**FACULTY OF MATHEMATICS, PHYSICS AND INFORMATICS**
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# ECONOMIC GROWTH AND CONVERGENCE IN TRANSITIVE ECONOMIES

**(Master Thesis)**

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I declare this thesis was written on my own, with the only help provided by my supervisor and the referred-to literature.

Bratislava, April 5, 2004 .....

I would like to express special thanks to my supervisor Dr. Menbere Workie Tiruneh, PhD. for his helpful assistance and patient guidance he offered throughout the elaboration of this thesis.

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# 1 Introduction

> *"If we want to understand why countries differ dramatically in standards of living, then we have to understand why countries experience such sharp divergences in long-term growth rates. Even small differences in these growth rates, when cumulated over a generation or more, have much greater consequences for standards of living than the kinds of short-term business fluctuations that have typically occupied most of the attention of macroeconomists."*
>
> *Barro, R. J. – Sala-i-Martin, X. (1995)*

Convergence - as a process of lessening focused-on differences - is from an economic point of view profoundly related to the concept of economic growth. To illustrate the connection between growth and worldwide differences in standards of living, one can look at often referred-to US example: if the average 1970 – 1990 real per capita GDP annual growth rate in USA had been only one percentage point below its actual value (which can be calculated to have been 1.75 percent per year), in 1990 the United States would have ranked 37$^{th}$ instead of 1$^{st}$ out of 127 countries with available data. Different levels of economic growth account not only for existence of income disparities; they also determine dynamics of these diversities development – whether differences across countries increase (case of divergence) or fall (the one of convergence) over time.

Economic convergence concerns the gaps in living standards between countries: are they closing or widening, and at what speed? Are relatively poor economies to remain poor for many generations? Are the rich countries of next century to be the same as relatively rich countries of nowadays? Is the degree of income inequality across economies increasing or falling over time? Posing these questions, motivating convergence debate, immediately raises the problem of the variable/variables that need to be considered. Some studies concentrate on real GDP per head, per worker or per worker-hour, others look at total factor productivity, while yet others focus on factor prices, such as real wages or rates of return on capital. Each measure provides different information. However, real per capita GDP stands for the most widely used variable in the convergence analysis.

There are two basic ways of measuring convergence; *beta* convergence and *sigma* convergence. *Sigma* convergence is concerned with the dispersion around the mean of per capita income in a group of economies, the dispersion typically being measured by the standard deviation or the

coefficient of variation. Other measures used include the Gini coefficient[1], the ratio of the highest to the lowest income or of the average relative to the highest.

*Beta* convergence is concerned with the relative growth performance of rich and poor countries. Convergence occurs when there is an inverse relationship between the initial value of per capita income and subsequent GDP growth. Thus, if countries with lower initial values of this variable grow faster, they can be said to be catching up with richer countries. However, even if poorer countries grow faster, their absolute income gap with the richer countries can increase for quite sometime, if there is a large initial inequality. Indeed, unless the ratio of growth rates between a poor and rich country equals or is greater than the ratio of their starting incomes, the absolute income gap will first increase, reach a maximum, and subsequently decline.

Two approaches to *beta* convergence are usually distinguished. The traditional approach involves argument that there is an inherent tendency for the poorer countries to grow faster than the richer ones since, on the conventional analysis of growth economics, greater effort is needed to raise output at higher levels of income. Thus, poor countries should grow faster than wealthy ones as long as their savings rates and technology are identical. Convergence ("absolute convergence") on a common level of income is then only a matter of time.

In the alternative approach ("conditional convergence"), however, poorer countries have the potential to grow faster than advanced countries, but only if they satisfy certain conditions. If these conditions are not satisfied, their growth rate may be below their potential, or even below that of richer countries. Because conditional convergence is closely related to policies needed for catching up, it takes up many of the traditional concerns of development economists.

Early empirical research on differences in long-term growth performance among countries found little support for unconditional (absolute) convergence. In response, more recent growth models have allowed for conditioning influences and a larger role for economic policy.

[1] The Gini coefficient was developed by Italian statistician Corrado Gini. It is a measure of income inequality in a society. The Gini coefficient is a number between 0 and 1, where 0 means perfect equality (everyone has the same income) and 1 means perfect inequality (one person has all the income, everyone else earns nothing). The Gini coefficient is calculated using areas on the Lorenz curve diagram. (The Lorenz curve is a graph that shows, for the bottom x % of households, the percentage y % of the total income which they have. The percentage of households is plotted on the x axis, the percentage of income on the y axis.) If the area between the line of perfect equality and Lorenz curve is A, and the area underneath the Lorenz curve is B, the Gini coefficient is A/(A+B). This is expressed as a percentage or as the numerical equivalent of that percentage, which is always between 0 and 1.

To name the motivational forces driving the study of convergence clearly, one can paraphrase Sala-i-Martin (2003), one of the leading researchers in the empirics of economic growth. According to him, there are three reasons why economic convergence has been important from an empirical point of view. The first reason is a theoretical one - to judge the extent to which theories of economic growth are empirically relevant. Convergence (as an implication of theoretical growth model) is studied because of the interest to apply theory, to test theory. The next reason to focus on empirical convergence studies is to see whether governmental policies designed to promote growth of poor regions actually work.[2] The third reason is to pay attention to the welfare of people around the world. Many voices claim the world is becoming a more unequal place. Whether the poor really tend to be poorer and the rich tend to be richer is an important question of divergence, which proves crucial in the world where mechanisms of globalization, integration in the means of economic cooperation and enlargement of existing unified structures (e.g. European Union) are functioning.

As was already mentioned, historical data (covering over 100 world economies) on real per capita GDP reveal no convergence in the sense of poor economies growing faster than rich ones. However, this kind of convergence does appear if a smaller and more homogenous group of economies is taken under examination. This has shown true for OECD countries, the member states of USA or the group of Japanese prefectures' economies. In this thesis, a group of transitive economies is considered.

Transitive economies can be easily believed to constitute a rather homogenous group. They all emerged following the collapse of communism in the late 1980s, when the disintegration of three communist federations – Czechoslovakia, the Soviet Union, and Yugoslavia – caused the number of countries in the world rise by approximately 15 percent. Naturally, the new states started to function as new economic subjects, too. They have taken the road leading from centrally planned towards market economy. In all transitive countries, the years following the collapse of communism can be compared to the periods that followed both World Wars. Especially the first years of transition are characterised by dramatic declines in income, growing poverty and unemployment, and huge inflation rates.

In this thesis, two basic questions are raised to be answered by providing empirical evidence on convergence or divergence using data on transitive economies. First, has the economic

[2] There was a strong evidence of convergence until the beginning of 1990s in Europe. Interestingly, this process of cohesion (convergence) within Europe slowed down, if not stopped, during the 1990s, which is precisely when the European governments tried to promote convergence.

performance of transitive economies during past 14 years led to convergence within the group of countries that all emerged as new economic subjects after the collapse of communism? Second, is convergence a reality among transitive economies and developed countries of OECD and European Union, or does the process of unification (e.g. enlargement of the European Union) and globalisation proceed solely on political grounds without detectable economic cohesion?

Prior to providing answers to these questions, basic definitions concerning convergence are followed by an overview of specific features, achievements and hurdles countries have had to overcome on their way from centrally planned towards market economy. After that, a summary of Solow-Swan model of economic growth is offered. Concept of convergence emerges here as a natural implication of the model. The distinctions between absolute (gross) and relative (conditional) convergence are stated. Subsequently, a group of transitive economies is tested for convergence. Methodology and used data sets are discussed. Finally, empirical results are presented and interpreted in connection with real macroeconomic situation of the countries concerned.

## 2 *Transition: Challenges and Achievements*

> *"It seems to me now that everyone almost forgot the evils and irrationalities of communism and is surprised that its dismantling is not fast enough and that it takes non-zero time to replace it with a full-fledged market economy."*
>
> *Klaus, V. (1999)*

Following the collapse of communism, an unprecedented transition process started in over 25 economies of Central and Eastern Europe and the former Soviet Union[3]. Countries had to change their political system (from authoritarian or dictatorial to democratic and pluralistic) at the same time as their economic system (from centrally planned to market). Never before did historical experience encounter any similar parallel transition.

At the beginning of the transition process, countries had to face very complicated situation. Economic heritage of communist years was characteristic of collective (state) ownership and huge over-employment. Total absence of competitive forces, international trade oriented solely toward the markets of COMECON (Council for Mutual Economic Assistance) which collapsed in 1988 – 1990, obsolete and energy-demanding industrial structure, centrally set price levels leading to immense latent inflation – all these features made the transformation of existing economic structures into functioning market economies seem almost impossible.

Economic reform that was needed in post-communist countries was completely different from any other economic reform ever conducted. It was not essential to privatize only some sectors, eliminate some regulations and state interventions or liberate existing market forces – what was needed was to lay the very foundations of capitalism. This proved to be a hard and costly task. As a matter of fact, there is no such thing as a free reform. Change of the whole system was very expensive. The transformation costs consisted mainly of the loss of output (and income), of the fundamental redistribution of gains and losses in society, and of the increase of inequality in income and wealth. The costs had to be paid by citizens of transitive countries themselves; the contribution of the rest of the world was marginal.

[3] This study is concerned with Central and Eastern European countries (Albania, Bulgaria, Croatia, Czech Republic, Hungary, Macedonia, Poland, Romania, Slovak Republic, and Slovenia). Serbia & Montenegro and Bosnia & Herzegovina are not included in the analysis due to data availability problems. Attention is also paid to countries of the former Soviet Union (Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, and Uzbekistan), from among which a group of Baltic economies (Estonia, Latvia, and Lithuania) is distinguished.

At the beginning of the reform process, it was rather generally expected that the output would go down due to both macroeconomic stabilization and reallocation of resources from unproductive sectors to those that could be profitable at world prices. Indeed, according to Fisher and Sahay (2000), output declined on average by 28 percent in Central and Eastern European countries (CEEC)[4], by 43 percent in the Baltics, and by 54 percent in the other countries of former Soviet Union (OCFSU). Output had bottomed out by 1992 in CEEC, by 1994 in the Baltics, and by 1995 in OCFSU. To illustrate the seriousness of output decline, one has to note that even by 1998 it was only Poland, Slovakia, and Slovenia to have surpassed their 1989 output levels.

**Table 2.1: Stabilization Programs and Inflation in Transitive Economies.**

| Country | Stabilization Program Started in | Pre-Program Inflation[a], % | Exchange Regime Adopted[b] | Maximum Annual Inflation, % | Year of Highest Inflation | Inflation in 2002, % |
|---|---|---|---|---|---|---|
| **Albania** | August 1992 | 293 | Flexible | 237 | 1992 | 6 |
| **Armenia** | December 1994 | 1885 | Flexible/Fixed | 10896 | 1993 | 1 |
| **Azerbaijan** | January 1995 | 1651 | Flexible/Fixed | 1787 | 1994 | 3 |
| **Belarus** | November 1994 | 2180 | Flexible/Fixed | 1997 | 1993 | 43 |
| **Bulgaria** | February 1991 | 245 | Flexible | 579 | 1997 | 2[c] |
| **Croatia** | October 1993 | 1903 | Fixed | 2585 | 1989 | 2 |
| **Czech Republic** | January 1991 | 46 | Fixed | 52 | 1991 | 0[c] |
| **Estonia** | June 1992 | 1086 | Fixed | 947 | 1992 | 1[c] |
| **Georgia** | September 1994 | 56476 | Flexible/Fixed | 7486 | 1993 | 5 |
| **Hungary** | March 1990 | 26 | Fixed | 35 | 1990 | 4[c] |
| **Kazakhstan** | January 1994 | 2315 | Flexible/Fixed | 2961 | 1992 | 6 |
| **Kyrgyz Republic** | May 1993 | 934 | Flexible/Fixed | 958 | 1992 | 2 |
| **Latvia** | June 1992 | 818 | Flexible/Fixed | 1162 | 1992 | 3[c] |
| **Lithuania** | June 1992 | 709 | Flexible/Fixed | 1162 | 1992 | -1[c] |
| **Macedonia** | January 1994 | 248 | Fixed | 1780 | 1992 | 1 |
| **Moldova** | September 1993 | 1090 | Flexible | 2198 | 1992 | 6 |
| **Poland** | January 1990 | 1096 | Fixed | 640 | 1989 | 1[c] |
| **Romania** | October 1993 | 314 | Flexible | 295 | 1993 | 15[c] |
| **Russia** | April 1995 | 218 | Flexible/Fixed | 2510 | 1992 | 15 |
| **Slovak Republic** | January 1991 | 46 | Fixed | 58 | 1991 | 8[c] |
| **Slovenia** | February 1992 | 288 | Flexible | 247 | 1991 | 6[c] |
| **Tajikistan** | February 1995 | 73 | Flexible | 7344 | 1993 | 12 |
| **Turkmenistan** | Not started | - | - | 9743 | 1993 | 5 |
| **Ukraine** | November 1994 | 645 | Flexible/Fixed | 10155 | 1993 | -1 |
| **Uzbekistan** | November 1994 | 1555 | Flexible | 1281 | 1994 | 26 |

[a] Inflation in the twelve months prior to the month of the stabilization program.
[b] Fixed regimes include a currency board, a peg at a fixed rate or a narrow crawling band. Flexible regimes include a free regime or a managed floating. Countries with flexible/fixed exchange rate regimes started with flexible regime, but soon adopted a peg or currency board or announced an exchange rate corridor.
[c] Preliminary figure for 2003.
Source: [10], [27], [30].

[4] Decline by 28 percent means that GDP kept falling down until it reached 72 percent of 1989 GDP level and only then started to grow.

Most countries entered the transition process with a monetary overhang and the need for price liberalization. Inflation was a major threat. Starting with Poland in 1990, stabilization packages had been put in place by 1995 in all countries but Turkmenistan. Depending on the extent of the monetary overhang and the delay in starting a stabilization program, the 12-month pre-stabilization inflation rates varied widely: from the hyperinflationary 56 500 percent per annum in Georgia to 26 percent in Hungary (see Table 2.1). By now, inflation rates had been brought down to single digits in most countries. Inflation stabilization is one of the major successes of the transition process.

The choice of exchange rate regime was an important part of the initial stabilization strategy. CEEC and the Baltics chose a mix of fixed (Croatia, Czech Republic, Estonia, Hungary, Poland, and Slovakia) and flexible (Albania, Bulgaria, Macedonia, Latvia, Lithuania, Romania, and Slovenia) regime while OCFSU chose a flexible regime at the start of their programs. Soon after starting the stabilization programs, however, OCFSU de facto adopted a peg to dollar or deutsche mark. Several countries undertook monetary reforms and introduced new currencies. Lithuania in April 1994 and Bulgaria in July 1997 instituted currency boards[5]. Latvia pegged to the SDR in February 1994. Russia and Ukraine announced narrow exchange rate corridors in 1995. With most exchange rates either explicitly or implicitly fixed, inflation rates declined rapidly. After a few years, almost all countries adopted flexible regimes. The dangers of not entering flexible arrangement in time in the context of unsustainable fiscal policies and high capital mobility are well exemplified by the Russian case.

At the time of transition, fiscal balances had also deteriorated sharply. According to Fisher and Sahay (2000), the average fiscal deficit in OCFSU worsened to more than 15 percent of GDP in 1992, in CEEC it worsened to 4 – 5 percent, while in the Baltics the fiscal balance went from a surplus of more than 5 percent to nearly zero. As stabilization programs were implemented, the fiscal balance improved sharply in the OCFSU, worsened moderately in the CEEC, and slightly in the Baltics.

For the transition economies, fiscal deficits in the initial years were almost inevitable. While it was clear that hard budget constraints would need to be imposed on state enterprises, the scope for raising revenues in the short-run was limited. Traditional tax systems and the institutional setup for collecting revenues had collapsed. Consequently, revenues declined sharply. On the other

[5] Currency board is an institution that issues notes and coins convertible on demand and at a fixed rate into a foreign currency or other external "reserve" asset. Currency board regime of exchange rate is a system of fixed exchange rates (currency board exchanges its notes and coins for an external reserve asset and vice versa at a fixed rate).

hand, demands on expenditures were high as investments in reforms undertaken by the state could not be postponed. Also, despite the financing constraints, spending on human capital (education and health) was not cut. Since public debt was generally low and GDP growth potential was high, a relatively long period of sustained fiscal deficits was consistent with successful stabilization. However, the stabilization process was not sustained in countries that had persistent fiscal deficits and slow structural reforms. The problem of budgetary arrears, significant in some countries, has posed major threats to stability and budget discipline in both the public and private sectors.

At the start of the transition process, the economic characteristics of former communist countries varied widely. The OCFSU were less familiar with market-based institutions than the Baltics and the CEEC, having had 20 – 30 years more of communist rule. In terms of per capita income, the CEEC were on average better than OCFSU and Baltics. Geographical position of the Baltics and the CEEC was more favourable than that of OCFSU to reorient their trade towards the industrialized countries. Macroeconomic imbalances were worse in the countries of former Soviet Union than in the CEEC. Czechoslovakia started with the best macroeconomic conditions, while Bulgaria, Croatia, Hungary, and Poland had inherited large external debts. Following the break-up of the Soviet Union, Russia assumed all the Soviet era foreign debt, thus freeing other countries from past external obligations.

Having differed in the initial macroeconomic characteristics, each country pursued its own transition strategy. However, it was common to note by then that rapid policy actions were only possible in some areas of reform - price and trade liberalization, inflation stabilization, and small scale privatization - but in others it was clear that reform would take a long time. As for reform sequencing, some reforms were seen as preconditions for others – for instance, privatization would fail unless the right legal framework or financial system or both were in place, and price decontrol should not take place until macroeconomic stabilization could be assured.

Debates on privatization strategy focused mainly on the speed with which it should occur and the form it should take (mass privatization versus direct sales). Within each country, there was generally a discussion of whether foreigners should be allowed to buy shares. The main arguments centred on the need to separate the firms quickly from the state, to stop asset stripping, and to avoid newly formed vested interest groups from blocking privatization later on.

It was taken for granted by most proponents of reform that external financial assistance would be needed at the early stages to encourage reform and help sustain the reformers. External technical

assistance would also be necessary in light of the lack of experience in the running of a market economy and its institutions of control. Despite much talk of a Marshall Plan, financial assistance on a massive scale simply did not materialize. The tasks of external financial and technical assistance were assigned largely to the international financial institutions, whose number was augmented by the creation of the European Bank for Reconstruction and Development (EBRD). Advice from well-known academics and bilateral technical and financial assistance, including from the EU, played a prominent part as well.

The distribution of financial inflows across post-communist countries has been highly uneven. According to Fisher and Sahay (2000), the CEEC and Baltics have received far more capital inflows per capita than the OCFSU. While the Baltics and CEEC were successful in attracting foreign direct investment, Russia (as the only country) on a net basis *exported* capital throughout the transition period.

On the other hand, some similarities across countries are revealed when considering the composition of financial inflows. As Fisher and Sahay (2000) point out, long-term inflows have been significantly higher than short-term inflows. In addition, there was a large recourse to exceptional financing (defined as debt forgiveness, restructuring, official aid) at the beginning of the transition period and a subsequent reorientation of capital flows towards FDI and other private flows. This validates the notion that provided reforms were implemented, official assistance could speedily be replaced by private sector inflows.

Taking stock, large external assistance that was expected to finance the reform process did not materialize. Instead, technical assistance combined with limited new official aid was given. Over time, private flows began to trickle in but became significant only in a limited set of countries, those that seemed to have the best records in the speed with which reforms were implemented.

To illustrate the policy change during the transition period, it is not sufficient to look at the inflation and fiscal data that summarize progress in macroeconomic stabilization. To measure the extent of structural reforms, one has to judge the degree of privatization and financial sector reforms, the extent of the market-oriented reforms of the external sector, and the degree of internal liberalization of prices and market, including the extent to which competition exists in the economy. According to the information provided by EBRD, early reformers of the CEEC (Croatia, Czech Republic, Hungary, Poland, Slovak Republic, and Slovenia) score highest in

terms of the extent and speed of reforms, followed by the Baltics, the later reformers of the CEEC, and then the OCFSU.

Privatization is often seen as a key element in the reform process. Taking its inherently time consuming nature into account, privatization did proceed at a fairly rapid pace in most countries, whether by privatizing state owned firms or by the emergence of the new sector. Some countries chose the mass privatization route (such as Czechoslovakia and Russia) with the use of vouchers, while others chose to and were able to sell enterprises (Hungary and Poland). Several conclusions have emerged. At a general level, the imposition of hard budget constraints on enterprises, whether public or private, appears to be an important determinant for successful privatization. Country experiences indicate that insider privatization, whether worker controlled (as in the former Yugoslavia) or manager controlled (as in Russia), does not seem to have led to self-induced restructuring, as expected. On the other hand, small-scale privatization (by voucher or by sale to insiders) was generally successful.

Market economy requires an institutional infrastructure of laws, regulations, accounting procedures, markets, and the institutions to enforce them, including a judiciary. The need for legal reform, the creation of financial markets, the creation of a central bank and effective fiscal system, and other aspects of modern government were widely recognized from the start of the transition process. Considerable amounts of technical assistance in these areas were provided both by the international financial institutions and also bilaterally to all the transitive economies. Indeed, there has been some success in reducing corruption via limiting opportunities for rent-seeking by reducing excessive and complex regulations, such as licensing requirements and various tax exemptions, as well as by engaging in civil service reforms. The outcomes have, nonetheless, differed to a great extent, with corruption and governance problems apparently endemic in some countries, and far less prevalent in others.

There can be little doubt that the absence of a predictable legal framework has hindered growth, most visibly by reducing the flow of foreign investment, but no less importantly by reducing domestic investment and encouraging capital flight. The cure for these problems lies mainly in domestic politics but external assistance to encourage transparency and strengthen institutions, and the conditioning of future assistance on progress in these areas can contribute.

Summing up, post-communist countries had to implement a set of diverse but interdependent economic reforms in the transition process. The measures taken were aimed at liberalization of

prices and foreign trade, stabilization of inflation (leading to subsequent macroeconomic stabilization), enterprise privatization and restructuring, and bank consolidation and privatization, while legislative together with institutional reform was crucial, too. Historical experience revealed that countries which took these measures consistently and relatively fast were those to subsequently report best achievements in economic performance. However, many reforms failed or had very high costs because of their partiality and because of the time inconsistency problem connected with the fact that individual reform measures have different time dimensions. Still, for many countries, the prospect of joining the European Union has served as a powerful spur to reform. The absence of that prospect for most countries of the former Soviet Union could play a non-negligible role in retarding reform.

The experience accumulated in the past decade provides support for the view that the most successful transitive economies are those that have both stabilized and undertaken comprehensive reforms, and that more and faster reform is better than less and slower reform. As can be seen from the above account (or can also be illustrated by more specific information contained in Appendix I), much was achieved but much still remains a challenge.

# 3 Convergence

> *„Classical convergence refers to an empirical specification based on the Solow-Swan economic growth model. The central hypothesis is that diminishing returns to investment cause the growth rate of a country to decline as it approaches its steady state level of capital per unit of effective labour – implying that, ceteris paribus, richer economies grow slower than poorer economies.“*
>
> *Dowrick, S. – Rogers, M. (2001)*

## 3.1 Theory behind: The Solow-Swan Model

The Solow-Swan model provides a theoretical framework from which all convergence analyses as well as the convergence concept itself emerge as a natural implication of the theory. The model considers a household/producer who owns the inputs (physical capital *K*, labour *L*) and also manages the technology that transforms inputs into outputs (aggregate output *Y*). The process of transforming inputs into outputs is captured formally by production function

$$Y = F(K, L). \tag{3.1.1}$$

The Solow-Swan model operates with *neoclassical* production function which satisfies following three properties. First, for all $K > 0$ and $L > 0$, *F(.)* exhibits positive and diminishing marginal products with respect to each input:

$$\frac{\partial F}{\partial K} > 0, \qquad \frac{\partial^2 F}{\partial K^2} < 0,$$

$$\frac{\partial F}{\partial L} > 0, \qquad \frac{\partial^2 F}{\partial L^2} < 0. \tag{3.1.2}$$

Second, *F(.)* exhibits constant returns to scale:

$$F(\lambda K, \lambda L) = \lambda \cdot F(K, L) \qquad \text{for all } \lambda > 0. \tag{3.1.3}$$

Third, marginal product of each input approaches infinity as input goes to zero and approaches zero as input goes to infinity:

$$\lim_{K \to 0}(F_K) = \lim_{L \to 0}(F_L) = \infty,$$

$$\lim_{K \to \infty}(F_K) = \lim_{L \to \infty}(F_L) = 0. \tag{3.1.4}$$

These last properties are called Inada conditions.

The condition of constant returns to scale implies that output can be written as

$$Y = F(K, L) = L \cdot F(K / L, 1) = L \cdot f(k), \tag{3.1.5}$$

where $k \equiv K / L$ is the capital/labour ratio. If $y \equiv Y / L$ is per capita output and the function $f(k)$ is defined to equal $F(K, 1)$, then the production function can be expressed in its intensive form as

$$y = f(k). \tag{3.1.6}$$

The Solow-Swan model assumes a one-sector production technology in which output (*Y*) is a homogenous good that can be consumed (*C*), or invested (*I*) to create new units of physical capital (*K*). Since the model operates within a framework of a closed economy, output equals income, and the amount invested equals the amount saved. Let $s = const > 0$ be the fraction of output that is saved (the saving rate) so that $1 - s$ is the fraction that is consumed. Let further $\delta = const > 0$ denote the rate of capital depreciation. Then, the net increase in the stock of physical capital at a point in time equals gross investment less depreciation:

$$\dot{K} = I - \delta K = s \cdot F(K, L) - \delta K, \tag{3.1.7}$$

where $\dot{K}$ stands for derivative of *K* with respect to time, and $0 \le s \le 1$. Equation (3.1.7) determines the dynamics of *K* for a given labour force *L*.

The labour force (*L*) varies over time because of population growth, changes in participation rates, and shifts in the amount of time worked by the typical worker. The growth of population reflects, in turn, the behaviour of fertility, mortality, and migration. Due to simplicity reasons, the model assumes that population grows at a constant, exogenous rate, $\dot{L} / L = n \ge 0$, and that everyone works at a given intensity, while all other effects (such as migration) are neglected. If the number of people at time 0 is normalized to 1 and the work intensity per person is normalized to 1, too, then the population and labour force evolves in time according to the following equation:

$$L(t) = e^{nt}. \tag{3.1.8}$$

Equation (3.1.7) defines the change in the capital stock over time. After dividing both sides of the expression by *L*, one obtains:

$$\dot{K} / L = s \cdot f(k) - \delta k. \tag{3.1.9}$$

Since

$$\dot{k} \equiv \frac{d(K / L)}{dt} = \frac{\dot{K} L - K \dot{L}}{L^2} = \dot{K} / L - nk, \tag{3.1.10}$$

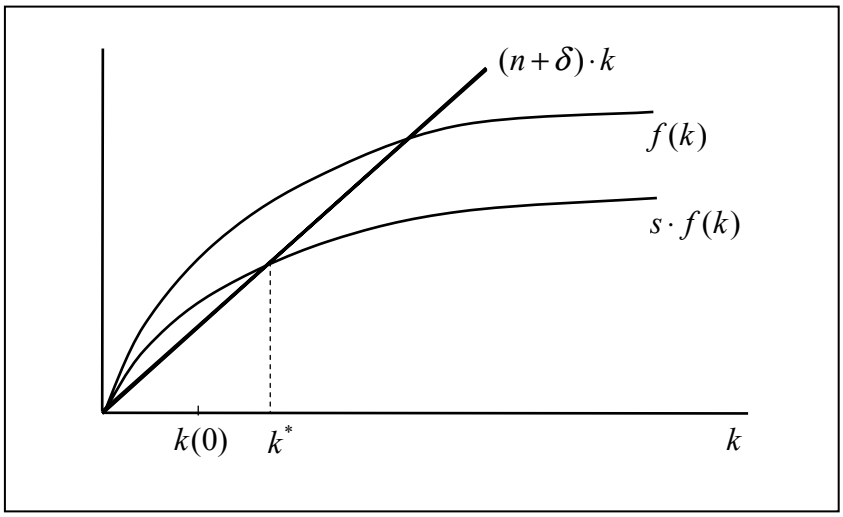
equation (3.1.9) can be written as:

$$\dot{k} = s \cdot f(k) - (n + \delta) \cdot k \,, \qquad (3.1.11)$$

which is called the *fundamental differential equation* of the Solow-Swan model. This nonlinear equation depends only on *k*.

The term $n + \delta$ on the right-hand side of equation (3.1.11) can be considered the effective depreciation rate for the capital/labour ratio *k*. In a situation with zero savings (saving rate $s = 0$), *k* would decline partly due to depreciation of *K* at the rate of $\delta$ and partly due to growth of *L* at the rate of $n$.

**Figure 3.1.1: The Solow-Swan Model.**




Source: [2].

Figure 3.1.1 shows the workings of equation (3.1.11). The curve for gross investment $s \cdot f(k)$ is proportional to the production function $f(k)$. Effective depreciation of *k* is given by a straight line $(n + \delta) \cdot k$. The change in *k* (i.e. $\dot{k}$) is seen as the vertical distance between $s \cdot f(k)$ and $(n + \delta) \cdot k$. The steady-state level of capital ($k^*$) is determined at the intersection[6] of the $s \cdot f(k)$ curve with the $(n + \delta) \cdot k$ line[7].

[6] The intersection in the range of positive *k* exists and is unique because $f(0) = 0$, $n + \delta < \lim_{k \to 0}[s \cdot f'(k)] = \infty$, $n + \delta > \lim_{k \to \infty}[s \cdot f'(k)] = 0$, and $f''(k) < 0$.

[7] Steady state is defined as a situation in which various quantities grow at constant rates. In the Solow-Swan model, the steady state corresponds to $\dot{k} = 0$ in equation (3.1.11). It can be easily shown as follows. Dividing both sides of

Thus, the steady-state value of capital ($k^*$) algebraically satisfies the condition

$$s \cdot f(k^*) = (n+\delta) \cdot k^* . \qquad (3.1.12)$$

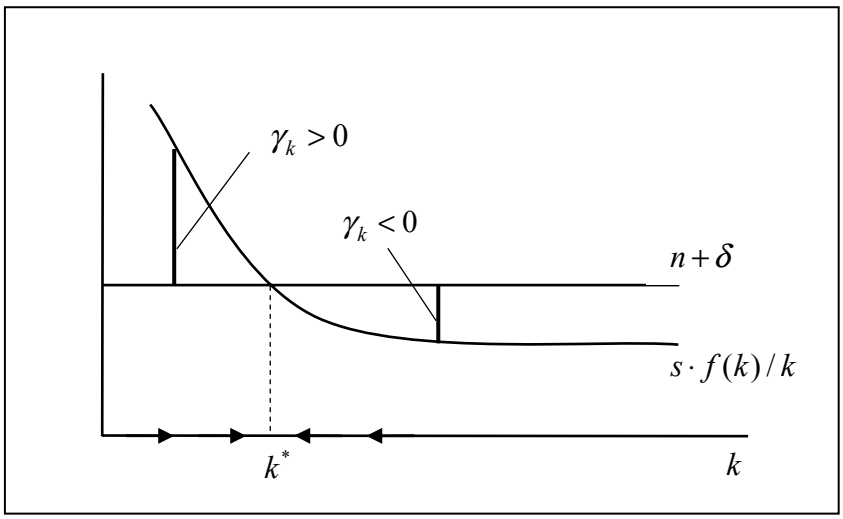
Since $k$ is constant in the steady state, $y$ and $c$ are also constant at the values $y^* = f(k^*)$ and $c^* = (1-s) \cdot f(k^*)$, respectively. Hence, in the Solow-Swan model, the per capita quantities $k$, $y$, and $c$ do not grow in the steady state. The constancy of the per capita magnitudes means that the variables $K$, $Y$, and $C$ grow in the steady state at the rate of population growth ($n$). Growth rates of per capita output, capital, and consumption are equal to zero in the steady state. For this reason, the Solow-Swan model does not provide explanations of the determinants of long-run per capita growth.

The model does, however, have more interesting implications about transitional dynamics. This transition shows how an economy's per capita income converges toward its own steady-state value and to the per capita incomes of other economies.

Dividing both sides of equation (3.1.11) by $k$, one obtains an expression for the growth rate of $k$:

$$\gamma_k \equiv \dot{k}/k = s \cdot f(k)/k - (n+\delta) . \qquad (3.1.13)$$

**Figure 3.1.2: Dynamics of the Solow-Swan Model.**




Source: [2].

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equation (3.1.11) by $k$ one obtains $\dot{k}/k = s \cdot f(k)/k - (n+\delta)$. According to the definition of steady state, the left-hand side ($\dot{k}/k$) is constant. Since $s$, $n$, and $\delta$ are constants, $f(k)/k$ must be constant in steady state. The time derivative of $f(k)/k$ equals $-\{[f(k) - k \cdot f'(k)]/k\} \cdot (\dot{k}/k)$. The expression $f(k) - k \cdot f'(k)$ stands for the marginal product of labour and is positive. Therefore, as long as $k$ is finite, $\dot{k}/k$ must be equal to zero in the steady state.

Figure 3.1.2 illustrates the dynamics of the Solow-Swan model. The growth rate of *k* equals the difference between two terms, $s \cdot f(k)/k$ and $(n+\delta)$. The first term is a downward-sloping[8] curve, which asymptotes to infinity at $k = 0$[9] and approaches zero as *k* tends to infinity[10]. Term $(n+\delta)$ is plotted as a horizontal line. The vertical distance between the curve and the line equals the growth rate of per capita capital. The crossing point corresponds to the steady state. Since $(n+\delta)$ is greater than zero and $s \cdot f(k)/k$ falls monotonically from infinity to zero, the curve and the line intersect once and only once. Hence, except for the trivial solution $k^* = 0$, the steady-state capital/labour ratio exists and is unique.

Figure 3.1.2 shows that if $k < k^*$, then the growth rate of *k* is positive and *k* increases toward $k^*$. If $k > k^*$, then the growth rate of *k* is negative and *k* decreases toward $k^*$. As a consequence of this, the steady-state per capita capital $k^*$ is stable. It also has to be noted that, along a transition from an initially low capital per person, the growth rate of *k* declines monotonically toward zero. As *k* increases, $\gamma_k$ declines and approaches zero as *k* approaches $k^*$.

The source of these results is the statement of diminishing returns to capital. When *k* is relatively low, the average product of capital, $f(k)/k$, is relatively high. By assumption, a constant fraction (*s*) of this product is saved and invested. Hence, when *k* is relatively low, gross investment per unit of capital, $s \cdot f(k)/k$, is relatively high. Capital per worker, *k*, effectively depreciates at a constant rate of $(n+\delta)$. Consequently, the growth rate, $\dot{k}/k$, is also relatively high.

However, the growth rate of capital per person is only one of several variables to focus attention on. Behaviour of output along transition from an initial toward the steady-state value is of interest, too. Growth rate of output per capita is given by

$$\gamma_y \equiv \dot{y}/y = f'(k) \cdot \dot{k}/f(k) = [f'(k) \cdot k / f(k)] \cdot \gamma_k . \qquad (3.1.14)$$

Relation between $\gamma_y$ and $\gamma_k$ depends on the form of production function $f(k)$. Cobb-Douglas production function,

---

[8] The derivative of $s \cdot f(k)/k$ with respect to *k* equals $-s \cdot [f(k) - kf'(k)]/k^2$. The expression in brackets is the marginal product of labour and is positive. Since $s > 0$, the derivative is negative.

[9] Applying l'Hôspital's rule one gets $\lim_{k \to 0}[s \cdot f(k)/k] = s \cdot \lim_{k \to 0}[f'(k)/1] = s \cdot \infty = \infty$.

[10] Applying l'Hôspital's rule one gets $\lim_{k \to \infty}[s \cdot f(k)/k] = s \cdot \lim_{k \to \infty}[f'(k)/1] = s \cdot 0 = 0$.

$$Y = AK^{\alpha}L^{1-\alpha}, \tag{3.1.15}$$

is often thought to provide a reasonable description of actual economies. $A > 0$ represents the level of technology; $\alpha$ is a constant satisfying condition $0 < \alpha < 1$. The Cobb-Douglas production function can be written in its intensive form as

$$y = Ak^{\alpha}. \tag{3.1.16}$$

In the Cobb-Douglas case, one simplifies the expression (3.1.14) to obtain

$$\gamma_y = [f'(k) \cdot k / f(k)] \cdot \gamma_k = \alpha \cdot \gamma_k. \tag{3.1.17}$$

Thus, $\gamma_y$ is the $\alpha$ fraction of $\gamma_k$, and – consequently – behaviour of $\gamma_y$ mimics that of $\gamma_k$.

As the level of consumption per capita is given by $c = (1-s) \cdot y$, and the saving rate *s* is constant, the growth rates of *y* and *c* are equal at all points of time in the Solow-Swan model. Consumption thus exhibits the same dynamics as output which in the Cobb-Douglas case copies the dynamics of capital. Therefore, further analyses concentrate on growth rate and dynamics of capital per person.

Differentiating the growth rate of per capita capital as given by equation (3.1.13) with respect to *k*, one obtains

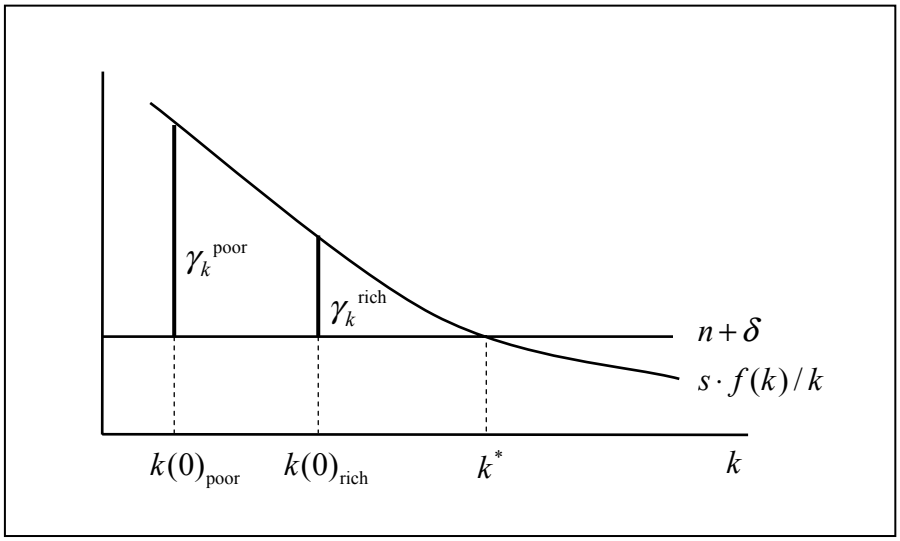
$$\frac{\partial \gamma_k}{\partial k} = -\frac{s}{k^2} \cdot [f(k) - k \cdot f'(k)] < 0.^{11} \tag{3.1.18}$$

As follows, other things equal, smaller values of *k* are associated with larger values of $\gamma_k$. Thus, economies with lower capital per person tend to grow faster in per capita terms. This result implies that there tends to be *convergence* across economies.

Indeed, if a group of closed economies that are structurally similar (they can be assigned the same values of parameters *s*, *n*, and $\delta$ and the production function takes form of $f(k)$ for all) is thought of, then these economies are said to have the same steady-state values $k^*$ and $y^*$. Provided that the only difference among economies is the initial quantity of capital per person, less-advanced economies with lower values of $k(0)$ and $y(0)$ display higher growth rates of *k*. In the case of Cobb-Douglas production function, the growth rate of *y* is also higher in more backward economies.

[11] Since the expression in brackets equals the marginal product of labour, which is positive, the derivative of $\gamma_k$ with respect to *k* is negative.

**Figure 3.1.3: Absolute Convergence in the Solow-Swan Model.**

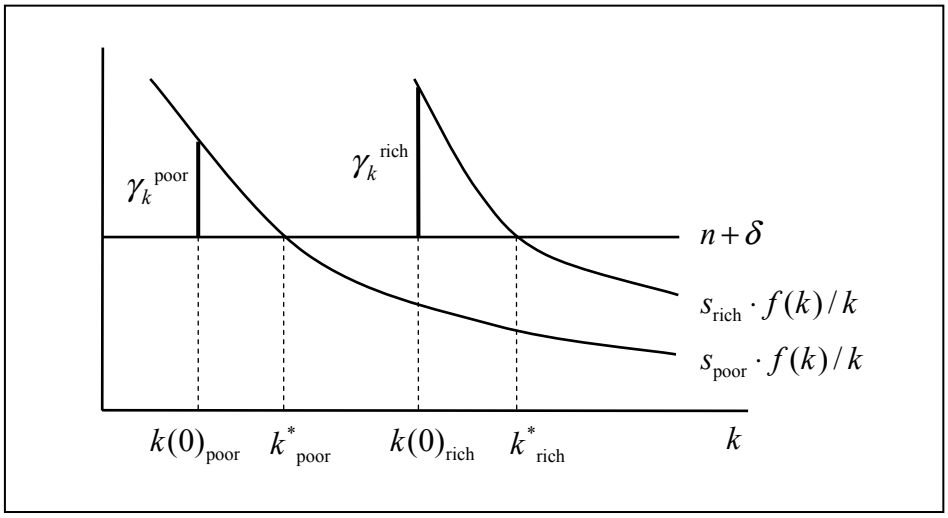



Source: [2].

Figure 3.1.3 introduces two economies that differ in initial values of $k$ – one has low, $k(0)_{\text{poor}}$, while the other has high, $k(0)_{\text{rich}}$, initial value of $k$. Since both economies are characteristic of the same underlying parameters, the dynamics of $k$ are in both cases determined by the same $s \cdot f(k)/k$ and $n+\delta$ curves. Hence, growth rate $\gamma_k$ is explicitly larger for the poorer economy. This result implies a form of convergence: regions or countries with lower starting values of capital/labour ratio have higher per capita growth rates and tend thereby to catch up or converge to those countries that initially have higher capital/labour ratios. The hypothesis that poor economies tend to grow faster (in per capita terms) than rich ones, without conditioning on any other characteristics of economies, is referred to as *absolute convergence*.

If heterogeneity across economies is allowed for, particularly if the assumption of all economies having the same parameters (and therefore the same steady states) is dropped, then the concept of *conditional convergence* emerges. Once economies differ in their steady states, each one grows faster the further it is from its own steady state.

**Figure 3.1.4: Conditional Convergence in the Solow-Swan Model.**




Source: [2].

Figure 3.1.4 again introduces two economies. This time, however, economies differ not only in initial values of $k$ ($k(0)_{\text{poor}} < k(0)_{\text{rich}}$), but also in saving-rate values ($s_{\text{poor}} < s_{\text{rich}}$). Holding $n$ and $\delta$ the same for both economies and following previous analysis, it is obvious that the steady-state values of capital per person display the same relationship as saving rates, i.e. $k^*_{\text{poor}} < k^*_{\text{rich}}$. Considering such initial values of $k$ as given in Figure 3.1.4, it is possible that the rich economy may be proportionally further from its steady-state position than the poor economy. As a consequence of this, the rich economy is predicted to grow faster in per capita terms than the poor economy.

As $\gamma_k^{\text{poor}} < \gamma_k^{\text{rich}}$ in Figure 3.1.4, absolute $\beta$ convergence does not hold for economies that differ in fundamental characteristics. The Solow-Swan model does not predict convergence in all circumstances; a poor country may grow at a slower rate than a rich one. What the neoclassical model does predict is that each economy converges toward its own steady state and that the speed of this convergence is inversely related to the distance from the steady state. In other words, the model predicts conditional convergence in the sense that a lower starting value of real per capita income tends to generate higher per capita growth rate once the determinants of the steady state are controlled for.

As can partly be seen from equation (3.1.12), the steady-state value of $k$ depends on the saving rate $s$, the level of the production function $f(.)$, and on various government policies that effectively shift the position of production function. It is these determinants of $k^*$ to be held

constant in order to isolate the predicted inverse relationship between growth rates and initial positions.

The Solow-Swan model as presented so far assumed that the level of technology is constant over time. As a result, all per capita variables turned out to be constant in the long run. This feature of the model is not at all plausible since positive per capita growth rates have been recorded for a broad section of economies for over 100 years. In the absence of technological progress, diminishing returns would have made it impossible to maintain per capita growth for so long just by accumulating more capital per worker. This problem can be solved by amending the basic model to allow for the technology to improve over time. These improvements provide an escape from diminishing returns and thus enable economy to grow in per capita terms in the long run.

The way to incorporate technological progress into the basic Solow-Swan model is to enrich the definition of the production function. The production function that includes so-called labour-augmenting[12] technological progress can be written in the form

$$Y = F[K, L \cdot A(t)], \tag{3.1.19}$$

where $A(t)$ is the technological index satisfying the condition $\dot{A}(t) \geq 0$.

Let the technological term $A(t)$ grow at a constant rate *x* and let a new variable $\hat{L}$, $\hat{L} \equiv L \cdot A(t)$, be defined as the physical quantity of labour multiplied by its efficiency ($\hat{L}$ is referred to as the effective amount of labour). Then $\hat{k}$, $\hat{k} \equiv \frac{K}{L \cdot A(t)}$, is the capital per unit of effective labour and $\hat{y}$, $\hat{y} \equiv \frac{Y}{L \cdot A(t)}$, is the output per unit of effective labour. Hence, the production function in its intensive form is given by

$$\hat{y} = F(\hat{k}, 1) = f(\hat{k}). \tag{3.1.20}$$

Following the same procedure as was applied in the case of production function without technological progress (expression (3.1.5)), one obtains the *fundamental differential equation* of the model in the form

$$\dot{\hat{k}} = s \cdot f(\hat{k}) - \hat{k} \cdot (\delta + n + x).^{13} \tag{3.1.21}$$

[12] Technological progress defined in this way is called labour-augmenting because it raises output in the same way as an increase in the stock of labour.

The effective depreciation rate for $\hat{k}$ is given by $(\delta + n + x)$. If the saving rate were zero, then $\hat{k}$ would decline partly due to depreciation of *K* at the rate $\delta$ and partly due to growth of $\hat{L}$ at the rate $n + x$.

Dividing both sides of equation (3.1.21) by $\hat{k}$ one obtains an expression for the growth rate of $\hat{k}$:

$$\gamma_{\hat{k}} \equiv \dot{\hat{k}} / \hat{k} = s \cdot f(\hat{k}) / \hat{k} - (\delta + n + x). \tag{3.1.22}$$

Furthermore, the steady-state value of capital ($\hat{k}^*$) algebraically satisfies the condition

$$s \cdot f(\hat{k}^*) = (\delta + n + x) \cdot \hat{k}^*. \tag{3.1.23}$$

In the steady state, the variables $\hat{k}$, $\hat{y}$, and $\hat{c}$ are constant. As follows, the per capita variables *k*, *y*, and *c* grow in the steady state at the exogenous rate of technological progress, *x*.

The transitional dynamics of $\hat{k}$ are qualitatively similar to those of *k* in the original model without technological progress. The relation between the initial value of $\hat{k}$ and the growth rate of $\hat{k}$, as well as the whole convergence analysis, can be repeated accordingly.

An interesting point to investigate is the speed of transitional dynamics. To assess the speed of convergence quantitatively, the form of production function needs to be specified. As before, the Cobb-Douglas production function, given by equation (3.1.15), is used throughout the analysis.

Using equation (3.1.22), the growth rate of $\hat{k}$ in the Cobb-Douglas case can be determined as

$$\gamma_{\hat{k}} = s \cdot A \cdot (\hat{k})^{\alpha - 1} - (\delta + n + x). \tag{3.1.24}$$

A log-linear approximation of equation (3.1.24) around the steady state results in:

$$\gamma_{\hat{k}} = \frac{d[\log(\hat{k})]}{dt} \cong -\beta \cdot [\log \frac{\hat{k}}{\hat{k}^*}],^{14} \tag{3.1.25}$$

---

[13] Dividing $\dot{K} = s \cdot F(K, L \cdot A) - \delta \cdot K$ by $(L \cdot A)$ gives $\frac{\dot{K}}{L \cdot A} = s \cdot f(\hat{k}) - \delta \cdot \hat{k}$. Since $\dot{\hat{k}} = \frac{d[K/(L \cdot A)]}{dt} = \frac{\dot{K} \cdot L \cdot A - K \cdot (\dot{L} \cdot A + L \cdot \dot{A})}{L^2 \cdot A^2} = \frac{\dot{K}}{L \cdot A} - \hat{k} \cdot (n + x)$, $\dot{\hat{k}}$ satisfies equation (3.1.21).

[14] To obtain equation (3.1.25), one has to rewrite equation (3.1.24) in terms of $\log(\hat{k})$. It is to be noted that $\gamma_{\hat{k}}$ is the time derivative of $\log(\hat{k})$, and that $(\hat{k})^{\alpha - 1}$ can be written as $e^{-(1-\alpha) \cdot \log(\hat{k})}$. The steady-state value of $s \cdot A \cdot (\hat{k})^{\alpha - 1}$ equals $(\delta + n + x)$. Taking a first-order Taylor expansion of $\log(\hat{k})$ around $\log(\hat{k}^*)$, one gains the form of equation (3.1.25).

where coefficient $\beta$ is defined as

$$\beta = (1-\alpha)\cdot(\delta + n + x)\,. \qquad (3.1.26)$$

The coefficient $\beta$ determines the speed of convergence from $\hat{k}$ to $\hat{k}^*$. It also indicates how rapidly an economy's output per effective worker, $\hat{y}$, approaches its steady-state value, $\hat{y}^*$.[15]

According to the equation (3.1.26), the speed of convergence ($\beta$) is not affected by the saving rate *s*, and is also independent of the level of the technology *A*. Setting benchmark values of parameters that enter into expression (3.1.26) at empirically reasonable levels of $x = 0.02$, $n = 0.01$, $\delta = 0.05$, and $\alpha = 1/3$, coefficient $\beta$ can be calculated to amount to 5.6 percent per year. As will be discussed later, previously conducted empirical studies do not support such a high speed of convergence. Rather, data reveal a convergence coefficient in the range of 1.5 – 3.0 percent per year. To accord with an observed convergence rate of about 2 percent per year, the neoclassical model requires a much higher capital-share coefficient $\alpha$, $\alpha = 3/4$. Although the capital share of 0.75 is too high for a narrow concept of physical capital, this share is reasonable for an expanded measure that also includes human capital. Thus, with a broader concept of capital, the Solow-Swan model can generate the rates of convergence that are empirically relevant.

[15] The coefficient $\beta$ also applies to the growth rate of $\hat{y}$. In case of Cobb-Douglas production function, $\gamma_{\hat{y}} = \alpha \cdot \gamma_{\hat{k}}$, and $\log(\hat{y}/\hat{y}^*) = \alpha \cdot \log(\hat{k}/\hat{k}^*)$. Substituting these formulae into the equation (3.1.25), one gets $\gamma_{\hat{y}} \cong -(1-\alpha)\cdot(\delta + n + x)\cdot[\log\frac{\hat{y}}{\hat{y}^*}]$, which has the same form as equation (3.1.25). Therefore, the coefficient $\beta$ for $\hat{y}$ is the same as for $\hat{k}$.

## *3.2 Empirical Specification*

Two concepts of convergence appear in discussions of economic growth across countries. In one view, convergence applies if economies that are further from their steady states grow faster than those that are nearer to their steady states. This corresponds to the concept of $\beta$ convergence. The second concept concerns cross-sectional dispersion. In this respect, convergence occurs if the dispersion – measured in any of possible ways – declines over time. This process is referred to as $\sigma$ convergence. Convergence of the first kind tends to generate convergence of the second kind; however, the relationship between the two concepts of convergence is not that straightforward.

### *β convergence*

Measurement of $\beta$ coefficient rests profoundly on the theory of the Solow-Swan model of economic growth. However, the empirical specification offered by Barro and Sala-i-Martin (1995) goes beyond this framework of exogenous and constant saving rates. It enriches the theoretical background with the assumption that the saving rate and consumption are determined by optimizing households and firms that interact on competitive markets. Households choose the level of consumption to maximize their dynastic utility, subject to an intertemporal budget constraint. Such a specification of consumer behaviour acts as a key element in Ramsey growth model as constructed by Ramsey in 1928.[16]

Let the adult population $L$ be given by $L(t) = e^{nt}$. If $C(t)$ is total consumption at time $t$, then $c(t)$, $c(t) \equiv C(t) / L(t)$, is consumption per adult person. Each household maximizes overall utility $U$, which is given by

$$U = \int_0^{\infty} u[c(t)] \cdot e^{nt} \cdot e^{-\rho t} dt, \qquad (3.2.1)$$

where the utility function $u(c)$[17] relates the flow of utility per person to the quantity of consumption per person. Parameter $\rho$, $\rho > 0$, represents the rate of time preference. It is assumed that $\rho > n$.

There are two forms of capital - assets and loans, both of which pay the same real rate of return $r(t)$. Let $a(t)$ denote the net household's assets per person measured in real terms. Households take

[16] As it is not an aim of this paper to introduce another growth model in detail, only a short summary of key steps of the model construction follows.
[17] Function $u(c)$ is increasing in $c$, concave, and satisfies the Inada conditions.

*r(t)* and *w(t)*, the wage rate paid per unit of labour services, as given. Total income per capita received by a household is the sum of labour income and financial or interest income. The flow budget constraint for a household is therefore

$$\dot{a} = w + r \cdot a - c - n \cdot a \,. \tag{3.2.2}$$

The household's optimization problem is to maximize $U$ in equation (3.2.1), subject to the restriction (3.2.2), the stock of initial assets *a(0)*, and the following limitation on borrowing:

$$\lim_{t \to \infty} \left\{ a(t) \cdot \exp\left[ -\int_0^t [r(v) - n] dv \right] \right\} \geq 0 \,. \tag{3.2.3}$$

Solving the problem using the present-value Hamiltonian provides the basic condition for choosing consumption over time:

$$r = \rho - \frac{du'/dt}{u'} = \rho - \frac{u''(c) \cdot c}{u'(c)} \cdot \frac{\dot{c}}{c} \,. \tag{3.2.4}$$

Equation (3.2.4) says that households choose consumption so as to equate the rate of return, *r*, to the rate of time preference, $\rho$, plus the rate of decrease of the marginal utility of consumption, $u'$, due to growing per capita consumption, *c*.

As the utility function is often thought of in the form of $u(c) = \frac{c^{1-\theta} - 1}{1 - \theta}$, the equation (3.2.4) can be rewritten as

$$\dot{c}/c = (1/\theta) \cdot (r - \rho) \,. \tag{3.2.5}$$

So far, the behaviour of households has been described. As for firms, they produce goods, pay wages, and make rental payments for capital input. Each firm has access to the production technology,

$$Y = F(K, \hat{L}) \,, \tag{3.2.6}$$

where $Y$ is the flow of output, $K$ is capital input, $L$ is labour input, and $\hat{L}$, $\hat{L} \equiv L \cdot A(t)$, is the effective amount of labour input, while *A(t)* is the level of technology growing at a constant rate $x \geq 0$. The function *F(.)* satisfies the neoclassical properties discussed in the Solow-Swan model.

If $\hat{y} \equiv \frac{Y}{\hat{L}}$ and $\hat{k} \equiv \frac{K}{\hat{L}}$, the production function writes itself in an intensive form as

$$\hat{y} = f(\hat{k}). \tag{3.2.7}$$

The representative firm's flow of profit, $\pi$, at any point in time is given by

$$\pi = F(K, \hat{L}) - (r + \delta) \cdot K - w \cdot L, \tag{3.2.8}$$

where $F(K, \hat{L})$ stands for gross receipts from the sale of output, $(r + \delta) \cdot K$ represents the rentals to capital, and $w \cdot L$ stands for wages paid to workers. Rewriting equation (3.2.8) in terms of variables per effective unit of labour, one gets

$$\pi = \hat{L} \cdot [f(\hat{k}) - (r + \delta) \cdot \hat{k} - w \cdot e^{-xt}. \tag{3.2.9}$$

A competitive firm, which takes *r* and *w* as given, maximizes its profit for given $\hat{L}$ by setting

$$f'(\hat{k}) = r + \delta, \tag{3.2.10}$$

that is, the firm chooses the ratio of capital to effective labour to equate the marginal product of capital to the rental price. In a full market equilibrium, *w* must be such that profit equals zero, namely:

$$w = \left[ f(\hat{k}) - \hat{k} \cdot f'(\hat{k}) \right] \cdot e^{xt}. \tag{3.2.11}$$

To characterize the structure of overall competitive market equilibrium, the behaviours of households and firms have to be combined. As the representative household must end up with zero net debt[18], assets per adult person, *a*, must equal capital per worker, *k*. The household's flow budget constraint in equation (3.2.2) determines $\dot{a}$. Applying $a = k$, $\hat{k} = k \cdot e^{-xt}$, and the conditions for *r* and *w* from equations (3.2.10) and (3.2.11), one obtains

$$\dot{\hat{k}} = f(\hat{k}) - \hat{c} - \hat{k} \cdot (\delta + n + x), \tag{3.2.12}$$

where $\hat{c} \equiv C / \hat{L} = c \cdot e^{-xt}$ and $\hat{k}(0)$ are given.

The differential equation (3.2.12) is the key relation that determines the evolution of $\hat{k}$ and, hence, $\hat{y} = f(\hat{k})$ over time. What is missing here, however, is the determination of $\hat{c}$. In the Solow-Swan model, the missing relation was provided for by the assumption of a constant saving rate, which implied the linear consumption function, $\hat{c} = (1 - s) \cdot f(\hat{k})$. In the present framework, the behaviour of saving rate is not so simple. However, equation (3.2.5) provides information on

[18] This is a closed-economy framework.

the growth of $c$. If the condition (3.2.10) is used together with the expression for $\hat{c}$, $\hat{c} = c \cdot e^{-xt}$, then one obtains

$$\dot{\hat{c}}/\hat{c} = \dot{c}/c - x = (1/\theta) \cdot [f'(\hat{k}) - \delta - \rho - \theta x]. \tag{3.2.13}$$

This equation, together with equation (3.2.12), forms a system of two differential equations in $\hat{c}$ and $\hat{k}$. This system, together with the initial condition, $\hat{k}(0)$, and the transversality condition[19], determines the time paths of $\hat{c}$ and $\hat{k}$.

In the Ramsey model, the steady-state growth rates of $\hat{c}$ and $\hat{k}$ must be zero, just as in the Solow-Swan model. As follows, the steady-state values of $\hat{c}$ and $\hat{k}$ are determined by setting the growth rates in equations (3.2.12) and (3.2.13) equal to zero.

To provide a quantitative assessment of the speed of convergence toward the steady-state in the Ramsey model, a log-linearized version of the dynamic system for $\hat{c}$ and $\hat{k}$ (equations (3.2.12) and (3.2.13)) is needed. The log-linearization is carried out for the Cobb-Douglas production function, $f(\hat{k}) = A \cdot (\hat{k})^{\alpha}$.

The first step is to rewrite the dynamic system in terms of $\log(\hat{c})$ and $\log(\hat{k})$:

$$\begin{aligned} d[\log(\hat{k})]/dt &= A \cdot e^{-(1-\alpha)\cdot\log(\hat{k})} - e^{\log(\hat{c}/\hat{k})} - (\delta + n + x) \\ d[\log(\hat{c})]/dt &= (1/\theta) \cdot [\alpha A \cdot e^{-(1-\alpha)\cdot\log(\hat{k})} - (\rho + \theta x + \delta)] \end{aligned} \tag{3.2.14}$$

In the steady state, where $d[\log(\hat{k})]/dt = d[\log(\hat{c})]/dt = 0$, it is true that

$$\begin{aligned} A \cdot e^{-(1-\alpha)\cdot\log(\hat{k}^*)} - e^{\log(\hat{c}^*/\hat{k}^*)} &= (\delta + n + x) \\ \alpha A \cdot e^{-(1-\alpha)\cdot\log(\hat{k}^*)} &= (\rho + \theta x + \delta) \end{aligned} \tag{3.2.15}$$

It is possible to take a first-order Taylor expansion of equation (3.2.14) around the steady-state values determined by equation (3.2.15):

$$\begin{aligned} &\begin{pmatrix} d[\log(\hat{k})]/dt \\ d[\log(\hat{c})]/dt \end{pmatrix} = \\ &= \begin{pmatrix} \zeta & \delta + n + x - (\rho + \theta x + \delta)/\alpha \\ -(1-\alpha)\cdot(\rho + \theta x + \delta)/\theta & 0 \end{pmatrix} \cdot \begin{pmatrix} \log(\hat{k}/\hat{k}^*) \\ \log(\hat{c}/\hat{c}^*) \end{pmatrix} \end{aligned} \tag{3.2.16}$$

---

[19] The transversality condition can be written in the form $\lim_{t\to\infty}\left\{\hat{k} \cdot \exp\left[-\int_0^t [f'(\hat{k}) - \delta - x - n]dv\right]\right\} = 0$. The transversality condition says that the value of household's assets must approach zero as time tends to infinity.

Parameter $\zeta$ is defined as $\zeta \equiv \rho - n - (1-\theta)\cdot x$.

The determinant of the characteristic matrix equals

$$-[(\rho+\theta x+\delta)/\alpha - (\delta+n+x)]\cdot(\rho+\theta x+\delta)\cdot(1-\alpha)/\theta. \qquad (3.2.17)$$

Since $\rho+\theta x > x+n$ (from the transversality condition) and $\alpha<1$, the determinant is negative. It implies that the two eigenvalues of the system have opposite signs, which guarantees the saddle-path stability. To compute the eigenvalues $\lambda$, one has to evaluate the expression

$$\det\begin{pmatrix} \zeta-\lambda & \delta+n+x-(\rho+\theta x+\delta)/\alpha \\ -(1-\alpha)\cdot(\rho+\theta x+\delta)/\theta & 0-\lambda \end{pmatrix} = 0. \qquad (3.2.18)$$

Solving the quadratic equation which results from equation (3.2.18), two eigenvalues are obtained in the form

$$2\lambda = \zeta \pm \left[\zeta^2 + 4\cdot\frac{1-\alpha}{\theta}\cdot(\rho+\theta x+\delta)\cdot[(\rho+\theta x+\delta)/\alpha - (\delta+n+x)]\right]^{1/2}. \qquad (3.2.19)$$

Let $\lambda_1$ denote the root with positive sign, which is positive, and $\lambda_2$ the root with negative sign, which is negative. The log-linearized solution for $\log(\hat{k})$ takes form

$$\log[\hat{k}(t)] = \log(\hat{k}^*) + \psi_1\cdot e^{\lambda_1 t} + \psi_2\cdot e^{\lambda_2 t}, \qquad (3.2.20)$$

where $\psi_1$ and $\psi_2$ are arbitrary constants of integration. Since $\lambda_1>0$, $\psi_1=0$ must hold for $\log[\hat{k}(t)]$ to tend asymptotically to $\log[\hat{k}^*]$. The other constant, $\psi_2$, is then determined from the initial condition:

$$\psi_2 = \log[\hat{k}(0)] - \log[\hat{k}^*]. \qquad (3.2.21)$$

Substituting values of $\psi_1$ and $\psi_2$ to the equation (3.2.20), the time path for $\log[\hat{k}(t)]$ is obtained:

$$\log[\hat{k}(t)] = (1-e^{\lambda_2 t})\cdot\log(\hat{k}^*) + e^{\lambda_2 t}\cdot\log[\hat{k}(0)]. \qquad (3.2.22)$$

Since $\log[\hat{y}(t)] = \log(A) + \alpha\cdot\log[\hat{k}(t)]$, the time path for $\log[\hat{y}(t)]$ is given by

$$\log[\hat{y}(t)] = (1-e^{\lambda_2 t})\cdot\log(\hat{y}^*) + e^{\lambda_2 t}\cdot\log[\hat{y}(0)]. \qquad (3.2.23)$$

If $\beta$ is defined as $2\beta = \left[ \zeta^2 + 4 \cdot \frac{1-\alpha}{\theta} \cdot (\rho + \theta x + \delta) \cdot [(\rho + \theta x + \delta)/\alpha - (\delta + n + x)] \right]^{1/2} - \zeta$, then $\lambda_2 = -\beta$[20]. The result (3.2.23) thus can be written in the form

$$\log[\hat{y}(t)] = e^{-\beta t} \cdot \log[\hat{y}(0)] + (1 - e^{-\beta t}) \cdot \log[\hat{y}^*], \tag{3.2.24}$$

where $\beta > 0$. Thus, for any $t \geq 0$, $\log[\hat{y}(t)]$ is a weighted average of the initial and steady-state values of $\hat{y}$, with the weight on the initial value declining exponentially at the rate $\beta$. Equation (3.2.24) means that the average growth rate of per capita output, $y$, over an interval from an initial time 0 to any future time $T \geq 0$ is given by

$$\frac{1}{T} \cdot \log[y(T)/y(0)] = x + \frac{1 - e^{-\beta T}}{T} \cdot \log[\hat{y}^*/\hat{y}(0)]. \tag{3.2.25}$$

If the steady-state growth rate, *x*, the convergence speed, $\beta$, and the averaging interval, *T*, are held constant, then the equation (3.2.25) says that the average per capita growth rate of output depends negatively on the ratio of $\hat{y}(0)$ to $\hat{y}^*$. Thus, as in the Solow-Swan model, the effect of initial position is conditioned on the steady-state position. To put it another way, the Ramsey model also predicts conditional rather than absolute convergence.

Equation (3.2.25) can be applied to discrete periods of unit length (e.g. years). Augmenting it to include also a random disturbance, one obtains

$$\log[y_{it}/y_{i,t-1}] = a + (-1 + e^{-\beta}) \cdot \log[y_{i,t-1}] + u_{it}, \tag{3.2.26}$$

where *t* denotes the year and *i* denotes the country or region. Theory implies that the intercept $a = x + (1 - e^{-\beta}) \cdot [\log(\hat{y}_i^*) + x \cdot (t-1)]$, where $\hat{y}_i^*$ is the steady-state level of $\hat{y}_i$. Random variable $u_{it}$ is assumed to have zero mean, variance $\sigma^2_{ut}$, and is distributed independently of $\log(y_{i,t-1})$, $u_{jt}$ for $j \neq i$, and lagged disturbances.

Considering that there are only two observations available (at times *0* and *T*), equation (3.2.26) implies that the average growth rate of output over the interval from *0* to *T* is given by

$$\frac{1}{T} \cdot \log[y_{iT}/y_{i0}] = a + \frac{-1 + e^{-\beta T}}{T} \cdot \log[y_{i0}] + u_{i0,T}, \tag{3.2.27}$$

[20] It can be shown that under an assumption of constant saving rate, the complicated formula for the speed of convergence, $\beta$, simplifies to the result that applied in the framework of the Solow-Swan model: $\beta = (1 - \alpha) \cdot (\delta + n + x)$.

where $u_{i0,T}$ represents the average of the error terms ($u_{it}$) between dates *0* and *T*, and the intercept *a* can be written as $a \equiv x + \frac{1-e^{-\beta T}}{T} \cdot \log[\hat{y}^*]$.

To state finally the way empirical data are to be tested for convergence, one can rewrite the equation (3.2.27) to obtain non-linear equation in the form

$$\frac{1}{T} \cdot \log[y_{it} / y_{i,t-T}] = a + \frac{-1+e^{-\beta T}}{T} \cdot \log[y_{i,t-T}], \qquad (3.2.28)$$

which has to be estimated in a regression. The expression $y_{i,t-T}$ stands for per capita income in state *i* at the beginning of the interval. Convergence occurs if $\beta$ is greater than zero and is statistically significant. To calculate $\beta$, the non-linear equation (3.2.28) can be linearized introducing a new parameter *b*, $b = \frac{-1+e^{-\beta T}}{T}$, as follows:

$$\frac{1}{T} \cdot \log[y_{it} / y_{i,t-T}] = a + b \cdot \log[y_{i,t-T}]. \qquad (3.2.29)$$

Once this regression is run and the parameter *b* estimated, one can calculate coefficient $\beta$ as

$$\beta = -\frac{\log(1+bT)}{T}. \qquad (3.2.30)$$

Equation (3.2.29) provides the means of detecting absolute $\beta$ convergence within a group of economies. However, as it was already stated before, both Solow-Swan and Ramsey models predict conditional rather than absolute convergence. To detect this type of convergence within a group of countries, the equation (3.2.29) has to be augmented by including other variables (fundamental economic characteristics) that control for the differences across steady states. Thus, the equation to be estimated in a regression is

$$\frac{1}{T} \cdot \log[y_{it} / y_{i,t-T}] = a + b \cdot \log[y_{i,t-T}] + \boldsymbol{\varphi} \cdot \mathbf{X}_{it}, \qquad (3.2.31)$$

where $\mathbf{X}_{it}$ is a vector of variables that hold constant the steady state of economy *i*, and $\boldsymbol{\varphi}$ is a vector of corresponding regression coefficients. The coefficient $\beta$ is calculated again according to the rule (3.2.30).

### *σ convergence*

Empirical measure of the dispersion or inequality of per capita income within a group of economies, $i = 1,...N$, is provided by the sample variance of $\log(y_{it})$:

$$D_t = \frac{1}{N} \cdot \sum_{i=1}^{N} [\log(y_{it}) - \mu_t]^2 , \qquad (3.2.32)$$

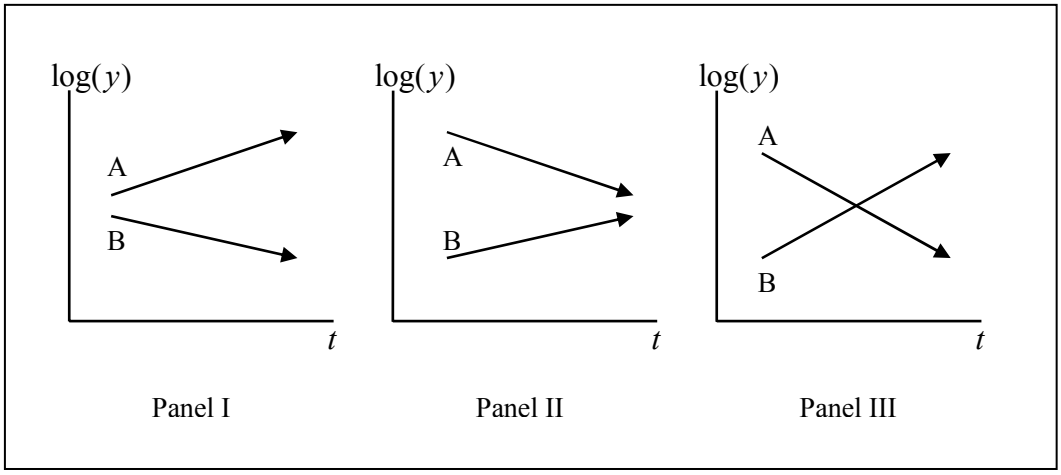
where $\mu_t$ is the sample mean of the $\log(y_{it})$. Evaluating $D_t$ over a time interval $(0,T)$ makes it possible to assess whether the cross-sectional dispersion in terms of per capita income falls or rises over time, i.e. to assess $\sigma$ convergence.

### *β convergence versus σ convergence*

The debate on the relationship between $\beta$ and $\sigma$ convergence was started by Sala-i-Martin (1996). The main point of controversy was identified as a presumption that $\beta$ convergence be a necessary condition of $\sigma$ convergence. The assumption seemed reasonable since it is agreeable to think that if there is convergence, the growth rate should fall over time.

However, $\beta$ convergence is a necessary but not sufficient condition of $\sigma$ convergence. The situation is illustrated in Figure 3.2.1.

**Figure 3.2.1: Beta versus Sigma Convergence.**




Source: [23].

Figure 3.2.1 introduces two economies (A, B) and their $\log(y)$ evolution over time. Panel I indicates the absence of both $\beta$ convergence and $\sigma$ convergence between economies A and B. Countries diverge in terms of their per capita income and the gap between them increases over time. Panel II illustrates situation in which the income gap between A and B decreases over time while also a decline in the dispersion of per capita income across economies A and B is reported. This corresponds to mutual occurrence of both $\beta$ convergence and $\sigma$ convergence. Panel III indicates the possibility of $\beta$ convergence to appear without $\sigma$ convergence.

## *3.3 Review of Previous Empirical Research*

Growth rate of real GDP per capita is, according to the theory, negatively related to the initial level of real per capita GDP. In convergence studies, attention has also been paid to examine the relationship between GDP growth rate and other economic indicators (e.g. investment, public consumption, etc.). The major results of the work in this field are summarized in the following paragraphs.

The first growth economist to conduct an empirical study on convergence was Baumol (1986). He used data on GDP levels across 16 rich countries[21] covering the period of years 1870 – 1979. On these data, he documented the existence of cross-country convergence. He found that convergence was especially strong after World War II. This evidence, however, was quickly downplayed by Romer (1986) and DeLong (1988), on the grounds of ex-post sample selection bias. The data set of nations which were industrialized ex-post (i.e. by 1979) being used, those countries that did not converge were automatically excluded from the sample. As follows, convergence in Baumol's study was guaranteed. As soon as the data set was enriched to include ex-ante rich countries (i.e. countries rich by 1870), the evidence for convergence disappeared.

Solution to the sample selection problem was to analyse a larger set of countries. This was made possible in the mid 1980s when Summers and Heston created a new data set comprising GDP levels for more than 100 world countries. The first year for which the data are available is 1960. Summers-Heston data set is the most widely used source of information needed for convergence analyses.

Based on Summers-Heston data set, Sala-i-Martin (1996) showed that the dispersion of GDP per capita across 110 countries increased steadily from 1960 to 1990. The behaviour of economies was divergent in the sense of $\sigma$ during the 30 years. On the other hand, if the attention was focused on OECD countries only, $\sigma$ convergence was reported rather than $\sigma$ divergence during the same time period.

[21] The data Baumol used were constructed by Maddison in 1982, following the methodology of the United Nations' International Comparison Project. The data across countries are comparable and are therefore suitable for use in the analysis of convergence.

As for $\beta$ convergence, Sala-i-Martin (1996) reported that the data on 110 world economies did not support its existence. The speed of convergence estimated in a regression[22] was figured to be $\beta = -0.004$, meaning that during 1960 – 1990 the set of 110 world economies did not converge in the sense of $\beta$ either.

Since the empirical data on world countries do not reveal absolute $\beta$ convergence, and also the theory predicts rather conditional than absolute $\beta$ convergence, Sala-i-Martin (1996) defined two ways to examine *conditional* $\beta$ convergence. One method is to run a modified regression, such as specified by equation (3.2.31). This approach detects conditional convergence within a given data set. The other way to control for the differences among economies' steady states is to limit the group of countries under examination so that it contains economies with similar fundamental characteristics – to create a homogenous group of economies. This approach in fact detects absolute convergence within a set of "more similar" countries.

Focusing the attention on homogenous groups of countries or regions, Sala-i-Martin (1996), and Barro and Sala-i-Martin (1995) showed that $\beta$ convergence across the states of USA, across 47 Japanese prefectures and across 90 regions in 8 European countries did exist and, moreover, was strikingly similar – approximately 2 percent per year. A delicate conclusion can be drawn from the similarity argument: since the degree to which national governments use regional cohesion policies is very different, and still the cross-sectional speed of convergence is very similar, one can say that public policy plays but a small role in the overall process of regional convergence.

Other appealing ideas are to be found in literature on convergence as well. Robert J. Barro (1991), observing more than 100 countries in the period 1960 – 1985, argued that the growth rate of real per capita GDP was positively related to initial human capital and negatively related to the initial level of real per capita GDP. Barro showed that growth was inversely related to the share of government consumption in GDP and insignificantly related to the share of public investment.

Barro's argument is based on neoclassical growth model with the assumption of diminishing returns to reproducible capital. Human capital is believed to play a key role in generating endogenous economic growth by serving as an input to the research sector generating new products and ideas that underlie technological progress. Barro stresses that countries with greater initial stocks of human capital experience a more rapid rate of introduction of new goods and

[22] The same methodology was used as described in *3.2 Empirical Specification*.

thereby tend to grow faster. In Barro's study, school-enrolment rate was used as a proxy to human capital.

Inclusion of human capital accumulation to the basic Solow-Swan model was seriously dealt with by Mankiw, Romer, and Weil (1992). They offered an augmented version of the model, in which they considered human as well as physical capital. To test their version of the model, they included a proxy for human capital accumulation as an additional explanatory variable in cross-country regressions. They took the percentage of the working-age population attending secondary school as a proxy for the rate of human capital accumulation. The results revealed that the human capital measure entered significantly in the regressions, thus providing a sound argument for including human capital in analyses of growth and convergence.[23]

The contribution of government expenditures to economic growth has also been examined by several economists. The conclusion is that the ratio of real government consumption expenditure to real GDP has a negative association with growth and investment (Barro and Sala-i-Martin, 1995). The reason is that government consumption has no direct positive effect on private activity, but lowers savings and growth due to the distortion effects from taxation or government expenditure program. Moreover, high government expenditure in a closed economy implies higher demand for money resulting in increasing interest rate, which brings about the crowding-out effect that is clearly detrimental to the private sector. High government expenditure, ceteris paribus, also means high public debt, financing of which creates economic distortions.

Turning back to the pioneer Baumol's analysis (1986), its crucial bequest is mainly to show that diffusion of technology among industrialized countries brings about much convergence. It is assumed that while national policies and behavioural patterns do substantially influence productivity growth, the spillovers from leader economies to followers are large at least within the group of industrialized countries. The diffusion of productivity growth from one developed country to another involves innovation and investment, whereby the former sharing is straightforward. This process is believed to put pressure on rival firms to obtain the level of innovation to remain competitive in the market, which generates more convergence among industrialized countries. However, as pointed out by Menbere (1998), scarce qualified human capital in poor countries caused by both lack of education and human capital flight makes the possible transfer of technology and expertise from rich to poor countries slow and difficult.

[23] In accord with regression specification given by formula (3.2.31), human capital accumulation enters the regression as one element of the vector of additional explanatory variables, **X**.

Consequently, poorer countries do not enjoy convergence enhancement via the channel of technology diffusion.

Similar to Baumol, Ben-David (1993) deals with the effect of trade liberalization on convergence. He argues that income inequality among countries is due to differences in the rate at which countries implement new technologies, which brings about a direct effect of having different levels of GDP. There is strong evidence that technology diffusion through international trade of goods and international investment have played an important role in the process of convergence of production levels. It is concluded that the effect of trade liberalization is one of the major factors that induced convergence between European Economic Community (EEC) countries.

The impact of trade barriers' removal on convergence in EEC is examined by observing the post war period and year preceding the World War II. Income differences of three countries (Spain, Portugal, and Greece) that joined EEC in 1973 are also looked at by Ben-David, and it is concluded that trade liberalization has been the driving force for convergence for these countries.

The role of foreign aid in inducing economic growth has also been the subject of research. Boone (1995) found that foreign aid does not significantly increase investment and it does not benefit the poor as measured by improvements in human developments' indicators. Instead, aid increases the size of the government. It was emphasized that the impact of foreign aid does not vary according to whether recipient governments are liberal and democratic or highly repressive. On the other hand, the basic Barro's model predicts that foreign assistance causes faster growth and higher investment, which puts the theory in contrast with empirics.

To sum up, the cardinal message of previously conducted empirical studies on convergence lies in the lack of evidence in favour of absolute worldwide convergence. However, this is not true for narrower, more homogenous groups of economies. Various economic fundamentals and policy measures are of interest in the convergence analysis – namely measures of investment, human capital accumulation, government expenditures, and foreign aid.

Although the process of enlarging the European Union has been a topical issue in recent years and there were many papers written on the economic performance of accession (mostly transitive) countries, what still lacks is a thorough analysis of convergence within transitive, former communist economies in general. However, there is one serious problem to be faced – unsatisfactory data availability. Therefore, many interesting questions inspired by the above-

mentioned previous empirical research cannot be, in case of transitive countries, answered by re-examination of relationships reported in the studies of other world economies.

A number of studies deal with transitive economies from the point of view of convergence. However, they generally do not map past experience of these countries, they rather attempt to assess and predict future performance with respect to the ongoing integration of these economies to the European Union. For example, Wagner and Hlouskova (2002) analyse real convergence prospects of ten candidate countries (CEEC10) towards the EU average. They project future economic growth in CEEC10 and predict the evolution of per capita GDP in CEEC10 *relative* to the EU. They conclude that the average time needed for Central and Eastern European countries to achieve 70 percent of the enlarged EU25 GDP is to be in the vicinity of 40 years. Therefore, the convergence of the CEEC10 towards the EU average income level is believed to be a long-run perspective.

This paper aims at a completely different convergence analysis of transitive economies. The vision, which is to provide at least a small contribution to the convergence debate, is very appealing as little work seems to have been done in the field.

# 4 Convergence across Transitive Economies

*"The transition has yielded some notable successes. Some countries are quite close to convergence with the advanced economies. Others still face a long journey."*

*Köhler, H. (2002)*

## 4.1 Data and Sample

To test transitive economies for convergence, one has to compromise between what analysis is desired and what analysis data allow to be conducted. Data on real per capita GDP are available for almost all transitive economies[24]. However, other information covering more specific issues (such as government budget deficits) could not be obtained. Thus, from among the variables identified previously as crucial[25], only government consumption, foreign aid, and investment measures are available for further analyses. Nevertheless, additional explanatory variables are included – rate of inflation and population growth rate, the influence of which on GDP growth rate seem reasonable enough not to be omitted. As no more reasonable measure of human capital accumulation is available for transitive economies, life expectancy at birth is used as a proxy.

Based on the assumption of decreasing returns to capital, the Solow-Swan model predicts negative correlation between economic growth and initial level of GDP. Government consumption, financing of which is growth-retarding (because of disincentive effects of taxes), relates negatively to economic growth. On the other hand, investment, which raises capital stock, exhibits positive correlation to GDP growth rate. Foreign aid, as aimed at increasing the level of investment and promoting technology, is expected to relate positively to GDP growth. Inversely, higher rates of inflation discourage investment and are negatively related to economic growth. Population growth relates negatively to GDP growth, as all the debate is constituted on measures of growth of GDP *per capita*. Eventually, life expectancy relates positively to GDP growth, since it approximates accumulation of human capital in economy.

Table 4.1.1 introduces variables entering the regressions specified by formulae (3.2.29) and (3.2.31). Data used are described, their source indicated, and expected sign of the regression coefficient specified there. Thus, the growth rate of real GDP per capita is regressed on initial

[24] Turkmenistan's economic statistics are state secrets; the data on Uzbekistan are not available. Thus, the two countries are excluded from further analyses.
[25] See e.g. page 35, paragraph 5 in this thesis.

GDP per capita, government consumption, investment, foreign aid, inflation, population growth, and life expectancy.

**Table 4.1.1: Variables Entering Regressions Based on the Solow-Swan Model.**

| Variable | Abbreviation | Description | Source | Expected Sign |
|---|---|---|---|---|
| **Initial GDP** | $GDP_0$ | Log of initial level of GDP per capita | PWT[a] | - |
| **Government Consumption** | GC | Average government consumption share of GDP | PWT | - |
| **Investment** | INV | Average investment share of GDP | PWT | + |
| **Foreign Aid** | FUNDS | Total fund credit and loans from IMF as a share of GDP | IMF[b] | + |
| **Inflation** | INFL | Current inflation rate | IMF | - |
| **Population Growth** | POP | Current population growth rate | PWT | - |
| **Life Expectancy** | LE | Log of initial period's life expectancy at birth | WB[c] | + |

[a] Penn World Table 6.1 (see [13])
[b] International Monetary Fund Database (see [30])
[c] The World Bank Database (see [32])
Source: the author.

Countries included in the convergence analysis are foremost the transitive countries. These are the former Soviet Union countries (except for Turkmenistan and Uzbekistan), and the transitive countries of Central and Eastern Europe. Convergence is examined within the group of these economies. Furthermore, convergence among transitive countries and the developed countries of European Union and OECD is tested, too. A group of all European countries (except for Malta and Cyprus for which there are no sufficient data available) is tested for convergence as well.

Although one cannot expect countries to converge within five or six years, the convergence analysis was mostly conducted on data covering time period of no longer duration. Unfavourable availability of necessary data left the only way to solve the problem – if the analysis was to be carried out, it had to be based on 1995 – 2000 GDP time series mainly. Time period captured by the analysis differed from 1990 – 2000 to 1996 – 2000, depending on what countries were chosen to constitute a group[26] of economies tested for convergence.

[26] There were ten groups of economies constructed: CEEC (transitive countries of Central and Eastern Europe), CEEC -2 (CEEC excluding Romania and Bulgaria), V5 (Visegrad countries), CEEC + FSU (all post-communist transitive countries), EUROPE + CEEC + FSU (all European countries plus all post-communist transitive countries), EU15 (countries of EU15), EU15 + V5 (countries of EU15 plus Visegrad countries), EU25 (enlarged European Union countries), OECD + CEEC + FSU (countries of OECD plus all post-communist transitive countries), and OECD + CEEC (countries of OECD plus transitive countries of Central and Eastern Europe).

## *4.2 Results and Discussion*

Two crucial questions were raised in the introduction to this thesis as a motivation to the study. Providing empirical evidence on convergence or divergence using data on transitive economies, it is desired to find out: first, whether the economic performance of transitive economies during past years led to convergence within the group of countries that all emerged as new economic subjects after the collapse of communism; and second, whether convergence is a reality among transitive economies and developed countries of OECD and European Union or whether the process of unification (e.g. enlarging of the European Union) proceeds solely on political grounds without detectable economic cohesion.

To answer these questions, two approaches to measuring convergence were applied. Previously defined groups of countries were tested for *sigma* and *beta* convergence.

### *σ convergence*

Sigma convergence is said to occur if the dispersion of per capita income across countries falls over time, i.e. if the differences in standards of living of different populations diminish over time. Following the above-described[27] way to measure dispersion, it is straightforward to calculate sample variance of logarithms of per capita GDP within a group of economies covering the period of recent years. Table 4.2.1 provides the evolution of dispersion of per capita GDP for different groups of economies over time.

**Table 4.2.1: Sigma Convergence.**

| Group | 1990 | 1991 | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CEEC** | | | | | | 0.204 | 0.201 | 0.241 | 0.249 | 0.238 | 0.241 | ↑ |
| **CEEC -2** | | | | | | 0.233 | 0.225 | 0.260 | 0.256 | 0.229 | 0.232 | 0 |
| **V5** | 0.072 | 0.062 | 0.054 | 0.054 | 0.051 | 0.050 | 0.049 | 0.043 | 0.040 | 0.038 | 0.036 | ↓ |
| **CEEC + FSU** | | | | | | | 0.384 | 0.373 | 0.379 | 0.382 | 0.383 | 0 |
| **EUROPE + CEEC + FSU** | | | | | | | 0.704 | 0.698 | 0.713 | 0.710 | 0.706 | 0 |
| **EU15** | 0.046 | 0.045 | 0.046 | 0.052 | 0.053 | 0.053 | 0.053 | 0.055 | 0.055 | 0.055 | 0.058 | ↑ |
| **EU15 + V5** | 0.107 | 0.132 | 0.139 | 0.139 | 0.138 | 0.137 | 0.131 | 0.131 | 0.131 | 0.131 | 0.133 | ↑ |
| **EU25** | | | | 0.208 | 0.214 | 0.217 | 0.211 | 0.204 | 0.202 | 0.208 | 0.205 | ↓ |
| **OECD + CEEC + FSU** | | | | | | | 0.687 | 0.680 | 0.691 | 0.688 | 0.683 | ↓ |
| **OECD + CEEC** | | | | | | 0.346 | 0.341 | 0.365 | 0.372 | 0.373 | 0.371 | ↑ |

Source: the author.

[27] See page 30, formula (3.2.32).

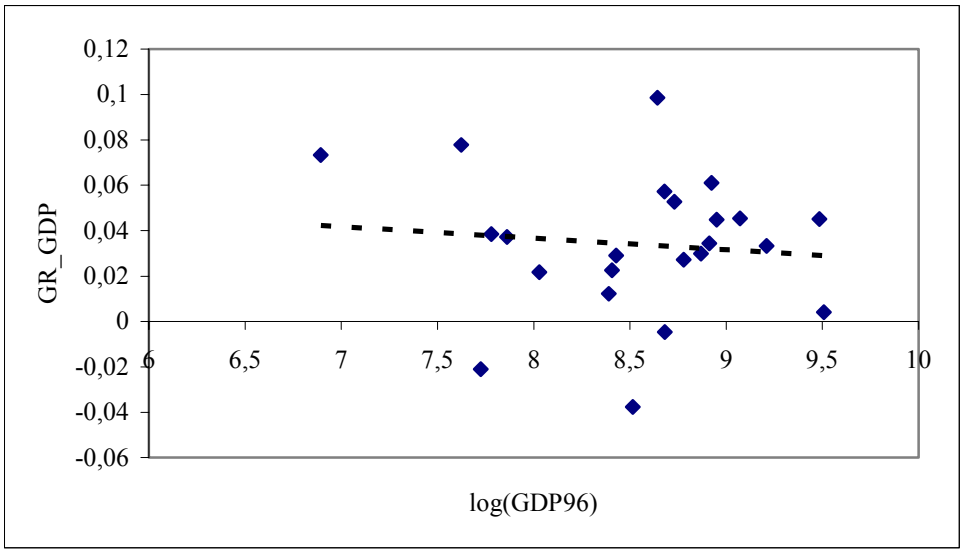
As Table 4.2.1 suggests, transitive countries of Central and Eastern Europe (CEEC) did not converge in the sense of $\sigma$ over the years 1995 – 2000. These countries did neither converge to each other nor to the countries of OECD. Within the two groups, dispersion of per capita income raised significantly during 1995 – 2000. On the other hand, relatively stable evolution of per capita income dispersion was reported by CEEC countries if Romania and Bulgaria were excluded from the sample (CEEC -2). A conclusion can be drawn from this, that it were Romania and Bulgaria who acted divergently within the group of CEEC countries. Relatively stable development of per capita income dispersion was detected also within the group of all transitive economies (CEEC + FSU) comprising the countries of Central and Eastern Europe and the countries of the former Soviet Union. The differences in per capita income did neither raise nor fall significantly within the group consisting of all European (only Malta and Cyprus were excluded) and all transitive countries. The differences slightly fell within the group of OECD and transitive countries (OECD + CEEC + FSU) and within the group of countries that will soon constitute the new enlarged European Union, EU25[28]. The most significant decline in dispersion of per capita income was detected within Visegrad countries. The differences in GDP per capita among Czech Republic, Hungary, Poland, Slovak Republic, and Slovenia decreased steadily from 1991 to 2000. It is interesting to note that, during the same time period, dispersion of per capita income among the countries of EU15 steadily *increased*.

## *β convergence*

Transitive countries were tested for absolute convergence running a regression specified by equation (3.2.29). For each of ten groups of countries (described above), an average growth rate of GDP per capita over corresponding period of time was regressed on the initial level of GDP per capita. The expected correlation between economic growth and the initial level of income was negative. However, as Figure 4.2.1 illustrates, no straightforward relationship of such nature is revealed by data on CEEC and FSU countries.

[28] Here, again, Malta and Cyprus were excluded from the sample due to data availability problems. Thus, the more appropriate abbreviation would probably label the group EU23.

**Figure 4.2.1: Average 1996 – 2000 GDP growth rate vs. initial GDP for CEEC and FSU.**




Source: the author.

The results of the regressions run to detect absolute convergence among transitive countries and among transitive and developed countries are provided in Table 4.2.2. Regression coefficients are given, t-values are stated in brackets, coefficient of determination $R^2$ is stated, and implied beta coefficient calculated in accordance with expression (3.2.30).

**Table 4.2.2: Absolute Beta Convergence.**

| Group | Period | const. | $GDP_0$ | $R^2$ | beta |
|---|---|---|---|---|---|
| **CEEC** | 1995 – 2000 | -0.066 | 0.010 | | |
| | | *(-0.370)* | *(0.499)* | 0.030 | **-0.010** |
| **CEEC -2** | 1995 – 2000 | 0.049 | -0.002 | | |
| | | *(0.604)* | *(-0.173)* | 0.005 | **0.002** |
| **V5** | 1991 – 2000 | 0.321 | -0.032 | | |
| | | *(1.876)* | *(-1.727)* | 0.498 | **0.038**[x] |
| **CEEC + FSU** | 1996 – 2000 | 0.077 | -0.005 | | |
| | | *(0.855)* | *(-0.480)* | 0.011 | **0.005** |
| **EUROPE + CEEC + FSU** | 1996 – 2000 | 0.047 | -0.002 | | |
| | | *(1.092)* | *(-0.318)* | 0.003 | **0.002** |
| **EU15** | 1991 – 2000 | 0.068 | -0.004 | | |
| | | *(0.367)* | *(-0.234)* | 0.004 | **0.004** |
| **EU15 + V5** | 1991 – 2000 | 0.082 | -0.006 | | |
| | | *(0.963)* | *(-0.670)* | 0.024 | **0.006** |
| **EU25** | 1993 – 2000 | 0.077 | -0.005 | | |
| | | *(1.168)* | *(-0.675)* | 0.021 | **0.005** |
| **OECD+CEEC+FSU** | 1996 – 2000 | 0.056 | -0.003 | | |
| | | *(1.452)* | *(-0.608)* | 0.008 | **0.003** |
| **OECD + CEEC** | 1995 – 2000 | -0.016 | 0.005 | | |
| | | *(-0.310)* | *(0.847)* | 0.021 | **-0.005** |

* t-values are given in brackets
[x] significant at 20 % level
Source: the author.

Absolute beta convergence is said to occur if parameter beta obtained from regression is positive and statistically significant. As can be seen from Table 4.2.2, the only statistically significant (though just at a 20 % level) parameter beta was obtained when testing convergence among V5 countries. Visegrad countries were found to converge to each other absolutely. Other results are not statistically significant, implying the absence of absolute beta convergence not only within the group of all transitive economies and the group of transitive and developed economies but also among the countries of EU15. There are even cases in which implied beta figures as a negative number, but it is not statistically significant meaning that the divergence hypothesis cannot be accepted.

Overall, it can be concluded that no empirical evidence was found to support the existence of absolute convergence among all transitive countries. Neither was there any evidence provided for transitive countries converging to developed economies of EU or OECD. What is important is the finding that a group of *Visegrad countries* exhibits convergence behaviour. One can say that as the Solow-Swan model predicts absolute convergence among economies that do not differ in their steady states, Visegrad countries rather constitute a group of economies with similar fundamental characteristics. One can also argue that although there was no evidence found to support absolute convergence among transitive countries and developed economies, it can be due to differences in their steady states and therefore conditional convergence should be tested for before the convergence hypothesis is thoroughly rejected.

However, testing for conditional convergence requires implementation of additional explanatory variables to the regression that is run for absolute convergence detection. Since it would not be a statistically correct approach to run a regression with a relatively high number of explanatory variables when compared to the number of observations provided by cross-section data (few degrees of freedom), the conditional convergence analysis was not carried out on cross-section data. Rather, panel data were constructed.

Menbere (2003a) discusses the advantages of panel data over simple cross-section data approach. He summarizes and identifies major problems related to cross-section regressions to be an omitted variable bias (the obvious differences in production functions across countries are not captured by cross-section regression), utilisation of only a portion of all available information (limiting the time series to a cross-section regression means not all available information is utilised), and endogeneity problem (two or more explanatory variables are correlated with each other). On the other hand, panel data approach minimizes the omitted variable problem by allowing for the

differences in production functions in the form of unobservable individual "country effects" and it also allows to control for time specific effects (as the worldwide conditions for growth may not be equally advantageous over time). Finally, panel data approach increases the number of observations, which means generating more plausible results via increasing the number of degrees of freedom.

Therefore, in order to carry out a conditional convergence analysis, panel data were constructed, so that the average growth rate of GDP over available time period was substituted by a number of year-on-year growth rates of GDP[29]. On such constructed panel data set, absolute convergence analysis was repeated (now with more observations available) and the conditional convergence analysis was conducted, too, according to the formula (3.2.31).

**Table 4.2.3: Beta Convergence Based on Panel Data.**

| | | **Absolute convergence** | | | **Conditional convergence** | | |
|---|---|---|---|---|---|---|---|
| **Group** | **Period** | **$GDP_0$** | **$R^2$** | **beta** | **$GDP_0$** | **$R^2$** | **beta** |
| **CEEC** | 1995 – 2000 | 0.012 | | | -0.142 | | |
| | | *(0.878)* | 0.016 | **-0.012** | *(-6.544)* | 0.605 | **0.247[a]** |
| **CEEC -2** | 1995 – 2000 | -0.003 | | | -0.088 | | |
| | | *(-0.248)* | 0.002 | **0.003** | *(-3.831)* | 0.465 | **0.115[a]** |
| **V5** | 1993 – 2000 | -0.029 | | | -0.058 | | |
| | | *(-2.205)* | 0.128 | **0.032[b]** | *(-3.321)* | 0.256 | **0.075[a]** |
| **CEEC + FSU** | 1996 – 2000 | 0.005 | | | -0.030 | | |
| | | *(0.481)* | 0.003 | **-0.005** | *(-1.953)* | 0.131 | **0.031[c]** |
| **EUROPE + CEEC + FSU** | 1996 – 2000 | 0.003 | | | -0.006 | | |
| | | *(0.596)* | 0.002 | **-0.003** | *(-0.943)* | 0.091 | **0.006** |
| **EU15** | 1993 – 2000 | 0.007 | | | -0.040 | | |
| | | *(0.825)* | 0.007 | **-0.007** | *(-3.457)* | 0.292 | **0.047[a]** |
| **EU15 + V5** | 1993 – 2000 | -0.004 | | | -0.023 | | |
| | | *(-0.778)* | 0.004 | **0.004** | *(-4.353)* | 0.211 | **0.025[a]** |
| **EU25** | 1993 – 2000 | -0.001 | | | -0.009 | | |
| | | *(-0.295)* | 0.001 | **0.001** | *(-1.140)* | 0.145 | **0.010** |
| **OECD + CEEC + FSU** | 1996 – 2000 | 0.001 | | | 0.002 | | |
| | | *(0.260)* | 0.000 | **-0.001** | *(0.427)* | 0.067 | **-0.002** |
| **OECD + CEEC** | 1995 – 2000 | 0.006 | | | -0.004 | | |
| | | *(1.425)* | 0.011 | **-0.006** | *(-0.769)* | 0.124 | **0.004** |

* t-values are given in brackets
[a] significant at 1 % level
[b] significant at 5 % level
[c] significant at 10 % level
Source: the author.

[29] The same philosophy is applied to construct panel data set of each variable included in the regressions.

Results of the regressions run on panel data are in detail presented in Appendix II. Table 4.2.3 briefly summarizes them and shows the implied values of beta convergence parameter.

Absolute convergence analysis conducted on panel data confirms the results of the regressions based on cross-section data. Again, the only group of economies found to exhibit convergence behaviour is the group of Visegrad countries. Results for other groups of countries do not support the absolute convergence hypothesis. As a matter of fact, absolute convergence does not show a reality for the group of all transitive countries (suggesting there really are profound differences among these countries meaning they head for different steady states), neither does it show true for all European and transitive countries, nor for the economies of enlarged European Union (see Table 4.2.3).

As for conditional convergence, the results confirm its existence among all transitive countries (and among the countries constituting different subgroups of the set of all transitive countries). However, countries of enlarged European Union are not found to converge conditionally towards each other. While the process of conditional convergence has been a detectable reality within EU15 during the time period examined, this is not true for the enlarged EU25. Thus, conditional convergence among transitive and developed countries (either EU or OECD or all European developed countries) is not supported by any empirical evidence of the past years. Visegrad economies being again an exception, they are found to have done well during the time period examined and their convergence towards EU economies can be empirically documented (see Table 4.2.3).

In order to carry out a more comprehensive analysis which would also allow controlling for time specific effects, the set of panel data was further enriched by introduction of other additional variables – time specific dummies. Similar to additional economic variables introduced before (foreign aid, inflation rate, etc.) that control for differences among steady states, time specific dummies control for structural changes over time that are not captured by the economic variables. Regressions run on panel data with time specific dummies are in detail presented in Appendix III and are summarized in Table 4.2.4.

**Table 4.2.4: Beta Convergence Based on Panel Data with Time Specific Dummies.**

| Group | Period | $GDP_0$ | $R^2$ | beta |
|---|---|---|---|---|
| **CEEC** | 1995 – 2000 | -0.148 | | |
| | | *(-6.865)* | 0.640 | **0.269**[a] |
| **CEEC -2** | 1995 – 2000 | -0.091 | | |
| | | *(-4.109)* | 0.513 | **0.122**[a] |
| **V5** | 1993 – 2000 | -0.116 | | |
| | | *(-5.137)* | 0.486 | **0.241**[a] |
| **CEEC + FSU** | 1996 – 2000 | -0.026 | | |
| | | *(-1.676)* | 0.168 | **0.027**[c] |
| **EUROPE + CEEC + FSU** | 1996 – 2000 | -0.006 | | |
| | | *(-0.981)* | 0.100 | **0.007** |
| **EU15** | 1993 – 2000 | -0.033 | | |
| | | *(-3.101)* | 0.448 | **0.038**[a] |
| **EU15 + V5** | 1993 – 2000 | -0.029 | | |
| | | *(-3.545)* | 0.347 | **0.032**[a] |
| **EU25** | 1993 – 2000 | -0.012 | | |
| | | *(-1.530)* | 0.229 | **0.013** |
| **OECD + CEEC + FSU** | 1996 – 2000 | 0.001 | | |
| | | *(0.381)* | 0.083 | **-0.001** |
| **OECD + CEEC** | 1995 – 2000 | -0.004 | | |
| | | *(-0.792)* | 0.130 | **0.004** |

***** t-values are given in brackets
[a] significant at 1 % level
[b] significant at 5 % level
[c] significant at 10 % level
Source: the author.

As Table 4.2.4 suggests, regressions run on panel data with time specific dummies confirm the findings of previous approach based on panel data without time specific effects. The whole group of transitive countries as well as all the examined subgroups of transitive countries are found to converge conditionally. The economies of European Union and the economies of EU and Visegrad countries are shown to converge conditionally towards each other, too. Again, no empirical evidence supporting conditional convergence among transitive and developed countries in general is provided.

Additional variables included in the analysis of conditional convergence introduced to control for differences among steady states of different economies comprise economic and time specific variables. As Appendices II and III present in detail, the expected partial correlations[30] between additional variables and economic growth were not always confirmed. Among the economic additional variables, the most striking finding was the one concerning foreign aid.

[30] See Table 4.1.1.

In this thesis, foreign aid (approximated by funds received from the IMF) was shown to have little power in promoting cross-country convergence. Although theoretical model of Barro implies positive correlation between foreign aid and economic growth, empirical findings often contradict this view. Similar to Boone (1996), analysis offered in this thesis shows that foreign aid simply does not play a significant role in promoting convergence. Boone's argument goes that foreign help increases the size of recipient country's government rather than promotes economic growth of the country via increasing investment.

As the results of regressions suggest, foreign aid was shown to be an insignificant explanatory variable almost in all cases. The only case in which funds were found significant and positively related to the GDP growth was the case of CEEC countries. However, when Bulgaria and Romania were excluded from the group (case of CEEC -2), foreign aid proved insignificant again. Foreign aid can be considered promoting catching-up of these two European Union candidate countries.

On the other hand, funds from the IMF were found significant and *negatively* related to GDP growth within the group of V5 countries and among the countries of enlarged European Union. One can conclude that foreign aid does not promote economic growth in recipient countries meaning it fails in what it aims at. More correctly, however, as the argument goes via foreign aid enhancing investment, the conclusion can be drawn that the coefficient on foreign aid obtained from the regressions is biased[31]. The results obtained from run regressions may also be distorted due to the fact that it is mainly slowly growing economies, economies facing serious problems, to receive funds from the IMF.

As for the time specific additional explanatory variables, one may expect them to support the view that as the transition process advances over time, economic performance of transitive countries improves. Increasing values[32] of coefficients estimated for time specific dummies would advocate the view since they would indicate an increasing trend of GDP growth rate. However, as can be seen from Appendix III, no such general tendency for transitive economies is detected. Rather than tending to grow faster over time, transitive economies perform better in the sense of macroeconomic stabilization and achieving *sustainable* growth as the transition proceeds.

[31] Due to correlation between variables INV and FUNDS.

[32] Increasing in the sense of $coeff_{T93-94} < coeff_{T94-95} < ... < coeff_{T98-99}$.

# 5 Conclusion

> *"Although the neo-classical growth model predicts convergence in the sense that countries with lower initial capital-labour ratio are predicted to have higher growth rates, it appears that this is only valid for moderately backward countries that belong to a relatively advanced convergence club (poorer members of OECD and EU) or those countries that are well integrated into the global economy through foreign trade and investment (East Asia)."*
>
> *Menbere, W. T. (2003)*

According to Köhler (2002), ten years after the collapse of communism, it can be concluded that most transitive economies have passed the point of no return on the journey toward democracy and market economy. However, considerable differences among countries have to be recognized in the progress achieved. Some countries of the former Soviet Union are still in the early stages of building market economy institutions, while Visegrad countries implement a second generation of reforms in order to make the market economy work more effectively and competitively.

The main successes achieved in the process of transition can be documented by several facts - resumed economic growth, inflation under control, extensively liberalized prices, foreign trade and exchange systems, advanced privatization and structural reforms in almost all transitive economies rank among the most important achievements.

On the other hand, there have been serious disappointments. High unemployment rates, standards of living lower than a decade ago, accompanied by increased poverty and inequality on an intra-national level often create tension and cause a lack of sustained political support for reform.

Although the transitive economies succeeded in many areas of economic reform and they have done in just a few years what took decades for the industrialized countries after the World War II, there still remain serious challenges ahead. Fighting corruption, defining an appropriate role for the state, and preserving hard-won macroeconomic and financial stability identify the main three areas deserving attention.

Bearing all these issues in mind, it is appealing to assess the extent to which the journeys of individual transition economies leading from centrally planned to market economy converge or diverge. One would expect the ways (though they definitely are different from country to country)

of transition to converge to the same point, represented by market economy. However, the aimed-at targets can, in fact, differ as much as the starting points differed.

Analyses carried out in this thesis provided empirical evidence on absolute beta convergence among the countries of V5. Conditional beta convergence was detected among all transitive economies, among the countries of EU15, and within the group comprising EU and Visegrad countries.

The most important finding of the conducted analyses is the confirmation of both sigma and beta convergence among V5 countries. These countries not only constitute a homogenous geographic region, they – more importantly – display similarities in their economic performance. For example, all heading for EU accession, the countries have managed to continue transition and accession processes simultaneously, which resulted in lessened differences concerning their per capita levels of GDP or comparative price levels. If country's per capita GDP relative to per capita GDP of EU is taken as a measure, V5 countries managed to reduce the differences among themselves almost twofold during 1990 – 2002. The similar was achieved concerning V5 countries' comparative price levels.[33]

However, conditional convergence was not confirmed among the countries of enlarged European Union. To conclude from this that the process of unification is artificial and it lacks a solid background provided by economic convergence and cohesion among the countries concerned would probably be too harsh since, although beta convergence was not detected within EU25, differences among per capita income within this group of countries were found to lessen in the sense of sigma. Nevertheless, no empirical evidence for convergence among transitive and developed countries in general was provided. In spite of it, transitive countries can be said to have done relatively well during the time period examined. In the most recent years of the time period examined (1998 – 2000), a tendency to decrease differences in per capita income (convergence in the sense of sigma) was reported among the European and transitive countries as well as among the OECD and transitive economies. The transitive countries can be said to have stepped on the right way. One could not expect them to converge within five or six years. They have gone through a difficult process, especially the countries of Central and Eastern Europe which have had to face transition and integration at the same time. Transition process is very costly. Nevertheless, adjustment costs related to the integration process have been high, too. During the past decade or more, all transitive countries concentrated mainly on stabilization; so far they have preferred it to

[33] See Appendix IV for details.

sound economic growth. However, all the measures taken during the transition process lay the path that would lead the transitive economies to achieve sustained economic growth.

To conclude, there are also two things to bear in mind when interpreting the results of the analyses presented above. At first, the regressions should be viewed critically and cautiously due to short time series used, questionable quality of data on some countries, and rather low explanatory power represented by low statistical significance of the regressions. The second argument is the extraordinarity of the transition process. It is a process that standard models of market economies fail to capture. It is a process during which, especially at the beginning, standard economic relationships do not hold[34]. Seen in this light, the fact that the used data cover only the recent part of the transition process (recent years) seems less a flaw.

[34] For example, Wagner and Hlouskova (2002) illustrate the extraordinarity of the transition process by pointing out the negative correlation between average investment share of GDP and average per capita GDP growth in the early stages of transition. According to them, this type of correlation (contrary to what would be generally expected) reflects huge transitional change and disorganization of the then-existing economic structure.

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## *Appendix I: Specific Country Information*

### *ALBANIA*

During the transition to a market economy, Albanian government has taken measures to curb violent crime and to stimulate economic activity and trade. However, severe energy shortages have forced small firms out of business, increasing unemployment, scaring off foreign investors, and spurring inflation. The government plans to boost energy imports to relieve the shortages. In addition, the government moves to improve the poor national road network, a long-standing barrier to sustained economic growth.

### *ARMENIA*

While still a part of Soviet central planning system, Armenia developed a modern industrial sector. On the other hand, the agricultural sector has long-term needs for more investment and updated technology. The privatization of industry has taken place at a slower pace, but has been given renewed emphasis by current administration. The ongoing conflict with Azerbaijan over the ethnic Armenian-dominated region of Nagorno-Karabakh and the break-up of the centrally directed economic system of the former Soviet Union contributed to a severe economic decline in the early 1990s. By 1994, however, the Armenian government had launched an ambitious IMF-sponsored economic program that resulted in positive growth rates in 1995-2003. Armenia has also managed to slash inflation, stabilize the local currency, and privatize most small- and medium-sized enterprises. Armenia's severe trade imbalance has been offset partly by international aid, domestic restructuring of the economy, and foreign direct investment. Economic ties with Russia remain close, especially in the energy sector.

### *AZERBAIJAN*

Azerbaijan faces problems common to all the former Soviet republics during transition. However, its considerable energy resources distinguish this country and brighten its long-term prospects. Still, Baku has only recently begun making progress on economic reform, and old economic ties and structures are slowly being replaced. One obstacle to economic progress is the need for stepped up foreign investment in the non-energy sector. A second obstacle is the continuing conflict with Armenia over the Nagorno-Karabakh region. Trade with Russia and the other former Soviet republics is declining in importance while trade is building with Turkey and the nations of Europe.

***BELARUS***

Belarus has seen little structural reform since 1995 when President Lukashenko launched the country on the path of "market socialism". Administrative controls over prices and currency exchange rate were imposed and the state's right to intervene in the management of private enterprises was expanded. In addition to the burdens of high inflation and persistent trade deficits, businesses have been subject to pressure on the part of central and local governments (e.g. arbitrary changes in regulations, numerous rigorous inspections, retroactive application of new business regulations, and arrests of "disruptive" businessmen and factory owners). A wide range of redistributive policies has helped those at the bottom of the ladder. Close relations with Russia, possibly leading to reunion, colour the pattern of economic development. Belarus remains self-isolated from the West and its open-market economies.

***BULGARIA***

Bulgaria, a former communist country striving to enter the European Union, has experienced macroeconomic stability and strong growth since a major economic downturn in 1996 led to the fall of the then socialist government. As a result, the government became committed to economic reform and responsible fiscal planning. A $300 million stand-by agreement negotiated with the IMF at the end of 2001 has supported government efforts to overcome high rates of poverty and unemployment.

***CROATIA***

Before the dissolution of Yugoslavia, the Republic of Croatia, after Slovenia, was the most prosperous and industrialized area with a per capita output one-third above the Yugoslav average. The economy emerged from its mild recession in 2000 with tourism the main factor, but massive structural unemployment remains a key negative element. The government's failure to press the economic reforms needed to spur growth is largely the result of coalition politics and public resistance, particularly from the trade unions. Opponents fear reforms would cut jobs, wages, and social benefits. The country is likely to experience only moderate growth without disciplined fiscal and structural reform.

***CZECH REPUBLIC***

One of the most stable and prosperous of the post-communist states, the Czech Republic has been recovering from recession since mid-1999. Growth in 2000-2003 was supported by exports to the EU, primarily to Germany, and a near doubling of foreign direct investment. Domestic demand plays an important role in underpinning growth. High current account deficits - averaging around

5 percent of GDP in the last several years - could be a persistent problem. Inflation is under control. Measures taken to complete bank, telecommunication, and energy privatization are thought to encourage additional foreign investment, while intensified restructuring among large enterprises and banks and improvements in the financial sector should strengthen output growth.

***ESTONIA***

Estonia, as a new member of the World Trade Organization, steadily moves toward a modern market economy with increasing ties to the West, including pegging of its currency to the euro. The economy benefits from strong electronics and telecom sectors, and is greatly influenced by developments in Finland, Sweden, and Germany - three major trading partners. However, the high current account deficit remains an issue.

***GEORGIA***

Despite the severe damage the economy has suffered due to civil strife, Georgia (receiving help from the IMF and the World Bank) has made substantial economic gains since 1995, achieving positive GDP growth and curtailing inflation. However, the Georgian government suffers from limited resources due to a chronic failure to collect tax revenues. Georgia also faces problems of energy shortages. The country pins its hopes for long-term growth on its role as a transit state for pipelines and trade.

***HUNGARY***

Hungary can be said to have made the transition from a centrally planned to a market economy. It continues to demonstrate strong economic growth. The private sector accounts for over 80 percent of GDP. Foreign ownership of and investment in Hungarian firms are widespread, with cumulative foreign direct investment totalling more than $23 billion since 1989. However, Hungarian sovereign debt was upgraded in 2000 to the second-highest rating among the Central European transition economies. On the other hand, inflation has declined substantially. Short-term issues include the reduction of the public sector deficit to 3 percent of GDP by 2004 and avoiding unjustified increases in wages.

***KAZAKHSTAN***

The break-up of the USSR in December 1991 and the collapse in demand for Kazakhstan's traditional heavy industry products resulted in a short-term contraction of the economy with the steepest annual decline occurring in 1994. In 1995-1997, the pace of the government program of economic reform and privatization quickened, resulting in a substantial shifting of assets into the

private sector. Kazakhstan enjoyed double-digit growth in 2000-2001 thanks largely to its booming energy sector but also to economic reform and foreign investment. The country has embarked upon an industrial policy designed to diversify the economy away from overdependence on the oil sector by developing light industry.

***KYRGYZ REPUBLIC***

Kyrgyzstan has been progressive in carrying out market reforms such as an improved regulatory system and land reform. It was the first CIS country to be accepted into the World Trade Organization. Much of the government's stock in enterprises has been sold. Drops in production had been severe after the break-up of the Soviet Union but by mid-1995 production began to recover and exports started to increase. Growth was held down in 1998 largely because of the spillover from Russia's economic difficulties but moved ahead in 2001. Inflation was lowered to 2 percent in 2002. The government and the international financial institutions have been engaged in a comprehensive medium-term poverty reduction and economic growth strategy. Further restructuring of domestic industry and success in attracting foreign investment are keys to future growth.

***LATVIA***

Latvia's transitive economy recovered from the 1998 Russian financial crisis largely due to the Skele government's budget stringency and a gradual reorientation of exports toward EU countries, lessening Latvia's trade dependency on Russia. The majority of companies, banks, and real estates has been privatized although the state still holds sizable stakes in a few large enterprises. Latvia officially joined the World Trade Organization in February 1999. The current account and internal government deficits remain major concerns but the government's efforts to increase efficiency in revenue collection may lessen the budget deficit.

***LITHUANIA***

Lithuania, the Baltic state that conducted the most trade with Russia, slowly rebounds from the 1998 Russian financial crisis. Unemployment remains high (approximately 11 percent in 2003) but is improving. Growing domestic consumption and increased investment further the recovery. Being the member of World Trade Organization, Lithuania’s trade increasingly orientates itself toward the West. Privatization of the large, state-owned utilities, particularly in the energy sector, is nearing completion. On the whole, more than 80 percent of enterprises have already been privatized. Foreign government and business support have helped in the transition from the old command economy to a market economy.

***MACEDONIA***

At independence in November 1991, Macedonia was the least developed of the Yugoslav republics producing a mere 5 percent of the total federal output of goods and services. The collapse of Yugoslavia ended transfer payments from the centre and eliminated advantages stemming from inclusion in a de facto free trade area. Absence of infrastructure, UN sanctions, and a Greek economic embargo over a dispute about the country's constitutional name and flag hindered economic growth until 1996. GDP subsequently rose each year through 2000. However, the leadership's commitment to economic reform, free trade, and regional integration was set back by the ethnic Albanian insurgency of 2001. The economy shrank because of decreased trade, intermittent border closures, increased deficit spending on security needs, and investor uncertainty. Growth barely recovered in 2002 but then rose to approximately 3 percent in 2003. Unemployment at one-third of the labour force remains the most critical economic problem. But even this issue is overshadowed by the fragile political situation.

***MOLDOVA***

Despite recent progress, Moldova remains a very poor country. After the break-up of the Soviet Union in 1991, energy shortages contributed to sharp production declines. As a part of an ambitious reform effort, Moldova introduced a convertible currency, liberalized all prices, stopped issuing preferential credits to state enterprises, backed steady land privatization, removed export controls, and freed interest rates. The government entered into agreements with the World Bank and the IMF to promote growth and reduce poverty. Consequently, the economy exhibited positive growth rates in 2000-2003. However, higher fuel prices and scepticism of foreign investors remain the main factors of economy’s vulnerability.

***POLAND***

Poland has steadfastly pursued a policy of economic liberalization throughout the 1990s. Although the transition has been a success, much remains to be done. The privatization of small and medium state-owned companies and a liberal law on establishing new firms have encouraged the development of the private business sector but legal and bureaucratic obstacles alongside persistent corruption hamper its further development. Poland's agricultural sector remains handicapped by structural problems, surplus labour, inefficient small farms, and lack of investment. Restructuring and privatization of "sensitive sectors" (e.g., coal, steel, railroads, and energy), while recently initiated, have stalled due to lack of political will on the part of the government. Structural reforms in health care, education, the pension system, and state administration have resulted in larger than expected fiscal pressures. Further progress in public

finance depends mainly on privatization of remaining state sector, the reduction of state employment, and an overhaul of the tax code. Improving Poland's export competitiveness and containing the internal budget deficit are top priorities.

***ROMANIA***

Romania began the transition in 1989 with a largely obsolete industrial base and a pattern of output unsuited to the country's needs. In 2000, the country emerged from a punishing three-year recession thanks to strong demand in EU export markets. Despite the global slowdown in 2001-2002, strong domestic activity in construction, agriculture, and consumption have kept economic growth above 4 percent. An IMF stand-by agreement, signed in 2001, has been accompanied by slow but palpable gains in privatization, deficit reduction, and curbing of inflation. Nonetheless, recent macroeconomic gains have done little to address Romania's widespread poverty while corruption and red tape hinder foreign investment.

***RUSSIA***

More than a decade after the break-up of the Soviet Union in December 1991, Russia still struggles to establish a modern market economy and achieve strong economic growth. In contrast to its trading partners in Central Europe - which were able to overcome the initial production declines that accompanied the launch of market reforms within 3 to 5 years - Russia saw its economy contract for five years as the executive and legislature dithered over the implementation of many of the basic foundations of a market economy. Russia achieved a slight recovery in 1997 but the government's budget deficits and the country's poor business climate made it vulnerable when the global financial crisis swept through in 1998. The crisis culminated in the August depreciation of the rouble and a sharp deterioration in living standards for most of the population. The economy subsequently recovered, growing by an average of more than 6 percent annually in 1999-2002. These GDP numbers, along with a renewed government effort to advance lagging structural reforms, have raised business and investor confidence over Russia's prospects in its second decade of transition. Yet, serious problems persist. The country remains vulnerable to swings in world fuel prices. Russia's industrial base must be replaced or modernized if the country is to maintain vigorous economic growth. Weak banking system, poor business climate discouraging both to domestic and foreign investors, corruption, local and regional government intervention in the courts, and widespread lack of trust in institutions count for the major problems.

***SLOVAK REPUBLIC***

Slovakia has mastered much of the difficult transition from centrally planned to market economy. The government has made much progress in 2001-2003 in macroeconomic stabilization and structural reform. Major privatizations are nearly complete and foreign investment has picked up. Slovakia's economy exceeded expectations in 2001-2003, despite the general European slowdown. However, high unemployment rate (15 percent in 2003) remains an issue. In 2004, the government faces the challenges of cutting down the budget and current account deficits, containment of inflation, and strengthening of the health care system.

***SLOVENIA***

Slovenia, with its historical ties to Western Europe, enjoys a GDP per capita substantially higher than that of the other transitive economies of Central Europe. Privatization of the economy proceeded at an accelerated pace in 2002-2003, and the budget deficit dropped from 3 percent of GDP in 2002 to 2 percent in 2003. Despite the 2001-2003 economic slowdown in Europe, Slovenia maintained its growth rate at 3 percent. Structural reforms to improve the business environment allow for greater foreign participation in Slovenia's economy and help to lower unemployment. However, further measures to curb inflation are needed. Corruption and high degree of coordination between government, business, and central bank policy are the major issues of concern.

***TAJIKISTAN***

Tajikistan has the lowest per capita GDP among the 15 former Soviet republics. The civil war (1992-1997) severely damaged the already weak economic infrastructure and caused a sharp decline in industrial and agricultural production. Even though 60 percent of its inhabitants continue to live in abject poverty, Tajikistan has experienced steady economic growth since 1997. Continued privatization of medium and large state-owned enterprises is supposed to further increase productivity. An important debt restructuring agreement was reached with Russia in December 2002. Tajikistan's economic situation, however, remains fragile due to uneven implementation of structural reforms, weak governance, widespread unemployment, and external debt burdens.

***TURKMENISTAN***

With an authoritarian ex-communist regime in power and a tribally based social structure, Turkmenistan has taken a cautious approach to economic reform. Privatization goals have been limited. In 1998-2003, Turkmenistan suffered from the obligations on extensive short-term

external debt. At the same time, however, exports notably rose, largely because of higher international oil and gas prices. Still, the overall prospects in the near future are discouraging because of widespread internal poverty, the burden of foreign debt, and the unwillingness on the part of government to adopt market-oriented reforms. However, Turkmenistan's cooperation with the international community in transporting humanitarian aid to Afghanistan may foreshadow a change in the atmosphere for foreign investment, aid, and technological support. Turkmenistan's economic statistics are state secrets, and GDP and other figures are subject to wide margins of error.

***UKRAINE***

After Russia, the Ukrainian republic was by far the most important economic component of the former Soviet Union. Shortly after independence in December 1991, the Ukrainian government liberalized most prices and erected a legal framework for privatization but widespread resistance to reform within the government and the legislature soon stalled reform efforts and led to some backtracking. Loose monetary policies pushed inflation to hyperinflationary levels in 1993. By 1999, the output fell to less than 40 percent of its 1991 level. Dependence on Russia for energy supplies and lack of significant structural reform have made the Ukrainian economy vulnerable to external shocks. However, President Kuchma has pledged to reduce the number of government agencies, streamline the regulatory process, create a legal environment to encourage entrepreneurs, and enact a comprehensive tax overhaul. On the other hand, reforms in more politically sensitive areas of structural reform and land privatization are still lagging. The first GDP growth since independence was reported in 2000 and the economy continued to expand in 2001-2003, propped up by strong domestic demand, low inflation, and solid consumer and investor confidence.

***UZBEKISTAN***

Following independence in December 1991, the government sought to support its Soviet-style command economy with subsidies and tight controls on production and prices. Uzbekistan responded to the negative external conditions generated by the Asian and Russian financial crises by emphasizing import substitute industrialization and by tightening export and currency controls within its already largely closed economy. The government, while aware of the need to improve the investment climate, takes measures that increase the government's control over business decisions. Since independence, sharp and growing inequality of income distribution has badly hurt the lower ranks of society.

## *Appendix II: Absolute and Conditional Convergence – Results of Regressions Run on Panel Data*

The following tables provide results of the regressions run to explain GDP growth rate by initial GDP and other explanatory variables. Regression coefficients are presented, t-values given in brackets, and coefficients of determination placed there for 10 groups of economies tested for convergence. Each column stands for different regression – the regressions differ in number of included explanatory variables.

**Table II.1: CEEC Countries and CEEC -2 Countries.**

| | **CEEC 1995 -2000** | | | | **CEEC -2 1995 - 2000** | | | |
|---|---|---|---|---|---|---|---|---|
| | i | ii | iii | iv | i | ii | iii | iv |
| **const.** | -3.8419 | -3.8803 | -3.2691 | -0.0875 | 0.9793 | 0.7947 | 0.7112 | 0.0591 |
| | *(-2.8351)* | *(-2.9205)* | *(-2.8524)* | *(-0.6950)* | *(0.6129)* | *(4.2958)* | *(4.1051)* | *(0.6068)* |
| **$GDP_0$** | -0.1430 | -0.1453 | -0.1419 | 0.0124 | -0.0892 | -0.0944 | -0.0875 | -0.0027 |
| | *(-5.8377)* | *(-6.5921)* | *(-6.5438)* | *(0.8781)* | *(-3.1625)* | *(-4.0404)* | *(-3.8311)* | *(-0.2484)* |
| **GC** | -0.0704 | -0.0708 | - | - | -0.0327 | - | - | - |
| | *(-0.8998)* | *(-0.9143)* | *(-)* | *(-)* | *(-0.4372)* | *(-)* | *(-)* | *(-)* |
| **INV** | 1.0292 | 1.0486 | 1.0627 | - | 0.5412 | 0.5755 | 0.6240 | - |
| | *(5.8501)* | *(6.9898)* | *(7.1354)* | *(-)* | *(2.6414)* | *(3.1539)* | *(3.4784)* | *(-)* |
| **FUNDS** | 5.2594 | 5.3501 | 4.7706 | - | -2.7472 | -3.3354 | - | - |
| | *(3.0948)* | *(3.2840)* | *(3.1846)* | *(-)* | *(-0.7957)* | *(-1.2266)* | *(-)* | *(-)* |
| **INFL** | -0.0008 | - | - | - | -0.2524 | -0.2461 | -0.2076 | - |
| | *(-0.2175)* | *(-)* | *(-)* | *(-)* | *(-3.0436)* | *(-3.5738)* | *(-3.3624)* | *(-)* |
| **POP** | -3.3608 | -3.3838 | -3.1612 | - | -2.1341 | -2.1314 | -2.1054 | - |
| | *(-4.3638)* | *(-4.4856)* | *(-4.4357)* | *(-)* | *(-3.0744)* | *(-3.8092)* | *(-3.7387)* | *(-)* |
| **LE** | 1.1554 | 1.1680 | 1.0146 | - | -0.0510 | - | - | - |
| | *(3.4053)* | *(3.5332)* | *(3.5686)* | *(-)* | *(-0.1293)* | *(-)* | *(-)* | *(-)* |
| **$R^2$** | 0.6129 | 0.6125 | 0.6049 | 0.0158 | 0.4916 | 0.4873 | 0.4646 | 0.0016 |

* t-values are given in brackets
Source: the author.

**Table II.2: V5 Countries and CEEC + FSU Countries.**

| | V5 1993 – 2000 | | | | CEEC + FSU 1996 - 2000 | | | |
|---|---|---|---|---|---|---|---|---|
| | i | ii | iii | iv | i | ii | iii | iv |
| **const.** | -0.0556 | -0.6207 | -1.2957 | 0.3009 | 0.4725 | 0.1381 | 0.2371 | -0.0133 |
| | *(-0.0486)* | *(-0.7802)* | *(-1.8782)* | *(2.4998)* | *(0.6736)* | *(1.0428)* | *(1.9974)* | *(-0.1403)* |
| **$GDP_0$** | -0.0889 | -0.0964 | -0.0581 | -0.0287 | -0.0224 | -0.0203 | -0.0296 | 0.0053 |
| | *(-3.3741)* | *(-4.0830)* | *(-3.3209)* | *(-2.2052)* | *(-1.2764)* | *(-1.2808)* | *(-1.9532)* | *(0.4811)* |
| **GC** | 0.1068 | 0.1196 | - | - | 0.0939 | 0.0894 | - | - |
| | *(1.4947)* | *(2.0085)* | *(-)* | *(-)* | *(1.2894)* | *(1.2597)* | *(-)* | *(-)* |
| **INV** | -0.0063 | - | - | - | 0.3039 | 0.2958 | 0.3124 | - |
| | *(-0.0408)* | *(-)* | *(-)* | *(-)* | *(2.2194)* | *(2.4090)* | *(2.6571)* | *(-)* |
| **FUNDS** | -1.6157 | -1.2596 | - | - | -0.5976 | - | - | - |
| | *(-1.2605)* | *(-1.2463)* | *(-)* | *(-)* | *(-0.3493)* | *(-)* | *(-)* | *(-)* |
| **INFL** | -0.1038 | -0.0886 | - | - | -0.0064 | -0.0064 | - | - |
| | *(-1.2637)* | *(-1.6369)* | *(-)* | *(-)* | *(-1.2972)* | *(-1.2994)* | *(-)* | *(-)* |
| **POP** | 0.9285 | - | - | - | -1.4539 | -1.4785 | -1.5997 | - |
| | *(0.7088)* | *(-)* | *(-)* | *(-)* | *(-2.8270)* | *(-2.9204)* | *(-3.1581)* | *(-)* |
| **LE** | 0.2136 | 0.3601 | 0.4361 | - | -0.0739 | - | - | - |
| | *(0.7325)* | *(1.7856)* | *(2.3460)* | *(-)* | *(-0.4483)* | *(-)* | *(-)* | *(-)* |
| **$R^2$** | 0.3962 | 0.3846 | 0.2563 | 0.1284 | 0.1701 | 0.1666 | 0.1306 | 0.0027 |

* t-values are given in brackets
Source: the author.

**Table II.3: EUROPE + CEEC + FSU Countries and EU15 Countries.**

| | EUROPE + CEEC + FSU 1996 – 2000 | | | | EU15 1993 - 2000 | | | |
|---|---|---|---|---|---|---|---|---|
| | i | ii | iii | iv | i | ii | iii | iv |
| **const.** | 0.1801 | 0.0166 | 0.0655 | 0.0091 | 1.0387 | 0.4242 | 0.4249 | -0.0395 |
| | *(0.4498)* | *(0.2163)* | *(1.3010)* | *(0.2310)* | *(1.7492)* | *(3.6824)* | *(3.6975)* | *(-0.4559)* |
| **$GDP_0$** | -0.0005 | -0.0019 | -0.0062 | 0.0025 | -0.0353 | -0.0384 | -0.0398 | 0.0072 |
| | *(-0.0491)* | *(-0.2248)* | *(-0.9429)* | *(0.5962)* | *(-2.9359)* | *(-3.2907)* | *(-3.4568)* | *(0.8245)* |
| **GC** | 0.0405 | 0.0420 | - | - | -0.0864 | -0.0828 | -0.0920 | - |
| | *(0.7897)* | *(0.8460)* | *(-)* | *(-)* | *(-1.7378)* | *(-1.6687)* | *(-1.9212)* | *(-)* |
| **INV** | 0.1512 | 0.1498 | 0.1439 | - | -0.0771 | -0.0599 | - | - |
| | *(1.7051)* | *(1.8536)* | *(1.7885)* | *(-)* | *(-0.9293)* | *(-0.7354)* | *(-)* | *(-)* |
| **FUNDS** | -0.1277 | - | - | - | - | - | - | - |
| | *(-0.1006)* | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* |
| **INFL** | -0.0083 | -0.0081 | -0.0082 | - | -0.2800 | -0.2814 | -0.2711 | - |
| | *(-2.1640)* | *(-2.1425)* | *(-2.1716)* | *(-)* | *(-2.0659)* | *(-2.0748)* | *(-2.0140)* | *(-)* |
| **POP** | -0.8673 | -0.8975 | -0.9721 | - | 3.5560 | 3.8005 | 3.7633 | - |
| | *(-2.4543)* | *(-2.6074)* | *(-2.9247)* | *(-)* | *(5.1659)* | *(5.8604)* | *(5.8342)* | *(-)* |
| **LE** | -0.0409 | - | - | - | -0.1474 | - | - | - |
| | *(-0.4042)* | *(-)* | *(-)* | *(-)* | *(-1.0548)* | *(-)* | *(-)* | *(-)* |
| **$R^2$** | 0.0965 | 0.0954 | 0.0913 | 0.0022 | 0.3035 | 0.2956 | 0.2917 | 0.0066 |

* t-values are given in brackets
Source: the author.

**Table II.4: EU15 + V5 Countries and EU25 Countries.**

| | EU15 + V5 1993 – 2000 | | | | EU25 1993 - 2000 | | | |
|---|---|---|---|---|---|---|---|---|
| | i | ii | iii | iv | i | ii | iii | iv |
| **const.** | 1.3440 | 1.2430 | 0.2502 | 0.0686 | 1.8224 | 1.6333 | 1.2063 | 0.0443 |
| | *(3.1129)* | *(3.2074)* | *(4.8929)* | *(1.4897)* | *(4.4317)* | *(4.2507)* | *(3.5661)* | *(1.1290)* |
| **$GDP_0$** | -0.0294 | -0.0300 | -0.0233 | -0.0037 | -0.0127 | -0.0125 | -0.0092 | -0.0012 |
| | *(-3.3800)* | *(-3.4846)* | *(-4.3534)* | *(-0.7777)* | *(-1.5507)* | *(-1.5280)* | *(-1.1397)* | *(-0.2947)* |
| **GC** | -0.0459 | -0.0531 | - | - | -0.0412 | - | - | - |
| | *(-1.3143)* | *(-1.6543)* | *(-)* | *(-)* | *(-1.2733)* | *(-)* | *(-)* | *(-)* |
| **INV** | -0.0376 | - | - | - | -0.0880 | -0.0857 | - | - |
| | *(-0.5366)* | *(-)* | *(-)* | *(-)* | *(-1.5504)* | *(-1.5071)* | *(-)* | *(-)* |
| **FUNDS** | -1.8695 | -1.7179 | - | - | -2.4494 | -2.6639 | - | - |
| | *(-1.6911)* | *(-1.6117)* | *(-)* | *(-)* | *(-2.0683)* | *(-2.2679)* | *(-)* | *(-)* |
| **INFL** | -0.1068 | -0.0956 | - | - | -0.1475 | -0.1433 | -0.1275 | - |
| | *(-1.9989)* | *(-1.9492)* | *(-)* | *(-)* | *(-5.3641)* | *(-5.2392)* | *(-4.8240)* | *(-)* |
| **POP** | 3.1003 | 3.1063 | 3.0108 | - | 1.1760 | 1.3871 | 1.0757 | - |
| | *(5.9391)* | *(5.9680)* | *(5.9863)* | *(-)* | *(2.5079)* | *(3.1556)* | *(2.5518)* | *(-)* |
| **LE** | -0.2346 | -0.2118 | - | - | -0.3782 | -0.3362 | -0.2498 | - |
| | *(-2.3030)* | *(-2.2931)* | *(-)* | *(-)* | *(-3.7956)* | *(-3.5685)* | *(-2.8737)* | *(-)* |
| **$R^2$** | 0.2697 | 0.2681 | 0.2108 | 0.0044 | 0.1850 | 0.1764 | 0.1452 | 0.0005 |

* t-values are given in brackets
Source: the author.

**Table II.5: OECD + CEEC + FSU Countries and OECD + CEEC Countries.**

| | OECD + CEEC + FSU 1996 – 2000 | | | | OECD + CEEC 1995 - 2000 | | | |
|---|---|---|---|---|---|---|---|---|
| | i | ii | iii | iv | i | ii | iii | iv |
| **const.** | 0.0788 | 0.0170 | 0.0195 | 0.0224 | -0.0638 | -0.0659 | 0.0446 | -0.0280 |
| | *(0.2880)* | *(0.2536)* | *(0.5332)* | *(0.6169)* | *(-0.2396)* | *(-0.2492)* | *(1.0578)* | *(-0.7139)* |
| **$GDP_0$** | -0.0007 | -0.0008 | 0.0017 | 0.0010 | -0.0056 | -0.0053 | -0.0039 | 0.0058 |
| | *(-0.0780)* | *(-0.1101)* | *(0.4275)* | *(0.2597)* | *(-0.7162)* | *(-0.7452)* | *(-0.7692)* | *(1.4252)* |
| **GC** | 0.0360 | 0.0355 | - | - | -0.0068 | - | - | - |
| | *(0.7820)* | *(0.7757)* | *(-)* | *(-)* | *(-0.1515)* | *(-)* | *(-)* | *(-)* |
| **INV** | 0.0937 | 0.0986 | - | - | 0.1192 | 0.1183 | 0.1003 | - |
| | *(1.2633)* | *(1.3822)* | *(-)* | *(-)* | *(1.7089)* | *(1.7093)* | *(1.7841)* | *(-)* |
| **FUNDS** | -0.2194 | - | - | - | 0.3660 | 0.3365 | - | - |
| | *(-0.2177)* | *(-)* | *(-)* | *(-)* | *(0.3955)* | *(0.3705)* | *(-)* | *(-)* |
| **INFL** | -0.0088 | -0.0087 | -0.0096 | - | -0.0115 | -0.0115 | -0.0118 | - |
| | *(-2.3333)* | *(-2.3310)* | *(-2.6366)* | *(-)* | *(-3.6780)* | *(-3.7011)* | *(-3.8553)* | *(-)* |
| **POP** | -0.8162 | -0.8338 | -0.7818 | - | -0.0976 | - | - | - |
| | *(-2.4657)* | *(-2.5838)* | *(-2.6333)* | *(-)* | *(-0.2485)* | *(-)* | *(-)* | *(-)* |
| **LE** | -0.0143 | - | - | - | 0.0281 | 0.0277 | - | - |
| | *(-0.2120)* | *(-)* | *(-)* | *(-)* | *(0.4061)* | *(0.4062)* | *(-)* | *(-)* |
| **$R^2$** | 0.0779 | 0.0775 | 0.0665 | 0.0004 | 0.1257 | 0.1253 | 0.1243 | 0.0113 |

* t-values are given in brackets
Source: the author.

## *Appendix III: Conditional Convergence – Results of Regressions Run on Panel Data with Time Specific Dummies*

The following tables provide results of the regressions run to explain GDP growth rate by initial GDP and other explanatory variables including time specific dummies. Regression coefficients are presented, t-values given in brackets, and coefficients of determination placed there for 10 groups of economies tested for convergence. Each column stands for different regression – the regressions differ in number of included explanatory variables.

**Table III.1: CEEC Countries and CEEC -2 Countries.**

| | **CEEC 1995 – 2000** | | | **CEEC -2 1995 – 2000** | | |
|---|---|---|---|---|---|---|
| | i | ii | iii | i | ii | iii |
| **const.** | -3.9456 | -3.9507 | -4.0185 | 0.9656 | 0.8479 | 0.7318 |
| | *(-2.8923)* | *(-2.9804)* | *(-3.0964)* | *(0.5892)* | *(4.4247)* | *(4.3538)* |
| **$GDP_0$** | -0.1492 | -0.1469 | -0.1478 | -0.1003 | -0.1018 | -0.0912 |
| | *(-6.0083)* | *(-6.6003)* | *(-6.8646)* | *(-3.3910)* | *(-4.2115)* | *(-4.1086)* |
| **GC** | -0.0670 | -0.0672 | -0.0665 | -0.0028 | - | - |
| | *(-0.8552)* | *(-0.8761)* | *(-0.8813)* | *(-0.0357)* | *(-)* | *(-)* |
| **INV** | 1.0951 | 1.0781 | 1.0883 | 0.6360 | 0.6451 | 0.6793 |
| | *(6.0464)* | *(6.9711)* | *(7.3565)* | *(2.9299)* | *(3.4075)* | *(3.8539)* |
| **FUNDS** | 5.6598 | 5.6274 | 5.7458 | -4.0158 | -4.0124 | - |
| | *(3.2351)* | *(3.3679)* | *(3.5827)* | *(-1.1089)* | *(-1.4467)* | *(-)* |
| **INFL** | 0.0006 | - | - | -0.3028 | -0.2997 | -0.2349 |
| | *(0.1460)* | *(-)* | *(-)* | *(-3.2260)* | *(-3.8205)* | *(-3.8133)* |
| **POP** | -3.3009 | -3.2466 | -3.2586 | -1.9163 | -1.9364 | -1.9145 |
| | *(-4.2403)* | *(-4.2942)* | *(-4.4103)* | *(-2.6675)* | *(-3.3633)* | *(-3.4496)* |
| **LE** | 1.1899 | 1.1861 | 1.2024 | -0.0300 | - | - |
| | *(3.4834)* | *(3.5926)* | *(3.7239)* | *(-0.0742)* | *(-)* | *(-)* |
| **T93-94** | - | - | - | - | - | - |
| | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* |
| **T94-95** | - | - | - | - | - | - |
| | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* |
| **T95-96** | 0.0117 | 0.0161 | 0.0202 | 0.0222 | 0.0224 | 0.0192 |
| | *(0.7817)* | *(1.2628)* | *(1.7961)* | *(1.5085)* | *(1.6165)* | *(1.8314)* |
| **T96-97** | -0.0106 | -0.0058 | - | 0.0044 | 0.0045 | - |
| | *(-0.7053)* | *(-0.4582)* | *(-)* | *(0.3149)* | *(0.3338)* | *(-)* |
| **T97-98** | -0.0144 | -0.0099 | - | 0.0046 | 0.0045 | - |
| | *(-0.9995)* | *(-0.8160)* | *(-)* | *(0.3334)* | *(0.3445)* | *(-)* |
| **T98-99** | -0.0088 | - | - | -0.0033 | -0.0032 | - |
| | *(-0.6140)* | *(-)* | *(-)* | *(-0.2422)* | *(-0.2473)* | *(-)* |
| **$R^2$** | 0.6500 | 0.6463 | 0.6401 | 0.5470 | 0.5469 | 0.5127 |

* t-values are given in brackets
Source: the author.

**Table III.2: V5 Countries and CEEC + FSU Countries.**

| | **V5 1993 – 2000** | | | **CEEC + FSU 1996 – 2000** | | |
|---|---|---|---|---|---|---|
| | i | ii | iii | i | ii | iii |
| **const.** | -0.6258 | -0.1136 | 1.0209 | 0.5969 | 0.1667 | 0.2159 |
| | *(-0.5772)* | *(-0.1437)* | *(5.0802)* | *(0.8460)* | *(1.2372)* | *(1.8132)* |
| **$GDP_0$** | -0.1445 | -0.1324 | -0.1163 | -0.0256 | -0.0226 | -0.0256 |
| | *(-4.8490)* | *(-5.6221)* | *(-5.1365)* | *(-1.4394)* | *(-1.4121)* | *(-1.6759)* |
| **GC** | 0.1339 | 0.1200 | - | 0.1028 | 0.0965 | - |
| | *(2.0369)* | *(1.9733)* | *(-)* | *(1.4095)* | *(1.3582)* | *(-)* |
| **INV** | 0.4535 | 0.4080 | 0.5127 | 0.3297 | 0.3186 | 0.2696 |
| | *(2.1116)* | *(2.0904)* | *(2.6784)* | *(2.3892)* | *(2.5662)* | *(2.2340)* |
| **FUNDS** | -3.5434 | -3.5670 | -3.7555 | -0.7942 | - | - |
| | *(-2.6715)* | *(-2.7872)* | *(-3.1533)* | *(-0.4598)* | *(-)* | *(-)* |
| **INFL** | -0.1406 | -0.1455 | -0.1104 | -0.0060 | -0.0060 | -0.0073 |
| | *(-1.8313)* | *(-1.9651)* | *(-1.7736)* | *(-1.1805)* | *(-1.1959)* | *(-1.4969)* |
| **POP** | -1.0130 | - | - | -1.4834 | -1.5121 | -1.5056 |
| | *(-0.7155)* | *(-)* | *(-)* | *(-2.8394)* | *(-2.9357)* | *(-2.9881)* |
| **LE** | 0.4388 | 0.2966 | - | -0.0944 | - | - |
| | *(1.5617)* | *(1.5371)* | *(-)* | *(-0.5713)* | *(-)* | *(-)* |
| **T93-94** | 0.0528 | 0.0464 | 0.0550 | - | - | - |
| | *(2.4769)* | *(2.8230)* | *(3.1679)* | *(-)* | *(-)* | *(-)* |
| **T94-95** | 0.0445 | 0.0414 | 0.0458 | - | - | - |
| | *(2.7784)* | *(3.1890)* | *(3.3129)* | *(-)* | *(-)* | *(-)* |
| **T95-96** | 0.0219 | 0.0203 | 0.0220 | - | - | - |
| | *(1.9279)* | *(2.2621)* | *(2.3540)* | *(-)* | *(-)* | *(-)* |
| **T96-97** | 0.0128 | 0.0129 | 0.0150 | -0.0186 | -0.0168 | - |
| | *(1.3085)* | *(1.6066)* | *(1.8091)* | *(-1.1405)* | *(-1.0551)* | *(-)* |
| **T97-98** | -0.0011 | - | - | -0.0281 | -0.0273 | -0.0170 |
| | *(-0.1191)* | *(-)* | *(-)* | *(-1.7695)* | *(-1.7378)* | *(-1.3255)* |
| **T98-99** | -0.0093 | -0.0079 | - | -0.0129 | -0.0125 | - |
| | *(-0.9959)* | *(-1.0020)* | *(-)* | *(-0.8031)* | *(-0.7880)* | *(-)* |
| **$R^2$** | 0.6181 | 0.6080 | 0.4859 | 0.2038 | 0.1980 | 0.1682 |

***** t-values are given in brackets

Source: the author.

**Table III.3: EUROPE + CEEC + FSU Countries and EU15 Countries.**

| | **EUROPE + CEEC + FSU 1996 – 2000** | | | **EU15 1993 – 2000** | | |
|---|---|---|---|---|---|---|
| | i | ii | iii | i | ii | iii |
| **const.** | 0.1988 | 0.0293 | 0.0697 | 2.1644 | 2.0449 | 1.9050 |
| | *(0.4953)* | *(0.3772)* | *(1.3834)* | *(3.6982)* | *(3.5187)* | *(3.3128)* |
| **$GDP_0$** | -0.0012 | -0.0026 | -0.0065 | -0.0402 | -0.0364 | -0.0333 |
| | *(-0.1162)* | *(-0.3089)* | *(-0.9808)* | *(-3.6420)* | *(-3.3741)* | *(-3.1010)* |
| **GC** | 0.0389 | 0.0404 | - | -0.0753 | -0.0670 | - |
| | *(0.7564)* | *(0.8123)* | *(-)* | *(-1.6508)* | *(-1.4749)* | *(-)* |
| **INV** | 0.1576 | 0.1563 | 0.1457 | -0.2503 | -0.2422 | -0.2566 |
| | *(1.7677)* | *(1.9257)* | *(1.8130)* | *(-2.9667)* | *(-2.8752)* | *(-3.2285)* |
| **FUNDS** | -0.1347 | - | - | - | - | - |
| | *(-0.1051)* | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* |
| **INFL** | -0.0085 | -0.0083 | -0.0085 | -0.2938 | -0.2302 | -0.2225 |
| | *(-2.1740)* | *(-2.1506)* | *(-2.2401)* | *(-2.2724)* | *(-1.8733)* | *(-1.8031)* |
| **POP** | -0.8878 | -0.9192 | -0.9587 | 3.7065 | 3.6360 | 3.7487 |
| | *(-2.4907)* | *(-2.6478)* | *(-2.8869)* | *(5.9895)* | *(5.8779)* | *(6.0847)* |
| **LE** | -0.0424 | - | - | -0.3835 | -0.3668 | -0.3428 |
| | *(-0.4178)* | *(-)* | *(-)* | *(-2.8376)* | *(-2.7183)* | *(-2.5549)* |
| **T93-94** | - | - | - | -0.0271 | -0.0213 | -0.0208 |
| | *(-)* | *(-)* | *(-)* | *(-3.8769)* | *(-3.5923)* | *(-3.7607)* |
| **T94-95** | - | - | - | -0.0176 | -0.0117 | -0.0105 |
| | *(-)* | *(-)* | *(-)* | *(-2.6369)* | *(-2.1224)* | *(-2.0123)* |
| **T95-96** | - | - | - | -0.0318 | -0.0258 | -0.0240 |
| | *(-)* | *(-)* | *(-)* | *(-4.8891)* | *(-4.9230)* | *(-4.7920)* |
| **T96-97** | -0.0057 | -0.0055 | - | -0.0118 | -0.0056 | - |
| | *(-0.6090)* | *(-0.6009)* | *(-)* | *(-1.8260)* | *(-1.0940)* | *(-)* |
| **T97-98** | -0.0138 | -0.0138 | -0.0090 | -0.0089 | - | - |
| | *(-1.5041)* | *(-1.5050)* | *(-1.2125)* | *(-1.4007)* | *(-)* | *(-)* |
| **T98-99** | -0.0086 | -0.0087 | - | -0.0085 | - | - |
| | *(-0.9334)* | *(-0.9412)* | *(-)* | *(-1.3404)* | *(-)* | *(-)* |
| **$R^2$** | 0.1102 | 0.1091 | 0.0997 | 0.4805 | 0.4667 | 0.4477 |

***** t-values are given in brackets

Source: the author.

**Table III.4: EU15 + V5 Countries and EU25 Countries.**

| | **EU15 + V5 1993 – 2000** | | | **EU25 1993 - 2000** | | |
|---|---|---|---|---|---|---|
| | i | ii | iii | i | ii | iii |
| **const.** | 1.8177 | 1.7681 | 1.3473 | 1.9478 | 1.9055 | 1.6611 |
| | *(4.3179)* | *(4.2450)* | *(3.5018)* | *(4.8623)* | *(4.7798)* | *(4.4290)* |
| **$GDP_0$** | -0.0312 | -0.0302 | -0.0291 | -0.0125 | -0.0124 | -0.0122 |
| | *(-3.8196)* | *(-3.7181)* | *(-3.5452)* | *(-1.5698)* | *(-1.5605)* | *(-1.5301)* |
| **GC** | -0.0230 | - | - | -0.0513 | -0.0469 | - |
| | *(-0.6792)* | *(-)* | *(-)* | *(-1.6109)* | *(-1.4938)* | *(-)* |
| **INV** | -0.2053 | -0.2216 | -0.1460 | -0.1292 | -0.1135 | -0.1200 |
| | *(-2.6175)* | *(-3.1363)* | *(-2.2782)* | *(-2.2055)* | *(-1.9978)* | *(-2.1024)* |
| **FUNDS** | -1.9144 | -1.9587 | - | -2.5205 | -2.5575 | -2.7556 |
| | *(-1.8420)* | *(-1.8943)* | *(-)* | *(-2.2008)* | *(-2.2354)* | *(-2.4079)* |
| **INFL** | -0.1483 | -0.1449 | -0.1377 | -0.1392 | -0.1422 | -0.1334 |
| | *(-2.8786)* | *(-2.8999)* | *(-2.7479)* | *(-5.0650)* | *(-5.2120)* | *(-4.8894)* |
| **POP** | 3.4952 | 3.5490 | 3.4084 | 1.3990 | 1.3030 | 1.5889 |
| | *(6.9365)* | *(7.1723)* | *(6.8601)* | *(3.0098)* | *(2.8358)* | *(3.6488)* |
| **LE** | -0.3289 | -0.3203 | -0.2305 | -0.4035 | -0.3957 | -0.3410 |
| | *(-3.3538)* | *(-3.2911)* | *(-2.5276)* | *(-4.1660)* | *(-4.0982)* | *(-3.7089)* |
| **T93-94** | -0.0236 | -0.0213 | -0.0168 | -0.0166 | -0.0116 | -0.0104 |
| | *(-3.6984)* | *(-3.8338)* | *(-3.5873)* | *(-2.4043)* | *(-2.1594)* | *(-1.9360)* |
| **T94-95** | -0.0123 | -0.0096 | - | -0.0093 | - | - |
| | *(-2.0715)* | *(-1.8544)* | *(-)* | *(-1.4075)* | *(-)* | *(-)* |
| **T95-96** | -0.0228 | -0.0198 | -0.0155 | -0.0209 | -0.0165 | -0.0144 |
| | *(-3.9757)* | *(-3.9961)* | *(-3.6060)* | *(-3.2362)* | *(-3.3056)* | *(-2.9078)* |
| **T96-97** | -0.0063 | -0.0032 | - | -0.0009 | - | - |
| | *(-1.1114)* | *(-0.6590)* | *(-)* | *(-0.1460)* | *(-)* | *(-)* |
| **T97-98** | -0.0064 | -0.0033 | - | -0.0063 | - | - |
| | *(-1.1658)* | *(-0.6985)* | *(-)* | *(-1.0004)* | *(-)* | *(-)* |
| **T98-99** | -0.0059 | - | - | -0.0122 | -0.0085 | - |
| | *(-1.0706)* | *(-)* | *(-)* | *(-1.9478)* | *(-1.6906)* | *(-)* |
| **$R^2$** | 0.3895 | 0.3820 | 0.3466 | 0.2690 | 0.2551 | 0.2288 |

***** t-values are given in brackets

Source: the author.

**Table III.5: OECD + CEEC + FSU Countries and OECD + CEEC Countries.**

| | **OECD + CEEC + FSU 1996 – 2000** | | | **OECD + CEEC 1995 -2000** | | |
|---|---|---|---|---|---|---|
| | i | ii | iii | i | ii | iii |
| **const.** | 0.0940 | 0.0297 | 0.0244 | -0.0266 | 0.0621 | 0.0467 |
| | *(0.3437)* | *(0.4386)* | *(0.6687)* | *(-0.0987)* | *(1.1305)* | *(1.1072)* |
| **$GDP_0$** | -0.0012 | -0.0014 | 0.0015 | -0.0058 | -0.0046 | -0.0040 |
| | *(-0.1425)* | *(-0.1954)* | *(0.3812)* | *(-0.7361)* | *(-0.7963)* | *(-0.7916)* |
| **GC** | 0.0348 | 0.0343 | - | -0.0149 | -0.0122 | - |
| | *(0.7571)* | *(0.7516)* | *(-)* | *(-0.3259)* | *(-0.2729)* | *(-)* |
| **INV** | 0.0978 | 0.1028 | - | 0.1100 | 0.0948 | 0.1016 |
| | *(1.3206)* | *(1.4437)* | *(-)* | *(1.5498)* | *(1.6412)* | *(1.8068)* |
| **FUNDS** | -0.2141 | - | - | 0.3206 | - | - |
| | *(-0.2115)* | *(-)* | *(-)* | *(0.3416)* | *(-)* | *(-)* |
| **INFL** | -0.0089 | -0.0088 | -0.0100 | -0.0117 | -0.0119 | -0.0119 |
| | *(-2.3685)* | *(-2.3664)* | *(-2.7521)* | *(-3.6854)* | *(-3.8228)* | *(-3.8932)* |
| **POP** | -0.8135 | -0.8317 | -0.7595 | -0.1307 | -0.1230 | - |
| | *(-2.4542)* | *(-2.5760)* | *(-2.5718)* | *(-0.3315)* | *(-0.3159)* | *(-)* |
| **LE** | -0.0150 | - | - | 0.0223 | - | - |
| | *(-0.2234)* | *(-)* | *(-)* | *(0.3196)* | *(-)* | *(-)* |
| **T93-94** | - | - | - | - | - | - |
| | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* |
| **T94-95** | - | - | - | - | - | - |
| | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* | *(-)* |
| **T95-96** | - | - | - | -0.0106 | -0.0109 | - |
| | *(-)* | *(-)* | *(-)* | *(-1.4074)* | *(-1.4652)* | *(-)* |
| **T96-97** | -0.0063 | -0.0061 | - | -0.0063 | -0.0065 | - |
| | *(-0.7488)* | *(-0.7369)* | *(-)* | *(-0.8283)* | *(-0.8651)* | *(-)* |
| **T97-98** | -0.0168 | -0.0168 | -0.0123 | -0.0125 | -0.0125 | -0.0064 |
| | *(-2.0290)* | *(-2.0375)* | *(-0.8341)* | *(-1.6844)* | *(-1.6943)* | *(-1.1094)* |
| **T98-99** | -0.0069 | -0.0069 | - | -0.0071 | -0.0070 | - |
| | *(-0.8266)* | *(-0.8402)* | *(-)* | *(-0.9506)* | *(-0.9466)* | *(-)* |
| **$R^2$** | 0.0989 | 0.0985 | 0.0830 | 0.1426 | 0.1419 | 0.1304 |

***** t-values are given in brackets

Source: the author.

## *Appendix IV: Visegrad Countries Relative to the European Union Average*

The following table provides figures on GDP per capita at current PPPs and on comparative price levels for V5 countries. European Union average is taken to equal 100. The table shows the differences among Visegrad countries' economic indicators relative to the EU decrease over time.

**Table IV.1: V5 Countries Relative to the EU15 Average.**

| | GDP per capita | | Price level | |
|---|---|---|---|---|
| **Country** | **1990** | **2002** | **1995** | **2002** |
| **Czech Republic** | 69 | 63 | 35 | 47 |
| **Hungary** | 49 | 53 | 41 | 50 |
| **Poland** | 31 | 42 | 40 | 61 |
| **Slovak Republic** | 51 | 53 | 33 | 44 |
| **Slovenia** | 69 | 73 | 63 | 67 |
| **Sample variance** | **203** | **110** | **115** | **77** |

Source: [21], [29].