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Human Capital--Economic Growth Nexus in the Former Soviet Bloc*

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Nashville, TN – 2007

* This paper was presented at the Annual Meeting of the Comparative International Education Society (CIES), Baltimore, MD, March 2007.

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This study analyses the role and impact of higher education on per capita economic growth in the Former Soviet Bloc. It attempts to estimate the significance of educational levels for initiating substantial economic growth that now takes place in these two countries. This study estimates a system of linear and log-linear equations that account for different time lags in the possible impact of higher education on economic growth. The results indicate that an increase in access of population to higher education brings positive results for the per capita GDP growth in the long term. Increasing the number of college-educated specialists leads to sustainable economic growth. Apparently, background for the 2000-2005 rapid economic growth in Ukraine and in the Russian Federation was laid down in early 1990s. This contradicts commonly accepted perception about the crisis decade of 1990s in the former Soviet Bloc.

Introduction

Analysis of macroeconomic indicators often underestimates qualitative characteristics. Macroeconomic indicators are aggregates that focus on the quantitative characteristics of national production. More precise estimates of economic situation in the Russian Federation and Ukraine as well as other transition economies with its vectors and level of development over the last two decades requires consideration of such fundamental socio-economic characteristics as education and healthcare.

Access to education and medical services is crucially important in characterizing living standards and level of personal consumption of the population. It is as important in analysis of reproduction of human capital. Higher education and medical services are two technologically complex branches of the economy that characterize developed nations. Their complexity serves as an indicator of level of economic development as well as presence of the necessary conditions for economic growth.

This study analyses the role and impact of human capital on per capita economic growth in transition economies of the former Soviet Bloc. The factors that are associated with the human capital in terms of education levels are analyzed in order to measure this impact. Our approach is to estimate the significance of higher education for initiating significant and sustainable economic growth. We estimate a system of linear and log-linear equations that account for different time lags in the possible impact of human capital on economic growth.

Literature review

The negative economic growth of 1990s in the former Soviet Bloc created an impression among many that the initiation of positive and sustainable economic growth in the region is

highly problematic. The currency crisis of 1997-1998 added to the pessimistic estimates. Nevertheless, as shown by economic indicators, the major economies of the former Soviet Bloc, including, first of all, the Russian Federation, Ukraine, Belarus, and Kazakhstan, experience rapid economic growth of five to eleven percent over the last seven years. Apparently, the national economies managed to overcome the poverty trap that was conceptualized in 1960s by supporters of exogenous growth models (Leontief, 1958, 1966).

There is research on low-development traps within the endogenous growth theories as well. Aghion and Howitt (1998 b) consider the model, based on Acemoglu (1994, 1997) and developed by Redding (1996). The model concludes that complementarity between workers' education decisions and firms' R&D decisions surprisingly will not open the possibility for multiple steady-state growth paths, including a low-development trap. The more workers invest in education, the more will entrepreneurs invest in R&D. This can be formalized as the following:

$$\mu^* = 1 \text{ if } \alpha < \rho(\lambda - 1)(1 + \gamma \upsilon^{\theta})(1 - \beta),\ 0 \text{ otherwise,} \qquad (1)$$

Thus, the more workers invest in education, i.e., the higher is υ , the more will entrepreneurs invest in R&D.

Such a trap will involve $\mu = 0$ and therefore $\upsilon^* = \underline{\upsilon} = \left(\beta\rho\theta\gamma\right)^{\frac{1}{1-\theta}}$. For it to exist we simply need

$$\alpha > \delta(1 - \beta)(\lambda - 1)\left(1 + \gamma \left(\beta\rho\theta\gamma\right)^{\frac{1}{1-\theta}}\right) \qquad (2)$$

Conversely, in order to a high growth steady-state path to exist, we need

$$\alpha < \delta(1-\beta)(\lambda-1)\,(1+\gamma\,(\beta\rho\theta\gamma)^{\frac{1}{1-\theta}}) \qquad (3)$$

The corresponding growth rates will be $g = \underline{g} = ln\,\lambda$ in the high-growth equilibrium and $g = \underline{g} = 0$ in the low-development trap (Aghion and Howitt, 1998, p. 342).

Measurement of human capital and issues of allocation are presented by Mincer (1996), Ruth (1998), Barro (1999), Mulligan and Sala-i-Martin (2000). Emphasis on measurement of human capital and its implication for economic growth are made by Kalaitzidakis et al. (2001). Based on cross country growth regressions and measures of human capital, presented in studies by Mankiw, Romer, and Weil (1992), Benhabib and Spiegel (2000), Barro and Sala-i-Martin (1999), Pritchett (1996), Barro (1997), Krueger and Lindahl (2000), they argue that a semiparametric, partially linear regression model specification of the cross country growth regression function is a particularly useful way of studying the contribution of human capital to economic growth. The semiparametric partially linear regression model is written as:

$$Y_{it} = x_{it}^{T}\gamma + q(Z_{it}) + U_{it} \qquad (4)$$

Where x_{it} is a variable of dimension q, γ is $q \times 1$ vector of unknown parameters, Z_{it} is a continuous variable of dimension p and $g()$ is an unknown function. Z_{it} refers to various measures of human capital. Human capital is measured by the level of education and gender. They conclude that the effect of human capital accumulation on growth is nonlinear and that there are threshold levels of human capital and growth for each country.

Shioji (2001) incorporates human capital into the concept of public capital and estimates dynamic effects of public capital on output per capita. The other components of public capital are: infrastructure, conservation of national land, and agriculture and fishery. Based on an open economy growth model, he derives an income convergence equation augmented with public capital (*PUP*). The relationship between steady state output per unit (*Y*) of labor and public capital (*PUP*) is presented by following equation:

$$Y_{it}^{*} = \sum_{j=1}^{J} \phi_j \times PUP_{jit-\tau} + Y_i, \qquad (5)$$

where $\phi_i = C_i / (1 - a)$.

ϕ_i represents the long-run elasticity of output with respect to public capital per capita, and *C* is a short-run elasticity. Shioji found that each component of *PUP* had positive effects on *Y*, but infrastructure was more important to growth than education and had a more significant positive effect on productivity than education. These results can be interpreted as support for endogenous growth.

Aghion and Howitt (1996) examined heterogeneity in the structure of innovative activity by making a distinction between research and development. They pointed out: “One advantage that Schumpeterian’s growth models is their greater specificity concerning how knowledge is used, how it is generated, and how it creates losses as well as gains… There are many kinds of innovative activity, generating many different kinds of knowledge. An aggregate theory that fails to distinguish between these different activities is potentially misleading if the distinction matters.” (Aghion and Howitt, 1996) They concluded that the level of research tends to covary

positively with the rate of growth, even in the extreme case where the general knowledge that underlies long-run growth is created by secondary innovations arising from the development process. R&D effects on long-run growth were researched by Segerstorm (2000) and Sorensen (1999).

Access to higher education in the NIS

Number of students in higher education institutions per 10000 population is chosen to analyze access of population to higher education. This indicator reflects level or stock of human capital in the countries as well as dynamics of production of human capital during the significant periods of time. Number of students in higher education institutions per 10000 population in the NIS for the period of 1980-1999 is presented in Tables 1 and 2.

TABLE 1

Number of students in higher education institutions per 10000 population in the NIS, 1980-1989

Country	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Azerbaijan	172	172	172	169	163	158	155	149	140	140
Armenia	189	188	189	183	173	163	160	161	168	186
Belarus	183	183	185	185	186	181	179	177	175	185
Georgia	168	170	172	172	169	167	160	160	157	171
Kazakhstan	173	176	179	181	180	172	170	168	167	171
Kyrgyzstan	151	154	154	151	148	144	142	136	133	136
Moldova	127	129	130	128	128	126	123	121	122	127
Russia	219	219	218	216	213	206	200	194	190	193
Tajikistan	142	138	137	133	131	119	115	114	115	125
Turkmenistan	124	125	127	126	122	119	117	117	112	116
Uzbekistan	172	172	170	165	162	155	154	155	155	163
Ukraine	176	175	175	174	173	167	166	166	165	171

Source: Commonwealth of Independent States (CIS) - Official Statistics, retrieved from the database in August 8, 2006.

TABLE 2

Number of students in higher education institutions per 10000 population in the NIS, 1990-1999

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Azerbaijan	146	147	134	125	117	128	132	127	134	147
Armenia	191	181	156	124	97	97	142	149	157	160
Belarus	184	180	179	169	181	191	203	219	239	258
Georgia	190	188	167	168	251	231	239	234	236	248
Kazakhstan	171	170	165	163	165	165	176	188	206	245
Kyrgyzstan	133	129	119	117	129	142	169	210	274	325
Moldova	125	120	109	108	114	149	159	180	199	212
Russia	190	186	177	171	171	188	201	221	245	280
Tajikistan	128	124	127	121	127	126	127	126	123	130
Turkmenistan	113	104	96	90	86	70	62	…	…	…
Uzbekistan	165	159	146	123	102	84	71	66	65	68
Ukraine	170	168	164	159	172	180	192	220	242	259

Source: Commonwealth of Independent States (CIS) - Official Statistics, retrieved from the database in August 8, 2006.

Contrary to the beliefs about the crisis in the Russian Federation and Ukraine, statistics point to the continuous growth in the number of students in higher education institutions per 10000 population. While during the independence and start of the market reforms in 1991 this indicator in Ukraine was equal to 168, by the year 1999 number of students enrolled in higher education institutions per 10000 population has reached 259. This indicator is slightly lower than in the Russian Federation, where number of students per 10000 thousand population grew from 186 in 1991 to 280 in 1999.

Dynamics of the number of students in higher education institutions per 10000 population in the NIS for the period of 1980-1999 are presented in Figure 1.

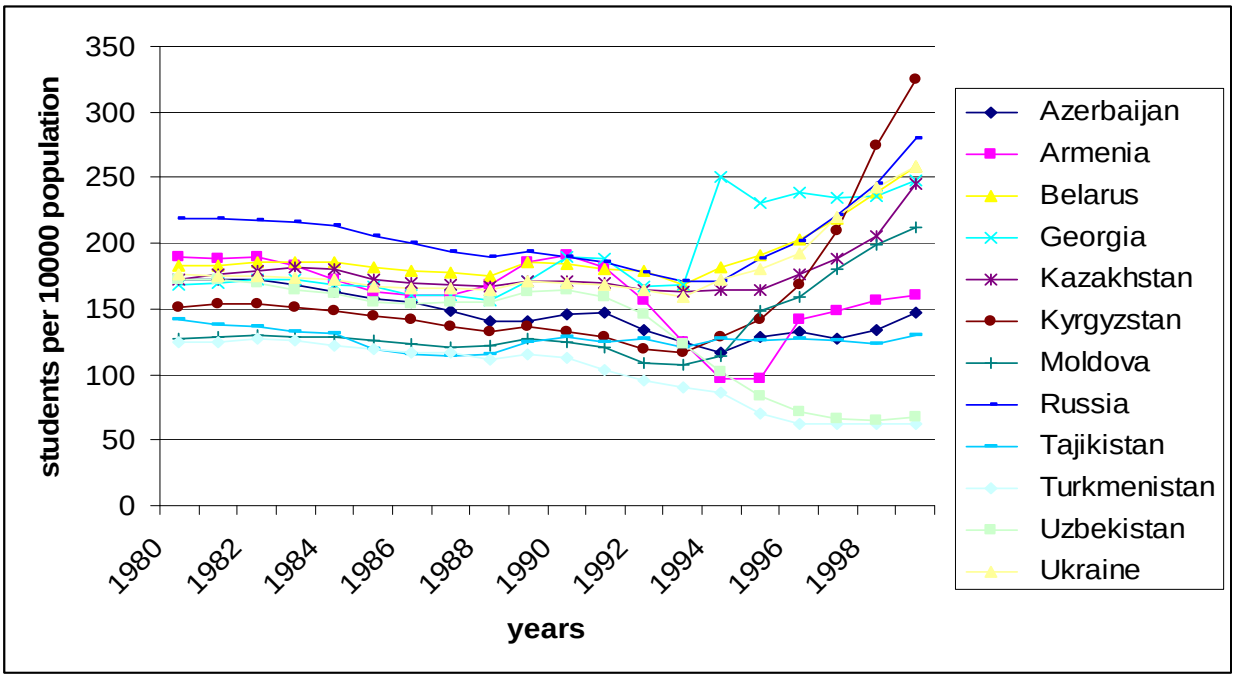

Figure 1. Number of students in higher education institutions per 10000 population in the NIS, 1980-1999

Data for the Russian Federation and Ukraine indicate that during the transition total number of students in higher education institutions per every ten thousand of population was increasing consistently since 1993 despite the decline in some other economic indicators. This proves not only the fact of the continuous positive developments in national systems of higher education based on the market reforms, but also shows continuous growth in accumulation and concentration of human capital in national economies.

Positive trends in the development of higher education industry and increasing access of population to higher education characterize such countries as Ukraine, the Russian Federation, and Belarus, but are not necessarily characteristics of all the former soviet republics. For instance, in Azerbaijan number of students in higher education institutions per every ten thousand of population as an indicator of access to higher education was declining till 1995 and reached level

of 1991 only in 1999, comprising 147 students. This indicator is almost twice lower than in the Russian Federation and Ukraine. In Armenia value of this indicator declined from 191 in 1990 to 97 in 1995 and then increased to 160 in 1999.

In some other former republics, the situation with access to higher education did not regain its positions of 1991. Indicator of number of students in higher education institutions per every ten thousand of population declined in Uzbekistan from 170 in 1990 to 68 in 1999, and in Turkmenistan—from 113 in 1990 to 62 in 1996. This statistics should always be correlated with demographic and migratory processes in the NIS. One should also account for students receiving their education in other countries, predominantly in other member countries of the NIS.

The development of education industry and high educational level of population in the former USSR is confirmed by the data on literacy, educational attainment, and educational levels presented in Tables 1-8 of Appendix A. As indicated by the data in Appendix A, educational level of population in the former Soviet Union was higher than in Poland and Hungary. Educational attainment in Ukraine, the Russian Federation, and other countries of Eastern Europe was among the highest in the world for decades, being on par and sometimes even higher than in such developed Western democracies as France, Switzerland, and the United Kingdom and way above educational level of population in such developing countries as Brazil and China.

The data indicate that despite the economic difficulties during the transition period, the number of students in higher education institutions per every ten thousand of population was increasing consistently since 1993. This confirms not only continuous and consistent development of the education industry, but also stable increase in the total volume and concentration of human capital in the country.

Descriptive statistics

The data used in the empirical study are selected macroeconomic indicators for the Russian Federation, and Ukraine and cover the period of 1989-2010. The indicators include GDP per capita growth, gross fixed investment (annual change), gross national savings rate (percent), and recorded unemployment (percent). Trajectories of the indicators over time are presented in Figures 1 to 4.

Dynamics of the GDP per capita growth for Hungary, Poland, the Russian Federation, and Ukraine for the period of 1989-2010 are presented in Figure 2.

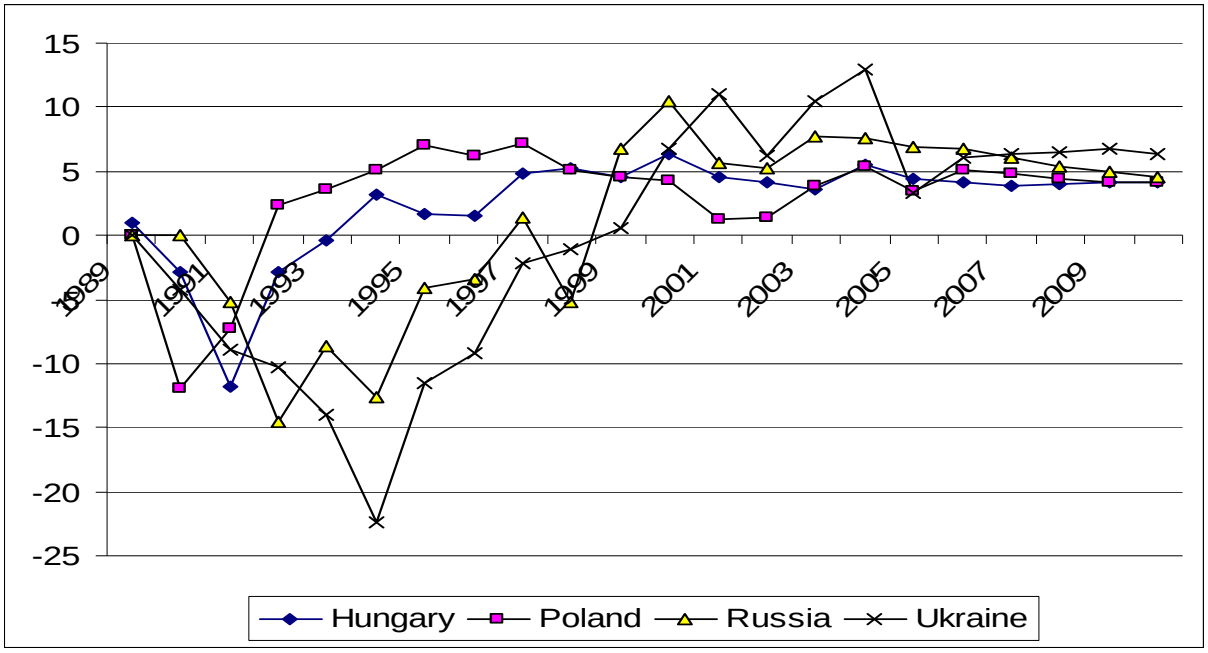

Figure 2. Real GDP per capita growth in Hungary, Poland, the Russian Federation, and Ukraine, 1989-2010

As shown in Figure 1, GDP per capita growth in Hungary, Poland, the Russian Federation, and Ukraine was in the different initial position in each country. The convergence of the GDP per capita growth rate in these countries occurs during the period of 1989-2010.

Dynamics of the gross fixed investment annual change for Hungary, Poland, the Russian Federation, and Ukraine for the period of 1989-2010 are presented in Figure 2.

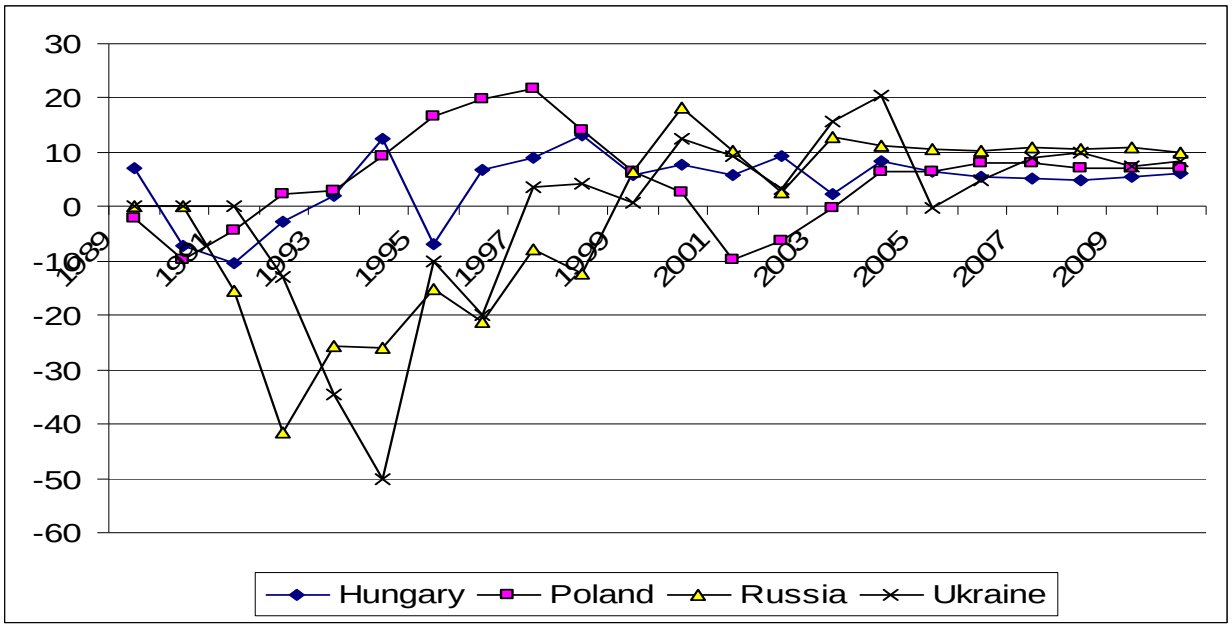

Figure 2. Investment in constant capital in Hungary, Poland, the Russian Federation, and Ukraine, 1989-2010

As shown in Figure 2, levels of the gross fixed investment in Hungary, Poland, the Russian Federation, and Ukraine were in the different initial positions in each country. However, gross fixed investment rates converge. The convergence of the gross fixed investment rates in these countries occurs during the period of 1989-2010. Gross fixed investment rates in Poland and Hungary were higher than in the Russian Federation and Ukraine. The process of convergence of the growth gross fixed investment rate coincides with the convergence of the GDP per capita growth in these countries that occurs during the period of 1989-2010. This confirms significant and positive effect of the investment on growth.

Dynamics of the savings rate annual change for Hungary, Poland, the Russian Federation, and Ukraine for the period of 1989-2010 are presented in Figure 3.

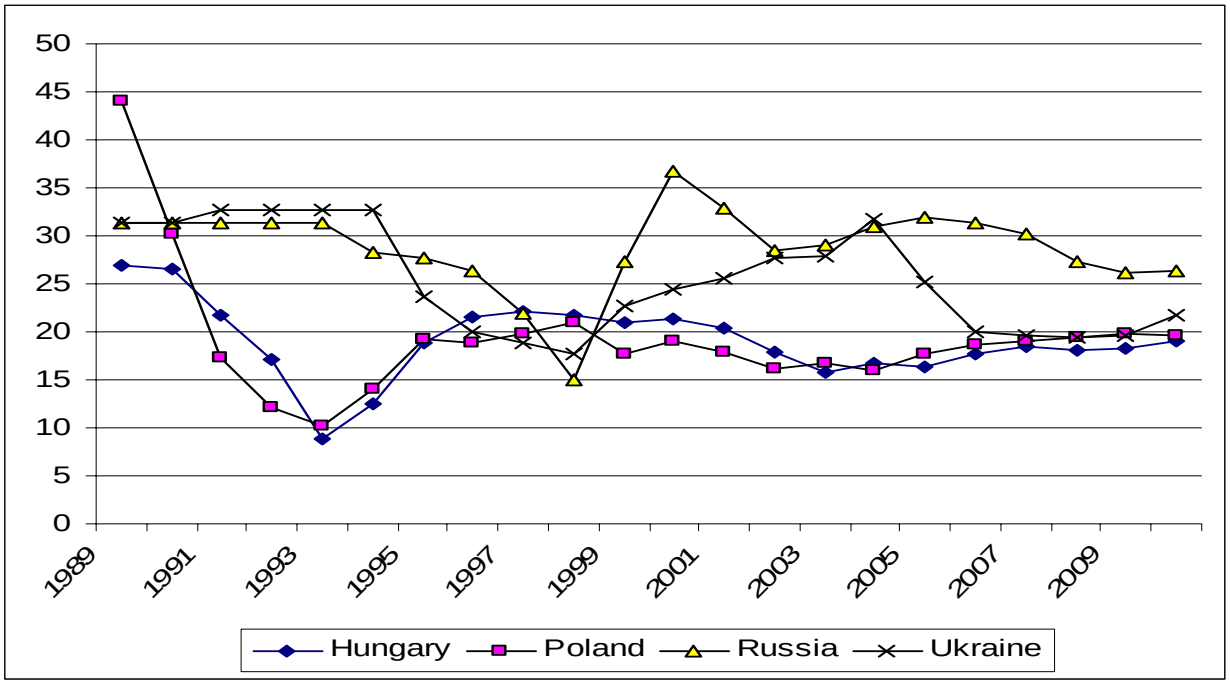

Figure 3. Savings rate in Hungary, Poland, the Russian Federation, and Ukraine, 1989-2010

As shown in the Figure 3, levels of the savings rate in Hungary, Poland, the Russian Federation, and Ukraine have not changed significantly during the period of 1989-2010. Sharp decline of the savings rate in the Russian Federation and Ukraine in 1999 can possibly be explained by the world financial crisis of 1997-1998.

Dynamics of the official rate of unemployment annual change for Hungary, Poland, the Russian Federation, and Ukraine for the period of 1989-2010 are presented in Figure 4.

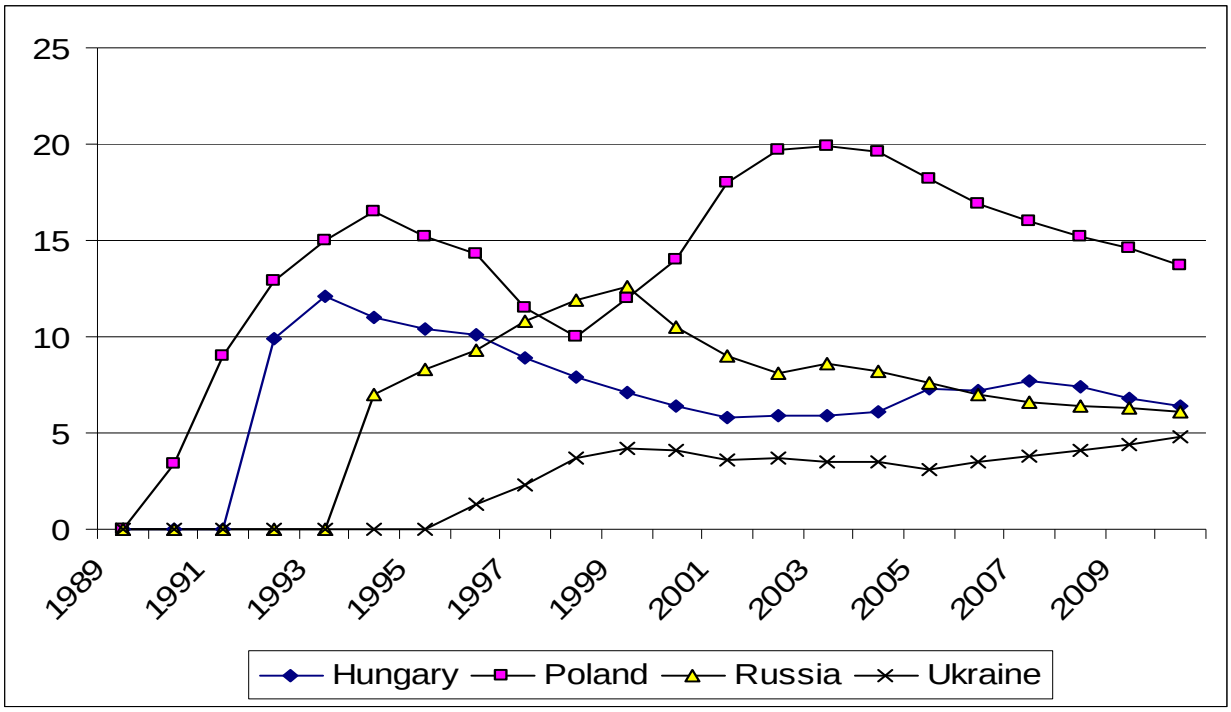

Figure 4. Registered level of unemployment in Hungary, Poland, the Russian Federation, and Ukraine, 1989-2010

As shown in Figure 4, levels of the official unemployment rate in Hungary, Poland, the Russian Federation, and Ukraine have risen dramatically in early 1990s and have stabilized later. Such a sharp increase in unemployment may be explained in part by the absence of the official unemployment in the USSR and Eastern Europe. Relatively low level of the registered unemployment in the Russian Federation and Ukraine in 1990s should be considered critically as it appears to be much lower than the real unemployment rate.

Empirical results

The presented calculations are based on the estimation of the system of linear and log-linear equations that account for changes in investment, savings, unemployment, education, and medical services. The independent variables were dropped consequently and the time lags were

taken as five-, six, seven, and ten-year time lags. We comment only on the coefficients with 5 percent level of significance. Regression results of GDP per capita growth to investment, savings, unemployment, education and healthcare for the Russian Federation and Ukraine for the period of 1990-2010 with the constant coefficient (1) and without the constant coefficient (2) are presented in Table 3. Indicators of the level of access to higher education and medical services are taken with the five year time lag.

Regression results of GDP per capita growth to investment, savings, education, and healthcare for the Russian Federation and Ukraine for the period of 1990-2010 with the constant coefficient (1) and without the constant coefficient (2) are presented in Table 4. Indicators of the level of access to higher education and medical services are taken with the five year time lag.

TABLE 3

Regression results of GDP growth to investment, savings, unemployment, education and healthcare for the Russian Federation and Ukraine, 1990-2010

Country	Russian Federation		Ukraine	
	(1)	(2)	(1)	(2)
Estimation method	OLS	OLS	OLS	OLS
Independent variable				
Investment	0.544219**	0.349321*	0.341820**	0.384583**
	(0.151921)	(0.088695)	(0.153252)	(0.142531)
	[3.582251]	[3.938462]	[2.230438]	[2.698245]
Savings	-0.038764	0.226039	0.901649	1.196193
	(0.260842)	(0.213105)	(0.728499)	(0.637364)
	[-0.148611]	[1.060695]	[1.237682]	[1.876784]
Unemployment	-1.156294	1.021889	0.410878	0.130104
	(1.554713)	(0.645762)	(1.675531)	(1.609592)
	[-0.743735]	[1.582455]	[0.245223]	[0.080831]
Education	-0.014755	0.041590	-0.066783	-0.060944
	(0.050371)	(0.037368)	(0.089199)	(0.086963)
	[-0.292917]	[1.112996]	[-0.748699]	[-0.700799]
Healthcare	-2.180633	-0.474601	2.500816	-0.346361
	(1.176011)	(0.366858)	(3.148024)	(0.212904)
	[-1.854263]	[-1.293691]	[0.794408]	[-1.626842]
R-squared	0.959353	0.941654	0.954202	0.941654
Adjusted R-squared	0.918707	0.883307	0.877871	0.883307
Mean dependent var	1.778636	1.778636	3.925778	3.925778
S.D. dependent var	7.173865	7.173865	7.361281	7.361281

Notes: each column is a separate regression of the growth rate on investment, savings, unemployment, education, and healthcare.

Standard errors are reported in parentheses. t-statistics are reported in square brackets.

Asterisk * indicates statistical significance at the 1-percent level, ** at the 5-percent level, and *** at the 10-percent level.

TABLE 4

Regression results of GDP growth to investment, savings, unemployment, education and healthcare for the Russian Federation and Ukraine, 1990-2010

Country	Russian Federation		Ukraine	
	(1)	(2)	(1)	(2)
Estimation method	OLS	OLS	OLS	OLS
Independent variable				
Investment	0.430864*	0.448183*	0.416201*	0.516480*
	(0.042274)	(0.052814)	(0.042274)	(0.105189)
	[10.19206]	[8.486119]	[3.862983]	[4.910021]
Savings	0.133635	0.015774	0.200090	0.394320
	(0.128833)	(0.151186)	(0.128833)	(0.488916)
	[1.037277]	[0.104332]	[0.453996]	[0.806520]
Education	0.017864	-0.001487	-0.040690	0.021822
	(0.022262)	(0.026335)	(0.022262)	(0.083934)
	[0.802457]	[-0.056456]	[-0.500659]	[0.259988]
Healthcare	-1.484476***	0.053926	5.761747	-0.298297
	(0.645769)	(0.143247)	(0.645769)	(0.186454)
	[0.05510]	[0.376454]	[1.692321]	[-1.599844]
R-squared	0.961679	0.929628	0.950381	0.924120
Adjusted R-squared	0.939781	0.903239	0.917301	0.891600
Mean dependent var	0.908000	0.908000	0.135273	0.135273
S.D. dependent var	7.475416	7.475416	10.96832	10.96832

Notes: each column is a separate regression of the growth rate on investment, savings, education, and healthcare.

Standard errors are reported in parentheses. t-statistics are reported in square brackets.

Asterisk * indicates statistical significance at the 1-percent level, ** at the 5-percent level, and *** at the 10-percent level.

Regression results of GDP per capita growth to investment, savings, education, and healthcare for the Russian Federation and Ukraine for the period of 1990-2010 with the constant coefficient (1) and without the constant coefficient (2) are presented in Table 5. Indicators of the level of access to higher education and medical services are taken with the six year time lag.

TABLE 5

Regression results of GDP growth to investment, savings, and education and healthcare for the Russian Federation and Ukraine, 1990-2010

Country	Russian Federation		Ukraine	
	(1)	(2)	(1)	(2)
Estimation method	OLS	OLS	OLS	OLS
Independent variable				
Investment	0.452827*	0.454333*	0.430281*	0.523992*
	(0.053285)	(0.046954)	(0.066924)	(0.065638)
	[8.498240]	[9.676147]	[6.429377]	[7.983083]
Savings	-0.014128	-0.018440	0.472994*	0.420083
	(0.155924)	(0.137815)	(0.222495)	(0.273993)
	[-0.090609]	[-0.133805]	[2.125865]	[1.533188]
Education	-0.004705	-0.005694	-0.076373	0.021073
	(0.027358)	(0.022957)	(0.055225)	(0.043700)
	[-0.171966]	[-0.248051]	[-1.382946]	[-0.248051]
Healthcare	0.029059	0.092991	5.349698***	-0.303923***
	(0.818807)	(0.131469)	(2.468013)	(0.168933)
	[0.035490]	[0.707324]	[2.167614]	[0.109700]
R-squared	0.935410	0.935359	0.953802	0.919064
Adjusted R-squared	0.903115	0.913812	0.927403	0.888713
Mean dependent var	1.363000	1.363000	0.404917	0.404917
S.D. dependent var	7.342776	7.342776	10.49951	10.49951

Notes: each column is a separate regression of the growth rate on investment, savings, education, and healthcare.

Standard errors are reported in parentheses. t-statistics are reported in square brackets.

Asterisk * indicates statistical significance at the 1-percent level, ** at the 5-percent level, and *** at the 10-percent level.

Regression results of GDP per capita growth to investment, savings, and education for the Russian Federation and Ukraine for the period of 1990-2010 with the constant coefficient (1) and without the constant coefficient (2) are presented in Table 6. Indicators of the level of access to higher education are taken with the five year time lag.

TABLE 6

Regression results of GDP growth to investment, savings, and education for the Russian Federation and Ukraine, 1990-2010

Country	Russian Federation		Ukraine	
	(1)	(2)	(1)	(2)
Estimation method	OLS	OLS	OLS	OLS
Independent variable				
Investment	0.456769*	0.436670*	0.507771*	0.596913*
	(0.050490)	(0.040954)	(0.104841)	(0.101002)
	[9.046741]	[10.66238]	[4.843235]	[5.909940]
Savings	-0.004268	0.048580	0.376908	0.562421
	(0.141282)	(0.117505)	(0.481814)	(0.521962)
	[-0.030207]	[0.413427]	[0.782269]	[1.077514]
Education	-0.006527	0.005975	0.022592	-0.068311
	(0.024251)	(0.016493)	(0.081200)	(0.068011)
	[-0.269131]	[0.362271]	[0.278230]	[-1.004410]
R-squared	0.932750	0.928382	0.926696	0.896375
Adjusted R-squared	0.907531	0.912466	0.895280	0.870469
Mean dependent var	0.908000	0.908000	0.135273	0.135273
S.D. dependent var	7.475416	7.475416	10.968320	10.96832

Notes: each column is a separate regression of the growth rate on investment, savings, and education.

Standard errors are reported in parentheses. t-statistics are reported in square brackets.

Asterisk * indicates statistical significance at the 1-percent level, ** at the 5-percent level, and *** at the 10-percent level.

Regression results of GDP per capita growth to investment, savings, and education for the Russian Federation and Ukraine for the period of 1990-2010 with the constant coefficient are presented in Table 7. Indicators of the level of access to higher education are taken with the six year time lag (1) and with the seven year time lag (2).

TABLE 7

Regression results of GDP growth to investment, savings, and education for the Russian Federation and Ukraine, 1990-2010

Country	Russian Federation		Ukraine	
	(1)	(2)	(1)	(2)
Estimation method	OLS	OLS	OLS	OLS
Independent variable				
Investment	0.451999*	0.449635*	0.517551*	0.513473*
	(0.045165)	(0.041511)	(0.064646)	(0.054756)
	[10.00766]	[10.83167]	[8.005908]	[9.377552]
Savings	-0.011663	-0.014491	0.431738	0.384124***
	(0.131625)	(0.124123)	(0.268069)	(0.204437)
	[-0.088608]	[-0.116749]	[1.610548]	[1.878933]
Education	-0.004157	-0.004167	0.018197	0.042449
	(0.021306)	(0.019454)	(0.040943)	(0.030395)
	[-0.195124]	[-0.214207]	[0.444446]	[1.396600]
R-squared	0.935400	0.935400	0.922793	0.922793
Adjusted R-squared	0.913866	0.913866	0.893841	0.893841
Mean dependent var	1.363000	1.363000	0.404917	0.404917
S.D. dependent var	7.342776	7.342776	10.499510	10.499510

Notes: each column is a separate regression of the growth rate on investment, savings, and education.

Standard errors are reported in parentheses. t-statistics are reported in square brackets.

Asterisk * indicates statistical significance at the 1-percent level, ** at the 5-percent level, and *** at the 10-percent level.

Regression results indicate positive effects of investments on the GDP per capita growth rate. An increase in investment leads to an increase in per capita GDP growth in all the countries. Other variables are not statistically significant. Effects of the variables that represent access of population to higher education and medical services are within the limits of statistical error. This statement holds when indicators of the level of access to higher education and medical services are taken with the five, six, and seven year time lags.

Positive effects of investment in fixed capital in the Russian Federation and Ukraine are higher than in Poland and Hungary. One percent increase in investments in the Russian Federation and Ukraine leads to an increase of the per capita GDP within the limits of 0.37 to 0.55 percent. While in Poland and Hungary this indicator stays within the limits of 0.22 to 0.37 percent.

The dependency between the per capita GDP growth and the independent variables we use in the regressions may be nonlinear. We test system of log-linear equations, where all independent variables are taken as logarithms. Initially, we estimate an equation that includes logarithms of all independent variables, including investment, savings, unemployment, education, and health. Then variables of unemployment and health are consequently taken out from the equations. Indicators of the level of access of population to higher education and medical services are taken consequently with the five, six, seven, and ten year time lags for all the equations. All combinations of log-linear equations are estimated with and without the constant coefficient.

Regression results indicate positive effects of an increase in investment on the per capita GDP growth in the Russian Federation and Ukraine. Investment coefficients are positive and statistically significant in all of the equations with the goodness of fit within the limits of 0.8 to 0.95. The complete records of the regression results can be obtained from the author. We will consider the most interesting results.

Regression results of per capita GDP growth to logarithms of investment, savings, and education with the constant coefficient in the Russian Federation and Ukraine, for the period of 1990-2010, presented in Table 9, indicate positive effect of an increase in investment in fixed capital, savings, and access to education on the per capita GDP growth. All coefficients of the

independent variables are statistically significant. Indicators of the level of access of population to higher education are taken with the ten year time lag.

Regression results of GDP per capita growth to investment, savings, and education for the Russian Federation and Ukraine for the period of 1990-2010 with the constant coefficient (1) and without the constant coefficient (2) are presented in Table 8. Indicators of the level of access to higher education are taken with the ten year time lag.

TABLE 8

Regression results of GDP growth to investment, savings, and education in Ukraine, 1990-2010

Country	Russian Federation	Ukraine	
	(2)	(1)	(2)
Estimation method	OLS	OLS	OLS
Independent variable			
Investment	1.461792***	2.141293**	3.389514*
	(0.708749)	(0.698971)	(1.035916)
	[2.062496]	[3.063492]	[3.271996]
Savings	6.209534**	19.06934*	6.853271***
	(1.937277)	(3.728733)	(3.637917)
	[3.205291]	[5.114161]	[1.883845]
Education	-3.356831**	11.31633**	-4.170212***
	(1.194651)	(4.021590)	(2.113641)
	[-2.809885]	[2.813894]	[-1.972999]
R-squared	0.674533	0.893438	0.673608
Adjusted R-squared	0.593166	0.853477	0.601077
Mean dependent var	6.668545	5.854083	5.854083
S.D. dependent var	1.575530	4.683886	4.683886

Notes: each column is a separate regression of the growth rate on investment, savings, and education.

Standard errors are reported in parentheses. t-statistics are reported in square brackets.

Asterisk * indicates statistical significance at the 1-percent level, ** at the 5-percent level, and *** at the 10-percent level.

Estimation of the equations that consider indicators of access to higher education and medical services with the seven year time lag does not bring statistically significant results. This supports our suggestion that an increase in access of population to higher education does not bring positive results for the per capita GDP growth in the short term. Moreover, enrollment in a higher education institution equates to temporary withdrawal from the work force. Both the level of unemployment and the opportunity costs of obtaining education are of certain concern here. However, an increase in access of population to higher education brings positive results for the per capita GDP growth in the long term. Increasing number of college-educated specialists leads to sustainable economic growth. Apparently, background for the 2000-2005 rapid economic growth in Ukraine and in the Russian Federation was laid down in early 1990s. This contradicts commonly accepted perception about the crisis decade of 1990s.

Estimation of the system of equations where all the variables—dependent and independent—were presented in the form of logarithms confirms positive effect of an increase in investment and per capita GDP growth. For instance, one percent increase in investment in fixed capital in Ukraine leads to 0.639 percent increase in per capita GDP growth.

Results of the Vector Autoregression Estimates (VAR), and Impulse Response Function indicate generally positive effects of investment on per capita GDP growth in the short run. In the long run a most significant positive influence of investment in fixed capital on per capita GDP growth occurs during the first two years and then diminishes.

Conclusion

As follows from the regression results, presented in this study, investments in fixed capital have positive effect on the GDP per capita growth rate. Contribution of investments to the

GDP per capita growth in the Russian Federation is more significant than in Hungary and Poland. Positive effect of investment on per capita GDP growth in Ukraine is more significant than that in the Russian Federation, Poland, and Hungary.

The results support theoretical statement made earlier that in transition and post-transition economies savings are not analogous to investments. This means that savings are not necessarily invested in the national economy at full scale. Process of reinvestment is weak. This finding makes obvious underdevelopment of the national stock markets and proves necessity for further development of the capital market, including institutional reform and strengthening of the national banking sector.

Regression results of per capita GDP growth to logarithms of investment, savings, and education with the constant coefficient in the Russian Federation and Ukraine for the period of 1990-2010 indicate positive effect of an increase in investment in fixed capital, savings, and access to education on the per capita GDP growth when indicators of the level of access of population to higher education are taken with the ten year time lag.

An increase in access of population to higher education brings positive results for the per capita GDP growth in the long term. Increasing number of college-educated specialists leads to sustainable economic growth. Apparently, background for the 2000-2005 rapid economic growth in Ukraine and in the Russian Federation was laid down in early 1990s. This contradicts commonly accepted perception about the crisis decade of 1990s.

Results of the Vector Autoregression Estimates (VAR) and Impulse Response Function indicate generally positive effects of investment on per capita GDP growth in the short run. In the long run a most significant positive influence of investment in fixed capital on per capita GDP growth occurs during the first two years and then diminishes. The regression results present

strong empirical evidence in support of continuing investment in fixed capital in order to sustain economic growth. Investments in fixed capital are backed by the growing education quality of the work force.

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Appendix A

Major indicators of literacy and educational attainment of the total population aged 25 and over in the USSR, Poland, Hungary, United Kingdom, France, Switzerland, Brazil, and China for 1960-2000

TABLE 1

U.S.S.R.

Educational Attainment of the Total Population Aged 25 and Over

Year	Population over age 25, thousands	Highest Level Attained							Average years of school
		No schooling	First level		Second level		Post-secondary level		
			total	complete	total	complete	total	complete	
			percentage of the population aged 25 and over						
1960	113705	1.5	68.8	35.4	25.6	10.1	4.2	3.6	7.59
1965	128811	1.5	58.2	30.0	35.0	13.8	5.3	4.6	8.14
1970	132128	0.5	47.9	24.8	44.4	17.5	7.2	6.2	8.83
1975	141265	1.4	45.9	23.9	43.4	17.1	9.3	8.1	8.94
1980	151526	1.6	45.8	24.4	43.5	17.1	9.1	7.9	8.93
1985	163255	1.4	40.1	22.7	47.6	18.7	10.9	9.4	9.36
1990	172997	0.0	22.8	14.9	63.3	24.9	13.9	12.0	10.52
1995	95210	0.0	33.9	22.2	48.6	19.1	17.5	15.1	10.24
2000	96348	0.0	31.0	20.3	48.9	19.2	20.1	17.4	10.49

Source: UNESCO, 2004. Retrieved from www.unesco.org
For years 1995 and 2000 the data is for the Russian Federation only.

TABLE 2

POLAND

Educational Attainment of the Total Population Aged 25 and Over

Year	Population over age 25, thousands	Highest Level Attained							Average years of school
		No schooling	First level		Second level		Post-secondary level		
			total	complete	total	complete	total	complete	
			percentage of the population aged 25 and over						
1960	15500	8.6	71.7	38.0	16.6	9.3	3.2	2.8	6.74
1965	16889	7.5	69.9	38.9	18.9	7.4	3.7	3.2	6.97
1970	17470	5.2	68.7	43.2	20.7	8.2	5.4	4.7	7.56
1975	19000	5.6	62.2	43.1	25.5	10.0	6.7	5.8	8.02
1980	20834	2.8	57.6	44.9	33.9	13.3	5.7	4.9	8.65
1985	22445	3.0	52.8	38.7	36.7	14.5	7.5	6.4	8.80
1990	23226	1.5	42.8	37.2	47.8	18.8	7.9	6.8	9.60
1995	23582	1.7	40.5	35.2	48.5	19.1	9.3	8.0	9.73
2000	24307	1.7	37.7	32.8	49.5	19.5	11.1	9.6	9.90

Source: UNESCO, 2004. Retrieved from www.unesco.org

TABLE 3

HUNGARY

Educational Attainment of the Total Population Aged 25 and Over

Year	Population over age 25, thousands	Highest Level Attained							Average years of school
		No schooling	First level		Second level		Post-secondary level		
			total	complete	total	complete	total	complete	
			percentage of the population aged 25 and over						
1960	6022	3.7	86.4	47.7	6.5	2.6	3.4	3.3	6.65
1965	6244	3.0	85.6	52.7	7.9	3.1	3.5	3.4	6.99
1970	6462	2.4	81.8	64.6	10.8	4.3	5.1	4.9	7.90
1975	6676	2.5	76.4	55.0	15.4	6.1	5.7	5.5	7.91
1980	6930	1.3	68.2	57.0	23.6	9.3	7.0	6.8	8.81
1985	6962	1.9	63.9	35.0	26.5	10.4	7.7	7.4	8.20
1990	6789	1.3	59.6	35.3	29.0	11.4	10.1	9.7	8.71
1995	6681	1.7	56.0	24.5	31.8	12.5	10.5	10.1	8.52
2000	6702	2.0	51.3	22.4	34.7	13.6	12.0	11.6	8.81

Source: UNESCO, 2004. Retrieved from www.unesco.org

TABLE 4

UNITED KINGDOM

Educational Attainment of the Total Population Aged 25 and Over

Year	Population over age 25, thousands	Highest Level Attained							Average years of school
		No schooling	First level		Second level		Post-secondary level		
			total	complete	total	complete	total	complete	
			percentage of the population aged 25 and over						
1950	32427	0.0	78.9	65.6	19.5	1.7	1.6	0.9	7.32
1960	33228	2.0	71.7	67.1	24.5	2.3	1.8	1.0	7.67
1965	33784	1.8	69.2	44.5	26.5	4.5	2.5	1.4	7.17
1970	33964	1.6	61.6	32.7	28.9	6.4	7.9	4.5	7.66
1975	35054	2.4	55.6	27.1	31.0	8.0	11.0	6.2	8.01
1980	35838	3.0	52.3	24.6	32.9	9.3	11.8	6.7	8.17
1985	36435	2.9	48.7	22.6	35.7	10.7	12.8	7.2	8.44
1990	38018	2.8	44.9	20.7	38.5	12.1	13.9	7.9	8.74
1995	39299	2.9	41.4	19.1	39.9	12.5	15.8	9.0	9.03
2000	40211	2.9	38.9	17.9	39.1	12.3	19.1	10.8	9.35

Source: UNESCO, 2004. Retrieved from www.unesco.org

TABLE 5

FRANCE

Educational Attainment of the Total Population Aged 25 and Over

Year	Population over age 25, thousands	Highest Level Attained							Average years of school
		No schooling	First level		Second level		Post-secondary level		
			total	complete	total	complete	total	complete	
			percentage of the population aged 25 and over						
1955	26838	.	.	.	10.3	2.6	1.8	0.9	.
1960	27972	0.0	72.3	42.0	25.7	9.6	2.1	1.1	5.78
1965	29210	0.0	71.6	41.3	25.8	10.4	2.7	1.4	5.86
1970	29849	0.5	70.5	39.7	26.0	10.6	3.0	1.5	5.86
1975	31622	0.9	67.2	35.4	26.8	11.0	5.2	2.7	6.08
1980	33347	1.0	56.0	24.0	34.5	12.9	8.5	4.4	6.77
1985	34911	1.1	52.1	23.3	36.3	19.1	10.5	5.4	7.31
1990	36721	0.6	51.1	23.2	36.9	22.1	11.4	5.8	7.56
1995	38509	0.5	47.6	21.7	37.3	22.4	14.5	7.4	7.94
2000	40157	0.7	43.7	19.8	37.3	22.4	18.4	9.4	8.37

Source: UNESCO, 2004. Retrieved from www.unesco.org

TABLE 6

SWITZELAND

Educational Attainment of the Total Population Aged 25 and Over

Year	Population over age 25, thousands	Highest Level Attained							Average years of school
		No schooling	First level		Second level		Post-secondary level		
			total	complete	total	complete	total	complete	
			percentage of the population aged 25 and over						
1960	3271	0.2	68.6	37.9	21.8	9.5	9.4	5.3	7.30
1965	3479	0.2	68.4	37.8	22.3	10.7	9.1	5.1	7.32
1970	3762	5.1	47.9	26.4	38.0	20.8	9.0	5.1	8.28
1975	3989	4.4	50.0	27.6	36.4	23.4	9.1	5.2	8.27
1980	4101	3.0	31.7	17.5	54.3	42.5	11.0	6.2	10.07
1985	4381	4.6	30.0	16.6	53.6	35.0	11.8	6.7	9.90
1990	4724	5.2	28.0	15.5	53.8	30.2	13.0	7.4	9.92
1995	5081	4.9	25.9	14.3	54.8	30.8	14.5	8.2	10.18
2000	5304	4.6	24.4	13.5	55.0	30.8	16.0	9.1	10.39

Source: UNESCO, 2004. Retrieved from www.unesco.org

TABLE 7

BRAZIL

Educational Attainment of the Total Population Aged 25 and Over

Year	Population over age 25, thousands	Highest Level Attained							Average years of school
		No schooling	First level		Second level		Post-secondary level		
			total	complete	total	complete	total	complete	
		percentage of the population aged 25 and over							
1960	27799	43.2	43.5	11.8	11.3	4.0	2.0	1.4	2.83
1965	32009	43.5	44.4	13.8	10.1	3.7	2.0	1.3	2.78
1970	36675	42.6	46.1	19.4	9.6	3.7	2.0	1.4	2.92
1975	42610	32.7	57.3	4.3	5.7	2.2	4.3	2.9	2.78
1980	49980	32.9	55.3	4.9	6.9	2.7	5.0	3.4	2.98
1985	58632	32.2	55.3	9.4	6.1	2.5	6.4	4.3	3.22
1990	68736	22.4	61.3	12.4	9.1	3.7	7.2	4.9	3.76
1995	78620	22.1	58.8	11.9	11.2	4.5	7.9	5.3	4.17
2000	89021	21.2	56.8	11.5	13.5	5.4	8.4	5.7	4.56

Source: UNESCO, 2004. Retrieved from www.unesco.org

TABLE 8

CHINA

Educational Attainment of the Total Population Aged 25 and Over

Year	Population over age 25, thousands	Highest Level Attained							Average years of school
		No schooling	First level		Second level		Post-secondary level		
			total	complete	total	complete	total	complete	
			percentage of the population aged 25 and over						
1960	296043	.	.	.	.	.	1.1	0.9	.
1965	315192	.	.	.	.	.	1.0	0.9	.
1970	342432	.	.	.	.	.	1.0	0.8	.
1975	383910	52.0	25.5	9.6	21.5	8.5	1.0	0.8	3.40
1980	447766	44.9	32.3	12.2	21.7	5.6	1.0	0.9	3.61
1985	508245	40.0	33.3	12.6	25.6	10.1	1.1	0.9	4.15
1990	584658	29.3	34.3	12.9	34.4	13.5	2.0	1.7	5.23
1995	677734	24.0	39.3	14.8	34.6	13.6	2.2	1.9	5.48
2000	761566	20.9	40.7	15.3	35.7	14.1	2.7	2.3	5.74

Source: UNESCO, 2004. Retrieved from www.unesco.org