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Convergence or Divergence: The Analysis of Economic Growth in the CIS Countries

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Annotation

This dissertation examines from a comparative perspective the growth experience for a sample of twelve countries of the former Soviet Union over the period from 1991 to 2008. Two methods of econometric analysis are applied: cross-section regressions and dynamic panel data estimation techniques. The main focus of the study has been to empirically establish whether countries in the region are converging or diverging in terms of their income per capita and to find important sources of cross-country differences which determine the shape of this process. I did not find statistically significant support for conditional convergence in any cross-section period. It is partly supported by the increased dispersion of per capita income levels during the sample period. Meanwhile, panel data fixed-effects and GMM methods provide strong support for conditional convergence hypothesis. The first-differenced GMM estimator indicates a rate of convergence of around 2 per cent a year, which is surprisingly similar to the standard cross-section findings in empirical literature. However, it could be the result of the cyclical behaviour of output during transition. In general, results indicate that structural transformation is not yet over in most of the countries. Therefore progress in market-oriented reforms and institutional development seem to be one of the influential factors of catch-up and convergence.

Keywords

economic growth, convergence, the neoclassical growth model, transition countries

Statement:

1. This statement is to confirm that this paper is a product of my own work and also to confirm that I used the listed sources in producing it.

2. I agree that the paper can be checked for research and studying purposes.

Prague, 21 May 2010 **Durbek Hakimov**

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Abbreviations

CEE	Central and Eastern Europe
CSB	Central and Southeastern Europe and the Baltics
CIS	Commonwealth of Independent States
EBRD	European Bank for Reconstruction and Development
EU	European Union
FDI	Foreign Direct Investment
FSU	Former Soviet Union
GDP	Gross Domestic Product
GMM	Generalised Method of Moments
IMF	International Monetary Fund
LSDV	Least Squares with Dummy Variables
OLS	Ordinary Least Squares
OVB	Omitted Variable Bias
PISA	Programme for International Student Assessment
PPP	Purchasing Power Parity
TFP	Total Factor Productivity
WB	World Bank
WDI	World Development Indicators
WGI	World Governance Indicators

INTRODUCTION

The inherent importance of economic growth and long-term economic development for human welfare cannot be overstated. As it was succinctly pointed by Lucas (1988) there is something universal and captivating in the study of economic development which makes it '*hard to think about anything else'*. It is well-known that steady pace of economic growth can change the fate of countries and the living standards of their citizens even in a historically short period of time. For instance, the economy with 7 per cent a year growth of GDP can double its income within a decade whereas the economy which is growing at 3 per cent a year will need more than two decades to reach the same level of growth.

Therefore the issue of different growth rates of countries and particularly rapid development and catch-up of some nations, while slow growth and stagnation of others has been one of the intriguing topics for discussion in economic theory. Renowned Solow growth model (1956) based on aggregate production function with decreasing returns to capital established one of the cornerstones of the study of economic growth. Taking saving ratio, population growth rate and technological change parameters as exogenous, it shows that in the long run countries converge towards their steady-state. A country with a higher saving rate will experience faster growth rates, whereas higher population growth decreases country's steady-state level. Owing to the law of diminishing returns to capital if countries are similar in all parameters except their initial income per capita poor countries should grow faster and converge towards the income levels of rich countries *(Mankiw, Romer and Weil 1992).* Alternative endogenous growth theories emerged in response to the failure of the neoclassical growth model to explain increasing income disparities in the world *(Islam 1995).* The key features of these models are the existence of externalities and increasing returns to broadly defined capital *(Sala-i-Martin 1996, 1026).* In contrast to the classic approach, according to the new growth theory effective government policies on research and development or education and more efficient institutions can have a lasting impact on the long-run growth rate of an economy.

In fact, the lack of absolute convergence across economies does not necessarily reject the validity of neoclassical growth theory. It arises from the misinterpretation of the key assumptions of the model, which actually predicts convergence of income levels under certain conditions. When these parameters are controlled for, the evidence supports conditional convergence in various samples of countries and regions *(Barro and Sala-i-Martin 2004).*

Another important characteristic of the model is that it is intended to address the conduct of development in economies with a market-based allocation mechanism, which is fundamentally different from planned economic system. It is well-known that during the socialist era there were continuous efforts to equalize income levels across the states and social classes through extensive redistributive systems *(Estrin and Urga 1997).* There has been some convergence of the planned rates of output and in key welfare indicators in the ex-communist block, but by the late 1980s '*convergence in per capita incomes remained elusive' (Cornia 2009).* Therefore, at the onset of transition the removal of socialist distortions and the implementation of market reforms were optimistically believed to eradicate income differences and countries were expected to catch-up with the advanced economies *(Campos and Coricelli 2002).* However, transition experience led to important differences among independent states both in terms of reform policies and economic outcomes, especially during the early transformational recession period. Consequently economic performance as measured by per capita income growth diverged sharply in post-communist transition countries, which prompted the World Bank study (2002) to conclude that the variability in growth performance across countries has intensified.

It is noteworthy that year 2011 marks the anniversary of twenty years of transition and Belovezha accords that dissolved the Soviet Union. The fall of communism led to the creation of laboratory of economic reforms and transformation, transition into market economy and economic change in a large geographic area. In light of this anniversary, it is a good time to analyse growth experience and income distribution of twelve independent economies which have undergone the major structural transformation during this period. Transition from a socialist political system towards democracy and from a centrally planned economy towards a market economy is a unique experience. Twenty years of transition have produced highly different outcomes across transition countries. It is particularly evident in the different level of development and growth rates of the former Soviet Union (FSU) countries. A few countries have experienced the acceleration in growth of GDP per capita, but other economies have lagged behind, raising questions as to the role of traditional factors of growth as well as government policies and institutions. Though all of the countries inherited the same socialist system and centrally planned economies, they had dissimilar starting positions reflecting their income per capita, structural differences, geography, culture and traditions. Diverse initial conditions and imbalances may partly explain the contrasted pace of reforms and development path in the early years of transition, because the negative effect of greater initial distortions was found to fade away in the advanced stages of transition. There are other more important variables such as progress in market-oriented reforms, macroeconomic and social stability, high investment rates and human capital that proved to be the means of stable economic growth for the longer periods.

The aim of the dissertation is to analyse from a comparative perspective the growth experience in the first two decades of transition from 1991 to 2008 in all countries of FSU but Baltic states. There are few studies on the relevance of standard growth factors in transition economies because of the main empirical focus on explaining transitional recession and recovery as well as relatively short time dimension available. Campos (2001) based on specifications from Mankiw, Romer, and Weil (1992) analysis estimates the standard growth equation for twenty-five transition economies in Central and Eastern Europe (CEE) and the FSU for the period from 1990 to 1997 and finds that none of the variables namely initial per capita income, secondary school enrolment and investment rate had the expected sign. Polanec (2001) obtains almost the same results for twenty-four transition countries for an extended period from 1989 to 1999. However, when controlling for measures of government failure such as corruption and unobserved cross-section differences through 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. Later a similar elaborate cross-country research was carried out by Polanec (2004) for the sample of twenty-five transition countries from 1990 to 2002, which finds the evidence of both absolute and conditional convergence hypotheses only for the advanced stage of transition.

The analysis builds particularly on the contributions of the two above-mentioned studies by Polanec but differs from them in a number of ways. First of all, time period of analysis is extended until 2008, which is the latest pre-crisis year available. Prolonged time span of analysis can shed more light on the patterns of economic growth by providing extra information on dynamics of development. Secondly, the analysis is focused on twelve countries of the FSU alone and studies the convergence process within the group. In majority of empirical literature the FSU states are usually controlled by a separate dummy variable recognizing their unique development pattern. It was also acknowledged in the World Bank study (2002) that there is a profound gap between Central and Southeastern Europe and the Baltics (CSB) and the Commonwealth of Independent States (CIS) both in terms of economic and political landscape. And the general consensus is that CIS countries are progressing some distance behind CSB in terms of economic growth and institutional development. Thirdly, there are several variables typically considered in empirical research as the proxies for technological differences among countries such as the measure of initial distortions and European Bank for Reconstruction and Development (EBRD) Transition Indicators of reform progress. In addition to them a number of quite region-specific variables such as natural resource abundance and especially hydrocarbon richness as well as migrant labours' remittances are included into regression estimations. Thus, extended time period, more homogenous sample of countries and additional control variables more characteristic to the countries of FSU may provide some additional insights into the determinants of convergence in the region.

The main research goals can therefore be formulated as the following:

1. To examine the distribution dynamics of income for the given set of countries using descriptive statistical methods;

2. To test empirically the question whether countries in transition are converging or not, using two methods for empirical estimations: cross-section regressions and dynamic panel data econometric modelling;

3. To find important cross-country characteristics potentially affecting convergence process and their relative influence in different stages of transition.

Results of the cross-section analysis indicate that the nature of relationship between most of the variables is non-linear and dynamic. The relative importance and influence of different variables change over time as countries progress through transition. When it comes to the key coefficient of interest, relationship between initial income and subsequent growth rates, the evidence is mixed, and as expected there is no evidence of absolute convergence. Moreover, results suggest little relevance of even conditional convergence hypothesis for the CIS countries during the transition period. In contrast to theoretical predictions, the coefficient estimates on initial income are significantly different from zero and positively signed, particularly when I control for the country-specific characteristics for the period from 2000 to 2008. At the same time, it seems reasonable to conclude that there are fundamental unobserved and unmeasured differences across these countries. One of the most robust and significant cross-section variables that promote growth appears to be investment rate, but causality cannot be claimed without using a valid instrument. It is highly likely indeed that causality runs in a reverse direction or there is an omitted variable where a high growing economy because of that factor can also accumulate high investments.

The regression results in panel data which allows to control for the cross-country heterogeneity and to better understand the dynamics of economic relationships support the conditional convergence hypothesis. In line with the results of previous research, the system GMM estimator is found to increase efficiency of parameter estimates in a short panel by tackling endogeniety problems and unobserved heterogeneity. Nevertheless, keeping in mind cyclical behaviour of output during transitional recession and recovery periods, when initially income growth declined at a decreasing rate and then accelerated at an increasing rate, panel data results should be interpreted with caution. Unlike significant positive effect of investment on growth in a cross-section, panel analysis shows its little or no role in fostering growth. On the other hand, in contrast to cross-section mixed evidence in favour of market building reforms, controlling for country- and time-invariant characteristics reveals their significant positive effect in explaining growth. Besides, primary energy production is highly statistically significant and positive, which indicates that growth in hydrocarbon-rich economies might be higher independently of the effects of other variables included in the model.

This dissertation empirically analyzes these issues and is structured as follows. Chapter 1 surveys the empirical literature on convergence concepts and briefly reviews evidence on the links between growth, transition and important conditioning factors in the countries of FSU. In Chapter 2 of the dissertation the research design is laid out where I also discuss some methodological and measurement issues associated with the data in transition countries; present the results starting with the cross-section estimates and proceeding to more complex panel data specifications. Final section concludes the dissertation with an interpretation of results; the main findings are highlighted and some recommendations are offered about how this research could be developed.

1. REVIEW OF GROWTH STUDIES AND THEORETICAL BACKGROUND

1.1 Theoretical framework of the link between convergence and different growth models

Divergent patterns of economic development and significant income differences around the world generated profound academic interest in the study of the sources of economic growth. Based on the traditional framework of growth theory the catch-up effect or convergence hypothesis states that if certain parameters including propensity to save, population growth rate and technological growth are the same across economies, then in the long run all economies converge to one another. Therefore, convergence as a concept has become the main testing toolbox of the validity of the predictions of economic growth models.

It should be noted that convergence process can be analysed from different aspects. According to the classification proposed by *Nazrul Islam (2003, 312)* the following seven dichotomies can be distinguished in the theoretical and empirical literature:

(a) Convergence within an economy versus convergence across economies;

(b) Convergence in terms of growth rate versus convergence in terms of income level;

(c) ß-convergence versus σ-convergence;

(d) Unconditional or absolute convergence versus conditional convergence;

(e) Global convergence versus local or club-convergence;

(f) Income-convergence versus TFP (total factor productivity)-convergence and

(g) Deterministic convergence versus stochastic convergence.

There are two streams of thought in economic growth theory. Until the 1990s the Solow's exogenous growth model (1956) has been the leading theory. According to the neoclassical model of capital accumulation, an economy converges towards a steady state by the "law" of diminishing returns to capital: countries with a low endowment of capital relative to labor will have a high rate of return to capital. In this framework, it is assumed that countries are equal by all parameters but their initial levels of capital per capita, and poor countries have higher marginal capital productivity than rich countries. As a result, given addition to the capital stock will have a larger impact on per-capita income in poor countries and this process will end with the equalisation of the countries' per capita outputs. In convergence literature this is known as the absolute or unconditional convergence hypothesis. Beta (β)-convergence is observed when the poor economies tend to grow faster than rich ones with the key assumption that the only difference across countries lies in their initial levels of capital *(Sala-i-Martin 1996, 1020)*. ß-convergence is usually estimated by regressing the average growth rate of gross domestic product per capita ($y_{i,t,t+T}$) over a sample period (t, t+T) on the initial income level (log ($y_{i,t}$)) across the cross–section of countries (i).

$$\mathbf{y_{i,t,t+T} = \alpha + \beta \log (y_{i,t}) + \varepsilon_{i,t}} \quad (1)$$

The name of this type of convergence is derived from the coefficient of the initial income variable in these regressions (β) and is expected to be negative if the hypothesis holds.

It should be reminded that originally Solow growth model was formulated to the course of events within a single country, but later it was interpolated to cross-country comparisons. The model has the following main predictions which are broadly consistent with experience *(Mankiw 1995, 277)*:

1. In the long run, the economy approaches a steady state that is independent of initial conditions;

2. The steady state level of income depends positively on the rates of savings and negatively on the population growth;

3. The steady state rate of growth of income per person depends only on the rate of technological progress;

4. In the steady state, the capital stock grows at the same rate as income, that is capital-to-income ratio remains constant;

5. In the steady state, marginal product of capital is constant, whereas marginal product of labour grows at the rate of technological progress.

The independence of the steady state from initial conditions (prediction 1) is closely related to the debate over convergence and has attracted much empirical attention. Though there is usually negative relationship between initial income and consequent rates of growth across the group of developed countries or within their regional units, empirical evidence for a large set of countries has not supported the convergence of income levels worldwide *(Barro 1991).* There is much more disparity in international living standards than the model predicts.

However, failure to find absolute convergence for a heterogeneous group of countries arises from simplifying assumptions of the neoclassical growth model. The most important simplification is the assumption that the long-term growth rate is solely determined by the rate of technological change which is taken to be exogenous. In general, it treats technology as a public input which is both nonrival and nonexcludable *(Romer 1990).* Technological innovation can be costlessly replicated, the benefits of innovation are shared equally between economic agents and nobody pays any compensation for gaining advantages from it.

To be sure, the neoclassical model's prediction of unconditional convergence is based on the key assumption that countries are similar by all other factors but their initial levels of per capita capital. Therefore, any factor that is relevant for growth and may affect the marginal addition to per-capita income must be controlled for, including variables such as investments in human capital, political climate or corruption. It follows that each country may have its own steady-state level of growth. A fundamental question then becomes finding the factors which are relevant in order to differentiate between countries by their individual growth patterns.

Centrepiece of the Solow growth model is a Cobb–Douglas type of production function *(Mankiw, 1995, 277)*:

$$\mathbf{Y_t = K_t^{\alpha} (A_t L_t)^{1-\alpha}} \ , \qquad (2)$$

where Y – output; K – capital, L – labour, A – total factor productivity, α – capital share.

Based on the assumption of constant returns to scale, the production function can be written in the form of per efficiency unit of labor as

$$\mathbf{y = f(k)}\ , \tag{3}$$

where y = Y/AL, k = K/AL, and f(k) = F(k, 1). The capital stock per effective labour (k) evolves according to

$$\mathbf{\Delta k = sf(k) - (n + g + \delta)k}\ , \tag{4}$$

where s is the rate of saving, n is the rate of population growth, g is the rate of growth in technology, δ is the rate at which capital depreciates. The model takes s, n, g, and δ as exogenous. As long as the production function is well behaved, the economy approaches a steady state over time. In the steady state, income per efficiency unit (y*) is constant. Income per person grows at rate g, and total income grows at rate (n + g). The steady state level of per capita income (y*) is given by *(Varblane and Vahter 2006, 22)*:

$$\mathbf{y^{*} = A_0\, e^{gt}\, [s/(n + g + \delta)]^{\alpha/1-\alpha}}\ . \tag{5}$$

The formula clearly exhibits that a country's steady state income level depends on A_0, s, g, n, δ and α. In case of unconditional convergence, all these factors should be the same for all countries. Generating the initial growth level based regression, this means that the sign of beta coefficient should be negative even if no other variable is included on the right-hand side. If we include a vector of variables to control for the different technological and behavioural parameters we get the concept known in the classical literature as conditional β-convergence *(Sala-i-Martin 1996, 1026).* Now the prediction of the neoclassical model is that the growth rate of an economy will be positively related to the distance that separates it from its own steady state and the growth rate falls as the economy approaches this long-run level.

The above model indicates that the countries with relatively similar starting positions are more likely to converge in the long-run because of common steady-states. Especially, it will be more imminent when these countries share the homogenous economic, political and social environments. This idea was recognized in convergence theory as the concept of club-convergence. According to the main notion of this concept, initial conditions determine, in part at least, long run outcomes and countries that are similar in observable characteristics will reach similar long-run outcomes *(Durlauf 2005, 38)*. It resembles the second approach to convergence called sigma (σ)-convergence, which may be generated by the existence of ß-convergence. It describes the process of growth when the income levels of countries will become more equal and the dispersion of their real per capita GDP levels tends to decrease over time. For the cross-section variance ($\sigma^2_{\log y,t}$) of income levels ($\log y_{i,t}$) σ-convergence is said to hold between times t and t+T, if it satisfies the following condition *(Durlauf 2005, 52)*:

$$\boldsymbol{\sigma^2_{\log y,t} - \sigma^2_{\log y,t+T} > 0} \,. \qquad (6)$$

It follows that once economic policy instruments are controlled to eliminate cross-country differences, then countries may converge. In the framework of the post-Soviet countries the central question of interest will be what the important factors of convergence are and how certain policies can help to speed up the convergence process.

To sum up, neoclassical growth theory with its simple assumptions and structure - a single homogenous good, Cobb-Douglas production function, exogenous labor augmenting technical progress and exogenous labor force growth provide a starting point for the analysis of long-term economic activity. According to the Solow growth model, better policies and institutions affect the level of economic efficiency with which resources are allocated in the economy. However, changes in economic policy will only lead to growth temporarily, but eventually the economy approaches a steady state in which growth is independent of the policy. In other words policy changes can have only level effects raising the level of per capita output but not growth effects. In the long-run all countries share the same growth rate which is determined by technological progress only and is expected to be available freely *(Jones 2002, 41)*. Applying this model to transition countries may provide the clues whether countries in transition converge or not and what the important conditioning variables are.

Inability of the neoclassical model to explain the magnitude of international income differences and the lack of empirical evidence of convergence process throughout most of the world stimulated the new generation of models of endogenous growth in the mid-1980s starting with Romer's pioneering paper (1986). Existence of the externalities, increasing returns and the lack of inputs that cannot be accumulated may lead to the absence of diminishing returns to capital. Technological growth is endogenously determined by the resources devoted to the creation of knowledge or human capital in a society. The theory emphasised the idea that technology is not a public good and monopoly rent is achieved mainly as a result of holding unique technology. This provides direct interest of firms in investing into research and development.

In new growth theory two economies with the same fundamentals can move apart along very different paths. Factors that potentially make for underdevelopment such as the distribution of economic or political power, institutional development and aspirations are themselves profoundly affected by the development process. Hence the model provides a completely new approach to the role of government and its economic policies such as taxation, maintenance of rule of law, regulation of the economy that can influence investment decisions and boost growth *(Ray 2007, 2)*.

The key difference of endogenous growth model from the standard applied framework is the absence of diminishing returns to investment. In this case knowledge spillovers and external benefits from human capital produce constant or increasing returns to capital and enable persistent growth *(Barro 1997, 6)*. There are several types of approach within the framework of the endogenous growth theory. The literature on endogenous growth has mainly relied on capital with externalities *(Romer 1986)* and accumulation of knowledge *(Lucas 1988).* An important line of thought to the new economic theory was added by *Abramowitz (1986)*. He argued that there are certain growth-inhibiting forces that impede a technologically backward country from making a leap forward. The pace of realization of the potential for catch-up depends not only on technological absorption capacity but also on the so-called "social capability", which includes human capital, institutions and societal characteristics.

According to the new theory of endogenous growth, there exists no quasi-automatic convergence. Lack of adequate social capability can be a serious barrier to convergence. In addition, for example, Lucas (1988) showed that under the conditions where human capital with increasing returns is the main driving force of economic growth, the possibility of brain drain may act as a vehicle of cross-country growth divergence. Other authors insisted that R&D and human capital creation, being the most important engines of growth, would also cause growing inequality between countries and instead of convergence on the global scene, divergence would start to dominate as poor countries have much less resources to invest into these areas *(Romer 1990)*. Nevertheless, the majority of authors are still relatively optimistic about the perspectives of the endogenous growth models of international convergence *(Varblane and Vahter 2006).*

1.2 Economic transformation during transition years in the post-Soviet countries

Growth dynamics of the ex-socialist countries in CEE and the FSU reveal two striking characteristics. The first is a sharp output decline, at least, according to the official statistics in every single country with no exceptions and the second is the contrasting experiences across these economies. Despite some initial optimistic expectations for the rapid efficiency gain and growth after removing the distorted socialist planning system,

[they] 'have not only failed to keep pace with economic development in the advanced market economies, but also failed to reduce the regional differences in per capita income between themselves.' (Polanec 2004, 55)

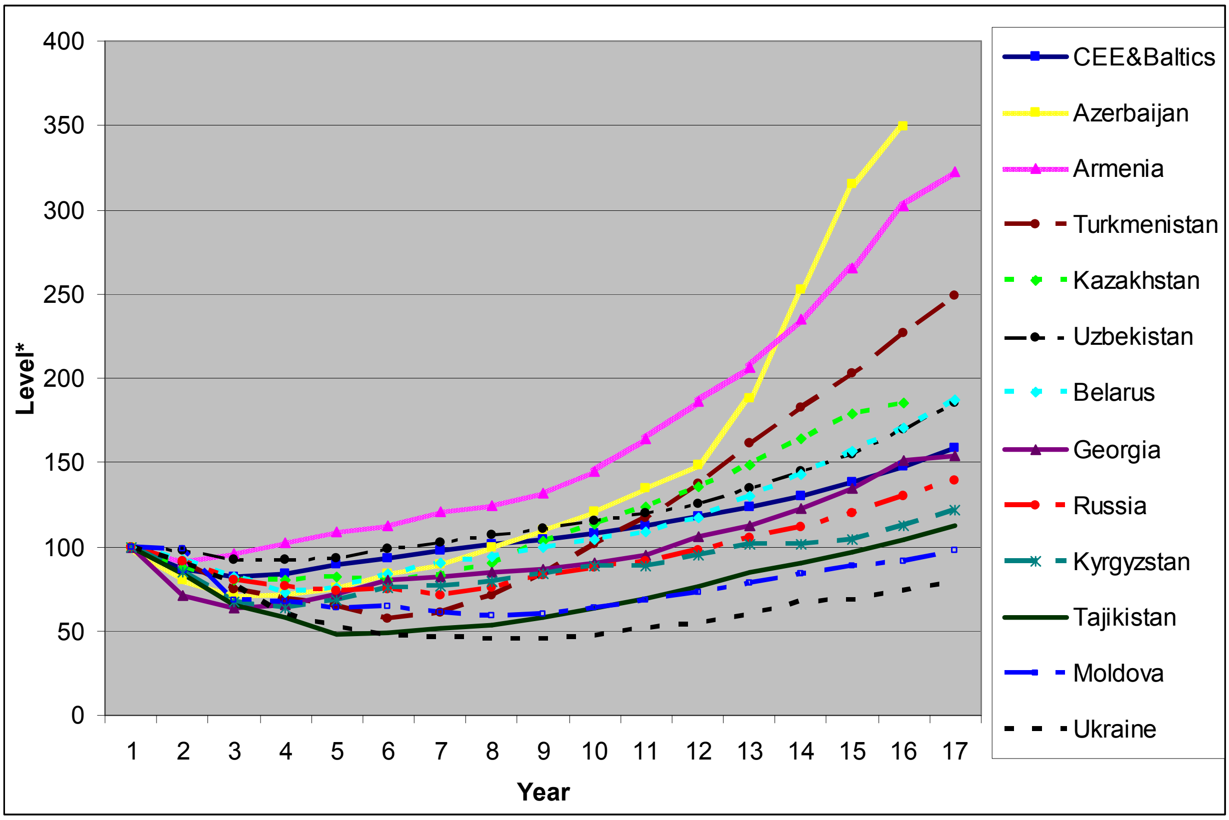
It was generally believed that the transformational recession is an inevitable outcome of reforms and reflects efficient reorganization and reallocation of productive resources. Early debates on the causes of the output fall have focused on the relative role of aggregate demand (Keynesian recession) versus aggregate supply-side explanations *(Polanec 2001, 2)*. It would, however, seem to be very difficult to explain output fall of such a magnitude with standard macroeconomic analysis alone. Another strand of research emphasized microeconomic foundations of the output contraction with negative effects of price liberalization and breakdown of trade relations.

Thus, one of the widely accepted explanations for a large decline in output is that the primary shock had mainly institutional or organizational origins. For example, Blanchard and Kremer (1997) argue that output decline took place because of the so-called disorganization phenomenon, that is the lack of an effective market coordination mechanism after the elimination of the existing one - a central planner. As a result of incomplete contracts and information asymmetries inefficient bargaining led to the collapse of the centralized production networks. Since chains of production linked many specialized producers, output declined sharply especially in the FSU than in Central Europe. Therefore, according to their interpretation, output decline is a consequence of the absence of fundamental market institutions which would prevent inefficient outcomes but take time to build.

Since output may fall without any change in capital in their model, resulting contraction can be perceived as a pure organizational technology shock *(Polanec 2004, 61)*. Whereas according to the search frictions and investment specificity model developed by Roland and Verdier (1999), disruption of previous production links caused by the process of liberalization may also reduce investment, at least temporarily. Aggregate output may decline after liberalization due to the failure of enterprises to replace obsolete capital and through the reduction in capital intensity while they are searching for the new long-term partner. It is also shown in a growth accounting exercise by Mark De Broeck and Vincent Koen (2000) for the FSU countries for the period from 1991 to 1997 that though capital accumulation slowed considerably, the output fall at the outset of transition could be mainly attributed to declines in total factor productivity rates.

Figure 1 illustrates the evolution of measured GDP since the beginning of transition in the FSU and Central Europe countries. As suggested by Blanchard (1997) it is better to measure time not as calendar time but as time since the beginning of transition in each country. Thus, the first year of transition is considered to be the year when there was a steep decline in industrial production in the early 1990s. This gives the starting point as 1990-1991 for CEE and Baltic states, 1991 for Ukraine, 1992 for all countries except Azerbaijan and Kazakhstan for which it equals 1993. Output fell everywhere across the region, while the relative size of the decline in GDP was higher in the CIS than in CEE and Baltic states. In the former it took longer to start GDP recovery, with the average minimum point being reached towards the end of the 1990s. Since recovery from transitional recession all countries have been growing. In 2008, all countries but Moldova and Ukraine exceeded their pre-recession level of output.

Figure 1. Index of real GDP

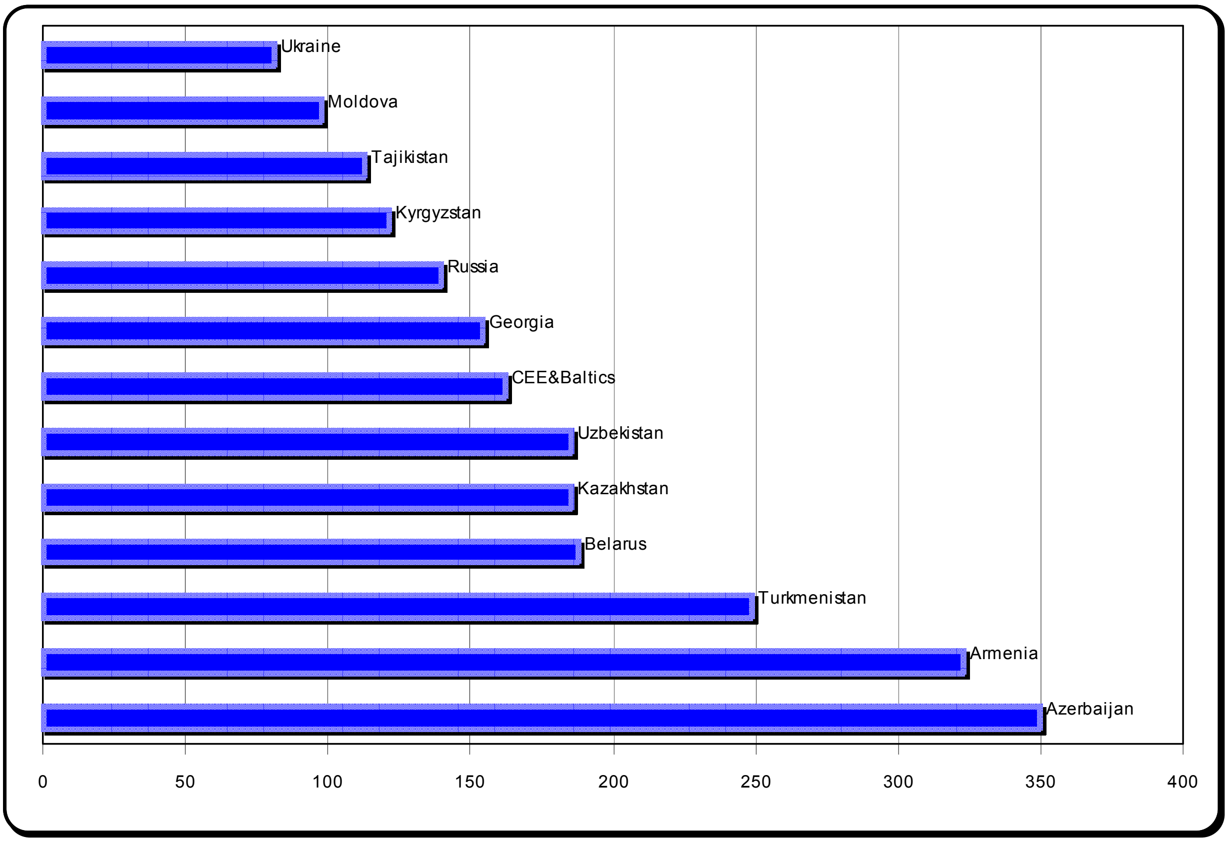


Source: Author's calculations using GDP in constant US dollars at PPP exchange rates from World Bank World Development Indicators. Central Europe and Baltic states include Croatia, Slovak Republic, Slovenia, Czech Republic, Hungary, Poland, Estonia, Latvia, and Lithuania. *Value in the year before transition = 100%

As shown in Figure 2, interestingly enough the countries that were most successful looked very much like a list of procrastinators in terms of economic liberalisation and non-democratic regimes in terms of political liberalisation: Turkmenistan, Uzbekistan, Belarus and Azerbaijan *(Popov 2007, 7)*. This surge in growth is attributed to the luck of higher energy prices, sufficient macroeconomic stability as well as the inevitability of hitting bottom in the transitional recession and bouncing back with high growth rates *(Havrylyshyn 2008, 61)*.

Figure 2. GDP in Central Europe and FSU economies

(GDP in 2008 as a % of that in the year before transition)



Source: Author's calculations using GDP in constant US dollars at PPP exchange rates from World Bank World Development Indicators database.

Another feature which stands out in the list is perhaps Armenia, which is not abundant in natural resources. Indeed, because of the fact that it is a small economy without major reserves of mineral resources makes it perhaps more dependent on international donor organizations and eager to implement institutional reforms faster. This argument seems to be justified by the superior results of Armenia in the cross-country rankings of institutional development. For instance, it has the best average ranking among the FSU countries in four out of six dimensions of governance quality in the Worldwide Governance Indicators *(see Kaufmann et al. 2009)*.

As transition progressed and countries throughout the region gradually recovered from initial decline of aggregate output, most cross-country empirical research attempted to explain divergent output performance on medium-term in terms of four main categories of explanatory factors: (i) variables measuring macroeconomic stability such as the low level of inflation and the fiscal surplus; (ii) variables describing progress made with structural reforms, in particular economic liberalisation and privatisation; and (iii) variables characterising initial conditions such as the degree of macroeconomic and structural distortions at the beginning of transition, and finally (iv) political stability measured by wars and internal conflicts *(Havrylyshyn and Rooden 2003, Falcetti et al. 2002)*. Due mainly to the lack of reliable longitudinal data, only a few exceptions discuss the impact of market enhancing institutions on growth *(Raiser et al. 2001, Campos and Coricelli 2003)*.

As Havrylyshyn (2008, 54) thoroughly summarised the general view of empirical literature:

'Traditional factor inputs were generally found to be unimportant, and a broad consensus emerged that for better performance stabilisation was a sine qua non, liberalising reforms generally promote growth as does institutional development and that unfavourable initial conditions retard it at least in early years of transition.'

Now I will examine these sources of cross-country differences in detail. Firstly, there is a general agreement that different starting points are likely to have a strong impact on subsequent development, at least in the short-term, particularly during the first years of transition. Therefore papers focused on constructing the series of potentially relevant initial conditions *(Fischer et al. 1996, De Melo et al. 2001)*. However, the negative influence of worse initial conditions is found to be diminishing over time *(Falcetti et al. 2002)*.

Initial conditions indicators are meant to reflect pervasive distortions and imbalances inherited from the previous regime such as GDP per capita in 1989, pre-transition growth rate, trade dependence on international socialist relations, degree of over industrialization, urbanization rate, abundance of natural resources, years spent under central planning, distance from Western European markets, pre-transition existence as a sovereign state, repressed inflation and black market premium *(EBRD 1999).* The main logic behind this factor is that countries with less favourable conditions were more constrained in the reform process and thus, followed a less radical reform path. At the same time, more inferior initial conditions might have adversely affected output performance *(Campos and Coricelli 2003).*

Secondly, most countries experienced an early burst of high inflation coupled with fiscal deficits so that a credible macroeconomic stabilization program was seen as a necessary precondition for economic recovery during the transition *(Fischer et al. 1996)*. Although there seems to be a threshold inflation level below which further improvements in growth are negligible, macroeconomic discipline is considered to reflect the degree of commitment by the authorities to a stabilization program *(Falcetti et al. 2006).*

Thirdly, a range of structural reforms were needed for sustainable growth beginning with early reforms such as price and trade liberalization and small-scale privatization, followed by deeper institutional market reforms, such as corporate restructuring, competition policy and financial sector development. Most papers in the empirical literature find that structural reforms have initially negative, but a significant positive lagged effect on economic growth in transition economies *(De Melo et al. 2001, Havrylyshyn and Rooden 2003)*.

Polanec (2004, 56) emphasised that because of the focus on output decline in the early transition period, relatively little work has been done on the relevance of the standard growth factors set up in the neoclassical growth model. But as it was pointed out succinctly

'A useful way of thinking about the current growth prospects of the transition economies is to consider them subject to two sets of forces: those arising from the transition and transformation process, and the basic neo-classical determinants of growth. The further along a country is in the transition process, the less the weight on the factors that determine

the transitional growth rate, and the greater the weight on the standard determinants of growth.' (Fischer et al. 1996, 231)

Campos (2001) based on specifications from Mankiw, Romer, and Weil (1992) study estimates the standard growth equation for twenty-five transition economies in Central and Eastern Europe and the FSU for the period from 1990 to 1997 and finds that none of the variables namely initial per capita income, secondary school enrolment and investment rate had the expected sign. Poor performance of these traditional variables of growth is explained with the fact that transition countries remain structurally different from other groups of developing and developed countries. Polanec (2001) obtains almost the same results for twenty-four transition countries for an extended period from 1989 to 1999. However, when he controls for measures of government failure such as corruption, or implements year-on-year panel data estimation to control for unobserved cross-section differences, the signs of estimates of the regression coefficients for initial income and investment rates are in line with neoclassical growth theory. Later on Polanec (2004) finds the evidence of the absolute and conditional convergence hypotheses for the same sample of countries for the advanced stage of transition (1998-2002), while they are rejected for the early (1990-1994) and intermediate (1994-1998) stages. But he cautions that the observed convergence may be a result of different cycling patterns between countries.

1.3 Cross-country evidence and descriptive statistic analysis

At first, following the approach taken by De Broeck and Koen (2000), it is useful to check the dynamics of the relationship between inputs and outputs by a simple growth accounting exercise, which allows to estimate the efficiency with which the factors of production in the form of physical capital and labor are employed. The exercise is based on the assumption that output is produced according to a Cobb-Douglas type production function. Dividing both sides of the equation (2) by the output, Y and differentiating with respect to time yields:

$$\mathbf{g_Y = g_A + \eta_K g_K + \eta_L g_L,} \tag{7}$$

where g_Y , g_A , g_K and g_L are the rates of growth of output, total factor productivity (TFP), capital stock and the inputs of labor, respectively, and where η_K and η_L denote the elasticities of output with respect to capital and labor, respectively. Further differentiation of equation (7) with respect to time gives the key formula of growth accounting:

$$\partial g_Y / \partial t = \partial g_A / \partial t + (\partial \eta_K / \partial t)\, g_K + \eta_K (\partial g_K / \partial t) + (\partial \eta_L / \partial t)\, g_L + \eta_L (\partial g_L / \partial t), \tag{8}$$

which allows to decompose changes in the growth rate of output into the growth rate of TFP and a weighted average of the growth rates of the two inputs period by period.

It should be noted that this type of accounting relies on the assumption of the constant returns-to-scale production function. For simplicity the elasticities of output with respect to capital and labor are assumed to equal 0.3 and 0.7, respectively, and to be constant over time. Data used for labor and capital are not corrected for hours worked or capacity utilization, that is changes in the quality of inputs. Therefore, bearing in mind biases due to methodological assumptions and measurement errors

'the computed changes in TFP should be interpreted as residuals that reflect a wide range of factors affecting the efficiency with which inputs are used.' (De Broeck and Koen 2000, 13)

The calculation results are summarized in Table 1, which reports average annual output, capital, labor force and TFP growth rates by country for the periods 1991-1997 and 1998-2008. Overall trend for all countries during the initial period of transition is a sharp fall of output and TFP growth rates. Share of decline is notably greater in productivity than in factor accumulation possibly reflecting the transitional transformation and reallocation of resources. With respect to individual results, it can be seen that productivity drop was much higher in countries with political instability and military conflicts, namely Azerbaijan, Georgia, Moldova and Tajikistan.

Table 1. Growth accounting results, period averages

Countries		Output growth	Capital growth	Labor growth	Factor contribution	TFP growth
Armenia	*Avg.91-97*	-8.8	-1.7	-2.5	-2.2	-6.5
	Avg.98-08	10.13	13.01	0.95	4.57	5.56
Azerbaijan	*Avg.91-97*	-10.7	1.3	0.0	0.4	-11.1
	Avg.98-08	15.20	19.34	2.38	7.47	7.73
Belarus	*Avg.91-97*	-4.4	1.9	-2.3	-1.1	-3.4
	Avg.98-08	7.63	7.51	0.00	2.25	5.37
Georgia	*Avg.91-97*	-13.1	-2.5	-3.0	-2.9	-10.2
	Avg.98-08	6.22	5.72	-0.51	1.36	4.86
Kazakhstan	*Avg.91-97*	-7.7	-0.5	-2.8	-2.0	-5.6
	Avg.98-08	7.75	13.35	0.78	4.55	3.20
Kyrgyzstan	*Avg.91-97*	-9.5	0.8	-0.5	-0.1	-9.4
	Avg.98-08	4.49	-4.39	1.77	-0.07	4.56
Moldova	*Avg.91-97*	-14.4	-0.5	-3.3	-2.5	-12
	Avg.98-08	3.87	4.08	-2.91	-0.81	4.69
Russia	*Avg.91-97*	-7.5	-0.1	-2.2	-1.6	-6.0
	Avg.98-08	5.88	7.14	0.61	2.57	3.31
Tajikistan	*Avg.91-97*	-13.8	-0.3	-1.1	-0.9	-12.9
	Avg.98-08	7.89	1.31	4.67	3.66	4.23
Turkmenistan	*Avg.91-97*	-9.5	5.3	1.2	2.4	-11.9
	*Avg.98-00**	13.92	7.27	3.07	4.33	9.59
Ukraine	*Avg.91-97*	-10.2	-0.3	-1.7	-1.3	-8.9
	Avg.98-08	5.43	5.49	-1.02	0.93	4.49
Uzbekistan	*Avg.91-97*	-1.5	2.2	1.3	1.6	-3.1
	Avg.98-08	5.94	2.47	3.33	3.07	2.87
Total	**Avg.91-97**	**-9.3**	**0.5**	**-1.4**	**-0.9**	**-8.4**
	Avg.98-08	**7.86**	**6.86**	**1.09**	**2.82**	**5.04**

Source: Results for the period 1991-1997 are taken from De Broeck and Koen (2000). Results for the period 1998-2008 are obtained by own calculations using GDP, gross capital formation and labor force data from the World Bank World Development Indicators. Annual capital depreciation rate is assumed to equal 0.4. Year-by-year results are given in the Appendix I. * No data for gross capital formation in Turkmenistan from 2001.

In contrast the next period is generally characterized with a strong positive growth of both output and TFP in nearly all countries. It seems that like the prominent role of TFP in output decline, the greater portion of growth too comes from the efficiency rise with possible exception of resource rich countries (Azerbaijan, Kazakhstan and Russia). It is pronounced in the results of countries such as Kyrgyzstan and Moldova where actual growth of factor inputs are negative. As it was highlighted in the World Bank study *(Mitra 2008, 4)* productivity growth was caused by both bouncing back from the transitional recession as well as reallocation of resources to more productive industries.

Table 2 is constructed in order to examine the output dynamics within the group over this period. It documents the data for total population and GDP per capita, relative to the Russian Federation, for 1991, 1995, 2000 and 2008. The countries are ranked in descending order in terms of their 1991 position. The choice of these periods is induced by the idea that the restructuring process and U-shaped growth experienced by transition countries will be responsible for different types of factors supporting growth during that period. During the initial period, most countries in the sample were experiencing macroeconomic shocks and transitional recession, the mid-1990s was that of heavy privatisation and reorientation of trade, while from the late 1990s onwards already represents certain macroeconomic stability combined with favourable external circumstances.

Despite some stability in relative positions, it seems that there is a general pattern for the economies which were initially in the upper part of the list. They have maintained their position relative to the Russian Federation or substantially improved it (Azerbaijan, Belarus and Kazakhstan). Ukraine and Georgia are two exceptions that saw their relative positions go down. Among the poorer nations in 1991, there are some countries that have improved their relative positions (Armenia, Turkmenistan) or relatively preserved it (Uzbekistan), and others that have performed badly (Kyrgyzstan, Moldova and Tajikistan). If we look at the mean and median of relative GDP per capita, there has been a moderate increase, suggesting a slight tendency for rising incomes. But it should be reminded that a wide variety of factors and experience lie behind these simple statistics.

Table 2. Cross country disparities in GDP per capita

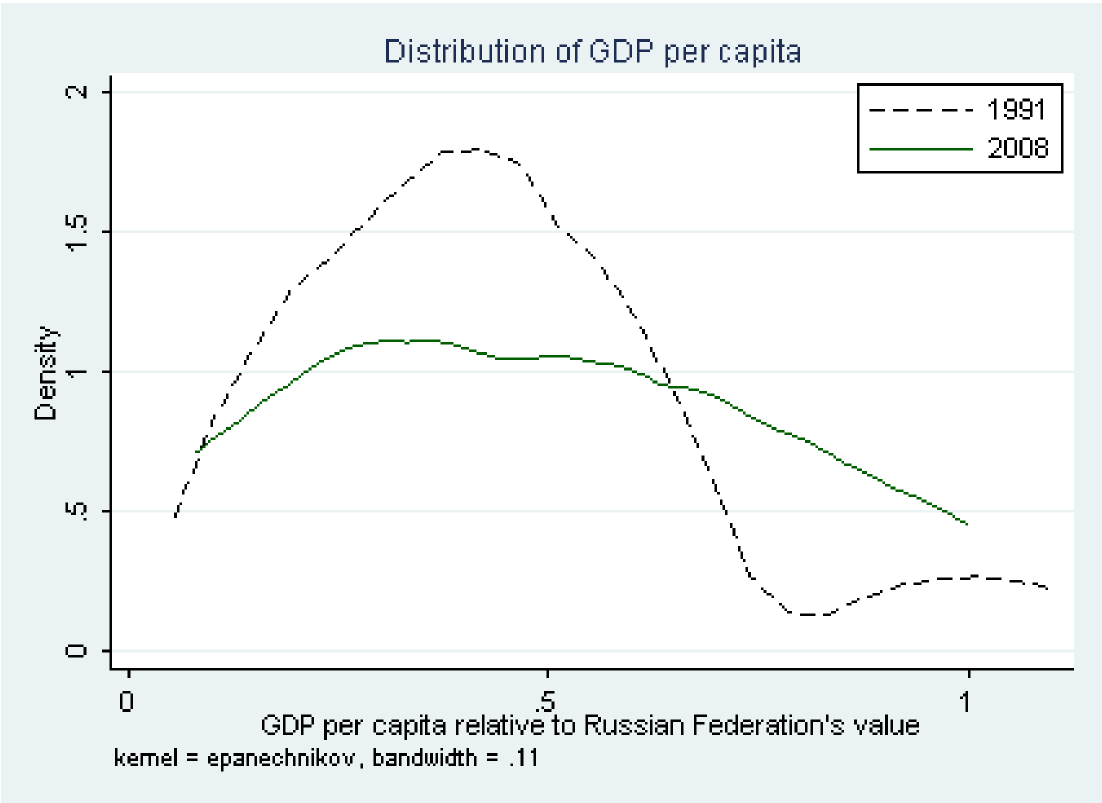
Country	Population (mill.2008)	R1991	R1995	R2000	R2008
Russia	141.8	1	1	1	1
Kazakhstan	15.68	0.58	0.63	0.69	0.77
Belarus	9.68	0.56	0.57	0.72	0.81
Ukraine	46.26	0.51	0.41	0.36	0.38
Azerbaijan	8.68	0.50	0.30	0.37	0.69
Georgia	4.36	0.48	0.28	0.36	0.41
Turkmenistan	5.03	0.39	0.35	0.36	0.55
Armenia	3.08	0.29	0.29	0.35	0.49
Moldova	3.63	0.28	0.21	0.18	0.19
Uzbekistan	27.31	0.27	0.31	0.31	0.27
Kyrgyzstan	5.28	0.17	0.14	0.16	0.12
Tajikistan	6.84	0.16	0.09	0.08	0.08
Mean		***0.43***	***0.38***	***0.41***	***0.48***
Median		***0.44***	***0.31***	***0.36***	***0.45***
σ–convergence		***0.23***	***0.25***	***0.26***	***0.29***

Source: Author's calculations using GDP per capita at constant prices and total population data from the World Bank World Development Indicators. R is GDP per capita as a fraction of that in Russian Federation.

The last row of Table 2 also gives the results of the analysis of sigma (σ)-convergence, which is calculated using standard deviation of real GDP per capita across countries for each period. It clearly implies that during the process of growth, the income levels of the countries have become more divergent and the variation between their GDP levels per capita has increased. However, it should be noted that this observation of increased dispersion does not necessarily reject the convergence hypothesis, because the predicted convergence is only conditional and inequality depends on idiosyncratic external shocks on each economy *(Barro 1997, 12)*. As it was emphasized by Sala-i-Martin (1996, 1022) *'ß-convergence, although necessary, is not a sufficient condition for σ-convergence.'*

Figure 3 shows kernel density estimates of the distribution of GDP per capita in 1991 and 2008 using the Russian Federation's 1991 value as the benchmark. It ascertains the previous analysis. The slight but noticeable rightwards shift of the mass of the distribution is partly because of the increase in average incomes that took place over this period. At the same time a thinning in the middle of the distribution can be spotted, implying the increase in the cross-country variance of the distribution and greater inequality in income per capita.

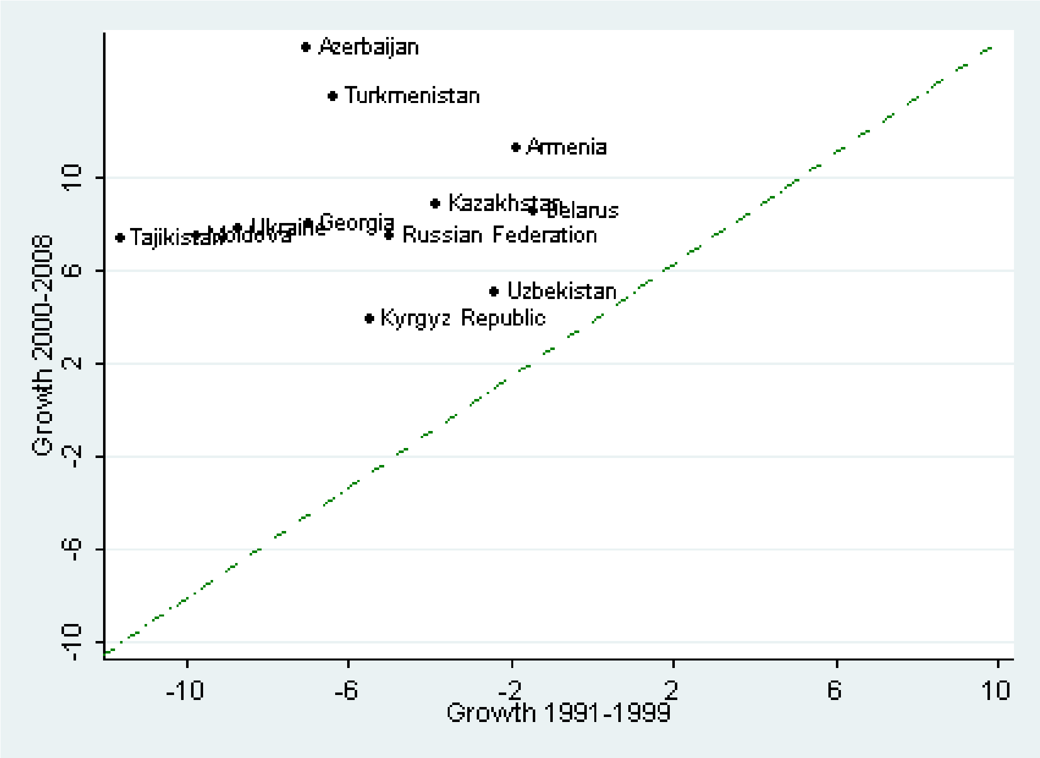
Figure 3. Cross-country density of output per capita



Source: GDP per capita in constant 2005 US dollars from the WB World Development Indicators database.

An alternative method for illustrating the variation in growth is to plot the growth rate in 2000-2008 against that in 1991-1999 as is done in Figure 4, which also includes a 45 degree line. All countries are above the line in the upper left quarter of the graph and have seen growth increase. This is an evidence for “V-shaped” cyclical pattern of output growth during transition when large initial falls followed by rapid recovery.

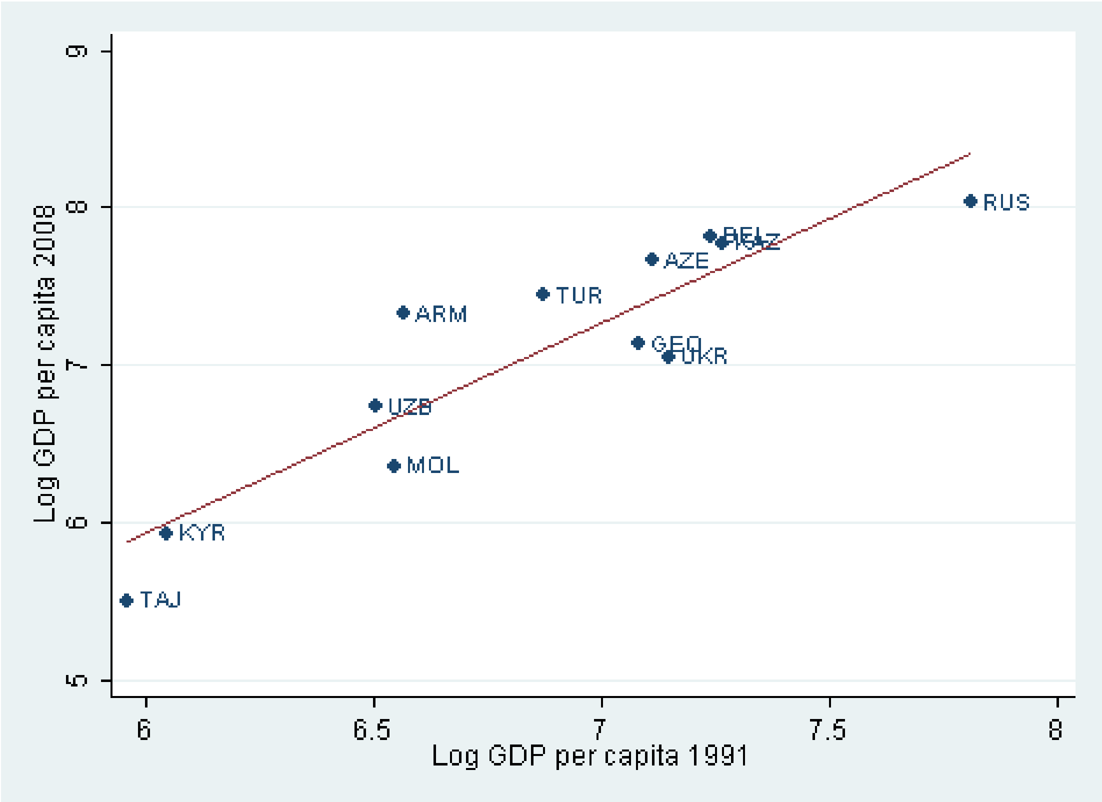
Figure 4. Growth rates in 1991-1999 versus 2000-2008



Source: Annual GDP growth based on constant 2000 US dollars from the World Bank WDI database.

Is the position in the cross-country ranking of GDP per capita in 1991 a good predictor of that in 2008? The answer is a qualified yes: the Spearman rank correlation is 0.89. This pattern is shown in more detail in Figure 5, which plots the log of GDP per capita in 2008 against that in 1991. It shows that the relative ranking of countries has changed little during this period. The high rank correlation is not a new phenomenon. Durlauf et al. (2005, 567) report that, for a set of 24 countries that together account for 4.3 billion people, the rank correlation of GDP per capita in 2000 with that in 1960 is 0.84.

Figure 5. Output per capita: 1991 versus 2008



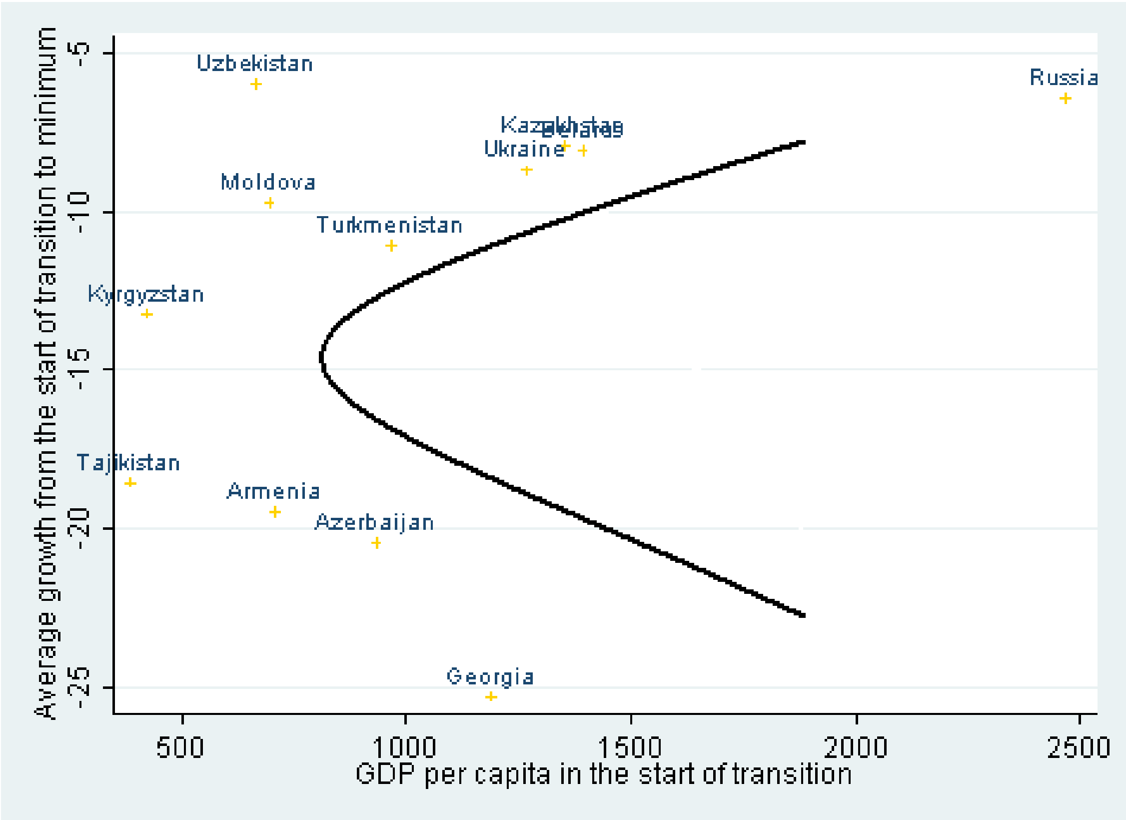
Source: GDP per capita in constant 2005 US dollars from World Bank WDI database.

One of the main tools of descriptive data analysis to highlight the validity of the absolute or unconditional convergence hypothesis is to plot an initial income level and subsequent growth rate. As was already mentioned, according to the absolute convergence (β-convergence) hypothesis, poor countries will grow much more rapidly than rich countries and this process will end with the equalisation of these countries' GDP per capita. Taking into account sharp output fall as a result of transitional reallocation and restructuring, first, it seems appropriate to look on such a relationship during the period of decline. Initial income level per person is determined as the year before the start of transition according to the previous classification (Figures 1 and 2). Then average GDP growth rates are calculated for each country until the year when the nadir in reported GDP was reached. Here again the results are diverse: GDP hit the bottom as early as in 1993 in Armenia and as late as in 1999 in Moldova and Ukraine[1]. Another distinct feature, as could be expected, is exceptionally high decline of real GDP in war-torn countries of the region

[1] all calculation results are presented in the Appendix II

– Armenia, Azerbaijan, Georgia and Tajikistan. The average drop of GDP in these countries is nearly 21 per cent, while for the rest of the economies this figure is just 9 per cent. The plot is shown in Figure 6. It can be seen that there is no any linear relationship or clear cut pattern as countries have experienced a wide variety of output declines. One of the reasons might be that there are other more important sources of different economic performance such as the market-oriented reform policies, political stability and the magnitude of socialist distortions which were more decisive factors during transitional recession rather than initial income levels.

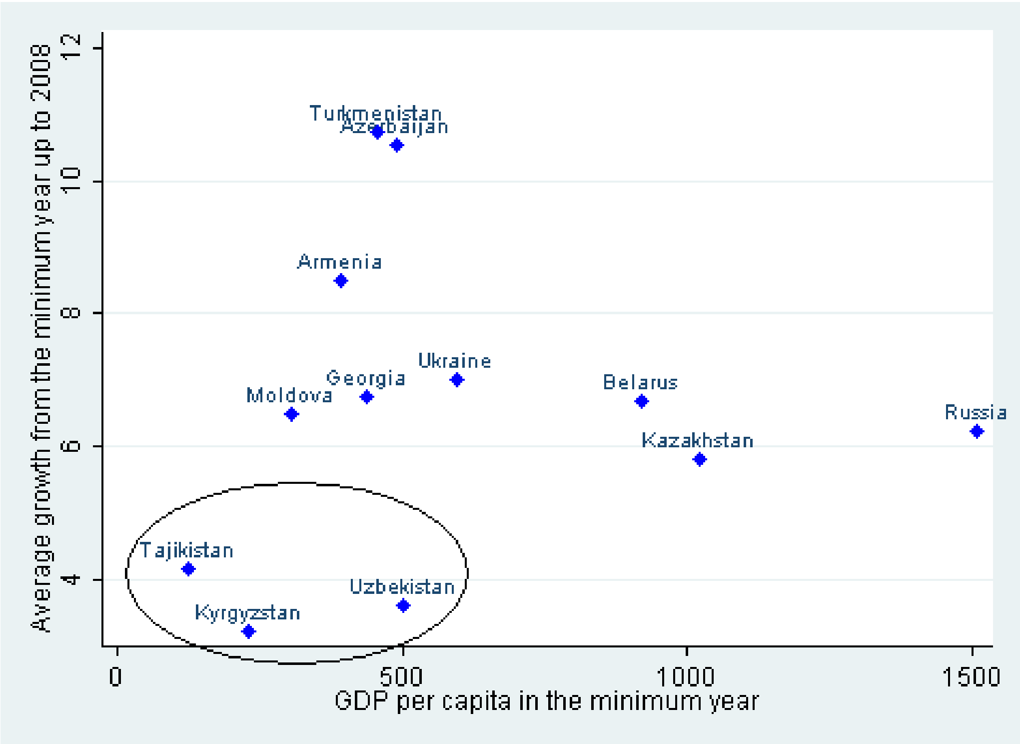
Figure 6. Growth vs initial income: from the start of transition up to minimum point



Source: GDP per capita in constant 2005 US dollars and annual GDP growth based on constant 2000 US dollars from World Bank World Development Indicators database.

Finally, Figure 7 presents the data about the growth rate from the year of minimum GDP until 2008 against the level of GDP per capita in the lowest point. The most obvious lesson to be drawn from this figure is the diversity of growth rates. The figure does not provide much support for the idea that countries are converging to a common level of income without controlling for differences in steady states, since that would require evidence of a downward sloping relationship between growth and initial income. In contrast it can be seen that, the slope of the fitted line to the plot is positive. It indicates that, if any, there is a positive relationship between initial income and the subsequent growth suggesting divergence of income levels.

Figure 7. Growth vs initial income: from the minimum point till 2008



Source: GDP per capita in constant 2005 US dollars and annual GDP growth based on constant 2000 US dollars from World Bank World Development Indicators database.

However, closer examination reveals group of outlier countries such as Kyrgyzstan, Tajikistan and Uzbekistan, whose position in the figure clearly contradicts the absolute convergence hypothesis and in the absence of which the fitted line would have a negative slope. In the graph all countries except the three named above are located more in line with the principle of unconditional convergence.

2. EMPIRICAL METHODOLOGY AND ESTIMATION RESULTS

2.1 Model specification and setup of the empirical analysis

The fundamental theoretical framework to study the convergence concept is the standard neoclassical growth model, the foundations of which were developed by Solow (1956). However, initially empirical convergence regressions were not formally derived from theoretical models of growth *(Islam 2003, 316).* Model-based specification to estimate the growth convergence equation based on the neoclassical growth model was carried out in Barro and Sala-i-Martin (1992), and Mankiw, Romer, and Weil (1992) (henceforth MRW). Although MRW extend the model with human capital, I will proceed with the basic neoclassic equation as derived in Islam (2003) without human capital.

There is a vast literature which finds that education enhances growth *(EBRD 2008, 56)*. Human capital is not considered here because of the several reasons including the lack of reliable panel data and the questionable nature of available measures of educational attainment and enrolment rates or public spending on education. These measures are not usually testament to the quality of education, which is more important for a final outcome. This is probably one of the reasons why *'economists find it surprisingly hard to prove the importance of human capital statistically.' (The Spence Report 2008, 53)* For example, Polanec (2001) obtains negative and statistically insignificant relation between human capital and growth in transition economies. Unfortunately, internationally comparable test scores measuring the quality of students' cognitive skills such as the Programme for International Student Assessment (PISA) test are available only for a few countries in our sample, namely Azerbaijan, Kyrgyzstan and Russian Federation. Moreover, both theoretically and empirically the positive impact of education on growth is likely to be realized in the long-term and is better captured with a time lag. If we take into account that the earliest statistical data on education for our sample is available from 1999, it becomes clear that time period of analysis is too short to undertake serious analysis.

Model building exercise is based on the derivation of the transitional dynamics around the steady-state first and then transformation of this motion into estimable regression equation. Departing point is the Cobb-Douglas production function (2) with constant returns to scale and labor augmenting technological progress, and the law of motion for physical capital in the Solow model (4). Now the first order Taylor approximation of (4) around the steady state gives,

$$\Delta k = [sf'(k^*) - (n + g + \delta)k](k - k^*), \tag{9}$$

where Δk is dynamics of capital per effective labour, and k^* is its steady-state value. Substituting for the saving rate (s) using the steady state relationship, $sf(k^*) = (n + g + \delta)k^*$, gives,

$$\Delta k = [(f'(k^*)k^*/f(k^*) - 1](n + g + \delta)(k - k^*). \tag{10}$$

Under the assumption that capital earns its marginal product, $f'(k^*)k^*/f(k^*)$ equals the steady state capital share in the production function, α. Using this relationship we get

$$\Delta k = \lambda(k^* - k), \text{ where} \tag{11}$$

$$\lambda = (1 - \alpha)(n + g + \delta). \tag{12}$$

The rate of adjustment (λ), which is also known in the empirical literature as the rate of convergence, gives the speed at which the gap between the steady state level of capital and its current level is closed. Substituting (11) into the production function reveals the same rate of convergence in terms of income per efficiency unit (y):

$$\Delta y = \lambda(y^* - y). \tag{13}$$

Switching to logarithms, solving the first order non-homogenous differential equation, and rearranging, we get from (13):

$$\ln y(t_2) - \ln y(t_1) = (1 - e^{-\lambda\tau}) [\ln y^*(t_1) - \ln y(t_1)], \tag{14}$$

where t_1 denote the initial period, t_2 the subsequent period, and $\tau = t_2 - t_1$. Since the steady-state level of output per worker is not known, by substituting for y* from expression (5), we get the equation for growth of productivity:

$$\mathbf{g_y = \theta_1 + \theta_2 \ln y(t_1) + \theta_3 \ln s + \theta_4 \ln(n + g + \delta)}\ , \qquad \textbf{(15)}$$

where $g_y = 1/t\ [\ln y(t_2) - \ln y(t_1)]$,

$\theta_1 = g + [(1 - e^{-\lambda\tau})/t] \ln A_0$,

$\theta_2 = - (1 - e^{-\lambda\tau})/t$,

$\theta_3 = [(1 - e^{-\lambda\tau})/t]\ [\alpha/(1-\alpha)]$,

$\theta_4 = - \theta_3$.

As it is evident in the last equation, the growth rate of output per effective labour is positively related with an increase in the growth rate of technology, initial technological level and investment rate, and negatively with an increase in the initial output per effective labour and the sum of depreciation rate, technological growth rate and employment growth rate.

The first empirical attempt to test cross-sectional convergence based on equation (15) was carried out in MRW. To estimate the convergence parameter in a cross-section regression model, (15) can be restated as *(Polanec 2004, 60)*:

$$\mathbf{g^i_y = \theta_1 + \theta_2 \ln y(t_1)^i + \theta_3 \ln s^i + \theta_4 \ln(n^i + g + \delta) + \varepsilon_i\ ,\ \varepsilon_i \sim IID(0, \sigma^2)}\ , \qquad \textbf{(16)}$$

where i denotes an index for country i and ε_i is an independently and identically distributed disturbance term with zero mean and constant variance for all i.

It can be seen that the cross-section regression analysis of this type requires technology to be identical across economies, since they are assumed to have access to the same technology. Alternatively the cost of imitation and adaptation of technology is believed to be cheap and available for the follower countries. For instance, in MRW the technological level and its growth are assumed to be part of the error term and a random process around the same mean for all countries. This enables the estimation of equation (16) by the ordinary least squares (OLS) method.

However there is overwhelming empirical evidence of significant heterogeneity in technology, preferences and institutions across countries *(Barro and Sala-i-Martin 2004, 541)*. Therefore researchers tried to find the proxies reflecting various aspects of technology such as the quality of institutions, technological know-how and resource endowments. Assumption of common technology seems to be a strong one, especially in the sample of transition countries. As it was examined above they differed greatly in terms of not only their initial conditions but also the pace and sequencing of subsequent market-oriented structural reform policies.

At the same time, this approach has been criticised for the lack of sound selection criteria of a large number of candidate variables used in cross-country regressions *(Durlauf 2000, 9)*. Two methods were suggested as a formal econometric selection criterion in identifying statistically robust variables. Levine and Renelt (1992) propose to use extreme bound analysis, while Sala-i-Martin (1997) develops a Bayesian approach. Though being useful exercises, both methods are questionable as a result of high correlation among candidate growth explanations *(Durlauf 2000, 11)*. Another problem with the estimation by OLS is a reverse causality between economic growth and its determinant variables. For example, the countries with higher investments have usually higher growth rates during the boom period *(Darvas 2009, 9)*. However, it is difficult to find suitable instruments which are uncorrelated with all omitted growth determinants. In light of the warning against the use of poor instruments *(Durlauf 2000, 5)*, the use of proxy variables for the level of technology will be justified theoretically instead.

Three groups of explanatory factors to account for the differences in technology in transition countries can be identified in the empirical literature *(Polanec 2004, 60).* It is worth noting that their relative influence on economic growth is considered to be nonlinear and dynamic over the different stages of transition. Their particular selection will be explained below.

Firstly, as it was noted in Chapter 1.2 the legacy of the previous regime characterized in particular with inefficient production structure and prior experience of market mechanisms were diverse in each country. As a result economies with larger initial distortions had to restructure and liberalize more, and face significant output shock, which also constrained their reform policies. Otherwise the fast implementation of market reforms without the minimal preconditions and functional institutions can lead to output decline because of “disorganization” effect *(Blanchard and Kremer 1997)* and to the development of dysfunctional institutions in the form of corruption and interenterprise arrears *(Coricelli 1998, 77, Campos 2002, 801)*. Therefore, the negative shocks to the output as a result of initial distortions will be taken as a proxy for the starting level of organizational technology.

In the empirical literature the variable which intended to proxy the starting differences in terms of minimum institutional structure was obtained by principal components analysis *(EBRD 1999)*. The set of variables, which characterize different economic conditions just before transition began, form the clusters of variables. The FSU countries usually rank high in the first principal component which explains 60-70 per cent of variability and puts more weight on macroeconomic distortions and unfamiliarity with market economy *(De Melo et al. 2001, 11)*. Since the influence of this factor is generally found to be diminishing over time, it can be considered as a proxy for the shock to the organizational technology during the early years of transition.

Secondly, from the early years all countries embraced the market-oriented structural reforms though to varying degrees and with varying success. A recommended road map of economic transition to market economy, known as the “Washington consensus” included privatisation, immediate macro economic stabilization and sustaining fiscal discipline, quick liberalisation and opening up the economy to foreign trade and investment *(Sachs et al. 2001, 148)*. The main idea behind the transfer of ownership to private sector is the belief that once in private hands, a series of self reinforcing forces would emerge to demand the creation of all the political and economic institutions required for private ownership, thereby accelerating the establishment of market economy. Although, in the short-run public owned enterprises will be incurring losses, the negative effects of old enterprises will be offset by the gains in the growing private sector. This policy, later termed by the World Bank as a "discipline-and-encouragement" approach *(World Bank 2002)*, is meant to discipline low-productivity old enterprises by imposing hard budget constraints and to encourage high-productivity new enterprises by creating favourable business environment. Moreover, in the long-run positive effects of economic reforms prevail putting the country on a competitive position and enhancing its growth potential. Thus, one can expect to find the positive relationship between the pace of economic reforms and growth of output in the intermediate and advanced stages of transition *(Polanec 2004, 75)*. Since the structural reforms are connected with productivity improvements of the firms they are expected to measure productive technology.

When it comes to the issue of choosing the proxy variable,

'[...]Strong statistical significance is generally found for broader measures of market reforms, such as the European Bank for Reconstruction and Development (EBRD) transition index, less so for individual components. [...] This suggests that it is the combined effect of several policies that matters in creating new opportunities for efficient resource allocation and rational decisions by the new private sector.' (Havrylyshyn 2008, 57)

Furthermore, it is clear that an aggregate measure of institutional change is the best choice when we are limited in degrees of freedom by an already low number of observations.

Thirdly, it can be argued that while the EBRD transition indicators capture the institutional transformation related with market economy, they do not reveal overall institutional capacity and rule of law in society. As it was suggested by Rodrik (2004, 156) the quality of institutions should be considered as a stock variable, whereas policy changes is a flow variable. Therefore, it seems appropriate to control for the quality of institutions in contrast to ongoing policy changes.

There is evidence of significant variation among transition economies in terms of building new institutions supporting a broad-based market economy *(Beck and Laeven 2006, 158)*. One of the potential reasons was suggested by North (1990, 16):

‘institutions are not usually created to be socially efficient, [but] are created to serve the interests of those with bargaining power to create new rules.’

Despite their obvious vital importance to growth, Campos (2002, 830) emphasizes that

‘there is a growing consensus on the importance of institutions, but the channels through which institutions affect growth are not well understood.’

It has been found that the role of institutions become increasingly important over time and maintaining growth requires continuous institutional improvement *(Havrylyshyn 2001, 73)*. Thus, we expect to find a positive influence for higher values of governance quality, since it raises the steady-state level of output per effective labour and, consequently, increases the growth rate for given values of the growth correlates.

Due to the lack of data on institutional quality for the initial periods of transition, there were no empirical studies measuring the impact of institutions on growth before the mid 1990s. Since there are now the data available measuring different aspects of institutional development which encompass transition countries as well, it has become feasible to assess the relationship between institutions and economic growth. One of the comprehensive indicators of institutional development is estimated in the World Bank study by Kaufmann, Kraay, and Mastruzzi (2009). Based on thirty five different data sources collected by thirty three different organizations they construct six different dimensions of institutional development for the period 1996-2008: voice and accountability, government effectiveness, rule of law, regulatory quality, absence of corruption and political stability.

It should be noted that leaving the level of technology (A_0) unrestricted or omitted from the analysis is problematic. Empirical approach of either assuming the technology to be identical across economies or allowing it to be different dependent on control variables were criticised by Durlauf and Quah (1999, 253). Whereas the first case in general does not withstand the evidence, in the latter one it becomes difficult to interpret the results of the regression theoretically since the control parameters carry the entire burden of explanation. I will continue with the estimations keeping these caveats in mind.

In light of above mentioned panel data estimation techniques will also be considered as an alternative solution to control for the persistent differences in technology across countries. There are several benefits of using panel data as identified in Baltagi (2005, 5). First, panel data allows to control for individual heterogeneity. It is especially helpful, when some of the country-invariant or time-invariant variables are difficult to measure or hard to obtain. As discussed above, despite sharing common socialist history, transition countries differ in terms of their starting positions, reform policies and natural endowments. Omission of these variables therefore may lead to obtaining biased results. Secondly, panel data offers more variability and larger degrees of freedom stemming from more observations, which increases the efficiency of parameter estimates. Thirdly, panel data are better suited to study the dynamic developments. In the context of transition, when all countries have been experiencing continuous adjustments to economic policy changes, it seems to be logical estimation choice.

One of the first attempts to apply panel data approach for studying growth convergence was implemented by Islam (1995). He reformulated MRW model as a dynamic panel model and obtained estimates of conditional convergence using fixed effects and minimum distance estimation techniques. His panel estimates of convergence rate were significantly higher than those obtained from cross-sectional approach, which were justified as an improvement of omitted variable bias (OVB). OVB problem arises if we understand and accept technology as a wide range of variables potentially affecting the efficiency with which inputs to the production process are transformed into output. In cross-section setup it is difficult to reject that there is still some unobservable and unmeasurable part of A_0 which can be correlated with included explanatory variables such as saving preferences, investment and fertility decisions. Thus

'One of the advantages of the panel approach is that it can correct the OVB problem by allowing for technological differences across countries (at least the unobservable and unmeasurable part of it) in the form of individual (country) effects.' (Islam 2003, 325)

In a dynamic panel model, the estimation equation (15) can be written as:

$$\mathbf{g_{it} = \gamma\, y_{i,t-1} + \beta_1 \ln s_{it} + \beta_2 \ln(n_{it} + g + \delta) + \mu_i + \eta_t + \varepsilon_{it}\,,\ \varepsilon_{it} \sim IID(0, \sigma^2)\,,} \qquad \mathbf{(17)}$$

where $g_{it} = \ln y(t_2) - \ln y(t_1)$

$\gamma = -(1 - e^{-\lambda\tau})$

$\beta_1 = (1 - e^{-\lambda\tau})\,[\alpha/(1-\alpha)]$

$\beta_2 = -\beta_1$

$\mu_i = (1 - e^{-\lambda\tau}) \ln A_0$

$\eta_t = g\,(t_2 - e^{-\lambda\tau}\, t_1)$

where subscript i denotes *i*th country and the subscript t denotes *t*th year, μ_i reflects time-invariant country specific technology, the period-specific intercepts (η_t) capture productivity changes that are common to all countries and ε_{it} is the error term that varies across countries and time periods and has mean equal to zero.

When it comes to the choice of estimation method, simple pooled least squares model seems to be inappropriate because of several disadvantages. It is based on the assumption of independence of the error term from the cross-sectional units (countries) and it does not control for the time-invariant country-specific effects that are likely to exist if panel data are used. But it is exactly the fact of unobserved cross-country heterogeneity that motivates the argumentation for the panel approach, the ignorance of which may lead to biased and inconsistent estimation results *(Varblane and Vahter 2006, 32)*. Now the selection is between the fixed versus random effects model. It was argued that

'the random effects model assumes exogeneity of all regressors with the random individual effects. In contrast, the fixed effects model allows for endogeneity of all the regressors with these individual effects.' (Baltagi 2005, 19)

In other words, one of the main assumptions of random effects model is that individual error terms are not autocorrelated across both cross-section and time series components. However, since the growth regressions usually contain lagged dependent variable on the right-hand side of the equation, it is highly likely to be the case. That is why the fixed effects model is most widely used and found to be performing well compared to other estimators *(Islam 1995, 1138)*.

It should be reminded that improvement with panel data estimation comes with its cost. As it was noted by Shioji (1997), the least squares with dummy variables (LSDV) applied to growth convergence suffers from cyclical pattern because of high frequency income movements and the focus of this estimation method on within variation only. If one takes into account structural breaks, the speed of convergence is lower and similar to that of cross-sectional approach. Since the data for transition period is likely to exhibit cyclical behaviour, the results should be interpreted with the limitations of estimation choice in mind. One of the solutions suggested to deal with the business cycle effects in growth regressions is to average panel data over shorter time horizons of five or ten years, which would reduce the cyclical component in the data *(Islam 2003, 332)*. Another correction could be the normalization of output with number of employees as suggested in Polanec (2001, 16).

Another problem of the OLS with fixed effects is that its estimates are biased due to the OVB. The right-hand side variables, especially initial level of income, are typically correlated with the country-specific effect, the initial level of efficiency, which is not observed. In order to avoid the OVB problem and to deal with endogeneity, Arellano and Bond (1991) proposed the estimation of a dynamic panel data model by the generalized method of moments (GMM) by first-differencing both sides of the equation. The first-differencing eliminates bias arising from country-specific effects and allows the use of the lagged values of the right-hand side variables as valid instruments. It was found that such an estimator delivers significant efficiency gains in dynamic panel data model compared to simpler instrumental variable alternatives. It will be consistent unless the white noise errors are serially correlated, which can be tested by checking the lack of second-order residual serial correlation. When the explanatory variables are endogenous, as in our case, the instrument variables should be lagged two or more periods *(Bond et al. 2001, 13)*. Following the annotations used in the empirical literature this method will be denoted by Dif-GMM.

At the same, Blundell and Bond (1998) argue that the lagged levels of the variables are only weak instruments for the subsequent first differences in three cases: when the time series observations are moderately small; when there is persistent autoregressive coefficient close to unity; and when there is greater relative variance of the fixed effects. They developed extended GMM estimator named system GMM that uses lagged differences of right-hand side variables as instruments for equation in levels, in addition to their lagged levels as instruments for equations in first differences. Monte Carlo simulations demonstrated significant efficiency gains and reduction in finite sample bias. Taking into account the fact that output series usually exhibit highly persistent series they suggest that this estimation approach is particularly relevant in the context of empirical growth research. Therefore, it is strongly recommended to check results obtained by first differenced GMM estimation with this estimation approach denoted here by Sys-GMM. According to the comparative analysis of the estimates obtained by four methods (OLS, fixed effects estimation, Dif-GMM and Sys-GMM) in Bond et al. (2001), Sys-GMM estimates of convergence are much lower than Dif-GMM estimates and close to those obtained from cross-sectional regressions.

2.2 The data

2.2.1 Sources and description of the data

The annual data for twelve FSU countries without Baltic states for the period 1991 to 2008 is collected from various sources, the major one being World Development Indicators database of the World Bank. The time series for the main variables for testing the hypothesis of conditional convergence including growth rates of GDP, shares of gross capital formation in GDP and labor force were obtained from this source. GDP per capita data are taken in constant prices converted to international dollars using purchasing power parity (PPP) rates. In case of missing values the data were also compiled and cross-checked where available with datasets published by EBRD and Interstate Statistical Committee of the CIS. All regression estimates are obtained with Stata statistical package. It is simple to operate and offers many specialized analysis for cross-section and time series data.

Since the population and employment data for transition countries would rather follow nonstationary trend, Polanec (2001) uses the log of GDP per employee instead of more frequently used in empirical regressions - GDP per capita. He argues that this corrects the mismeasurement and improves the results of growth regressions. But due to the lack of internationally comparable data for productivity levels for the period before 1996 and the fact that resulting real GDP growth rates will be unadjusted for PPP, I will use the PPP-adjusted GDP per capita as in MRW (1992). The data for saving or investment in physical capital are gross fixed capital formation which excludes investments in inventories.

Following Polanec (2004), in construction of a logarithm of the sum of labor force growth rate, technological growth rate and depreciation rate, $\ln(n_{it} + g + \delta)$, I assume fixed and common $g+\delta = 0.15$. It is higher than in MRW (1992), where it is assumed to be equal to 0.05. It is because of relatively low or even negative growth rates of the working age population, for which the logarithm function is not defined, in the early transition years. Technological growth rates and depreciation rates are assumed to be the same for all countries and constant over time.

Several proxy variables will be used to control for cross-country heterogeneity. The data on migrant remittances is taken from the IMF, Balance of Payment Statistics. Due to the missing data, the figures for Uzbekistan and Turkmenistan for the period from 2006 to 2008 are calculated based on the World Bank estimates (Mansoor and Quillin, 2007) and the statistics on cross-border transactions of individuals from the balance of payments of the Central Bank of

Russia. Following the lead taken in the empirical literature[2] in a cross-section analysis natural resource abundance is proxied by the share of primary goods in total exports, which is the sum of the shares of fuel exports, ores and metals exports and agricultural raw materials exports. When there is a missing data, especially for three Central Asian countries (Tajikistan, Turkmenistan and Uzbekistan), the figures were obtained from the previous research on this topic by Myant and Drahokoupil (2008). Since the data on trade structure is incomplete and available only from 1996, in a panel analysis I will use the logarithm of energy production, compiled by the International Energy Agency, including crude oil, natural gas, solid fuels and primary electricity, all converted into oil equivalents. It seems to be a reasonable choice and can be a good measure of natural resource endowments since energy resources make up significant share of revenues for most of the resource-rich countries of the FSU.

In a panel setup I will also control for trade openness. In empirical literature openness is usually measured by the ratio of trade to GDP and sometimes by the share of exports to GDP. But here the latter is preferred because it leads to more statistically significant estimation results and appears to be more robust in various model specifications. It can also be explained by the fact that exports from the majority of CIS countries are intensive in natural resources and unskilled labor, which are vital sources of revenue. It is clear that though exports to GDP ratio is not the best measure of openness, it represents one of its elements and determines the overall level of the integration of a country into the world economy.

The last year of observations for which the statistical data are available is 2008. I have to justify the decision to use the data for this year in light of the negative consequences of global financial crisis. Resulting economic downturn reflects a short or medium-term negative shock which leads to the deviation from a long-term trend. However, it was noted that the full negative impacts of global financial crisis such as the flow-out of capital and decline of exports was not yet reflected in real economy and statistic measurements of economic growth in 2008

[2] see, for example, Kronenberg, 2004

(EBRD 2008, vi). If we look at the figures for the real GDP per capita in 2008 compared to that in 2007, overall, its growth slowed down considerably, but remained in a positive range. In five countries it decreased almost twofold (Armenia, Azerbaijan, Georgia, Kazakhstan, and Ukraine) whereas in the rest it stayed nearly the same (Kyrgyzstan, Russia, Tajikistan, Turkmenistan, and Uzbekistan) or even increased (Belarus and Moldova).

In a cross-section analysis, following the approach taken by Polanec (2004) the whole transition period is divided into four sub-periods: the early period from 1991 to 1996, the intermediate stage from 1996 to 2000, the advanced stage from 2000 to 2004, and the latest period from 2004 to 2008. It was supported by the fact that various set of factors were responsible for output fall and recovery in different stages of transition.

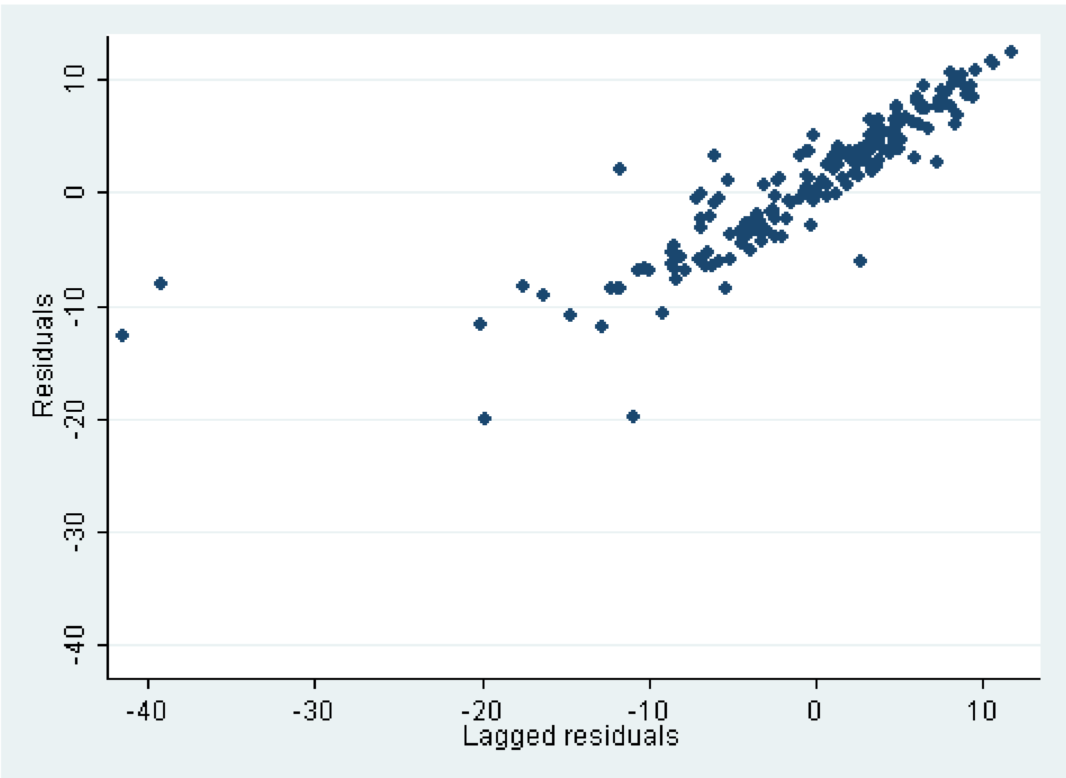
To move from cross-section into a panel framework the whole time period is divided into several shorter time spans. When determining the appropriate length of such time spans, Islam (1995, 1139) opted to take five-year time intervals. This, as suggested, is better than constructing annual panel dataset, which is more likely to be serially correlated and influenced by business cycle fluctuations. However, since overall period from 1991 to 2008 is already short, to benefit from more observations, four-year time intervals will be taken. Thus, we have five data points for each country: 1993, 1996, 2000, 2004, and 2008. For example, if t=2008, t-1 is 2004, and investment and other control variables for technology are averages over 2005-2008. When t=1993, initial income level is the year 1991 and averages are calculated for the two-year period of 1991-1992. Despite potential problem of dynamic misspecification arising from arbitrarily determining the time span over which regression is estimated *(Pritchett 2000, 240)*, I will continue with this method, because there is no other objective way of choosing panel time spans. Further, time points for panel analysis are based on the time periods of cross-section analysis which are justified by the previous empirical literature.

When one of the explanatory variables is a lagged dependent variable, as in our panel model, autocorrelation is likely to cause OLS to yield estimates that are inconsistent

(Dougherty 1992, 226). Figure 8 shows graphical analysis of regression residuals on lagged residuals after estimating the panel equation (17) with annual data by OLS, which indicates to the presence of autocorrelation in error terms with a positive linear relationship.

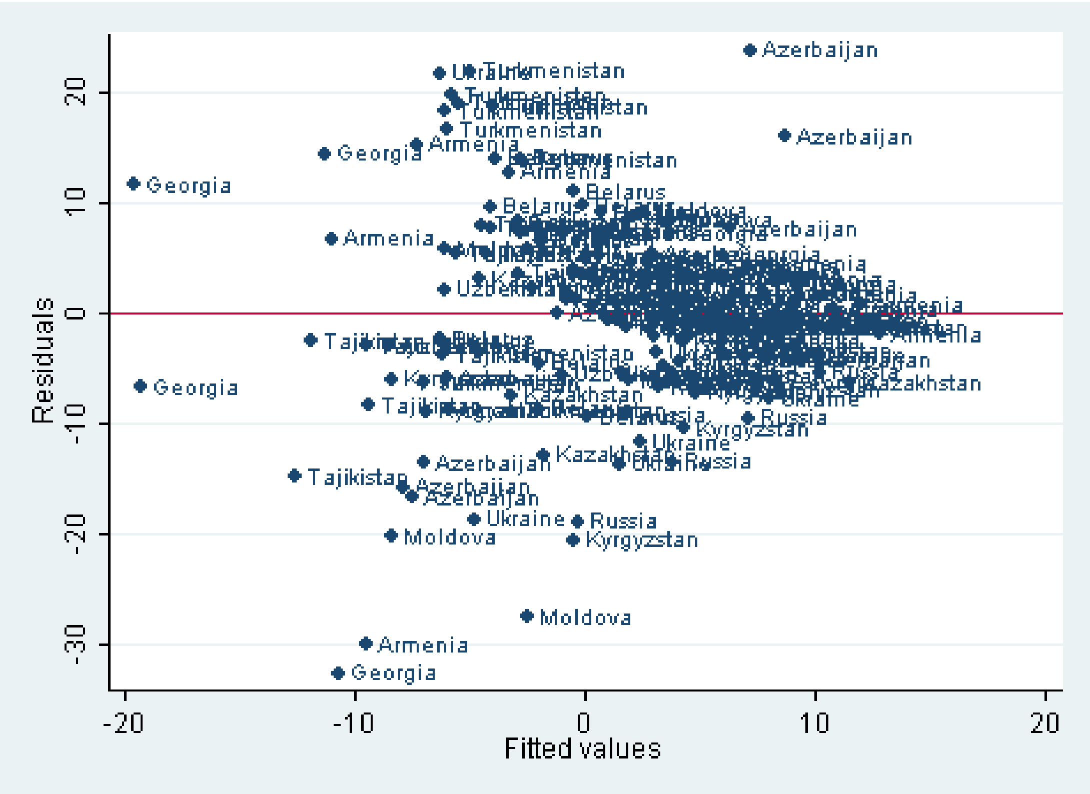
There is a simple test for autocorrelation in panel-data models developed by Wooldridge (2002). Drukker (2003) provides simulation results showing that the test has good size and power properties in reasonably sized samples. There is a user-written program, called xtserial to perform this test in Stata. According to the results of this test presented in Appendix III we can reject with 10 per cent significance H_0 assumption of no first-order autocorrelation in all variables including initial income level, investment rate, the sum of depreciation rate, population and technology growth as well as technology proxy variables. Moreover, even the use of four-year averages of the variables does not eliminate the systematic association of the disturbance term.

Figure 8. Residuals versus lagged residuals in a panel setup



Taking into account the heterogeneous nature of the cross-section it is natural to expect differences in size among observations in our sample. A heteroskedasticity test is performed to test the assumption of constant error variance by examining the relationship between squared standardized residuals to predicted values of the model. In a cross-section setup, we cannot reject the null hypothesis of constant variance, which can be expected due to our small sample. However, examining residuals plot graphically in a panel setup indicates to the presence of this problem, so the assumption of homoskedasticity is untenable. Much of the disturbance in variance seems to originate from Armenia, Azerbaijan and Georgia as depicted in Figure 9.

Figure 9. Residuals versus fitted values in a panel setup



Further, the results of Breusch-Pagan / Cook-Weisberg tests indicate that there is a significant degree of heteroskedasticity in a panel model[3]. Results from the test when the model is estimated by OLS suggest that in this instance we should reject the null hypothesis

[3] Results of the tests for autocorrelation and heteroskedasticity in panel-data are given in Appendix III

of constant variance. Especially, results are more significant for the model with EBRD transition indices, which is understandable due to the particular time trend of this variable when for most of the time both GDP growth rates and transition progress indicators have been growing over time. Though heteroskedasticity leaves the coefficient estimates unbiased, it causes the OLS procedure to underestimate the standard errors of the coefficients. Based on the above analysis we have to reside to heteroskedasticity and autocorrelation consistent standard errors when estimating the regression models.

2.2.2 Measurement issues

It is widely recognized that reliability and quality of statistical data in transition countries especially during the early years of transition is much questionable and rather low. For example, Aslund (2001) argues that both communist and post-communist statistics are imperfect for a number of reasons. In pre-transition much of the real output was left unregistered because of the focus on “gross material product” which was based on distorted prices and narrower measure of output. Moreover, socialist system stimulated interest in over-reporting production, which resulted in the upward bias of output measures. On the other hand growing private enterprises are inclined to avoid taxes and under-report their activities in post-transition, which increases the share of unofficial economy and leads to downward bias of GDP measures. Therefore, one has to take into account the direction of expected biases of the parameter estimates due to measurement errors.

Measurement errors in the dependent variable will not cause OLS regression estimates to be biased as soon as an explanatory variable is distributed independently of the disturbance term *(Dougherty 1992, 249).* However, in case of the presence of measurement error in the explanatory variable, the regression coefficients become inconsistent and biased. The direction of the bias positively depends on the magnitude of the measurement error in an observation. Polanec (2001, 8) notes that in initially low income transition countries for which we can include most of the FSU countries there are two aspects in the statistic measurement of GDP that work against the validation of conditional convergence. First, growth of income is possibly underestimated due to the poor statistical data collection, more depressed prices in services sector, significant underreporting of the economic activity and the growing informal economy. Secondly, as was suggested above, initial income was also likely biased upwards as a result of overreporting of the economic activity in pre-transition. These forces together bias the coefficient of the initial income level upwards both in cross-section and panel estimations, which limits the support for conditional convergence in the early transition period.

As was noted in the preceding section, three set of variables will be used to capture the differences in technology. An important factor which has significantly influenced the development path and pace of reforms in the initial transition period is the level of distortions inherited from the socialist regime. To account for these differences, which represent shocks to organizational technology, I use the calculations of principal component analysis from Falcetti et al. (2002). The resulting country scores for the first and second principal components with the variables included in the construction of the index are reported in the Appendix IV. The first common factor, which explains almost 50 per cent of the total variance places large weights on trade dependence, black market exchange rate premium, repressed inflation, more time spent under socialism and lower values for prior independent state history and advantageous location identified as geographical proximity to thriving market economies. Countries with higher scores on this constructed factor are expected to have more negative pre-transition conditions during the early years of transition.

To control for the positive impact of market-enhancing institutional reforms, I follow the lead taken in the literature by constructing unweighted average of well-known measures of progress in structural reforms, the EBRD Transition Indicators. Every year, the EBRD Transition Report assigns numerical scores to transition economies in a range of reform indicators that vary from 1, which represents little or no change from a planned economy, to 4+, which represents the standard of a hypothetical advanced market economy. When the score is reported with a '+' sign, 0.3 is added to the score and when reported with a '–' sign, 0.3 is subtracted from the score. Many studies on the relationship between reforms and growth in transition countries use the EBRD transition indicators as the measure of the progress in market-oriented reforms. Eight indicators comprise first-stage market-enabling reforms (price liberalization, trade and foreign exchange liberalization, small-scale privatization); second-stage of market-deepening reforms (large-scale privatization and financial sector reform) and finally third-stage market-sustaining reforms (governance and enterprise restructuring, competition policy) *(EBRD 2004).* In regression estimations the simple average of eight transition indicators will be used.

At the same time using a simple average assumes implicitly that a score of two in one dimension is equivalent to a score of two in another dimension. Because some reforms are easier to implement than others, harder-to-implement reforms should arguably have more weight. *"However, any weighting scheme will be somewhat arbitrary and difficult to justify" (Falcetti et al. 2006)* so that use of an unweighted average in the analysis is preferred.

Finally, there are numerous indicators of institutional development that assess the rule of law and the state of governance efficiency. To account for these differences I use the average of six institutional development indicators computed by Kaufmann et al. (2009). They apply an unobserved components model based on several hundred individual variables from various sources measuring institutional quality to construct broad measures of institutional development. The governance dimensions, which include estimates along voice and accountability, government effectiveness, rule of law, regulatory quality, absence of corruption and political stability, are measured in units ranging from -2.5 to 2.5 (where mean is zero and standard deviation is one), with higher scores corresponding to better governance outcomes. These indicators have a number of advantages, as they comprise broad range of institutional characteristics and cover relatively long period starting from 1996 up to 2008. Besides by using an aggregate measure we avoid difficulty of choosing among alternative variables measuring institutional quality that are highly correlated. Interestingly, authors have found that governance can improve or deteriorate even over relatively short periods of time.

The simple average of six categories for the whole period of observations per country range from the lowest score -1.33 in Turkmenistan to the highest one -0.43 in Armenia. Appendix V presents average values by periods across the 12 countries of the sample. The overall mean of institutional development in 2008 (-0.70) slightly improved from that in 1996 (-0.84), but still is below the mean for a world-wide sample (which is zero). At the same time, the standard deviation has decreased over the period from 0.53 to 0.49 respectively, indicating that, at least, the institutional gap has not widened in the region. It is also below the standard deviation for the world-wide sample (0.95), suggesting that there is less variation in institutional development across transition economies than across a broader sample of economies. If we look at individual governance dimensions, on average all countries score poorly in terms of political freedoms and control of corruption. It should be noted that in addition to overall average, individual indicators of governance will also be used in particular specifications where they are found to have a significant effect on growth.

Since the World Governance Indicators (WGI) are available from 1996, in cross-section estimations for the preceding period from 1991 to 1996 I use the simple average of two indicators (political rights and civil liberties) of democracy index from the "Nations in Transit" annual reports, published by Freedom House. It rates countries on a one-to-seven scale, with a one representing the highest and a seven the lowest level of progress on democratic development, human rights and the rule of law. Moreover, since the WGI estimations do not cover the whole period in a panel setup, Freedom House index will be used instead as a proxy for a broad-based institutional development. Indeed, pairwise correlation coefficient between these two variables is relatively high (ρ=0.73).

Usual caution applies to the interpretation of above-mentioned constructed indices such as the EBRD Transition Indicators and the WGI. It is clear that they are subjective or perceptions-based by their construction and probably biased due to prior knowledge of experts. However, these are the best measures we have and there are few alternatives to them that can be measured objectively. Moreover, it was noted that actually de facto implementation of formal rules better reflects the reality which is not always captured by fact-based data *(Kaufmann et al. 2009, 4)*.

2.3 Estimation of growth equations and discussion of results

2.3.1 Cross-section analysis

As it was mentioned in chapter 2.1, the neoclassical growth model does not predict absolute convergence, when initially poorer countries grow faster than richer countries independent of other differences. Absolute convergence applies only if economies share the same steady states determined by similar preferences and technologies *(Barro and Sala-i-Martin 2004, 382)*. Nevertheless, it is a usual starting point for testing the predictions of the model in empirical analysis. Table 3 contains the tests of absolute convergence with cross-section data for four different periods of the transition process estimated by OLS: the early period from 1991 to 1996, the intermediate stage from 1996 to 2000, the advanced stage from 2000 to 2004 and the latest period from 2004 to 2008. The dependent variable is the average growth rate of real per capita GDP over each period. In all periods productivity growth is not only statistically different from zero, but also slightly positively related to initial GDP per capita. Although not reported in the table, nearly the same result is obtained with regression for the whole sample period. Thus, the hypothesis of absolute convergence does not hold for our sample during this period. At least, results indicate that these economies have significant heterogeneity in terms of other explanatory variables such as investment ratios, population and technology growth rates as well as government policies.

Table 3. Tests of absolute convergence (cross-section data)

Dependent variable: g_y=1/t[lny(t_2) - lny(t_1)], average growth of real GDP per capita, PPP adjusted				
Regressor /Period	1996	2000	2004	2008
lny(t_1)	0.007 (0.31)	0.003 (0.38)	0.003 (0.30)	0.009 (1.00)
Constant	-0.16 (-0.79)	0.01 (0.20)	0.04 (0.60)	-0.006 (-0.08)
N	12	12	12	12
R-squared (F(1,10))	0.008 (0.09)	0.001 (0.15)	0.005 (0.09)	0.03 (0.99)

Notes: t-statistics are in parentheses

Besides, above mentioned results are reinforced by the summary statistics for the PPP-adjusted GDP per capita, in constant 2005 international dollars, presented in Table 4. Standard deviations reveal a gradual increase in dispersion of per capita income over the whole period. At the same time, one can see the steady rise of the average of the logarithm of productivity during this period. So, now we move to testing the relation between the growth rate and the initial income level after holding constant control variables or in other words, we will examine the concept of conditional convergence.

Table 4. Summary statistics of real GDP per capita, PPP-adjusted, σ–convergence

Statistic/Year	1996	2000	2004	2008
Mean	7.71	7.88	8.21	8.55
Standard deviation	0.63	0.64	0.66	0.71
Range (min-max)	6.78-8.93	6.91-9.06	7.25-9.31	7.47-9.61

To test the conditional convergence hypothesis, I extend the above regression equations by the average of the logarithm of gross fixed investment rate over four-year periods, $\ln s^i$, and the logarithm of the sum of growth rates of labour force, technology and depreciation rate, $\ln(n^i + g + \delta)$. Estimation results are summarized in Table 5.

Table 5. Tests of conditional convergence (cross-section data)

Dependent variable: g_y=1/t[lny(t_2) - lny(t_1)], average growth of real GDP per capita, PPP-adjusted				
Regressor/Period	1996	2000	2004	2008
lny(t_1)	-0.005 (-0.22)	0.01 (0.94)	-0.001 (-0.11)	-0.001 (-0.05)
$\ln s^i$	0.05 (1.89)*	0.01 (0.95)	0.02 (0.89)	0.13 (2.02)*
$\ln(n^i + g + \delta)$	0.02 (0.45)	0.06 (1.83)	0.000 (0.00)	0.14 (1.68)
Constant	-0.26 (-1.51)	-0.23 (-1.69)	0.002 (0.02)	-0.73 (-1.84)
N	12	12	12	12
R-squared (F(k,N-k-1))	0.26 (1.38)	0.36 (1.65)	0.08 (0.34)	0.54 (2.36)

Notes: t-statistics are in parentheses; * denotes 10 per cent statistical significance

The hypothesis of conditional convergence is not confirmed in any period. However, at least, here we can see the impact of the inclusion of explanatory variables. For given values of the control variables, the coefficient of initial income level has changed to a negative sign in three out of four periods. The coefficient for gross fixed investment rate is correctly signed in all periods and is significantly different from zero at the 10 per cent significance level in the early and the latest stages of transition. In contrast to the model expectations, the estimated coefficient on the labour force growth rate has slightly positive sign in all periods, but statistically insignificant.

As it was discussed in the preceding chapters the assumption of homogenous technology seems to be too strong for the transition economies. Short-term transitional shock and decline of output is better accounted for by the set of variables such as initial distance to market economy, restructuring and liberalization reforms, and macroeconomic stabilization policies. In the empirical literature it is considered to be the main reason for the poor explanation of the growth performance during this period by the standard growth factors. For example, Polanec (2004, 70) argues that the degree of output reduction was determined by the extent of initial distortions and the pace of market-oriented reform policies.

We also mentioned three set of proxy variables to control for heterogeneity in technology. The variable which measures initial conditions (IC^i) at the onset of transition will be taken from

Falcetti et al. (2002). We expect to find a negative influence of this constructed factor on growth during the early years of transition, because its higher values imply worse initial distortions. On the other hand, the variable measuring the pace of economic reforms, as measured by the change in average of EBRD Transition Indicators (TPI^i) is expected to enhance growth. To control for the favourable impact of political stability we use the dummy variable, denoted War, which equals 1 for Armenia, Azerbaijan, Georgia and Tajikistan, and 0 for all other countries. I will also test the significance of democracy index, obtained from Freedom House, which proxies the political development. Since the higher score in this index implies the worse democratic institutions, the predicted sign of the coefficient is negative. Due to the high pairwise correlation between this variable and transition progress indicator (ρ=-0.70), they are included into regressions separately. Note that since the employment growth variable is statistically insignificant and wrongly signed as before, it is excluded from the model specifications. Table 6 presents the results of augmented growth regressions.

Table 6. Augmented growth regressions for 1991-1996 (cross-section data)

Dependent variable: $g_y=1/5[\ln y(t_{96}) - \ln y(t_{91})]$, average growth of real GDP per capita, PPP-adjusted

Regressor	Equation 1	Equation 2	Equation 3	Equation 4
$\ln y(t_{91})$	-0.01 (-0.54)	-0.006 (-0.35)	-0.01 (-0.51)	-0.02 (-0.79)
$\ln s^i_{96/91}$	0.05 (1.26)	0.07 (2.14)*	0.07 (1.96)*	0.07 (1.93)*
IC^i_{91}	-0.02 (-1.09)	----	-0.01 (-0.62)	-0.01 (-0.67)
$TPI^i_{96/91}$	---	0.07 (2.44)**	0.06 (1.69)	---
War	-0.02 (-0.61)	---	---	---
$Democracy^i_{96/91}$	---	---	---	-0.01 (-0.62)
Constant	-0.08 (-0.37)	-0.39 (-2.06)*	-0.30 (-1.16)	-0.09 (-0.51)
N	12	12	12	12
R-squared (F(k,N-k-1))	0.43 (1.59)	0.47 (2.16)	0.50 (1.47)	0.42 (1.50)

Notes: t-statistics are in parentheses; * denotes 10 per cent statistical significance, ** denotes 5 per cent significance

All variables are correctly signed in all model modifications. The main coefficient of interest, the coefficient on initial income level is negatively signed, although still statistically insignificant. Another key variable is the measure of initial distortions, which is negatively signed in line with our expectations though statistically insignificant. This may suggest that the initial distortions had a negative impact on economic growth in the early years of transition. It is noteworthy that the estimated coefficient on gross fixed investment retains its statistical significance at the 10 per cent significance level. The variable measuring the progress with structural reforms over the period from 1991 to 1996 becomes significantly different from zero at the 5 per cent significance level. However, it might be the result of two-way relationship between reforms and growth, as Polanec warns (2001, 13). Since from the beginning more liberalized countries had less distorted market structure and were more ready for market allocation of resources, they had expected lower output decline and pursued faster liberalization reform policies. This argument is supported by the fact that the result is not robust to the introduction of variable measuring initial conditions as indicated by estimates in equation 3, where transition progress indicator becomes insignificant. This result is also in line with the previous empirical literature (Popov 2007, 6), which finds that the pre-transition distortions are at least as important as liberalisation reforms during transformational recession period. Negative coefficient on War dummy variable is statistically insignificant, but it highlights the harmful effects of military conflicts on productivity growth in war-torn countries. Negative sign of Democracy variable implies that more democratic countries had higher growth rates as expected, but the estimated coefficient is statistically insignificant.

Next we move into the discussion of the results of regressions analysis for the intermediate stage of transition. In this period all of the countries achieved macro economic stabilisation and started gradual recovery. However, we should keep in mind the adverse impacts of the Russian financial crisis in 1998, which is the influential economy in the region. As it is shown in Table 7, we can see the proof of the statement that the negative impact of starting conditions on economic growth fades away over time, since the coefficient changed its sign to positive, though being statistically insignificant.

Table 7. Augmented growth regressions for 1996-2000 (cross-section data)

Dependent variable: g_y=1/4[lny(t_{00}) - lny(t_{96})], average growth of real GDP per capita, PPP-adjusted			
Regressor	Equation 1	Equation 2	Equation 3
lny(t_{96})	0.01 (0.87)	0.01 (1.20)	0.01 (0.81)
$lns^{i}_{00/96}$	0.005 (0.29)	0.02 (2.05)*	0.01 (0.37)
IC^{i}_{91}	0.003 (0.31)	----	---
$TPI^{i}_{96/91}$(lagged)	-0.02 (-0.92)	-0.01 (-0.29)	---
War	---	0.02 (2.58)**	---
$Corruption^{i}_{96}$	---	---	-0.03 (-2.01)*
Constant	-0.01 (-0.17)	-0.14 (-1.93)*	-0.06 (-0.79)
N	12	12	12
R-squared (F(k,N-k-1))	0.28 (1.05)	0.52 (2.24)	0.37 (1.82)

Notes: t-statistics are in parentheses; * denotes 10 per cent statistical significance, ** denotes 5 per cent significance

Another interesting result is the positive sign of War dummy variable in equation 2, which is also significantly different from zero at the 5 per cent significance level. This is likely due to the higher growth rates and catch-up which took place in war-torn countries, though this partly reflected the extraordinarily low base. We can also see insignificant coefficient on lagged changes in the average EBRD Transition indicator. Although not reported similar result is obtained for the current indicator of market reforms either. This may be explained with the fact that cross-country regressions are not capturing the dynamic effects of liberalization reforms on economic growth, which will be better captured in a panel setup. It might be also the result of the negative consequences of transitional recession, when the institution building process was just under way and fast liberalisation could further increase organizational shock. This argument seems to be supported by the unexpected negative and statistically significant coefficient on the WGI corruption index in equation 3. Countries with more state regulation such as Belarus, Turkmenistan and Uzbekistan were the worst performers in terms of political freedoms, but they had also higher growth rates during this period. This result is also in line with the regression estimates obtained by Polanec (2004) for the advanced period of transition from 1998 to 2002, where he obtains positive coefficient on the variable measuring the level of prevalent corruption.

He interprets his finding by the fact that by this time even the limited reformers intensified their efforts and made some progress with political freedoms. At the same time, it should also be noted that when we control for the level of corruption, the coefficient on investment variable becomes smaller and statistically insignificant. The result indicates that corruption may have negative impact on growth through investment channel.

Due to the lack of statistically significant regression estimations for the period from 2000 to 2004, results for the advanced and latest periods of transition up to 2008 will be summarized together in Table 8 on next page. First of all, there is a promising result in the advanced stage of transition (2000-2004). The variable measuring the quality of institutional development (WGI^{i}_{t1}) is statistically significant at the 10 per cent significance level and correctly signed. It suggests that as the economies progressed through transition period, institution building and the quality of governance has become increasingly important for productivity growth. One of the unpredicted results is a negative sign of the lagged average of the EBRD Transition Indicators (column 1). It keeps its negative sign in various model specifications. Only when both lagged and current indicators of transition progress are included into the model, the former appears with a positive sign, though statistically insignificant (column 2). Coefficient on gross fixed investment variable is correctly signed in all specifications. Whereas it is marginally significant at 10 per cent significance level in column 2, in the last two equations it becomes highly significant at 1 and 5 per cent significance levels (correspondingly columns 3 and 4).

However, like in the intermediate stage, here again we have a number of estimated parameters that have incorrect sign judged from economic principles (column 3). First, at last initial income level is statistically significant at the 5 per cent significance level, but with a positive sign. This implies that higher GDP per capita in 2004 caused higher subsequent growth rates, which goes against the convergence hypothesis. Secondly, lagged variable measuring progress with market reforms is statistically significant at the 10 per cent significance level, but negatively signed. And finally, coefficient on the WGI political stability variable has a counterintuitive negative sign and also significant at the 5 per cent significance level, suggesting that during this period economies with more stable political situation had relatively slower growth of productivity. It should be noted that, overall, the goodness of fit of the last model specification is relatively high (R^2 adj.=69%) and all variables are statistically significant. Besides F statistic shows that the model has a high explanatory power.

Table 8. Augmented growth regressions for 2000-2008 (cross-section data)

Dependent variable: $g_y=1/t[\ln y(t_2)-\ln y(t_1)]$,average growth of real GDP per capita, PPP-adjusted				
Regressor/Period	2000-2004	2004-2008	2004-2008	2004-2008
$\ln y(t_1)$	-0.01 (-0.78)	-0.004 (-0.25)	0.01 (3.08)**	0.02 (1.18)
$\ln s^i(t_2/t_1)$	0.02 (1.16)	0.10 (1.69)	0.15 (3.68)***	0.11 (3.34)**
TPI^i_{t1} (lagged)	-0.05 (-1.74)	0.001 (0.01)	-0.01 (-2.20)*	---
TPI^i_{t2} (current)	---	-0.01 (-0.10)	---	---
$WGI^i(t_2/t_1)$	0.07 (2.13)*	---	---	---
$PolitStab^i_{t1}$	---	---	-0.06 (-2.69)**	---
$PrimaryExports^i(t_2/t_1)$	---	---	---	0.001 (2.59)**
$LogRemittances^i(t_2/t_1)$	---	---	---	0.01 (1.76)
Constant	0.27 (1.95)*	-0.18 (-1.15)	-0.56 (-3.11)**	-0.49 (-2.76)**
N	12	12	12	12
R-squared (F(k,N-k-1))	0.45 (1.65)	0.41 (1.70)	0.80 (7.02)**	0.74 (3.38)

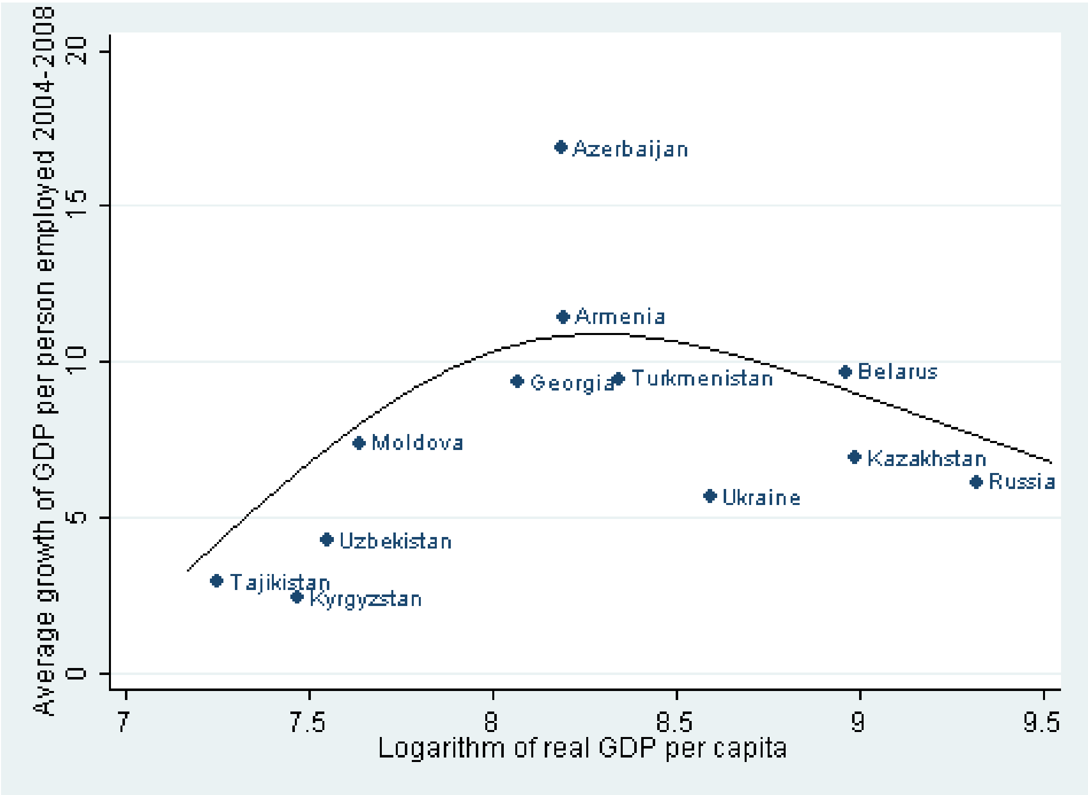
Notes: t-statistics are in parentheses; The individual coefficient is statistically significant at the * 10 per cent, ** 5 per cent, *** 1 per cent significance level

Several explanations can be put forward for such unpredicted estimation results. Firstly, we need to bear in mind there are a couple of outlier countries. Particularly, resource-rich Azerbaijan sustained an extremely high growth rates during the last decade mainly thanks to the growing revenues from oil and natural gas sector, while it has remained almost on the same level of institutional development. This fact makes it a strong outlier both in terms of the quality of governance indicators and market reform variables. This conclusion can be applied to several other resource-rich countries of the region such as Kazakhstan and Russia as well.

Secondly, as it is emphasized by the authors of the WGI, there is an unavoidable uncertainty associated with measuring institutional quality across countries *(Kaufmann et al. 2009, 2)*. Country estimates are therefore given with margins of error, where there is roughly a 70 per cent chance that the level of governance lies within plus or minus one standard error of the point estimate of governance. Authors encourage users to take into account these margins of error, especially when making comparisons across countries. If confidence intervals for governance based on the reported margins of error overlap, the data do not reveal statistically significant differences in governance. In our case, the individual estimates of political stability in 2004 actually lie in close range from the lowest score of -1.47 in Uzbekistan to the highest score of -0.11 in Kazakhstan with an average standard error of 0.24, and there are many concurrencies of confidence intervals.

Thirdly, graphical analysis shows that the relationship between most of the variables has a nonlinear shape. For instance, it is suggested in the empirical literature that the market reforms have nonlinear diminishing positive impact on growth. Once countries achieve basic level of progress in transition, further reforms are not expected to accelerate growth significantly, but they have longer term benefits for productivity growth. To better illustrate this point, on next page Figure 10 plots the relationship between initial income per capita in 2004 and its subsequent average growth rates. Apart from Azerbaijan being an outlier observation as was mentioned above, we can see that there is a clear nonlinear curve fitting the estimate points. There also seems to be a threshold initial level of income, only above which we can see the illustration of convergence behaviour.

Figure 10. Growth versus initial income: for the period from 2004 to 2008



Source: GDP per capita in constant 2005 US dollars and annual GDP per person employed growth rates from World Bank World Development Indicators database.

Finally, to account for cross-country heterogeneity two parameters will be controlled. Firstly, all four countries that lie below the seemingly "threshold level", Kyrgyzstan, Moldova, Tajikistan and Uzbekistan, plus Armenia were found to share similar parameters in terms of factor endowments, patterns of specialization, institutions or growth engines and were included to the same group by a formal cluster analysis *(Cornia, 2009).* It was argued that the economies of these countries depended initially on official development assistance and currently rely on significant inflow of remittances. Migrant labour' remittances constitute a significant portion of GDP by international standards and an important source of foreign exchange in the above mentioned four outlier countries. Since, mainly economic motivations drive migration, recent World Bank study suggests that increased migration in geographically adjacent groups of countries such as the CIS could be partly explained by the widening disparities in GDP per capita *(Mansoor and Quillin 2007, 9)*. Despite the poor nature of migration and workers' remittances data due to the relatively undocumented migrants and their earnings, the parameter coefficient is correctly signed and marginally significant at 10 per cent significance level (Table 8, column 4). Thus, this result re-confirms the results of previous cross-country growth studies, which found that remittances have a positive, although, relatively mild impact on economic growth by enhancing domestic consumption and investment, and reducing poverty *(Mansoor and Quillin 2007).*

Another important engine of growth in a number of countries starting from the late 1990s has been high commodity prices. Therefore we should separate the economic development in the energy-rich countries of the CIS, namely Azerbaijan, Kazakhstan, Russia, Turkmenistan and Uzbekistan, major oil and gas producers, and that in the resource-poor countries. The availability of energy resources, which have tended to generate larger resource rents, was found to be the key differentiating factor in explaining transition paths in the CIS *(Esanov et al. 2001).* It is clear that natural resources offer vast opportunities for development, and could give the economy the momentum it needs to finance a coordinated investment effort and break out of the poverty trap *(Guriev et al. 2009).* However, in the long-run the "resource curse" phenomenon may lead to low growth by reducing incentives to improve institutions, increasing rent-seeking environment and contributing to a higher macroeconomic volatility, particularly in countries with an initial low institutional development. In our model specification parameter coefficient on the variable measuring resource endowments (PrimaryExports(t_2/t_1)) is positive and significantly different from zero at 5 per cent significance level, which implies that resource abundance has not turned yet into a curse for the region (Table 8, column 4).

So far, one of the most robust and significant variables is investment rate, but causality cannot be claimed without using a valid instrument. It is highly likely indeed that causality runs in an opposite direction or there is an omitted variable where high growing economy thanks to this factor can also accumulate high investments. For example, Barro (1997, 33) emphasizes that

'[...] typical cross-country regressions reflects the reverse relation between growth prospects and investment.'

At the same time the magnitude of the coefficient is much lower than those obtained for both developed and developing countries in MRW (1992). Another variable of the basic Solow equation, the sum of labor force growth, technology growth and depreciation rate is statistically insignificant and wrongly signed in all periods and model specifications. One of the reasons for statistical insignificance and unpredicted signs for the traditional factor inputs, capital and labour in econometric studies for transition economies, as Havrylyshyn (2008, 55) noted, is that transitional adjustment and dynamics reveal large efficiency gains without new inputs and are different from traditional growth process:

'[...] it is not a matter of moving the economy to a higher production-possibility frontier rather it means first correcting the large inefficiencies of the communist period'.

Besides, we are assuming depreciation and technology growth rates to be the same across countries and constant over time, which of course seems to be a strong assumption.

Interestingly enough, in the last two model specifications the key parameter of interest, the coefficient estimates of initial income per capita have positive signs and even statistically significant in equation 3. Furthermore, we can see high goodness of fit of these equations. The coefficient estimates on initial income are positively signed, particularly when we control for the country specific characteristics for the period from 2000 to 2008. To sum up, the evidence is mixed, and at least, results suggest little relevance of conditional convergence hypothesis for the CIS countries during the transition period. At the same time, it seems reasonable to infer that there are fundamental unobserved and unmeasured differences across these countries. Therefore, next I proceed to panel data analysis which can really be helpful, as it allows to control for the cross-section heterogeneity and to better understand the dynamics of economic relationships.

2.3.2 Panel data estimation

In table 9 the regression results of the equation (17) by OLS are reported. Although this estimation method is inconsistent and could produce misleading results when the right-hand side explanatory variables and unobserved country-specific growth effects are possibly correlated, it is a useful way to summarize the strong correlations in the data and also to provide comparative values for other more appropriate models. All estimated coefficients are based on the standard errors that are robust to heteroskedasticity. The estimation equation of the simple Solow model without any control variables is omitted from presentation[4], because the variable measuring the sum of the depreciation rate, the growth of labor force and technology is highly significant, but with a positive sign in contrast to the theoretical expectations.

Table 9. Dynamic panel data estimations by OLS

Dependent variable is $\Delta lny^i(t_2/t_1)$					
Regressor/Equation	I	II	III	IV	V
$lny(t_1)$	-0.04	-0.004	-0.03	-0.04	-0.07
	(-1.56)	(-0.23)	(-1.66)	(-2.47)**	(-2.86)***
$lns^i(t_2/t_1)$	0.09	0.08	0.04	0.07	0.07
	(2.29)**	(2.34)**	(1.71)*	(2.89)***	(2.93)***
IC^i_{91}	-0.01	0.02	---	---	---
	(-0.57)	(1.29)			
$TPI^i(t_2/t_1)$	---	0.11	0.11	0.11	0.10
		(6.26)***	(6.42)***	(6.60)***	(6.75)***
$ThresholdDummy^i$	---	---	-0.06	-0.05	-0.05
			(-2.32)**	(-1.87)*	(-2.20)**
$Integration^i(t_2/t_1)$	---	---	---	0.08	---
				(2.87)***	
$Democracy^i(t_2/t_1)$	---	---	0.03	---	---
			(2.69)**		
$Energy^i(t_2/t_1)$	---	---	---	---	0.01
					(2.04)**
Constant	0.02	-0.51	-0.28	-0.39	0.04
	(0.09)	(-2.88)***	(-1.44)	(-1.80)*	(0.21)
N	60	60	60	60	60
R-squared (F stat.)	0.07	0.49	0.57	0.56	0.54
	(1.96)	(11.77)***	(14.45)***	(18.53)***	(25.83)***

Notes: t-statistics are in parentheses; The individual coefficient is statistically significant at the * 10 per cent, ** 5 per cent, *** 1 per cent significance level

[4] see Appendix VI for all estimation results

As observed in cross-section estimations gross fixed investment variable is positively signed and significantly different from zero in all equations. Also as anticipated the variable measuring initial conditions becomes statistically insignificant meaning that in the longer term the legacy of a poor starting position fades away (equation I). In line with previous empirical literature transition progress indicator appears as one of the most statistically significant and robust variables, which increases productivity growth. Moreover, its inclusion greatly improves the goodness of fit of the model. Although initial income level is negatively signed as expected in all specifications, it becomes significantly different from zero only when we include the dummy variable for four outlier countries (Kyrgyzstan, Moldova, Tajikistan and Uzbekistan). As discussed above and graphically illustrated in Figure 10 these countries seem to lie below "threshold level" and did not grow as fast as predicted by the convergence hypothesis. In fact the estimated coefficient is negative and statistically different from zero, which implies that productivity growth in this group of countries might be lower independently of the effects of other variables included in the model. Estimated coefficient on initial income (-0.04) is remarkably similar to the corresponding estimate obtained from OLS estimation in a panel for twenty five transition countries by Polanec (2001).

Similar to cross-section estimations institutional development measured by political freedoms do not yet show up an expected positive influence on growth. In equation III Freedom House index ($Democracy^{i}(t_2/t_1)$) is statistically significant, but wrongly signed. However, it is understandable to obtain such an unexpected estimation taking into account a relatively short time dimension of the sample of qualitatively similar countries. It was also argued by Barro (1997, 51) that there is likely to be a two-way relationship between economic growth and democracy, and it is theoretically inconclusive and nonlinear relation.

One of the widely held beliefs in the economics profession is that international trade is one of the underlying sources of growth, which has an important role in fostering economic convergence between rich and poor regions of the world *(Rodrik et al. 2004, Dollar and Kraay*

2004). For example, Frankel and Romer (1999) show that trade has quantitatively large and robust, though only moderately statistically significant, positive effect on income. Trade openness facilitates convergence by allowing poorer countries to import capital and modern technologies from the wealthier countries *(Sachs et al. 1995)*. In line with our expectations, in equation IV we can see a positive and statistically significant effect of exports (Integration $^{i}(t_2/t_1)$) on income growth. However, in a simple regression with OLS reverse causality cannot be ruled out, because countries whose income growth are high for reasons other than trade may also trade more.

Finally, in equation V I will control for natural resource endowment measured by primary energy production (Energy$^{i}(t_2/t_1)$). Estimated coefficient is statistically different from zero and indicates a small positive impact of hydrocarbon wealth on income growth. It is noteworthy that this final equation is the most robust specification, where the coefficient on initial income is negative and reaches the highest statistical significance at 1 per cent level.

Now to better control and reflect the omitted country specific differences that do not change over time, I will use the fixed effects regression model by entity-demeaned OLS regression. Here both the measure of initial distortions and threshold dummy variables are dropped from the model because they do not vary over time. Results for the most robust specification are reported in Table 10. The estimation equation is the basic Solow model without growth of labor force and two additional measures that could control for differences across countries. Control variables included in the estimations are EBRD's index of progress in market reforms (TPI^{i} (t_2/t_1)) and primary energy production (Energy$^{i}(t_2/t_1)$). Also there are time dummies in all specifications since they are found to be statistically significant.

All explanatory factors with the exception of gross fixed investment are highly significant and appear with expected signs, whereas the coefficient on initial income is significantly different from zero and confirm the hypothesis of conditional convergence. In fixed-effects model the estimate of rho (0.98) suggests that almost all of the variation in growth is related to interstate differences in growth rates. The F test following the regression of the null hypothesis that all cross-section specific disturbances are zero can safely be rejected. It indicates that there are significant individual (country level) effects, implying that pooled OLS would be inappropriate.

Table 10. Dynamic panel data estimations by LSDV with fixed effects and GMM estimators

Dependent variable is $\Delta lny^i(t_2/t_1)$			
Regressor/Equation	FE	Dif-GMM	Sys-GMM
$lny(t_1)$	-0.24 (-5.02)***	-0.09 (-1.69)*	-0.13 (-9.10)***
$lns^i(t_2/t_1)$	-0.005 (-0.23)	-0.06 (-1.35)	0.02 (1.12)
$TPI^i(t_2/t_1)$	0.06 (1.75)*	0.20 (2.95)***	0.06 (5.16)***
$Energy^i(t_2/t_1)$	0.16 (4.45)***	0.12 (2.09)**	0.13 (5.67)***
Constant	0.41 (1.01)	0.09 (0.19)	0.46 (4.20)***
N	60	36	48
R-squared (F stat.)	0.89 (36.76)***		
Time effects	Yes (significant)	Yes (significant)	Yes (significant)
AR(1)		0.04	0.25
AR(2)		0.21	0.54
Sargan test		0.98	0.12

Notes: t-statistics are in parentheses; The individual coefficient is statistically significant at the * 10 per cent, ** 5 per cent, *** 1 per cent significance level. 'FE' is fixed-effects estimation.

Instruments used for Dif-GMM are lny_{it1-1}, $lns_{i(t2/t1)-1}$, $TPI_{i(t2/t1)-1}$.

Additional instruments used for levels equations in Sys-GMM are Δlny_{it1}, $\Delta lns_{i(t2/t1)}$, $\Delta TPI_{i(t2/t1)}$.

The figures reported for the Arrelano-Bond test are the p-values for the null hypothesis, no autocorrelation in first-differenced errors, and those reported for the Sargan test are the p-values for the null hypothesis, valid specification.

Striking feature in column (I) is that estimated parameter on investment with fixed-effects estimator is negative and highly statistically insignificant, which shows that the effect of the investment comes totally from cross sectional differences and it may be correlated with non-observed country specific factors. On the other hand, it is not surprising as *Pritchett (2000, 238)* cautions that high frequency panel regressions suffer from a lower statistical power. In particular, by sweeping out permanent cross-national differences fixed effects approach may increase the standard errors and even change the sign of important estimates when there are differences in time-persistence between income growth and growth correlates, as well as in the presence of measurement-error, dynamic misspecification or endogeneity problems.

As was discussed in section 2.1, by construction, fixed-effects estimation in the presence of lagged dependent variable ($\ln y(t_1)$) among explanatory variables renders within estimator biased and inconsistent, particularly when time period is small relative to cross-section units. Therefore, the same model is regressed with two other linear dynamic panel-data estimations: Arrelano-Bond (1991) GMM estimator labelled as Dif-GMM and Blundell-Bond (1998) system GMM estimator labelled as Sys-GMM. Since it was shown that the estimated standard error of the two-step GMM estimator is seriously downward biased, I use one-step estimators *(Stata Corporation 2005, 26)*. Because Dif-GMM model has two lags, the first two years are lost and the estimator has less observations.

Both estimators' validity require that there be no autocorrelation in the idiosyncratic errors, which is why rejecting the null hypothesis of no serial correlation in the first-differenced errors at an order greater than one implies model misspecification. The output in Table 10 for both Dif-GMM and Sys-GMM estimations presents no significant evidence of serial correlation in the first-differenced errors at order 2, which means that moment conditions used by these models are valid. Furthermore, in both first-differenced and system GMM estimations the Sargan test of overidentifying restrictions does not detect any problem with instrument validity. It is marginally significant in the latter case, but Arrelano and Bond (1991) show that the one-step Sargan test overrejects in the presence of heteroskedasticity.

It should be noted that initial income level, investment and transition progress indicator variables are treated as potentially endogenous and their lagged values are included as instruments in both GMM estimators. Results show that the progress in market reforms has a significant positive effect on the steady state level of per capita GDP, even after controlling for unobserved country-specific effects and allowing for its likely endogeneity. Energy wealth as expected is also positive and statistically significant.

Comparing the coefficients on initial income in different models, in line with the results of previous empirical research, we can see that within estimator is likely to be seriously biased downwards while OLS is upward biased. That the estimate of the coefficient on initial income obtained by Sys-GMM produces a much higher estimate of the coefficient on initial income agrees with the results in Bond et al. (2001) and Polanec (2001). It lies acceptably above the corresponding fixed-effects estimate, and below the corresponding OLS levels estimate. When it comes to the small difference between Dif-GMM and Sys-GMM estimates the latter can perform better when the autoregressive parameters become too persistent or the ratio of the variance of the panel-level effect to the variance of idiosyncratic error is too large *(Stata Corporation 2005, 92).* I therefore assume that these forces are not too strong in the model to affect the estimation results and there is no problem of weak instruments in Dif-GMM model.

The rate of convergence (λ) can be uncovered from the estimated regression coefficient on initial income which equals to $[1 - e^{-\lambda\tau}]$ (17). The Dif-GMM estimator indicates a rate of convergence of around 2 per cent a year, which is surprisingly similar to the standard cross-section findings in empirical literature. Implied convergence rate with the Sys-GMM model is slightly higher at 3 per cent a year. Anyway since the system GMM estimator not only improves the precision but also reduces the finite sample bias *(Baltagi 2005, 148)* it should be preferred estimation.

To sum up, there are important changes in parameter estimates between cross-section and panel data. Unlike significant positive effect of investment on growth in a cross-section, panel analysis shows its little or no role in fostering growth. This result is qualitatively similar to that obtained by Polanec (2001) in a larger sample of transition countries. On the other hand, in contrast to cross-section mixed evidence in favour of market sustaining reforms, controlling for country- and time-invariant characteristics reveals their significant positive effect in explaining growth. In addition to these variables, primary energy production is considered, which indicates that growth in hydrocarbon-rich economies might be higher independently of the effects of other variables included in the model.

CONCLUSION

In my dissertation I endeavoured to quantitatively analyse economic growth and dynamics of income distribution in twelve countries of the FSU from 1991 to 2008. Two methods of econometric analysis were applied: cross-section regressions and dynamic panel data estimation techniques. The main focus of the study has been to empirically establish whether countries in the region are converging or diverging and to find important sources of cross-country differences which determine the nature of this process.

As was discussed in detail in Chapter 2, it is useful to remember that data deficiencies and measurement issues remain a serious problem. In addition, not all data were available for all transition countries and for all years. Hence, all conclusions should be interpreted with caution and the limitations of statistical techniques ought to be recognised. It is also important to remember that statistical significance does not necessarily mean causality in econometric studies of growth, because

'it is difficult to isolate changes in endogenous variables that are not driven by equilibrium dynamics or by omitted factors.' (Acemoglu 2009, 18)

But for the purposes of this dissertation it would be sufficient to interpret the relationships as correlations and to determine potential sources of differences in cross-country growth.

Departing from the neoclassical growth theory I started the analysis of economic growth based on the triple formula of technology, physical capital, and labor force. But these correlates are only proximate causes of economic growth, whereas its deeper roots lie in a wide range of factors such as education, geography, natural resources, government policies and other institutional differences, which potentially affect technology and accumulation choices in a society *(Acemoglu 2009, 20).* Therefore, a range of technology proxy variables were included into regression estimations to control for subtle differences among these countries.

As it is emphasised in a recent report by the Commission on Growth and Development, commissioned by the World Bank, also known as the Spence Report (2008), economic growth is rather context-specific phenomenon depending on unique circumstances and timing of various elements. But the study also highlights five shared characteristics of successful growth stories and potential sources of catch-up for poor countries: 1. Openness, which allows countries to import modern knowledge and to imitate advanced technologies as well as to exploit global demand and thus, increases innovation potential of the country; 2. Macroeconomic stability which implies modest inflation and sustainable public finances; 3. Future orientation indicated by the high rates of physical and human capital accumulation; 4. Market-based allocation which is based on the principle that prices guide resources and resources follow prices; 5. Committed, credible and capable governments which pursue inclusive policies *(Spence Report 2008, 32).*

In fact, all of these variables are important for transition countries as well and found to be significant in explaining their growth performance in several empirical studies *(Campos 2002).* Regression estimations in this dissertation also show that the countries with higher growth of income per capita have been those which are more integrated into the world economy, have macroeconomic and political stability, and higher investment rates, consistently pursue market-oriented reforms and improve on institutional development.

Regarding growth drivers, there are several potentially important factors for observed differences in cross-country performance. Cross-section regression results presented mixed evidence in favour of market reforms. But when individual heterogeneity is controlled in panel data, progress in market reforms turns out to be one of the most robust and statistically significant variables confirming the overall positive impact of liberalisation and market-supporting institutions on technological growth. Although strong statements about causation cannot be made on the basis of these correlations, the results suggest the possibility of a virtuous circle of reforms and growth going in tandem. In general, results show that market-oriented reforms are one of the influential factors of catch-up and convergence.

Although initial conditions variable is found to be correctly signed in the early transition period from 1991 to 1996, it is not statistically significant. Further, in later cross-section periods and panel setup it is wrongly signed suggesting that worse starting positions might have negative impact in the early years, but it disappears in advanced stages of transition. One of the most statistically significant variables in cross-country regressions is investment, though its implied importance is much lower than that estimated for larger sample of countries. This is possibly due to endogeneity problem and causality cannot be claimed as it becomes insignificant when individual heterogeneity is allowed in a panel data.

One of the most controversial results is obtained for the constructed indices of institutional development. In regression estimations the variable measuring progress with a particular dimension of governance quality is not robust and sometimes appears with unpredicted signs. Thus, evidence seems to be ambiguous. It is probably due to the relatively similar state of institutional development within the region and the relatively short time span of analysis.

The results for natural resource abundance proxied by the share of primary exports in cross-section and the logarithm of primary energy production in panel data indicate moderate positive impact of natural resources on income growth indicating that resource abundance has not yet turned into a curse for the region. But taking into account that most countries already score poorly when compared to the WGI worldwide average and the region is lagging behind CEE countries in terms of institutional development, it becomes obvious that possible threats to institution building are there and remain to be seen in the coming decades.

When it comes to the key coefficient of interest on initial income level, the results of cross-section estimations are dynamic and complex. To begin with, the hypothesis of absolute convergence does not hold for our sample during this period. However, it is not surprising considering the results of cross-country analysis which indicates that these economies significantly differed in terms of their initial conditions and subsequent reform policies. It is partly supported by the increased dispersion of per capita income levels during the sample period. When additional control variables are included, initial income coefficient is correctly negatively signed in most of the cross-section periods, but it is still statistically insignificant. Furthermore, the coefficient estimates on initial income become positive and significantly different from zero implying cross-country divergence, when we control for the distinct country-specific characteristics such as natural resource abundance and migrant labours' remittances in the latest stages of transition from 2000 to 2008.

In contrast to the results obtained by Polanec (2004) I did not find statistically significant support for conditional convergence in any cross-section period. Thus, his results could be driven by the larger sample of transition countries and in particular, interaction between CEE and FSU countries, where the latter group had lower productivity per capita and at the same time has been growing faster than the former during the last decade.

Meanwhile, panel data fixed-effects and GMM methods provide strong support for conditional convergence hypothesis. The first-differenced GMM estimator indicates a rate of convergence of around 2 per cent a year, which is surprisingly similar to the standard cross-section findings in empirical literature. Implied convergence rate with the system GMM estimator is slightly higher at 3 per cent a year. Nevertheless, panel results maybe driven by the cyclical features of transition economies, when initially income growth declined at a decreasing rate and then accelerated at an increasing rate. As Pritchett (2000, 28) warns:

'[...] the enormous volatility of growth around its trend (however defined) means that even over periods as long as a decade, growth can be dominated by shocks and recovery.'

To sum up, the answer to the main question of the dissertation seems to be unclear. However, certain observations can be made which seem to determine the convergence relationship in general and overall growth performance in the FSU countries.

Firstly, the relationship between most of the variables has a nonlinear shape. Economic growth is a complex and evolving process and it is therefore would perhaps be inappropriate to interpret results with linear relationships and in a straight-forward manner.

Secondly, groups of outlier countries can be recognized. For example, hydrocarbon-rich economies had higher growth of per capita income independently of the effects of other country-specific factors such as progress in market-oriented reforms. There also seems to be a group of initially poorer countries which lie below threshold level of income, only above which we can see the illustration of convergence behaviour. Being in this group they possibly have lower steady-state positions and consequently slower growth rates.

Thirdly, one of the reasons for poor performance of standard growth factors could also be the fact that structural transformation is not over yet in most of the countries. Both growth accounting exercise and cross-section regression estimations indicate that technological growth has been more important than capital deepening during the analysed period. In other words, economies are still moving from the interior of their aggregate production possibilities set toward its frontier which is different from balanced growth path of developed countries.

Last but not least, the analysis was based on a range of simplifying assumptions of Solow growth model where we neglected interdependencies across economies. As was noted by Polanec (2001) without knowing initial stock of physical capital and especially its later depreciation rate across countries and over time, estimates are likely to be biased. Therefore, convergence implications of the neoclassical growth model should not be yet dismissed.

Taking into account significant differences among countries one way of further research, as it seems to me, would be to analyse individual countries' growth experience based on their distinct development path, conditions and circumstances. It may allow to determine unique structural breaks and specific reasons for the particular patterns of their economic growth.

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APPENDIX I

Growth accounting year-by-year results from 1998 to 2008

№	Country	Year	Output growth	Capital growth	Labour growth	Factor Con-tribution	TFP growth
1	Armenia	1998	7.30	2.02	0.57	1.00	6.30
		1999	3.30	-6.02	0.36	-1.55	4.85
		2000	5.90	6.27	0.67	2.35	3.55
		2001	9.60	7.05	0.98	2.80	6.80
		2002	13.19	23.28	1.14	7.78	5.40
		2003	14.00	25.24	1.22	8.43	5.57
		2004	10.50	14.17	0.87	4.86	5.64
		2005	13.90	23.97	0.79	7.74	6.16
		2006	13.20	28.85	0.68	9.13	4.07
		2007	13.70	14.30	2.24	5.86	7.84
		2008	6.80	4.00	.	1.20	5.60
2	Azerbaijan	1998	10.00	19.00	2.63	7.54	2.46
		1999	7.40	20.69	2.38	7.87	-0.47
		2000	11.10	-15.74	2.92	-2.67	13.77
		2001	9.90	7.97	2.37	4.05	5.85
		2002	10.60	84.68	2.27	26.99	-16.39
		2003	11.20	68.13	2.14	21.94	-10.74
		2004	10.20	20.91	2.03	7.70	2.50
		2005	26.40	-4.97	1.74	-0.27	26.67
		2006	34.50	-1.46	0.87	0.17	34.33
		2007	25.05	-10.07	4.44	0.08	24.96
		2008	10.80	23.65	.	7.09	3.71
3	Belarus	1998	8.40	2.90	-1.20	0.03	8.37
		1999	3.40	-20.00	-1.05	-6.73	10.13
		2000	5.80	10.70	0.52	3.57	2.23
		2001	4.73	-2.11	0.65	-0.18	4.90
		2002	5.05	-1.56	0.37	-0.21	5.25
		2003	7.04	21.85	0.44	6.86	0.18
		2004	11.45	25.31	0.20	7.73	3.72
		2005	9.44	9.16	0.08	2.81	6.63
		2006	10.00	5.94	0.18	1.91	8.09
		2007	8.60	10.04	-0.16	2.90	5.70
		2008	10.00	20.36	.	6.11	3.89
4	Georgia	1998	3.10	64.04	-0.61	18.78	-15.68
		1999	2.87	-48.74	-0.15	-14.73	17.60
		2000	1.84	-4.03	-3.70	-3.80	5.64
		2001	4.81	6.25	3.30	4.19	0.62
		2002	5.47	10.62	-3.37	0.83	4.65
		2003	11.06	24.00	1.90	8.53	2.53
		2004	5.86	18.41	-2.12	4.03	1.82
		2005	9.60	9.00	-0.49	2.36	7.24
		2006	9.38	13.66	-0.09	4.04	5.34
		2007	12.43	13.87	0.23	4.32	8.11
		2008	2.00	-44.21	.	-13.26	15.26

№	Country	Year	Output growth	Capital growth	Labour growth	Factor Contribution	TFP growth
5	Kazakhstan	1998	-1.90	-6.80	-1.05	-2.78	0.88
		1999	2.70	5.70	-0.03	1.69	1.01
		2000	9.80	6.70	0.62	2.44	7.36
		2001	13.50	36.50	0.91	11.59	1.91
		2002	9.80	7.30	1.04	2.92	6.88
		2003	9.30	3.00	0.79	1.45	7.85
		2004	9.60	11.10	0.58	3.74	5.86
		2005	9.70	31.00	0.85	9.89	-0.19
		2006	10.70	27.70	1.08	9.07	1.63
		2007	8.90	19.90	3.04	8.10	0.80
		2008	3.20	4.70	.	1.41	1.79
6	Kyrgyzstan	1998	2.12	-35.51	2.07	-9.20	11.32
		1999	3.66	19.28	2.07	7.23	-3.57
		2000	5.44	18.14	1.78	6.69	-1.24
		2001	5.33	-9.60	1.46	-1.86	7.19
		2002	-0.02	-10.45	1.49	-2.09	2.07
		2003	7.03	-30.12	1.31	-8.12	15.15
		2004	7.03	19.60	1.72	7.08	-0.06
		2005	-0.18	-5.11	1.84	-0.24	0.07
		2006	3.10	25.20	2.29	9.16	-6.06
		2007	8.21	-35.29	1.72	-9.39	17.60
		2008	7.67	.	.	.	.
7	Moldova	1998	-6.50	3.27	-2.75	-0.94	-5.56
		1999	-3.40	-23.48	-3.04	-9.17	5.77
		2000	2.10	9.27	-3.13	0.59	1.51
		2001	6.10	-12.90	-3.40	-6.25	12.35
		2002	7.80	14.95	-3.51	2.03	5.77
		2003	6.60	6.50	-3.60	-0.57	7.17
		2004	7.41	3.94	-4.07	-1.67	9.08
		2005	7.50	9.25	-0.90	2.15	5.35
		2006	4.78	15.50	-0.02	4.64	0.15
		2007	2.99	16.53	-4.68	1.69	1.30
		2008	7.20	2.01	.	0.60	6.60
8	Russian Federation	1998	-5.30	-49.20	-0.12	-14.85	9.55
		1999	6.40	-10.60	-0.22	-3.34	9.74
		2000	10.00	71.20	1.53	22.43	-12.43
		2001	5.09	12.74	1.13	4.61	0.48
		2002	4.74	-6.63	0.58	-1.58	6.32
		2003	7.35	9.20	0.49	3.10	4.25
		2004	7.14	8.20	0.00	2.46	4.69
		2005	6.40	5.50	0.84	2.24	4.16
		2006	7.40	14.30	-0.30	4.08	3.32
		2007	8.10	18.60	2.14	7.08	1.02
		2008	7.30	5.24	.	1.57	5.73

№	Country	Year	Output growth	Capital growth	Labour growth	Factor Con-tribution	TFP growth
9	Tajikistan	1998	5.30	-21.48	3.52	-3.98	9.28
		1999	3.70	12.54	3.14	5.96	-2.26
		2000	8.30	-32.36	4.10	-6.84	15.14
		2001	10.20	35.20	6.32	14.98	-4.78
		2002	9.10	1.70	3.69	3.09	6.01
		2003	10.20	19.00	4.89	9.13	1.07
		2004	10.60	-7.20	4.01	0.64	9.96
		2005	6.70	-1.40	3.92	2.33	4.37
		2006	7.00	5.39	3.84	4.31	2.69
		2007	7.80	2.64	9.63	7.53	0.27
		2008	7.90	0.35	4.32	3.13	4.77
10	Turkmenistan*	1998	6.70	13.00	3.02	6.01	0.69
		1999	16.46	-1.00	3.36	2.05	14.40
		2000	18.59	9.80	2.83	4.92	13.67
11	Ukraine	1998	-1.90	-1.38	1.22	0.44	-2.34
		1999	-0.20	-3.90	-13.31	-10.49	10.29
		2000	5.90	8.10	0.46	2.75	3.15
		2001	9.20	19.46	0.64	6.28	2.92
		2002	5.20	-5.50	-0.07	-1.70	6.90
		2003	9.40	7.90	-0.45	2.06	7.34
		2004	12.10	0.96	0.05	0.32	11.78
		2005	2.70	-6.37	1.01	-1.20	3.90
		2006	7.30	15.48	-0.45	4.33	2.97
		2007	7.90	22.48	0.72	7.25	0.65
		2008	2.10	3.14	.	0.94	1.16
12	Uzbekistan	1998	4.30	0.60	3.16	2.39	1.91
		1999	4.30	-2.90	3.29	1.43	2.87
		2000	3.80	-3.10	2.96	1.14	2.66
		2001	4.20	0.00	3.14	2.20	2.00
		2002	4.00	-0.40	3.15	2.08	1.92
		2003	4.20	0.50	2.97	2.23	1.97
		2004	7.70	0.95	3.46	2.71	4.99
		2005	7.00	3.00	3.44	3.31	3.69
		2006	7.30	5.10	3.45	3.94	3.36
		2007	9.50	18.90	4.27	8.66	0.84
		2008	9.00	4.49	.	1.35	7.65

Source: Author's calculations using GDP, gross capital formation and labor force data from the World Bank World Development Indicators. Annual capital depreciation rate is assumed to equal 0.4.

* No data for gross capital formation in Turkmenistan from 2001.

APPENDIX II

Average growth rates of real GDP until and from the minimum point

№	Country	The year of sharp output fall, start of the transition	The year of minimum real GDP, bottom	Average growth rate till the min. point	Average growth rate from the min. point
1	Armenia	1992	1993	-19.43	8.49
2	Azerbaijan	1993	1995	-20.40	10.55
3	Belarus	1992	1995	-8.11	6.68
4	Georgia	1992	1994	-25.25	6.76
5	Kazakhstan	1993	1995	-7.93	5.82
6	Kyrgyzstan	1992	1995	-13.21	3.24
7	Moldova	1992	1999	-9.72	6.49
8	Russia	1992	1998	-6.44	6.24
9	Tajikistan	1992	1996	-18.52	4.17
10	Turkmenistan	1992	1997	-11.08	10.71
11	Ukraine	1991	1999	-8.72	7.02
12	Uzbekistan	1992	1995	-6.01	3.61

Source: GDP per capita in constant 2005 US dollars and annual GDP growth based on constant 2000 US dollars from World Bank World Development Indicators database.

APPENDIX III

Stata output of the tests for autocorrelation and heteroskedasticity in panel-data

```
. xtserial  gdpppgrowth loggdp

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      11) =      4.573
           Prob > F =      0.0558

. xtserial  gdpppgrowth  EBRD

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      11) =      3.317
           Prob > F =      0.0958

. xtserial  gdpppgrowth   loginv

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      11) =      3.881
           Prob > F =      0.0745

. xtserial  gdpppgrowth    logconstant

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      11) =      3.372
           Prob > F =      0.0935

. xtserial  gdpppgrowth   IC

Wooldridge test for autocorrelation in panel data
H0: no first-order autocorrelation
    F(  1,      11) =      3.749
           Prob > F =      0.0789

. estat hettest, rhs

Breusch-Pagan / Cook-Weisberg test for heteroskedasticity
         Ho: Constant variance
         Variables: loggdp_t1 meaninv meanTPI logenergyproduce

         chi2(4)      =    15.70
         Prob > chi2  =   0.0034
```

APPENDIX IV

Initial Conditions: individual country scores

Country	First principal component (IC1)	Second principal component (IC2)
Armenia	1.11	1.44
Azerbaijan	3.24	0.07
Belarus	1.07	1.94
Georgia	2.20	0.56
Kazakhstan	2.54	−0.04
Kyrgyzstan	2.27	−1.94
Moldova	1.09	−0.31
Russian Federation	1.09	1.91
Tajikistan	2.87	−2.22
Turkmenistan	3.43	−1.07
Ukraine	1.40	1.54
Uzbekistan	2.78	−1.94
Proportion of total variance explained	0.497	0.177

Country score calculated from the first principal component of a factor analysis over 11 indicators (GDP per capita in 1989; pre-transition growth rate; trade dependence on CMEA; degree of over industrialization; urbanization rate; natural resources dummy; years spent under central planning; distance to EU; dummy for pre-transition existence as a sovereign state; repressed inflation; black market premium). The country score is calculated by multiplying each variable with a factor loading.

Source: Falcetti et al. 2002.

APPENDIX V

Aggregate Governance Indicators 1996-2008

Country	1996	1998	2000	2002	2003	2004	2005	2006	2007	2008
Armenia	-0.61	-0.58	-0.64	-0.48	-0.37	-0.41	-0.31	-0.35	-0.33	-0.22
Azerbaijan	-0.95	-0.92	-0.93	-0.91	-0.88	-0.93	-0.85	-0.82	-0.81	-0.74
Belarus	-1.08	-0.82	-0.97	-1.06	-1.03	-1.08	-1.04	-1.08	-1.04	-0.88
Georgia	-0.83	-0.92	-0.81	-1	-0.94	-0.6	-0.5	-0.39	-0.25	-0.18
Kazakhstan	-0.73	-0.61	-0.67	-0.8	-0.72	-0.77	-0.6	-0.59	-0.57	-0.51
Kyrgyzstan	-0.45	-0.47	-0.66	-0.74	-0.78	-0.81	-0.93	-0.93	-0.85	-0.79
Moldova	-0.15	-0.16	-0.43	-0.57	-0.63	-0.69	-0.63	-0.58	-0.5	-0.45
Russian Federation	-0.64	-0.67	-0.77	-0.58	-0.6	-0.61	-0.65	-0.74	-0.74	-0.73
Tajikistan	-1.7	-1.65	-1.36	-1.23	-1.13	-1.17	-1.09	-1.09	-1.02	-1
Turkmenistan	-1.41	-1.19	-1.17	-1.34	-1.31	-1.46	-1.41	-1.4	-1.32	-1.28
Ukraine	-0.5	-0.69	-0.7	-0.66	-0.66	-0.62	-0.43	-0.41	-0.4	-0.39
Uzbekistan	-1.06	-1.15	-1.27	-1.32	-1.33	-1.4	-1.5	-1.41	-1.24	-1.19
Average	**-0.84**	**-0.82**	**-0.86**	**-0.89**	**-0.86**	**-0.88**	**-0.83**	**-0.82**	**-0.76**	**-0.70**

Source: Kaufmann et al. 2009

APPENDIX VI

Stata Output of Regression Estimations

Results of cross-section absolute convergence

```
. reg meanloggdp_9196 loggdp1991, r

Linear regression                                      Number of obs =      12
                                                          F(  1,    10) =    0.09
                                                          Prob > F      =  0.7644
                                                          R-squared     =  0.0079
                                                          Root MSE      =  .04741

------------------------------------------------------------------------------
             |               Robust
meanloggdp~6 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  loggdp1991 |   .0074453   .0241756     0.31   0.764    -.0464212    .0613118
       _cons |  -.1646655   .2074213    -0.79   0.446     -.626829    .2974979
------------------------------------------------------------------------------

. reg meanloggdp_9600 loggdp1996, r

Linear regression                                      Number of obs =      12
                                                          F(  1,    10) =    0.15
                                                          Prob > F      =  0.7111
                                                          R-squared     =  0.0088
                                                          Root MSE      =  .01945

------------------------------------------------------------------------------
             |               Robust
meanloggdp~0 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  loggdp1996 |   .0027865   .0073114     0.38   0.711    -.0135043    .0190773
       _cons |   .0112174   .0564171     0.20   0.846    -.1144876    .1369225
------------------------------------------------------------------------------

. reg meanloggdp_0004 loggdp2000, r

Linear regression                                      Number of obs =      12
                                                          F(  1,    10) =    0.09
                                                          Prob > F      =  0.7672
                                                          R-squared     =  0.0053
                                                          Root MSE      =  .02554

------------------------------------------------------------------------------
             |               Robust
meanloggdp~4 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  loggdp2000 |   .0027639    .009086     0.30   0.767    -.0174809    .0230087
       _cons |   .0450202   .0745825     0.60   0.560    -.1211599    .2112004
------------------------------------------------------------------------------

. reg meanloggdp_0408 loggdp2004, r

Linear regression                                      Number of obs =      12
                                                          F(  1,    10) =    0.99
                                                          Prob > F      =  0.3431
                                                          R-squared     =  0.0302
                                                          Root MSE      =   .0353

------------------------------------------------------------------------------
             |               Robust
meanloggdp~8 |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  loggdp2004 |   .0089752   .0090178     1.00   0.343    -.0111178    .0290682
       _cons |  -.0061825   .0753422    -0.08   0.936    -.1740553    .1616903
------------------------------------------------------------------------------
```

Results of cross-section conditional convergence

```
. reg meanloggdp_9196 loggdp1991 meanloginv_9196 meanlogconstant_9196, r

Linear regression                                      Number of obs =      12
                                                          F(  3,     8) =    1.38
                                                          Prob > F      =  0.3165
                                                          R-squared     =  0.2590
                                                          Root MSE      =  .04581
```

meanloggdp~6	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1991	-.004872	.0223638	-0.22	0.833	-.0564431	.046699
meanloginv~6	.0516836	.0273647	1.89	0.096	-.0114194	.1147866
meanlogcon~6	.0180735	.0397847	0.45	0.662	-.0736701	.1098171
_cons	-.2605373	.1720121	-1.51	0.168	-.6571979	.1361233

```
. reg meanloggdp_9600 loggdp1996 meanloginv_9600 meanlogconstant_9600, r

Linear regression                                      Number of obs =      12
                                                          F(  3,     8) =    1.65
                                                          Prob > F      =  0.2546
                                                          R-squared     =  0.3584
                                                          Root MSE      =   .0175
```

meanloggdp~0	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1996	.0086317	.009176	0.94	0.374	-.0125281	.0297915
meanloginv~0	.0120204	.0127169	0.95	0.372	-.0173048	.0413455
meanlogcon~0	.0587145	.0321103	1.83	0.105	-.0153319	.132761
_cons	-.2292759	.1357383	-1.69	0.130	-.542289	.0837372

```
. reg meanloggdp_0004 loggdp2000 meanloginv_0004 meanlogconstant_0004, r

Linear regression                                      Number of obs =      12
                                                          F(  3,     8) =    0.34
                                                          Prob > F      =  0.7970
                                                          R-squared     =  0.0828
                                                          Root MSE      =  .02742
```

meanloggdp~4	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp2000	-.0010714	.0100991	-0.11	0.918	-.02436	.0222172
meanloginv~4	.0238703	.0268443	0.89	0.400	-.0380329	.0857735
meanlogcon~4	.0000912	.0436955	0.00	0.998	-.1006709	.1008533
_cons	.0023509	.1333918	0.02	0.986	-.3052511	.3099528

```
. reg meanloggdp_0408 loggdp2004 meanloginv_0408 meanlogconstant_0408, r

Linear regression                                      Number of obs =      12
                                                          F(  3,     8) =    2.36
                                                          Prob > F      =  0.1475
                                                          R-squared     =  0.5401
                                                          Root MSE      =  .02718
```

meanloggdp~8	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp2004	-.0007162	.0133605	-0.05	0.959	-.0315256	.0300933
meanloginv~8	.1313015	.0649586	2.02	0.078	-.0184933	.2810963
meanlogcon~8	.1367584	.0813881	1.68	0.131	-.050923	.3244398
_cons	-.7263005	.3940448	-1.84	0.103	-1.634969	.1823683

Results of cross-section augmented conditional convergence (1991-1996)

```
. reg meanloggdp_9196 loggdp1991  meanloginv_9196 IC War, r

Linear regression                                      Number of obs =      12
                                                          F(  4,     7) =    1.59
                                                          Prob > F      =  0.2765
                                                          R-squared     =  0.4300
                                                          Root MSE      =  .04295
```

meanloggdp~6	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1991	-.0134855	.0248595	-0.54	0.604	-.0722688	.0452979
meanloginv~6	.0464358	.0368862	1.26	0.248	-.0407863	.1336579
IC	-.019294	.0176573	-1.09	0.311	-.0610469	.022459
War	-.0223554	.0366301	-0.61	0.561	-.1089717	.064261
_cons	-.0817134	.2227282	-0.37	0.725	-.608382	.4449552

```
. reg meanloggdp_9196 loggdp1991 meanloginv_9196 meanTPI_9196, r

Linear regression                                      Number of obs =      12
                                                          F(  3,     8) =    2.16
                                                          Prob > F      =  0.1701
                                                          R-squared     =  0.4739
                                                          Root MSE      =   .0386
```

meanloggdp~6	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1991	-.0060486	.0174691	-0.35	0.738	-.0463324	.0342351
meanloginv~6	.070256	.032825	2.14	0.065	-.0054385	.1459505
meanTPI_9196	.0759572	.0311734	2.44	0.041	.0040712	.1478432
_cons	-.3932457	.1908667	-2.06	0.073	-.8333851	.0468937

```
. reg meanloggdp_9196 loggdp1991  meanloginv_9196  meanTPI_9196 IC, r

Linear regression                                      Number of obs =      12
                                                          F(  4,     7) =    1.47
                                                          Prob > F      =  0.3083
                                                          R-squared     =  0.5005
                                                          Root MSE      =  .04021
```

meanloggdp~6	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1991	-.0114282	.0223228	-0.51	0.624	-.0642133	.0413569
meanloginv~6	.0717117	.0365402	1.96	0.090	-.0146921	.1581156
meanTPI_9196	.0589985	.0348533	1.69	0.134	-.0234165	.1414135
IC	-.0109991	.0176033	-0.62	0.552	-.0526243	.0306261
_cons	-.3006892	.2596521	-1.16	0.285	-.914669	.3132905

```
. reg meanloggdp_9196 loggdp1991 meanloginv_9196  IC meanfreedom_9196, r

Linear regression                                      Number of obs =      12
                                                          F(  4,     7) =    1.50
                                                          Prob > F      =  0.3004
                                                          R-squared     =  0.4227
                                                          Root MSE      =  .04322
```

meanloggdp~6	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1991	-.0173037	.0218407	-0.79	0.454	-.0689488	.0343414
meanloginv~6	.0703986	.0363928	1.93	0.094	-.0156568	.156454
IC	-.0128346	.0191853	-0.67	0.525	-.0582007	.0325315
meanfre~9196	-.0106303	.0171068	-0.62	0.554	-.0510815	.0298209
_cons	-.0907924	.1763335	-0.51	0.622	-.5077548	.3261701

Results of cross-section augmented conditional convergence (1996-2000)

```
. reg meanloggdp_9600 loggdp1996 meanloginv_9600 IC  meanTPI_9196, r

Linear regression                                      Number of obs =      12
                                                         F(  4,     7) =    1.05
                                                         Prob > F      =  0.4475
                                                         R-squared     =  0.2773
                                                         Root MSE      =  .01985
```

meanloggdp~0	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1996	.0086209	.0098781	0.87	0.412	-.0147371	.0319789
meanloginv~0	.0046416	.0158774	0.29	0.779	-.0329025	.0421856
IC	.0031724	.0102618	0.31	0.766	-.0210929	.0274378
meanTPI_9196	-.0235873	.025585	-0.92	0.387	-.0840863	.0369118
_cons	-.0140916	.0850421	-0.17	0.873	-.2151842	.187001

```
. reg meanloggdp_9600 loggdp1996 meanloginv_9600 War  meanTPI_9196, r

Linear regression                                      Number of obs =      12
                                                         F(  4,     7) =    2.24
                                                         Prob > F      =  0.1651
                                                         R-squared     =  0.5227
                                                         Root MSE      =  .01613
```

meanloggdp~0	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1996	.0126322	.0105656	1.20	0.271	-.0123515	.0376159
meanloginv~0	.0243311	.011848	2.05	0.079	-.0036851	.0523473
War	.0242682	.0093976	2.58	0.036	.0020465	.0464899
meanTPI_9196	-.0063834	.0216711	-0.29	0.777	-.0576275	.0448607
_cons	-.1361268	.070446	-1.93	0.095	-.3027052	.0304516

```
. reg meanloggdp_9600 loggdp1996 meanloginv_9600  corruption, r

Linear regression                                      Number of obs =      12
                                                         F(  3,     8) =    1.82
                                                         Prob > F      =  0.2210
                                                         R-squared     =  0.3691
                                                         Root MSE      =  .01735
```

meanloggdp~0	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp1996	.0054801	.0067753	0.81	0.442	-.0101439	.021104
meanloginv~0	.006138	.0167487	0.37	0.724	-.0324845	.0447605
corruption	-.0285263	.0142253	-2.01	0.080	-.0613299	.0042773
_cons	-.0559183	.0711823	-0.79	0.455	-.220065	.1082284

Results of cross-section augmented conditional convergence (2000-2008)

```
. reg meanloggdp_0004 loggdp2000  meanloginv_0004   meanTPI_9600   meanWGI_0004, r

Linear regression                                      Number of obs =      12
                                                         F(  4,     7) =    1.65
                                                         Prob > F      =  0.2633
                                                         R-squared     =  0.4520
                                                         Root MSE      =  .02266
```

meanloggdp~4	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp2000	-.0087547	.0112624	-0.78	0.462	-.0353861	.0178767
meanloginv~4	.0196003	.0168305	1.16	0.282	-.0201976	.0593982
meanTPI_9600	-.0514313	.029576	-1.74	0.126	-.1213675	.0185049
meanWGI_0004	.0757325	.0355896	2.13	0.071	-.0084237	.1598886
_cons	.2674021	.1372286	1.95	0.092	-.0570921	.5918963

```
. reg meanloggdp_0408 loggdp2004 meanloginv_0408  meanTPI_0004   meanTPI_0408, r
```

Linear regression

Number of obs =	12
F(4, 7) =	1.70
Prob > F =	0.2523
R-squared =	0.4111
Root MSE =	.03288

meanlogg~408	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp2004	-.0037721	.0149563	-0.25	0.808	-.039138	.0315939
meanlogi~408	.1000402	.0592711	1.69	0.135	-.0401136	.240194
meanTPI_0004	.0009621	.149225	0.01	0.995	-.351899	.3538232
meanTPI_0408	-.0140588	.1380679	-0.10	0.922	-.3405376	.31242
_cons	-.1855058	.1617474	-1.15	0.289	-.5679775	.196966

```
. reg meanloggdp_0408 loggdp2004 meanloginv_0408   meanTPI_0004 politstab, r
```

Linear regression

Number of obs =	12
F(4, 7) =	7.02
Prob > F =	0.0135
R-squared =	0.8004
Root MSE =	.01914

meanlogg~408	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp2004	.0158863	.005152	3.08	0.018	.0037037	.0280688
meanlogi~408	.1533431	.0416279	3.68	0.008	.0549088	.2517775
meanTPI_0004	-.0159562	.0072448	-2.20	0.064	-.0330875	.0011751
politstab	-.0638541	.0237795	-2.69	0.031	-.1200836	-.0076246
_cons	-.5626283	.1808779	-3.11	0.017	-.9903365	-.1349202

```
. reg meanloggdp_0408 loggdp2004 meanloginv_0408   meanprimaryexp_0408   logmeanremit_0408, r
```

Linear regression

Number of obs =	12
F(4, 7) =	3.38
Prob > F =	0.0769
R-squared =	0.7412
Root MSE =	.0218

meanlogg~408	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp2004	.0170713	.0144659	1.18	0.277	-.017135	.0512776
meanlogi~408	.1112276	.0332637	3.34	0.012	.0325715	.1898837
meanpri~0408	.0009744	.0003761	2.59	0.036	.0000852	.0018636
logmean~0408	.0149686	.0085264	1.76	0.123	-.0051932	.0351303
_cons	-.4917779	.1783178	-2.76	0.028	-.9134324	-.0701234

Results of panel data regressions by OLS (1991-2008)

```
. reg meangrowth loggdp_t1 meaninv meanconstant, r
```

Linear regression

Number of obs =	60
F(3, 56) =	5.99
Prob > F =	0.0013
R-squared =	0.2033
Root MSE =	.1093

meangrowth	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp_t1	-.0293117	.0184092	-1.59	0.117	-.0661897	.0075663
meaninv	.0711137	.0356921	1.99	0.051	-.0003862	.1426136
meanconstant	.0632027	.0198817	3.18	0.002	.0233748	.1030306
_cons	-.1556967	.1501546	-1.04	0.304	-.4564925	.1450991

```
. reg meangrowth loggdp_t1 meaninv IC, r

Linear regression                                      Number of obs =      60
                                                          F(  3,    56) =    1.96
                                                          Prob > F      =  0.1300
                                                          R-squared     =  0.0734
                                                          Root MSE      =  .11788

------------------------------------------------------------------------------
             |               Robust
  meangrowth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   loggdp_t1 |  -.0369886   .0237029    -1.56   0.124    -.0844712    .0104939
     meaninv |   .0960071   .0418817     2.29   0.026      .012108    .1799063
          IC |  -.0120164   .0209079    -0.57   0.568    -.0538999    .0298671
       _cons |   .0169132   .1958287     0.09   0.931    -.3753788    .4092052
------------------------------------------------------------------------------

. reg meangrowth loggdp_t1 meaninv IC  meanTPI, r

Linear regression                                      Number of obs =      60
                                                          F(  4,    55) =   11.77
                                                          Prob > F      =  0.0000
                                                          R-squared     =  0.4916
                                                          Root MSE      =   .0881

------------------------------------------------------------------------------
             |               Robust
  meangrowth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   loggdp_t1 |  -.0039817   .0172826    -0.23   0.819    -.0386168    .0306534
     meaninv |    .076821   .0328011     2.34   0.023     .0110862    .1425558
          IC |   .0230931   .0179146     1.29   0.203    -.0128085    .0589947
     meanTPI |   .1154444   .0184424     6.26   0.000     .0784849    .1524039
       _cons |  -.5136408   .1782897    -2.88   0.006    -.8709412   -.1563403
------------------------------------------------------------------------------

. reg meangrowth loggdp_t1 meaninv  meanTPI  ThresholdDummy, r

Linear regression                                      Number of obs =      60
                                                          F(  4,    55) =   21.22
                                                          Prob > F      =  0.0000
                                                          R-squared     =  0.5013
                                                          Root MSE      =  .08726

------------------------------------------------------------------------------
             |               Robust
  meangrowth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   loggdp_t1 |  -.0451371    .019845    -2.27   0.027    -.0849074   -.0053668
     meaninv |   .0792969   .0253494     3.13   0.003     .0284956    .1300981
     meanTPI |   .1064002   .0172874     6.15   0.000     .0717554    .1410449
ThresholdD~y |  -.0583864     .02886    -2.02   0.048    -.1162231   -.0005496
       _cons |  -.1038757   .2045668    -0.51   0.614    -.5138368    .3060854
------------------------------------------------------------------------------

. reg meangrowth loggdp_t1 meaninv  meanTPI  ThresholdDummy logmeanexports, r

Linear regression                                      Number of obs =      60
                                                          F(  5,    54) =   18.53
                                                          Prob > F      =  0.0000
                                                          R-squared     =  0.5618
                                                          Root MSE      =  .08255

------------------------------------------------------------------------------
             |               Robust
  meangrowth |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
   loggdp_t1 |  -.0458681   .0185929    -2.47   0.017    -.0831446   -.0085916
     meaninv |   .0682294   .0236285     2.89   0.006     .0208571    .1156017
     meanTPI |   .1172681   .0177711     6.60   0.000     .0816391    .1528971
ThresholdD~y |  -.0530654   .0283845    -1.87   0.067    -.1099729    .0038422
logmeanexp~s |   .0831745   .0289318     2.87   0.006     .0251697    .1411793
       _cons |  -.3984154   .2214823    -1.80   0.078    -.8424607    .0456298
------------------------------------------------------------------------------
```

```
. reg meangrowth loggdp_t1 meaninv  meanTPI  ThresholdDummy  logenergyproduce, r

Linear regression                                      Number of obs =      60
                                                       F(  5,    54) =   25.83
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.5439
                                                       Root MSE      =  .08422
```

meangrowth	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp_t1	-.0725189	.0253501	-2.86	0.006	-.1233428	-.0216951
meaninv	.0679956	.0231772	2.93	0.005	.021528	.1144632
meanTPI	.10618	.0157293	6.75	0.000	.0746446	.1377154
ThresholdD~y	-.0561825	.0254864	-2.20	0.032	-.1072797	-.0050853
logenergyp~e	.0119149	.0058286	2.04	0.046	.0002293	.0236005
_cons	.0421859	.2051584	0.21	0.838	-.369132	.4535038

```
. reg meangrowth loggdp_t1 meaninv  meanTPI  ThresholdDummy meanfreedom, r

Linear regression                                      Number of obs =      60
                                                       F(  5,    54) =   14.45
                                                       Prob > F      =  0.0000
                                                       R-squared     =  0.5731
                                                       Root MSE      =  .08148
```

meangrowth	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp_t1	-.0308748	.0186259	-1.66	0.103	-.0682176	.006468
meaninv	.0417169	.0244519	1.71	0.094	-.0073063	.0907401
meanTPI	.1122346	.0174931	6.42	0.000	.0771632	.1473061
ThresholdD~y	-.0636045	.0274009	-2.32	0.024	-.1185401	-.008669
meanfreedom	.0326767	.0121578	2.69	0.010	.0083018	.0570517
_cons	-.28403	.1966262	-1.44	0.154	-.6782419	.1101819

Results of panel data regressions by FE, Dif-GMM, Sys-GMM (1991-2008)

```
. xtreg meangrowth loggdp_t1 meaninv meanTPI logenergyproduce y93 y96 y00 y04, i(cc) fe

Fixed-effects (within) regression               Number of obs      =        60
Group variable: cc                                 Number of groups   =        12

R-sq:  within  = 0.8987                            Obs per group: min =         5
       between = 0.1808                                           avg =       5.0
       overall = 0.1390                                           max =         5

                                                   F(8,40)            =     44.35
corr(u_i, Xb)  = -0.9486                           Prob > F           =    0.0000
```

meangrowth	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp_t1	-.2355871	.0433571	-5.43	0.000	-.3232151	-.147959
meaninv	-.0046666	.0262284	-0.18	0.860	-.0576762	.0483429
meanTPI	.0586471	.0288056	2.04	0.048	.0004288	.1168653
logenergyp~e	.1587835	.0321114	4.94	0.000	.0938839	.223683
y93	-.1078317	.0455606	-2.37	0.023	-.1999131	-.0157504
y96	-.1547263	.0285745	-5.41	0.000	-.2124775	-.0969751
y00	-.1030026	.0277156	-3.72	0.001	-.159018	-.0469872
y04	-.0537144	.0228974	-2.35	0.024	-.0999916	-.0074371
_cons	.4115928	.3682282	1.12	0.270	-.3326242	1.15581
sigma_u	.34117792					
sigma_e	.04506528					
rho	.98285212	(fraction of variance due to u_i)				

```
F test that all u_i=0:     F(  11,  40) =     5.22              Prob > F = 0.0000
```

```
. xtreg meangrowth loggdp_t1 meaninv meanTPI logenergyproduce y93 y96 y00 y04, i(cc) robust fe

Fixed-effects (within) regression               Number of obs      =        60
Group variable: cc                                 Number of groups   =        12

R-sq:  within  = 0.8987                            Obs per group: min =         5
       between = 0.1808                                           avg =       5.0
       overall = 0.1390                                           max =         5

                                                   F(8,40)            =     36.76
corr(u_i, Xb)  = -0.9486                           Prob > F           =    0.0000

                                     (Std. Err. adjusted for clustering on cc)
```

meangrowth	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
loggdp_t1	-.2355871	.0469129	-5.02	0.000	-.3304015	-.1407726
meaninv	-.0046666	.0199552	-0.23	0.816	-.0449977	.0356644
meanTPI	.0586471	.0335948	1.75	0.089	-.0092505	.1265446
logenergyp~e	.1587835	.0356679	4.45	0.000	.0866959	.2308711
y93	-.1078317	.047023	-2.29	0.027	-.2028688	-.0127946
y96	-.1547263	.0265157	-5.84	0.000	-.2083166	-.101136
y00	-.1030026	.0250694	-4.11	0.000	-.1536698	-.0523354
y04	-.0537144	.0202476	-2.65	0.011	-.0946363	-.0127924
_cons	.4115928	.4066984	1.01	0.318	-.4103754	1.233561
sigma_u	.34117792					
sigma_e	.04506528					
rho	.98285212	(fraction of variance due to u_i)				

```
. xi: xtreg meangrowth loggdp_t1 meaninv meanTPI logenergyproduce y93 y96 y00 y04 i.cc
i.cc              _Icc_1-12          (naturally coded; _Icc_1 omitted)

Random-effects GLS regression                   Number of obs      =        60
Group variable: cc                                 Number of groups   =        12

R-sq:  within  = 0.8987                            Obs per group: min =         5
       between = 1.0000                                           avg =       5.0
       overall = 0.9033                                           max =         5

Random effects u_i ~ Gaussian                      Wald chi2(19)      =    373.49
corr(u_i, X)       = 0 (assumed)                   Prob > chi2        =    0.0000
```

meangrowth	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
loggdp_t1	-.2355871	.0433571	-5.43	0.000	-.3205655	-.1506086
meaninv	-.0046666	.0262284	-0.18	0.859	-.0560733	.04674
meanTPI	.0586471	.0288056	2.04	0.042	.0021892	.115105
logenergyp~e	.1587835	.0321114	4.94	0.000	.0958463	.2217207
y93	-.1078317	.0455606	-2.37	0.018	-.1971288	-.0185346
y96	-.1547263	.0285745	-5.41	0.000	-.2107313	-.0987214
y00	-.1030026	.0277156	-3.72	0.000	-.1573243	-.048681
y04	-.0537144	.0228974	-2.35	0.019	-.0985924	-.0088364
_Icc_2	-.494658	.1211187	-4.08	0.000	-.7320463	-.2572697
_Icc_3	-.0212316	.0725179	-0.29	0.770	-.1633641	.1209008
_Icc_4	-.183204	.0420023	-4.36	0.000	-.2655269	-.1008811
_Icc_5	-.5881431	.1583912	-3.71	0.000	-.8985842	-.2777021
_Icc_6	-.2819518	.0505289	-5.58	0.000	-.3809866	-.1829169
_Icc_7	.2316622	.0664383	3.49	0.000	.1014455	.3618788
_Icc_8	-.8892193	.2309468	-3.85	0.000	-1.341867	-.436572
_Icc_9	-.3089716	.0566284	-5.46	0.000	-.4199612	-.197982
_Icc_10	-.5836699	.1560293	-3.74	0.000	-.8894818	-.277858
_Icc_11	-.6459982	.159022	-4.06	0.000	-.9576756	-.3343208
_Icc_12	-.7696597	.1598874	-4.81	0.000	-1.083033	-.4562861
_cons	.7895133	.3303325	2.39	0.017	.1420735	1.436953
sigma_u	0					
sigma_e	.04506528					
rho	0	(fraction of variance due to u_i)				

```
. xtabond meangrowth L(0/1).logenergyproduce year, endogenous(loggdp_t1 meaninv meanTPI, lagstruct(0,2)) vce
> (gmm) artests(2)

Arellano-Bond dynamic panel-data estimation  Number of obs         =        36
Group variable: cc                           Number of groups      =        12
Time variable: year
                                             Obs per group:    min =         3
                                                               avg =         3
                                                               max =         3

Number of instruments =     25               Wald chi2(7)          =    243.72
                                             Prob > chi2           =    0.0000
One-step results
------------------------------------------------------------------------------
  meangrowth |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  meangrowth |
         L1. |  -.1327094   .1116068    -1.19   0.234    -.3514548     .086036
   loggdp_t1 |  -.0975892   .0578059    -1.69   0.091    -.2108868    .0157083
     meaninv |  -.0621081   .0459714    -1.35   0.177    -.1522104    .0279942
     meanTPI |    .204028    .069144     2.95   0.003     .0685082    .3395478
logenergyp~e |
         --. |   .1213162   .0579835     2.09   0.036     .0076707    .2349617
         L1. |  -.0872115   .0366306    -2.38   0.017    -.1590061   -.0154169
        year |   .0263834   .0153028     1.72   0.085    -.0036095    .0563763
       _cons |   .0899852   .4749435     0.19   0.850    -.8408869    1.020857
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).meangrowth L(2/3).loggdp_t1 L(2/3).meaninv L(2/3).meanTPI
        Standard: D.logenergyproduce LD.logenergyproduce D.year
Instruments for level equation
        Standard: _cons
. estat abond
artests not computed for one-step system estimator with     vce(gmm)

Arellano-Bond test for zero autocorrelation in first-differenced errors
  +-----------------------+
  |Order |  z     Prob > z|
  |------+----------------|
  |   1  |-2.0906  0.0366 |
  |   2  | 1.2421  0.2142 |
  +-----------------------+
   H0: no autocorrelation

. estat sargan
Sargan test of overidentifying restrictions
        H0: overidentifying restrictions are valid

        chi2(17)     =  6.597329
        Prob > chi2  =    0.9882

. xtdpdsys meangrowth L(0/1).logenergyproduce year, endogenous(loggdp_t1 meaninv meanTPI, lagstruct(0,2)) vc
> e(gmm) artests(2)

System dynamic panel-data estimation         Number of obs         =        48
Group variable: cc                           Number of groups      =        12
Time variable: year
                                             Obs per group:    min =         4
                                                               avg =         4
                                                               max =         4

Number of instruments =     37               Wald chi2(7)          =    636.86
                                             Prob > chi2           =    0.0000
One-step results
------------------------------------------------------------------------------
  meangrowth |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
  meangrowth |
         L1. |  -.0268531   .0636055    -0.42   0.673    -.1515175    .0978113
   loggdp_t1 |  -.1378903   .0151453    -9.10   0.000    -.1675746   -.1082061
     meaninv |   .0214971   .0192225     1.12   0.263    -.0161784    .0591726
     meanTPI |   .0573388   .0111127     5.16   0.000     .0355583    .0791194
logenergyp~e |
         --. |   .1356004   .0239304     5.67   0.000     .0886977    .1825031
         L1. |   -.104854   .0237522    -4.41   0.000    -.1514075   -.0583005
        year |   .0497378   .0062999     7.89   0.000     .0373902    .0620854
       _cons |   .4603964    .109642     4.20   0.000      .245502    .6752908
------------------------------------------------------------------------------
Instruments for differenced equation
        GMM-type: L(2/.).meangrowth L(2/3).loggdp_t1 L(2/3).meaninv L(2/3).meanTPI
        Standard: D.logenergyproduce LD.logenergyproduce D.year
Instruments for level equation
        GMM-type: LD.meangrowth LD.loggdp_t1 LD.meaninv LD.meanTPI
        Standard: _cons
```

```
. estat abond
artests not computed for one-step system estimator with    vce(gmm)

Arellano-Bond test for zero autocorrelation in first-differenced errors
```

Order	z	Prob > z
1	-1.1548	0.2482
2	.60673	0.5440

```
   H0: no autocorrelation

. estat sargan
Sargan test of overidentifying restrictions
        H0: overidentifying restrictions are valid

        chi2( 29)     =  38.07968
        Prob > chi2  =     0.1206
```