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Convergence at Last? Evidence from Transition Countries

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Abstract

This paper re-examines the hypotheses of absolute and conditional convergence for a sample of 25 transition countries over the period from 1990 to 2002. After splitting the sample into three four year periods, the hypotheses are confirmed only for the latest period of transition. Instead, for the early transition stage, we find a negative relation between productivity growth on one hand and the speed of price liberalization and initial conditions (measured by initial market distortions) on the other hand. In addition, past (lagged) institutional reforms are found to enhance productivity growth in the intermediate and advanced stages of transition. The confirmation of convergence for the latest stage of transition, however, should not yet be considered as a sign of a permanent return to convergence in these countries as it could be a result of differences in the transition cycles.

JEL Classification: O40, O41, O51, O52, O53

Keywords: convergence, neoclassical growth, regional growth

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1 Introduction

Ex-socialist countries in Central and Eastern Europe and the Former Soviet Union did not only fail to keep up with the pace of economic development in the advanced market economies, but also failed to reduce the regional differences in per capita income between themselves. As noted by Urga and Estrin (1997), who provide evidence on the lack of convergence of per capita income in ex-socialist countries over the period from 1970 to 1995, this finding is surprising as these countries introduced extensive redistributive systems aimed at reduction of regional income inequality. The planned economic system did not only fail to provide sufficient capital flows to reduce income inequality, but also created incentives for a relatively slow technological adoption of new inventions in the production processes which only exacerbated the existing per capita income differences (Iacopetta, 2004).

As opposed to the evidence for ex-socialist countries, the hypothesis of conditional convergence arising from the neoclassical growth model (Solow, 1956; Mankiw, Romer and Weil, 1992) and technological convergence (e.g., Barro and Sala-i-Martin, 1997; Quah, 1999) has been confirmed using various datasets and estimation methods (see e.g., Barro and Sala-i-Martin, 2004; Bloom, Canning and Sevilla, 2002). The datasets used in these studies contained predominantly the data for established market economies, which reinforced the belief between economists that the process of convergence should be observed also between transition countries which gradually reintroduce the market based allocation mechanism. In spite of that, economic reforms, primarily liberalization, caused a large decline in the official measures of aggregate output throughout the region. Hence, the focus of literature on the growth in transition was on the relative importance of structural factors (initial conditions) and (policies) in explaining diverging output performance (Campos and Coricelli, 2003).¹

In particular, Fischer, Sahay and Vegh (1996a, 1996b) find, for the early transition (1992-1994), a positive and statistically significant association between growth and fiscal surpluses, foreign aid, the extent of cumulative liberalization, the importance of choice of exchange rate regime for growth and a negative and significant association between growth and inflation and initial income. However, Aslund, Boone and Johnson (1996) find no robust relationship between growth and any measure reform when dummy variables for war torn countries and ruble zone are included. Furthermore, Heybey and Murrell (1997) find that initial conditions are more important than policy

¹In Campos and Coricelli (2003) an interested reader can find an extensive review of the existing empirical and theoretical transition literature.

variables in explaining growth differences. Similarly de Melo, Denizer, Gelb and Tenev (1997) also find that initial conditions are important not only for growth performance, but also for the speed of reforms. Moreover, they find a non-linear effect of liberalization and other reforms on growth, that is, while the initial impact of liberalization is negative, later on the relationship is positive.

As a consequence of the focus on output decline in the early transition period, there has been very little work done on the relevance of the standard growth factors framed in the neoclassical growth model (Solow, 1956; Mankiw, Romer and Weil, 1992) in explaining differences in growth performance in transition countries. Campos (2001) estimates the standard growth equation (e.g., Mankiw, Romer and Weil, 1992) for the period from 1990 to 1997 and finds that none of the variables (initial per capita income, secondary school enrolment and investment rate) had expected sign. Polanec (2001) confirms these results for extended period from 1989 to 1999. However, when controlling for measures of government failure (corruption) and unobserved differences (year on year panel data estimation), the signs of estimates of the regression coefficients for initial income and investment rates are in line with neoclassical growth theory.

The aim of this paper is to reevaluate the results of these studies on the sample of 25 transition countries over the period from 1990 to 2002. While we build on the contributions of existing studies, we amend the approach in several ways. First, in contrast with existing literature, we split the period of analysis into three four-year subperiods and justify this choice by substantial variation in the estimated regression coefficients over time. Second, we extend the time period of analysis to the latest available data and use the data on real productivity growth corrected for differences in purchasing power instead of real growth rates of per capita income. Third, in the estimations we combine the neoclassical growth factors, variables that were previously used as proxies for initial conditions (market distortions) from de Melo et al. (1997), EBRD Transition Indicators for proxies of reform progress and dummy variables for war torn countries and dictatorships. Fourth, following Quah's idea and empirical results on total factor productivity convergence in Bloom, Canning and Sevilla (2002), we interpret our results within frameworks of the standard neoclassical growth model and a simple model of technological convergence. And last, we discuss the importance of measurement errors for the biases in estimated coefficients.

The empirical results allow us to draw several important findings. First, while the hypotheses of absolute and conditional convergence are rejected for the early (1990-94) and intermediate (1994-98) stages of transition, the evidence for advanced (1998-2002) stage confirms these hypotheses. In addition,

investment rates are also rejected in estimation of standard growth equation without controls for differences in technology. Second, for the early transition, initial conditions and war dummies are crucial in explaining divergent growth performance, while their role subsides to lagged measures of reforms already in the intermediate stage of transition. Further, we find that progress in economic reforms affects the growth of productivity with a four year lag (which is assumed) both in intermediate and advanced stage of transition. Contrary, the current reform progress has statistically insignificant positive effect on productivity. At the end, a word of caution is necessary. Since initial conditions have a large statistically significant and positive effect on growth in advanced stage of transition, which is perfectly correlated with initial productivity, the observed convergence may be a result of different cycling patterns between countries. Namely, those countries that experienced larger and longer productivity declines in the early and intermediate transition stages had also higher growth rates in the advanced stage of transition and vice versa.

The paper is organized as follows. In the next section, we shortly review the relevant theoretical literature and derive the estimation equation. In the third section, we discuss the sources and limitations of the data and resulting biases in the estimates. In the fourth section, we summarize the empirical results and in the last section, we conclude.

2 Theoretical background

The basic theoretical setup for the estimation of growth equations is the standard neoclassical growth model. Solow (1956), who first laid out the foundations of this model, assumed a simple two factor production function with labor and capital. While we could extend the model with human capital as suggested in Mankiw, Romer and Weil (1992), this is not done in this paper as there is convincing evidence that available measures of human capital investment (enrolment rates in different education levels) cannot (yet) account for differences in growth rates of per capita income or productivity (Campos, 2001; Polanec, 2001).² While it may be a good idea to consider measures of stock of human capital as potential factors of growth, these are available only for a small subset of transition countries and thus not considered in this

²In fact, Polanec (2001) finds evidence of a negative response of enrolment rates to a decline in output. Spagat (2002) provides theoretical explanations why there is a reverse causal relationship. In the long run, however, we can expect that lower enrolment rates will cause lower steady state productivity. The length of periods in our analysis is, however, too short to be able to detect this relationship empirically.

work.

Solow (1956) assumes the Cobb-Douglas production function with constant returns to scale and labor augmenting technological progress:

$$Y_t = K_t^\alpha (A_t L_t)^{1-\alpha}, 0 < \alpha < 1, \quad (1)$$

where Y_t , denotes aggregate level of output, K_t and L_t are aggregate amounts of physical capital and labor, respectively, A_t is an index of technology while t denotes time index. Labor and technology are assumed to grow at constant growth rates, n and g , respectively. α is the share of capital income in aggregate output and the elasticity of output to capital. The marginal return to physical capital is assumed to decrease, which is implied by the assumption of α being less than 1. The law of motion for the physical capital is

$$\dot{K}_t = sY_t - \delta K_t, \quad (2)$$

where δ is the rate of depreciation of the physical capital and s is a constant saving or investment rate (in a closed economy). The balanced growth path output per employee in period t can be expressed as

$$y_t^* = A_t \left(\frac{s}{n + g + \delta} \right)^{\frac{\alpha}{1-\alpha}}. \quad (3)$$

If the economy is not on the balanced growth path, it grows according to the adjustment equation which is obtained as a first order Taylor approximation around the steady state:

$$\frac{1}{t} \ln \frac{y_t}{y_0} = g + \frac{(e^{\lambda t} - 1)}{t} \left(\ln \frac{y_0}{y_0^*} \right), \quad (4)$$

where $\lambda = -(1 - \alpha)(n + \delta + g)$ is negative due to assumption of decreasing returns to capital. The first term in (4) states that the average growth rate of output per employee increases one to one with the growth rate of technology. The second term combines the rate of adjustment, λ , and the distance of initial actual from initial steady state level of output per employee, $\frac{y_0}{y_0^*}$. The faster is the rate at which marginal returns to capital decrease (lower is α) and the larger is the ratio between actual and steady state levels of output per employee, the higher is the growth rate of output per employee. Since the balanced growth path of output per employee is not known, it is convenient to replace y_0^* in (4) with expression in (3). The equation for growth of productivity is thus:

$$\bar{g}_y = \theta_1 + \theta_2 \ln y_0 + \theta_3 \ln s_K + \theta_4 \ln(n + g + \delta), \quad (5)$$

where

$$\begin{aligned}\bar{g}_y &= \frac{1}{t} \ln \frac{y_t}{y_0}, \\ \theta_1 &= g + \frac{(1 - e^{\lambda t})}{t} \ln A_0, \\ \theta_2 &= -\frac{(1 - e^{\lambda t})}{t}, \\ \theta_3 &= \frac{(1 - e^{\lambda t})}{t} \frac{\alpha}{1 - \alpha}, \\ \theta_4 &= -\frac{(1 - e^{\lambda t})}{t} \frac{a}{1 - \alpha}.\end{aligned}$$

The growth rate of output per employee increases with an increase in the growth rate of technology, initial technological level and investment rate and decreases with an increase in the initial output per employee and the sum of depreciation rate, technological growth rate and employment growth rate. For the estimation, we can restate (5) in the following way:

$$\bar{g}_y^i = \theta_1 + \theta_2 \ln y_0^i + \theta_3 \ln s_K^i + \theta_4 \ln(n^i + g + \delta) + \varepsilon_i, \varepsilon_i \sim i.i.d. \quad (6)$$

where i is an index for country i and ε_i is an error term.

In equation (6), we made an implicit assumption that all countries have access to the same technology. Empirical evidence, probably best exemplified in Barro and Sala-i-Martin (2004), is however at odds with this assumption. Therefore, it has become customary in the empirical growth literature to replace the common constant reflecting initial level and average growth of technology, θ_1 , with some function $\theta_1(x)$, where x denotes a vector of variables that measure various aspects of technology.³ For transition countries in our sample, there is ample evidence that the assumption of common technology is not appropriate. Not only had these countries different types of socialist system (e.g. centrally planned versus market planned), but also inherited different levels of per capita income and production structure. Furthermore, they chose different sequencing and speed of economic reforms during transition period. Therefore, in the remainder of this section, we justify the selection of some of the variables intended to capture these differences in technology.

³This approach is, however, under serious criticism and since we find arguments convincing, we review the main points in fourth section. In spite of that the data limitations leave us with little room for improvement.

Before we turn to discussion of these variables, it is useful to make two distinctions. First distinction separates the factors that are crucial in the early period of transition from those that are relevant for the intermediate or advanced stages of transition. Second, we distinguish between institutional (organizational) and productive technology, where the former reflects the prevalent state of political and economic institutions, while the latter captures only productive efficiency of firms.

In the early transition, all transition countries in Central and Eastern Europe and in the Former Soviet Union experienced a large output decline caused by economic reforms. In particular, in the theoretical literature the process of liberalization of firm-level decisions (on prices, quantities, contracting partners, etc.) is seen as the primary cause. For example, Blanchard and Kremer (1997) argue that output decline took place due to disorganization, that is, lack of an effective market coordination mechanism after the dissolution of existing prevalent coordination mechanisms: planning ministries for national and Council for Mutual Economic Assistance for international trade. Therefore, according to their explanation output decline is a consequence of non-existing market institutions that would prevent inefficient outcomes, such as failures to agree on terms of contract and therefore trade. Since there is no change in capital in their model, output decline may take place without any change in capital to labor ratio and can be interpreted as a pure organizational technology shock. However, according to the model developed in Roland and Verdier (1999), the process of liberalization may also reduce investment and thus cause output decline through the reduction in the capital intensity. Nevertheless, the primary shock is institutional (or organizational) and is as such also considered in our empirical exercise.

Although these theoretical ideas offer little guidance for the specification of growth equation, it is implied that the shock to output is larger in economies that had more to liberalize and did it faster. If liberalization was to start from different initial market distortions to the same end state, initial distortions would be perfectly correlated to the speed of liberalization and it would have been sufficient to amend the growth equation with a proxy that measures initial distortions. However, since countries had different initial conditions and speed of reforms and these measures are not necessarily linearly related to productivity growth, it is useful to include both measures of initial distortions and speed of liberalization. The measure of initial distortions should primarily reflect initial distortions to pricing mechanism and thus the scope for correction with price liberalization. As we already noted earlier, researchers exploring relationship between growth performance and the speed of economic reforms in transition constructed such measures of initial conditions (distortions). The most prominent one is that by de Melo et

al. (1997) who provide eleven different variables which reflect different, but correlated, distortions to the pricing mechanism. In what follows, we take a subset of these measures and construct a single measure of initial distortions applying the method of principal components and use it in estimations together with a measure of the speed of liberalization. Together, these two variables measure the shock to the organizational technology.

In the later periods of transition process, the negative output shock due to liberalization gradually fades away and positive effects of economic reforms prevail. The long-term benefits are associated primarily with privatization and liberalization. The privatization of state (or socially) owned assets aims at creating incentives for firms to maximize their market value, while liberalization should eliminate constraints limiting the firms' freedom of choice in pursuit of this goal. These two elements of reforms are very much in line with ideas of North and Thomas (1973) and North (1981) who emphasized the importance of equivalence between social and private returns for creation of incentives for investment in human and physical capital and new technology, for which protection of private property rights is quintessential. For a large sample of countries, Hall and Jones (1998) show that differences in institutions explain a large part of cross-country differences in per capita income. Similarly, Knack and Keefer (1995) provide evidence on importance of rule of law (which is a measure of private property rights protection) for growth of per capita income. In line with these ideas and evidence, we expect to find a positive relationship between growth of productivity and the speed of economic reforms in the intermediate and advanced stages of transition process.

Since it is easy to think of many economic and political institutions that have, aside to freedom of choice and protection of property rights, an important effect on economic growth and we are limited in degrees of freedom by already low number of observations, we use in our empirical exercise an aggregate measure of progress in economic reforms. The most comprehensive measure of the progress in economic reforms is the average of transition indicators constructed at the European Bank for Reconstruction and Development (EBRD). This measure of institutional change is the most comprehensive measure and is described in detail subsequently.

There is another, potentially more important, element to technological growth. This is the process of technological convergence which is related to both organizational and productive technology. Since transition countries are well below the world technological frontier, it is reasonable to assume that the process of technological imitation is much more important for growth than the process of technological innovation. According to the models of technological diffusion developed by Barro and Sala-i-Martin (1997) and Connolly

(1999) poorer countries tend to converge even if capital convergence did not take place, as long as imitation is cheaper than innovation. For technological convergence between imitating countries, we need to further assume that costs of imitation increase with the level of technology, a plausible assumption.

The idea of technological convergence can be summarized with a simple ad hoc mechanism proposed by Quah (1999):

$$A_{i,t+1} = A_{i,t} \left(\frac{A_{f,t}}{A_{i,t}} \right)^\gamma, \gamma < 1, \quad (7)$$

where $A_{i,t}$, $A_{f,t}$ denote technological levels in countries i and technological leader(s), denoted f in period t and γ is the rate of decreasing returns to technological adoption. The assumption of γ being less than 1 is crucial for decreasing returns to technological adoption or increasing cost of imitation. This process of technological adoption can be written more compactly:

$$g_{A_{i,t+1}} = \gamma \ln A_{f,t} - \gamma \ln A_{i,t}, \quad (8)$$

where $g_{A_{i,t+1}}$ denotes growth rate of technology for country i between periods t and $t + 1$.

Note that this mechanism does not require an introduction of additional proxy for the growth of technology in the growth equation (6). Namely, the dependent variable, the average growth rate in productivity reflects the growth rate in technology, while the explanatory variable, the initial productivity is affected the initial technological level. Since we do not have a separate measure of initial capital intensity we cannot distinguish between TFP and capital intensity convergence as in Bloom, Canning and Sevilla (2002). Thus, we cannot interpret the estimated coefficient, $\hat{\theta}_2 < 0$, only as a result of decreasing marginal returns to capital, but also due to decreasing returns in technology imitation. Therefore, in what follows, we interpret $\hat{\theta}_2$ in this, more general way.

3 The data

3.1 Sources of the data

The dataset we use is constructed from various sources, the main one being carefully compiled data at the Office of the Chief Economist at EBRD. The original sources of EBRD data were National Statistical Offices, European Comparison Programme (ECP), International Monetary Fund, World Bank and International Labor Organization. A large part of this dataset is publicly

available as it has been published in a sequence of EBRD Transition Reports. We use the data for 25 transition countries⁴ over a span from 1990 to 2002 for the following variables: real growth rates of GDP, levels and growth rates of employment, GDP per capita adjusted for differences in purchasing power from 1996 ECP, gross investment rates and well known measures of progress in structural reforms, EBRD Transition Indicators. In addition, we use several proxies for shocks to organizational technology, well known in transition literature. These measures of initial conditions are taken from de Melo et al. (1997), while liberalization indices are also from EBRD. In regressions, we also include dummies for war torn countries and dictatorships. Dummy for war affected countries assumes 1 if in a four year period there was a war and 0 otherwise.⁵ Similarly, dummy for dictatorship assumes 1 if a country was ruled by a dictator in a four year period and 0 otherwise.⁶

3.2 Measurement issues

It is a well known fact that the quality of the data for transition countries is rather low. If the only measurement problem related to this was a classical measurement error, the estimated regression coefficients would be downward biased. However, we believe there are important biases due to relationship between measurement errors in dependent and explanatory variables, which may cause larger biases in the estimated coefficients. It is therefore essential to provide a short discussion of variable definitions and possible direction of biases in the estimates due to measurement errors.

The key variable in the neoclassical growth model (Solow, 1956) is a measure of aggregate labor productivity. Some researchers use GDP per capita (e.g., Barro, 1991), while others use GDP per labor force (e.g., Mankiw, Romer and Weil, 1992). If the ratios between population or labor force and aggregate employment were stationary, than it is irrelevant, which measure is used. These ratios are, however, not stationary over the sample period and consequently GDP per capita (or per labor force) is a biased measure of labor productivity. In addition, the data on population is based on population registers that did not record large emigration, which became clear only recently after publication of the most recent population surveys.⁷

⁴These countries are: Albania, Armenia, Azerbaijan, Belarus, Bulgaria, Croatia, Czech Republic, Estonia, FYR Macedonia, Georgia, Hungary, Kazakhstan, Kyrgyzstan, Latvia, Lithuania, Moldova, Poland, Romania, Russia, Slovak Republic, Slovenia, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. For the remaining transition countries not included in the analysis the data are widely unavailable.

⁵War torn countries are: Armenia, Croatia, FYR Macedonia, Georgia, Tajikistan.

⁶The dictatorships are: Azerbaijan, Belarus, Turkmenistan, Ukraine, Uzbekistan.

⁷The data on employment are, however, not ideal either. There are some missing

The panel data on GDP per employee are constructed by combining the panel data on real GDP growth rates, population and employment, and internationally comparable GDP per capita. Before we proceed, note that international comparability of productivity levels applies only to year 1996, for which the data from ECP are available. The purchasing power parity (PPP) adjusted GDP per employee in 1996 is therefore the benchmark that we use to calculate time-series applying real GDP growth rates and employment growth rates. The real GDP growth rates applied to generate time series and PPP adjusted growth rates of GDP per employee are not the same. Therefore, use of real GDP growth rates unadjusted for PPP may create a bias in the estimated coefficients. In particular, the relative prices of services that might grow faster in poorer (low productivity) countries are likely to be lower and thus real GDP growth rates lower than PPP adjusted growth rates. As a consequence, the estimate of θ_2 is upward biased, which runs against the convergence hypotheses.

There are several other, potentially much more important reasons, why we believe there is a bias in the estimates of θ_2 caused by measurement errors in productivity. The second one is under-reporting of economic activity of newly established firms (Bartholdy, 1997) and growing informal economy (Lacko, 2000) at the outset of transition process. Since countries with lower initial productivity are more likely to have more pervasive problems with development of statistical practice in line with the standard set in UN's System of National Accounts, the positive relationship between initial productivity and its subsequent unaccounted growth might again render estimates of θ_2 upward biased.

The third reason for a bias in estimates of θ_2 in the early transition period is over-reporting of economic activity in the pre-transition period. Over-reporting is associated with incentives created by the mandatory planning system, which was in place in many transition countries, but particularly characteristic for the former Soviet Union (Winiński, 1991), which consisted of many relatively poor countries in the region. The direction of this bias is however ambiguous, as shown in the Appendix. Since estimates of informal economy suggest paramount importance to under-reporting, we believe that the net effect of these biases runs against the hypotheses of conditional convergence in the early transition period.

The opposite, however, is true for the later stages of transition. Since countries with the greatest problems with under-reporting of economic ac-

values in year 2002 which were supplemented by values for 2001 to prevent losing degrees of freedom. Additional problem is that employment rates depend on labor market institutions which differ across countries. Countries with government transfers to inactivity have usually higher employment rates.

tivity and wide-spread informal economy started to improve statistical practice and include informal economy to official measures of economic activity, the speed of measured convergence exceeds the actual speed of convergence. That is, the coefficient θ_2 is downward biased.

Next, we discuss the construction of saving or investment rates in physical capital. Ideally, we would use the data on gross fixed capital formation that correctly excludes (dis)investments in inventories. However, since available data are only on gross capital formation, we use these data instead. Nevertheless, averaging of investment rates over longer periods (four year periods) should make this bias less relevant. Summers and Heston (1991) warn against the potential bias in estimates of regression coefficient for investment rate, θ_3 , due to a negative relationship between initial productivity and relative prices of investment goods. That is, poorer countries tend to pay higher relative (and absolute) prices for investment goods than richer countries. As a consequence of this correlation, the measured effect of investment rates on growth rates of productivity is biased downwards.

We also need to note that in construction of a log of the sum of employment growth rate, technological growth rate and depreciation rate, $\ln(n^i + g + \delta)$, we take for $n^i = \frac{1}{4} \frac{L_t^i}{L_{t-4}^i}$ and assume fixed and common $g + \delta = 0.15$. Note that 0.15 is higher than in Mankiw et al. (1992) since logarithm function is not defined for negative values that could result due to relatively low (negative) employment growth rates. We assume that technological growth rates and depreciation rates are the same over time and countries.

In the previous section, we discussed theoretical reasons why inclusion of variables that measure differences in technology is needed. There we argued for two types of variables: (1) measures of initial market distortions and (2) measures of institutional reforms. Following de Melo et al. (1997), we use the following measures of initial conditions: initial price and trade liberalization, share of trade within Council of Mutual Economic Assistance, repressed inflation (1987-1990), black market premium, over-industrialization, time under socialism and dummy for neighboring capitalist economy. All but price and trade liberalization which are EBRD Transition Indicators, described below, these variables are taken from de Melo, Denizer, Gelb and Tenev (1997), where interested reader can find detailed description of these variables.

For measures of institutional reforms, we believe that the most comprehensive approach to evaluation of the progress in building of market institutions is provided by the EBRD. It's Office of the Chief Economist constructed a set of measures called Transition Indicators (TI's) that can be classified in one of the three dimensions: (1) reform of enterprises, (2) markets and trade and (3) financial institutions. Reform of enterprises is further divided in

progress in three aspects: (i) small and (ii) large privatization and (iii) restructuring. The dimension measuring progress in developing markets and trade has also three aspects: (i) price liberalization, (ii) trade and foreign exchange system liberalization and (iii) competition policy. The dimension on development of financial institutions has further division into: (i) progress in banking reform and interest rate liberalization, (ii) development of securities markets and non financial institutions.

Each of these aspects of institutional reforms is measured on a scale ranging from 1 to $4\frac{1}{3}$, with a step $\frac{1}{3}$. Evaluations of reform progress capture the state of institutions (thus are cumulative in nature) and are updated each year for all transition countries. Thus these data can be readily used in our panel dataset. Here, we use a simple average of all of these eight TI's.

There are obvious limitations related to these measures. They are made by country economists at EBRD, who are well aware of the ongoing growth performance in the country they evaluate. Although they attempt to reduce this bias by carefully defining standards, there is always a scope for bias. Letting this issue aside, potentially more important is the cardinal nature of the scale which is not measuring cardinal aspects. Thus using these measures we assume that a change in reform from e.g. 1 to 2 has the same effect on productivity growth as that from 3 to 4. It is highly unlikely that this is indeed the case. However, since these are the best data we have, we proceed with our exercise with these limitations in mind.

4 Estimation of growth equations

4.1 Choice of estimation method

In our empirical exercise, we follow the traditional approach to growth empirics (Barro and Sala-i-Martin, 2004). Recently, this approach has been criticized for lack of sound selection criteria for inclusion of various variables in growth equations (e.g., Levine and Renelt, 1992; Durlauf and Quah, 1999). The number of growth factors proposed in a large variety of papers well exceeds the number of countries for which all these variables are available. Therefore, Levine and Renelt (1992) suggest to use an extreme bounds analysis as a formal econometric selection criterion. Dissatisfied with strictness of Levine and Renelt approach (1992), Sala-i-Martin (1997) proposes to use a Bayesian approach to selection of robustly correlated variables. Hoover and Perez (2001), however, show that general-to-specific modelling selects different variables than either of the two proposed methods and argue for use of general-to-specific modelling in growth regressions. With only 25 countries

in the sample, according to the standard rule of thumb of 5 observations per parameter, we already exceed this by including 5 variables in growth regressions. Due to these data limitations, we do not apply any of these selection procedures and justify the selection on theoretical and empirical transition literature instead.

Next, we justify why we estimate growth equations by ordinary least squares (OLS). Islam (1995) and followers suggest to use the fixed effects estimators instead of OLS as former eliminate persistent unobserved (technological) heterogeneity between countries, presence of which renders OLS estimator biased. Islam (1995) also points at much higher convergence rates estimated using panel data techniques. However, panel data are higher frequency data which are always more cyclical and Shioji (1997) shows that fixed effects estimates are very similar if cyclical component is eliminated from high frequency data. The data for transition countries also exhibit cyclical behavior and Polanec (2001) confirms convergence hypothesis for panel data, while it is rejected using OLS. This indicates that the panel data for transition countries confirm convergence hypotheses only due to cyclical behavior of productivity time-series.

The standard growth regressions suffer also from a simultaneity bias, because causality between growth and explanatory variables often runs in both directions. This problem is particularly worrisome for contemporaneous variables, such as government budget deficits, which are usually a consequence of poor growth and not vice versa. Among variables in our empirical exercise, investment rates are the most problematic as they are highly pro-cyclical. As a consequence, the estimates of θ_3 should be biased upwards. However, as we show below, the estimates of regression coefficient for investment rates is even negative in the early transition period and becomes positive and statistically significant in the latest period and correction for this bias makes little difference. Simultaneity bias may also affect the regression coefficients for different measures of economic reforms. For example, countries with worse initial conditions might have decided to make less radical reforms to avoid larger costs in terms of lost output. However, according to our estimates, these correlations are weak and not statistically significant. Thus corrections for these are not considered. Aside to these arguments, it is not clear which variables qualify as valid instruments, especially in the light of warning against use of poor instruments by Bound, Jaeger and Baker (1995).

4.2 Results

In this section, we provide tests of the absolute and conditional convergence hypotheses as defined in Barro and Sala-i-Martin (2004). Absolute conver-

gence refers to a situation where countries with higher productivity grow slower than those with lower productivity. Although neoclassical growth model does not explicitly predict absolute convergence, it is nevertheless a good starting point for analysis.

Table 1 contains the tests of absolute convergence for three different periods of transition process: the early transition from 1990 to 1994, the intermediate period of transition from 1994 to 1998 and the advanced stage of transition from 1998 to 2002. In the early transition, the productivity growth is positively related to initial productivity level at 10% significance level. In the intermediate stage of transition, the sign is negative, but not statistically different from zero, while in the advanced stage, the sign becomes negative and statistically significant at 5% significance level. Thus, the process of absolute convergence in terms of labor productivity started only recently for transition countries.

Table 1: Tests of absolute convergence

Dependent variable: $dy_{t|t-4} = \frac{1}{4} \ln\left[\frac{y_t}{y_{t-4}}\right]$

Var \ t	1994	1998	2002
$\ln y_{t-4}$	0.064 (1.8)	-0.01 (-0.4)	-0.02 (-2.1)*
Cons.	-0.68 (-2.0)	0.1 (0.6)	0.26 (2.65)*
N	25	25	25
R ² adj. (F(1,23))	0.09 (3.3)	-0.03 (0.2)	0.12 (4.4)*

Notes: *t*- statistics are in parentheses;

* denotes 5% statistical significance

These results are reinforced by the summary statistics for the logarithm of labor productivity, shown in Table 2. Standard deviations (SD) and coefficients of variation (CV) show a large increase in dispersion of productivity from 1990 to 1994, a mild increase of dispersion between 1994 and 1998 and a decrease of dispersion from 1998 to 2002. Note also a large decrease of the average (Mean) of logarithm of productivity in the early transition stage and its subsequent growth.

Table 2: Summary statistics for logarithm of GDP per employee
(σ -convergence)

Stat \ Year	1990	1994	1998	2002
<i>Mean</i>	9.597	9.308	9.408	9.63
<i>SD</i>	0.423	0.602	0.617	0.576
<i>CV</i>	0.044	0.064	0.066	0.059
<i>Range</i> (min – max)	8.81 - 10.17	8.17-10.26	8.09-10.35	8.40-10.49

Next, we test the conditional convergence hypothesis as framed in the Solow (1956) model. For this purpose, we extend the above regression equations by the log of average gross investment rate over four year periods, s , and log of the sum of growth rates of employment and technology and depreciation rate ($n + g + \delta$). The hypothesis of conditional convergence is rejected for the early and intermediate periods of transition and confirmed for the advanced transition period, in line with tests of absolute convergence. The coefficient for gross investment rate is not significantly different from zero in any of transition stages, although in advanced stage it is finally correctly signed. The employment growth rate has a correct sign for the respective coefficient in the intermediate and advanced stages of transition. These results confirm the claim by Fischer, Sahay and Vegh (1996b) of an increasing relevance of the standard growth factors in explaining growth performance.

Table 3: Tests of conditional convergence

Dependent variable: $dy_{t|t-4} = \frac{1}{4} \ln[\frac{y_t}{y_{t-4}}]$

Var \ t	1994	1998	2002
$\ln y_{t-4}$	0.04 (0.7)	-0.004 (-0.3)	-0.024 (-2.8)*
$\ln s$	-0.004 (-0.04)	-0.001 (-0.07)	0.02 (1.3)
$\ln(n + g + \delta)$	0.01 (0.16)	-0.04 (-3.4)*	-0.08 (-4.1)*
Cons.	-0.44 (-0.8)	-0.02 (-0.15)	0.15 (1.5)
N	20	24	25
R^2 adj. (F($k, N - k - 1$))	-0.14 (0.23)	0.28 (4.0)*	0.49 (8.6)*

Notes: t - statistics are in parentheses;
* denotes 5% statistical significance

In the second section, where we review related theoretical literature, we argue against the assumption of homogeneity of technology for the sample of transition countries analyzed in this paper. In particular, in the early transition period, countries experienced a shock to organizational technology which caused a decline of aggregate output. As tests of absolute and

conditional convergence hypotheses suggest, the standard factors could not account for observed differences in output decline. Thus, the analysis of the early transition can be considered as disequilibrium analysis as it attempts to identify causes of output decline. Both theoretical and empirical analysis of early transition period, as shortly reviewed earlier, suggest that output decline was a consequence of economic reforms, in particular liberalization of firms' decisions. Furthermore, the extent of output decline should depend on initial distance from some hypothetical market system and the speed of liberalization process.

In the third section, we list a set of proxy variables, taken from de Melo, Denizer, Gelb and Tenev (1997), that measure these initial distortions. Since we have a relatively small sample size, we cannot include all of these variables in growth equation. In addition, these variables are highly correlated and thus their interpretation in a sense of keeping the other variables fixed is not possible. Therefore, the method of principal components seems most suitable approach to (i) reduction of dimensionality of the set of initial conditions and (ii) finding an appropriate (common) interpretation to these related variables.

In Table 4, we show the eigenvector or the factor loadings corresponding to the first principal component with eigenvalue 3.9. This component explains 50% of total variance in the set of measures of initial distortions. The factor loadings, which reflect the strength of correlation between the component and individual initial conditions, are all but one, in line with expectations. The constructed factor has a higher value for countries that had higher black market exchange rate premium, had higher repressed inflation, traded more within CMEA and spent more time under socialism. Also, countries with neighbors that are established market economies and were more liberalized initially have a lower value of constructed factor. For over-industrialization, we would expect a positive correlation with constructed factor, however, it seems that countries with larger market distortions were "under-industrialized". Nevertheless, we believe that the constructed factor adequately captures the extent of initial distortions.

**Table 4: Factor loadings of measures of initial conditions
(distortions)**

Variable	Factor loadings
Over-industrialization in 1990	- 0.38
Location dummy	- 0.62
Repressed inflation	0.79
Black market exchange rate premium	0.91
CMEA Trade share	0.83
Time under socialism	0.78
Price liberalization index (EBRD)	- 0.60
Trade liberalization index (EBRD)	- 0.53

In Table 5 below, we summarize the estimates of augmented growth regressions. The key variable of interest is the measure of initial conditions (or better distortions) denoted IC_{90} . Note that higher value of this variable implies worse initial distortions. Irrespective of the set of other conditioning variables, the estimates are in line with expectations, statistically significant at 1 percent significance level and suggest that output decline was larger in countries with worse initial distortions. At the same time, the speed of economic reforms ($dTI_{94|90}$), as measured by the change in average of EBRD Transition Indicators over a period from 1990 to 1994, is negatively related to productivity growth. However, the last equation indicates that the underlying element of these reforms was in fact the process of price liberalization ($dPriLib_{94|90}$) which is the main element of reforms causing output decline. Again, we avoid giving exact interpretation to the measure of economic reforms or price liberalization as the scale for these measures is not clearly determined.

Note that in estimations, we exclude the investment rate as it did not prove statistically significant in prior estimations and missing values for this variable further reduce the sample size. On the other hand, we include a dummy variable to account for the devastating effects of military conflicts (D_{War}). The estimates of respective coefficient suggest that the average growth rate of productivity was reduced between 6 and 8 percent per year in war torn countries, depending on specification. At last, we note that the sign for initial productivity changed to negative, although it is not statistically significant. Thus, divergence in productivity is caused by the process of liberalization and the extent of output decline depends primarily on initial distortions. This result is encouraging as it suggests that in time the importance of initial distortions should fade away.

The last comment is related to measurement errors. We argued earlier that the coefficient for initial productivity should be upward biased, primarily due to large under-reporting of economic activity of small enterprises and

growing informal economy. Since it is very likely that organizational shock pushed economic activity from measured to unmeasured, inclusion of variables that measure initial distortions could reduce the measurement bias and thus give less biased estimates of the speed of productivity convergence.

Table 5: Augmented growth regressions for 1990-1994

Dependent variable: $dy_{94|90} = \frac{1}{4} \ln\left[\frac{y_{94}}{y_{90}}\right]$

Var	Eq. 1	Eq. 2	Eq. 3
$\ln y_{90}$	-0.010 (-0.7)	-0.010 (-0.5)	-0.025 (-1.2)
D_{War}	-0.06 (-2.7)*	-0.08 (-3.4)*	-0.06 (-3.1)*
IC_{90}	-0.06 (-6.3)*	-0.06 (-6.9)*	-0.06 (-7.3)*
$dTI_{94 90}$	-	-0.03 (-2.0)	-
$dPriLib_{94 90}$	-	-	-0.03 (-2.5)*
$\ln(n + g + \delta)$	0.01 (0.2)	0.01 (0.3)	-0.01 (-0.3)
Cons.	0.1 (0.5)	0.1 (0.5)	0.21 (1.1)
N	25	25	25
$R^2_{adj. (F)}$	0.72 (16.7)*	0.76 (16.1)*	0.78* (17.8)

Notes: t - statistics are in parentheses;

* denotes 5% statistical significance

Now we turn to the discussion of results for the intermediate stage of transition, for which results are shown in Table 6 below. Again, we exclude the investment rate from regression equations. In addition to variables included in growth regressions for early period, we also include a dummy variable for dictatorships (D_{Dic}). This decision is justified by the profound effect of dictatorships on the speed of economic reforms, that is, dictators usually slowed down the process of transition and created new distortions to already liberalized markets. On average growth of productivity in these countries was at least 5 per cent lower each year than in other transition countries, everything else equal. Consistent with results shown in Table 5, war torn countries also grew at slower rate, although the coefficient is not robust to inclusion of variables measuring the speed of reforms as indicated by estimates in the last column.

The proof that the impact of initial market distortions on productivity fades away over time is given in third column. The coefficient is still negative, but not statistically significant. In the fourth column, we include current (1994-1998) and lagged (1990-1994) changes in average EBRD Transition Indicator. While current reform progress has smaller and statistically

insignificant effect on productivity growth, lagged reform progress has larger statistically significant effect. Note that in column 5, lagged reform progress is correlated with dictatorship and war dummy which reduces the coefficient and renders it statistically insignificant. This is likely to be a result of correlation between dummy variables and reforms, in particular, war torn countries probably had also harder time pursuing economic reforms. It is also interesting that further contemporaneous price liberalization did not cause such large disruptions as in the early period as the sign is lower and also statistically insignificant. This is indication of a non-linear effect of liberalization on disorganization. Finally, initial productivity has expected negative sign, although only marginally significant at 10 percent significance level in third and last columns.

Table 6: Augmented growth regressions for 1994-1998

Dependent variable: $dy_{98|94} = \frac{1}{4} \ln\left[\frac{y_{98}}{y_{94}}\right]$

Var	Eq. 1	Eq. 2	Eq. 3	Eq. 4
$\ln y_{94}$	-0.019 (-1.5)	-0.03 (-1.8)	-0.02 (-1.5)	-0.02 (-1.8)
D_{War}	-0.06 (-2.4)*	-0.06 (-2.4)*	-	-0.03 (-1.1)
D_{Dic}	-0.06 (-3.2)*	-0.05 (-2.0)*	-	-0.08* (-0.9)
IC_{90}	-	-0.02 (-1.0)	-	-
$dTI_{98 94}$	-	-	0.03 (1.0)	-
$dTI_{94 90}$	-	-	0.05 (3.2)*	0.02 (1.4)
$dPriLib_{98 94}$	-	-	-	-0.02 (-1.1)
$\ln(n + g + \delta)$	-0.03 (3.0)*	-0.04 (-3.1)*	-0.04 (-3.4)*	-0.04 (-3.5)*
Cons.	0.15 (1.2)	0.24 (1.2)	0.07 (0.5)	0.15 (1.2)
N	25	25	25	25
$R^2_{adj. (F)}$	0.53 (7.7)*	0.53 (6.4)*	0.50 (7.0)*	0.57 (6.3)*

Notes: t - statistics are in parentheses;

* denotes 5% statistical significance

The results shown in Tables 1 to 3 indicate that in the advanced stage of economic transition, standard growth theories became increasingly important in explaining differences in growth performance, even without controls like investment rates or proxies for differences in technology. In Table 7, we present results of augmented growth regressions for the advanced transition period. As opposed to early and intermediate transition periods, here we also include investment rates as these are also found statistically relevant. On the other hand, dummies for wars and dictatorships are not statistically

significant. This is not surprising as only one country was affected by a relatively short-lived civil war and thus the effect of it on growth of four year average productivity was milder than in the early or intermediate stages of transition. On average, dictatorships started to grow at rates similar to more democratic countries. A probable underlying cause for this is that even these countries introduced sufficiently many economic freedoms and thus did not entirely break the process of economic growth. In addition, the pressure of international community through contingent financing agreements forced these dictatorships to step up the speed of economic reforms.

The progress in economic reforms again shows up as an important factor in productivity growth. However, the major impact on productivity comes with delay, similar to what is found for the intermediate transition period. In the last column of Table 7, we include also our measure of initial conditions. We include it to show that countries with adverse initial conditions overcame these and can successfully grow. Surprisingly, the effect of initial conditions is in fact positive and statistically significant. At the same time, the coefficient for initial productivity becomes statistically insignificant. This is indication of a correlation between initial conditions in 1990 and productivity in 1998. Those countries with low initial conditions had larger output decline in the early and intermediate transition and thus lower productivity in 1998. At the same time these countries' productivity grew at higher rates between 1998 and 2002. Thus tentative conclusion that transition countries already behave in line with the neoclassical growth model or model of technological convergence and will continue to do so may be a bit too early. It is likely that this result is partly driven by measurement errors which in this later period work in the opposite direction to what we found for the early transition period. Alternatively, this result could be a consequence of differences in amplitude of cycles caused by reforms. Those countries that had more dramatic declines in early transition had also more steep growth in the advanced stages. Despite these caveats in interpretation of results, we should not dismiss strong indications of absolute and conditional productivity convergence in most recent period of transition.

Table 7: Augmented growth regressions for 1998-2002Dependent variable: $dy_{02|98} = \frac{1}{4} \ln\left[\frac{y_{2002}}{y_{1998}}\right]$

Var	Eq. 1	Eq. 2	Eq. 3
$\ln y_{98}$	-0.026 (-1.9)	-0.018 (-2.4)*	0.001 (-0.1)
$\ln s$	0.02 (0.9)	0.04 (2.5)*	0.06 (3.9)*
IC_{90}	-	-	0.02 (3.0)*
D_{War}	-0.05 (-1.5)	-0.03 (-1.5)	-0.01 (-0.8)
D_{Dict}	0.01 (0.5)	-	-
$dTI_{02 98}$	-	0.002 (0.1)	0.04 (1.4)
$dTI_{98 94}$	-	0.05 (2.7)*	0.04 (3.5)*
$\ln(n + g + \delta)$	-0.08 (-4.0)*	-0.07 (-3.9)*	-0.06 (-4.2)*
Cons.	0.10 (0.8)	0.13 (1.6)	-0.002 (-0.03)
N	25	25	25
$R^2_{adj.} (F)$	0.50 (5.8)*	0.62 (7.7)*	0.74 (10.8)*

Notes: t - statistics are in parentheses;

* denotes 5% statistical significance

5 Conclusions

In this paper we confirm the validity of conjecture made by Fischer, Sahay and Vegh (1996b) that over the process of transition, the factors pertinent to the standard growth theory will be increasingly important in explaining the cross-country differences in growth of productivity. For this, we found it useful to split the process of the past transition into three four year windows. Although the choice of windows was somehow arbitrary in attempt to strike a compromise between the length of sub-periods and capturing different factors at work, the choice is justified by results which indicate changing relation between initial productivity and its subsequent growth. Thus, in line with conjecture, in the early transition, factors like investment rates or initial productivity did not play any role in explaining large differences in output declines. The test of absolute convergence for this early period even shows the opposite - divergence in productivity. This process already seized in the intermediate period, while in the advanced period started to reverse as we observe both absolute and conditional convergence of productivity.

Our results suggest that initial divergence in productivity is mainly a result of the process of liberalization. Namely, the larger were initial distortions of economic system and faster was the process of liberalization, greater was subsequent output decline. Inclusion of these variables in regression equa-

tions also turns over the sign for initial productivity. That is, controlling for differences in initial distortions, productivity does not exhibit divergence.

Also, we find that in later stages of transition, measures of economic reforms matter for productivity growth, although with a lag, which is in our exercise equal to four years. This result confirms importance of reform efforts in enhancing the potential for growth.

Finally, since in our analysis we use relatively short time windows (four years as opposed to ten years), we cannot be certain that the process of convergence is not a consequence of different cyclical features of analyzed countries. Therefore, the conclusion that growth patterns in transition countries are already governed only by standard growth factors may be a bit too early.

6 Appendix: Effects of measurement errors

Case 1 *We assume that the true growth equation has a modified form of the growth equation given in (4):*

$$y_{it} = \theta_0 + \theta_1 y_{i0} + \varepsilon_i, \varepsilon_i \sim IID(0, \sigma^2), \quad (9)$$

where y_{it} is actual per employee growth of GDP for country i over a period from 0 to t , y_{i0} is actual initial GDP per employee and θ_1 is the true value of conditional convergence parameter. ε_i is a regression error, identically and independently distributed with zero mean and variance σ^2 . We further assume, that the bias in the observed growth rate (y_{it}^*) is negatively related to actual initial income. In the main text of this Chapter, we put forward two reasons: (1) unmeasured economy is more spread in initially poorer countries and (2) measured growth may have been lower for poorer countries because liberalization removed incentives for over-reporting of output. Therefore, we can write the measured output growth as

$$y_{it}^* = y_{it} + \alpha y_{i0} + \mu_i; \quad \alpha > 0 \text{ and } \mu_i \sim IID(0, \omega_1^2), \quad (10)$$

where μ_i is a classical measurement error with identically and independently distributed with zero mean and variance ω_1^2 . Measured initial income may also be biased due to classical measurement error and we assume that bias of observed initial income δy_{i0} also depends on the actual initial income and a classical measurement error, ξ_i :

$$y_{i0}^* = y_{i0} + \delta y_{i0} + \xi_i, \delta < 0, \xi_i \sim IID(0, \omega_2^2). \quad (11)$$

The estimated coefficient β^* differs from the true value of coefficient θ_1

$$\beta^* = \frac{Cov(y_{it}^*, y_{i0}^*)}{Var(y_{i0}^*)} = \frac{\theta_1 + \alpha}{1 + \frac{\omega_2^2}{(1+\delta)Var(y_{i0})}} \quad (12)$$

and the size of the bias depends on parameters a and δ and variances of a classical measurement error, ξ_i , and initial income. Primarily we are interested in the bias created by under and over reporting of economic activity. While the effect of under-reporting has a clear bias against convergence (as it only increases α), initial over-reporting and later removal of dysfunctional institutions, increases α on one hand (bias against convergence) and decreases δ (bias in favor of convergence). While in general the net effect is not known, we believe that a problem of under-reporting was more pervasive than the problem of over-reporting and the bias works against the hypothesis of conditional convergence.

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