ECONOMIC GROWTH AND CONVERGENCE IN THE EUROPEAN FORMER SOVIET UNION

Robert Rountree

May 2012

Abstract

This paper investigates the growth and income convergence of countries in Eastern Europe and the Former Soviet Union with developed OECD countries, using data collected from the dissolution of the Soviet Union in 1991 to the present. Based on panel estimation and the presented empirical research, it supports conditional output convergence, as described in Solow (1956), of the European Former Soviet Union. Evidence is strongest in years after 1998, as many Former Soviet states experienced recessions in the early 1990's due to transition. Investment shows strong correlations with growth, and diminishing productivity of capital as predicted in Solow (1956) is observed.

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I. INTRODUCTION

Many countries in Eastern Europe, former Soviet republics in particular, went through deep recessions following the break-up of the Soviet Union in the early 1990's. Capital and labor had to be reallocated from the public to the private sector, and many economies were slow to adjust to the dramatic shift. Additionally, most countries did not have the institutional framework set up to efficiently support a market economy. Some countries did not report positive economic growth until 1999. However, since then Eastern Europe has experienced greater average rates of economic growth than developed western economies. This opens up the possibility that these lower-income countries are now experiencing greater returns to capital and labor as predicted by Solow (1956) and may be on a course for convergence with developed economies.

The theory of convergence stems from Solow (1956), who predicted that because of diminishing returns to capital, economies could only grow so much by increasing capital stock more quickly than the labor force. Furthermore, economies that had less capital per worker would experience greater returns, and thus greater economic growth, from investment in capital. Research to date on convergence in Eastern Europe has found some evidence for convergence, but has been inconclusive on the whole. Vamvakidis (2009) finds evidence of convergence in emerging Eastern Europe, while Kuboniwa (2011) finds evidence of convergence only during the "favorable period" from 1999 to 2008. Kuboniwa (2011) designates this favorable period by noting that economies in the Former Soviet Union (FSU) faltered in the early years of transition and were hit hard by the Russian financial crisis in 1998. Thereafter the FSU and Eastern Europe as a whole experienced very strong economic growth until the global financial crisis of 2008, when they again dipped into recession.

The potential consequences of the economic convergence of Eastern Europe are far-reaching. Russia has received acknowledgement as one the BRIC countries – a group of large nations whose quickly-growing economies are changing the global scene. The European Union is looking to expand, and many Eastern European candidate nations are being judged heavily on their economic performance. If Eastern Europe is converging in economic status with developed nations, it will have a significant effect on global economic and political interactions.

This paper will compare growth across regions to determine whether Eastern Europe and the FSU are converging with developed nations. Growth can be analyzed through the use of empirical evidence and available economic data, creating linear growth models based on the Solow Growth model as in Solow (1956), and augmented Solow model as in Mankiw, Romer, and Weil (1992). In addition to the factors accounted for in these models, this paper will also study the effects of macroeconomic policies, foreign capital flows, and demographic structure on growth. Convergence will be tested by using panel estimation incorporating the FSU[1], non-FSU Eastern European countries[2], and adjusted OECD countries[3]. Initial GDP in each country, set to their real GDP per capita adjusted for Purchasing Power Parity (PPP) in 1991, will be used to test for convergence. Dummy variables for both the FSU and for Eastern Europe will be used as alternative measures of convergence, testing growth patterns in these regions specifically. This paper expects that formerly Soviet countries will experience conditional convergence consistent with Solow (1956).

The paper will be subdivided into the following sections: Literature Review, Data and Methodology, Results, and Conclusions. Literature Review will discuss what results are

[1] FSU countries include: Belarus, Estonia, Latvia, Lithuania, Moldova, Russia, Ukraine

[2] Eastern Europe includes non-FSU Eastern European high-income OECD members: Czech Republic, Hungary, Poland, Slovak Republic, Slovenia.

[3] Adjusted OECD includes 25 countries: all high-income OECD members minus Estonia and the 'Eastern Europe' countries.

expected drawing from earlier research on growth, convergence, and transition economies. Data and Methodology is used to familiarize the reader with statistical data used in the paper and the models that the data illustrate. The Results section analyzes the data gathered by applying the model and discusses the extent to which convergence is indicated. Conclusions will address the implications of the results and their significance as an addition to earlier research.

II. LITERATURE REVIEW

Works that discuss convergence both in the transition economies and in other parts of the world often tend to focus on growth and its causes. Quah (2001) defines economic growth as a sustained increase in welfare combined with changes in the industrial structure and distribution of income. Convergence is the extent to which poor economies will catch up to rich ones, and can be measured simply by observing whether the growth rate in a poor country is higher than that in a rich country. The Solow (1956) growth model implies that given similar savings rates, poor countries will tend to grow faster than rich countries.

Solow (1956) starts by defining *Y*, output, and using the savings-investment identity to show that changes to the capital stock *K* are equal to investment, or the savings rate times output. Output is a function of capital and labor:

$$Y = F(K,L).$$

Solow (1956) goes on to show that given diminishing marginal productivity of capital, as in the Cobb-Douglas function, the ratio of capital to labor, $r = K/L$, would increase to a point r^*, after which capital and labor would grow in proportion. This point r^* is called the steady state. Assuming diminishing returns to capital and noting that the output function is dependent upon

positive amounts of K and L, Solow (1956) shows that an economy cannot maintain per-capita economic growth indefinitely by increasing K faster than L.

Also, because of diminishing marginal productivity of capital, economies with a lower capital-labor ratio, r, will experience greater returns to capital than economies with a higher r. Thus with similar savings rates, these economies are expected to achieve higher economic growth per capita (Solow, 1956). Economies that have invested in capital beyond the steady-state ratio r^* are expected to experience negative returns to capital. Thus relaxing the assumption of constant gains to productivity, Solow (1956) predicts that the majority of economic growth, particularly for economies close to r^*, comes from increases in technology and productivity, represented in the model by a constant $A(t)$:

$$Y = A(t)F(K,L).$$

Economic growth, as discussed in this paper, refers specifically to the growth of real GDP per capita in terms of Purchasing Power Parity (PPP). PPP is a measurement typically used to adjust for the differences between countries' levels of purchasing power not captured by exchange rates, and was developed to a large extent in Summers and Heston (1991). However, Quah (2001) shows that even after adjustment for PPP, convergence is not always observed. The 90:10 ratio is a measurement used to show the disparity within a data set by expressing the value of the 90^{th} percentile as a ratio of the 10^{th} percentile. From the early 1960's to the late 1980's the global 90:10 ratio had doubled from 12 to 24. In this case the ratio represents the income, measured by GDP per capita adjusted for PPP, of the 90^{th} percentile of all nations expressed as a ratio of the income of the 10^{th} percentile, acting as a proxy for income inequality. Thus from the early 1960's to late 1980's very rich countries typically grew more quickly than very poor countries. This type of observation is overcome in empirical studies by controlling for the

appropriate variables including investment and education, a practice that is typical in research analyzing growth (Quah 2001).

Education is a form of human capital not accounted for by Solow (1956), but it became an integral part of the augmented Solow model proposed by Makiw, Romer, and Weil (1992). Mankiw et al. (1992) adds human capital stock to the traditional Solow production function by adding an additional term, *H*. It is assumed that human capital depreciates at the same rate as physical capital and also experiences decreasing marginal productivity. The amount of working age-population enrolled in secondary school is used as a proxy to measure human capital.

Peters (2001) builds on Mankiw et al. (1992) by recognizing the dual aspects of human capital as both education and health. In Peters (2001), life expectancy is used as a proxy for health. The results of Peters (2001) and Mankiw et al. (1992) support the explanatory power of the Solow model when variables accounting for human capital accumulation are added. Peters (2001) additionally clarifies the predictions resulting from Solow (1956) by stressing that it predicts conditional convergence. This means that economies will converge after the determinants of the steady state including physical and human capital, labor, and technological progress have been accounted for. Unconditional convergence is defined as convergence irrespective of the determinants of steady state, and is not predicted by Solow (1956).

Literature focusing on the convergence and economic development of the FSU recognizes both a period of recession immediately following the breakup of the Soviet Union, as well as a period of strong growth across the region in the following years. The length of recessions experienced by former Soviet countries varied greatly, with some countries experiencing economic growth as early as 1994 and others not seeing sustained economic growth until 1999 (Kolodko, 1999).

Some research has supported the notion that extensive and expeditious privatization had negative effects on the economy initially, prolonging and deepening the transition recession (Hamm, Stuckler, and King, 2010). These researchers theorize that a gradual transition, including gradual institutional changes, is necessary to have the desired effects on output growth (Kolodko, 1999). Balcerowicz (2005), on the other hand, argued that economies with more extensive and immediate economic reforms experienced more favorable outcomes on average. He favored introducing liberalization policies rapidly, and found delaying or implementing them gradually to be "almost hopeless."

Research shows that political reforms may have little marginal effect on growth. Fidrmuc (2003) argues that introducing democracy early in the transition period may have negative results, with political consequences potentially leading to the government not enacting important economic reforms, or enacting inefficient policies. The introduction of democracy in FSU states had little initial effect, and in the later transition period (late 1990s) had had a positive and significant effect, because of correlated changes in economic liberalization. Fidrmurc (2003) concludes that democracy does not stimulate economic growth on its own, but warns autocratic countries such as Russia and Belarus that democratization facilitates economic liberalization, and as a result is often correlated with higher growth.

There is strong evidence for high growth and even convergence of Eastern Europe and the FSU with developed economies in the period from 1999 to 2008 (Ericson, 2009; Libman and Vinokurov, 2010). According to Vamavakidis (2009), emerging Europe (including states outside of the FSU) grew by an average 5.9% from 2001 to 2007. Yegorov (2007) notes that this number is actually misleading, as during this time the exchange rates of the countries were also changing substantially, leading to much higher growth of real GDP in terms of PPP than the

numbers for real GDP indicate. After the 1998 Russian crisis, when resource prices plummeted and Russia defaulted on sovereign debt (Chiodo and Owyang, 2002), Russia experienced a period of reforms and recovery, leading to high economic growth until 2008 (Ericson, 2009). Belarus experienced declines in industrial production until 1995, after which it began to show strong growth (Zheltkov, 2005). Osipian (2008) notes impressive sustained economic growth in the Ukraine in the early 2000's, with rapidly increasing national income per capita.

Total Factor Productivity (TFP) is defined as the output not accounted for by inputs of production (capital and labor). This translates to how "efficiently and intensely" those inputs of capital and labor are used (Comin, 2006). Kuboniwa (2011) uses the Solow model and Cobb-Douglas production function to measure Russian economic growth from 1995 to 2010. He determines that TFP growth was the leading cause of economic growth, followed by capital investment. These findings are consistent with Solow (1957), which suggested that up to seven-eighths of productivity growth in the US from 1909-1949 was due to TFP growth. Kuboniwa (2011) uses the following two variations of a production function with constant technology change:

$$Y = A\exp(\lambda t)\, K^{\alpha} L^{(1-\alpha)} \qquad \text{And:} \qquad \log y = \alpha \log k + \lambda t + \log A$$

where Y = real GDP, A = a constant, K and L = capital and labor, λ = the TFP, and α = the elasticity of GDP with respect to capital (Kuboniwa, 2011). Estimation of capital stock, K, can be especially difficult because FSU economies have little reliable data available from before 1991, and their capital stock tends to be outdated. In Kuboniwa (2011) capital stock is accounted for by taking the real capital stock of the previous period, factoring in losses due to depreciation, and adding the real investment of the period.

Vamvakidis (2009) uses a similar methodology to measure growth and convergence in emerging Europe from 2003-2007, and finds evidence of unconditional convergence - that income levels are converging irrespective of countries' characteristics (Ickes, 2008). Vamvakidis (2009) uses a Solow model with labor, capital, and constant returns to scale, where Y is real GDP, A is TFP, and K and L are capital and labor:

$$Y(t) = A(t)\, F\,[K(t), L(t)]$$

In contrast to Kuboniwa (2011), Vamvakidis (2009) argues that capital stock cannot be calculated using investment information because it may be unreliable given the lack of information before the 1990's. He makes an assumption that in developing Europe the ratio of capital to GDP is somewhere between low- and middle-income countries. This measure may be more reliable than relying on the small available amounts of investment data. His analysis finds the same results as Kuboniwa (2011): that TFP is the greatest contributor to growth, followed by capital.

Vamvakidis (2009) finds that based on fundamentals, emerging European economies including all of Eastern Europe and the European FSU have high potential growth rates and positive indications of convergence. However many of these economies have been growing faster than their potential growth rates, suggesting either overheating or at least a future slowdown in growth. Vamvakidis (2009) finds that further structural reforms could increase the potential growth rates of these economies even more. He concludes that in the future emerging Europe is expected to continue to grow quickly and converge with developed nations, albeit at a slower pace in the absence of further economic reforms.

Global shocks due to business cycle fluctuations in the world economy can have significant consequences in the data. In order to isolate economic shocks experienced in Russia,

Kuboniwa (2011) splits his study into two pieces: the overall period from 1995-2010, and the favorable period from 1998-2008, in which there was relatively constant positive economic growth. He argues that the Russian default of 1998 and the Great Recession in 2008 were isolated incidences and should be omitted from the convergence data.

Zheltkov (2005) debates whether the growth in Belarus from 1996-2003 was simply "recovery growth" due to the productive factors being reemployed after the transition recession, and therefore it is reasonable to expect weakened growth in the future. Vamvakidis (2009) also predicts slower growth (and slower convergence) in the future, based on empirical evidence. If some of the growth from 1998-2008 was indeed recovery growth, implying that transition from a command to a market economy is still underway, it is reasonable to assume that convergence will slow, absent further economic liberalization in the future (Vamvakidis, 2009).

Evidence from Iradian (2007) supports the idea of recovery growth. He finds that transition countries that experienced larger economic declines in the early 1990's tended to grow at faster rates, but does not address the possibility that they may simply be experiencing greater returns to capital investment. He also notes that the high growth many transition states experienced in the early 2000's was enhanced by external conditions including global technological innovation and high commodity prices. As these developing economies converge towards developed economies, cheap labor, borrowable ideas, and productivity improvements will become ever-harder to come by, and growth rates may slow.

III. DATA AND METHODOLOGY

Data for my analysis is obtained from the World Bank's databank, specifically the "World Development Indicators" and "Global Development Finance" databases. I use data starting with the dissolution of the Soviet Union in 1991, up through 2011. For many countries data for 2011, and in rare cases for 2010, was not yet available as of March 2012 – for this reason the period examined is effectively only through 2010. There are three groups used: the FSU, developed OECD countries, and Eastern Europe. The FSU includes seven formerly Soviet countries located in Europe – Estonia, Latvia, Lithuania, Belarus, Moldova, Ukraine, and the Russian Federation. Eastern Europe includes five Eastern European OECD countries defined by the World Bank as "high income," a term referring to countries with GDP per capita over $12,276. These countries exhibited significantly lower initial (1991) per capita income than other OECD countries, and are transition economies along with the FSU. They are the Czech Republic, Hungary, Poland, the Slovak Republic, and Slovenia. The OECD sample includes 25 of the 31 OECD countries that are defined by the World Bank as high-income. The six countries excluded from the 31-nation high-income OECD group are the five countries included in the Eastern Europe group as well as Estonia, which is included in the FSU group.

I use a time-series panel regression approach, starting with a simple Solow model exhibiting constant technology change:

(1) $$Y = A(t)F(K,L)$$

where Y is GDP, A is technology change, and K and L are capital and labor respectively (Solow, 1956). Next, I follow the augmented Solow model as presented in Mankiw, Romer, and Weil (1992) in recognizing that A can be combined with L to form a unit of effective labor, $A(t)L(t)$, which grows at rate $n+g$:

(2) $$L(t) = L(0)e^{nt}$$

(3) $$A(t) = A(0)e^{gt}$$

where n is population growth rate and g is the rate of technological change. I use the following equation to express changes in capital (Mankiw et al., 1992):

(4) $$\Delta K = s_k Y(t) - \delta K(t)$$

where s is the savings rate and δ represents the depreciation rate of capital. Because investment equals savings in a closed economy as assumed by Solow (1956), I can express investment in capital as equal to the savings rate multiplied by annual income, so that net changes in capital are equal to investment minus depreciation. The constants δ and g in equations (3) and (4) are assumed to be constant across countries.

Next, I again follow the examples of Mankiw, Romer, and Weil (1992) by adding human capital accumulation to the Solow model. It is now represented by:

(5) $$Y(t) = F(K(t),H(t),A(t)L(t))$$

where H represents human capital accumulation, which is accumulated at rate s_h. I can now define y as $y=Y/L$, or income (alternatively output) per capita. Thus we can express $y(t)$ by a new function f:

(6) $$y(t) = f(K(t),H(t),A(t)L(t)).$$

Solow (1956) and Mankiw et al. (1992) predict that a typical production function with decreasing marginal productivity will lead economies with given inputs to converge to a steady state. Any changes to K, H, A or L will change the steady state of the economy and in doing so will cause a resulting shift in y. Generally positive correlations with y are expected for K, H, and A, while a negative correlation is expected for L. Levels of physical and human capital and technology are expected to improve productive effectiveness and capacity, increasing GDP per

capita. Increases in the labor force are expected to spread the available resources over a greater number of individuals, reducing GDP per capita (Mankiw et al. 1992).

We use the factors observed in equation (6) to account for most of the variables affecting our model. We start by defining our dependent variable, output growth, $\Delta\%y$:

(7) $\Delta\%y = \ln(y(t)) - \ln(y(t\text{-}1))$, expressed in my paper as: ygrowthrate

To clarify, the annual percentage change in GDP per capita adjusted for PPP (at constant 2005 international dollars) is measured by the one-year difference in the natural log of real GDP per capita adjusted for PPP at constant 2005 international dollars.[4]

Change in physical capital, investment, is measured using gross fixed capital formation[5] in constant 2000 dollars. This does not take depreciation rate, δ, into account, but because our primary area of concern is cross-country comparisons we may assume differences in δ to be insignificant. Solow (1956) argues that unless growth is due to changes in technology or productivity, it is a function of the existing capital-labor ratio r and the change in capital per change in labor, $\Delta K/\Delta L = I/n = \dot{r}$. Thus absent changes to productivity or technology, changes to the growth rate of output will be caused by changes to investment I. Because gross fixed capital formation measures total investment, this can be expressed as the annual difference in the natural log of gross fixed capital formation:

(8) $\Delta\%I = \ln(I(t)) - \ln(I(t\text{-}1))$ or: logI D1.

The annual percentage change in investment will have a positive impact on the output growth rate, $\Delta\%y$.

[4] Throughout the rest of the paper, GDP per capita in constant 2005 international dollars adjusted for PPP will simply be called GDP per capita, with the assumption that it is real GDP adjusted for PPP being discussed unless otherwise noted.

[5] Gross fixed capital formation is the sum of all capital investment in a country, measured using constant 2000 international dollars.

Changes to the labor force L are determined exclusively by the labor force growth rate. Annual growth of the labor force, n, is estimated by the one-year difference in the natural log of the total labor force:

(9) $$n = \ln(L(t)) - \ln(L(t\text{-}1)) \quad \text{or:} \quad \text{logL D1.}$$

Following the example of Peters (2001), I recognize the dual aspects of human capital as health and education. We account for these using two indicators: years of secondary schooling for education, and life expectancy at birth for health. Human capital is similar to physical capital in that it can be expressed with a savings (investment) rate and depreciation, as in Peters (2001):

(10) $$\Delta H = s_h Y(t) - \delta H(t).$$

However, I prefer instead to specify it as a function of health, q, and education, e:

(11) $$\Delta H = F(q,e).$$

Thus differences in investment in human capital across countries can be estimated using the indicators life expectancy and secondary schooling as proxies for health and education respectively. This data may be used to show the affects investment in human capital has on national income per capita growth rates.

Next I expand on the augmented Solow model as presented in Mankiw et al. (1992) and define several other variables that will affect growth across countries. First among these is the age-dependency ratio, measured using the total number of age-dependents (defined as people under 15 years old and above 64 years old) as a percentage of the total population. Countries with higher age-dependency ratios are expected to grow more slowly than countries with a larger portion of their population of the working age, because there is a lack of productive individuals. However, some evidence shows that in the short run higher age-dependency ratios could have an

ambiguous effect on growth, as more productive jobs are made available to those entering the labor force, and age-dependents will still engage in consumption (Herzog, 2012).

Drawing on Peters (2001), I determine that macroeconomic stability is crucial to economic growth, as expectations play a large role in consumer behavior. Inflation can be used as a proxy for macroeconomic stability. Excess inflation can have substantial negative effects on economies by eroding purchasing power and consumer confidence, creating uncertainty. Annual percentage inflation is included in my analysis, measured by the GDP deflator, which shows the rate of price changes in each economy.

Peters (2001) also notes the importance of economic openness. As a proxy to estimate differences in openness across countries, I include the net inflows of foreign direct investment (FDI) as a percentage of GDP. Though the annual sum of FDI is included as a part of gross fixed capital formation, gross fixed capital formation focuses on total investment while FDI focuses only on foreign investment, serving as a useful proxy to determine the effects of innovations and investment that stem from economic openness.

Finally, the last and most important variables to my analysis address potential convergence – they are initial GDP, an FSU dummy, and an Eastern Europe dummy. Initial GDP is measured as the real GDP per capita adjusted for PPP of a specific country in 1991. That same value is used in all subsequent years for each country, so at any given time t a specific country's initial GDP will be equal to y (t=1991). This variable is particularly important to convergence – if on average a country's GDP growth rate is uncorrelated with its initial GDP, then this coefficient will be equal to zero. A negative coefficient implies that initially poorer countries experience higher rates of growth, and this would be consistent with conditional convergence as predicted by Solow (1956). A positive coefficient would imply that initially

richer countries experience higher growth rates than initially poorer countries, and would be evidence of divergence (Peters, 2001).

Alternatively, convergence can also be measured for the former Soviet countries and other Eastern European countries using dummy variables. As opposed to the initial GDP measurement described above, this will determine only whether being a former Soviet or Eastern European country has a correlation with growth. Countries are given a value of either zero or one depending on what group they are in. FSU countries will receive an FSU dummy value of 1, and other countries will receive a 0. Once the regressions are run, positive and statistically coefficients will imply that FSU or Eastern European countries experience faster rates of growth on average than countries in the OECD group. This would support the hypothesis that these countries are converging with developed countries, and because these countries also tend to start out with lower GDP per capita, it would be consistent with conditional convergence as described in augmented Solow.

The following table provides a summary of the variables and groups analyzed in the Results section. Note that human capital indicators are excluded – this will be explained in Results.

Table 1. Descriptive Statistics

Summary Statistics								
Variable:	Mean	Std. dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
	OECD				**OECD without Korea**			
ygrowthrate	0.016784	0.025518	-0.09202	0.098802	0.01576	0.024529	-0.09202	0.098802
logK D1.	0.020479	0.082	-0.71484	0.295986	0.02005	0.08205	-0.71484	0.295986
logL D1.	0.011149	0.01295	-0.041	0.053923	0.01108	0.01304	-0.041	0.053923
Agedependencyratio	49.9118	4.313	38.076	66.184	50.3267	3.8745	43.08449	66.184
FDI	13.16129	58.83194	-15.0277	564.916	13.6868	59.9977	-15.0276	564.916
InflationGDPdeflator	2.761077	2.8733	-6.3815	20.6117	2.6954	2.8618	-6.3815	20.6117
InitialGDP	24577.61	6545.554	12337.01[6]	45758.1	25088.7	6173.008	16910	45758.1
	FSU				**FSU after 1998**			
ygrowthrate	0.01159[7]	0.101636	-0.37607[8]	0.121807	0.0475	0.062388	-0.19292	0.1218
logK D1.	0.006105	0.212244	-0.7032	0.4787	0.048577	0.17948	-0.70319	0.27704
logL D1.	-0.006953	0.01627	-0.04483	0.041203	-0.00143	0.01636	-0.0447	0.0412
Agedependencyratio	47.7959	4.3342	38.537	56.899	45.59922	3.6477	38.537	53.02927
FDI	3.675	3.316	0.041122	21.1529	4.4974	3.4494	0.34232	21.1225
InflationGDPdeflator	161.9887	431.8993	-3.70578	3334.798	18.62	39.3763	-3.7057	316.7933
InitialGDP	8504.981	2715.739	3839.38	11961.63	8504.981	2715.739	3839.38	11961.63
	EEUR							
ygrowthrate	0.02935	0.03329	-0.0925	0.09869				
logK D1.	0.03971	0.08939	-0.26551	0.2632				
logL D1.	0.002314	0.018018	-0.03861	0.1192				
Agedependencyratio	45.1762	4.0381	37.376	54.7274				
FDI	4.3864	8.2824	-32.643	52.0515				
InflationGDPdeflator	13.1142	24.1122	-1.1785	208.175				
InitialGDP	11891.45	2702.731	7581.136	14980.69				

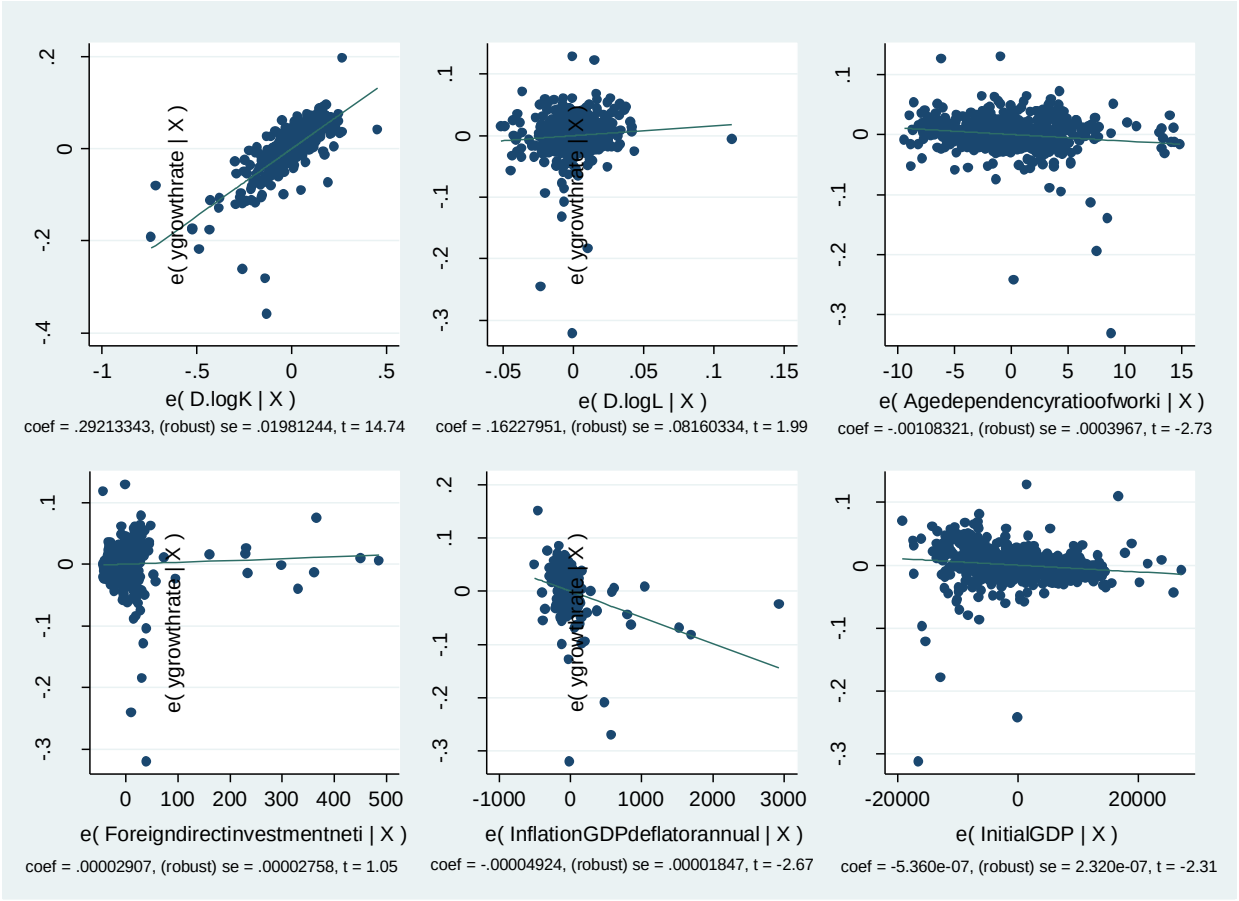
The presence of Korea, which has an initial GDP roughly equal to the Eastern European average, noticeably distorts the OECD sample. By omitting Korea, I obtain a sample that is

[6] The OECD minimum GDP of $12,337 represents the Republic of Korea.
[7] The FSU mean growth rate of 1.1% is much smaller than the post-1998 mean growth rate.
[8] The FSU minimum growth rate of -37.6% occurs between 1991-1997.

more representative of developed countries, with both a noticeably higher mean initial GDP and lower mean growth rate. Note that both OECD samples show a greater mean growth rate than the unadjusted FSU sample. However, when the transition period 1991-1997 is removed from the FSU sample, the mean FSU growth rate is much higher, and more than twice the OECD growth rate. The mean growth rate of the Eastern Europe sample is also higher than that of the OECD sample. Mean initial GDP is shown to be the lowest in the FSU, followed by Eastern Europe and then the OECD sample.

The following plots show data from my analysis, demonstrating each variable's correlation with the GDP growth rate (y-axis). Most of these correlations are consistent with theory. There is a strong positive correlation between changes to investment and the GDP growth rate, and a strong negative correlation between inflation and the GDP growth rate. There are weaker correlations with the expected signs for initial GDP, age-dependency ratio, and foreign direct investment. However, changes to the labor force show an unexpected positive correlation with GDP growth rate. This will be examined further in the Results section.

Graph Set A. Scatter Plots, 1991-2010



IV. RESULTS

Table 1 provides the first two regressions, isolating the effect of human capital on growth in the sample and using initial (1991) GDP to measure convergence.

Table 2. Convergence and Human capital

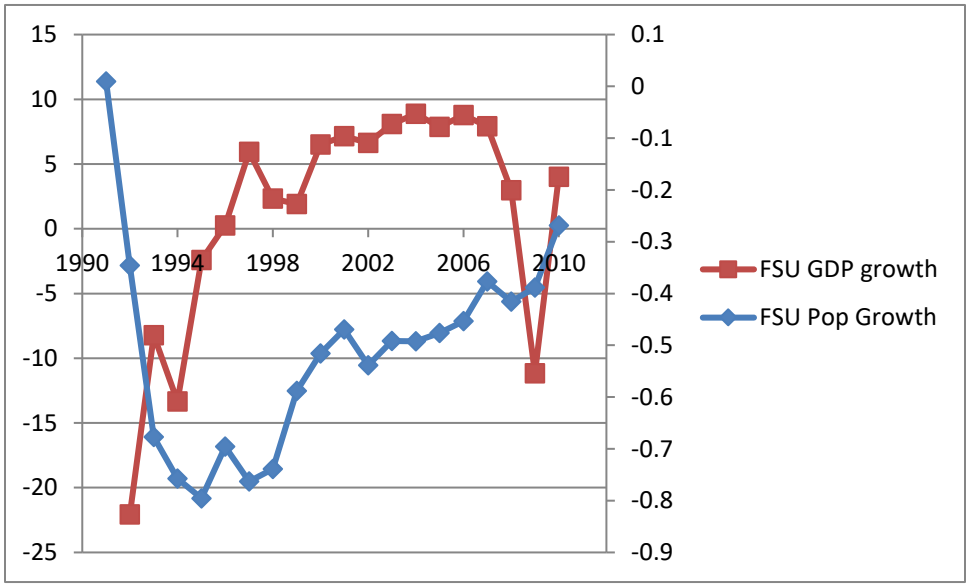
Dependent variable: ygrowthrate		
Explanatory variables	(1)	(2)
logI D1.	0.2732**	0.290663**
	(28.72)	(28.33)
logL D1.	0.1011424	0.1621013**
	(1.25)	(1.98)
logLIFE D1.	-0.1271637	…
	(-0.44)	…
Agedependencyratio	0.0002296	-0.0012333**
	(-0.78)	(-3.8)
Foreigndirectinvestment	0.0000634**	0.0000254
	(2.88)	(0.89)
InflationGDPratio	-0.0000778**	-0.0000504**
	(-3.88)	(-8.07)
SecondaryEduyears	0.0017068	…
	(1.34)	…
InitialGDP	-1.16E-06**	-5.21E-07**
	(-6.89)	(-2.68)
CONSTANT	0.0382023**	0.082946**
	(2.19)	(5.45)
R^2	0.7237	0.6719
#obs	472	650
#groups	37	37

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Model 1 shows that change in gross fixed capital formation (logI D1.) has a large and highly significant coefficient, implying that changes to investment are highly correlated with changes in GDP growth. Change to the labor force (logL D1.) is expected to have a negative correlation with GDP per capita, but here is insignificant. It is possible that there are not

sufficient cross-country differences in growth rates in order to explain this variable, as most of these countries have relatively stable populations. Another explanation is that the variable may be skewed by FSU and Eastern European economies experiencing population declines due to emigration while concurrently experiencing very large decreases in GDP per capita (Graph 1).

Graph 1. FSU average GDP growth rate vs. population growth, 1991-2010



The left axis is the growth rate of real GDP per capita adjusted for PPP and the right axis is the annual population growth rate. As the graph shows, the largest declines in population were during early transition and were accompanied by either large decreases in GDP or low growth in GDP.

Both life expectancy and secondary education were insignificant in Model 1. This is likely because there is little difference among countries in terms of human capital – even poorer countries in the FSU and Eastern Europe have relatively high life expectancies and secondary schooling rates. Balcerowicz (2005) argues that there was an over-investment in human capital in Soviet countries, creating a surplus of educated people. This supports the notion that post-communist economies may have had stocks of human capital that were unusually large for

countries of their income levels. The insignificance of both secondary education and life expectancy suggests that on average the 37 countries examined may have similar levels of investment in human capital, and that their small differences may not outweigh exogenous factors.

Thus in this case it is possible to remove human capital from the model, as in Table 1, Model 2. Most variables remain significant and with the same signs as in Model 1. However, age dependency ratio has become significant with the expected sign, supporting the notion that economies with more age-dependents will grow slower, and foreign direct investment has become insignificant.

In both Models 1 and 2, that is with and without controlling for human capital, initial GDP was found to have a highly significant effect on GDP growth. The coefficient implies that economies that started out poorer in 1991 had a tendency to grow faster, controlling for other dependent variables, than countries that started out richer in 1991. Model 2 will serve as the control model for regressions of all 37 economies. The regression equation obtained from Model 2 is:

$$\log(y(t)\text{-}y(t\text{-}1)) = .0829 + .291(\log I(t)\text{-}\log I(t\text{-}1)) + .162(\log L(t)\text{-}\log L(t\text{-}1)) - .001233\ (ADR) + .0000254\ (FDI) - .0000504(IFL) - .00000116\ (Y(t=0))$$

where *ADR* is age-dependency ratio, *FDI* is foreign direct investment, *IFL* is inflation, and all other variables are as previously defined.

Table 2 provides Model 2 as previously shown, as well as Models 3 and 4, which use dummy variables for the FSU and Eastern Europe as alternate methods of predicting convergence.

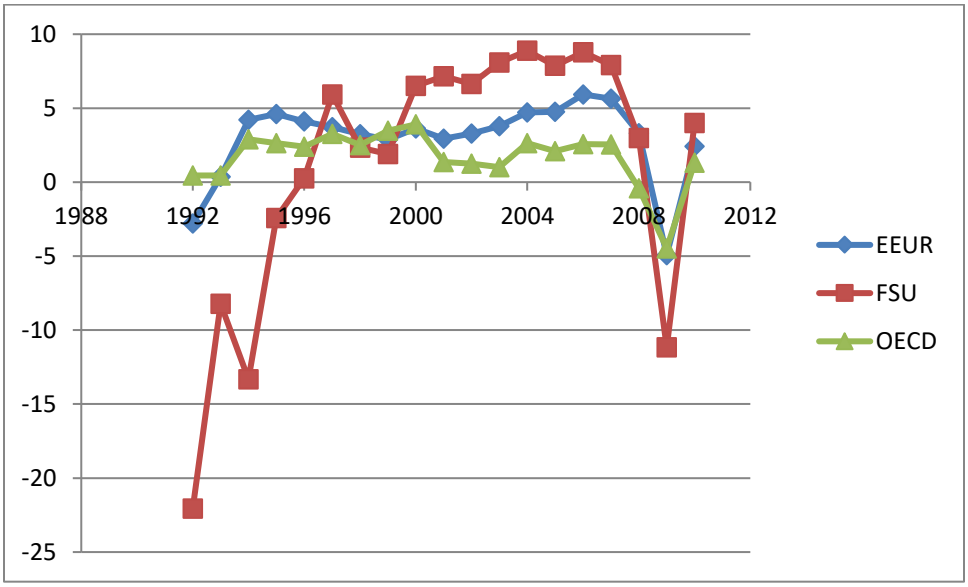
Table 3. Convergence: Initial GDP, FSU and EEUR, FSU

Dependent variable: ygrowthrate			
Explanatory variables	(2)	(3)	(4)
logI D1.	0.290663**	0.2901766**	0.2908587**
	(28.33)	(28.22)	(28.38)
logL D1.	0.1621013**	0.192949**	0.1756369**
	(1.98)	(2.25)	(2.09)
Agedependencyratio	-0.0012333**	-0.0012512**	-0.0013789**
	(-3.8)	(-3.68)	(-4.31)
Foreigndirectinvestment	0.0000254	1.50E-06	8.23E-07
	(0.89)	(0.06)	(0.03)
InflationGDPratio	-0.0000504**	-0.0000513**	-0.0000508**
	(-8.07)	(-8.11)	(-8.05)
InitialGDP	-5.21E-07**	…	…
	(-2.68)	…	…
FSUdummy	…	0.0117721**	0.0104303**
	…	(2.63)	(2.4)
EEUR dummy	…	0.0050006	…
	…	(1.01)	…
CONSTANT	0.082946**	0.0706728**	0.0779072**
	(5.45)	(4.12)	(4.92)
R^2	0.6719	0.672	0.6709
#obs	650	650	650
#groups	37	37	37

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Table 2 compares results of Model 2 to those of Models 3 and 4. Model 3 replaces the initial GDP variable in favor of a dummy variable both for Eastern Europe and the FSU. The FSU dummy is statistically significant with a positive sign, indicating that FSU countries on average will grow more quickly than countries not in the FSU when the other relevant variables are controlled for. The insignificance of EEUR, the dummy variable for Eastern Europe, suggests that the same does not hold true for those countries. It may be that these countries' marginal returns to capital and labor are closer to the levels of developed economies, and therefore they grow slower with given inputs than FSU countries.

Graph 2. OECD, EEUR, and FSU average growth rates



Model 4 examines the same sample of 37 countries, but instead only uses a convergence variable for the FSU, grouping Eastern Europe together with the other OECD countries. The coefficient and statistical significance of the FSU dummy variable are slightly reduced, which is to be expected given that Eastern European growth rates tend to be higher than those of OECD countries (Graph 2. For individual graphs of each region see Graph Set A, appendix p.42). However the change in the coefficient was minimal, and the dummy variable still indicates that FSU countries exhibit signs of conditional convergence as predicted by Solow (1956).

The transition recession and sharp economic decline of the FSU in the early 1990's is very visible in both Graphs 1 and 2. I follow the example of Kuboniwa (2011), who studied growth in Russia from the output trough in 1998 to its peak in 2008, by assuming that data from earlier than 1998 may be unduly influenced by recessions that occurred as a part of transition. As a result, it may be useful to omit this earlier data. However unlike Kuboniwa, I do not omit data from after 2008, assuming that the global recession, which hit FSU and Eastern European economies particularly hard, was an occurrence of the business cycle.

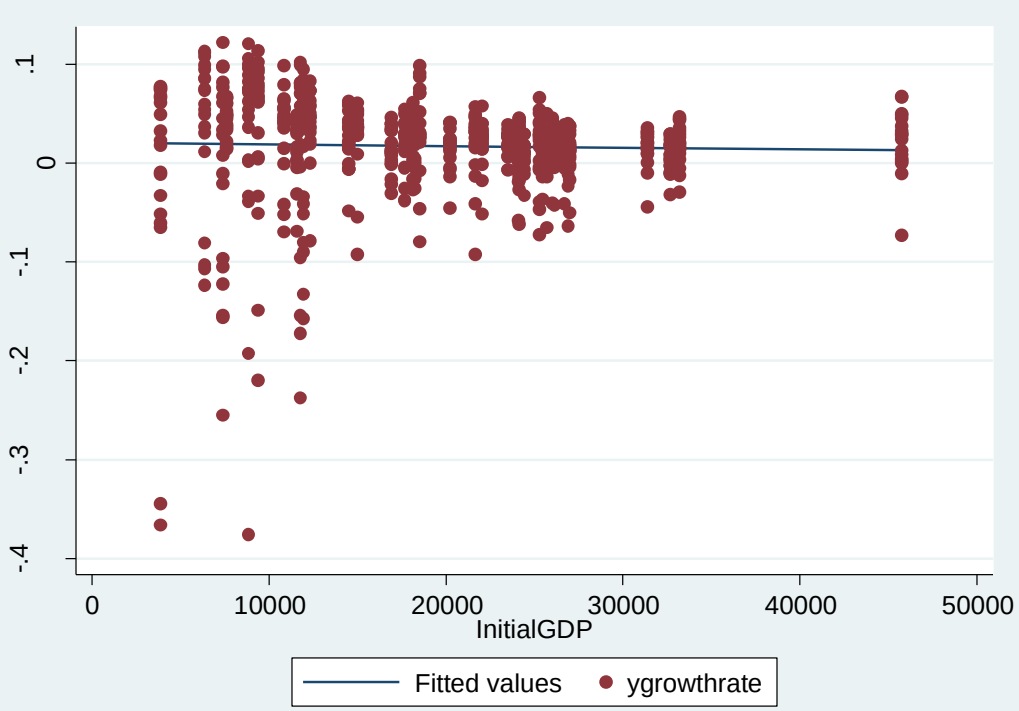
Table 4. Post-1998

Dependent variable: ygrowthrate		
	1991-2010	Post-1998
Explanatory variables	(2)	(5)
logI D1.	0.290663**	0.284620**
	(28.33)	(30.18)
logL D1.	0.1621013**	0.031953
	(1.98)	(0.39)
Agedependencyratio	-0.0012333**	-0.0000477
	(-3.8)	(-0.16)
Foreigndirectinvestment	0.0000254	0.0000702**
	(0.89)	(3.41)
InflationGDPratio	-0.0000504**	0.0001088*
	(-8.07)	(1.94)
InitialGDP	-5.21E-07**	-1.27E-06**
	(-2.68)	(-7.32)
CONSTANT	0.082946**	0.0427668**
	(5.45)	(3.28)
R^2	0.6719	0.7379
#obs	650	402
#groups	37	37

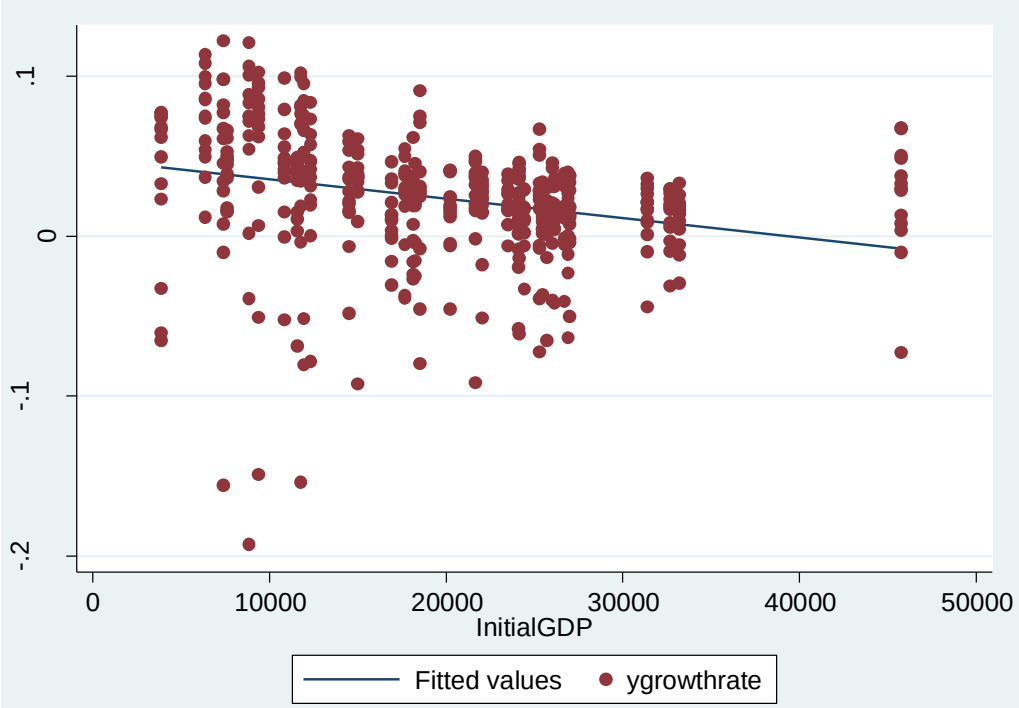
Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Table 3 holds several interesting coefficients. Changes in labor has become insignificant, supporting the theory that its positive coefficient and significance in some other regressions may be due to correlations between negative GDP growth and large population decreases that occurred in the early 1990's in the FSU. The massive drops in GDP in the FSU from 1991-1996 (Graph 2) may have skewed the foreign direct investment and inflation coefficients in earlier regressions. The coefficient of initial GDP, the convergence variable, almost doubled as a result of dropping the years 1991-1997, meaning that evidence for convergence is even stronger in this period. This can also be observed by comparing Graphs 3 and 4 below.

Graph 3. Growth vs. initial GDP, 1991-2010



Graph 4. Growth vs. initial GDP, 1998-2010



Graph 3 shows all observations 1991-2010, while Graph 4 shows only post-1998. While Graph 3 shows a barely-perceptible negative correlation between initial GDP and GDP growth rates, Graph 4 removes many outliers that occurred before 1998 and shows an obvious negative correlation. This supports the evidence presented thus far in this paper, as well as convergence as predicted in Solow (1956).

The evidence presented thus far in this paper has heavily supported the argument that transition economies, particularly the FSU countries, are converging towards developed OECD countries. Whether these countries are converging with one another is another matter. Perfect adherence to Solow (1956) would suggest that we should expect conditional convergence among these countries. However, the similar levels of initial GDP and varying economic policies across countries may make it difficult to detect empirically.

Table 4 removes data from high-income OECD countries, using data only from the Eastern Europe and FSU samples, from 1991-2010.

Table 5. Eastern Europe and FSU

Dependent variable: ygrowthrate		
Explanatory variables	(6)	(7)
logI D1.	0.3198563**	0.3190594**
	(16.22)	(16.25)
logL D1.	0.1585347	0.1756346
	(0.84)	(0.94)
Agedependencyratio	-0.0026829**	-0.0028016**
	(-3.05)	(-3.18)
Foreigndirectinvestment	2.67E-04	2.99E-04
	(0.45)	(0.49)
InflationGDPratio	-0.0000379**	-0.0000386**
	(-3.68)	(-3.75)
InitialGDP	-4.60E-07	…
	(-0.32)	…
FSUdummy	…	0.0105486
	…	(1.04)
CONSTANT	0.1476763**	0.1425415**
	(3.21)	(3.49)
R^2	0.7065	0.7098
#obs	209	209
#groups	12	12

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Most of the coefficients in Models 6 and 7 have been explained elsewhere and are not surprising. Labor is insignificant and inflation and age-dependency ratio have the expected signs. However, unlike in earlier regressions such as Models 2 and 3, neither the initial GDP nor the FSU dummy variables are significant. Thus this evidence does not support the convergence of FSU and Eastern European economies with each other. This can be attributed to similar levels of initial GDP per capita among these twelve countries.

As a final set of control models, I examine the growth patterns and evidence of convergence within the high-income OECD group, removing both the FSU and Eastern Europe. Because these countries are wealthier it is hypothesized that they will have higher capital-labor ratios and thus experience lower returns to productive inputs. Again, adherence to Solow (1956) predicts that convergence will occur.

Table 6. Adjusted OECD

Dependent variable: ygrowthrate		
Explanatory variables	only OECD (8)	OECD minus Korea[9] (9)
logI D1.	0.2336863**	0.2262965**
	(24.29)	(23.44)
logL D1.	0.1350384*	0.1187147*
	(1.87)	(1.68)
Agedependencyratio	-0.0000816	0.0003157
	(-0.32)	(1.21)
Foreigndirectinvestment	3.01E-05*	2.40E-05
	(1.66)	(1.39)
InflationGDPratio	0.000024	0.0000892
	(0.07)	(0.25)
InitialGDP	-5.32E-07**	-2.47E-07
	(-2.61)	(-1.29)
CONSTANT	0.026892**	-0.0005772
	(1.96)	(-0.04)
R^2	0.6037	0.5957
#obs	441	423
#groups	25	24

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

The coefficient of ΔI (logI D1.) is considerably lower in Models 8 and 9 than in Models 6 and 7, indicating that the wealthier countries experience lower returns to capital as described in Solow (1956). Model 8 shows the expected coefficient signs for capital and FDI, but an

[9] Korea is an outlier in this sample, with an initial GDP of $12,337. The next closest economy, Portugal, has an initial GDP of $16,910.

unexpected positive correlation with labor, similar to that seen in Models 2, 3, and 4. However unlike Models 2-4, this sample does not include FSU and eastern European countries, so the positive correlation between labor force growth and GDP per capita growth cannot be explained by events of the transition recessions. Instead, it is possible that increasing amounts of labor in these countries causes more efficient use of that labor, driving GDP per capita up.

From Model 8, it appears that convergence is to be expected in high-income OECD countries. However, Model 9 makes adjustments by omitting the outlier Korea, which with an initial per capita income of only $12,337, causes distortion of the sample. The adjusted sample finds initial GDP to be insignificant, along with most other variables. The disparity in policies and relatively high standards of living across the sample may cause these difficulties in determining the causes of growth for high-income economies.

Regression diagnostics show that residuals do not experience normal distribution. There are deviations from normal both in the middle of the distribution and at the ends. This tendency is most pronounced at the lower tail of the distribution. This is not entirely unexpected, as volatility in the data from recessions and transition will skew the data. Residual plots are included in the Technical Appendices.

V. CONCLUSIONS

This paper has attempted to determine whether there is evidence of convergence of former Soviet republics and other Eastern European countries with developed countries. The findings as discussed in the Results section support conditional convergence, confirming the convergence literature to date, which has found similar results. It also confirms the results of earlier works on Eastern Europe and the FSU, which have also supported convergence. My findings support Kuboniwa (2011), who showed that extreme growth data for the FSU from 1991-1998 has adverse effects on convergence models. In my models, evidence of convergence with developed countries increased dramatically when the years 1991-1997 were omitted from the sample, and this omission is justified by the one-time nature of a transition recession.

Many observations of Solow (1956) are also confirmed, including the effect of investment on growth and diminishing returns to capital. However, there was mixed evidence of the effect of changes in the labor force on output growth per capita. While Solow (1956) predicts a negative correlation between labor force growth and income per capita growth, results in this paper were often positive or insignificant. This could be partly due to skewed FSU and Eastern European data which exhibits unusual changes in GDP accompanied with the transition recession in the early 1990s. It is also possible that increases in the size of the labor force cause workers to be more competitive and thus more productive, having a positive effect on GDP per capita growth.

Several variables suggested in Peters (2001) were examined that are not typically present in Solow-based convergence regressions. The most successful of these was inflation, which was used as an indicator of macroeconomic stability, and which had a small yet significant impact on GDP growth in most regressions. The age-dependency ratio and foreign direct investment were

inconsistent indicators and may have been influenced by other variables. Human capital, though used extensively in the literature including Mankiw et al. (1992) and Peters (2001), was found to be insignificant in this sample. This can be attributed to the fact that minimal differences exist both in the time series and cross-sections of the indicators, greatly a result of the Soviet-era excess supply of human capital in the FSU and Eastern Europe (Balcerowicz, 2005).

There was no evidence for convergence of OECD countries amongst each other or for FSU and Eastern European countries with each other. This is not surprising given that within their own samples, countries have relatively close initial GDP levels and can have wildly varying policies. While evidence for convergence of the Eastern Europe sample with the OECD was indecisive, it can be attributed to the limited number and relatively high incomes of Eastern European countries included in the sample.

Though the primary focus of this paper was the FSU, future research on convergence in non-FSU Eastern European states could include a greater sample and variety of Eastern European countries than the sample examined in this paper. Other research on transition economies could delve specifically into the growth-promoting institutions and policies that can be enacted by Eastern European countries to encourage growth. It may also be interesting to conduct a more thorough examination of the productivity of labor force growth in transition economies.

VI. REFERENCES

Barcelowicz, Leszek. "Postcommunist Transition in Comparative Perspective." *Development Challenges in the 1990s: Leading Policymakers Speak from Experience.* The World Bank and Oxford University Press: Washington and New York, 2005. http://books.google.com/books?hl=en&lr=&id=BNbxfZkRHwsC&oi=fnd&pg=PA233&dq=Balcerowicz&ots=ECp4aSYJmU&sig=15VE-p9XmcWjyeWCiXaF9ne7jMY#v=onepage&q=Balcerowicz&f=false

Chiodo, Abbigail J. and Owyang, Michael T. "A Case Study of a Currency Crisis: The Russian Default of 1998." Federal Reserve Bank of St. Louis, November/December 2002. http://research.stlouisfed.org/publications/review/02/11/ChiodoOwyang.pdf

Comin, Diego. "Total Factor Productivity." New York University and NBER, August 2006. http://www.people.hbs.edu/dcomin/def.pdf

Ericson, Richard E. "The Russian Economy in 2008: Testing the 'Market Economy'." *Post-Soviet Affairs*, 2009, 25(3), pp. 209-231. http://bellwether.metapress.com/content/l773188p1340245p/

Fidrmuc, Jan. "Economic reform, democracy and growth during post-communist transition." *European Journal of Political Economy,* September 2003, 19(3), pp.583-604. http://siteresources.worldbank.org/INTDECINEQ/Resources/fidrmuc.pdf

Hamm, Patrick; Stuckler, David; and King, Lawrence. "The Governance Grenade: Mass Privatization, State Capacity and Economic Growth in Post-communist Countries." University of Massachusetts Amherst: Political Economy Research Institute, Working Paper Series No. 222, May 2010. http://www.peri.umass.edu/fileadmin/pdf/working_papers/working_papers_201-250/WP222.pdf

Herzog, Ryan W. "A Dynamic Panel Model of GDP growth, Saving, Age Dependency, and Openness." Gonzaga University, Department of Economics. March 21, 2012. http://cahnrs-cms.wsu.edu/ses/seminars/Documents/Saving_Age_GMM_V1.pdf

Ickes, Barry W. "Introduction to Development Economics." Penn State University, Fall 2008. http://econ.la.psu.edu/~bickes/introdev.pdf

Iradian, Garbis. "Rapid Growth in the CIS: Panel Regression Approach." IMF Working Paper, Middle East and Central Asia Department, 170(07). July 2007. http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1007919##

Jones, Derek C. and Mygind, Niels. "The Effects of Privatization on Productive Efficiency: Evidence from the Baltic Republics." *Annals of Public & Cooperative Economics*, 2000, 71(3), pp. 415-439. http://home.cerge-ei.cz/hanousek/jel_survey/Table%202/Jones%20and %20Mygind%20(2000).pdf

Kolodko, Grzegorz W. "Transition to a market economy and sustained growth. Implications for the post-Washington consensus." *Communist and Post-Communist Studies*, September 1999, 32(3), pp. 233-261. http://www.sciencedirect.com/science/article/pii/S0967067X99000112

Kuboniwa, Masaaki. "The Russian growth path and TFP changes in light of esitmation of the production function using quarterly data." *Post-Communist Economies,* September 2011, 23(3), pp.311-325. http://hermes-ir.lib.hit-u.ac.jp/rs/bitstream/10086/18940/1/RRC_WP_No30.pdf

Libman, Alexander and Vinokurov, Evgeny. "Regional Integration and Economic Convergence in the Post-Soviet Space: Experience of the Decade of Growth." *Munich Personal RePEc Archive*, MPRA paper No. 21594, March 2010. http://mpra.ub.uni-muenchen.de/21594/1/MPRA_paper_21594.pdf

Mankiw, Gregory; Romer, David; and Weil, David. "A Contribution to the Empirics of Economic Growth." *The Quarterly Journal of Economics*, May 1992, 107(2), pp. 407-437. http://www.amenezes.uac.pt/macroeconomiaII/macroeconomiaII_20062007/papers/mrw1992.pdf

Osipian, Ararat. "Economic Growth – Human Capital Nexus in Post-Soviet Ukraine, 1989-2009." *Munich Personal RePEc Archive*, MPRA paper No. 7731, March 2008. http://mpra.ub.uni-muenchen.de/7731/1/MPRA_paper_7731.pdf

Peters, Amos C. "The Determinants of Growth in the English Speaking Caribbean." *Savings and Development*, 2001, 25(3), pp.313-332. http://www.unc.edu/~acpeters/Peters32001%5B2%5D.pdf

Quah, Danny. "Economic Growth: Measurement." LSE Economics Department, August 2001. http://econ.lse.ac.uk/~dquah/p/0108iesbs.pdf

Summers, Robert and Heston, Alan. "The Penn World Table (Mark 5): An expanded set of international comparisons, 1950-1988." The Quarterly Journal of Economics, May 1991, 106(2), pp. 327-368. http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=ecff6010-1d0b-4eff-bc1c-f4081b6b1e04%40sessionmgr14&vid=5&hid=18

Solow, Robert M. "A Contribution to the Theory of Economic Growth." *Quarterly Journal of Economics*, February 1956, 70(1), pp. 65-94. http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=2af9bdcd-0361-449a-8c8e-806c3e5808b8%40sessionmgr113&vid=2&hid=126

Solow, Robert M. "Technical Change and the Aggregate Production Function." *The Review of Economics and Statistics*, August 1957, 39(3), pp. 312-320. http://www.jstor.org/stable/1926047?seq=1

Vamvakidis, Anthanasios. "Convergence in Emerging Europe: Sustainability and Vulnerabilities." *Eastern European Economics*, May-June 2009, 47(3), pp.5-27. http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=a846c5c8-a8a3-4192-8594-22266cc2dbe4%40sessionmgr10&vid=2&hid=9

Yegerov, Igor. "Levels of economic development and the sources of economic growth for Eastern European and the Post-Soviet countries." Centre for S&T Potential Studies, National Academy of Sciences of Ukraine and the Institute of Statistics, State Committeee of Statistics of Ukraine, 2007. http://bbs.mis.brighton.ac.uk/eaces/papers/2c2.pdf

Zheltkov, Igor M. "Factors of Industrial Growth in the Republic of Belarus in 1996-2003." *Problems of Economic Transition*, May 2005, 48(1), pp.22-43. http://web.ebscohost.com/ehost/pdfviewer/pdfviewer?sid=76d9192b-fd59-4085-b81e-75c83dc385bb%40sessionmgr11&vid=4&hid=18

VII. TECHNICAL APPENDICES

Table 1. Descriptive Statistics

Summary Statistics								
Variable:	Mean	Std. dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
	OECD				**OECD without Korea**			
ygrowthrate	0.016784	0.025518	-0.09202	0.098802	0.01576	0.024529	-0.09202	0.098802
logK D1.	0.020479	0.082	-0.71484	0.295986	0.02005	0.08205	-0.71484	0.295986
logL D1.	0.011149	0.01295	-0.041	0.053923	0.01108	0.01304	-0.041	0.053923
Agedependencyratio	49.9118	4.313	38.076	66.184	50.3267	3.8745	43.08449	66.184
FDI	13.16129	58.83194	-15.0277	564.916	13.6868	59.9977	-15.0276	564.916
InflationGDPdeflator	2.761077	2.8733	-6.3815	20.6117	2.6954	2.8618	-6.3815	20.6117
InitialGDP	24577.61	6545.554	12337.01	45758.1	25088.7	6173.008	16910	45758.1
	FSU				**FSU after 1998**			
ygrowthrate	0.01159	0.101636	-0.37607	0.121807	0.0475	0.062388	-0.19292	0.1218
logK D1.	0.006105	0.212244	-0.7032	0.4787	0.048577	0.17948	-0.70319	0.27704
logL D1.	-0.006953	0.01627	-0.04483	0.041203	-0.00143	0.01636	-0.0447	0.0412
Agedependencyratio	47.7959	4.3342	38.537	56.899	45.59922	3.6477	38.537	53.02927
FDI	3.675	3.316	0.041122	21.1529	4.4974	3.4494	0.34232	21.1225
InflationGDPdeflator	161.9887	431.8993	-3.70578	3334.798	18.62	39.3763	-3.7057	316.7933
InitialGDP	8504.981	2715.739	3839.38	11961.63	8504.981	2715.739	3839.38	11961.63
	EEUR							
ygrowthrate	0.02935	0.03329	-0.0925	0.09869				
logK D1.	0.03971	0.08939	-0.26551	0.2632				
logL D1.	0.002314	0.018018	-0.03861	0.1192				
Agedependencyratio	45.1762	4.0381	37.376	54.7274				
FDI	4.3864	8.2824	-32.643	52.0515				
InflationGDPdeflator	13.1142	24.1122	-1.1785	208.175				
InitialGDP	11891.45	2702.731	7581.136	14980.69				

Table 2. Convergence and Human capital

Dependent variable: ygrowthrate		
Explanatory variables	(1)	(2)
logI D1.	0.2732**	0.290663**
	(28.72)	(28.33)
logL D1.	0.1011424	0.1621013**
	(1.25)	(1.98)
logLIFE D1.	-0.1271637	…
	(-0.44)	…
Agedependencyratio	0.0002296	-0.0012333**
	(-0.78)	(-3.8)
Foreigndirectinvestment	0.0000634**	0.0000254
	(2.88)	(0.89)
InflationGDPratio	-0.0000778**	-0.0000504**
	(-3.88)	(-8.07)
SecondaryEduyears	0.0017068	…
	(1.34)	…
InitialGDP	-1.16E-06**	-5.21E-07**
	(-6.89)	(-2.68)
CONSTANT	0.0382023**	0.082946**
	(2.19)	(5.45)
R^2	0.7237	0.6719
#obs	472	650
#groups	37	37

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Table 3. Convergence: Initial GDP, FSU and EEUR, FSU

Dependent variable: ygrowthrate			
Explanatory variables	(2)	(3)	(4)
logI D1.	0.290663**	0.2901766**	0.2908587**
	(28.33)	(28.22)	(28.38)
logL D1.	0.1621013**	0.192949**	0.1756369**
	(1.98)	(2.25)	(2.09)
Agedependencyratio	-0.0012333**	-0.0012512**	-0.0013789**
	(-3.8)	(-3.68)	(-4.31)
Foreigndirectinvestment	0.0000254	1.50E-06	8.23E-07
	(0.89)	(0.06)	(0.03)
InflationGDPratio	-0.0000504**	-0.0000513**	-0.0000508**
	(-8.07)	(-8.11)	(-8.05)
InitialGDP	-5.21E-07**	…	…
	(-2.68)	…	…
FSUdummy	…	0.0117721**	0.0104303**
	…	(2.63)	(2.4)
EEUR dummy	…	0.0050006	…
	…	(1.01)	…
CONSTANT	0.082946**	0.0706728**	0.0779072**
	(5.45)	(4.12)	(4.92)
R^2	0.6719	0.672	0.6709
#obs	650	650	650
#groups	37	37	37

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Table 4. Post-1998

Dependent variable: ygrowthrate		
	1991-2010	Post-1998
Explanatory variables	(2)	(5)
logI D1.	0.290663**	0.284620**
	(28.33)	(30.18)
logL D1.	0.1621013**	0.031953
	(1.98)	(0.39)
Agedependencyratio	-0.0012333**	-0.0000477
	(-3.8)	(-0.16)
Foreigndirectinvestment	0.0000254	0.0000702**
	(0.89)	(3.41)
InflationGDPratio	-0.0000504**	0.0001088*
	(-8.07)	(1.94)
InitialGDP	-5.21E-07**	-1.27E-06**
	(-2.68)	(-7.32)
CONSTANT	0.082946**	0.0427668**
	(5.45)	(3.28)
R^2	0.6719	0.7379
#obs	650	402
#groups	37	37

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Table 5. Eastern Europe and FSU

Dependent variable: ygrowthrate		
Explanatory variables	(6)	(7)
logI D1.	0.3198563**	0.3190594**
	(16.22)	(16.25)
logL D1.	0.1585347	0.1756346
	(0.84)	(0.94)
Agedependencyratio	-0.0026829**	-0.0028016**
	(-3.05)	(-3.18)
Foreigndirectinvestment	2.67E-04	2.99E-04
	(0.45)	(0.49)
InflationGDPratio	-0.0000379**	-0.0000386**
	(-3.68)	(-3.75)
InitialGDP	-4.60E-07	…
	(-0.32)	…
FSUdummy	…	0.0105486
	…	(1.04)
CONSTANT	0.1476763**	0.1425415**
	(3.21)	(3.49)
R^2	0.7065	0.7098
#obs	209	209
#groups	12	12

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Table 6. Adjusted OECD

Dependent variable: ygrowthrate		
Explanatory variables	only OECD (8)	OECD minus Korea (9)
logI D1.	0.2336863**	0.2262965**
	(24.29)	(23.44)
logL D1.	0.1350384*	0.1187147*
	(1.87)	(1.68)
Agedependencyratio	-0.0000816	0.0003157
	(-0.32)	(1.21)
Foreigndirectinvestment	3.01E-05*	2.40E-05
	(1.66)	(1.39)
InflationGDPratio	0.000024	0.0000892
	(0.07)	(0.25)
InitialGDP	-5.32E-07**	-2.47E-07
	(-2.61)	(-1.29)
CONSTANT	0.026892**	-0.0005772
	(1.96)	(-0.04)
R^2	0.6037	0.5957
#obs	441	423
#groups	25	24

Note: Z-statistics in parentheses.
* denotes significance at the 10% level.
** denotes significance at the 5% level.

Chart 1. Estonia, real GDP per capita (PPP), 1991-2010

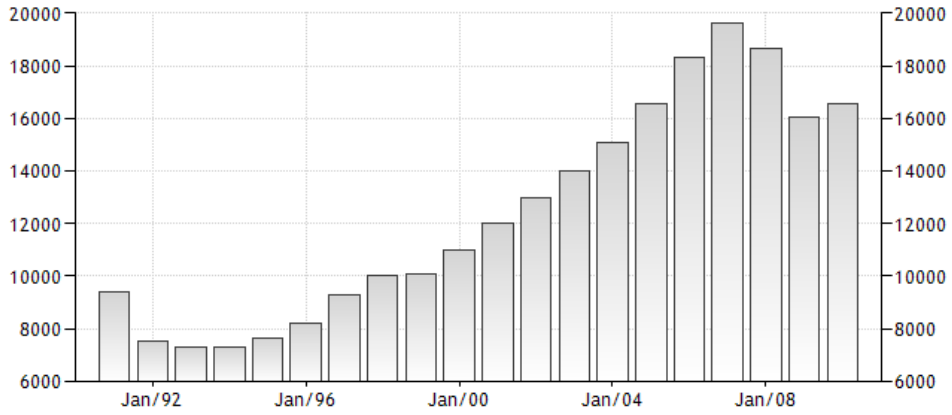


Chart 2. Moldova, real GDP per capita (PPP), 1991-2010

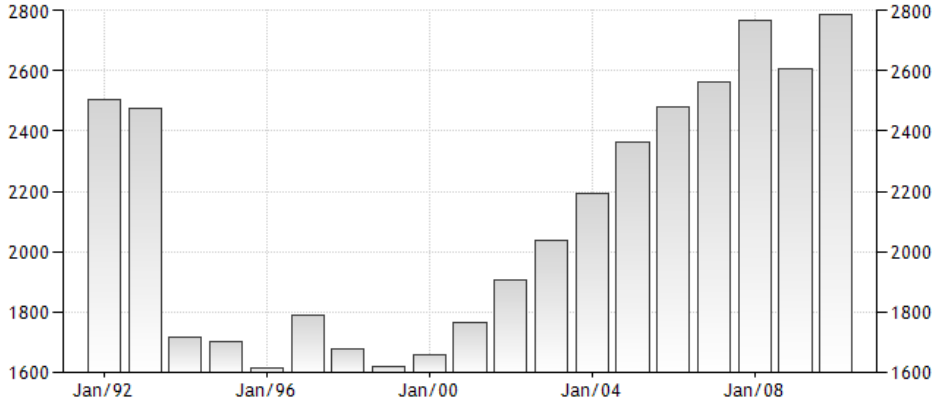


Chart 3. Russia, real GDP per capita (PPP), 1991-2010

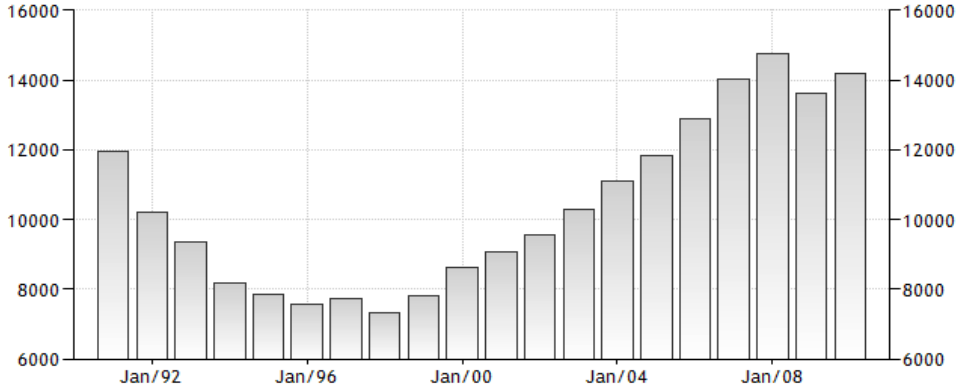


Chart 4. Poland, real GDP per capita (PPP), 1991-2010

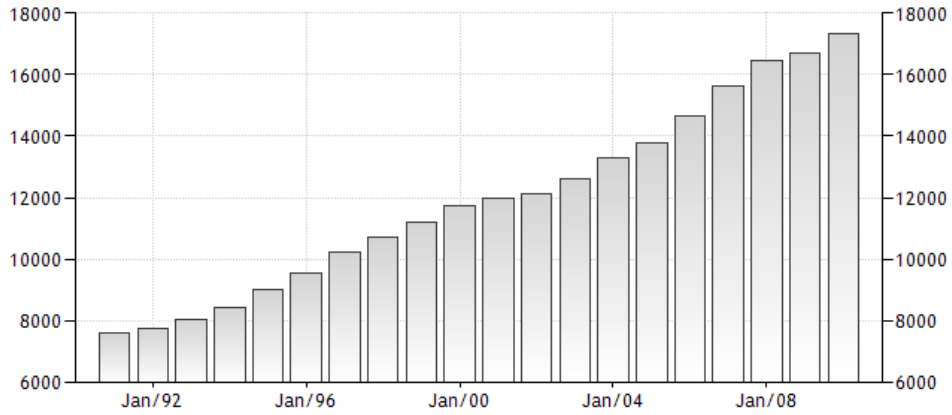


Chart 5. Korea, real GDP per capita (PPP), 1991-2010

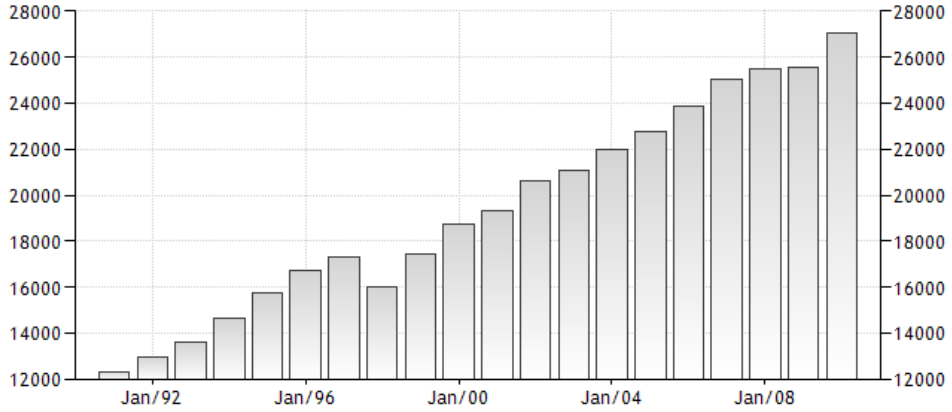
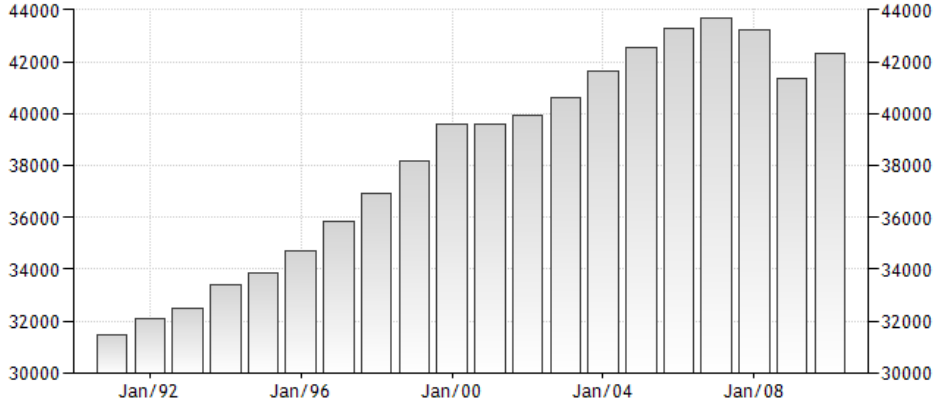
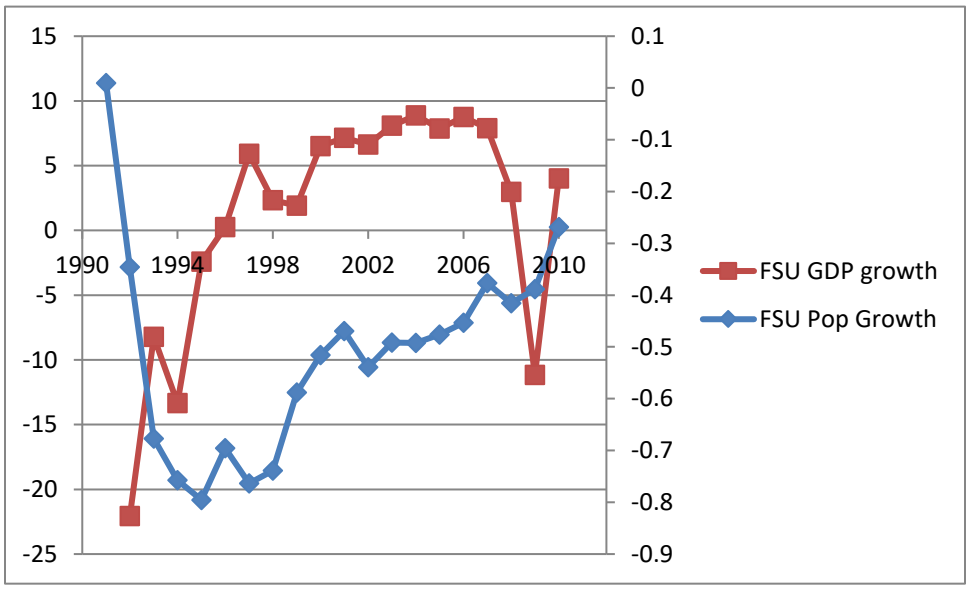


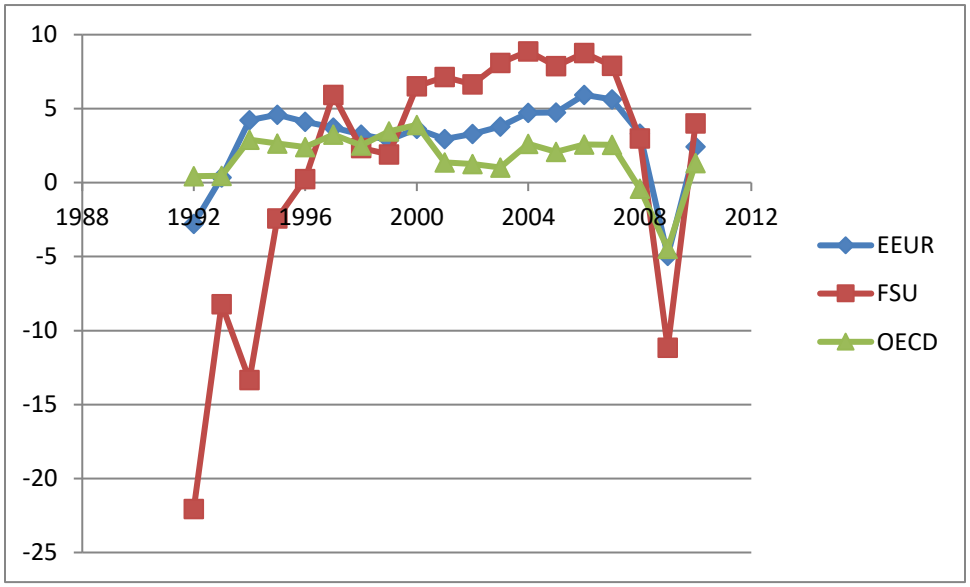
Chart 6. United States, real GDP per capita (PPP), 1991-2010



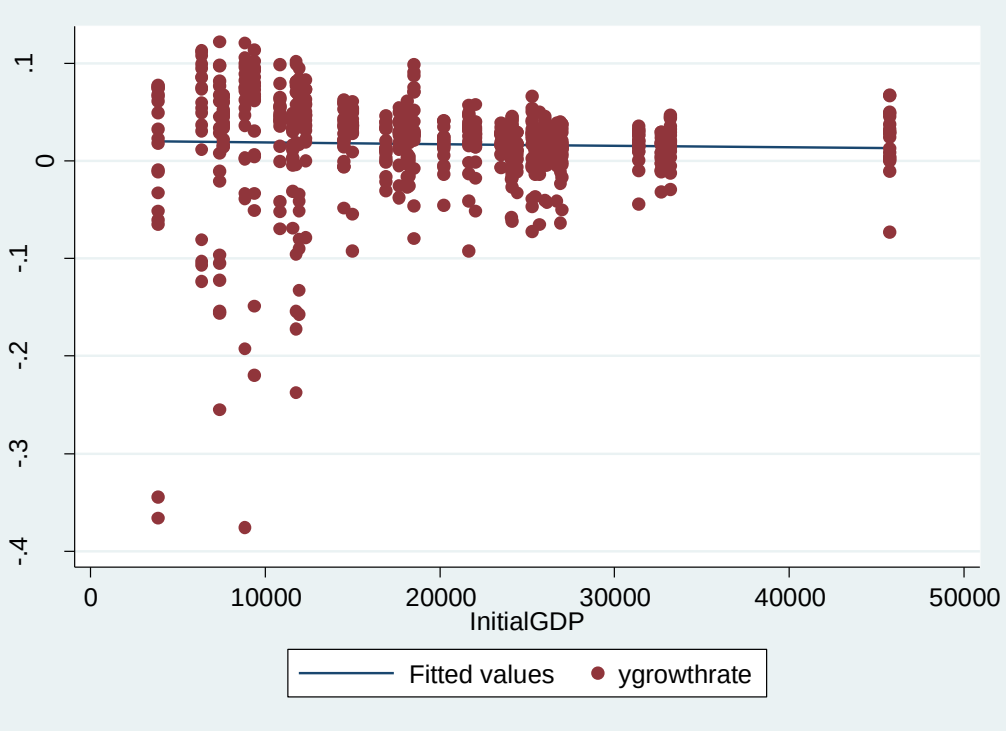
Graph 1. FSU average GDP growth rate vs. population growth, 1991-2010



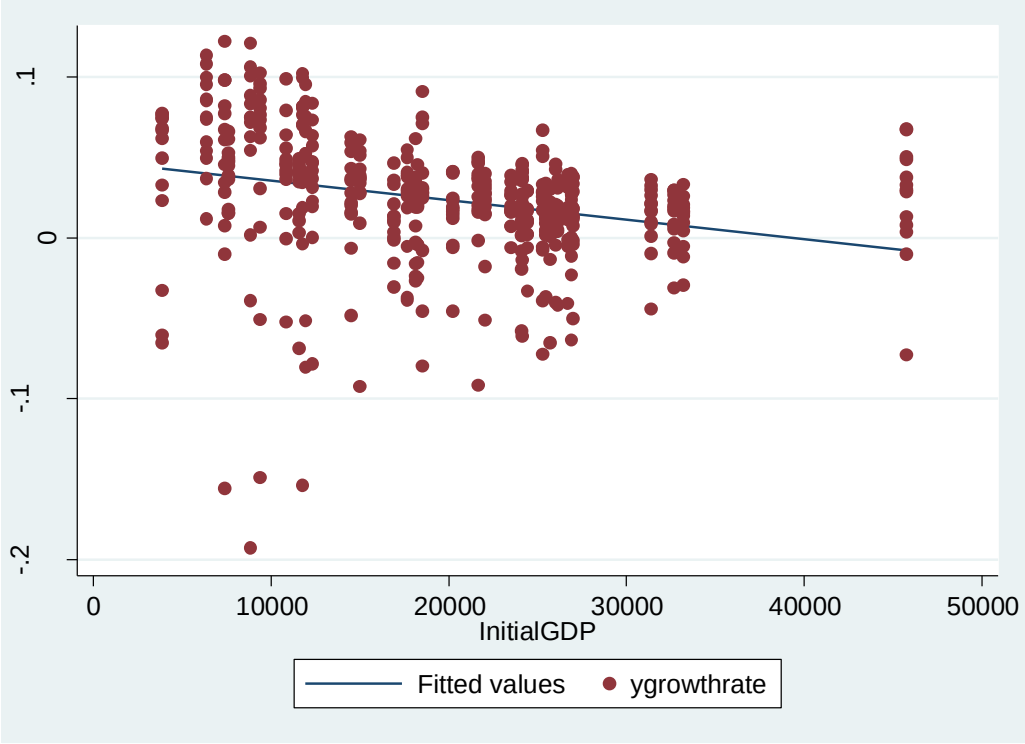
Graph 2. OECD, EEUR, and FSU average growth rates



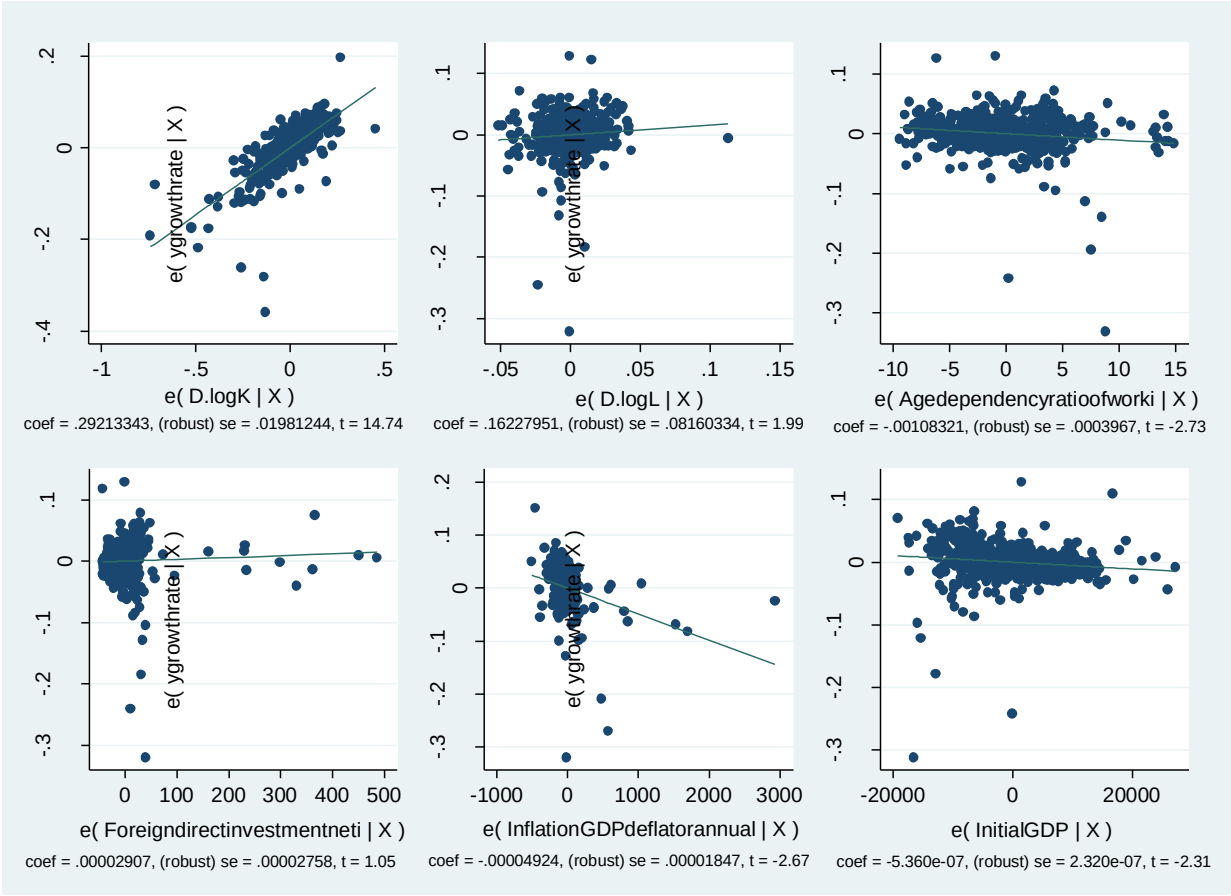
Graph 3. Growth vs. initial GDP, 1991-2010



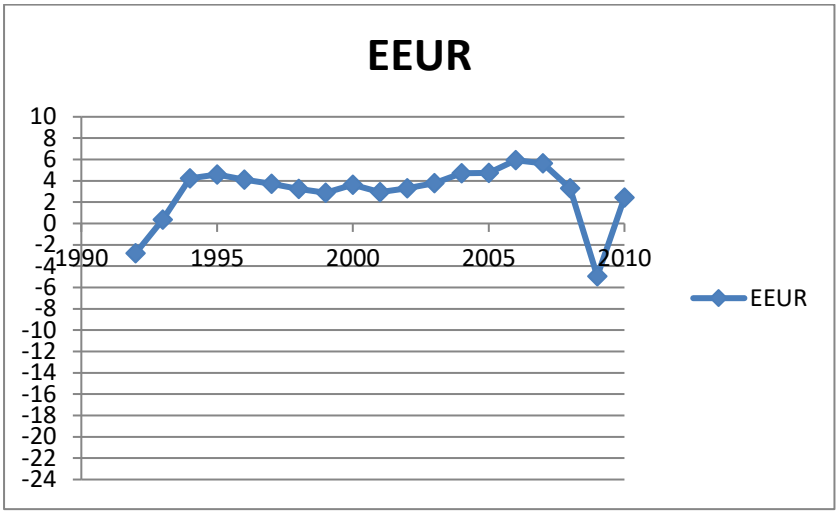
Graph 4. Growth vs. initial GDP, 1998-2010

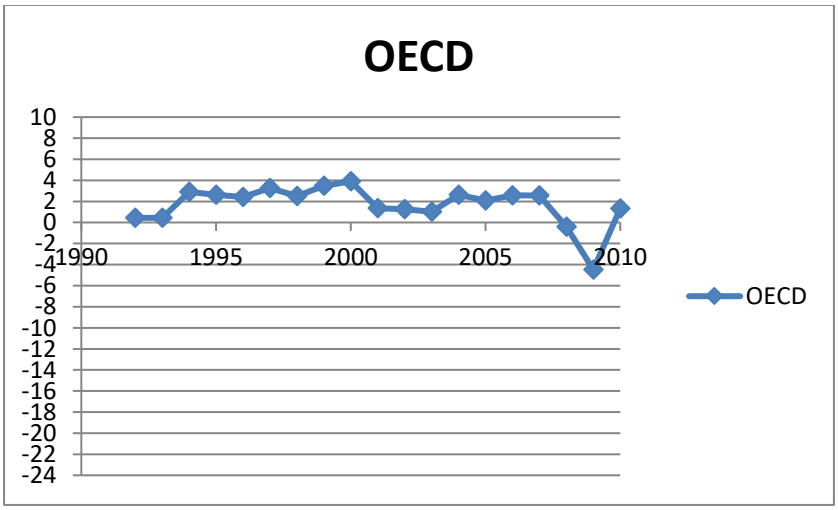


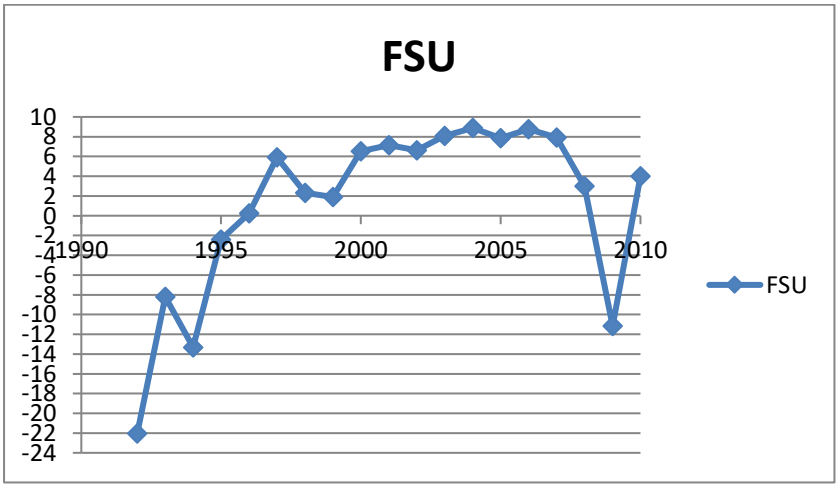
Graph Set A. Scatter Plots, 1991-2010



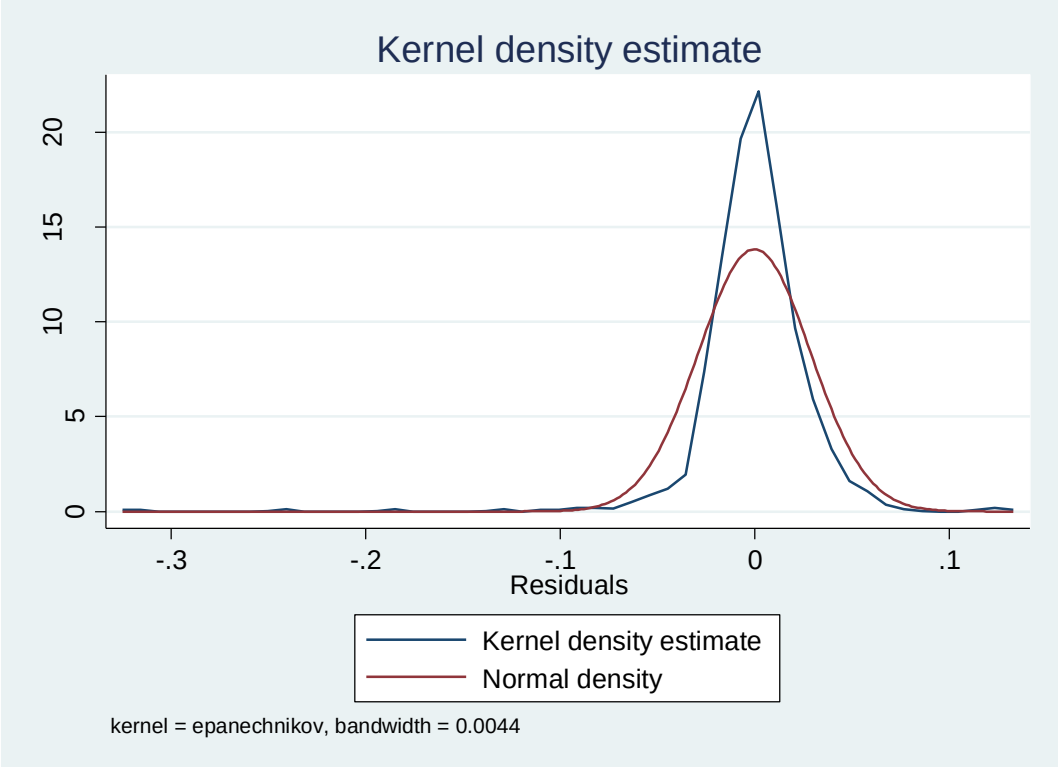
Graph Set B. OECD, EEUR, FSU

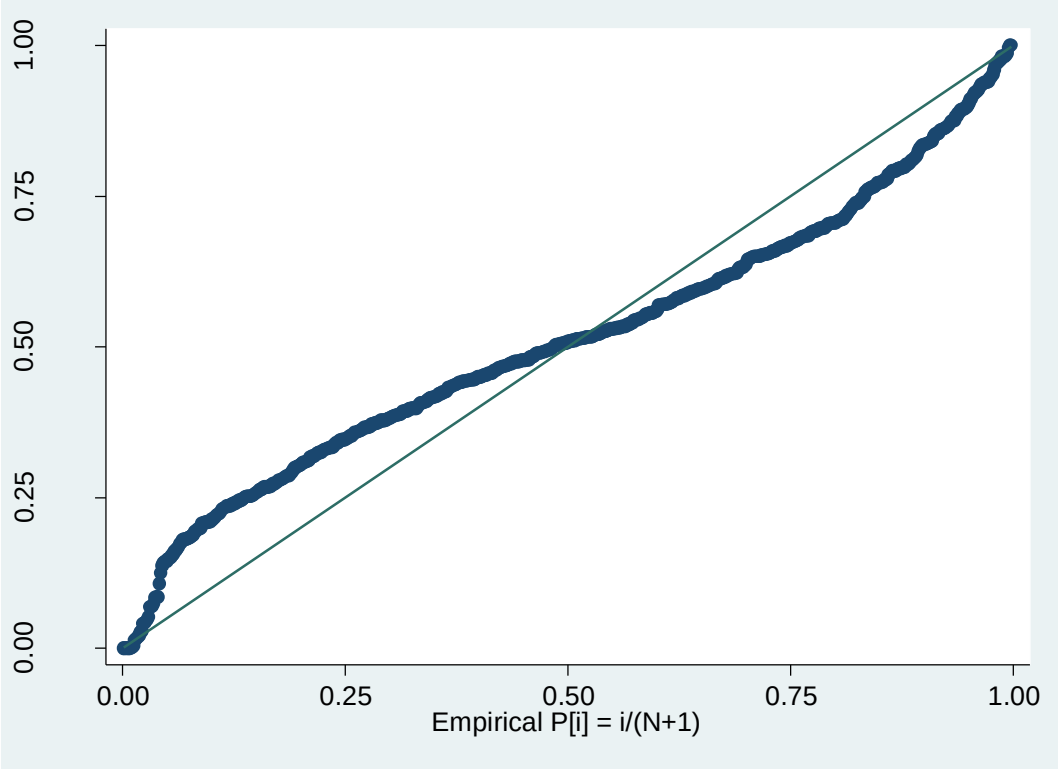






Graph Set C. Residual Plots





Graph Set C. Residual Plots (continued)