Capital accumulation and growth in Hungary, 1924-2006

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1. Introduction

The transition in Eastern Europe in the 1990s has triggered many studies into the sources of economic growth. Several studies discuss Hungary, most of which focusing on the transition period. The majority of those studies, which ignore human capital, argue that Total Factor Productivity (TFP) growth was small in Hungary between ca. 1960-1989 and increasing afterwards (Roman 1982; Campos and Coricelli 2002; Darvas and Simon 2000; Doyle, Kuijs and Jiang 2001). Indeed, although Pryor (1985, 222) argues that overall TFP growth was equal in Eastern and Western countries during socialism, he also stresses that this is mostly caused by a larger share of agriculture and industry in Eastern Europe. Since TFP growth is usually estimated to be larger in agriculture and industry than in services (the value of the latter sector being often calculated from input costs) the magnitude of TFP growth in Eastern Europe was strongly dependent on structural changes. With investments in fixed capital drying up and the shift from agriculture to industry and services, TFP growth declined only to increase again after transition.

Acknowledging that many growth theories see an important role for human capital, a tendency of including human capital in growth regressions has started for Eastern European countries as well. In line with earlier growth accounting studies, Ganev (2005) finds that it is largely TFP, as opposed to human capital, that drives economic growth in the post-transition period. He explains this finding by arguing that much of the

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productivity increase after the transition (including technology imports) manifests itself as TFP growth. However, then he acknowledges that the share of TFP is also artificially increased by the mismeasurement of human capital as "the employment dynamics is almost the same as the dynamics of the measure of human capital" (Ganev 2005, 11). Estimating a long-run series of average years of schooling for Hungary, Földvári and Van Leeuwen (2009), however, find that contribution of human capital in economic growth increased considerably after transition. They claim that the value of human capital stock increased after transition, since the market economy ensured a more efficient allocation of human capital than the state-socialist planning. This increase in efficiency results in an improvement of the value of human capital as marked by an increase in the rate of returns to education (Campos and Jolliffe 2003). In this text we further explore the long-run changes of human capital and find that the results are sensitive to the choice of human capital indicator. Since the rate of returns to education fell during socialism, which is clearly a sign of not only the strict wage control imposed by the plan-economy but also a less efficient allocation of human capital, measures based on the rate of returns reflect a drop in per capita human capital stock. As an alternative, we suggest a prospective (income based) measure, which is comparable to the micro-approach by Dagum and Slottje (2000). Even though there is a clear difference in the picture reflected by the two measures, both seem to suggest that the pace of human capital accumulation changed significantly during the 20th century, which has profound effect on results from growth accounting exercises, or even regression analysis.

The objective of this paper is to analyse the role of both human- and physical capital in economic growth in Hungary during the 20th century. This we do with significant extensions, improvements and also a revision of our previous paper (Földvári and van Leeuwen 2009).

First, we extend our physical capital stock estimates from a PIM methodology back to the interwar period. Second, we bring back in time the traditional rate of returns based human capital measure (see Hall and Jones 1999). So far the rate of returns was available only for the 1980s and 1990s when one can use different surveys for a micro-estimation with a Mincerian methodology. Prior to the 1970s we have to take a different approach and use data on skill premium to have some raw estimates of the rate of private returns to education. The problem is that this frequently used human capital measure will reflect only the effect of a biased technological development when skill premium/rate of returns to education to fall or rise, or if the average schooling changes. If the technological development is neutral, affecting schooled and unschooled labour productivity proportionally, it will not be observed by this index. Therefore, thirdly, we use some improved measure of human capital, based on the net present value of future incomes. Finally, we use these human and physical capital measures to extend the growth accounting back to the interwar period.

The paper is structured as follows. In the next section we discuss how the series of physical capital stock were constructed and use alternative methods as tools of cross-validation. Section 3 briefly discusses our estimates of average years of education, which we then compare with our human capital measure based on the rate of return and our income based measure respectively. Section 4 then applies both capital stocks in a TFP analysis. The paper ends with a brief conclusion.

2. Physical capital stock in Hungary

2.1 Some fundamental methodological issues

The physical capital stock is a crucial variable in almost all growth theories and growth accounting exercises. Since it is only investments we have some reliable statistics on, most methods employ in one way or the other a perpetual inventory method in which the following identity is made use of:

$$K_t = (1-\delta)K_{t-1} + I_t \quad (1.)$$

where K is the stock of physical capital, δ is depreciation, and I is the gross fixed capital investment.

The capital investment data are obtained from the World Development Indicators of the World Bank (2007), the (KSH, 1969, 1974, 1979, 1980a, 1980b, 1981), and Mitchell (2007). For the pre-1940 period, we used data from Eckstein (1955). All series were made comparable, including residential capital. With underlying assumptions about asset lives and the rate of depreciation, these investment data can be converted in the stock of physical capital. In Hungary, the official capital formation series start in 1950 and are, directly or indirectly, the source of several physical capital stock estimates (Darvas and Simon 2000; Pula 2003). Since there are doubts about the quality of the available data, these stock estimates normally stretch back only to 1980. Yet, for the period prior to 1980, the Hungarian Statistical Office offers some estimates of the physical capital stock that start from 1950 (from 1960 annually) in both current and constant prices (KSH, 1969, 1974, 1979, 1980a, 1980b, 1981). The reliability of these estimates is also in question.

It is a general problem with capital stock estimates that the rate of depreciation, calculated from asset life assumptions, is rather arbitrary. Pula (2003, 7), for example, used the average of the service life in 12 OECD countries as a baseline. Assumptions like that are necessary in case of Eastern Europe since independent estimates are rare, but there is no direct reason to assume depreciation to be the same as in the West (Pryor 1985, 217). Indeed, some independent estimates for Hungary show that average service life was higher than in the West (Pula 2003, 7-8). Also, in almost all studies on physical capital in Eastern Europe some assumptions are made about the decline in the physical capital stock in the early 1990s as a result of transition. These assumptions are also rather arbitrary and might be in need of some revision.

2.2 Estimation with a Perpetual Inventory Method

We start by calculating the stock of physical capital using the standard assumptions of a linear depreciation and an asset life of 20 years. Further, we had to make an estimate of the one-off physical capital stock decline during the transition in the early 1990s.

In order to arrive to stock estimates without needing to take benchmark form another work, we assumed a linear depreciation of 20 years for the period 1967-2006.[2] This leads to stock estimates 23309 billion HUF at 2000 prices in 2001 (124,572 million G-K int. USD at 1990 prices). which is roughly 166% of the GDP (K/Y=1.66). This is higher than the estimate by Pula for the same year which is 18325 billion 2000 HUF that

[2] $K_t = \sum_{i=0}^{20} \left(1 - \frac{i}{20}\right) I_{t-i}$ with 20 years chosen this is equivalent with roughly 8.8% geometric depreciation per annum.

is 1.3 times the GDP. The possible reason is that Pula's series does not contain the residential stock of capital while our series does.

However, it is unlikely that the physical capital stock of Hungary at that year could have been significantly lower than our estimates. We know that the share of capital incomes (we call this α) must have been around 1/3-1/2 of the total income, if we assume a Cobb-Douglas type production function, and that capital is paid its marginal product, it is straightforward that the rate of returns to capital should equal $\alpha \frac{Y}{K}$. Depending on our estimate of α, therefore the rate of returns should have been 20-30%, in other words a payback period of 3.3-5 years, which is high but still feasible. With a K/Y ratio of 1.3 payback period would be much shorter, around 2.6-3.9 years. Such high rate of returns should have set off a very high capital inflow into the country, even with all additional risks involved, increasing the K/Y ratio quickly.

This type of cross-check exercise has some consequence on capital stock estimates in general: if one sticks to the traditional estimate of share of capital incomes being around 1/3, than the K/Y ratio cannot be much lower than 0.8-1. In all other cases (except for exogenous shocks like war) having a too low K/Y ratio would imply an unrealistically high profit rate (above 33%).

For the period between 1960 and 1966 we used a geometric depreciation rate of 8% as in (1). This is close to the finding of Pula (2003) who uses a rate of depreciation of 2% for buildings and 9.2% for machinery. For 1950-59 we used net capital formation as given in Mitchell (2007)

There are two breaks in the series: the first is during World War II and the first years of reconstruction, while the second is during the years of transition, when some of the physical capital stock has lost its value or had been completely withdrawn from production. There are different estimates about the magnitude of capital loss during transition years. The IMF estimated a 35 percent drop in capital stock for Hungary in 1991, calculated as a sum of a 20 percent loss due to the collapse of CMEA trade and an additional 15 percent due to the so-called "disorganization" effect (IMF (1999)). This view is challenged by Pula (2003, 9), who, based on a Cobb-Douglas type production function, assuming 60% share of labour incomes and 0% TFP growth, estimates that the observed 15% drop in aggregate income must have been caused by a one-time drop of 25% in physical capital in the early 1990s. Similarly to Pula we use a level accounting (or development accounting) with no change in TFP assumed to estimate the magnitude of capital loss. We assume a production function similar to Mankiw, Romer and Weil (1992):

$$Y_t = A_t K_t^{\alpha} H_t^{\beta} L_t^{1-\alpha-\beta} \quad (2)$$

If we assume that the TFP remained constant, and α=β=1/3, we can estimate the ratio of physical capital stock between any two years as follows:

$$\frac{K_t}{K_0} = \left(\frac{Y_t}{Y_0}\right)^{\frac{1}{\alpha}} \left(\frac{A_t}{A_0}\right)^{-\frac{1}{\alpha}} \left(\frac{L_t}{L_0}\right)^{\frac{\alpha+\beta-1}{\alpha}} \left(\frac{H_t}{H_0}\right)^{-\frac{\beta}{\alpha}} \quad (3)$$

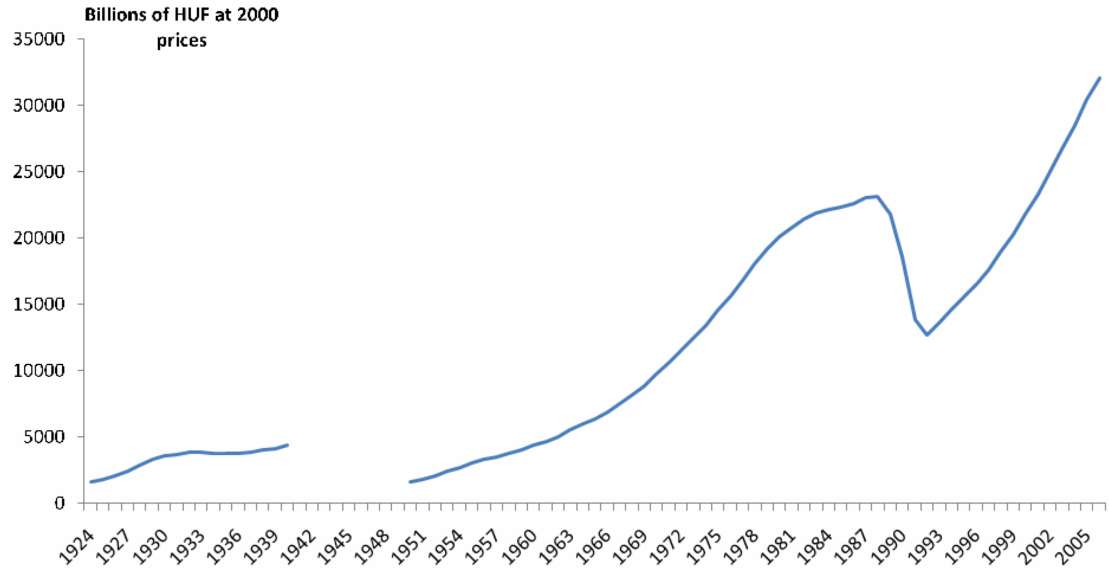
Since we know the necessary data (on the human capital series please see section 3), using the above equation method, with no TFP change assumed, we can estimate the probable magnitude of the capital loss during the years of the transition 1989-1992, which is altogether 54%. This is more than other estimates, but one should bear in mind that we assumed that this drop occurred over four years and not during a single year as by

IMF (1999) and Pula (2003). If we restricted the capital loss to 1991 only, we would arrive at 25% similarly to Pula.

We apply the same method to estimate the stock of physical capital in 1939. We use 1950 as reference year, and since there is 11 year difference we assume a TFP growth of 10%. So we arrive at an estimate of 4,168 billion HUF at 2000 prices (22,248 million G-K int. USD at 1990 prices), which is 85% of the GDP. We apply here a lower rate of depreciation, 7%, than after 1950. This is in accordance with the estimate of Prados de la Escosura and Rosés (2008, table 2) who find that average depreciation is around 2% smaller in the first half of the twentieth century. We chose a higher rate of depreciation though, because assuming 6% would have implied extremely low K/Y ratio in the 1920s. Using 7%, however, leads to 1,620 billion 2000 HUF (8,657 million 1990 G-K USD) in 1924, which is 55% of the GDP. This low ratio can be attributed to the effect of war, and the following unstable period paired with hyperinflation, hence is a feasible estimate.

Figure 1

Estimated stocks of physical capital in Hungary



3. Human capital stock

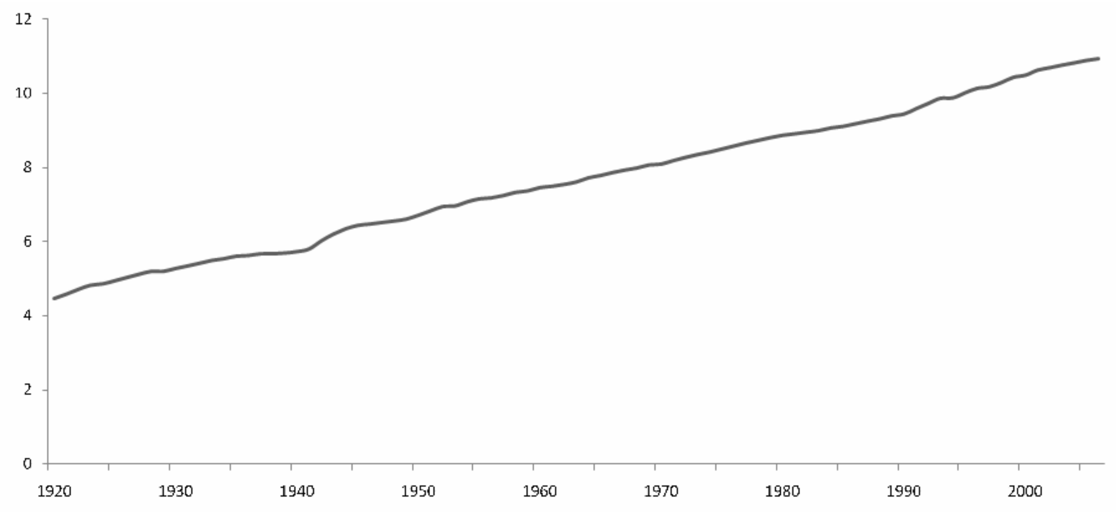
3.1 Average years of education in Hungary 1860-2006

The data for human capital are obtained from Földvári and Van Leeuwen (2009) on average years of education 1920-2006. In that paper we used the attainment census method that is generally considered to give the best results. Yet, since data in censuses are generally only available every 10th year, they calculated the in-between years based on modified version of the perpetual inventory method by Barro and Lee (2003) based on enrolment statistics.

The modification was needed since the unbiasedness of the Barro and Lee estimates has been questioned by several authors. As Portela *et al* (2004) argue, the main source of bias in the Barro and Lee series is that they implicitly assume the mortality rate to be independent of the level of education, which results in a downward bias when they forecast from a census year and an overestimation in case of backcasting. In Földvári and Van Leeuwen (2009) we base our method on the assumption that the two type of bias can offset each other. Hence, we estimate the average years of education series between census years as an average of the backward and forward estimates.

In the above mentioned 2009 paper we estimated the average years of education between 1920 and 2006 (see Figure 2).

Figure 2
Average years of education in Hungary 1920-2006



Source: Földvári and van Leeuwen (2009)

3.2 Rate of returns to education

By looking at only average years of education one can have only a partial view on human capital. The situation is similar as if one wished to estimate the physical capital stock by the total number of machines or the time requirement to maintain all capital goods. It surely offers some view on the time spent on forming the capital stock but tells us almost nothing on the quality of human capital or its productive efficiency (reflected by its market value).

A quite popular way, to improve the ability of the educational attainment variable to capture the market value of human capital is based on a combination of average years of education and the rate of returns to education (Hall and Jones 1999; Pritchett 2001). The rate of returns to education can be defined as the relative impact of an additional year of education on the individual's wage, or at a social level, as the average impact of an additional year of education on wages. Since wages reflect changes in the marginal product of labour (including human capital) an improvement of the rate of returns should also reflect an improvement in the productive efficiency of human capital. Of course, since labour usually exhibits decreasing marginal product, theoretically one can find an increasing rate of returns to education if the quantity (volume) of human capital stock reduces.

First, we are going to use the approach suggested by Hall and Jones (1999) and Pritchett (2001), which is based on a Mincerian approach (Mincer 1974). The per capita human capital stock is defined as follows:

$$h = e^{r_t S_t} \quad (4)$$

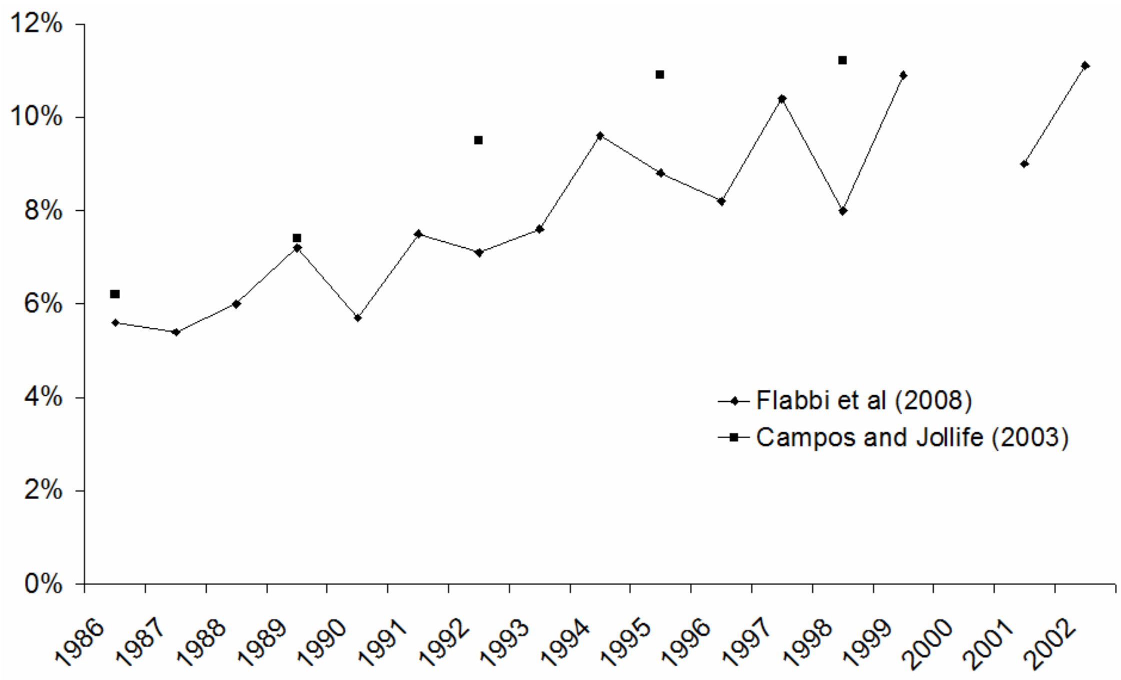
where r denotes the rate of returns to education, and S is the average years of education. That is both the quality and the quantity of human capital is captured in (4). The change of this value therefore reflects changes in the value of human capital and can be employed in a growth accounting.[3]

[3] We are hesitant to identify h in equation 4 as the value of human capital. Instead we treat it as a proxy. The reason is that there are methods that lead to estimates of the value of human capital expressed in monetary units. (see Wössman 2003 or van Leeuwen and Földvári 2008 for some further discussions). At the moment we interpret h as an index of per capita human capital stock, where the value of 1 equals the per capita human capital stock in a society where there is no formal education (or at least no returns to it).

For the 1980s and 1990s we have quite certain knowledge on the change in rate of returns to education. Campos and Jolliffe (2003) estimated the rate of returns to education in Hungary in 1986, 1989, 1992, 1995, 1998. They find that the r grew considerably after the Transformation (6.2%, 7.4%, 9.5%, 10.9%, 11.2% respectively). Flabbi *et al*. (2008) arrive at a similar conclusion: they find that the rate of returns grew gradually from 5.6% in 1986 to 11.1% in 2002 (see Figure 3). These findings suggest the productive efficiency of human capital (its marginal product for example) increased as a result of transition to market economy.

Figure 3

Rate of returns to education in Hungary in 1986-2002



Note: rate of returns to education is defined here as the relative effect of an additional year of formal education on wage

We have no reason to assume that the rate of returns to education remained constant prior to 1986, but we do not have microeconomic data (household surveys for example) to estimate the rate of returns to education for a longer period. Hence, we need to use a less reliable method to estimate the rate of returns to education in Hungary using skill premium data.

Theoretically, the rate of returns to education can be estimated in the following way:

$$r_t = \left(\frac{w_t^s}{w_t^u} \right)^{\frac{1}{l}} - 1 \quad (5)$$

Where r is the rate of returns to education, w^s and w^u denote the nominal wages of skilled and unskilled labour and l is the assumed difference in the duration of education between the two groups in years.

The wage data we use to estimate the rate of returns comes from different statistical sources. For the period from 1953 we used the ILO October Inquiry (various issues) data on construction workers and some wage data found in HSO Statistical Yearbooks. For the interwar years we could rely on industrial wages for clerks and labourers reported in the Hungarian Statistical Yearbooks (KSH, various issues).

For the interwar period we could assume that the average labourer had 4 years of education, while the average clerk had a completed secondary education (12 years), which is supported by the statistical yearbook data on the composition of the clerks. In Table 1 we report the estimated average years of education under the assumption of 8 years difference in education between the two groups.

Table 1

Rate of returns to education in Hungary, industrial wages, 1921-1940

year	*number of clerks*	*number of labourers*	*average wage clerks*	*average wage labourers*	*rate of returns (8 years difference assumed)*
1921	14797	152591	66	34	8.8%
1922	17873	189299	67	33	9.1%
1923	19620	206445	83	34	11.7%
1924	20162	193470	189	71	13.1%
1925	19695	198509	271	88	15.1%
1926	19647	205524	295	90	16.0%
1927	18357	242147	308	110	13.7%
1928	18748	242875	323	119	13.3%
1929	19091	244120	334	120	13.6%
1930	18800	216842	349	116	14.7%
1931	17492	190696	340	110	15.1%
1932	16200	175551	323	97	16.3%
1933	16032	192435	300	87	16.7%
1934	16981	208254	291	89	16.0%
1935	16279	231538	392	87	20.7%
1936	18112	259531	380	90	19.7%
1937	20190	293431	378	91	19.5%
1938	23119	299603	377	96	18.6%
1939	27735	362630	392	100	18.6%
1940	29746	366560	417	115	17.5%

Note: wages are expressed in golden crown prior to 1926 and pengő afterwards

Source: HSO Hungarian Statistical Yearbook, various issues

For the interwar period we find relatively high rate of returns to education, but they are still of acceptable magnitude, at least when compared to rate of returns to education in some developing countries by Psacharopulos and Patrinos (2002).[4]

For the socialist periods, we do not have a comparable intact wage series. For 1953-1961 we have data on the average earnings of certain skilled workers but only two of the reported jobs have an apparent difference in educational requirements (hewer and team-carman). We assumed three years difference in their education (the carmen are

[4] Columbia 1965: 17.3%, Venezuela 1975: 13.7%, Mexico 1991: 16.1%

assumed to have only primary education, while the hewers have an additional vocational education). For 1962-85 we used the ILO October Inquiry data on bricklayers and unskilled workers. Here, theoretically, we should opt for 3 year difference in education as well, but using 4 years brings these series much closer to the more reliable estimated from 1986 by Flabbi *et al.* (2008), and also seems to fit better with the series estimated from the mineworkers' wages.

Table 2 has our estimates (period averages):

Table 2

Rate of returns to education estimated from skill premium data (period averages)

Period	Rate of returns to education
1921-1930	12.9%
1931-1940	17.9%
1957-1960	6.7%
1961-1970	5.0%
1971-1980	6.8%
1981-1989	6.3%
1991-2000*	8.7%

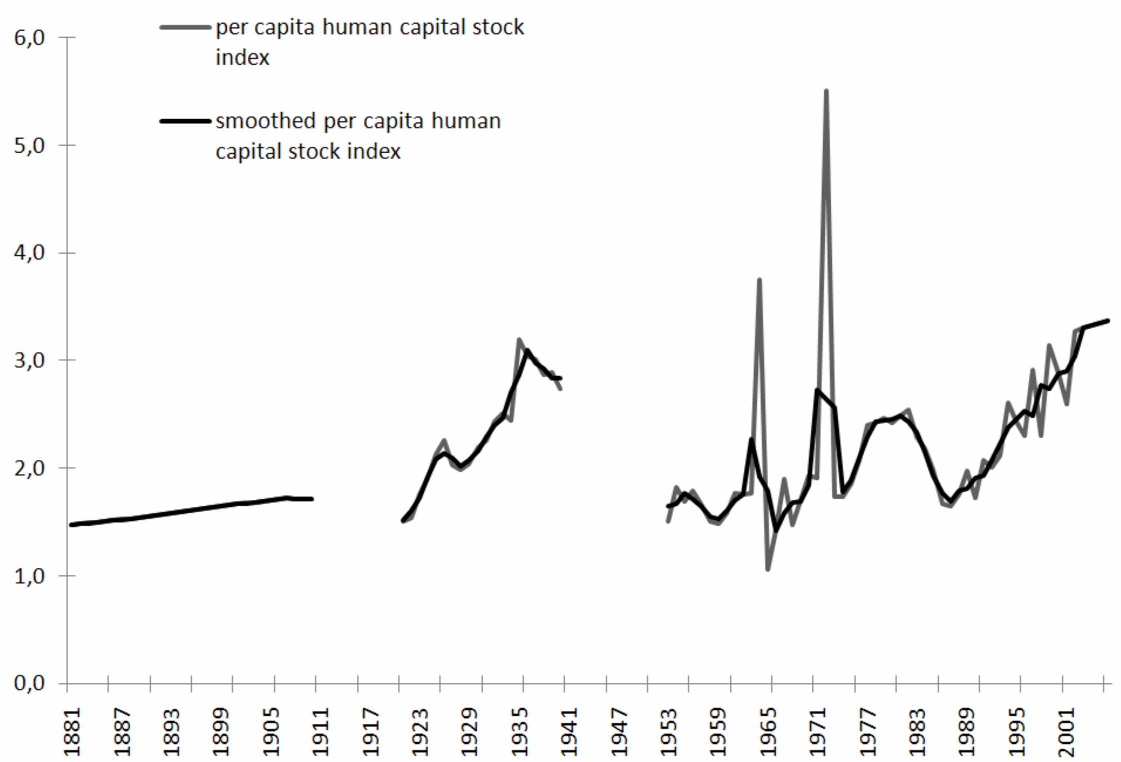
*Flabbi et al. (2008)

As Table 2 suggests the rate of returns to education were generally lower during socialism than in the 1990s and the interwar period, and the interwar period saw rate of returns comparable with that of the late 1990s.

Using our rate of returns to education data, we can calculate the change of human capital stock using equation 4 (Figure 4). This confirms our conclusion drawn from the rate of returns series: the per capita human capital stock (if calculated as defined in equation 4) reduced during the Socialism. In Figure 4 we also report the smoothed series, since quite significant changes in the rate of returns may results from measurement errors. This is contrary to the volume of human capital, as given in Figure 2, which shows no noticeable break in growth during the socialist period.

Figure 4

Per capita human capital index using the rate of returns based Mincerian method (h1)



Note: In case of the smoothed per capita human capital stock we used a centred MA(3) filter on the rate of returns to education series before calculating h. After 1985 we used the Flabbi et al (2008) estimates. For the years 2003-2006 we used the 2002 estimates of 11.1%.

Looking at Figure 4, it is inevitable that one has doubts whether the series indeed reflect the value of the stock of human capital, even though the methodology we used is widely employed in the economic literature. It seems questionable that the per capita human capital stock indeed dropped during socialism, since there was a large scale physical capital accumulation in this period and that should have *ceteris paribus* increased the rate of returns to education and so the value of human capital stock. Also this measure has already led to quite surprising results in cross-country comparisons (van Leeuwen and Földvári, 2008), indicating that in its current form it is too sensitive to changes or differences in rate of returns while obviously it does not (or just in an indirect way) take other factors into consideration like expected lifespan, prospects of economic growth, or technological development. Obviously, the rate of returns to education may reflect the effect of biased technological change (change of skill premium) but will not necessarily be affected by a neutral, unbiased technological development (since this increases all wages proportionally). To sum up, even though the first type of criticism could be dismissed by pointing out that socialism brought about a fundamental change in institutions, and seemingly this is reflected by the dropping rate of returns, the results are sensitive to outliers and do not capture neutral technological development. Therefore, we we choose to use a similar, but in our view more reliable estimation procedure of human capital stock.

In developing a new stock, our point of departure is the way how human capital is defined in prospective measurement methods. In those methods, human capital is understood in parallel with investments: the price of an asset, like a bond or stock, will tend to equal the present value of all expected future flows of income from it. Since when one invests in human capital, one expects a higher wage, the present value of the individual human capital can be seen as the present value of the future expected wages, corrected for the individual chance of survival. This is exactly how the Dagum-Slottje (2000) method works, but that is basically developed for use in household surveys. We seek to derive a similar formula, but for macro-level usage.

We first define human capital as the sum of all discounted expected future wage flows (we assume continuous time for convenience and use real wages):

$$h_{i,x} = \int_{t=0}^{65-x} E\left(w_{i,t}\right) e^{-qt} dt \quad (6)$$

where x and E($w_{i,x}$) is age and the expected real wage of individual *i*, and *q* is a discount factor. The formula above assumes that the individual remains in the labor force until his age 65. Since we are interested in the human capital stock of the average individual, the formula can be simplified:

$$\overline{h} = \int_{t=0}^{65-\overline{x}} E\left(\overline{w}_t\right) e^{-qt} dt \ (7)$$

Where $\overline{x}$ denotes the average age in the population. Now by assuming that the average individual expects that his/her real wage is going to grow at a constant rate *g*, the formula further simplifies:

$$\overline{h} = \int_{t=0}^{65-\overline{x}} \overline{w} e^{(g-q)t} dt = \frac{\overline{w}}{g-q}\left(e^{(g-q)(65-\overline{x})} - 1\right) (8)$$

Now, if we have some assumptions regarding *g-q*, with the average age and wage of the population, we can express the average (per capita) stock of human capital in monetary units, which is an improvement over the previous method in (4).[5] We assume in this paper that *q-p*=0.02, that is people expect that there utility resulting from higher wages

[5] We can establish a relationship between the two methods. Since the average wage can be expressed as the product of the wage of an unschooled individual times the effect of schooling on wages as follows: $\overline{w} = w_u e^{rS}$ equation (19) can easily be rewritten as: $\overline{h} = \int_{t=0}^{65-\overline{x}} w_u e^{rS} e^{(g-q)t} dt$. It is straightforward that if we assume that the unschooled wages remain constant (no productivity growth in the long-run), and the discount factor and the expected growth of real wages are equal (g-q=0), and r and S are constant, we revert to equation (4). That is the first method is equivalent with the prospective method suggested by us only under some very strict assumptions. Pritchett (2001) also acknowledges that the measure in equation (4) fails to capture changes in the unskilled wages.

will increase with time. Applying (8) on the data, we obtain the following series of human capital stock for Hungary:

Figure 5

The stock of human capital in Hungary 1920-2007 with prospective method in millions of HUF, constant 2000 prices (h2)

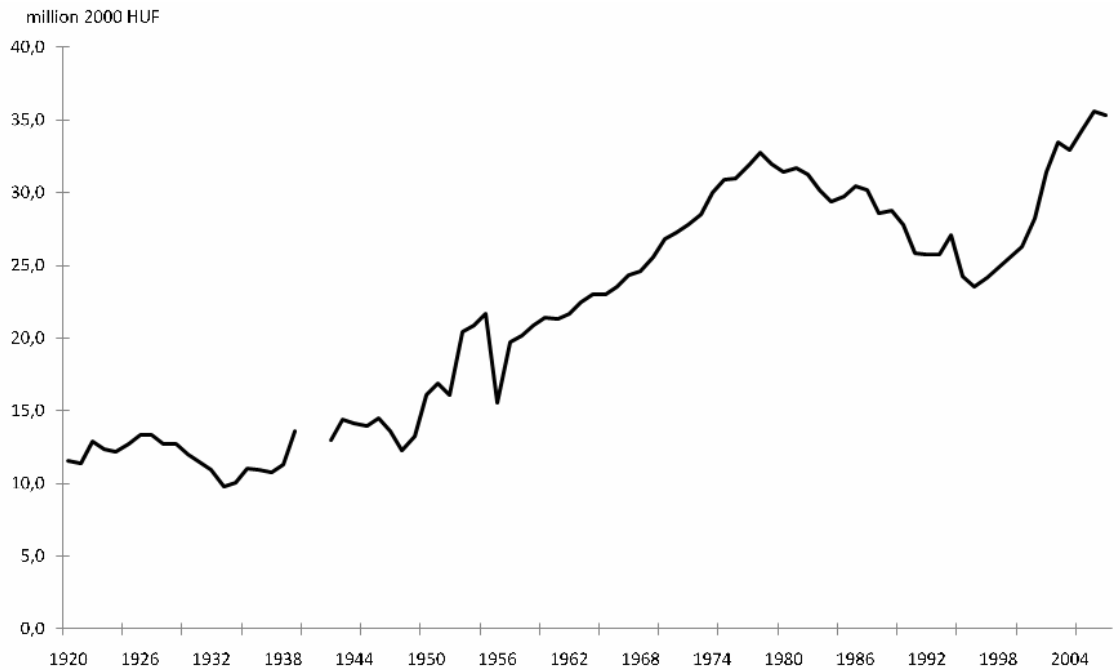
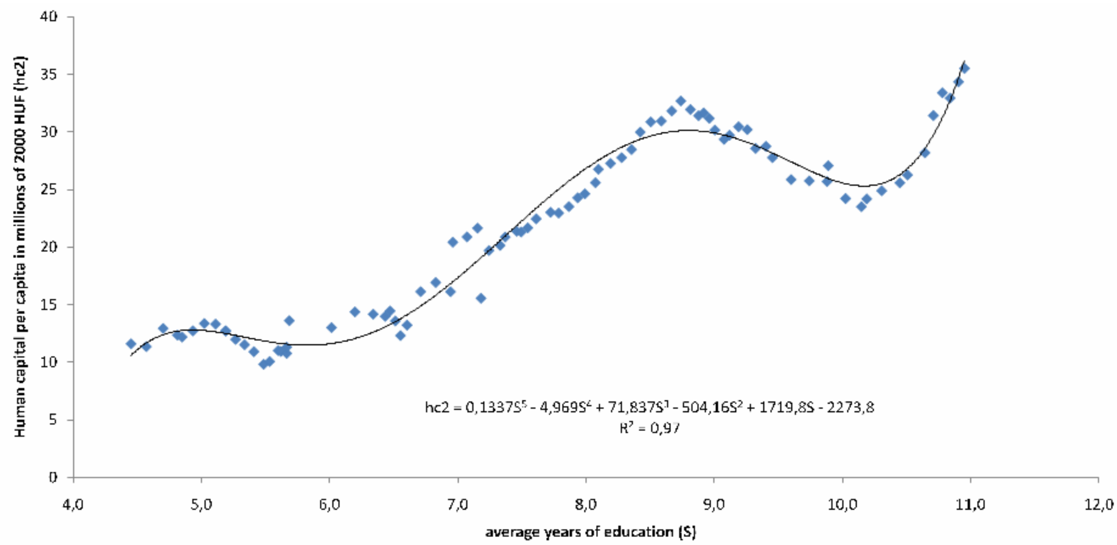


Figure 5 reflect a clear upward trend, not without breaks, though. After 1975, the per capita human capital stock seems to fall which continues until the end of transition. In comparison with the first measure in Figure 4, we find that the first measure, because of the reduction in the rate of returns to education, indicates a much lower per capita human capital stock relative to the interwar years, than the second method. The drop in human capital stock also occurs with the second measure, but only after 1975. Both measures lead to the conclusion that the human capital stock rose sharply after 1995.

While the relationship between formal education in the form of "average years of education" and the Mincerian human capital measure is straightforward (see equation 4), its relation with our second human capital measure is more complex. In Figure 6 we plot the second human capital series against average years of education.

Figure 6

Relationship between formal education (average years of schooling) and the human capital stock



The relationship is mostly positive, but not monotonous, which can be attributed to the economic problems of the eighties and the transition itself. If we assume that there is dynamic relationship between formal education and human capital, we can model this relationship with a partial adjustment model:

$$\underset{(37.3)}{\ln hc2_t = 9.81} + \underset{(12.6)}{0.863} \ln hc2_{t-1} + \underset{(7.68)}{0.230 \cdot S_t} + \underset{(2.49)}{0.151 D_t^{soc}} + \underset{(2.34)}{0.107 \cdot D_t^{trans}} \qquad (9)$$

$$R^2 = 0.98,\ N=83,\ Q(2)=0.557,\ Q(5)=9.21$$

Where D^{trans} is a dummy capturing the effect of transition during 1990-94. The results from the above regression suggest that an additional year of formal education has an immediate 23% impact on our income based human capital measure, with the long-run impact 171.6%. The half-life (that is the time needed for 50% of the effect to wear out) is about five years. Since (9) is a dynamic specification, the DW statistics would be misleading, so we report Ljung-Box statistics instead for the second and fifth lag.

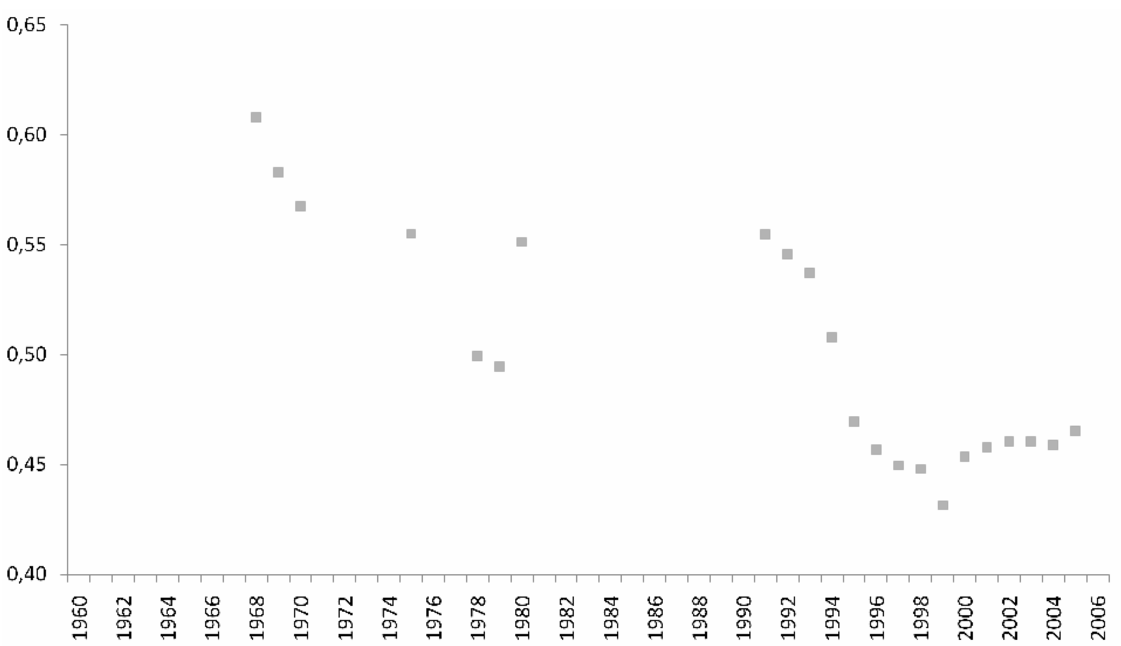
4. Growth accounting and regression analysis for Hungary 1920-2006

4.1 Growth accounting

Now that we have annual estimates of physical-and human capital for Hungary before, during, and after socialism, it is possible to employ them in a growth accounting analysis. Growth accounting, that is the estimation of the share of economic growth that cannot be explained by the accumulation of the observed production factors, is a frequently used technique, suggested by Solow (1957) and made popular by Dennison (1974). In most cases it is assumed that the factor shares in aggregate income remain constant, which is in accordance with unit elasticity of substitution (a Cobb-Douglas type production function). Even though this is obviously a simplification, it is generally very difficult to have accurate data on factor shares. On the income sides of National Accounts Statistical Bureaus report categories that are fundamentally different from their theoretical counterparts: the compensation of employees' category contains just a part of total labour income, while the category labelled as "mixed income" contains the labour and capital income of entrepreneurs, making these practically inseparable. Also, the reported category of "gross operating surplus" is far too aggregate to give us any clue what is paid to capital owners, what is deducted as rents, and what can be deemed as economic profit. This problem is especially evident in Hungary, where the share of private entrepreneurs gradually increased from the 1960s as a result of the relatively liberal economic policy of the regime. Therefore, even though using the National Accounts of the HSO for different years, we get the impression that the share of labour in aggregate income gradually decreased in the second half of the 20th century, this might be caused by the increasing share of private enterprises, and hence the increasing measurement problems. This seems to be supported by the implausibly low share of employee compensation in the 1990s.

Figure 7

Share of compensation of employees in aggregate income



Note: the HSO National Accounts reported Net National Product prior to the 1970s, which is not equivalent with GDP. The observations for the 1960s are therefore just indicative.

Also, one should not forget, that the wage bill reflects not only the share of labour in total income, but also that of human capital. Even though practically these are inseparable, theoretically it is usually done (see Mankiw, Romer and Weil 1992). We find it therefore safer to assume that all factors of production in our model (physical capital, human capital and labour) has the same one-third share of aggregate income.

For the growth accounting we use our PIM estimates as physical capital stock. The GDP per capita growth rate data is taken from Maddison (2003), while the labor force benchmarks are calculated from Mitchell (2007) and interpolated with the total population taken from Maddison (2003).

Table 3
Growth accounting 1924-2001, average annual growth rates

Period	GDP growth rate	Capital stock growth rate	Human capital growth rate	Labour growth rate	TFP growth with hc effect deducted	TFP growth with neglecting hc
1924-1930	5.04%	14.22%	0.85%	0.83%	-0.26%	14.11%
1931-1940	1.75%	1.99%	3.17%	0.97%	-0.29%	1.13%
1951-1956	3.81%	12.47%	3.14%	1.70%	-1.96%	12.73%
1957-1967	5.16%	7.76%	5.35%	0.48%	0.64%	5.56%
1968-1975	2.55%	8.58%	3.63%	0.20%	-1.59%	8.43%
1976-1980	2.04%	6.73%	0.84%	0.10%	-0.52%	6.80%
1981-1985	0.69%	2.12%	-2.09%	-0.91%	0.98%	2.16%
1986-1990	-0.77%	-3.46%	-2.01%	-0.92%	1.36%	-3.69%
1991-1995	-2.22%	-2.52%	-4.51%	-1.92%	0.76%	-1.53%
1996-2000	4.01%	6.94%	2.27%	0.20%	0.87%	5.60%
2001-2006	4.25%	6.65%	6.22%	0.47%	-0.20%	4.71%
Weighted average	2.75%	5.93%	2.21%	0.26%	-0.05%	5.24%

Note: in the last column we assume 1/3 share for physical capital, 2/3 share for labour incomes.

Table 3 suggests that with the exception of the period 1981-95 human capital accumulation was an important factor in economic growth in Hungary. The role TFP growth, which is often referred to as an indicator of technology and to a certain degree institutions as well (see Hall and Jones 1999) is strongly reduced by the inclusion of human capital. With the human capital accumulation neglected, we obtain that the TFP grew by 5.24 per cent annually on average. If the human capital effect is deducted this reduces to -0.05% p.a.. What is more, there are periods when the TFP growth is negative: during the first half of the 20th century (until the fifties).

Should the reduction of the role of TFP by including human capital worry us? If one believed that institutions and technological development is independent of the value of the factors of production, it should certainly should. Nevertheless, that would be a point of view very difficult to defend: better allocation of resources, more productive technologies, should all result in higher returns to factors of production thereby increasing their value. Hence what we find here is by no means that institutions or technology did not play a role in economic development in Hungary, but rather that their effect is through factor accumulation (e.g. Eicher, García Peñalosa, and Teksoz 2006). We find Abramovitz's (1993) view on the Solow residual, "lower-bound measure of ignorance about the sources of growth" much more fitting. From that perspective, having a TFP growth close to zero in the long-run is the best we could have hoped to find.

Growth accounting is however the least challenging task when one is about to find out how human capital contributes to economic growth. Since it is already assumed that human capital plays a role in the production process, it is guaranteed that one has some results. The rest is usually a question of narrative. It is much more difficult to have human capital included in some growth regressions, and see that the human capital variable ultimately behaves as expected. Benhabib and Spiegel (1994) find that education has seemingly no role in the growth process. The lack of success resulted in two different kind of reactions. Pritchett (2001) in his famous article basically accepts the lack of macroeconomic relationship between growth and education and tries to find an economic-social answer why education does not turn out to be a key of economic success. Kreuger and Lindhal (2001), similarly to Cohen and Soto (2007), claim that data and measurement error is mainly responsible for the insignificant or even negative coefficients. Our point of view is closer to this latter strand of the literature, with the major difference that while they still rely on educational attainment or closely related data, we believe that the strange empirical results are due to the wrong indicators. Human capital should be expressed in terms of monetary units, similarly to physical capital stock and not proxied by an indirectly related educational indicator. In order to prove this point, we estimate a simple, Cobb-Douglas type production function with our measure of human capital employed.

Table 4

Results from regression analysis

	1	2
constant	7.261 (13.9)	5.328 (4.33)
lnK	0.228 (15.7)	0.215 (14.6)
lnH	0.314 (6.26)	0.302 (6.38)
lnL	0.241 (1.70)	0.514 (2.84)
trend	0.007 (10.12)	0.008 (10.9)
D^{soc}	-	-0.053 (-1.86)
D^{trans}	-	-0.118 (-5.39)
R^2	0.992	0.995
N	71	71
DW	0.694	1.030

Note: Dependent variable is the log of GDP. Robust t-statistics in parentheses

We find that all factors of production yield the expected coefficients in Table 4. We can also safely reject the possibility that the regression is spurious, since the Durbin-Watson statistics are much higher than null, indicating that the residual has no unit-root.

6. Conclusion

In this paper we had two objectives. First, we estimated the physical and human capital stocks for Hungary, for the period 1924-2006. We used two measures to estimate the value of the human capital stock in Hungary. The first one, based on rate of returns to education, indicates a reduction in the value of human capital stock in the Socialist period. The second method on the other hand results in different results, with the human capital stock starting to decline only after 1975. That the value of human capital stock decreased during the last two decades of Socialism, we attribute to the much less efficient allocation mechanisms when compared to market economy. As in an earlier work for the transition period (Földvári and van Leeuwen 2009), we find that the Solow residual's contribution to economic growth significantly reduces when one subtracts the effect of human capital accumulation. Letting go the growth accoutinga ssumption that human capital must affect economic growth, we also find that the prospective measure labelled (h2) yields a positive and significant coefficient in regression analysis.

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