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Vadims Sarajevs

Convergence of European transition economies and the EU: What do the data show

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Convergence of European transition economies and the EU: What do the data show

Abstract

This is an empirical study of the real income convergence among the fifteen European Union members and the eleven transition economies of Central and Eastern Europe. Debates and research on EU enlargement tends to concentrate on normative issues, so empirical studies constitute a small share of published work on the subject. This empirical investigation relies on available data on transition, and employs several econometric techniques including graphic analysis, classical cross-section regression and dynamic panel data estimations. Most estimation methods find positive convergence, but estimated rates of convergence vary considerably.

JEL Classification: C80, O57
Key words: convergence, enlargement, and dynamic panel

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Vadims Sarajevs

Siirtymätalouksien ja EU-maiden lähentyminen: Mitä tiedot paljastavat?

Työssä tutkitaan Keski- ja Itä-Euroopan 11 siirtymätalotalouden ja Euroopan unionin 15 jäsenmaan reaalisten tulojen lähentymistä. Euroopan unionin laajentumisesta käytävä julkinen keskustelu sekä tutkimus keskittyvät yleensä normatiivisiin kysymyksiin, ja siten empiiriset tutkimukset muodostavat vain pienen osan tutkimustyötä. Tässä empiirisessä tutkimuksessa käytetään siirtymätalousmaista saatavia tietoja, joita analysoidaan käyttäen monia ekonometrisiä menetelmiä, kuten graafista analyysiä, klassista poikkileikkaus-regressiomallia sekä dynaamisia paneeliestimointimenetelmiä. Useiden estimointimenetelmien avulla saadut tulokset osoittavat, että tulot lähentyvät, mutta estimoidut lähentymisvauhdit vaihtelevat huomattavasti.

JEL luokittelu: C80, O57

Asiasanat: lähentyminen, laajentuminen, dynaaminen paneelimalli

1 Introduction

This paper addresses the issue of real income convergence between the EU and eleven transition economies of Central and Eastern Europe. With the exception of Albania, all these countries are accession candidates. Convergence is seen as a catching-up process, whereby these poorer economies strive for higher growth rates than their richer EU neighbours.

The lack of empirical research on convergence in transition economies is unfortunate for two reasons. First, the prospects of candidate countries' accession to the EU raises questions of convergence with the EU. Indeed, the European Commission, when assessing enlargement challenges, specifically targeted the issue of the low per-capita incomes of applicants.[1] Second, there are major policy considerations in choosing between real and nominal convergence. Transition countries that pursue rapid disinflation programs with tight fiscal and monetary polices risk impairing real per capita GDP growth and their progress in structural reforms.

Most accession candidates expect to join the EU soon (some as early as 2004), yet no specific economic conditions have been defined for the EU enlargement process. The "Copenhagen criteria" set out at the European Council's meeting in Copenhagen in June 1993 give three rather broad conditions.

- Stable institutions guaranteeing democracy, the rule of law, human rights and respect for the protection of minorities;
- A functioning market economy and capacity to cope with competitive pressures and market forces within the EU; and
- An ability to take on the obligations of membership, including adherence to the aims of political, economic and monetary union.[2]

While these conditions lack quantitative economic targets, the last condition clearly implies that accession countries should be able to join Economic and Monetary Union (EMU). Most applicant states, however, see accession as full participation in all EU initiatives, including the euro. Therefore, from an economic perspective, all of these countries must apply considerable effort to satisfy the Maastricht convergence criteria as prerequisites to joining the euro area.[3,4]

[1] See *Impact Study - Agenda 2000*: Section 2.2 Problem Areas and Risks.

[2] See European Council (1993).

[3] Temprano-Arroyo and Feldman (1999) provide an excellent overview of normative and institutional matters relevant for the EMU and EU accession.

[4] The Maastricht convergence criteria are the following (from Temprano-Arroyo and Feldman 1999, Notes to Table 3, p. 788): 1) annual consumer price inflation must not be exceed that of

In light of future costs and benefits and the optimality of EU enlargement, it is arguable that real convergence or divergence is what matters. The greater the degree of real convergence, the smoother the future functioning of the enlarged EU. When less money is needed in the form of subsidies from the rich to the poor, more money will be available for structural adjustments to help harmonisation of business cycles. Leaving aside the constructed indices for the quality of living, the ultimate benchmark for measuring convergence is the convergence in levels of real per capita income, real per capita GDP. Many researchers[5] observe that countries can meet the Maastricht convergence criteria at the expense of real convergence and progress in restructuring. The often-quoted example is the trade-off between the tight fiscal and monetary policies for rapid disinflation and the pace of real GDP growth, i.e. real per capita income convergence. Squeezing public finances into the Maastricht convergence mould can also adversely affect restructuring in areas that require considerable investment expenditures such as institutional reform, environmental protection and infrastructure. Hence, overly rapid nominal convergence to the Maastricht criteria may actually delay EU accession prospects.

There are bi-directional links between the nominal and real sides of the economy in the presence of imperfect markets and nominal rigidities, and both types of factors undoubtedly feature prominently in transition. Conventional economic wisdom, however, posits that development in the real sector is what creates the sustainable basis for nominal convergence. Therefore, the study of real convergence should be at least as important as the studies devoted to nominal convergence and institutional and legal reforms.

As a caveat, there is an obvious explanation for the lack of empirical research on real convergence in transition. Until recently, available time-series for transition countries were simply too short for anything more than simple descriptive comparisons. Even now, we found only a handful of studies related to convergence and transition. Two important studies of convergence between the EU and European transition economies are presented by Andreff (1998) and by Fisher, Sahay, and Vegh (1998a and b). Andreff (1998) studies nominal and real conver-

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the three best-performing members by more than 1.5%; 2) long-term interest rate on government securities (bonds with 10-year maturity) must be no more than 2% higher compared to those in three member states with the lowest inflation; 3) the government deficit should not exceed 3% of gross domestic product (GDP) and public debt should not exceed 60% of GDP; 4) exchange rate should be kept within the normal fluctuation bands for at least two years. For the new Exchange Rate Mechanism (ERM II) the standard fluctuation bands are ±15% vis-à-vis the euro. While these criteria are clearer than the Copenhagen criteria, Andreff (1998, pp. 117-119) notes that most of these criteria do not have the same meaning for transition economies as for developed market economies. Moreover, the EU has stated that the Maastricht criteria are *not* criteria for EU membership.

[5] Temprano-Arroyo and Feldman (1999, pp: 750-751, 769-771) and Andreff (1998, pp. 117-118, 124-125, 132).

gence combining a simple descriptive approach and a classical approach to convergence *a la* Barro and Sala-i-Martin. His data set comprised annual observations from 1990 to 1996. He found positive evidence of sigma-convergence and absolute beta-convergence for real incomes during 1992-1996. The times necessary to reduce the income gap by half ($T_{1/2}$) and by 90% were 9.8 years and 30 years, respectively. In their study of income gaps dynamics, Fisher, Sahay and Vegh (1998a and b) performed a speculative exercise for conditional beta-convergence that found it might take from 20 to 45 years for best and worst performers to reach the current average per capita income level of the OECD/EU.

Two studies apply advanced econometric techniques. Brada and Kutan (2001) use cointegration tests on monthly data to study the convergence of money supply dynamics between transition economies and that of the EU approximated by Germany. They find mixed evidence with positive results for the Czech Republic, Estonia, Slovakia and Slovenia. Kočenda (1999) studies convergence among transition countries using monthly time-series on industrial output, money aggregate (M1) and inflation from 1991 to 1998. He also applies panel unit-root test as an econometric tool. His study finds limited evidence of convergence for some groups of countries, i.e. the Czech Republic, Poland and Hungary converge in the growth of industrial output, while the Baltic states exhibit inflation convergence.[6] However, the use of high-frequency, noisy, monthly data together with not robust, low-power techniques such as cointegration and unit-root tests in assessment of an intrinsically long-term phenomenon like convergence does not seem fully appropriate.

By no means the study of real convergence is constrained to the study of real income convergence. In a recent work by Fidrmuc (2001) the convergence problem is approached from the point of view of business cycle convergence. Using six years of observations from 1993 to 1999, he concludes that although the time series are too short for a definite answer the business cycles in Hungary, Slovenia, and, to a lesser extent, Poland are strongly correlated with the business cycle in Germany.

This paper aims to contribute to the study of convergence among EU and transition economies by studying real income convergence as opposed to nominal convergence studied by Kočenda (1999) and Brada and Kutan (2001). Second, the annual time series used are longer than those of Andreff (1998). Third, convergence is studied both among the EU and the candidates and within transition country groups. Finally, a full range of statistical and econometric techniques is employed from graphic analysis, nonparametric tests, and cross-section regression to dynamic panel data estimations. Since the overwhelming majority

[6] Similar findings are reported by Richards and Tersman (1996).

of methods detect the positive convergence in the sample this finding should be quite robust.

The remainder of the paper is organised so that the second section provides definitions of convergence and describes data and the methodology of our empirical estimations. Next, we present our empirical findings and compare them with results of other research on convergence. Finally, we offer a summary and concluding remarks.

2 Convergence: Definitions, Data, Methodology

The subject of convergence is intrinsically related to the theory of growth. Its roots can be traced already in the 18th century treatises of Adam Smith on the wealth of nations. However, considerable empirical research on convergence or cross-country growth has appeared prominently only in 1980s and 1990s when large data sets of macroeconomic time-series were compiled for large groups of countries, first, by Maddison (1982) and then by Summers and Heston (1988). Many prominent researchers have contributed to this field since. In particular, we have the contributions of Barro (1991, 1997), Barro and Sala-i-Martin (1991, 1992), Sala-i-Martin (1996, 1997), Mankiw, Romer, and Weil (1992) and Mankiw (1995).[7]

2.1 Definitions

Here, we employ standard definitions of beta- and sigma-convergence as suggested by Sala-i-Martin (1996). We observe *absolute β-convergence* when "poor economies tend to grow faster than the rich ones." This definition assumes that all economies converge to the same steady-state level of per capita GDP. Let $y_{i,t}$ is country i's real GDP per capita, then the annualised growth rate of GDP between dates t and t+T can be defined as

$$\gamma_{i,t,t+T} \equiv \log\left(y_{i,t+T} \Big/ y_{i,t} \right) \cdot \frac{1}{T}.$$

The concept of *absolute β-convergence* in regression terms is given by

[7] Jones and Manuelli (1997) provide a concise survey of theoretical developments in the field of endogenous growth theory. de la Fuente (1997, 1998, and 2000) and Quah (1999) have compiled recent surveys of growth and convergence.

Equation 1 *Absolute β-convergence*

$$\gamma_{i,t,t+T} = a - b \cdot \log(y_{i,t}) + \varepsilon_{i,t+T},$$

where $b > 0$ means that there is convergence in the data set. The failure of many empirical studies to find *absolute β-convergence* leads, through the works of Barro and Sala-i-Martin (1992), and Mankiw, Romer, and Weil (1992) to a concept of *conditional β-convergence* whereby "the growth rate of an economy will be positively related to the distance that separates it from its own steady state."[8] This concept reflects the fact that neither Solow's (1956) neoclassical growth model nor its optimal savings versions by Cass (1965) and Koopmans (1965) imply convergence to the same steady state of per capita income. If economies have different technological and preference parameters, then nothing prevents them from converging to different steady states. Therefore, to investigate for the possibility of *conditional β-convergence*, one needs to include regression variables that determine the steady state:

Equation 2 *Conditional β-convergence*

$$\gamma_{i,t,t+T} = a - b \cdot \log(y_{i,t}) + \psi X_{i,t} + \varepsilon_{i,t+T},$$

where $X_{i,t}$ is a vector of variables that hold constant the steady state of the economy i, and, as before, b > 0 means that the data set exhibits *conditional β-convergence*.

The next concept to be defined is *σ-convergence*. While *β-convergence* reflects the movement of individual countries within a group, the concept of *σ-convergence* describes the evolution of income distribution of the entire group. Let σ_t be the time t standard deviation of log of real per capita GDP, then "a group of economies are converging in the sense of σ if the dispersion of their real per capita GDP levels tends to decrease over time. That is, if $\sigma_{t+T} < \sigma_t$".[9]

2.2 Data

Our data set comprises statistics on per capita GDP measured in the US dollars (USD) for fifteen current members of the EU and eleven transition economies in Central and Eastern Europe. All observations are at the annual frequency cover-

[8] Sala-i-Martin 1996, p. 1027.
[9] Sala-i-Martin 1996, p. 1020.

ing 1991 to 1999. Additionally, for all countries, we have time series on consumer price inflation, broad-money-to-GDP ratio, and depreciation of the real effective exchange rate.[10] These time series are used to hold constant the steady state of the economy with the following justification. First, we need to acknowledge the fact that these were the only time series available in full for the sample. Second, due to the short size of the sample – only nine years, many traditional variables assumed important for the long-term growth (a number of decades) do not seem relevant for our study.[11] For example, rates of *secondary school enrolment* would not show any variation over the sample as in the socialist past children had to go to school. As acknowledged by many transition economy researchers, the problem has never been a deficit of human capital, but the fact that the market economy demands different skills. Another variable, *life expectancy*, is too long-term in nature for our 9-year sample to have any impact. Finally, data on investment, foreign and domestic, although valuable and informative, start for most transition countries only in the latter half of the present sample. Where earlier data is available, it is not comparable to that of the EU due to different accounting practices.

Domestic inflation and broad-money-to-GDP ratio are used to control for domestic developments that may impact on the steady state level of per capita income. Both reflect the dynamics of macroeconomic stabilisation and development of the financial sector.[12] The depreciation of the real effective exchange rate was chosen as a summary indicator that captures the developments in the foreign sector, changes in productivity and competitiveness.

The eleven transition economies (**TE-11**) from Central and Eastern Europe are Albania, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Slovenia. They are then differentiated into five subgroups, which at least partly reflect geographical proximity, common trade and historical links. The **TE-8** subgroup comprises all the countries above except Balkan countries, Albania, Bulgaria, and Romania. **TE-5** comprises all the countries except Balkan and Baltic states, Estonia, Latvia and Lithuania. The five remaining countries, Czech Republic, Hungary, Poland, Slovak Republic, and Slovenia are founding members of CEFTA, Central European Free Trade Agreement, signed in March 1993 in recognition of their high level of mutual trade flows. Sometimes we refer to this group as the "leaders." **TE-3Balkans** comprises Albania, Bulgaria, and Romania. **TE-3Baltics** comprises Estonia, Lat-

[10] Data on GDP and inflation is from IMF. Data on broad money aggregates are from IMF and OECD. Data on real effective exchange rate are from the Bank for International Settlements for transition economies and from the IMF for EU members.

[11] Sala-i-Martin (1997) counts up to 60 variables, which appeared significant in studies on economic growth.

[12] Berthelemy and Varoudakis (1996) provide relevant discussion.

via, and Lithuania. **TE-3** includes the three transition countries with the largest GDP: Czech Republic, Hungary and Poland.

Before turning to the methodological aspects of our empirical study, we formulate its research agenda as three questions.

- Can one detect real income convergence between the EU and European transition economies?
- Can one detect the real income convergence among European transition economies?
- Do income dynamics become more similar, i.e. σ-convergence?

Given the mixed results of previous studies, the research on convergence and transition economies is still very much at the fact-finding stage.

2.3 Methodology

Panel data (time-series on a cross-section of countries) on convergence is the most precious commodity in that kind of research. Therefore, one should be careful not to ignore potentially useful information. In our investigation of the data, we pass through three stages of increasing sophistication of applied econometric technique. As a preliminary comment, we note that many studies on convergence are based on averaged macroeconomic data, usually 5-year averages. Barro (1995, pp. 15-16) argues even for larger time spans as "relationships at the annual frequency would likely be dominated by mistiming and, hence, effectively by measurement error." It should be said at the onset that however reasonable, this approach is impossible to carry out in the research on transition due to data limitations. One thus needs to be extremely cautious in interpreting results.

We commence from S*imple Descriptive Analysis* and graphic representation of the data, which succinctly summarise major features and trends. We calculate mean income time series for every group and then plot mean income dynamics, as measured by the difference between the EU mean income and that of the corresponding TE group, Y_t(EU) – Y_t(TE group), t=1991..1999. We repeat the analysis for median income, a more robust measure of the central tendency of the data. Since the classical definition of convergence given by Equation 1 to Equation 2 refers to the log of real per capita GDP we applied the log transformation from beginning, and hence all the plots are for log of mean income. Then, following Andreff's (1998, p. 113) analysis of *σ-convergence*, we calculate the coefficient of variation defined as the ratio of the standard deviation to the mean values of income in the group and plot it over time. We repeat the analysis using

the robust form of the coefficient of variation: interquartile range over median. The interquartile range (IQR) is formed by subtracting the 25th percentile of the data from the 75th percentile of the data. The IQR is a robust estimate of the spread of the data (with respect to outliers) since changes in the upper and lower 25% of the data do not affect it.

To test the significance of group factor and to carry out multiple pair-wise comparisons of groups, we employ Friedman's non-parametric test,[13] which is similar to two-way analysis of variance. However, unlike two-way analysis of variance, Friedman's test does not treat the two factors symmetrically and does not test for interaction. Instead, it is a test for whether the columns (groups) are different after adjusting for possible row (time dimension) differences. The test is based on an analysis of variance using the ranks of the data across categories of the row factor. The major advantage of Friedman's test, as with most non-parametric tests, is the fact that it does not make any assumptions (say, normality) about the distribution from which the sample was drawn, and the test is robust in this sense. This advantage, however, comes at the price of lower power to distinguish among the groups that are different by a small margin.

The whole approach bears the same hallmark of a trade-off between robustness and precision of conclusions as the Friedman's test. It is robust with respect to many assumptions required by classical and advanced econometric techniques, but what looks one way on the plot may prove to be different when tested formally.

At the second level of analysis, we employ the "*Classical Approach to Convergence*" in the spirit of Barro and Sala-i-Martin as exposed in Sala-i-Martin (1996), i.e. we apply a cross-section regression to our panel data as described by Equation 1 to Equation 2. This is the basic formalisation of the first approach with the graphic representation of the data. It gives a quantitative assessment of convergence phenomenon and its significance. To calculate the annualised growth rate of GDP, we always use 1999 as the end year and years from 1991 to 1995 consecutively as the start date (*Y_0*). We employ different starting dates to see their effect on convergence. In Andreff's study,[14] the sample from 1990 to 1996 showed no absolute convergence for transition economies and the EU while the sample 1992-1996 delivered the positive results. This is partly explained by the fact that in the beginning of 1990s most of transition economies suffered a dramatic fall in GDP and a prolonged structural/ transformational recession.

The advantage of simple cross-section tests over time-series ones for convergence was emphasised recently by Bernard and Durlauf (1996, p. 171). They argued that cross-sectional tests are more suitable for data that is derived from

[13] See Hollander and Wolfe (1999, pp. 270-284) for fuller treatment.
[14] 1998, p. 131.

economies, which are far from their steady states, and we assume it is true for the data from transition. The cross-sectional tests study the cross-sectional correlation between the initial income levels and subsequent growth rates for a group of countries. The time-series-based tests study the long-run dynamics of differences in per capita income among countries. Here convergence implies the cointegration between output levels of any two economies in the group. As advocated by Bernard and Durlauf,[15] the two approaches assume very different characteristics for the data under investigation. Under the cross-section approach, the data are considered to be "in transition towards a limiting distribution and convergence is interpreted as meaning that initial output differences dissipate over a fixed time period." In the time-series approach the data are considered to be "generated by economies near their limiting distributions and convergence is interpreted to mean that initial conditions have no (statistically significant) effect on the expected value of output differences." Hence, we do not to test for stationarity and cointegration of our output time series here. Moreover, these time-series are too short for such tests to be conclusive.

Finally, at the third stage of our analysis we employ *Dynamic Panel Data Analysis*, and turn to the most recent econometric tools for estimation of dynamic panel data (DPD) sets. These tools make the full use of the time dimension of the data set, therefore, expanding a simple cross-section by an extra dimension, time, to a panel. It is a middle ground between pure cross-section and time-series tests. We apply a first-order autoregressive fixed-effect dynamic panel model to study convergence in our sample.

Equation 3 *First-order autoregressive fixed-effect dynamic panel model*

$$y_{it} = \alpha \cdot y_{i,t-1} + \beta \cdot x_{it} + \mu_i + \varepsilon_{it}$$

The choice of one lag only for the dependent variable (real per capita GDP) is dictated by the small sample size limitation. Although dynamic panels are not new,[16] their acceptance for econometric analysis of macroeconomic time-series data took until the mid-1990s.[17] The present research uses this techniques for research on transition economies convergence with the EU. Two recent applications of this approach to growth and convergence are presented in Knight *et al* (1993) and Islam (1995). Their major argument for panel approach as opposed to

[15] 1996, p. 171.

[16] See Hsiao, 1982.

[17] Several other books deserve mention. Baltagi (1995) provides an advanced treatment of dynamic panel data estimations with lots of references. Mátyás and Sevestre (eds.) (1995) show many applications, as does the recent book edited by Krishnakumar and Ronchetti (2000).

the cross-section approach is that it allows for important country-specific effects. As Islam notes, "The country-specific aspect of the aggregate production function that is ignored in single cross-section regression, is correlated with the included explanatory variables, and this creates omitted variable bias. The panel data framework makes it possible to correct this bias."[18] He argues further that it is not feasible to remedy this problem of the single cross-section approach with instrumental variable estimation. Such an instrument may correlate with the explanatory variables but not with country-specific technology effects such as production technology, resource endowment, climate and preferences.

The panel approach finds faster rates of conditional convergence compared with the single cross-section approach. Statistically, this is due to a bias from correction for omitted variables. From the growth theory and conditional convergence perspective, it means that steady-state income levels depend on country-specific technology effects in a significant way. Therefore, these country-specific technology effects must be considered. As emphasised by Islam (1995) and many other researchers, the faster rate of convergence is good news. Unfortunately, here we are looking at *conditional* convergence. That is, groups of countries and separate countries are converging fast to their respective steady states of income level, and nothing, of course, can guarantee that it is a good steady state. Therefore, there is a room for activism on the government side to adopt policies that can improve the steady state level: investment to infrastructure, R&D sector, education. For many transition countries, it also means institutional reform and fighting corruption.

Two problems with this approach deserve a brief mention. First, is the issue of specifying fixed and random effects. The second is the performance of various dynamic panel estimators in small samples. With respect to specification choice, we note Islam's observation that country-specific effects are correlated with the explanatory variables, and hence, random effects specification is unsuitable. In line with the arguments of Hsiao[19] and Baltagi[20] the choice of fixed effects option is more appropriate when the research focuses on a specific set of N countries, which are not drawn randomly from a large population, and the outcomes of the study are viewed as conditional on this set of countries. This situation precisely reflects our convergence study where the choice of country matters for answers we search for. This choice was confirmed during estimations with Hausman's test always favouring the fixed effects specification.

Turning to the choice and performance of various dynamic panel estimators one should first note the large variety available. The most widely used include

[18] Islam, 1995, p. 1128.
[19] Hsaio, 1981, pp. 41-43.
[20] Baltagi, 1995, p. 10.

- Least Squares with Dummy Variables (LSDV);
- Instrumental Variable method by Anderson-Hsiao (AHL and AHD), where lagged level or difference of the dependent variable can be used;
- Generalized Method of Moments by Arellano and Bond (1991), one and two-step, (GMM and GMM2);
- Two and Three Stage Least Squares (2SLS and 3SLS);
- Chamberlain's Minimum Distance Estimator (MD);[21] exact/unconditional Maximum Likelihood Estimator (MLE) by Nerlove (2000);[22] and
- the Pooled Mean Group Estimator by Pesaran *et al* (1999).

Theoretically the estimators that make use of all available information (MD, exact MLE, GMM2, 3SLS) are asymptotically the same and dominate simpler and less efficient estimators (LSDV, AHL or AHD, one-step GMM, 2SLS). Unfortunately, this information is of no use to a practitioner working with small samples. While no consistent picture has emerged, there are a number of Monte Carlo studies on the estimators' performance in small samples.[23] The general view is that simpler estimators such as LSDV or 2SLS should be preferred to more sophisticated ones such as GMM2 or 3SLS in small samples of noisy data. Islam remarks that more advanced estimators must use an optimal weighting matrix, which in turn has to be estimated from data and thus adds extra noise to the estimator.[24] Another general point is that estimations vary widely depending on the method. Finally, Monte Carlo studies specifically designed for growth data, Summers-Heston data set, and/or on macroeconomic issue of convergence as by Islam (1998), and Judson and Owen (1999), find that simple estimators such as LSDV, AHD/AHL (and sometimes one-step GMM) perform best in terms of bias and root mean square error (RMSE). Judson and Owen (1999) strongly recommend the use of bias-corrected LSDV estimator version developed in Kiviet (1995), Bun and Kiviet (1999) for small panels. In their study, bias-corrected LSDV performed best in terms of bias and RMSE in small panels with a time dimension of less than ten observations. The considerations above led us to the following choice of dynamic panel data estimators: LSDV, 2SLS, AHD, and one-step GMM. We report the results for all.

[21] Explained in Mátyás and Sevestre (1995, Ch. 14).
[22] Nerlove main argument is that estimation procedure matters a great deal in panel data econometrics, and that higher values of convergence found, for example, by Islam (1995) are statistical artefacts due to incorrect specification and estimation of dynamic panel data models.
[23] See Kiviet (1995), Bun and Kiviet (1999), Islam (1998), and Judson and Owen (1999).
[24] Islam 1998, p. 15.

3 Empirical Results

In this section we summarise our empirical findings and compare results of the different levels of analysis. Accompanying graphics and tables are presented in the Appendices.

3.1 Simple Descriptive Analysis

Descriptive graphic analysis is presented on Figure 1 to Figure 4. Figure 1 and Figure 2 show income dynamics as measured by the difference between the EU income and that of the corresponding TE group, Y_t(EU) – Y_t(TE group), t=1991..1999. First, we draw the evolution for mean income differences, and then for median income differences. These first two figures represent the concept of *absolute β-convergence*. First, we examine the "leaders," the TE-5 and TE-3 subgroups. Both subgroups behave similarly. They start converging with the EU early in 1992 and around 1998, the slow-but-steady convergence ceases. In 1999, they start to show the signs of divergence. The new trend reflects the impact of the Asian and Russian crises on these transition economies. It reveals their high vulnerability with respect to economic developments outside the European Economic Area. Three other subgroups: TE-11, TE-8, and TE-3Baltics, display the same pattern except for the later start of convergence (1994). Finally, the Balkan country subgroup, which has the greatest income gap with the EU, displays fast convergence from 1992 to 1995, and even faster divergence from 1995 to 1998. The use of median instead of mean does not alter the picture significantly, though few remarks are necessary. First, the Balkan country subgroup divergence since 1995 is particularly strong. Second, TE-5 and TE-3 hardly show any convergence at all now, i.e. their real income grows approximately at the same pace as that of the EU. Third, the TE-8 subgroup representing all transition economies except the Balkans shows steady convergence from 1992.

Figure 3 and Figure 4 deals with the concept of *σ-convergence* between transition groups and the EU. As *β-convergence* is a necessary, although not sufficient, condition for *σ-convergence*, the patterns are very similar to the ones analysed above.[25] Country groups start converging at the same different dates, and all are affected by the aftermaths of the Asian and Russian crises. The use of the robust measure of the coefficient of variation (interquartile range over median) for the analysis delivers the same picture, but emphasises very strong convergence for TE-5.

[25] See Sala-i-Martin 1996, p. 1021.

The results of non-parametric Friedman's test for *absolute β-convergence* and *σ-convergence* are presented in Table 1 to Table4. Friedman's test results show that belonging to the group always matters, and pair-wise comparisons reveal this. These results complement the graphic analysis and show that with respect to mean income level, the EU and the TE-8, TE-5, and TE-3 subgroups are indistinguishable at the 95% confidence level. This is broadly in line with the findings of the graphic analysis. When one uses median income, a more robust measure of central tendency of data, the conclusions are that the EU and the TE-5 and TE-3 subgroups are indistinguishable at the 95% confidence level. Thus, the use of the robust criterion makes stronger separation among transition economies. Only the richer transition economies of Central Europe seem to be steadily converging with the EU.

Table 3 and Table 4 deal with *σ-convergence* and deliver similar results to graphic analysis. In particular, the dispersion of income decreases between the EU and TE-8, TE-5, TE-3, TE-3Baltics and TE-3Balkans subgroups, but not between the EU and the TE-11 subgroup. In Table 4 we employ the robust variant of the coefficient of variation – the ratio of the interquartile range to the median income. This has no effect on results.

Summarising the present situation, one can observe a significant reduction in income variability between the EU and transition economies. While this is possibly due to intensified trade links and large integration efforts, it seems unlikely that these forces could yet produce the same impact on income level convergence. The TE-3Balkans subgroup is distinct from the rest. After a good start, from 1995 there are diverging with the EU in terms of real income levels. Obvious candidates for explanations are the Balkan wars and the trade embargo imposed on Yugoslavia that affected adversely the whole region. In addition, their economic reform policies were inconsistent and badly designed and implemented, with inflation going out of control into hyperinflation in Bulgaria in 1996-1997. The Baltic country group, TE-3Baltics, despite the later start of transition seems to be catching up steadily with the "leaders" and the EU.

Finally, we look at the dynamics of income distribution, *σ-convergence*, within separate groups of countries, but not with respect to the EU. This is an interesting exercise because it may reveal the consistency of group definition. If countries converge within the subgroup, then that subgroup's overall behaviour is more consistent. The subgroup is itself a representative entity for the analysis, which thus reduces the dimensionality of the analysis. Similar analysis of *β-convergence* is unnecessary here, since *β-convergence* is mostly important with respect to the EU. However, later in the Dynamic Panel Approach section we present results on *absolute β-convergence* for separate groups in Table 14 and Table 15. The analysis that uses the robust measure of *σ-convergence* is presented on Figure 6. The graphics expose three interesting facts. First, the conver-

gence within the EU itself essentially stopped after 1995. This may complicate the analysis of convergence by weakening the results for the mixtures of the EU and separate groups of transition economies. Second, all subgroups, except TE-11 and the Baltics, show some positive degree of convergence. The divergence within transition economies as the whole, TE-11, may be explained by the increasing income gap between the richer reformers and the Balkan countries with the addition of possibly Lithuania. The last surprising trend revealed by the graph is the divergence within such seemingly homogeneous in historical and geographical terms group as the Baltics, TE-3Baltics. Clearly, Estonia that has similar language and common border with the EU member, Finland, converges to the EU significantly faster than two other group members, Latvia and Lithuania. If the trend continues the Baltic subgroup will have to be split, with Estonia joining the "leaders," and to which it is already formally affiliated as a first-wave accession candidate.

3.2 Classical Approach to Convergence

We start with results for *absolute β-convergence* and then *conditional β-convergence*. We present both tables with regression statistics on convergence coefficient and summary tables, where we entered *Yes/No* for the fact of convergence and Half-Time $(T_{1/2})$, i.e. time necessary to reduce income gap by half. All calculations were performed with Stata 6 software.

Absolute β-convergence is both the strongest and most interesting concept because it implies convergence to the same steady state. This is the situation normally implied when officials talk about the long-term results of the EU enlargement. Table 6 and Table 7 display the results. The findings are in line with the earlier simple descriptive analysis. Not all transition economies (TE-11) are converging with the EU. In particular, the results are negative for the Balkan subgroup, TE-3Balkans. For the TE-8, TE-5, TE-3 and TE-3Baltics subgroups the conclusions are positive, but the convergence is extremely slow with Half-Time values ranging from 111 to 176 years. Nevertheless, the mere fact of finding *absolute β-convergence* is remarkable, given that only eight years have passed since the European Council meeting in Copenhagen that took decision on enlargement, and on average only ten years since the beginning of transition. With the rising volume of mutual trade, ongoing institutional reform and integration efforts, and expanding cultural links one can expect a significant increase in the speed of convergence.

Results for *conditional β-convergence* are displayed in Table 8 and Table 9. Here, Half-Time results range from 180 to 35 years. Clearly, the lower bound fell some three-fold, implying much faster convergence rates in some cases. How-

ever, one needs to remember here that countries are not necessarily converging to the same steady states. In particular, in the light of the previous analysis it seems that the Balkan countries are converging fast to their own steady state, which is quite different from that of the EU and other transition economies.

Finally, it is interesting to compare our results with findings reported in the literature for other economic groups estimated over much longer time span when is available to us. Table 5 presents some of these results. As can be seen the range of Half-Time values is large, from 69 years for regions of Italy to 22 years for Japanese prefectures. This range overlaps our findings. In particular, all of our values for the case of *conditional β-convergence* are within this range.

3.3 Dynamic Panel Data Study

Again we first report with results for *absolute β-convergence* and then for *conditional β-convergence*, and present both tables with regression statistics on convergence coefficient and summary tables: Table 10 to Table 13. As with many studies cited before the rates of convergence are significantly higher when dynamics is taken into account. Another general observation is that even for the same group results vary widely depending on the estimation method[26].

Table 11 shows results for an *absolute β-convergence*. Most of the results are unconvincingly small for Half-Time values, i.e. the convergence rate is too high. However, if one chooses the three-year value as a conservative estimate for Half-Time convergence, it means around ten years for convergence to 90% of the EU average, and this estimate already does not look improbable. Another interesting observation is that in the case of the dynamic panel approach, even the Balkan country group shows positive convergence with the EU for some estimation methods, namely, 2SLS and one-step GMM.

Results for *conditional β-convergence* are displayed in Table 12 and Table 13. They share similar features with the results for *absolute β-convergence*. They range from very slow convergence for the EU and TE-11 group (47 to over 70 years for Half-Time values) to acceptable Half-Time values for other subgroups (32 years for the EU and TE-8, 5 to 3 years for other subgroups).

Concluding this section we present results for *absolute β-convergence* for separate groups in Table 14 and Table 15. The analysis reveals that for the EU,

[26] Calculations for DPD section are performed using the most recent version, version 7, of Stata software package. The arrival of this new version relieved us from writing our own programme code for DPD estimations, and this, of course, should mean easier reproducibility of the research. We believe that previous absence of DPD estimation tools from widely used standard software packages was the major deterrent to the wide applications of DPD approach.

two methods (LSDV and 2SLS) out of four failed to find positive *absolute β-convergence*. If this is not a statistical artefact, it poses yet one more complication for the convergence study. If there is no clear convergence within the EU, then it is more difficult to detect the convergence of transition economies to the EU. Another finding is more controversial. We detect positive *absolute β-convergence* for the Baltics, while in our Simple Descriptive Analysis section (see Figure 6) found that the Baltic subgroup is diverging in terms of *σ-convergence*. Here, we think the DPD results are unconvincing and possibly statistical artefacts.

Finally, for comparison we present some typical findings in the literature in Table 16. Depending on the estimation method and country subgroup, the range for Half-Time values is 3.5 to 16 years. This includes some of our results, but overlapping is more erratic than in classical study.

4 Conclusions

Conclusions are the riskiest and the most difficult exercise in research on convergence in transition. As to the query posed by the title of the paper, we conclude that σ- and β-convergence are present in the sample. A host of statistical and econometric techniques were employed here, ranging from graphic analysis, non-parametric tests and cross-section regression to dynamic panel data estimations. The finding of positive convergence is robust for most methods. This result is very important for the prospects of EU enlargement as it invalidates the argument that enlargement process should be halted because there is no convergence between the EU and the candidates.

To paraphrase Shakespeare's Hamlet, "Speed, that is the question!" The range of values for the time necessary to reduce the income gap by half is stretching well over the century depending on the method used for estimation. Two cures may be prescribed. The first stems from the hypothesis that a short and noisy data sample is the major hurdle to this study. Hence, bearing in mind Barro's suggestion of using five-, or better, ten-year averages of macroeconomic time series for estimations, one simple solution is to wait ten or more years until the required time series have accumulated. A more practical approach is of a technical nature. It is tailored to this particular sample Monte-Carlo investigation of the performance of the DPD estimators and their comparison with the classical approach. It may shed more light on estimators' performance and, hopefully, reduce the range of obtained values to an acceptable width.

The second, supplementary part of the research was devoted to the behaviour of income in the separate groups. Two important findings are that the Baltic sub-

group is diverging in the sense of *σ-convergence* (i.e. income distribution), and the EU shows few signs of σ- and β-convergence, especially after 1995. The latter finding necessarily complicates the study of convergence to the EU as its behaviour changes after 1995.

Generally, the lack of conclusive evidence from the data on the rate of catch-up makes it advisable for transition countries to opt for growth-enhancing policies rather than concentrate their efforts on nominal convergence with Maastricht criteria.

As to some possible future extensions of this research, one can suggest a complementary study of factors behind the recent growth performance in transition economies. It might determine the sustainability of the recent positive growth in most transition economies. This will help to answer the major convergence question as to how long it will take for transition countries to close the income gap with the EU. Since the size and the quality of the present data sample is the major hurdle, we should turn to indirect evidence on possible developments between the EU and accession candidates. First, one can resort to a number of case studies related to the accession experiences of countries such as Greece, Spain and Portugal. These countries started with large income disparities with the EU average. The study of what have happened to them before and after accession may shed light on what may happen to present candidates. Second, one can look at the historical data covering the common experience of the European countries during let say 1900-1940. During this period many of the candidates were independent countries with market economies. The study of their convergence experience then may provide clues as to what might happen in the future.

Appendices: Graphs and Tables

Descriptive graphic analysis

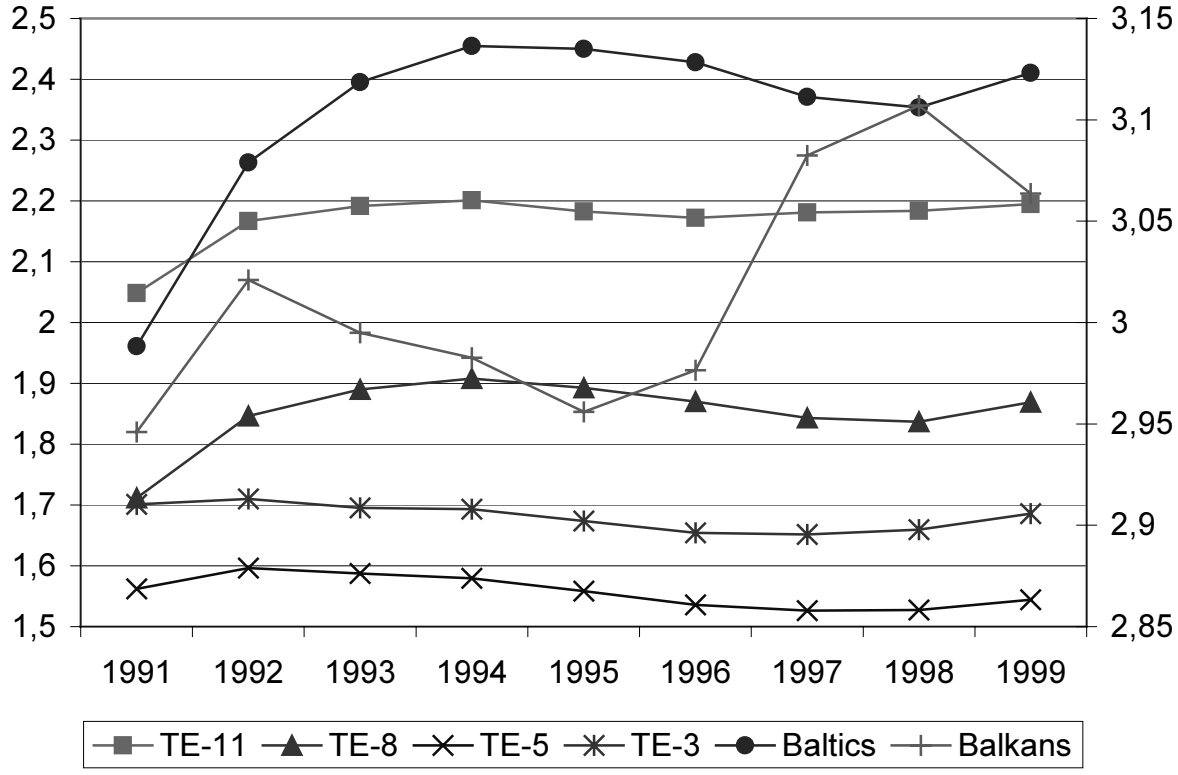

Figure 1. Mean Income Dynamics, Balkans – on the right scale

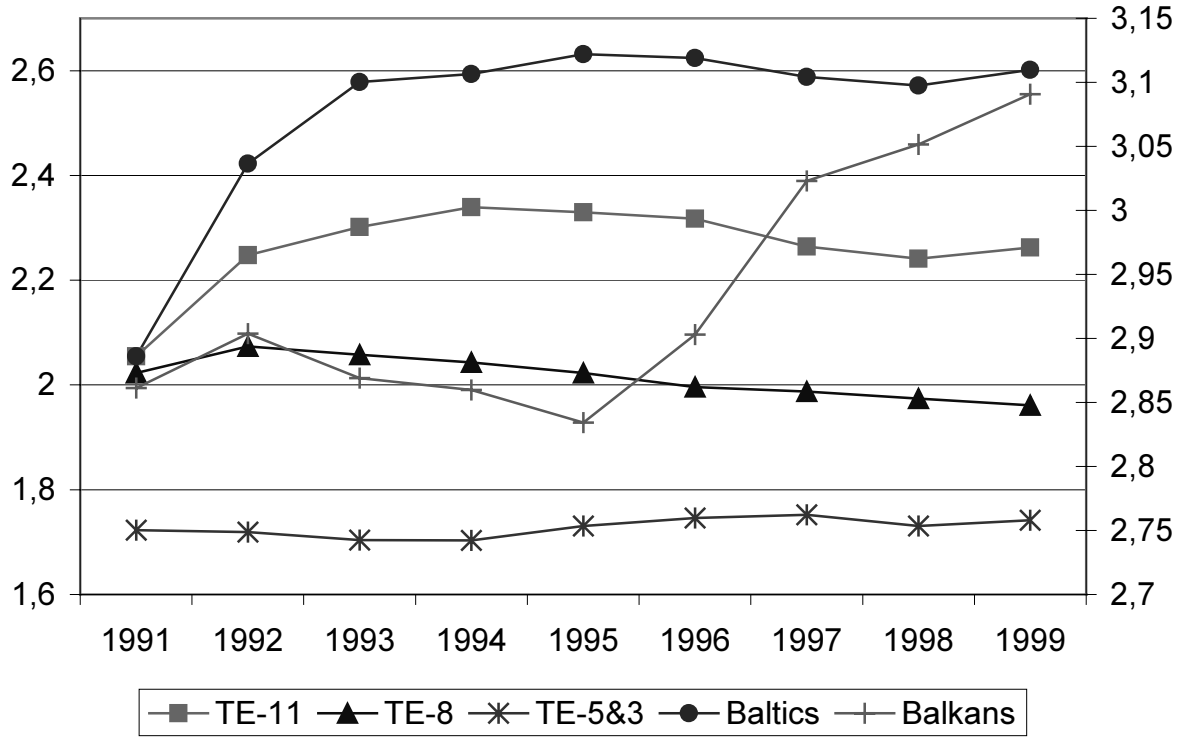

Figure 2. Median Income Dynamics, Balkans – on the right scale

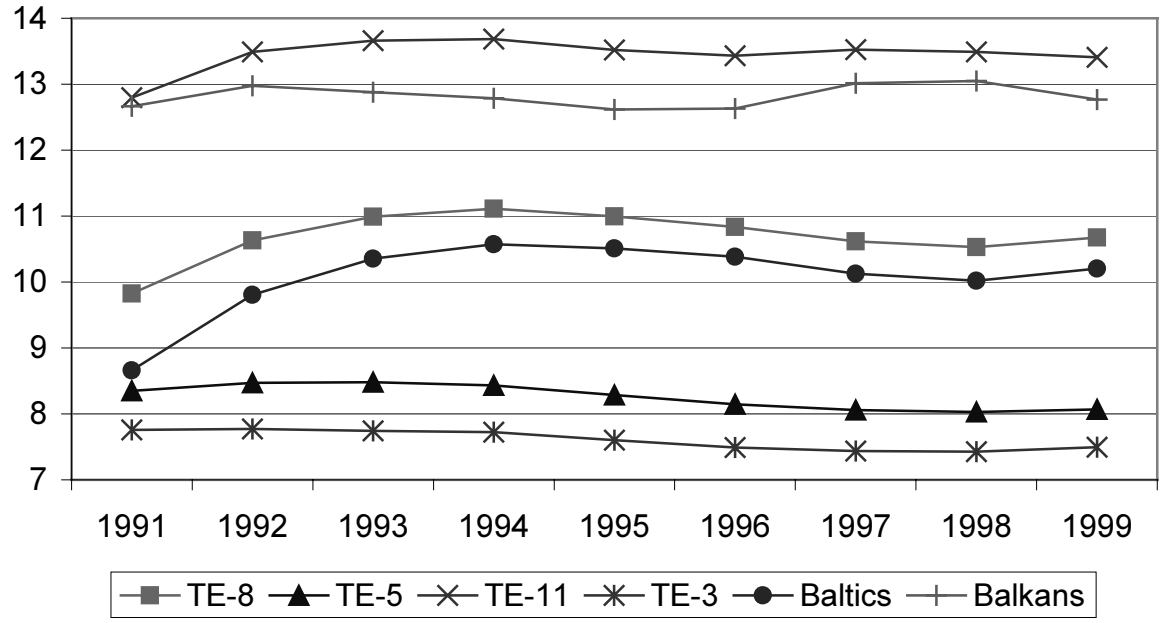

Figure 3. Coefficient of Variation, Standard Deviation over Mean

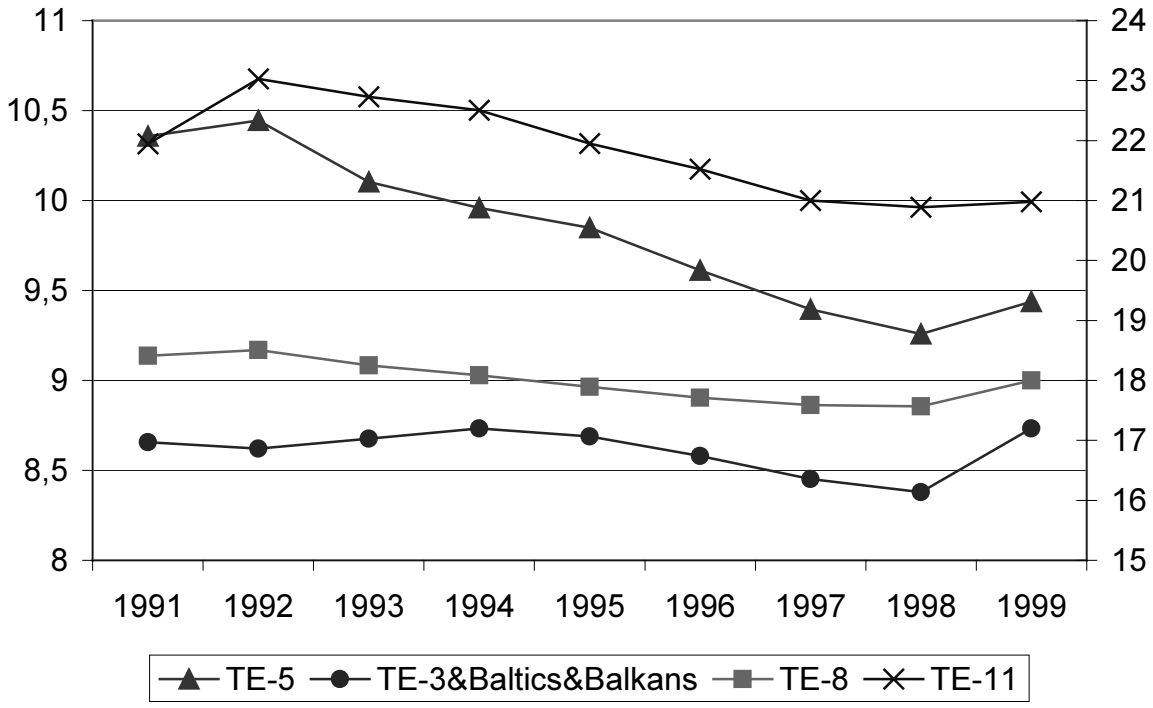

Figure 4. Coefficient of Variation, Robust Measure: Interquartile Range over Median
Note to Figure 4: TE-11 and TE-8 are on the right scale. For TE-3, TE-3Baltics, and TE-3Balkans values are the same.

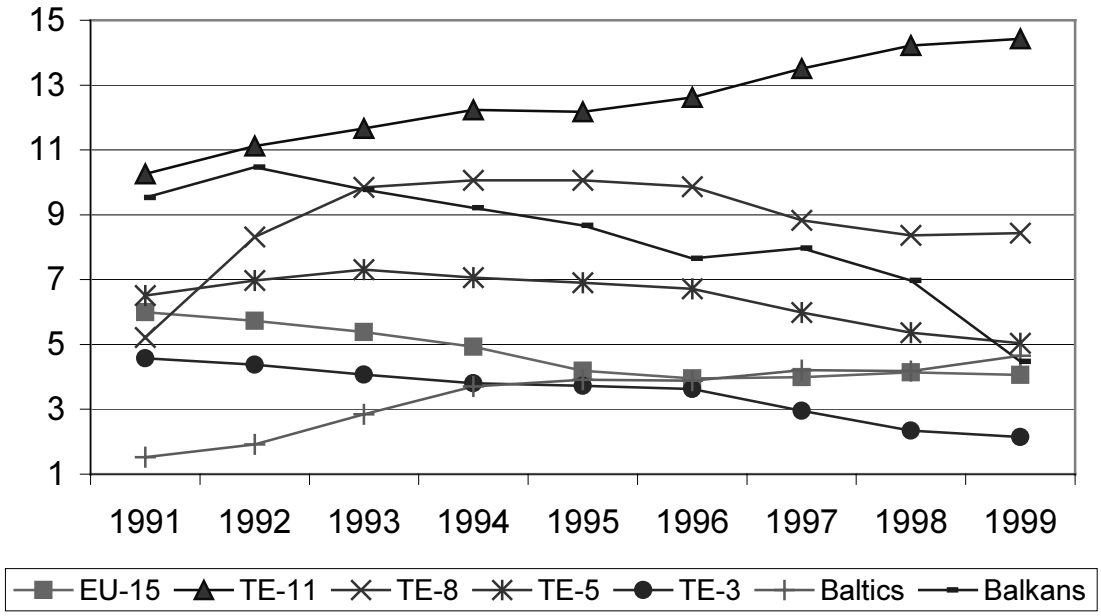

Figure 5. Coefficient of Variation, Robust Measure: Interquartile Range over Median. Sigma-convergence within separate groups, not with the EU.

Friedman's test results

Low p-value of test statistics means that the null hypothesis that some groups are different cannot be rejected. When lower and upper 95% confidence interval values have different sign, two groups are not distinguishable. The following descriptor table provides the correspondence between groups' names and groups' numbering.

Group Name	Group Number
EU-15	1
TE-11	2
TE-8	3
TE-5	4
TE-3	5
TE-3Baltics	6
TE-3Balkans	7

Friedman's Test p-value 8.8E-10				
Multiple comparison test of means (one row for each pair of groups)				
Group	Group	CI-95%(L)	Difference in Means	CI-95%(U)
1	2	1.108689	4.111111	7.113533
1	3	-0.002422	3	6.002422
1	4	-2.002422	1	4.002422
1	5	-1.002422	2	5.002422
1	6	1.886467	4.888889	7.891311
1	7	2.997578	6	9.002422
2	3	-4.113533	-1.111111	1.891311
2	4	-6.113533	-3.111111	-0.108689
2	5	-5.113533	-2.111111	0.891311
2	6	-2.224644	0.777778	3.7802
2	7	-1.113533	1.888889	4.891311
3	4	-5.002422	-2	1.002422
3	5	-4.002422	-1	2.002422
3	6	-1.113533	1.888889	4.891311
3	7	-0.002422	3	6.002422
4	5	-2.002422	1	4.002422
4	6	0.886467	3.888889	6.891311
4	7	1.997578	5	8.002422
5	6	-0.113533	2.888889	5.891311
5	7	0.997578	4	7.002422
6	7	-1.891311	1.111111	4.113533

Table 1. Friedman's test results for mean income

Friedman's Test p-value 7.72E-10				
Multiple comparison test of means (one row for each pair of groups)				
Group	Group	CI-95%(L)	Difference in Means	CI-95%(U)
1	2	1.083069	4.055556	7.028043
1	3	0.027513	3	5.972487
1	4	-1.472487	1.5	4.472487
1	5	-1.472487	1.5	4.472487
1	6	1.971957	4.944444	7.916931
1	7	3.027513	6	8.972487
2	3	-4.028043	-1.055556	1.916931
2	4	-5.528043	-2.555556	0.416931
2	5	-5.528043	-2.555556	0.416931
2	6	-2.083598	0.888889	3.861376
2	7	-1.028043	1.944444	4.916931
3	4	-4.472487	-1.5	1.472487
3	5	-4.472487	-1.5	1.472487
3	6	-1.028043	1.944444	4.916931
3	7	0.027513	3	5.972487
4	5	-2.972487	0	2.972487
4	6	0.471957	3.444444	6.416931
4	7	1.527513	4.5	7.472487
5	6	0.471957	3.444444	6.416931
5	7	1.527513	4.5	7.472487
6	7	-1.916931	1.055556	4.028043

Table 2. Friedman's test results for median income

Friedman's Test p-value 4.4E-09				
Multiple comparison test of means (one row for each pair of groups)				
Group	Group	CI-95%(L)	Difference in Means	CI-95%(U)
1	2	-6.891311	-3.888889	-0.886467
1	3	-5.446867	-2.444444	0.557978
1	4	-4.113533	-1.111111	1.891311
1	5	-1.335755	1.666667	4.669089
1	6	-1.446867	1.555556	4.557978
1	7	-5.002422	-2	1.002422
2	3	-1.557978	1.444444	4.446867
2	4	-0.224644	2.777778	5.7802
2	5	2.553133	5.555556	8.557978
2	6	2.442022	5.444444	8.446867
2	7	-1.113533	1.888889	4.891311
3	4	-1.669089	1.333333	4.335755
3	5	1.108689	4.111111	7.113533
3	6	0.997578	4	7.002422
3	7	-2.557978	0.444444	3.446867
4	5	-0.224644	2.777778	5.7802
4	6	-0.335755	2.666667	5.669089
4	7	-3.891311	-0.888889	2.113533
5	6	-3.113533	-0.111111	2.891311
5	7	-6.669089	-3.666667	-0.664245
6	7	-6.557978	-3.555556	-0.553133

Table 3. Friedman's test results for coefficient of variation (standard deviation/mean)

Friedman's Test p-value 1.68E-08				
Multiple comparison test of means (one row for each pair of groups)				
Group	Group	CI-95%(L)	Difference in Means	CI-95%(U)
1	2	-7.224644	-4.222222	-1.2198
1	3	-5.7802	-2.777778	0.224644
1	4	-4.446867	-1.444444	1.557978
1	5	-1.669089	1.333333	4.335755
1	6	-2.224644	0.777778	3.7802
1	7	-5.224644	-2.222222	0.7802
2	3	-1.557978	1.444444	4.446867
2	4	-0.224644	2.777778	5.7802
2	5	2.553133	5.555556	8.557978
2	6	1.997578	5	8.002422
2	7	-1.002422	2	5.002422
3	4	-1.669089	1.333333	4.335755
3	5	1.108689	4.111111	7.113533
3	6	0.553133	3.555556	6.557978
3	7	-2.446867	0.555556	3.557978
4	5	-0.224644	2.777778	5.7802
4	6	-0.7802	2.222222	5.224644
4	7	-3.7802	-0.777778	2.224644
5	6	-3.557978	-0.555556	2.446867
5	7	-6.557978	-3.555556	-0.553133
6	7	-6.002422	-3	0.002422

Table 4. Friedman's test results for coefficient of variation (interquartile range/median)

Note to Table 4: This is robust form of the coefficient of variation. The inter-quartile range (IQR) is formed by subtracting the 25th percentile of the data from the 75th percentile of the data. The IQR is a robust estimate of the spread of the data since changes in the upper and lower 25% of the data do not affect it.

Data set	Year	Absolute	$T_{1/2}$	Conditional	$T_{1/2}$	Panel, cond.	$T_{1/2}$
OECD	1960-90	0.014	50	0.029	24		
USA, 48 states	1880-1990	0.021	33	0.017	41	0.022	32
Japan, 47 prefectures	1955-90	0.019	36	0.019	36	0.031	22
Europe, 90 regions	1950-90	0.015	46	0.015	46	0.018	39
Germany, 11 regions	1950-90	0.014	50	0.014	50	0.016	43
UK, 11 regions	1950-90	0.02	35	0.03	23	0.029	24
France, 21 regions	1950-90	0.016	43	0.016	43	0.015	46
Italy, 20 regions	1950-90	0.01	69	0.01	69	0.016	43
Spain, 17 regions	1955-87	0.021	33	0.023	30	0.019	36

Table 5. Typical Results for the Speed of Convergence

Note to Table 5: Coefficient values and Half-Time, reproduced and calculated from Sala-i-Martin (1996, p. 1024). He uses a static panel with time effects and the same coefficients for all sub-periods. Citing other studies he says that the typical estimated speed of conditional convergence is around 2% per year, i.e. $T_{1/2}$ is 35 years.

Classical Approach to Convergence

	EU & TE-11			EU & TE-8			EU & TE-5		
Y_0	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
1991	0.0063535	0.0042678	1.49	0.0107398	0.0069103	1.55	-0.002913	0.0037534	-0.78
1992	0.0009842	0.0048218	0.2	0.0024138	0.004377	0.55	-0.0050735	0.0036757	-1.38
1993	-0.0003021	0.0043899	-0.07	-0.0019167	0.0032543	-0.59	-0.0056756	0.0037777	-1.5
1994	-0.0010945	0.0046291	-0.24	-0.0046728	0.0027259	-1.71	-0.0061462	0.0041322	-1.49
1995	0.0008273	0.0055981	0.15	-0.0038845	0.0029687	-1.31	-0.0037848	0.0050356	-0.75
	EU & TE-3			EU & TE-3Baltics			EU & TE-3Balkans		
Y_0	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
1991	-0.0032936	0.00481	-0.68	0.0223992	0.0058098	3.86	0.0025016	0.0058687	0.43
1992	-0.0037905	0.0048176	-0.79	0.0073789	0.0043687	1.69	-0.0005091	0.0070496	-0.07
1993	-0.0033807	0.0045961	-0.74	0.0001485	0.0034566	0.04	0.0009019	0.0074973	0.12
1994	-0.0037537	0.0048917	-0.77	-0.0040974	0.0026338	-1.56	0.0020612	0.0083186	0.25
1995	-0.0010621	0.0061012	-0.17	-0.0040391	0.0028256	-1.43	0.0053321	0.0102196	0.52

Table 6. Absolute Convergence Tests

Y_0	EU&TE-11	EU&TE-8	$T_{1/2}$	EU&TE-5	$T_{1/2}$	EU&TE-3	EU&Baltics	$T_{1/2}$	EU&Balkans
1991	No	No	n.a.	?	n.a.	?	No	n.a.	No
1992	No	No	n.a.	Yes	133	?	No	n.a.	?
1993	?	?	n.a.	Yes	120	?	No	n.a.	No
1994	?	Yes	147	Yes	111	?	Yes	167	No
1995	No	Yes	176	?	n.a.	?	Yes	172	No

Table 7. Summary Table for Absolute Convergence Tests

Note to Summary Tables: “?”means that the coefficient has the correct sign for convergence to exist but standard errors are too large. When the whole column for the group is negative or uncertain the Half-Time column is not calculated and is omitted.

	EU & TE-11			EU & TE-8			EU & TE-5		
Y_0	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
1991	-0.0068479	0.0024995	-2.74	-0.0043518	0.0048303	-0.9	0.0003863	0.0055576	0.07
1992	0.0037859	0.0047053	0.8	-0.0038373	0.0037905	-1.01	-0.0041042	0.0037221	-1.1
1993	0.0002144	0.0045553	0.05	-0.0068262	0.0031296	-2.18	-0.0052713	0.0043673	-1.21
1994	-0.0132474	0.0030097	-4.4	-0.0067182	0.0040264	-1.67	-0.0018829	0.0079811	-0.24
1995	-0.0117592	0.0041209	-2.85	-0.0004775	0.0116302	-0.04	0.0049506	0.011529	0.43
	EU & TE-3			EU & TE-3Baltics			EU & TE-3Balkans		
Y_0	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
1991	-0.0166007	0.0143471	-1.16	-0.0053254	0.0141213	-0.38	-0.0094036	0.001852	-5.08
1992	-0.0079963	0.0148801	-0.54	-0.0060673	0.0110529	-0.55	0.0093391	0.0022128	4.22
1993	-0.0188407	0.0187272	-1.01	-0.0073429	0.0032096	-2.29	-0.0155439	0.0046364	-3.35
1994	-0.0099266	0.0155725	-0.64	-0.0074518	0.0029479	-2.53	-0.0143945	0.0022863	-6.3
1995	0.0069554	0.0143452	0.48	-0.0148223	0.0117548	-1.26	-0.0175232	0.0017275	-10.14

Table 8. Conditional Convergence Tests

Y_0	EU&TE-11	$T_{1/2}$	EU&TE-8	$T_{1/2}$	EU&TE-5	$T_{1/2}$	EU&TE-3	$T_{1/2}$	EU&Baltics	$T_{1/2}$	EU-15&Balkans	$T_{1/2}$
1991	Yes	98	?	n.a.	No	n.a.	Yes	39	?	n.a.	Yes	71
1992	?	n.a.	Yes	180	Yes	167	?	n.a.	?	n.a.	No	n.a.
1993	No	n.a.	Yes	100	Yes	129	Yes	35	Yes	93	Yes	42
1994	Yes	51	Yes	102	?	n.a.	?	n.a.	Yes	91	Yes	46
1995	Yes	58	?	n.a.	No	n.a.	No	n.a.	Yes	45	Yes	38

Table 9. Summary Table for Conditional Convergence Tests

Dynamic Panel Data Approach

	EU & TE-11			EU & TE-8			EU & TE-5		
Method	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
LSDV	0.809242	0.046735	17.32	0.804336	0.04512	17.83	1.129703	0.029187	38.71
2SLS	0.775129	0.122971	6.3	0.769592	0.130868	5.88	1.158646	0.051575	22.47
AHD	0.137728	0.112314	1.23	0.302209	0.070238	4.3	0.483094	0.121775	3.97
GMM	0.333668	0.107078	3.12	0.391955	0.066193	5.92	0.743108	0.06377	11.65
	EU & TE-3			EU & TE-3Baltics			EU & TE-3Balkans		
Method	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
LSDV	1.129	0.028	40.250	0.730	0.053	13.840	1.103	0.050	21.880
2SLS	1.144	0.054	21.220	0.550	0.191	2.880	0.815	0.234	3.490
AHD	0.621	0.134	4.640	0.319	0.078	4.090	-0.369	0.416	-0.890
GMM	0.779	0.081	9.620	0.399	0.068	5.890	0.563	0.251	2.250

Table 10. Absolute Convergence Tests, Autoregressive Dynamic Panel Data with Fixed Effects

Method	EU&TE-11	$T_{1/2}$	EU&TE-8	$T_{1/2}$	EU&TE-5	$T_{1/2}$	EU&TE-3	$T_{1/2}$	EU&Baltics	$T_{1/2}$	EU&Balkans	$T_{1/2}$
LSDV	Yes	3.27	Yes	3.18	No	n.a.	No	n.a.	Yes	2.20	No	n.a.
2SLS	Yes	2.72	Yes	2.65	No	n.a.	No	n.a.	Yes	1.16	Yes	3.39
AHD	Yes	0.35	Yes	0.58	Yes	0.95	Yes	1.46	Yes	0.61	No	n.a.
GMM	Yes	0.63	Yes	0.74	Yes	2.33	Yes	2.78	Yes	0.75	Yes	1.21

Table 11. Summary Table for Absolute Convergence Tests, Dynamic Panel Approach

	EU & TE-11			EU & TE-8			EU & TE-5		
Method	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
LSDV	0.991	0.033	30.230	1.055	0.030	35.620	1.105	0.027	40.220
2SLS	0.985	0.137	7.190	0.979	0.153	6.400	1.325	0.106	12.460
AHD	0.214	0.135	1.590	0.253	0.118	2.150	0.543	0.129	4.220
GMM	0.753	0.034	21.910	0.699	0.057	12.190	0.798	0.040	19.770
	EU & TE-3			EU & TE-3Baltics			EU & TE-3Balkans		
Method	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
LSDV	1.111	0.032	34.560	1.060	0.037	28.370	1.116	0.038	29.370
2SLS	1.158	0.056	20.750	0.883	0.136	6.490	0.871	0.321	2.710
AHD	0.671	0.142	4.740	0.297	0.137	2.170	0.537	0.204	2.620
GMM	0.840	0.050	16.740	0.646	0.067	9.640	0.803	0.071	11.330

Table 12. Conditional Convergence Tests, Autoregressive Dynamic Panel Data with Fixed Effects

Method	EU&TE-11	$T_{1/2}$	EU&TE-8	$T_{1/2}$	EU&TE-5	$T_{1/2}$	EU&TE-3	$T_{1/2}$	EU&Baltics	$T_{1/2}$	EU&Balkans	$T_{1/2}$
LSDV	Yes	77.56	No	n.a.	No	n.a.	No	n.a.	No	n.a.	No	n.a.
2SLS	Yes	47.27	Yes	32.56	No	n.a.	No	n.a.	Yes	5.56	Yes	5.00
AHD	Yes	0.45	Yes	0.50	Yes	1.14	Yes	1.74	Yes	0.57	Yes	1.11
GMM	Yes	2.44	Yes	1.94	Yes	3.08	Yes	3.97	Yes	1.59	Yes	3.16

Table 13. Summary Table for Conditional Convergence Tests, Dynamic Panel Approach

	EU-15			TE-11			TE-8					
Method	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value			
LSDV	1.155	0.031	36.830	0.624	0.077	8.070	0.591	0.079	7.500			
2SLS	1.385	0.100	13.920	0.948	0.271	3.500	0.911	0.121	7.510			
AHD	0.759	0.160	4.740	0.053	0.171	0.310	0.248	0.089	2.780			
GMM	0.817	0.081	10.120	0.275	0.095	2.910	0.390	0.064	6.090			
	TE-5			TE-3			Baltics			Balkans		
Method	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value	Coefficient	Robust S.E.	t-value
LSDV	1.084	0.065	16.650	1.049	0.062	16.830	0.338	0.113	3.000	0.868	0.247	3.510
2SLS	1.094	0.058	18.840	1.041	0.066	15.700	0.748	0.222	3.360	0.853	0.349	2.440
AHD	0.028	0.236	0.120	0.176	0.333	0.530	0.257	0.138	1.860	-6.593	19.404	-0.340
GMM	0.579	0.167	3.480	0.859	0.099	8.700	0.468	0.064	7.310	0.790	0.090	8.800

Table 14. Absolute Convergence Tests for Groups, Autoregressive Dynamic Panel Data with Fixed Effects

Method	EU-15	$T_{1/2}$	TE-11	$T_{1/2}$	TE-8	$T_{1/2}$	TE-5	$T_{1/2}$	TE-3	$T_{1/2}$	Baltics	$T_{1/2}$	Balkans	$T_{1/2}$
LSDV	No	n.a.	Yes	1.47	Yes	1.32	No	n.a.	No	n.a.	Yes	0.64	Yes	4.89
2SLS	No	n.a.	Yes	12.98	Yes	7.43	No	n.a.	No	n.a.	Yes	2.39	Yes	4.37
AHD	Yes	2.51	Yes	0.24	Yes	0.50	Yes	0.19	Yes	0.40	Yes	0.51	No	n.a.
GMM	Yes	3.44	Yes	0.54	Yes	0.74	Yes	1.27	Yes	4.55	Yes	0.91	Yes	2.94

Table 15. Summary Table for Absolute Convergence Tests for Groups, Dynamic Panel Approach

Source	Data sample	Method	Results for $T_{1/2}$
Knight *et al* (1993, p. 528, Table 1, use implied η to calculate $T_{1/2}$)	98 countries (22 OECD and 76 Developing), 1960-1985	Camberlain's Minimum Distance Estimator (MD)	11 years
Islam (1995, pp. 1145-6, Tables III and IV, use γ to calculate $T_{1/2}$)	OECD-22 and NONOIL-96 1960-1985	MD and LSDV	14.7 and 7.7 for OECD 16 and 10 for NONOIL
Nerlove (2000, p. 25, Table 3, use γ to calculate $T_{1/2}$)	OECD-22, 1960-1985	LSDV Other methods	4.5 years 3.5 to 10.5 years

Table 16 Typical Results for Dynamic Panel Data Estimations of Convergence

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