New Technology, Human Capital and Growth for European Transitional Economies.*

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Abstract

We consider a transitional country with three sectors in economy: consumption goods, new technology, and education. Productivity of the consumption goods sector depends on new technology and skilled labor used for production of the new technology. Then there might be three stages of economic growth. In the first stage the country concentrates on production of consumption goods; in the second stage the country imports both physical capital and new technology capital; in the last stage the country imports new technology capital and invests in training and education of high skilled labor in the same time.

Keywords: Optimal growth model, New technology capital, Human Capital, Developing country.
JEL Classification: D51, E13

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1 Introduction

Technology and adoption of technology have been important subjects of research in the literature of economic growth in recent years. Sources of technical progress might be domestic or/and international though there always exists believes amongst economic professionals that there is an important difference between developed and less developed countries, i.e. the first one innovates and exports technology while the second one imports and copies. But it is important to stress that these countries also need to care about their human capital (Lucas [1988]) which might be the key factor that determines whether a country, given their level of development, can take off or might fall into proverty trap.

This line of argument comes from the fact that the developing countries today are facing a dilemma of whether to invest in physical, technological, and human capital. As abundantly showed in literature (e.g. Barro [1997], Barro & Sala-i-Martin [1995], Eaton & Kortum [2000], Keller [2001], Kumar [2003], Kim & Lau [1994], Lau & Park [2003]) developing countries are not convergent in their growth paths and in order to move closer to the world income level, a country needs to have a certain level in capital accumulation.

In their recent work, Bruno, Le Van and Masquin [2005] point out the conditions under which a less developed country can optimally decide to either concentrate their whole resources on physical capital accumulation or spend a portion of their national wealth to import technological capital. These conditions are related to the nation's stage of development which consists of level of wealth and endowment of human capital and thresholds at which the nation migh switch to another stage of development. However, in their model, the role of education that contributes to accumulation of human capital and effecient use of technological capital is not fully explored.

In this paper we extend their model by introducing an educational sector with which the developing country would invest in to train more skilled labor. We show that the country once reaches a critical value of wealth will have to consider the import of new technology. But when the level of wealth passes this value it is always optimal for the country to use new technology which requires high skilled workers. We show further that with possibility of investment in human capital and given "good" conditions on the qualities of the new technology, production process, and/or the number of skilled workers there exists alternatives for the country either to purchase new technology and spend money in training high skilled labor or only purchase new technology but not to spend on formation of labor. Following this direction, we can determine the level of wealth at which the decision to invest in training and education has to be made. In the whole, the paper allows us to determine the optimal share of the country's investment in physical capital, new technology capital and human capital formation in the long-run growth path. Two main results can be pointed out: (1) the richer a country is, the more money will be invested in new technology and training and education, (2) and more interestingly, the share of investment in human capital will increase with the wealth while the one for physical and new technology capitals will decrease. In any case, the economy will grow without bound.

The paper is organized as follows. Section 2 presents the model and its dynamic properties with infinitely lived representative consumer. Section 3 presents empirical data from Poland, Hungary and Czech Republik which seem to confirm our theoretical results.

2 The model and its dynamic properties

Consider an economy where exists three sectors: domestic sector which produces an aggregate good Y_d, new technology sector with output Y_e and education sector characterized by a function $h(T)$ where T is the expenditure on training and education. The output Y_e is used by domestic sector to increase its total productivity. The production functions of two sectors are Cobb-Douglas, i.e, $Y_d = \Phi(Y_e)K_d^{\alpha_d}L_d^{1-\alpha_d}$ and $Y_e = A_eK_e^{\alpha_e}L_e^{1-\alpha_e}$ where $\Phi(.)$ is a non decreasing function which satisfies $\Phi(0) = x_0 > 0$, K_d, K_e, L_d, L_e and A_e be the physical capital, the technological capital, the low-skilled labor, the high-skilled labor and the total productivity, respectively, $0 < \alpha_d < 1, 0 < \alpha_e < 1$.

We assume that this country imports capital good, the price of which is considered as numeraire. The price of the new technology sector is higher and equal to λ such that $\lambda \geq 1$. Assume that labor mobility between sectors is impossible and wages are exogenous.

Let S be available amount of money denoted to the capital goods purchase. We have:

$$K_d + \lambda K_e + p_T T = S.$$

For simplicity, we assume $p_T = 1$, or in other words T is measured in capital goods.

Thus, the budget constraint of the economy can be written as follows

$$K_d + \lambda K_e + T = S$$

where S be the value of wealth of the country in terms of consumption goods.

The social planner first maximizes the following program

$$\max\ Y_d = \max\ \Phi(Y_e)K_d^{\alpha_d}L_d^{1-\alpha_d}$$

subject to

$$\begin{aligned}
&Y_e = A_e K_e^{\alpha_e} L_e^{1-\alpha_e}, \\
&K_d + \lambda K_e + T = S, \\
&0 \le L_e \le L_e^* h(T), \\
&0 \le L_d \le L_d^*.
\end{aligned}$$

where h is the education technology.

Assume that $h(.)$ is an increasing concave function and $h(0) = h_0 > 0$. Let

$$\Delta = \{(\theta, \mu) : \theta \in [0,1], \mu \in [0,1], \theta + \mu \le 1\}.$$

From the budget constraint, we can define $(\theta, \mu) \in \Delta$:

$$\lambda K_e = \theta S \ , K_d = (1 - \theta - \mu) S \text{ and } \ T = \mu S.$$

Observe that since the objective function is strictly increasing, at the optimum, the constraints will be binding. Let $L_e = L_e^* h$, $L_d = L_d^*$, then we have the following problem

$$\max_{(\theta,\mu)\in\Delta} \Phi(r_e \theta^{\alpha_e} S^{\alpha_e} h(\mu S)^{1-\alpha_e})(1-\theta-\mu)^{\alpha_d} S^{\alpha_d} L_d^{*1-\alpha_d}.$$

where $r_e = \frac{A_e}{\lambda^{\alpha_e}} L_e^{*1-\alpha_e}$.

Let

$$\psi(r_e, \theta, \mu, S) = \Phi(r_e \theta^{\alpha_e} S^{\alpha_e} h(\mu S)^{1-\alpha_e})(1-\theta-\mu)^{\alpha_d} L_d^{*1-\alpha_d}.$$

The problem now is equivalent to

$$\max_{(\theta,\mu)\in\Delta} \psi(r_e, \theta, \mu, S). \tag{P}$$

Since the function ψ is continuous in θ and μ, there will exist optimal solutions. Denote

$$F(r_e, S) = \max_{(\theta,\mu)\in\Delta} \psi(r_e, \theta, \mu, S).$$

Then by Maximum Theorem, F is continuous and $F(r_e, S) \ge x_0 L_d^{*1-\alpha_d}$.

Suppose that function $\Phi(x)$ is a constant in an initial phase and increasing linear afterwards:

$$\Phi(x) = \begin{cases} x_0 \ \text{ if } \ x \le X \\ x_0 + a(x - X) \text{ if } x \ge X, a > 0. \end{cases}$$

Define

$$B = \{S \ge 0 : F(r_e, S) = x_0 L_d^{*1-\alpha_d}\},$$

Remark 1 *Observe that* $F(r_e, S) \geq x_0 L_d^{*1-\alpha_d}$. *If the optimal value for* θ *equals* 0 *then the one for* μ *is also* 0 *and* $F(r_e, S) = x_0 L_d^{*1-\alpha_d}$.

The following proposition shows that if S is small, then the country will not invest in new technology and human capital. When S is large, then it will invest in new technology. Moreover there exists a critical value S^c.

Proposition 1 *i) There exists* $\underline{S} > 0$ *such that if* $S \leq \underline{S}$ *then* $\theta = 0$ *and* $\mu = 0$.
ii) There exists $\overline{S}$ *such that if* $S > \overline{S}$ *then* $\theta > 0$.
iii) Let $S^c = \max\{S \geq 0 : S \in B\}$. *Then* $S^c \geq \underline{S}$ *and if* $S < S^c$ *then* $\theta(S) = 0$ *and* $\mu(S) = 0$, *and if* $S > S^c$ *then* $\theta(S) > 0$.

Proof: See Le Van and al. (2007). ■

We assume that $h'(0)$ is finite. In this case, we are not ensured that the country will invest in human capital when $S > S^c$. But it will do if it is sufficiently rich.

Proposition 2 *Assume* $h^{'}(0) < +\infty$. *Then there exists* S^M *such that* $\mu(S) > 0, \theta(S) > 0$ *for every* $S > S^M$.

Proof: See Le Van and al. (2007). ■

The following proposition shows that, if $h'(0)$ is low, then the country will not invest in human capital when S belongs to some interval $(S^c,\ S^m)$.

Proposition 3 *There exists* $\alpha > 0$ *such that, if* $h'(0) < \alpha$, *then there exists* $S^m > S^c$ *such that* $\mu(S) = 0, \theta(S) > 0$ *for* $S \in [S^c, S^m]$.

Proof: See Le Van and al. (2007). ■

One of our main results is the following proposition.

Proposition 4 *Assume* $h'(0) < +\infty$. *Then there exists* $\widehat{S} \geq S^c$ *such that:*
(i) $S \leq \widehat{S} \Rightarrow \mu(S) = 0$,
(ii) $S > \widehat{S} \Rightarrow \mu(S) > 0$.

Proof: Let

$$\widetilde{S} = \max\{S_m : S_m > S^c, \text{ and } S \leq S_m \Rightarrow \mu(S) = 0\},$$

and

$$\widetilde{\widetilde{S}} = \inf\{S_M : S_M > S^c, \text{ and } S > S_M \Rightarrow \mu(S) > 0\}.$$

From Propositions 2 and 3, the sets $\{S_m : S_m > S^c, \text{ and } S \leq S_m \Rightarrow \mu(S) = 0\}$ and $\{S_M : S_M > S^c, \text{ and } S > S_M \Rightarrow \mu(S) > 0\}$ are not empty. One can prove we have $\widetilde{\widetilde{S}} \geq \widetilde{S}$. If $\widetilde{\widetilde{S}} > \widetilde{S}$, then take $S \in (\widetilde{S}, \widetilde{\widetilde{S}})$. From the definitions of $\widetilde{S}$ and $\widetilde{\widetilde{S}}$, there exist $S_1 < S$, $S_2 > S$ such that $\mu(S_1) > 0$ and $\mu(S_2) = 0$. But the author can check that is a contradictiction. Hence $\widetilde{\widetilde{S}} = \widetilde{S}$. Put $\widehat{S} = \widetilde{\widetilde{S}} = \widetilde{S}$ and conclude. ■

Let us recall $r_e = \frac{A_e L_e^{*(1-\alpha_e)}}{\lambda^{\alpha_e}}$ where A_e is the productivity of the new technology sector, λ is the price of the new technology capital and L_e^* is the number of skilled workers.

Recall also the productivity function of the consumption goods sector $\Phi(x) = x_0 + a(x - X)$ if $x \geq X$. The parameter $a > 0$ is an indicator of the impact of the new technology product x on the this productivity. We will show in the following proposition that the critical value S^c diminishes when r_e increases, i.e. when the productivity A_e and/or the number of skilled workers increase, and /or the price of the new technology capital λ decreases, and /or the impact indicator a increases.

Proposition 5 *Assume $h(z) = h_0 + bz$, with $b > 0$. Let $\theta^c = \theta(S^c)$, $\mu^c = \mu(S^c)$. Then*

(i) $\mu^c = 0$, θ^c increases when a increases.

(ii) S^c decreases if r_e or h_0 increases.Assume $aX - x_0 \geq 0$. Then S^c decreases if a increases.

Proof: See Le Van and al (2007). ■

The following proposition shows that the optimal shares θ, μ converge when S goes to infinity and the ratio between physical capital and the total of new technology capital and the amount devoted to human capital formation decreases when S increases.

Proposition 6 *Assume $h(z) = h_0 + bz$, with $b > 0$. Then the optimal shares $\theta(S), \mu(S)$ converge to $\theta_\infty, \mu_\infty$ when S converges to $+\infty$. Consider $\widehat{S}$ in Proposition 4. Then*

(i) If $x_0 < aX$, $\theta(S)$ decreases from θ^c to $\widehat{\theta} = \theta(\widehat{S})$ when S goes from S^c to $\widehat{S}$.The sum $\theta(S) + \mu(S)$ decreases when S increases from S^c to $\widehat{S}$.

(ii) If $x_0 \geq aX$, $\theta(S)$ increases from θ^c to $\widehat{\theta} = \theta(\widehat{S})$ when S goes from S^c to $\widehat{S}$.The sum $\theta(S) + \mu(S)$ increases when S increases from S^c to $\widehat{S}$.

(iii)If ar_e is large enough, $\theta(S)$ decreases from $\widehat{\theta}$ to $\theta_\infty = \frac{\alpha_e}{1+\alpha_d}$ when S increases from $\widehat{S}$ to $+\infty$. The sum $\theta(S) + \mu(S)$ increases with S for $S > \widehat{S}$. Moreover, $\mu(S)$ also increases with S for $S > \widehat{S}$.

Proof: See Le Van and al (2007). ■

Now consider an economy with one infinitely lived representative consumer who has an intertemporal utility function with discount factor $\beta < 1$. At each period, her savings will be used to import physical capital or/and new technology capital and/or to invest in human capital. We suppose the capital depreciation rate equals 1.

The social planner will solve the following dynamic growth model

$$\begin{aligned}
\max \quad & \sum_{t=0}^{\infty} \beta^t u(c_t) \\
\text{s.t} \quad & c_t + S_{t+1} \leq \Phi(Y_{e,t}) K_{d,t}^{\alpha_d} L_{d,t}^{1-\alpha_d} \\
& Y_{e,t} = A_e K_{e,t}^{\alpha_e} L_{e,t}^{1-\alpha_e} \\
& K_{d,t} + \lambda K_{e,t} + T_t = S_t, \\
& 0 \leq L_{e,t} \leq L_e^* h(T_t), 0 \leq L_{d,t} \leq L_d^*. \\
& \text{ the initial resource } S_0 \text{ is given.}
\end{aligned}$$

The problem is equivalent to

$$\begin{aligned}
\max \quad & \sum_{t=0}^{\infty} \beta^t u(c_t) \\
\text{s.t} \quad & c_t + S_{t+1} \leq H(r_e, S_t), \forall t,
\end{aligned}$$

with

$$H(r_e, S) = F(r_e, S) S^{\alpha_d}.$$

where $r_e = \frac{A_e}{\lambda^{\alpha_e}} L_{e,t}^{*1-\alpha_e}$. Obviously, $H(r_e, .)$ is continuous, strictly increasing and $H(r_e, 0) = 0$.

As in the previous section, we shall use S^c defined as follows:

$$S^c = \max\{S \geq 0 : F(r_e, S) = x_0 L_d^{*1-\alpha_d}\}$$

where

$$F(r_e, S_t) = \max_{0 \leq \theta_t \leq 1, 0 \leq \mu_t \leq 1} \psi(r_e, \theta_t, \mu_t, S_t).$$

We shall make standard assumptions on the function u under consideration.

H2. The utility function u is strictly concave, strictly increasing and satisfies the Inada condition: $u^{'}(0) = +\infty, u(0) = 0$.

At the optimum, the constraints will be binding, the initial program is equivalent to the following problem

$$\begin{aligned}
& \max \sum_{t=0}^{\infty} \beta^t u(H(r_e, S_t) - S_{t+1}) \\
\text{s.t} \quad & 0 \leq S_{t+1} \leq H(r_e, S_t), \forall t. \\
& S_0 > 0 \text{ given.}
\end{aligned}$$

By the same arguments as in Bruno et al. [2005], we have the following property

Proposition 7 *i) Every optimal path is monotonic*

ii) Every optimal trajectory (S_t^*) from S_0 can not converge to 0.

Let denote θ_t^*, μ_t^* be the optimal capital shares among technological capital stock and expenditure on training,

$$\lambda K_{e,t}^* = \theta_t{}^* S_t^* \text{ and } \ T_t^* = \mu_t^* S_t^*.$$

We then obtain the main result of this paper:

Proposition 8 *Assume $h(z) = h_0 + bz$, with $b > 0$ and $\alpha_e + \alpha_d \geq 1$. If a or/and r_e are large enough then the optimal path $\{S_t^*\}_{t=1,+\infty}$ converges to $+\infty$ when t goes to infinity. Hence:*

(i) there exists T_1 such that

$$\theta_t^* > 0 \ \forall t \geq T_1$$

(ii) there exists $T_2 \geq T_1$ such that

$$\theta_t^* > 0 \ , \mu_t^* > 0, \ \forall t \geq T_2$$

The sum $\theta_t^* + \mu_t^*$ and the share μ_t^* increase when t goes to infinity and converge to values less than 1.

Proof: Let S^s be defined by

$$\alpha_d (S^s)^{\alpha_d - 1} x_0 L_d^{*1-\alpha_d} = \frac{1}{\beta}. \tag{1}$$

If $S_0 > \widehat{S}$ ($\widehat{S}$ is defined in Proposition 4) then $\theta_t^* > 0, \ \mu_t^* > 0$ for every t.
If $S_0 > S^c$ then $\theta_t^* > 0$ for every t. If S_t^* converges to infinity, then there exists T_2 where $S_{T_2}^* > \widehat{S}$ and $\theta_t^* > 0, \ \mu_t^* > 0$ for every $t \geq T_2$.
Now consider the case where $0 < S_0 < S^c$. Obviously, $\theta_0^* = 0$. It is easy to see that if a or/and r_e are large then $S^c < S^s$. If for any t, we have $\theta_t^* = 0$, we also have $K_{e,t}^* = 0 \ \forall t$, and the optimal path (S_t^*) will converge to S^s (see Le Van and Dana [2003]). But, we have $S^c < S^s$. Hence the optimal path $\{S_t^*\}$ will be non decreasing and will pass over S^c after some date T_1 and hence $\theta_t^* > 0$ when $t \geq T_1$.
If the optimal path $\{S_t^*\}$ converges to infinity, then after some date T_2, $S_t^* > \widehat{S}$ for any $t > T_2$ and $\theta_t^* > 0, \mu_t^* > 0$.

It remains to prove that the optimal path converges to infinity if a or/and r_e are large enough. For that, first use Euler equation:

$$u'(c_t^*) = \beta u'(c_{t+1}^*) H_s'(r_e, S_{t+1}^*).$$

If $S_t^* \to \overline{S} < \infty$, then $c_t^* \to \overline{c} > 0$. We then get

$$H_s^{'}(r_e, \overline{S}) = \frac{1}{\beta}.$$

One has just to show show that $H_s^{'}(r_e, S) > \frac{1}{\beta}$ for any $S > S^c$. We have

$$\begin{aligned} H_s^{'}(r_e, S) &= F_s^{'}(r_e, S) S^{\alpha_d} + \alpha_d F(r_e, S) S^{\alpha_d - 1} \\ &\geq F_s^{'}(r_e, S) S^{\alpha_d}. \end{aligned}$$

From the envelope theorem we get:

$$\begin{aligned} H_s^{'}(r_e, S) &\geq L_d^{*1-\alpha_d}(1 - \theta^* - \mu^*)^{\alpha_d}[ar_e \theta^{*\alpha_e}(h^*(\mu S))^{1-\alpha_e}\alpha_e S^{\alpha_d + \alpha_e - 1}] \\ &\geq L_d^{*1-\alpha_d}(1 - \overline{\zeta})^{\alpha_d}[ar_e \underline{\theta}^{\alpha_e}(h^*(0))^{1-\alpha_e}\alpha_e (S^c)^{\alpha_d + \alpha_e - 1}] \end{aligned}$$

since $h(x) \geq h(0)$ and $\alpha_d + \alpha_e - 1 \geq 0$.

If $\alpha_d + \alpha_e = 1$, then

$$H_s^{'}(r_e, S) \geq L_d^{*1-\alpha_d}(1 - \overline{\zeta})^{\alpha_d}[ar_e \underline{\theta}^{\alpha_e}(h^*(0))^{1-\alpha_e}\alpha_e], \tag{1}$$

and when ar_e becomes very large, the RHS of inequality (1) will be larger than $\frac{1}{\beta}$.

Now assume $\alpha_d + \alpha_e > 1$. then

$$H_s^{'}(r_e, S) \geq L_d^{*1-\alpha_d}(1 - \overline{\zeta})^{\alpha_d}\underline{\theta}^{\alpha_e}(h^*(0))^{1-\alpha_e}\alpha_e \gamma (\frac{\gamma}{ar_e})^{\frac{\alpha_d - 1}{\alpha_e}}$$

It is obvious that, since $\alpha_d - 1 < 0$, when ar_e is large, we have $H_s^{'}(r_e, S) > \frac{1}{\beta}$.

Remark 2 *To summarize, at low level of economic growth this country would only invest in physical capital but when the economy grows this country would need to invest not only in physical capital but also in first, new technology and then, formation of high skilled labor. Under some mild conditions on the quality of the new technology production process and on the supply of skilled workers, the optimal path* (S_t^*) *converges to* $+\infty$*, i.e. the country grows without bound. In this case, the share of investment in new technology and human capital* $(\theta_t^* + \mu_t^*)$ *will increase while the one in physical capital will decrease (this is in accordance with the empirical results in Lau and Park (2003)). More interestingly, and in accordance with the results in Barro and Sala-i-Martin (2004), the share* μ_t^* *will become more important than the one for physical and new technology capitals when* t *goes to infinity.*

■

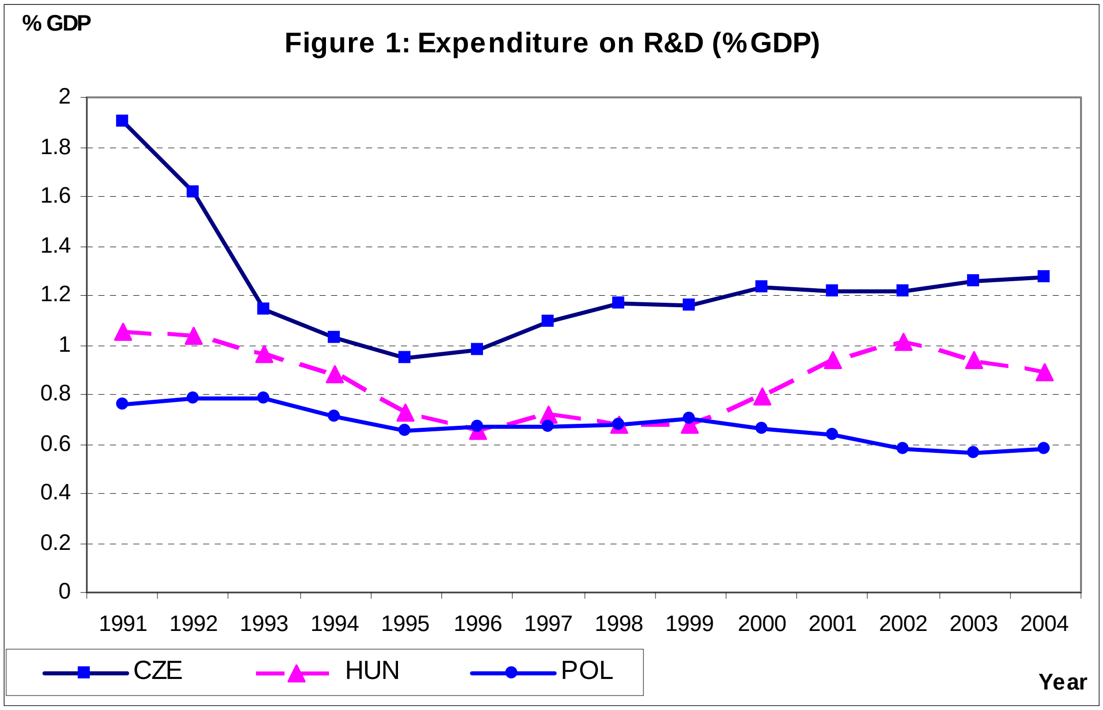
3 Do Poland, Hungary and Czech Republic Economic Growths Confirm Our Results?

Due to the changes of political and economic institutions in these three countries since 1990, many economic, science and technology indicators for these economies are not available for years before 1991. Furthermore, even these indicators were available they may not be relevant for our model since economic activities in centrally planned economy period are mostly not market-driven but highly planned. Thus, we just look at the data range from 1991 to 2004 in considering our model.

In our model, the new technological capitals are produced in R&D sector, then we use indicator of expendituture for R&D as a proxy for investment in technological capital (λK_e).

We also assume that the ratios of budget available for investing on technological capital, high-skilled human capital and physical capital (S) to GDP are constant in the whole period. Thereby, the movement of ratios of λK_e and investment of high-skilled human capital (T) to GDP are congruent to the movement of ratios of λK_e and T to S.

The figure 1 shows the movement of share of investment in technological capital to GDP in these economies. After the collapse of communism expenditure for R&D in Hungary and Czech Republic both slumped down in first three years, then Czech Republic shows a clear upward trend while the trend in Hungary is ambiguous. The transition in Poland is more gentle, the share of expenditure on R&D did not fluctuate much in the period however it seems going down slowly.



The level of development may play a role in these trends. Of the three economies, Czech Republic is wealthier in term of GDP per capita. In 1991 GDP per capita of Czech Republic is \$11146 in PPP, while the figure for Hungary and Poland are \$8563 and \$5885 respectively. By the end of the period (2004), the figures for Czeech, Hungary and Poland are \$19426, \$16519 and \$13089 respectively.

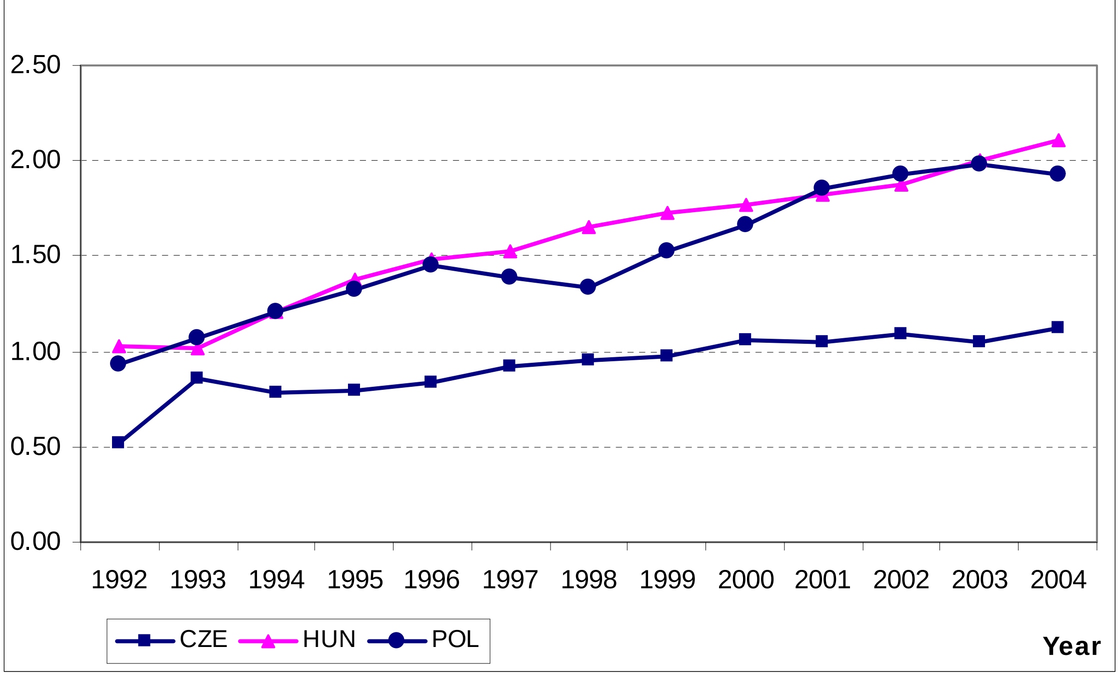
In principle we can use the total expendititure for tertiary education as a proxy for investment of high-skilled human capital (T). However the data of total costs for tertiary education is complicated to calculate. It includes governments (of all level, central, regional and local) expenditure, household expenditures, funds from private institutions, expenditures of private firms for specified education activities and all funding sources from abroad. Unfortunately those data are not available for three economies in question.

In the estimation of the data of total expenditures on tertiary education in these three economies we assume that the annual educational expenditures per student in purchasing power parity (current PPP) price are constant in the period. This asumption implies that in these economies the annual educational expenditures per student in PPP USD increase yearly by United States' inflation rate. The total expenditures on tertiary education then will be estimated by number of enrolled students in tertiary level and annual educational costs per student[1].

[1]For Czech Republic and Hunggary in the first three years 1991, 1992 and 1993 the role of private contributions to tertiary education is negligible for two reasons: (i) many private

Arcording to OECD (2006) the annual educational expenditures per student in purchasing power parity (PPP) price in 2003 in Czech Republic, Hungary and Poland are \$6774.2, \$8576.22 and \$4588.63 respetively. Using United States' inflation rates (OECD statistics) we have the estimation of the annual educational expenditures per student in purchasing power parity (current PPP) and then the total expenditure for tertiary education.

Figure 2: Expenditure for tertiary education (% GDP)



As figure 2 shows, in these economies the rations of total expenditures for tertiary education to GDP increase steadily as the model predicts. The combined expenditures on R&D and tertiary education also confirm the prediction of our model as shown in figure 3.

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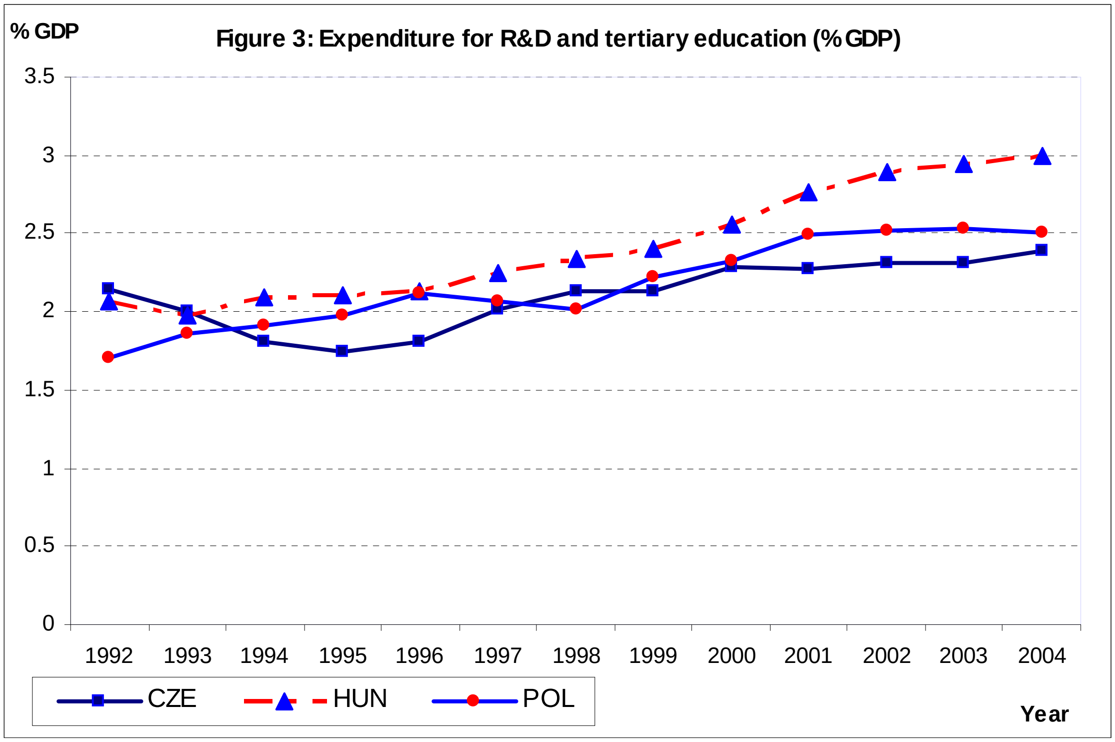
educational institutions were not established yet; (ii) there was no difference in term of government's financial supports between private and public school at these time. Therefore we can assume that the public expenditutes on tertiary education at that time approximately equal the total spending on tertiary education. The estimated figures are used from 1994 on.

In contrast, private institutions are present earlier in Poland (e.g. academic institutions that belong to Churches operated in Poland's tertiary education sector before 1991). A non-state educational institution receives around 50% those that a public institution gets from goverment's financial supports. Moreover, even in state educational institutions only regular students (full-time) receive full financial support from government, the others have to pay tution fees. Hence,in case of Poland, we use estimated figures for the whole period.



Accordingly, the experiences of economic growth in Czech Republic, Hungary and Poland do not reject our results but, to a significant extend, confirm.

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