convergence is:

$$T_4 = \frac{(N - 2.5)}{4} \frac{\left[\hat{\pi}^2 - 1 + \frac{\hat{\sigma}_u^2}{\hat{\sigma}_{t_0}^2}\right]^2}{\hat{\sigma}_u} \tag{7}$$

Where $\hat{\sigma}_{t_0}^2$ denotes the cross-country variance of productivity in the initial period, the term $\hat{\sigma}_u^2$ is the estimated variance of the error term in regression (2) and $\hat{\pi}$ is the coefficient estimate of regression (2). In both tests T_3 and T_4 I use $(N - 2.5)$ rather than N to improve the χ^2 approximation in small samples[7].

As pointed out Lichtenberg's (1994) test T_1 is biased towards finding no convergence and it's adjusted version T_2 performs worse than the likelihood-ratio test in small samples. However the hypothesis that the variance of productivities is decreasing is more practical in situations where the dispersion is increasing compared to T_3 and T_4 which H_0 hypotheses are $\hat{\sigma}_t^2 = \hat{\sigma}_{t_0}^2$ and $\pi^2 = \bar{\pi}^2$ respectively. The tests T_3 and T_4 therefore test whether the initial value and end value are the same. The fact that they are not the same with increasing dispersion leads to rejection of the null when there is no σ-convergence but σ-divergence. Another problem with T_2 arises when $|\pi| > 1$ since then T_2 cannot be determined. As in Carree and Klomp (1997) I interpret these cases as no convergence.

I prefer T_2 over the other test's. However the tests T_3 and T_4 provide further evidence especially when the sample size is small. Furthermore I represent a figure depicting the development of the productivity level standard deviation for most of the studied samples. This aids to interpret the σ-tests especially in cases where the dispersion is in fact increasing.

[7]Conserning the multiplying factor of the χ^2 approximation Carree and Klomp (1997) and Egger and Pfaffermayr (2009) both refer to an older edition of Morrison (2005). However atleast in this newer edition Morrison (2005) refers to Bartlett (1954).

4 Results

4.1 The world converging?

The results from the NLS-regression (3) for the sample of all countries are shown in table 6. The columns of table 6 contain the β-estimates for the different periods, whereas the different measures of GDP for a specific sample are reported row-wise. The standard errors of the coefficients are heteroscedasticity robust (White, 1980), whereas the p-values are from the T distribution with $N - 2$ degrees of freedom. For brevity I report only the significances of the estimates in table 6. The number of observations differs for different initial years as more observations are available the nearer the initial years is to date.

The coefficient estimates for the sample of all countries are all negative and from on the initial year 1970 significant at the 0.1 significance level, moreover except for one case all the estimates are significant at the 0.05 significance level. For the period 1960-2014 only the estimate for national accounts GDP is significant at the 0.1 significance level and furthermore all the estimates for this period are close to zero. For the period 2000-2014 the estimates are notably smaller indicating that the β-convergence has been ongoing with a larger rate compared to the other periods. Overall the different GDP measures result in seemingly similar estimates of the β-coefficients the only exception being that the national accounts GDP estimates are more often significant.

The results in table 6 differ from the earlier studies by Barro (1991) and Barro and Sala-i-Martin (1992). For example Barro and Sala-i-Martin (1992) find a positive β for the period 1960-1985 in a rich cross-country setting consisting of 98 countries from the Summers and Heston (1988) dataset. Moreover Rodrik (2013) claims that actually unconditional convergence can only be found among the states/regions of an unified economy such as United States or the country group OECD. The results in table 6 however indicate that from on the initial year 1970 the world has been β-converging.

The difference between the earlier results and the results here might spring from three different sources. Firstly, the larger sample size might affect the results, indicating that

the sample selection bias contaminates the earlier results. Secondly, the difference might result from the different span of the sample indicating that the convergence process is stronger in the later years of the whole period 1960-2014. The fact that the estimates are close to zero for the period 1960-2014 supports this conclusion. Thirdly, the improvements in the quality of the dataset most likely affects the results.[8]

The studies by Quah (1993, 1996) indicate that there is no unconditional convergence to be found in a rich cross-country setting further stating that actually rich countries get richer and poor countries poorer. Therefore, to further study convergence in the universal scope I run the σ-tests for the World sample. Overall the tests for σ-convergence support the claims in Quah (1993, 1996) that actually rich countries get richer and poor countries poorer. Figure 1 depicts the increasing dispersion of the productivity levels in the period 1960-2014. The σ-tests are reported in table 1 where I report the test statistics and the associated p-values in parenthesis for the tests T_2, T_3, T_4. A $-$ sign marks the cases where T_2 is not determined. The number of observations differs for different initial years as more observations are available the nearer the initial years is to date.

[Figure 1 here.]

Figure 1 shows clear increasing in the dispersion of productivity from 1960 to 2014. Overall the evolution of the productivity dispersion is quite similar for all the GDP measures. The fact that more observations were available in the later years might affect the standard deviation increasingly as the latest countries added to the dataset are likely economically more far behind compared to the countries providing data early on. To avoid this shortcoming I depict two different lines. The red line is the standard deviation of only

[8]It is somewhat interesting to notice that the results from the PWT8.1 dataset differs from the results shown here while the sample size in PWT9.0 is only slightly larger. Moreover, PWT9.0 produces larger (in absolute terms) β-regression estimates and improves the significances of these estimates probably since the better harmonization of the data. However in both datasets the β-convergence in the period 2000-2014 (2000-2011 for PWT8.1) is evident.

the countries covered for all years, $N = 82$, whereas the blue line is the standard deviation of all countries provided in a particular year, that is, N increases along the x-axis.

Despite the clear overall increase of productivity dispersion an interesting observation is that after the year 2000 it seems that the dispersion starts to decrease (at least when considering the 82 countries covered for all years). This result emerges also from table 1. From on the initial year 2000 the tests for the productive capacity GDP and living standards GDP come close to the rejection of the null at the 0.05 significance level. The test for the national accounts GDP rejects the null in favour of σ-convergence.

[Table 1 here.]

The results of β-convergence tests are in line with the σ-tests since both suggest convergence from on the initial years 2000. Whether there actually is a turning point towards the convergence of the world productivities somewhere in the beginning of the 21st century remains to be seen. However the claim by Rodrik (2013) that actually unconditional convergence can only be found among the states/regions of an unified economy such as United States or the country group OECD, does not seem to hold, at least not with the data provided by PWT9.0. That is, for the sample of all provided countries β-convergence exits from on the initial year 1970 and the convergence rate is even larger from on the year 2000. Despite the existing β-convergence from on 1970 the σ-convergence seems to start only after the year 2000.

To test whether some regions or clubs convergence I next divide the dataset into country groups, or in other words into subsets of the whole dataset, as is common in the club convergence literature. See, for instance, Durlauf and Johnson (1995). I form subsamples (clubs) directly from continents and international organisations, namely OECD, EU and APEC. For the content of each country group see appendix A. The further results are in some favour of the concept of club-convergence studied earlier by Durlauf and Johnson (1995), Quah (1997), Desdoigts (1999) and more recently, for example, Bernardini Papalia and Bertarelli (2013).

4.2 OECD, EU and APEC

I start this section with the results for OECD countries. As is common in the literature I find that OECD countries converge. For instance Madsen and Timol (2011) finds evidence on converging manufacturing labour productivity among the OECD countries for the period 1870-2006. Indeed the β-regressions reported in table 6 for the founding OECD countries produce negative estimates which are all significant at the 0.1 significance level for all initial years and GDP measures. One interesting detail is that the speed of convergence is higher for the initial years starting from 2000 than for the earlier initial years.

The green line in figure 2 depicts the productivity dispersion for the OECD founders, $N = 20$. There has been clear σ-convergence from on the initial year 1960. However from the initial year 1990 onwards the σ-tests, which are not reported (available on request), result often in p-values larger than 0.05. Indeed figure 2 supports the test results with the standard deviation stabilizing somewhere around 0.25 after the year 1990.

[Figure 2 here.]

The founders of OECD have been converging within the period 1960-2014. However the club has grown since the beginning of its formation in 1961 from its founding 20 to its present 34 members. The results from β-regressions with all current OECD member countries included are reported in table 6. Here I include all countries available to the regression, that is, also the countries that during an initial year were not yet members but countries to become members. It is questionable how much the characteristics of the club affect the convergence of its members. More likely there are countries that possess some characteristics and are therefore desired as club members.

The results from the β-regressions for the founders of OECD and for all OECD countries are seemingly similar. This is expected since the founders still account for most of the observations. However, when adding the other OECD countries to the sample of OECD founders all the estimates are significant at the 0.01 significance level and the absolute values of the estimates are larger compared to the sample of the founders. This strengthens the conclusion that OECD countries are converging in the productivity levels. The σ-tests

reported in table 2 and the depicted dispersion in figure 2 further confirms that also the productivity dispersion is decreasing within the sample of all OECD countries.

[Table 2 here.]

In figure 2 there are two lines in addition to the above mentioned green line. The red line is the standard deviation of only those OECD countries that are covered for all years, $N = 28$, whereas the blue line is the standard deviation of all OECD countries provided in a particular year. The two countries added in 1970 increase the standard deviation remarkably compared to the standard deviation shown by the red line, however the overall decreasing of productivity dispersion is evident. The σ-tests in table 2 reject the null more often than with the sample of the OECD founders, actually in all cases at the 0.05 significance level, indicating that the σ-convergence is more eminent when considering all OECD countries.

[Figure 3 here.]

Overall the results support the earlier findings that indeed OECD countries are converging. Moreover the conclusion holds whether considering national accounts GDP or the more sophisticated measures of GDP. I find that among the founding OECD countries the dispersion of productivity levels has clearly decreased compared to the year 1960 however after the year 1990 the decreasing is uncertain. With the sample of all OECD countries σ-convergence is evident in all period considered.

I further study convergence in EU. Both organisations EU and OECD advocate economic and political integration within the member countries. OECD evolved from the former Organisation for European Economic Co-operation (OEEC) which was initially set up to administer Marshall Plan the recovery program for Europe after the Second World War. OECD had also non-European founders, namely USA and Canada, and has enlarged internationally. EU evolved from European Atomic Energy Community (EURATOM), European Coal and Steel Community (ECSC) and European Economic Community (EEC) and has enlarged only in Europe. Since 21 out of the total 28 countries in EU are also members in

OECD (See appendix A), one would expect that convergence is present also in EU. Indeed this is what I find.

[Table 3 here.]

The results from the NLS-regression (3) for core EU countries and all EU countries are reported in table 6. The β-estimates for core EU countries are significant at the 0.01 level with the exception that the estimates for the initial years 1990 and 2000 for national accounts GDP are not significant. Adding the additional EU countries to the sample of core EU countries confirms the finding that productivity levels β-converge in EU. Compared to the results for the core EU countries the results are even more explicit. All the estimates are significant and they are more often larger than smaller in absolute terms compared to the core EU estimates. One interesting observation is that compared to the sample of OECD countries the rate of convergence within the period 2000-2014 is seemingly stronger in the sample of EU countries.

I report the σ-tests for all EU countries in table 3. According to the tests there is definitely σ-convergence in EU. All tests T_2, T_3 and T_4 reject the null at the 0.05 significance level. This result is confirmed in figure 3 which depicts the evolution of the productivity dispersion for all EU countries. The red line in figure 3 is the standard deviation of only the countries covered for all years, $N = 18$, whereas the blue line is the standard deviation of all countries provided in a particular year. The observation is evident. The dispersion has decreased among the EU countries from 1960 to 2014.

To save space I don't report the σ-tests for the sample of core EU countries (available on request). However I note that the results are similar to the results for the OECD founders. That is, sometime around the 1970s the productivity dispersion saturated somewhere around 0.2 and there by stopped decreasing. This result emerges also from figure 3 where the green line represents the productivity dispersion for the core EU countries, $N = 15$.

[Figure 4 here.]

The literature shows somewhat less attention on the development of the Asia-Pacific

Economic Cooperation (APEC). APEC was established in 1989 and it consists of 21 members which from 13 are founders (See appendix A). APEC was founded to increase economic cooperation among the economies around the Pacific, meaning, for example, coordinated trade policies. As with EU also some members of APEC are simultaneously members in OECD. Indeed there are 8 countries which belong to both. The results reported next indicate that the members of APEC were converging already before the formation of the club.

[Table 4 here.]

The β-convergence results for APEC are reported in table 6. Interestingly the occurrence of β-convergence is evident also for APEC. The convergence rate is however smaller than in OECD or EU. When excluding the countries with membership to both APEC and OECD the estimates are significant for all GDP measures only after the initial year 1980. After the initial year 1980 the estimates are virtually the same as the estimates for the whole APEC. To save space these result are not reported (available on request).

The σ-tests for APEC are reported in table 4 and the dispersion of productivity levels is depicted in figure 4. The red line in figure 4 is the standard deviation of only the countries covered for all years, $N = 17$, whereas the blue line is the standard deviation of all countries provided in a particular year. The green line represents the sample of the founders, $N = 12$. The added observations in 1970 and 1980 increase the dispersion however overall the standard deviations seem to decline. The σ-tests reject the hypothesis of no σ-convergence at the 0.1 significance level in all cases.

The results for the APEC founders differ from the results for OECD founders and core EU countries. The difference is, that contrary to OECD founders and core EU countries the productivity dispersion of APEC founders does not seem to saturate at any level but rather it continues to decrease within the 1960-2014 period. The green line in figure 4 depicts the evolution of the productivity dispersion of the APEC founders. The σ-tests confirm the observation made from figure 4, that is, the dispersion of the founders has continued to decrease. All test reject the null of no σ-convergence at the 0.1 significance level for all

periods and all GDP measures. For brevity these results are not reported (available on request). The dispersion is also remarkably larger compared to OECD founders and core EU. The values of the estimated β-coefficients for the APEC founders compared to the β-coefficients for all APEC countries are virtually the same.

[Figure 5 here.]

In this section there is yet one matter of interest. Since countries in OECD, EU and APEC all converge within the respective club, it is most expected that when combined together as a single group, convergence occurs also within this new group. Indeed this is what I find. The results for this combined sample are reported in table 6. All the β-estimates are negative and significant. The σ-tests T_2, T_3 and T_4 reported in table 5 all reject the hypothesis of no σ-convergence. Both lines in figure 5 decline steeply for all GDP measures. The red line is the standard deviation of only the countries covered for all years, $N = 40$, and the blue line is the standard deviation of all countries provided in a particular year.

[Table 5 here.]

All and all both partly overlapping club's OECD and EU have been converging in terms of both β- and σ-convergence. Moreover adding the later-joined-members to the sample of founders rather strengthens the rate of convergence implying that the later-joined-members are caching up. Therefore, the results support the earlier findings of the convergence literature, that is, convergence occurs in OECD and EU. I also find that APEC is β- and σ-converging however the convergence rate is smaller compared to EU and OECD and the σ-convergence is slightly more uncertain. When combining the countries of OECD, EU and APEC into one sample, according to the considered tests, both β- and σ-convergence are indisputable.

[Table 6 here.]

4.3 Continent's forming clubs?

I start this section by noting that the rate of convergence for the whole sample is remarkably smaller compared to the group of APEC, EU and OECD countries. In the spirit of Baumol (1986) I depict the OLS-regressions (1) for the whole world and for a club consisting the members of OECD, EU and APEC in figure 6 for the national accounts GDP. The figures for living standards GDP and productive capacity GDP are not reported (available on request) however overall they are seemingly similar with figure 6.

[Figure 6 here.]

The blue dots in figure 6 are the observations of the club, whereas the red dots and the blue dots together form the observations of the world. The red regression line is from the sample of all dots, whereas the blue regression line is from the club sample. As evident from sections 4.1 and 4.2 the blue line has a clearly larger slope in absolute terms than the red line. Moreover, as the initial year grows the blue dots seem to concentrate more closely with each other contrary to all the dots.

According to the test results in sections 4.1 and 4.2the international organisations APEC, EU and OECD converge faster than the sample of all countries raises the question whether there are other country groups which also have a converge rate that is faster than the "world's normal" rate. Furthermore, are there some country groups which are responsible for the lower "world's normal" convergence rate. In this section I provide some insight over these questions.

The literature gives no unambiguous practice to define clubs. Durlauf and Johnson (1995) form clubs with reference to countries stage of development, whereas Desdoigts (1999) propose a geographical structure. A more recent paper by Bernardini Papalia and Bertarelli (2013) utilize a mapping model to detect clubs from TFP-levels. Furthermore they note that the clubs they form are in line with Durlauf and Johnson (1995) and they find that each group β-converges with a unique rate in a conditional multiple regime panel data setting. The paper however does not test unconditional convergence or σ-convergence. Anyhow here I simply form groups straight from the continents, that is, the clubs are Africa,

Asia, Europe and South America.[9] I agree that forming clubs from continents is not necessarily the best approach. However Desdoigts (1999) finds clubs determined strongly by continental location and moreover the continents are actually often tested in separate studies in the literature (Dobson et al., 2006).

The estimation results for Africa are reported in table 11. The estimates are negative but mostly not significant. For national accounts GDP and productive capacity GDP the β-estimates are negative and significant at the 0.05 significance level, except for the initial years 1980, 1990 and 2000, which for the estimates are insignificant. For the living standards GDP all estimates are insignificant at the 0.05 significance level. The overall conclusion is that while a few β-estimates are significant the β-convergence in Africa is nevertheless rather uncertain.

[Figure 7 here.]

Despite the slight tendency towards β-convergence there exists no σ-convergence in Africa. Table 7 confirms this. The test T_2 cannot reject the null of no σ-convergence in any of the cases. The results indicate that the dispersion of productivity in Africa has not decreased. Conversely the dispersion has increased as figure 7 shows. As before the red line is the standard deviation of only the countries covered for all years, $N = 22$, whereas the blue line is the standard deviation of all countries provided in a particular year for Africa.

[Table 7 here.]

Even though the productivity levels in Africa are not converging the variation of existing partly overlapping international organisations and unions[10] in Africa slightly hint that there might be some convergence within some of these organisations. For brevity I do not

[9] See Appendix A for countries involved in each club.

[10] To name some: Community of Sahel-Saharan States , Common Market for Eastern and Southern Africa, Southern African Development Community and Economic Community of West African States

test the converging of these organisations in this study. The sample of Africa is however divided into North-West-South ($N = 26$) countries and East-Central countries ($N = 24$). These groups do not converge. For both the North-West-South sample and the East-Central sample some of the β-estimates turn out significant and negative. Nevertheless for both samples the σ-tests do not reject the hypotheses of no sigma-convergence in any period, implying that splitting Africa roughly into two groups consisting about the same number of countries does not alter the result that Africa is not σ-converging. For brevity these results are not reported (available on request).

The results for Asia are reported in table 11. Except for one case the estimates for all the GDP measures are negative and significant at the 0.05 significance level (all are significant at the 0.1 level). The overall conclusions is that Asia is β-converging in all the GDP measures. Moreover, the rate of convergence increases as the initial year gets closer to date.

The productivity dispersion of Asia is depicted in figure 8. Again the red line is the standard deviation of only the countries covered for all years, $N = 19$, whereas the blue line is the standard deviation of all countries provided in the particular year. The first notice is that the increase of $N = 19$ to $N = 29$ in the year 1970 increased the dispersion remarkably. From the beginning of the 70s there however seems to be some decreasing in the blue line, whereas the red line shows some increasing of the dispersion except for the national accounts GDP.

[Figure 8 here.]

The σ-test results in table 8 confirm the observations made from figure 8. All the GDP measures are σ-converging from on the initial year 1970. However, for the period 1960-2014 none of the tests reject the null. Clearly the additional observations from on 1970 affects the test results in favour of σ-convergence.

[Table 8 here.]

Southeast Asia can be seen as a separate club (Desdoigts, 1999). This area consists of

observations from 10 countries which are also the members of the Association of Southeast Asian Nations (ASEAN). I test whether this group of countries is converging. The estimates for the initial years 1960 and 1970 are all insignificant and often close to zero. From on the initial year 1980 however the β-coefficients are negative and significant for all the GDP measures. Indicating that the club β-converges from on the initial year 1980. The β-estimates are reported in table 11.

The σ-tests for Southeast Asia show that within the period 1980-2014 the dispersion of productivity levels of all GDP measures considered have decreased however the decreasing has stopped from on the initial year 1990. Interestingly this is somewhat the story also for the sample of all Asian countries as figure 8 depicts. For brevity estimates for the ASEAN countries are not reported (available on request).

The results for Europe are reported in table 11. The results are clear. The estimates are negative and significant at the 0.01 significance level for all GDP measures and all initial years. Moreover the rate of convergence is faster for the later initial years, which is partly due to the increase in observations. This result suggests that the countries which are covered only for the later years in the dataset are catching up. Most of these countries belonged to the so called Eastern Bloc. The results for Europe were obviously predictable from the results reported in section 4.2. After all from Europe's 40 countries 28 are members of EU.

[Figure 9 here.]

The results for Europe's σ-tests in table 9 indicate clear σ-convergence as expected. This is indeed the result taking shape in figure 9. The red line indicates the standard deviation of only the countries covered for all years, $N = 21$, whereas the blue line is the standard deviation of all countries provided in a particular year. The blue line increases steeply between the years 1969-1970 and the years 1989-1994. This is mostly due to the increase in observations. After both sample changes the line declines.

[Table 9 here.]

As stated earlier in section 4.2 adding the later-joined-members to the sample of EU founders strengthens the rate of convergence. The explanation is that many of these later-joined-members were under Soviet Union's influence, and after its collapse in 1991 those countries started to converge towards the founding EU countries. Indeed this is the case also with the sample of all European countries. In figure 10 I plots β-regression (1) from on the initial year 1990 for Europe and mark all the Eastern Bloc countries with a different color than the rest of Europe. As comes clear from figure 10 the convergence is strongly influenced by the Eastern Bloc countries. It is even somewhat striking to notice how well the observations fit the story that the Eastern Bloc countries are initially worse off than the rest of Europe but also the growth rates are higher. For the period of 2000-2014 the regression fit is especially convincing in all the GDP measures. The figures for living standards GDP and productive capacity GDP are not reported (available on request).

[Figure 10 here.]

The catching up Eastern Bloc results also in σ-convergence which comes apparent from figure 9 where somewhere around 1995 the productivity dispersion of all European countries marked by the blue line starts to decrease sharply. Since the dispersion for the core EU countries stabilizes already sometime around the 1980s as shown in section 4.2 the Eastern Bloc countries added to the sample are evidently catching up. Else the dispersion of the whole sample would likely not decrease.

The results for South America are reported in table 11. The β-estimates for South America are negative. Compared to the national accounts GDP the estimates for living standard GDP and productive capacity GDP are larger in absolute terms. Furthermore for the national accounts GDP only the estimate for the period 2000-2014 is significant at the 0.05 significance level. Differing from national accounts GDP the estimates for the measures of productive capacity GDP and living standards GDP are all significant at the 0.05 significance level. Overall the results indicate that there exists β-convergence in the PPP fixed real terms in South America. For the traditional national accounts GDP the β-convergence is however uncertain.

[Figure 11 here.]

A difference compared to the other continents is that the number of countries in South America is rather small, $N = 11$. Therefore I assumed that the countries in Middle America belong to the same club. For the productive capacity GDP and the living standards GDP the estimates are negative and more significant. However, for the national account GDP the estimates are closer to zero and more insignificant. These β-estimates are reported in table 11. Adding also the island countries to the sample alters the estimates in favour of no convergence. For brevity these results are not reported (available on request).

The test results for the sample of South America are reported in table 10. The result indicate that there might exists some σ-convergence for the productive capacity GDP and the living standards GDP, since some of the test results nearly reject the null. However this is rather speculative as none of the tests reject the hypothesis of no σ-convergence at the 0.05 significance level. The evolution of the productivity dispersion is depicted in figure 11. There seems to be some decreasing in the dispersion for the living standard GDP and the productive capacity GDP. The dispersion however varies quite a lot which results in the non-rejection of the test hypotheses and leaves it unclear whether the dispersion has decreased permanently or not. The p-values for the σ-tests for the sample were the Middle American countries are included are mostly larger compared to the sample of South America, indicating no σ-convergence. For brevity these results are not reported (available on request).

[Table 10 here.]

One further interest arises. Since Africa is the continent were convergence is most uncertain. Could it be that actually the countries of Africa actually result in the overall slow "world's normal" rate of convergence? Or since most of Europe is initially richer than Asia could the countries in Asia actually converge towards the countries in Europe. To answer these questions I test these combinations of the continents.

I start from Europe and Asia which locate on an unified land-area. I do find negative and significant β-estimates for Eurasia implying that the countries of Europe and Asia β-

converge. The β-estimates are reported in table 11. Also the σ-tests reject the null from on the initial year 1970 for all GDP measures. For brevity these results are not reported (available on request).

I next exclude the countries of Africa out of the sample of all countries. It is somewhat distracting to discover that indeed according to these tests the world without Africa is β-converging with a clearly faster rate than the whole world. Furthermore all the estimates are significant. The β-estimates are reported in table 11. From on the initial year 1970 all tests T_2, T_3, and T_4 support σ-convergence. For brevity these results are not reported (available on request). All and all these findings suggest that when considering any rich cross-country sample excluding countries of Africa might result in unconditional β-convergence and σ-convergence.

I end this section with a similar figure as I started it with. Figure 12 depicts the OLS-regressions (1) for all countries, Europe, Asia, Africa and South America for national accounts GDP. The figures for living standards GDP and productive capacity GDP are not reported (available on request).

[Figure 12 here.]

There are 5 regression lines in figure 12. Blue is for all observations, purple for Europe, green for Asia, red for Africa and orange for South America. Clearly the purple line is overall the steepest. Indeed this is what I find above, Europe's rate of convergence is the largest, Asia's second largest. The rate for South America is the third largest but the estimates are significant mostly only for the living standards GDP and productive capacity GDP. Convergence in Africa is doubtful and the rate of convergence, whenever significant, remarkable smaller compared to the other continents.

Combined with the results from sections 4.1 and 4.2 the results here imply that unconditional convergence is not self-evident even in specific country groups. However, there are country groups other than OECD where unconditional convergence exists. While the group of APEC, OECD and EU contains countries of all continents except Africa (and Antarctic), all the studied continents as such don't converge or the converging is discontinuous.

However according to the above results the claim by Rodrik (2013), that given any reasonably long time horizon whatever convergence one can find at country level is conditional, does not seem to hold. This is of course only true if the periods considered here are reasonably long.

[Table 11 here.]

4.4 Panel Estimates for β-convergence

The main results of this paper are those reported in sections 4.1, 4.2 and 4.3. For robustness I also test β-convergence in a panel data setting, which is common in the convergence literature. See, for instance, Barro (2015), Rodrik (2013), Madsen and Timol (2011) and Islam (1995). Here I run regression (1) transformed into unconditional panel regression. Therefore I exclude country fixed effects and simply estimate the regression with pooled OLS. The standards errors are adjusted for heteroskedasticity and serial correlation Arellano (1987). The data is transformed into 3 year, 5 year and 10 year intervals. The results are reported in appendix B.

I first ran the regressions without time effects however as Barro (2015) states including a separate constant for each time period adjusts the regression from over time changing world (club) average growth rates. Inclusion of time effects makes no dramatical changes on the estimates. Therefore I only report the estimates from the time effects adjusted regressions.

Overall the panel estimates provide no big surprises. The convergence rate estimates for the sample of all countries are "small" however in most cases significant.[11] The estimates for OECD, EU and APEC are negative and significant for all GDP measures and intervals. This is also true for Europe. For Africa the estimates are, except for one, insignificant

[11] For Anguilla, Antigua and Barbuda, Bermuda, British Virgin Islands, Cayman Islands, Curacao, Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Sint Maarten and Turks and Caicos Islands employment data is short of necessary years, mainly 2014, and therefore these countries are excluded from the sample.

yet in some cases negative. The estimates for Asia are significant and negative. For South America the national accounts GDP estimates are negative but insignificant. However the estimates for living standards GDP and productive capacity GDP are significant and negative (except for the productive capacity GDP 3 year interval estimate).

The above presented results are based on an unbalanced panel. As Rodrik (2013), with data on manufacturing industries, notes the disadvantage of a highly unbalanced panel is that the developed countries are highly more represented as the developing countries. Here the problem is more severe for the earlier years of the dataset since from on 1990 almost all countries are covered. To test whether the unbalanced panel is distorting the results, I run the panel regressions with a sample starting from 1991. This results in estimates from balanced panels. Most of the estimates are seemingly similar. However the estimates for EU and Europe are notably larger compared to the unbalanced estimates. This is also the case with the whole sample.

All and all the results here are in line with the results in 4.1, 4.2 and 4.3 as expected. Therefore these panel data results strengthen the main results of this paper.

5 Conclusions

In this study I do not take part in the discussion on which factors lead economies to converge in productivity. I simply test which groups have been converging during the period 1960-2014 with traditional tests proposed in the literature. The results in this study strengthen some earlier findings, for example, OECD, EU and Europe are converging.

Contrary to earlier findings this study suggests that also the sample of the whole world β-converges within the period 1970-2014. However the rate is rather small, that is, around 0.4 percent per year. Despite the negative and significant β-estimates the productivity dispersion has overall increased. Interestingly however it seems that after the year 2000 the tests slightly support the view that actually the dispersion has started to decrease, suggesting σ-convergence for the sample of the whole world for the period 2000-2014.

Furthermore I conclude that convergence occurs in the following country groups;

OECD, EU and APEC. Also Europe and Asia as continents are clearly converging. In Africa and South America however β-convergence and especially σ-convergence is more uncertain or even non-existing. The only continent that lacks clear evidence from both β-convergence and σ-convergence is Africa. Furthermore when Africa is excluded from the sample of all countries of the world both β-convergence and σ-convergence exits within this sample.

Barro (2015) finds evidence that for per capita GDP the 2 percent per year conditional convergence rate may well be a empirical regularity. (Rodrik, 2013) finds evidence that for labour productivity in manufacturing industries the unconditional convergence rate is between 2-3 percent depending on the different specifications. The unconditional convergence rate estimates I find vary notably depending on the specific sample, the period and the GDP measure. All and all however the significant estimates here are smaller than those (Rodrik, 2013) finds as expected. For the whole period 1960-2014 it seems plausible to say that the convergence rate for the samples of OECD, EU, APEC and Europe is roughly 1 percent. According to the panel estimates however the rate for OECD, EU and Europe is around 2 percent and for APEC around 1 percent.

The study also tests how convergence is affected when considering the different real GDP measures. For instance, South America is found to β-converge in the living standards GDP and productive capacity GDP but in terms of national accounts GDP the convergence is more uncertain. The international organisations OECD, EU and APEC and the continents Europe and Asia converge in all GDP measures. All and all the different GDP measures produce quite similar results when compared with each other.

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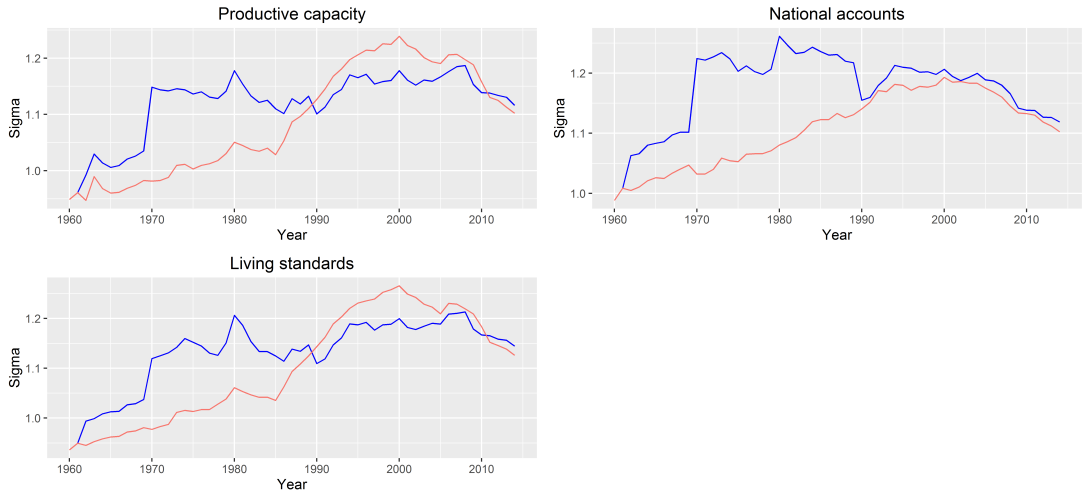
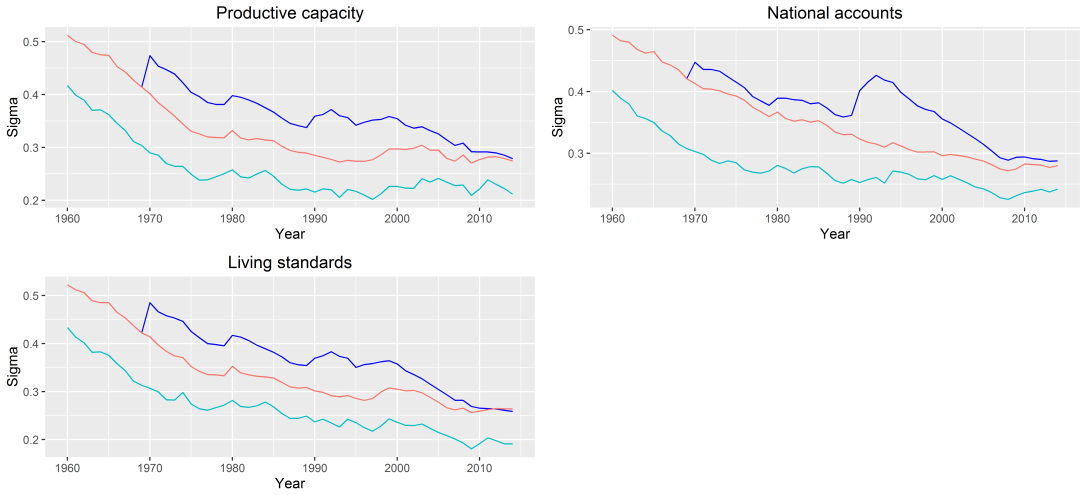
Figure 1: World's standard deviation of productivity



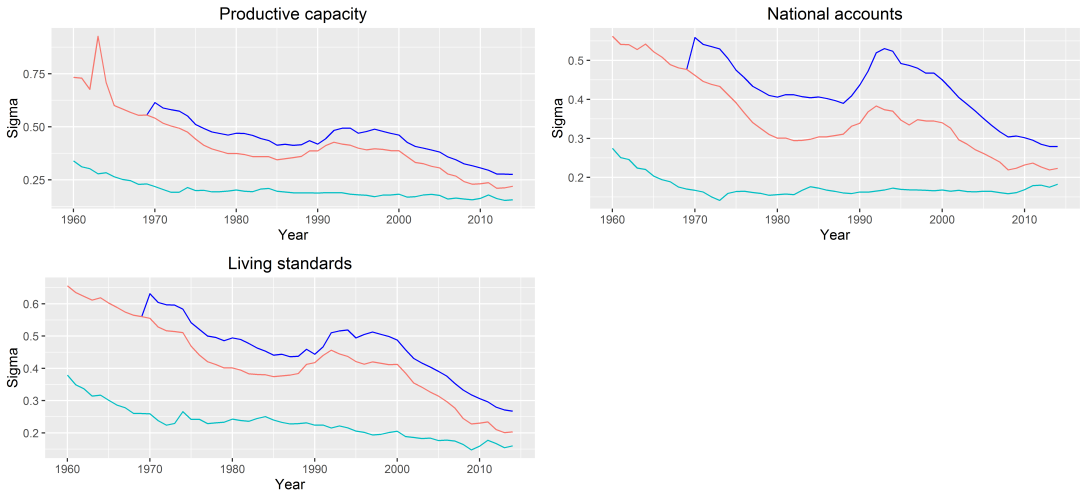
Note: The red line represents the standard deviation of only the countries covered for all years, $N = 82$. The blue line is the standard deviation of all countries provided in a particular year, $1960 \rightarrow: N \simeq 82, 1970 \rightarrow: N \simeq 103, 1980 \rightarrow: N \simeq 142, 1990 \rightarrow: N \simeq 166, 2000 \rightarrow: N = 169$.

Figure 2: OECD founders and all OECD countries, standard deviation of productivity



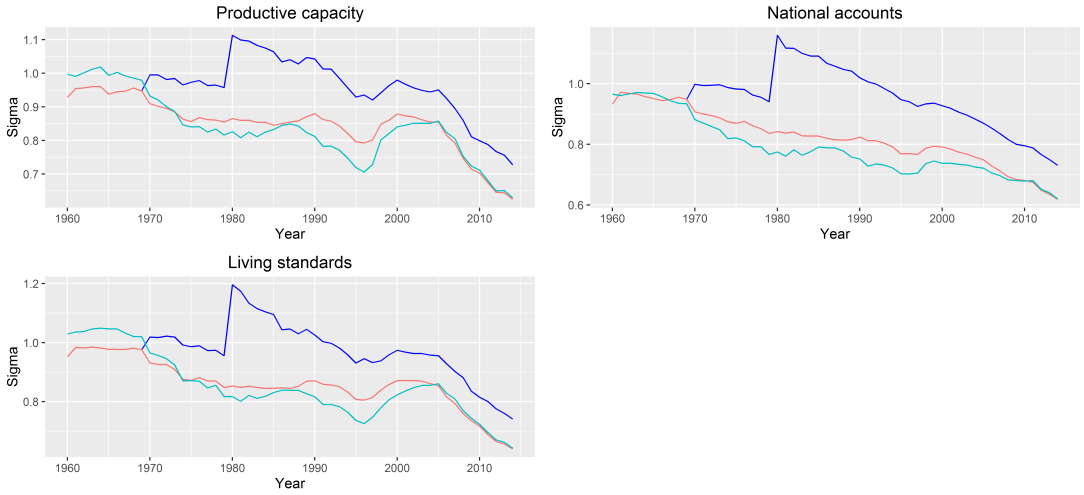
Note: The green line represents the standard deviation of the OECD founders, $N = 20$. The red line represents OECD countries covered for all years, $N = 28$. The blue line represents all OECD countries provided in a particular year, $1960 \rightarrow: N = 28, 1970 \rightarrow: N = 30, 1990 \rightarrow: N = 34$.

Figure 3: EU founders and all EU countries, standard deviation of productivity



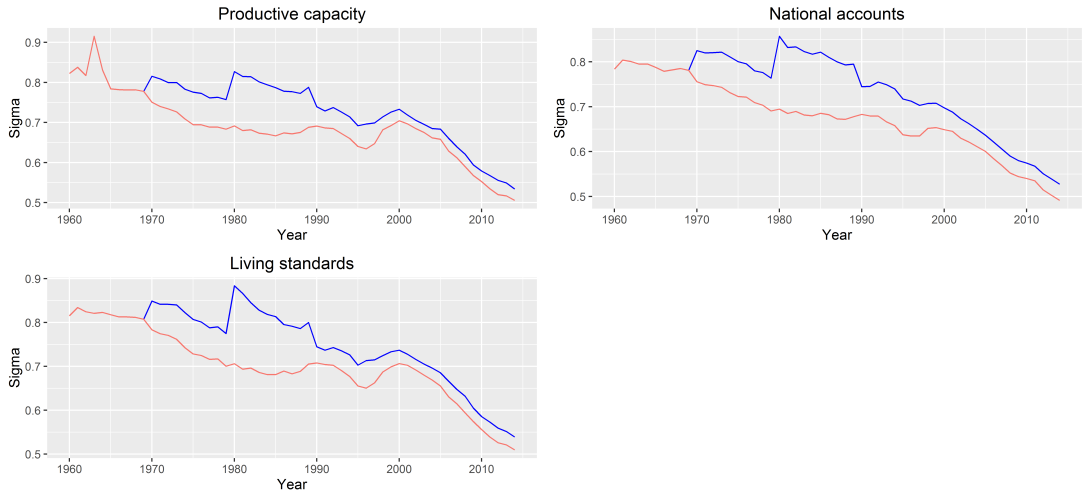
Note: The green line represents the standard deviation of the EU founders, $N = 15$. The red line represents EU countries covered for all years, $N = 18$. The blue line represents all EU countries provided in a particular year, $1960 \rightarrow: N = 18, 1970 \rightarrow: N = 21, 1990 \rightarrow: N = 28$.

Figure 4: APEC founders and all APEC countries, standard deviation of productivity



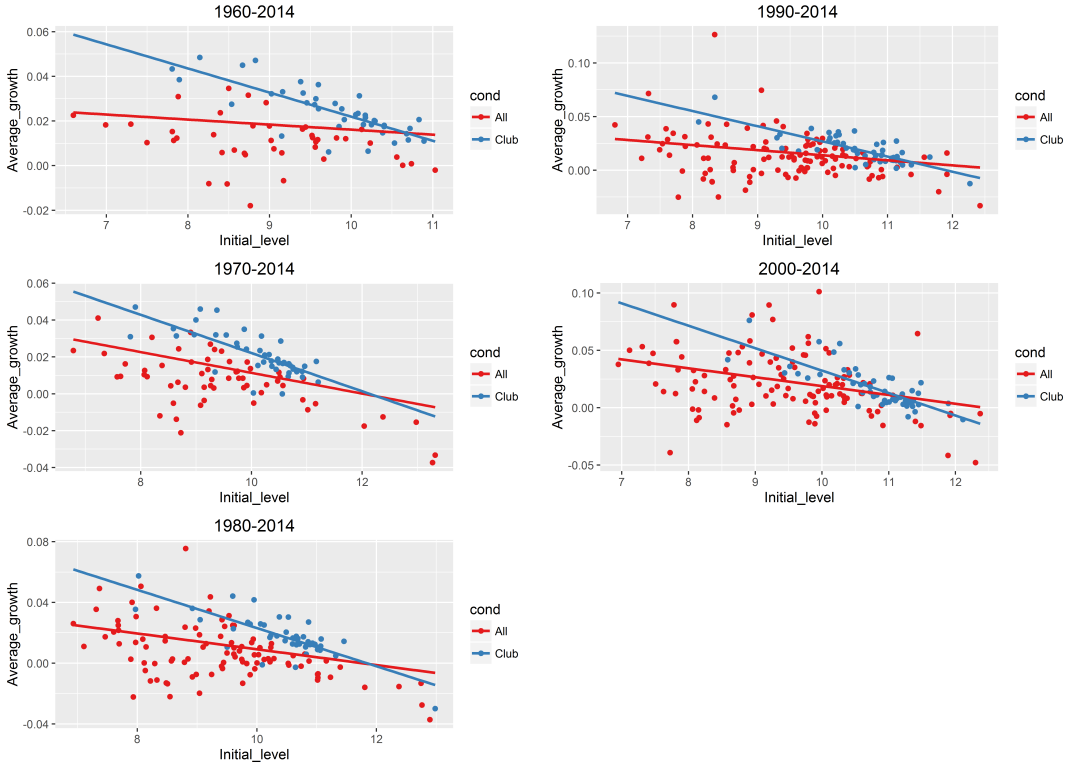
Note: The green line represents the standard deviation of the APEC founders, $N = 12$. The red line represents APEC countries covered for all years, $N = 17$. The blue line represents all APEC countries provided in a particular year, $1960 \rightarrow: N = 17, 1970 \rightarrow: N = 18, 1980 \rightarrow: N = 19, 1990 \rightarrow: N = 20$. Actually the green line represents the sample of APEC founders except Brunei Darussalam which is excluded since it's data is available only after 1980. If included the line jumps as the blue line at 1979-1980.

Figure 5: OECD, EU and APEC, standard deviation of productivity



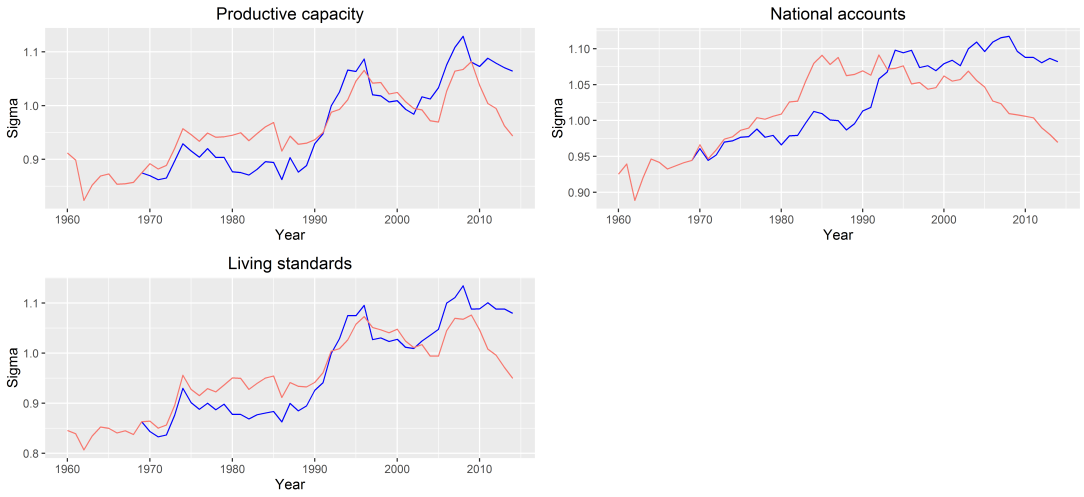
Note: The red line represents OECD, APEC and EU countries covered for all years, $N = 40$. The blue line represents all OECD, APEC and EU countries provided in a particular year, $1960 \rightarrow: N = 40, 1970 \rightarrow: N = 44, 1980 \rightarrow: N = 45, 1990 \rightarrow: N = 53$.

Figure 6: All countries vs. OECD, EU and APEC, β-convergence



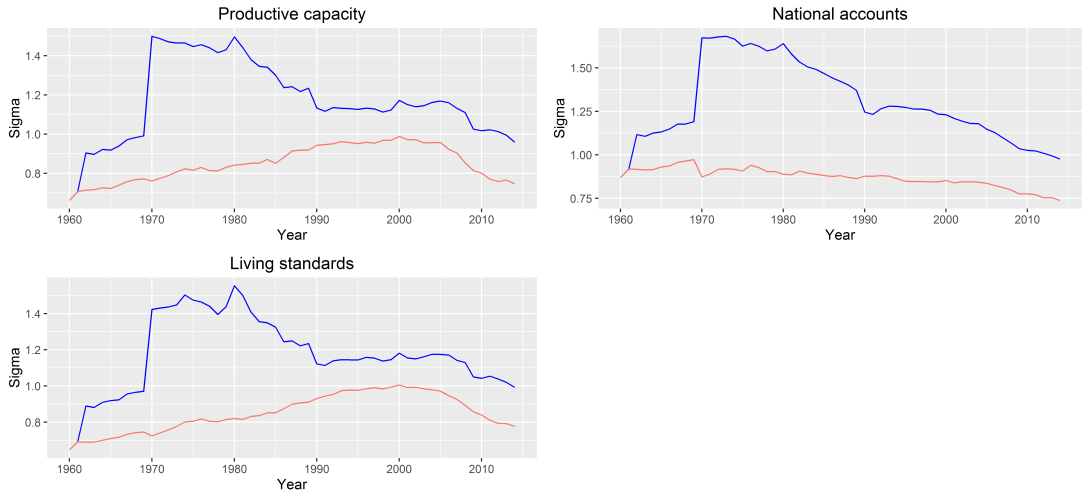
Note: All (red dots and blue dots): $N = 82, 103, 142, 166, 169$; OECD, EU and APEC (blue dots): $N = 40, 44, 45, 53, 53$.

Figure 7: Africa, standard deviation of productivity



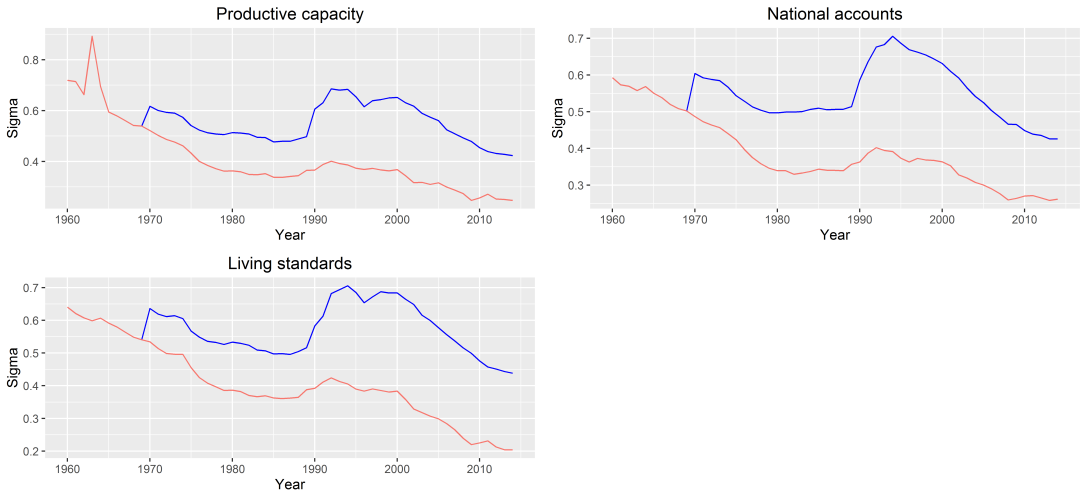
Note: The red line represents countries of Africa covered for all years, $N = 22$. The blue line represents all countries of Africa provided in a particular year, $1960 \rightarrow: N = 22, 1970 \rightarrow: N \simeq 24, 1980 \rightarrow: N \simeq 49, 2000 \rightarrow: N = 50$.

Figure 8: Asia, standard deviation of productivity



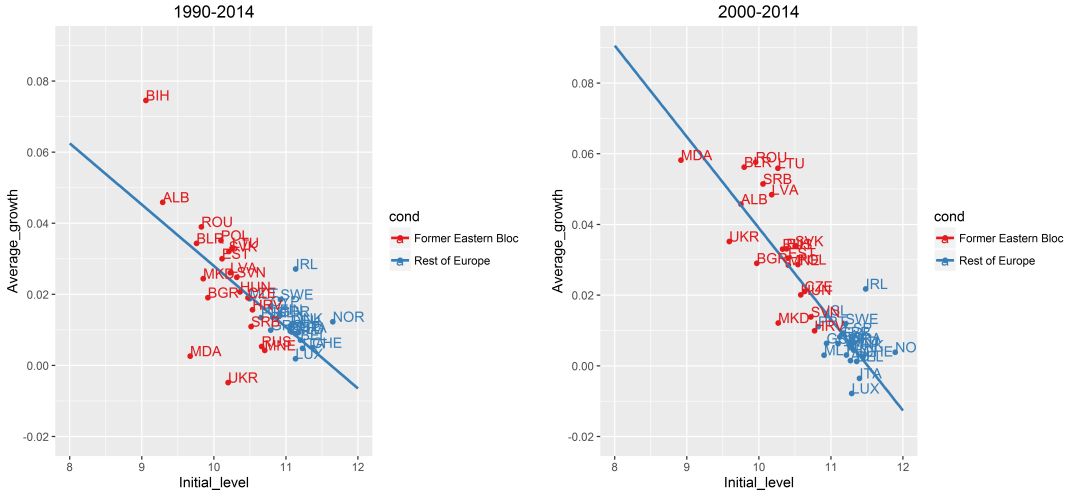
Note: The red line represents countries of Asia covered for all years, $N = 19$. The blue line represents all countries of Asia provided in a particular year, $1960 \rightarrow: N \simeq 19, 1970 \rightarrow: N = 29, 1980 \rightarrow: N \simeq 36, 1990 \rightarrow: N \simeq 46$.

Figure 9: Europe, standard deviation of productivity



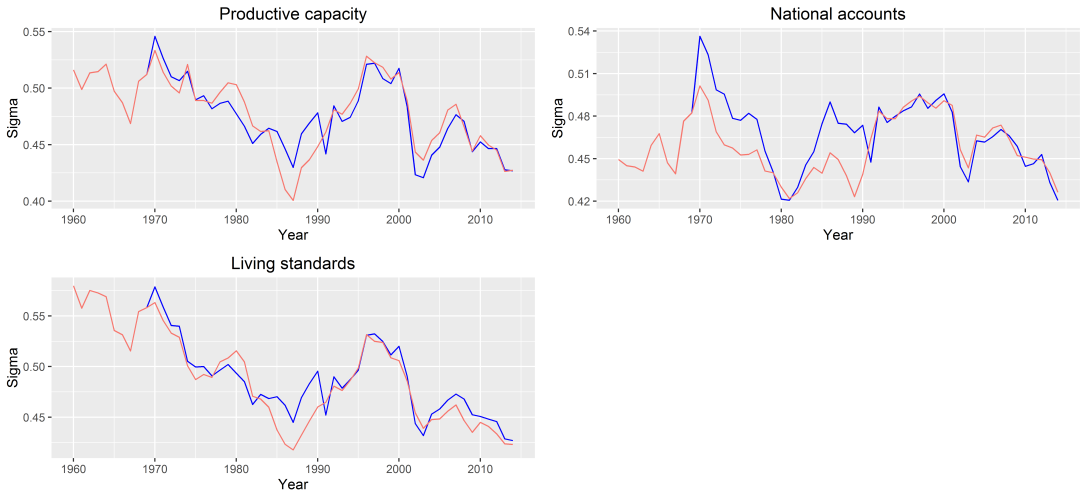
Note: The red line represents countries of Europe covered for all years, $N = 21$. The blue line represents all countries of Europe provided in a particular year, $1960 \rightarrow: N = 21, 1970 \rightarrow: N = 25, 1990 \rightarrow: N = 40$.

Figure 10: Europe - East and West, National accounts GDP, β-regression



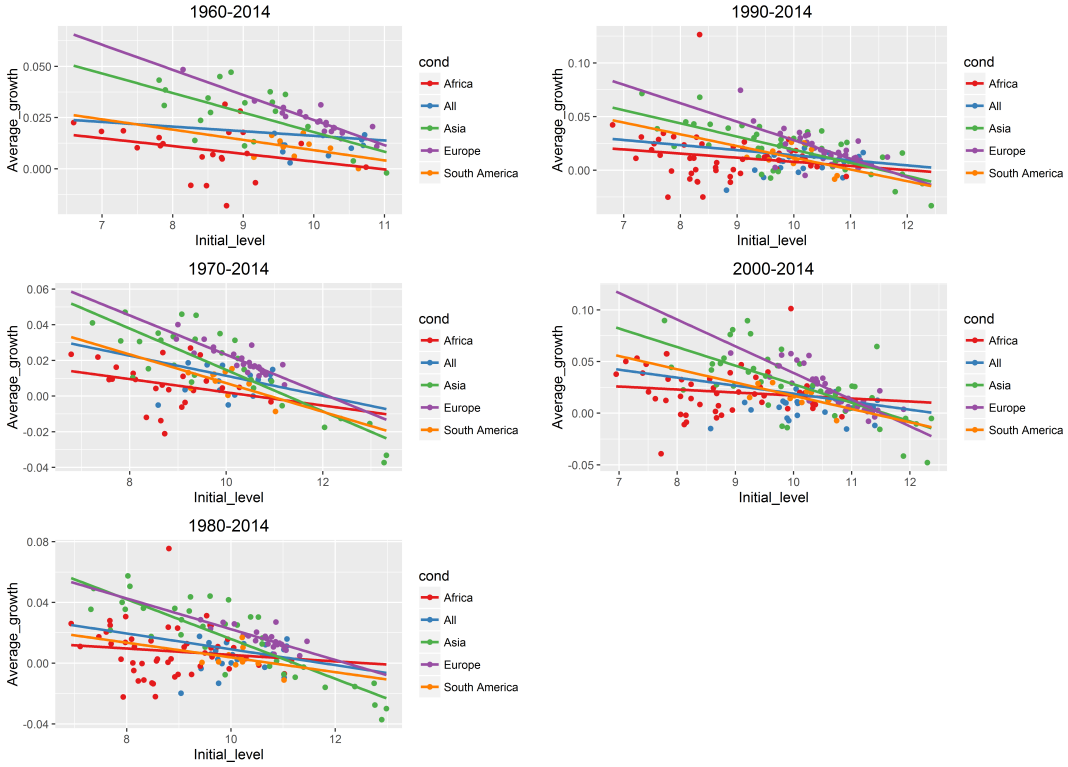
Note: East Europe (red): $N = 20$; West Europe (blue): $N = 20$.

Figure 11: South America, standard deviation of productivity



Note: The red line represents countries of South America covered for all years, $N = 9$. The blue line represents all countries of South America provided in a particular year, $1960 \rightarrow: N = 9, 1970 \rightarrow: N = 10, 1980 \rightarrow: N = 11$.

Figure 12: All vs. Continents, National accounts GDP, β-convergence



Note: All (blue line, all dots), Africa (red), Asia (green), Europe (purple), South America (orange).

Table 1: World σ-tests

World		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	-2.38 (0.99)	0.77 (0.22)	0.16 (0.44)	-0.20 (0.58)	1.56 (0.06)
	Likelihood	4.00 (0.05)	0.63 (0.43)	0.03 (0.87)	0.04 (0.84)	3.52 (0.06)
	Wald	4.55 (0.03)	0.48 (0.49)	0.02 (0.89)	0.03 (0.86)	2.57 (0.11)
Liv. stand.	Adjusted ROV	-3.64 (1.00)	0.03 (0.49)	0.21 (0.42)	-0.72 (0.76)	1.42 (0.08)
	Likelihood	6.41 (0.01)	0 (0.97)	0.05 (0.83)	0.44 (0.51)	2.91 (0.09)
	Wald	7.62 (0.01)	0 (0.98)	0.03 (0.86)	0.36 (0.55)	2.04 (0.15)
Nat. Acc.	Adjusted ROV	-1.86 (0.97)	1.81 (0.03)	1.61 (0.05)	1.12 (0.13)	2.34 (0.01)
	Likelihood	2.47 (0.12)	3.68 (0.05)	3.24 (0.07)	1.62 (0.20)	12.19 (0.00)
	Wald	2.57 (0.11)	2.5 (0.11)	2.06 (0.15)	1.22 (0.27)	8.69 (0.00)
	N	82	103	142	166	169

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 2: OECD countries σ-tests

OECD		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	6.68 (0.00)	5.31 (0.00)	3.08 (0.00)	2.37 (0.01)	2.46 (0.01)
	Likelihood	10.29 (0.00)	8.78 (0.00)	4.88 (0.03)	4.49 (0.03)	6.85 (0.01)
	Wald	48.35 (0.00)	46.14 (0.00)	33.73 (0.00)	37.45 (0.00)	60.89 (0.00)
Liv. stand.	Adjusted ROV	7.88 (0.00)	6.7 (0.00)	4.39 (0.00)	3.62 (0.00)	3.43 (0.00)
	Likelihood	12.62 (0.00)	12.15 (0.00)	8.29 (0.00)	9.35 (0.00)	12.27 (0.00)
	Wald	59.8 (0.00)	64.83 (0.00)	55.61 (0.00)	79.72 (0.00)	117.43 (0.00)
Nat. Acc.	Adjusted ROV	5.74 (0.00)	4.34 (0.00)	2.75 (0.00)	3.48 (0.00)	2.34 (0.01)
	Likelihood	9.81 (0.00)	8.11 (0.00)	4.88 (0.03)	10.87 (0.00)	9.41 (0.00)
	Wald	49.6 (0.00)	47.12 (0.00)	35.28 (0.00)	80.42 (0.00)	86.79 (0.00)
	N	28	30	30	34	34

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 3: EU all countries, σ-tests

EU		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	22.04 (0.00)	8.38 (0.00)	4.09 (0.00)	4.05 (0.00)	5.48 (0.00)
	Likelihood	30.28 (0.00)	19.45 (0.00)	8.75 (0.00)	10.14 (0.00)	16.8 (0.00)
	Wald	174.76 (0.00)	91.33 (0.00)	50.69 (0.00)	71.02 (0.00)	111.78 (0.00)
Liv. stand.	Adjusted ROV	20.69 (0.00)	9.57 (0.00)	5.20 (0.00)	5.36 (0.00)	7.03 (0.00)
	Likelihood	32.24 (0.00)	24.13 (0.00)	14.03 (0.00)	16.33 (0.00)	27.12 (0.00)
	Wald	252.37 (0.00)	124.79 (0.00)	85.89 (0.00)	116.18 (0.00)	203.55 (0.00)
Nat. Acc.	Adjusted ROV	11.86 (0.00)	6.65 (0.00)	2.65 (0.00)	4.64 (0.00)	5.08 (0.00)
	Likelihood	20.00 (0.00)	18.64 (0.00)	6.85 (0.01)	16.78 (0.00)	19.94 (0.00)
	Wald	129.28 (0.00)	103.13 (0.00)	50.34 (0.00)	124.38 (0.00)	149.33 (0.00)
	N	18	21	21	28	28

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 4: APEC, σ-tests

APEC		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	2.75 (0.00)	2.39 (0.01)	3.32 (0.00)	3.17 (0.00)	2.63 (0.00)
	Likelihood	3.49 (0.06)	4.23 (0.04)	9.96 (0.00)	16.85 (0.00)	17.87 (0.00)
	Wald	4.58 (0.03)	4.91 (0.03)	11.04 (0.00)	26.07 (0.00)	32.39 (0.00)
Liv. stand.	Adjusted ROV	2.73 (0.00)	2.33 (0.01)	3.8 (0.00)	2.8 (0.00)	2.43 (0.01)
	Likelihood	3.35 (0.07)	3.74 (0.05)	9.45 (0.00)	12.3 (0.00)	17.76 (0.00)
	Wald	4.17 (0.04)	4.07 (0.04)	8.91 (0.00)	16.97 (0.00)	32.44 (0.00)
Nat. Acc.	Adjusted ROV	2.84 (0.00)	2.35 (0.01)	3.59 (0.00)	2.85 (0.00)	2.14 (0.02)
	Likelihood	3.38 (0.07)	3.48 (0.06)	8.37 (0.00)	11.56 (0.00)	14.82 (0.00)
	Wald	4.38 (0.04)	3.91 (0.05)	8.11 (0.00)	15.76 (0.00)	27.13 (0.00)
	N	17	18	19	20	20

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 5: OECD, EU and APEC, σ-tests

OECD, EU, APEC		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	5.68 (0.00)	4.2 (0.00)	4.45 (0.00)	4.48 (0.00)	4.44 (0.00)
	Likelihood	13.85 (0.00)	13.5 (0.00)	19.44 (0.00)	27.55 (0.00)	33.44 (0.00)
	Wald	24.79 (0.00)	23.98 (0.00)	36.03 (0.00)	67.02 (0.00)	88.24 (0.00)
Liv. stand.	Adjusted ROV	5.42 (0.00)	4.59 (0.00)	5.26 (0.00)	4.43 (0.00)	4.39 (0.00)
	Likelihood	13.29 (0.00)	15.21 (0.00)	21.85 (0.00)	27.21 (0.00)	36.08 (0.00)
	Wald	23.98 (0.00)	25.5 (0.00)	36.59 (0.00)	65.03 (0.00)	97.03 (0.00)
Nat. Acc.	Adjusted ROV	5.38 (0.00)	4.67 (0.00)	5.15 (0.00)	4.82 (0.00)	3.97 (0.00)
	Likelihood	13.17 (0.00)	15.44 (0.00)	21.89 (0.00)	33.89 (0.00)	36.03 (0.00)
	Wald	25.68 (0.00)	27.47 (0.00)	38.98 (0.00)	87.09 (0.00)	107.99 (0.00)
	N	40	44	45	53	53

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 6: World, OECD, EU and APEC, β-convergence (NLS)

		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
World	Prod. cap.	-0.002	-0.004***	-0.004***	-0.005**	-0.008***
	Liv. stand.	-0.001	-0.004**	-0.004***	-0.004*	-0.007***
	Nat. acc.	-0.002*	-0.005***	-0.005***	-0.004***	-0.007***
	N	82	103	142	166	169
OECD	Prod. cap.	-0.011***	-0.013***	-0.014***	-0.014***	-0.019***
	Liv. stand.	-0.011***	-0.012***	-0.014***	-0.015***	-0.022***
	Nat. acc.	-0.010***	-0.011***	-0.012***	-0.014***	-0.016***
	N	28	30	30	34	34
OECD founders	Prod. cap.	-0.011***	-0.013***	-0.013***	-0.014***	-0.017**
	Liv. stand.	-0.010***	-0.011***	-0.013***	-0.014***	-0.019***
	Nat. acc.	-0.009***	-0.008***	-0.009***	-0.007**	-0.009*
	N	20	20	20	20	20
EU	Prod. cap.	-0.011***	-0.011***	-0.012***	-0.016***	-0.029***
	Liv. stand.	-0.010***	-0.011***	-0.012***	-0.017***	-0.03***
	Nat. acc.	-0.010***	-0.010***	-0.009***	-0.015***	-0.026***
	N	18	21	21	28	28
EU core	Prod. cap.	-0.011***	-0.014***	-0.016***	-0.017***	-0.026***
	Liv. stand.	-0.010***	-0.011***	-0.013***	-0.015***	-0.021***
	Nat. acc.	-0.009***	-0.010***	-0.010***	-0.009	-0.005
	N	15	15	15	15	15
APEC	Prod. cap.	-0.008***	-0.008***	-0.010***	-0.012***	-0.017***
	Liv. stand.	-0.009***	-0.008***	-0.011***	-0.011***	-0.016***
	Nat. acc.	-0.009***	-0.009***	-0.011***	-0.012***	-0.015***
	N	17	18	19	20	20
APEC founders	Prod. cap.	-0.008***	-0.008***	-0.010***	-0.010***	-0.016***
	Liv. stand.	-0.008***	-0.009***	-0.012***	-0.011***	-0.014***
	Nat. acc.	-0.008***	-0.008***	-0.012***	-0.011***	-0.013***
	N	12	12	13	13	13
OECD, EU and APEC	Prod. cap.	-0.009***	-0.008***	-0.010***	-0.012***	-0.019***
	Liv. stand.	-0.009***	-0.008***	-0.011***	-0.012***	-0.019***
	Nat. acc.	-0.009***	-0.009***	-0.010***	-0.012***	-0.017***
	N	40	44	45	53	53

Note: The estimates are from the NLS β-regressions (3). The significance levels are appointed accordingly: $0.1^{*}, 0.05^{**}, 0.01^{***}$. The standard errors of the coefficients (not shown) are heteroscedasticity robust (White, 1980) whereas the associated p-values are from the T distribution with $N-2$ degrees of freedom.

Table 7: Africa, σ-tests

Africa		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	-0.22 (0.59)	-0.68 (0.75)	-2.10 (0.98)	-1.19 (0.88)	-1.05 (0.85)
	Likelihood	0.04 (0.84)	0.35 (0.56)	3.00 (0.08)	1.25 (0.26)	0.65 (0.42)
	Wald	0.05 (0.82)	0.46 (0.50)	4.02 (0.04)	1.47 (0.23)	0.64 (0.42)
Liv. stand.	Adjusted ROV	-0.77 (0.78)	-1.10 (0.86)	-2.31 (0.99)	-1.38 (0.92)	-0.91 (0.82)
	Likelihood	0.50 (0.48)	0.74 (0.39)	3.41 (0.06)	1.62 (0.20)	0.53 (0.47)
	Wald	0.70 (0.40)	1.05 (0.30)	4.60 (0.03)	1.93 (0.17)	0.51 (0.48)
Nat. Acc.	Adjusted ROV	-0.35 (0.64)	-0.02 (0.51)	-1.61 (0.95)	-0.74 (0.77)	-0.06 (0.53)
	Likelihood	0.10 (0.75)	0.00 (0.99)	1.42 (0.23)	0.40 (0.53)	0.00 (0.95)
	Wald	0.12 (0.73)	0.00 (0.98)	1.54 (0.21)	0.39 (0.53)	0.00 (0.95)
	N	22	24	49	49	50

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 8: Asia, σ-tests

Asia		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	-0.66 (0.74)	4.51 (0.00)	4.85 (0.00)	2.44 (0.01)	2.61 (0.00)
	Likelihood	0.39 (0.53)	13.13 (0.00)	26.37 (0.00)	8.41 (0.00)	12.42 (0.00)
	Wald	0.90 (0.34)	7.56 (0.01)	17.91 (0.00)	7.24 (0.01)	10.46 (0.00)
Liv. stand.	Adjusted ROV	-1.00 (0.84)	3.66 (0.00)	5.03 (0.00)	1.81 (0.03)	2.29 (0.01)
	Likelihood	0.88 (0.35)	9.62 (0.00)	23.66 (0.00)	4.12 (0.04)	9.55 (0.00)
	Wald	2.17 (0.14)	5.73 (0.02)	14.25 (0.00)	3.44 (0.06)	7.65 (0.01)
Nat. Acc.	Adjusted ROV	0.97 (0.17)	5.91 (0.00)	5.88 (0.00)	3.49 (0.00)	3.02 (0.00)
	Likelihood	0.66 (0.42)	19.03 (0.00)	28.45 (0.00)	19.51 (0.00)	17.84 (0.00)
	Wald	0.88 (0.35)	9.95 (0.00)	16.68 (0.00)	15.95 (0.00)	14.55 (0.00)
	N	19	29	36	45	46

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 9: Europe, σ-tests

Europe		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	17.71 (0.00)	6.25 (0.00)	3.71 (0.00)	3.83 (0.00)	5.42 (0.00)
	Likelihood	27.31 (0.00)	15.61 (0.00)	9.13 (0.00)	9.12 (0.00)	32.19 (0.00)
	Wald	120.78 (0.00)	59.19 (0.00)	42.71 (0.00)	28.11 (0.00)	120.1 (0.00)
Liv. stand.	Adjusted ROV	21.03 (0.00)	7.84 (0.00)	4.99 (0.00)	2.99 (0.00)	5.71 (0.00)
	Likelihood	33.26 (0.00)	22.32 (0.00)	16.01 (0.00)	7.02 (0.01)	42.59 (0.00)
	Wald	226.96 (0.00)	94.33 (0.00)	82.06 (0.00)	22.7 (0.00)	169.52 (0.00)
Nat. Acc.	Adjusted ROV	10.09 (0.00)	5.49 (0.00)	3.14 (0.00)	3.52 (0.00)	4.94 (0.00)
	Likelihood	20.53 (0.00)	18.92 (0.00)	12.14 (0.00)	10.11 (0.00)	35.97 (0.00)
	Wald	106.98 (0.00)	81.23 (0.00)	65.2 (0.00)	33.67 (0.00)	151.33 (0.00)
	N	21	25	25	40	40

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 10: South America, σ-tests

		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Prod. cap.	Adjusted ROV	0.83 (0.2)	1.10 (0.14)	0.54 (0.29)	0.66 (0.26)	1.29 (0.10)
	Likelihood	0.41 (0.52)	0.79 (0.37)	0.22 (0.64)	0.41 (0.52)	3.73 (0.05)
	Wald	1.60 (0.21)	2.80 (0.09)	0.97 (0.32)	1.82 (0.18)	17.47 (0.00)
Liv. stand.	Adjusted ROV	1.53 (0.06)	1.51 (0.07)	0.71 (0.24)	0.82 (0.21)	1.31 (0.10)
	Likelihood	1.20 (0.27)	1.37 (0.24)	0.37 (0.54)	0.59 (0.44)	3.65 (0.06)
	Wald	3.90 (0.05)	4.49 (0.03)	1.54 (0.21)	2.51 (0.11)	16.83 (0.00)
Nat. Acc.	Adjusted ROV	0.25 (0.40)	1.05 (0.15)	0.01 (0.49)	0.66 (0.26)	1.13 (0.13)
	Likelihood	0.04 (0.83)	0.82 (0.36)	0.00 (0.99)	0.38 (0.54)	2.99 (0.08)
	Wald	0.22 (0.64)	3.03 (0.08)	0.00 (0.98)	1.73 (0.19)	14.6 (0.00)
	N	9	10	11	11	11

Note: The statistics of the σ-tests and the associated p-values in parenthesis.

Table 11: Continents, β-convergence (NLS)

		1960-2014	1970-2014	1980-2014	1990-2014	2000-2014
Africa	Prod. cap.	-0.005***	-0.003**	-0.004	-0.008	-0.004
	Liv. stand.	-0.004*	-0.002	-0.003	-0.008	-0.005
	Nat. acc.	-0.003***	-0.003**	-0.002	-0.004*	-0.003
	N	22	24	49	49	50
Asia	Prod. cap.	-0.005**	-0.009***	-0.010***	-0.010***	-0.015***
	Liv. stand.	-0.004*	-0.008***	-0.010***	-0.009***	-0.014***
	Nat. acc.	-0.008***	-0.009***	-0.011***	-0.011***	-0.016***
	N	19	29	36	45	46
Europe	Prod. cap.	-0.010***	-0.010***	-0.011***	-0.017***	-0.024***
	Liv. stand.	-0.010***	-0.010***	-0.011***	-0.015***	-0.024***
	Nat. acc.	-0.009***	-0.009***	-0.009***	-0.014***	-0.022***
	N	21	25	25	40	40
South America	Prod. cap.	-0.007**	-0.008**	-0.009**	-0.009**	-0.013**
	Liv. stand.	-0.007**	-0.008***	-0.009**	-0.010**	-0.014**
	Nat. acc.	-0.004	-0.007*	-0.004	-0.010*	-0.012**
	N	9	10	11	11	11
ASEAN	Prod. cap.	-0.003	-0.001	-0.009***	-0.01***	-0.014***
	Liv. stand.	-0.003	0	-0.01***	-0.009***	-0.014***
	Nat. acc.	-0.006	-0.002	-0.01***	-0.011***	-0.015***
	N	5	8	10	10	10
South and Middle Am.	Prod. cap.	-0.008***	-0.007***	-0.013***	-0.016***	-0.015*
	Liv. stand.	-0.008***	-0.008***	-0.013***	-0.015***	-0.014*
	Nat. acc.	-0.004	-0.005*	-0.001	-0.003	-0.004
	N	12	15	19	19	19
Eurasia	Prod. cap.	-0.006***	-0.009***	-0.009***	-0.01***	-0.017***
	Liv. stand.	-0.006***	-0.008***	-0.009***	-0.009***	-0.016***
	Nat. acc.	-0.007***	-0.009***	-0.01***	-0.011***	-0.016***
		40	54	61	85	86
World without Africa	Prod. cap.	-0.007***	-0.008***	-0.008***	-0.01***	-0.016***
	Liv. stand.	-0.007***	-0.007***	-0.009***	-0.009***	-0.015***
	Nat. acc.	-0.007***	-0.008***	-0.009***	-0.009***	-0.014***
	N	60	79	93	117	119

Note: The estimates are from the NLS β-regressions (3). The significance levels are appointed accordingly: $0.1^{*}, 0.05^{**}, 0.01^{***}$. The standard errors of the coefficients (not shown) are heteroscedasticity robust (White, 1980) whereas the associated p-values are from the T distribution with $N - 2$ degrees of freedom.

A Appendix

Table 12: Country groups 1

OECD	**OECD founders**	**EU**	**Core EU**	**EU canditates**	**Apec**	**Apec founders**
Australia	-	Austria	Austria	Albania	Australia	Australia
Austria	Austria	Belgium	Belgium	Iceland	Brunei Darussalam	Brunei Darussalam
Belgium	Belgium	Bulgaria	-	Macedonia	Canada	Canada
Canada	Canada	Croatia	-	Montenegro	Chile	-
Chile	-	Cyprus	-	Serbia	Hong Kong	-
Czech Republic	-	Czech Republic	-	Turkey	Indonesia	Indonesia
Denmark	Denmark	Denmark	Denmark		Japan	Japan
Estonia	-	Estonia	-	**Former Eastern bloc**	Malaysia	Malaysia
Finland	-	Finland	Finland	Albania	Mexico	-
France	France	France	France	Belarus	New Zealand	New Zealand
Germany	Germany	Germany	Germany	Bosnia and Herzegovina	People's Republic of China	-
Greece	Greece	Greece	Greece	Bulgaria	Peru	-
Hungary	-	Hungary	-	Croatia	Philippines	Philippines
Iceland	Iceland	Ireland	Ireland	Czech Republic	Russian Federation	-
Ireland	Ireland	Italy	Italy	Estonia	Singapore	Singapore
Israel	-	Latvia	-	Hungary	South Korea	South Korea
Italy	Italy	Lithuania	-	Latvia	Thailand	Thailand
Japan	-	Luxembourg	Luxembourg	Lithuania	United States	United States
Korea	-	Malta	-	Macedonia	Vietnam	-
Luxembourg	Luxembourg	Netherlands	Netherlands	Moldova	Taiwan	-
Mexico	-	Poland	-	Montenegro		
Netherlands	Netherlands	Portugal	Portugal	Poland	**Excluded since no data**	
New Zealand	-	Romania	-	Romania	Papua New Guinea	
Norway	Norway	Slovakia	-	Russia		
Poland	-	Slovenia	-	Serbia		
Portugal	Portugal	Spain	Spain	Slovakia		
Slovakia	-	Sweden	Sweden	Slovenia		
Slovenia	-	United Kingdom	United Kingdom	Ukraine		
Spain	Spain					
Sweden	Sweden					
Switzerland	Switzerland					
Turkey	Turkey					
United Kingdom	United Kingdom					
United States	United States					
$N = 34$	$N = 20$	$N = 28$	$N = 15$	$N = 6, N = 20$	$N = 21$	$N = 13$

Table 13: Country groups 2

Afrika	**Asia**	**Europe**	**South America**	**Not included**
	Armenia	Austria	Argentina	Australia
North-South-West	Azerbaijan	Belgium	Bolivia	Fiji
Algeria	Bahrain	Cyprus	Brazil	New Zealand
Benin	Bangladesh	Denmark	Chile	
Botswana	Bhutan	Finland	Colombia	Canada
Burkina Faso	China	France	Ecuador	United States
Cape Verde Islands	Georgia	Germany	Paraguay	
Egypt	Hong Kong	Greece	Peru	
Gambia	India	Iceland	Suriname	
Ghana	Iran	Ireland	Uruguay	
Guinea	Iraq	Italy	Venezuela	
Guinea-Bissau	Israel	Luxembourg		
Ivory Coast	Japan	Malta	**Middle America**	
Lesotho	Jordan	Netherlands	Belize	
Liberia	Kazakhstan	Norway	Costa Rica	
Mali Republic	South Korea	Portugal	El Salvador	
Mauritania	Kuwait	Spain	Guatemala	
Morocco	Kyrgyzstan	Sweden	Honduras	
Namibia	Lebanon	Switzerland	Mexico	
Niger Republic	Macau	United Kingdom	Nicaragua	
Nigeria	Maldives		Panama	
Senegal Republic	Mongolia	**East-Europe**		
Sierra Leone	Nepal	Albania	**Middle (islands)**	
South Africa	Oman	Belarus	Anguilla	
Sudan	Pakistan	Bosnia and Herzegovina	Antigua and Barbuda	
Swaziland	Qatar	Bulgaria	Aruba	
Togo	Saudi Arabia	Croatia	Bahamas	
Tunisia	Sri Lanka	Czech Republic	Barbados	
	State of Palestine	Estonia	Bermuda	
East-Central	Syria	Hungary	British Virgin Islands	
Angola	Taiwan	Latvia	Cayman Islands	
Burundi	Tajikistan	Lithuania	Curacao	
Cameroon	Turkey	Macedonia	Dominica	
Central African Republic	Turkmenistan	Moldova	Dominican Republic	
Chad Republic	United Arab Emirates	Montenegro	Grenada	
Comoros	Uzbekistan	Poland	Haiti	
Congo	Yemen	Romania	Jamaica	
Dem. Republic of the Congo		Russia	Montserrat	
Djibouti	**ASEAN**	Serbia	Saint Kitts and Nevis	
Equatorial Guinea	Brunei	Slovakia	Saint Lucia	
Ethiopia	Cambodia	Slovenia	Sint Maarten	
Gabon Republic	Indonesia	Ukraine	St. Vincent and the Grenadines	
Kenya	Laos	Ukraine	Trinidad and Tobago	
Madagascar	Malaysia		Turks and Caicos Islands	
Malawi	Myanmar			
Mauritius	Philippines			
Mozambique	Singapore			
Rwanda	Thailand			
Sao Tome and Principe	Vietnam			
Seychelles				
Tanzania				
Uganda				
Zambia				
Zimbabwe				
$N = 50$	$N = 47$	$N = 40$	$N = 40$	$N = 5$

[1] Note: For Anguilla, Antigua and Barbuda, Bermuda, British Virgin Islands, Cayman Islands, Curacao, Dominica, Grenada, Montserrat, Saint Kitts and Nevis, Sint Maarten and Turks and Caicos Islands employment data is short of necessary years mainly 2014.

Table 14: Balanced panel estimates for β, time dummies

Prod. cap.	Value	3 Years	5 Years	10 Years	Liv. Stand.	Value	3 Years	5 Years	10 Years	Nat. Acc.	Value	3 Years	5 Years	10 Years
World	Beta	-0.004**	-0.007***	-0.008***		Beta	-0.003	-0.005***	-0.007***		Beta	-0.003**	-0.006***	-0.006***
	N	1351	676	338		N	1351	676	338		N	1351	676	338
OECD	Beta	-0.016**	-0.014***	-0.015***		Beta	-0.019***	-0.017***	-0.019***		Beta	-0.017***	-0.019***	-0.02***
	N	272	136	68		N	272	136	68		N	272	136	68
EU	Beta	-0.023***	-0.03***	-0.029***		Beta	-0.024***	-0.03***	-0.03***		Beta	-0.021***	-0.029***	-0.03***
	N	224	112	56		N	224	112	56		N	224	112	56
APEC	Beta	-0.012***	-0.016***	-0.014***		Beta	-0.011***	-0.013***	-0.013***		Beta	-0.013***	-0.014***	-0.013***
	N	160	80	40		N	160	80	40		N	160	80	40
OECD, EU, APEC	Beta	-0.014***	-0.016***	-0.016***		Beta	-0.013***	-0.014***	-0.015***		Beta	-0.014***	-0.016***	-0.016***
	N	424	212	106		N	424	212	106		N	424	212	106
Europe	Beta	-0.026**	-0.027***	-0.024***		Beta	-0.02**	-0.026***	-0.024***		Beta	-0.023***	-0.027***	-0.026***
	N	320	160	80		N	320	160	80		N	320	160	80
Africa	Beta	-0.002	-0.008**	-0.012**		Beta	0.001	-0.007*	-0.011**		Beta	-0.001	-0.003	-0.005
	N	399	200	100		N	399	200	100		N	399	200	100
Asia	Beta	-0.011***	-0.016***	-0.013***		Beta	-0.008**	-0.013***	-0.012***		Beta	-0.011***	-0.015***	-0.014***
	N	368	184	92		N	368	184	92		N	368	184	92
South America	Beta	-0.013***	-0.016***	-0.010***		Beta	-0.013*	-0.015**	-0.011***		Beta	-0.009	-0.009	-0.01*
	N	88	44	22		N	88	44	22		N	88	44	22
Eurasia	Beta	-0.012***	-0.016***	-0.014***		Beta	-0.009***	-0.013***	-0.013***		Beta	-0.011***	-0.015***	-0.014***
	N	672	336	168		N	672	336	168		N	672	336	168

Note: The estimates are from the balanced panel β-regressions including time dummies. The data sample spans the period 1990-2014. The significance levels are appointed accordingly: 0.1^{*}, 0.05^{**}, 0.01^{***}. The standards errors of the coefficients (not shown) are adjusted for heteroskedasticity and serial correlation Arellano (1987).

Table 15: Panel estimates for β, time dummies

Prod. cap.	Value	3 Years	5 Years	10 Years	Liv. Stand.	Value	3 Years	5 Years	10 Years	Nat. Acc.	Value	3 Years	5 Years	10 Years
World	Beta	-0.003*	-0.005***	-0.005***		Beta	-0.002	-0.004**	-0.004***		Beta	-0.003**	-0.003***	-0.004***
	N	2446	1418	669		N	2446	1418	669		N	2446	1418	669
OECD	Beta	-0.021***	-0.022***	-0.022***		Beta	-0.022***	-0.022***	-0.022***		Beta	-0.017***	-0.016***	-0.017***
	N	566	318	156		N	566	318	156		N	566	318	156
EU	Beta	-0.017***	-0.020***	-0.022***		Beta	-0.022***	-0.019***	-0.021***		Beta	-0.021***	-0.017***	-0.021***
	N	425	242	116		N	425	242	116		N	425	242	116
APEC	Beta	-0.008***	-0.012***	-0.011***		Beta	-0.009***	-0.014***	-0.013***		Beta	-0.009***	-0.012***	-0.012***
	N	340	191	94		N	340	191	94		N	340	191	94
OECD, EU, APEC	Beta	-0.009***	-0.012***	-0.012***		Beta	-0.011***	-0.013***	-0.013***		Beta	-0.010***	-0.011***	-0.012***
	N	855	483	235		N	855	483	235		N	855	483	235
Europe	Beta	-0.019***	-0.019***	-0.021***		Beta	-0.019***	-0.015***	-0.019***		Beta	-0.019***	-0.014***	-0.019***
	N	558	321	151		N	558	321	151		N	558	321	151
Africa	Beta	-0.001	-0.004	-0.007**		Beta	0.001	-0.003	-0.006*		Beta	0.000	0.000	-0.002
	N	709	417	195		N	709	417	195		N	709	417	195
Asia	Beta	-0.011***	-0.016***	-0.015***		Beta	-0.01***	-0.015***	-0.015***		Beta	-0.012***	-0.012***	-0.014***
	N	651	379	177		N	651	379	177		N	651	379	177
South America	Beta	-0.013**	-0.013**	-0.011*		Beta	-0.013**	-0.014**	-0.013**		Beta	-0.010	-0.009*	-0.009
	N	191	107	53		N	191	107	53		N	191	107	53
Eurasia	Beta	-0.010***	-0.012***	-0.012***		Beta	-0.009***	-0.011***	-0.012***		Beta	-0.011***	-0.011***	-0.012***
	N	1177	681	319		N	1177	681	319		N	1177	681	319

Note: The estimates are from the unbalanced panel β-regressions including time dummies. The data sample spans the period 1960-2014. The significance levels are appointed accordingly: $0.1^{*}, 0.05^{**}, 0.01^{***}$. The standards errors of the coefficients (not shown) are adjusted for heteroskedasticity and serial correlation Arellano (1987).