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Education and Economic Development: An Empirical Perspective

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There is surprisingly little macroeconomic empirical research which would support a presumed link between education and development. I identify three major reasons why it remains difficult to estimate the economic relevance of education as a determinant of growth and development. First, most empirical research has ignored some of the crucial productivity aspects of education as proposed by new growth models. Second, measuring the contribution of education to economic development has largely ignored international differences in rates of return and the quality of education. Third, the allocation of resources within the education sector usually does not follow considerations of efficiency, which implies that additional spending on education cannot be expected to produce substantial output effects.

I. Introduction

Many recent contributions to the theory of economic growth and development have focused on the pivotal role of human capital formation. While human capital formation is a fairly encompassing concept in economic theory, most recent empirical contributions have focused on education as a readily available proxy for human capital. Despite the almost self-evident role of education in an explanation of microeconomic income differences, the macroeconomic role of education has remained elusive up to now. This state of affairs is very unsatisfactory from an economic policy point of view, not least because many national and international organizations consider the advancement of education as a proven recipe to overcome poverty and economic backwardness.

In this paper, I briefly review the international empirical literature on the macro-economic link between education and economic development. Apart from purely statistical problems, I identify three major reasons why it remains difficult to estimate the economic relevance of education as a determinant of growth and development:

Theory is much ahead of empirics in the macroeconomics of education. Most empirical research so far relies on rather traditional models of growth and development, which ignore some of the crucial aspects of the new growth models.

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Measuring the contribution of education to economic development has mainly relied on cross-country estimates of average years of education, which may be grossly inadequate if rates of return to investment in education or the quality of education differ substantially across countries (as they do).

In almost all countries, the allocation of resources within the education sector obviously follows political mechanisms rather than economic considerations of efficiency, which implies that additional spending on education cannot be expected to produce substantial output effects without a reform of the underlying (inefficient) system itself.

The next section summarizes the standard approach to estimating the macroeconomic role of education in growth by highlighting various possible specifications of the education variable. Section III reports what can be learned about the macroeconomic role of education from recent so-called development accounting studies, which are based on calibrating (instead of estimating) the key parameters of macroeconomic production functions. Both types of studies produce a broad range of results for the macroeconomic role of education which do not allow for a clear-cut assessment. Finally, Section IV looks in greater detail into the sector which is assumed to produce a large fraction of the economy-wide human capital, namely the schooling sector. The somewhat depressing finding is that schooling productivity seems to have declined in a number of developed and developing countries over the last 25 years or so. With a view on the implications of these findings for economic policies aiming to foster human capital formation, Section V outlines directions for further research.

II. Modeling the Macroeconomic Productivity of Education

Up to now, the human capital augmented neoclassical growth model has remained the workhorse of empirical research on the macroeconomic productivity of education. The model is fairly flexible because it allows for alternative specifications which can be adjusted to best match the available data at hand. Many specific versions of the model have been used in the empirical literature, but the underlying basic structure can be derived from no more than two slightly different production functions.

1. Basic Equations to Identify the Macroeconomic Role of Human Capital

One version of the neoclassical growth model considers human capital as an independent factor of production. Output at time t is described as

$$Y(t) = K(t)^a H(t)^b \big(A(t)L(t)\big)^{1-a-b}\ , \qquad (1)$$

where the notation is standard: Y is output, K is the stock of physical capital, H is the stock of human capital, A is the level of technology, and L is labor. A and L are assumed to grow exogenously at rates g and n. This production function can be estimated in its structural form as

$$\ln(Y/L)_t = (1-\boldsymbol{a}-\boldsymbol{b})[\ln A(0) + gt] + \boldsymbol{a}\ln(K/L)_t + \boldsymbol{b}\ln(H/L)_t\,, \tag{2}$$

with $\boldsymbol{a}$ and $\boldsymbol{b}$ as the production elasticities of physical and human capital. Assuming that constant fractions of output, s_k and s_h, are invested in physical and in human capital, and defining k as the stock of physical capital per effective unit of labor ($k = K/AL$) and, similarly, $y = Y/AL$ and $h = H/AL$, the evolution of the economy is governed by

$$\dot{k}(t) = s_k y(t) - (n + g + \boldsymbol{d})k(t)\,, \tag{3a}$$

$$\dot{h}(t) = s_h y(t) - (n + g + \boldsymbol{d})h(t)\,, \tag{3b}$$

where the dot denotes absolute changes of the variables over time, and $\boldsymbol{d}$ is the depreciation rate. The underlying assumption of this modeling framework is that the same production function applies to human capital, physical capital, and consumption. Hence the depreciation rate is the same both for human and for physical capital.

For decreasing returns to all capital ($\boldsymbol{a} + \boldsymbol{b} < 1$), Equations (3a) and (3b) give the steady state values k^* and h^* as

$$k^* = \left(\frac{s_k^{1-b} s_h^{b}}{n + g + \boldsymbol{d}}\right)^{1/(1-a-b)} \tag{4a}$$

$$h^* = \left(\frac{s_k^{a} s_h^{1-a}}{n + g + \boldsymbol{d}}\right)^{1/(1-a-b)}. \tag{4b}$$

Substituting Equations (4a) and (4b) into the production function (1) by using the definitions for k and h, and taking logs, gives the reduced-form equation for the steady state *level* of output per worker as a function of the fraction of output invested in human capital (s_h) and other variables such as the initial level of technology, the growth rate of technology, the fraction of output invested in physical capital, the growth rate of the labor force , and the depreciation rate:

$$\ln(Y/L)_t = \ln A(0) + gt + \frac{\boldsymbol{a}}{1-\boldsymbol{a}-\boldsymbol{b}}\ln(s_k) + \frac{\boldsymbol{b}}{1-\boldsymbol{a}-\boldsymbol{b}}\ln(s_h) - \frac{\boldsymbol{a}+\boldsymbol{b}}{1-\boldsymbol{a}-\boldsymbol{b}}\ln(n + g + \boldsymbol{d}). \tag{5}$$

Approximating around the steady state, Mankiw *et al*. (1992) show that the *growth rate* of output per worker between some initial date 0 and time t can be described as a function of the above determinants of the steady state plus the initial level of output:

$$\ln(Y/L)_t - \ln(Y/L)_0 = \left(1-e^{-\lambda t}\right)\frac{\alpha}{1-\alpha-\beta}\ln\left(s_k\right) + \left(1-e^{-\lambda t}\right)\frac{\beta}{1-\alpha-\beta}\ln\left(s_h\right)$$

$$-\left(1-e^{-\lambda t}\right)\frac{\alpha+\beta}{1-\alpha-\beta}\ln\left(n+g+\delta\right) - \left(1-e^{-\lambda t}\right)\ln\left(Y/L\right)_0 , \qquad (6)$$

where investment in human capital is again one of the right-hand-side variables and λ is the rate of convergence to the steady state.

An alternative way to identify the role of human capital in determining the level of output per worker is given by

$$\ln(Y/L)_t = \ln A(0) + gt + \frac{\alpha}{1-\alpha}\ln\left(s_k\right) + \frac{\beta}{1-\alpha}\ln\left(h^*\right) - \frac{\alpha}{1-\alpha}\ln\left(n+g+\delta\right), \qquad (7)$$

which can be derived from solving Equation (4b) for s_h and substituting into Equation (5). This equation uses a stock measure rather than a flow measure of human capital as a right-hand-side variable, and predicts different coefficients on the terms for investment in physical capital and for the growth of the labor force. Equation (7) can also be used to approximate around the steady state, similar to Equation (6).

In the second version, human capital is considered as being directly linked to labor and not as an independent factor of production, as recently suggested by Bils and Klenow (2000). If so, the initial production function (1) can be rewritten as

$$Y(t) = K(t)^{\alpha}\left(A(t)L(t)e^{school}\right)^{\beta} \quad \text{with} \quad \alpha + \beta = 1, \qquad (1.1)$$

where *school* is a variable which measures the combined impact of the rate of return to investment in education r and the average number of years of schooling (S). This specification is inspired by the empirical microeconometric success of the so-called Mincer equation (Mincer (1974)) and implies that human capital generated by schooling is given as

$$H_S(t) = L(t)\cdot e^{rS}, \qquad (8)$$

Using Equation (3a) as before, the evolution of capital intensity per effective worker is now given as

$$\dot{k} = s_k k^{\alpha} e^{\beta\cdot school} - \left(n+g+\delta\right)k, \qquad (3.1.a)$$

implying that k converges to a steady state value k^* which follows (see Equation (4a)) as

$$k^* = \left[s_k\, e^{\beta\cdot school}/\left(n+g+\delta\right)\right]^{1/(1-\alpha)}. \qquad (4.1.a)$$

Substituting (4.1.a) into the production function (1.1) and taking logs, output per worker equals

$$\ln\left(Y/L\right)_t = A(0) + gt + \frac{a}{1-a}\ln\left(s_k\right) + \frac{b}{1-a}school - \frac{a}{1-a}\ln\left(n + g + d\right), \tag{9}$$

which looks very similar to Equation (7) except for the measure of human capital, which now does not enter in logarithmic form.

This recapitulation of the basic structure of the most popular empirical growth models shows that even within a fairly narrow theoretical setting, there are many ways to estimate the macroeconomic role of human capital formation as measured by education. With perfect data, it should not matter whether stock or flow data are used: the implied estimate of b should be the same in specifications like (2), (5), (6), and (7). But the available data are far from perfect. Hence empirical results are likely to differ depending on the specification used. In addition, the various specifications encounter different econometric problems with regard to endogeneity, multicollinearity, and measurement error, which also impact on the results (Gundlach (1999)). Furthermore, results based on specifications (7) and (9) have to be interpreted differently although the regression coefficient on the human capital variable is predicted to be the same (and to be equal to 1 for constant returns to scale).

Because of these statistical, econometric, and interpretational problems, it does not come as a big surprise that the estimates of the production elasticity of human capital reported in the literature differ widely. In the following, I review selected empirical results which allow for an identification of the production elasticity of human capital. This is not meant as a comprehensive review of the recent literature. The overview is only meant as an attempt to evaluate by statistical and economic criteria the broad range of empirical findings which have been produced on the basis of alternative specifications derived from the underlying production function.

2. Empirical Estimates

Depending on the availability of cross-sectional or time-series stock and flow data for physical and human capital, the macroeconomic role of education can be inferred from estimates of the regression coefficients on the human capital variables. There would be positive empirical evidence in favor of a macroeconomic productivity of education if the direct or implied estimate of b in the above specifications resembles the share of human capital in factor income.

As a measure of reference, the share of human capital in factor income can be assessed by back-of-the-envelope calculations. One possibility is to consider the minimum wage as the return on labor with no education. Historically, the minimum wage has been 30 to 50 percent of the average wage in the United States. On this account, it would follow that the return to education equals about 50 to 70 percent of labor income. And since labor income is about 70 percent of total factor income in the United States and other industrialized countries, the share of human capital in total factor income should be about 35 to 50 percent.

The problem with this kind of benchmark estimate is that comparable data for other countries than the United States are difficult to come by. Especially in developing countries, the minimum wage is less enforced and less likely to be applicable, and solid data are harder to obtain in any case. An alternative possibility to derive a benchmark estimate is to focus on the estimated rate of return to education and on average years of schooling (as in Equation (8)). If each year of schooling substantially raises a worker's income, it becomes possible to calculate the difference between incomes achieved with and without education.

For the world as a whole, a social rate of return to secondary education of 13 percent and an average of 8 years of schooling have been estimated (Psacharopoulos (1994)). The income generating effect of schooling can be calculated as average years of schooling times the rate of return to schooling raised to the power of e. So for the world as a whole, one would conclude that the average worker earns about three times [$e^{8 0.13}$] as much as he would without any schooling. Therefore, the share of human capital in labor income should be about two thirds, as was suggested by the calculations based on the minimum wage. And the share of human capital in total factor income, as proxied by the production elasticity, should be estimated as about 45 percent in econometric studies.

Lau *et al.* (1991) estimate a variant of the structural form of the production function (see Equation (2)). They relate aggregate real GDP to physical capital stock, labor force, land, and average education of the labor force as a proxy for the stock of human capital. For a sample of developing countries, they find production elasticities of physical capital of about 60 percent, but relatively small production elasticities of human capital in the range of 2 percent for various specifications. Only if they allow for region specific effects, their estimates for the production elasticity of human capital increase to 20 percent for Latin America and East Asia. Also based on a variant of the structural form of the production function, Kim and Lau (1992) find production elasticities of physical capital for industrialized countries which are close to conventional factor shares. However, the estimated production elasticities of human capital turn out to be rather small, covering a range from 10 percent (United States) to 20 percent (Japan).

In a rather influential study, Benhabib and Spiegel (1994) use a first-difference version of the structural form of the production function (Equation (2)) to estimate the role of human capital for a sample of industrialized and developing countries. They report that in such a specification, the regression coefficient on the change in average schooling years turns out to be statistically insignificant and sometimes even enters with a negative sign. In order to obtain a more positive role of human capital formation, they suggest an alternative growth model. In this new model, human capital externalities can be considered to be embodied in new physical capital (technology import) or in subsequent advances in knowledge, as suggested in the models of Lucas (1988) and Romer (1990). Their empirical results seem to suggest that the level of schooling, which enters with a statistically significant positive regression coefficient, is indeed facilitating adoption of technology from abroad and creation of appropriate domestic technologies.

But their model has an unpleasant implication. If it holds, the estimated production elasticity of physical capital should be much larger than its factor share because of the presumed externalities. But it is not: the estimated regression coefficient of physical capital is pretty close to its expected factor share in the range of 30 percent. Therefore, some doubts remain as to the usefulness of the new model. Measurement error may be a simple alternative explanation for the initial finding of statistically insignificant or even negative estimates of the effect of the change in schooling on growth.

This interpretation is supported by a recent econometric reexamination of the link between education and growth by Topel (1999), who found that measurement errors in education severely attenuate estimates of the effect of the change in schooling on GDP growth. At the same time, these measurement errors are unlikely to cause a spurious correlation between the initial level of schooling and growth conditional on the change in schooling. According to this study, both the level and the change in schooling appear to be positively correlated with growth. Such a finding could be interpreted as indicating externalities from education, but it is difficult to reconcile with the neoclassical growth model which does not allow for such externalities in the specifications presented above.

In turn, Krueger and Lindahl (2000) explore whether the significant effect of the initial level of schooling continues to hold conditional on several theoretical restrictions which are implicitly imposed on the underlying growth equation which endorses the possible existence of human capital externalities. For instance, they allow the coefficient on education to vary across countries, as would be suggested by country-specific empirical results on the rates of return to investment in education, and they relax the neither theoretically nor empirically substantiated assumption of linearity between the initial level of education and growth. Krueger and Lindahl find that the positive statistical effect of the initial level of education on growth actually depends on econometric restrictions which are not supported by the data. Hence they conclude that despite a voluminous theoretical literature highlighting potential externalities from education, the empirical evidence of a positive effect of the level of education on a country's growth rate is tenuous, probably with the exception of countries at very low levels of income.

Mankiw *et al.* (1992) is the seminal paper using a reduced form of the production function in levels and in growth rates (Equations (5) and (6)) to estimate production elasticities of physical and human capital. In an international cross-country analysis, they find production elasticities for both human and physical capital of about one third. Although these estimates may still suffer from all sorts of econometric problems, they obviously do less so than estimates based on the structural form of the production function.

For instance, according to the underlying neoclassical growth theory, the investment rate is assumed to be exogenous, so no simultaneity problem arises as long as the theory is correct. By implication, the stock variables used in the structural form (see Equation (1.1)) are necessarily endogenous if the basic neoclassical model is right, as can be seen from Equations (3a) and (3b). This is why reduced form estimation should be preferred, at least as long as appropriate instruments for the endogenous variables are notoriously difficult to come by at the macroeconomic level. Moreover, measurement error is likely to play a smaller role because investment rates (flows) in the form of schooling enrollment rates are probably better proxies for the true human capital variable than accumulated stock variables. And if measurement error is less likely to be a problem, so is multicollinearity, at least in a cross-country context.

Yet an estimate of the production elasticity of human capital of about one third seems to be somewhat on the low side given the previous back-of-the-envelope calculations. Using

Equation (7) which employs average years of schooling rather than schooling enrollment rates as a right-hand-side variable, my own results indicate that human capital's share in factor income could be about two thirds rather than one third (Gundlach (1995)). Alternative estimation techniques reveal that this finding does not suffer from an upward bias due to the potential endogeneity of the stock of human capital. At the same time, the Mankiw *et al.* (1992) finding does not seem to suffer from downward bias due to measurement error.

This outcome may suggest an alternative growth model which is capable of explaining both sets of results. However, an unpleasant implication turns up. If human capital has a factor share of two thirds and physical capital has a factor share of one third, one ends up with a combined physical and human capital share of 100 percent. Such a capital share is not compatible with observed rates of convergence in the range of 2 percent, which are only supported by a combined capital share of about 80 percent (Barro and Sala-i-Martin (1992)).

Another extension of the Mankiw *et al.* framework is suggested by Gemmel (1996), who uses an alternative measure of human capital formation based on school enrollment rates and labor force data which is intended to distinguish between stocks and flows. He finds that initial stocks *and* subsequent growth of human capital play a role in fostering faster economic growth. However, the theoretical foundation of the underlying regression equation remains somewhat unclear. If both the stock and the flow of human capital are included in the regression equation, as could be motivated by endogenous growth models such as Romer (1990), it is no longer clear what kind of growth model is actually estimated. But if the model to be estimated is not known a priori, the reported regression coefficients cannot be interpreted in economic terms.

Accordingly, Gemmel (1996) evaluates his findings solely on the basis of statistical significance. Yet statistically significant regression coefficients are not necessarily meaningful from an economic point of view even if they have the right sign. His estimated regression coefficients on initial income provide a case in point, because they have a negative sign and are statistically different from zero (compare Equation (6)). Unfortunately, they are larger than 1 in absolute value. This result is incompatible with the rate of convergence predicted by the neoclassical growth model.[1] Therefore, this model cannot be used as a justification for the specification of the regression equation. But if an endogenous growth model is used, initial income should probably have a positive regression coefficient or may not enter the regression equation at all.

Heckman and Klenow (1997) use a special variant of Equation (9) in a cross-country context to estimate the macroeconomic return to an additional year of schooling. They account for international differences in capital intensity and find that the macroeconomic return to an additional year of education seems to be close to the microeconomic return in the range of 10 percent as reported in the literature (see Psacharopoulos (1994)). They interpret their finding as indicating that human capital externalities as highlighted by many new growth models do not have a solid empirical basis. However, their interpretation of the estimated regression coefficient as a measure of the rate of return is not straightforward

1. See the regression coefficient on initial income in Equation (6), which has to be smaller than 1 in absolute value in order to allow for an estimate of the rate of convergence l.

within the applied production function context such as Equation (1.1). In that case, the regression coefficient follows as the product of the factor share and the rate of return to education, if average years of schooling is used as the explanatory variable. Hence the jury is out on the question of human capital externalities.

Finally, Gundlach and Matus-Velasco (2000) estimate Equation (9) in a cross-country context by constructing a measure of H_S based on world-average rates of return to investment in education and by taking into account international differences in the quality of schooling as reported by Hanushek and Kim (1995). We find that the regression coefficient on our human capital measure is statistically indifferent from 1 (as it should) and that the implied estimate of the production elasticity of physical capital is about one third, which implies a production elasticity of human-capital-adjusted labor of about two thirds. Although this estimate cannot be directly compared with the estimates based on a production function which models human capital as an independent factor, it nevertheless confirms that education, and especially quality-adjusted education, seems to play an important role at the macroeconomic level. This is all the more important because an important macroeconomic role of education has been questioned recently (Pritchett (1996) and see next section).

III. Education in Development Accounting

As an alternative to econometric estimates of the production elasticity of human capital, one may also identify the macroeconomic productivity of education with the help of so-called development accounting studies. This approach borrows from the older literature on growth accounting but focuses on international differences in levels of output per worker, hence development accounting. According to recent studies of development accounting by Hall and Jones (1999), Klenow and Rodríguez-Clare (1997), and Prescott (1998), international differences in output per worker are difficult to explain by differences in factor endowments. These studies attribute a rather small role especially to human capital and, accordingly, find large cross-country total factor productivity residuals. Large international total factor productivity differences question the usefulness of the traditional neoclassical model of growth and development, which is based on an exogenous rate of productivity growth.

But these findings deserve second thoughts (Gundlach *et al.* (2000)). First, the size of the estimated total factor productivity residual crucially depends on an identifying assumption about the specific factor-augmenting properties of productivity. The difficulty is that it is impossible to discriminate between the alternative assumptions of Hicks-neutral and Harrod-neutral productivity under the standard restrictions imposed on the production function in virtually all applied analyses. Hence, residual productivity differences estimated by standard development-accounting methods always reflect an untestable a priori assumption, which necessarily influences the relative weight of factor inputs and productivity in a decomposition of output per worker. Second, large international total factor productivity residuals may reflect measurement errors or omitted variables. The leading candidate for mismeasurement is the stock of human capital. If improved measures of human capital can explain a larger fraction of international income differences, this will necessarily reduce the residual productivity measure, independent of the chosen productivity assumption.

1. Theoretical Background

The inherent problem of a decomposition of output into factor inputs and productivity is that it is impossible to discriminate empirically between changes in factor inputs that reflect a movement along a given production function and changes in total factor productivity (the residual) that reflect a shift of the production function. Because total factor productivity is not observed directly, one cannot conclude from observations of changes in output per worker and changes in factor inputs *how* changes in total factor productivity might have shifted the production function (Nelson (1973)).

This problem is also present in development accounting studies, where output and factor inputs are measured at a given point in time. Any difference between output and the sum of weighted factor inputs, which equals residual productivity, obviously depends on the weighting scheme employed. But the weighting scheme itself depends on an assumption about the specific neutrality properties of total factor productivity (the residual). Within the model, it is a question of theory, not empirics, which weighting scheme has to be preferred to possible alternatives.

In the older literature on growth accounting,[2] the standard practice was to assume Hicks-neutral productivity. More recent papers on development accounting claim that it is more appropriate to assume Harrod-neutral productivity. To compare these identifying assumptions, consider a most simple Cobb-Douglas production function

$$Y = K^{a} L^{(1-a)} e^{l}\ , \tag{10}$$

where Y is the level of output, K is the stock of physical capital, L is labor used in production, and e^{l} denotes productivity. It remains to interpret l in terms of alternative neutrality concepts of productivity.[3]

Hicks-neutral productivity would leave unchanged the relation between the marginal product of labor and the marginal product of capital (the wage-rental ratio) for any given capital-labor ratio. The effect of factor accumulation on output growth would be measured as the growth rate of the capital-labor ratio. Hence Hicks-neutrality amounts to a proportionate increase in K and L at a common rate, m:

$$Y = \left(e^{m}K\right)^{a}\left(e^{m}L\right)^{(1-a)}, \tag{11}$$

which is equal to Equation (10) with $l = m$.

Harrod-neutral productivity would leave unchanged the marginal product of capital (the rental rate of capital) for any given capital-output ratio. The effect of factor accumulation on output would be measured as the growth rate of the capital-output ratio. Hence Harrod-neutrality amounts to a purely labor-augmenting effect of total factor productivity, n:

2. For a recent review, see Barro (1999).

3. On the following, see, e.g., Allen (1967).

$$Y = K^{a}\left(e^{n}L\right)^{(1-a)}, \tag{12}$$

which is equal to Equation (10) with $l = n(1-a)$.

It follows that Hicks-neutral total factor productivity is equal to Harrod-neutral total factor productivity raised to the power of $(1-a)$ for $m = n$. That is, assuming Harrod-neutrality implicitly gives a larger weight to total factor productivity in a decomposition of output than assuming Hicks-neutrality. For instance, if log output equals 1 and Harrod-neutral total factor productivity is found to explain 90 percent of log output, then, all other things equal, Hicks-neutral total factor productivity only explains 60 percent of log output if a = 1/3. Assuming Harrod-neutrality is one of the reasons why recent studies of development accounting (Hall and Jones (1999), Klenow and Rodríguez-Clare (1997)) find a relatively large contribution of total factor productivity.

The motivation for using Harrod-neutrality instead of Hicks-neutrality is based on growth theory. The appropriate identifying productivity assumption must be consistent with two steady-state requirements of the neoclassical growth model. First, since all the variables in the model have to grow at the same rate in the steady state, the capital-output ratio must remain constant along a balanced steady-state growth path. Second, based on empirical evidence, the factor shares of capital and labor must also remain constant in the steady state. Barro and Sala-i-Martin (1995) show that Harrod-neutral total factor productivity change turns out to be the only identifying assumption that is consistent with these conditions of a steady state.

While this assertion is true for a general growth model with no specific restrictions imposed on the production function, it is a well-known fact that it does not hold for a Cobb-Douglas production function. Since the Cobb-Douglas production function implies a unit elasticity of substitution, factor shares remain constant for any capital-labor ratio and for any capital-output ratio. This is why the Cobb-Douglas production function has unequivocal neutrality properties (Hahn and Matthews (1964)) with regard to productivity shifts.[4]

When the production function used in a development or growth accounting exercise is Cobb-Douglas, as happens to be the case in most applied work, neoclassical growth theory does not help to decide whether Hicks- or Harrod-neutrality should be used as the identifying productivity assumption. This insight has long been known, but it seems to have been overlooked in recent contributions on development accounting.

2. The Empirical Contribution of Education

Apart from assuming a special variant of total factor productivity, the empirical contribution of human capital in explaining international differences in output per worker mainly depends on the adequate measurement of international differences in education.

4. Barro and Sala-i-Martin (1995, Appendix to Ch. 1) claim to prove that productivity shifts must be Harrod-neutral in order for the neoclassical model to have a steady state, but their formal proof is in fact a demonstration of the steady-state compatibility of both Harrod- and Hicks-neutral productivity shifts for the Cobb-Douglas case.

Measuring human capital as in Equation (8), Klenow and Rodriguez-Clare (1997) as well as Hall and Jones (1999) found that education only plays a minor role in explaining international differences in output per worker.

However, these studies are not entirely convincing for a number of empirical reasons. First, the empirical rate of return to investment in education to be used in Equation (8) should be based on the so-called full method instead of the Mincer-equation, because otherwise a variable age-earnings profile cannot be taken into account (Psacharopoulos (1994)). Second, what matters for an economy-wide assessment of education are social rates of return instead of private rates. Third, to account for country specific educational differences it may be reasonable to use country specific rates of return instead of international averages. Fourth, and most importantly, the quality of education as measured by student performance at specific grades certainly differs across countries, as highlighted for instance by the results of the recent Third International Mathematics and Science Study (TIMSS (1996)).

To account for international differences in student performance, Equation (8) can be reformulated as

$$H_S(t) = L(t) \cdot e^{r \cdot S \cdot Q}, \tag{8.1}$$

where Q is an index of schooling quality which can be calculated on the basis of international data on cognitive achievement tests as reported by Hanushek and Kim (1995).

To account for the statistical contribution of education, physical capital, and total factor productivity (the residual), a covariance method can be used as proposed by Klenow and Rodriguez-Clare (1997). In order to provide a point of reference, the first line in the upper panel of Table 1 replicates their results, which imply that international differences in human capital only account for about 10 percent of the international differences in output per worker while international differences in total factor productivity account for more than 60 percent.

Table 1 Education in Development Accounting[a]

Technology Assumption	Harrod-neutrality			Hicks-neutrality		
Factor Input	Human Capital	Physical Capital	Residual	Human Capital	Physical Capital	Residual
Full Sample Results[b]						
1. Klenow and Rodriguez-Clare (1997)	0.11	0.23	0.66	-	-	-
2. Hall and Jones (1999)	0.22	0.19	0.59	0.15	0.46	0.39
3. with country specific social rates of return to education	0.20	0.19	0.60	0.14	0.46	0.40
4. with world average social rates of return to education and country specific quality diff.	0.46	0.19	0.35	0.31	0,46	0.23

Table 1 (Continued)

Technology Assumption	Harrod-neutrality			Hicks-neutrality		
Factor Input	Human Capital	Physical Capital	Residual	Human Capital	Physical Capital	Residual
OECD Results[c]						
1. Hall and Jones (1999)	0.44	0.15	0.41	0.29	0.43	0.28
2. with country specific social rates of return to education	0.52	0.15	0.34	0.35	0.43	0.22
3. with world average social rates of return to education and country specific quality diff.	0.98	0.15	0.13	0.66	0.43	0.09

[a] Average fraction of the international variation in output per worker that can be explained by factor inputs or by the residual; in percent (covariance method).

[b] Line 1: 98 countries, 1985 data. Line 2-4: 131 countries, 1990 data.

[c] 23 countries, 1990 data.

Source: Gundlach *et al.* (2000).

The second line in Table 1 shows that the statistical contribution of human capital doubles if the underlying production function is specified as in Hall and Jones (1999) and updated 1990 data are used for a slightly different sample of countries. Assuming Hicks-neutrality somewhat reduces the contribution of total factor productivity, but at the same time the contribution of human capital falls relative to assuming Harrod-neutrality. This outcome simply reflects the underlying specification of the production function. First, under Harrod-neutrality, the statistical contribution of the residual must be larger than under Hicks-neutrality (see Equations (11) and (12)). Second, given the modeling of human capital as directly linked to labor and not as an independent factor of production with a constant (human) capital output ratio, international differences in human capital formation receive a larger weight under Harrod-neutrality than under Hicks-neutrality.

The latter follows because using H as in Equation (8) or (8.1) instead of L in Equation (10), assuming Harrod-neutrality implies that the relative weights of factor inputs and total factor productivity in country i can be estimated in terms of output per worker $y \equiv Y/L$ as

$$y_i = \left(\frac{k_i}{y_i}\right)^{a/(1-a)} h_i A_{i(Harrod)}, \tag{13}$$

with $k \equiv K/L$ as the physical capital-labor ratio, $h \equiv H/L$ as the human capital-labor ratio, and $A_{i(Harrod)} = e^n$. By contrast, assuming Hicks-neutrality implies that

$$y_i = k_i^a h_i^{(1-a)} A_{i(Hicks)}, \tag{14}$$

so it follows that $A_{i(Hicks)} = e^{m} = A_{i(Harrod)}^{(1-a)}$. This shows that in Equation (13), human capital receives a larger weight relative to physical capital in explaining output per worker than in Equation (14).

The third line of Table 1 shows that calculating H with country specific social rates of return to investment in education rather than with international averages for private rates of return as in line 2 does not make a difference for the results, probably because country specific measurement errors by and large cancel out each other at the aggregate level. But including country specific measures of the quality of education as in line 4 of Table 1 suggests that almost 50 percent of the international differences in output per worker can be statistically explained by differences in human capital per worker under the assumption of Harrod-neutrality and about 30 percent can be explained under the assumption of Hicks-neutrality.

These calculations are meant to demonstrate that in the presence of imperfect measures of human capital, results on the macroeconomic role of education tend to be highly sensitive with regard to theoretical technology assumptions, specific modeling approaches, estimation procedures, and sample selection. For instance, it turns out that considering differences in country-specific rates of return does increase the statistical contribution of human capital in explaining differences in output per worker for a sample of OECD countries, where measurement error appears to be a smaller problem and workers can reasonably be assumed to work with the same technology (second panel of Table 1, line 1 vs. line 2). Moreover, considering differences in the quality-adjusted educational attainment of the labor force accounts for almost all of the variation in output per worker across OECD countries if one assumes Harrod-neutrality and to about two thirds if one assumes Hicks-neutrality. In both cases, these results amount to a statistical overexplanation (negative estimate of technological differences) because OECD-differences in the stock of physical capital per worker also contribute to a statistical explanation of differences in output per worker (second panel of Table 1, line 3).

For given differences in physical capital per worker, differences in quality-adjusted measures of human capital as reported in Gundlach *et al.* (2000) are apparently larger than differences in output per worker across OECD countries. These findings demonstrate that at least for this specific sample, considering international differences in rates of return and the quality of education substantially improves the statistical exp lanation of differences in output per worker. Hence recent contributions to development accounting have gone one step too far by overstating the importance of total factor productivity differences in explaining differences in output per worker. The impact of alternative identifying technology assumptions and especially the impact of alternative methods of measuring human capital is potentially large. Since macroeconomic research cannot provide a clear-cut answer regarding the empirical role of human capital up to now, it may be reasonable to look in greater detail into the sector which is supposed to produce a large part of the economy-wide stock of education, namely the schooling sector.

IV. Assessing the Productivity Growth of Schooling

In the average OECD country, the schooling sector accounts for larger fractions of output and employment than many manufacturing industries. Nevertheless, very little is known about the productivity growth of schooling. This lack of information should be a matter of concern because changes in the productivity of schooling may have a large impact on the labor-market performance of low-skilled workers, especially in times of fast technological change.

Schooling, like other services, is most likely to be a sector with stagnant productivity. The proverbial example of a stagnant-productivity service is a haircut, where the consumer is part of the product, the production is labor intensive, and the technology is tried and tested. In a way, schooling seems to share the same features. The combination of these features hinders productivity growth: the resources and the time required to produce a haircut or a unit of schooling output may not have changed that much over time, notwithstanding changes of fashion.

1. Productivity Growth in Schooling: Theory

The cost-disease model suggested by Baumol (1967) was devised to explain the cost problems that will be encountered by any sector with little or zero productivity growth. The model describes an economy with two sectors, one with rising and the other with constant productivity. An application to the schooling sector is straightforward and was already envisaged in the paper by Baumol (1967). To keep the theoretical structure as simple as possible, a constant amount of labor (L) is assumed to be the only factor of production. The two sectors of the model are schooling (S), with constant productivity, and the rest of the economy (R) with exponential productivity growth. Output of the two sectors can be described by two production functions as

$$Y_S = aL_S \quad \text{and} \tag{15}$$

$$Y_R = bL_R e^{rt} , \tag{16}$$

where Y_i is the level of output of sector i in time t (t subscripts are omitted), a and b are constants, L_i is quantity of labor employed in sector i, and r is the exogenous rate of sectoral productivity growth that is assumed to be zero in the case of schooling. Wages per unit of labor (w) in the economy are determined in a competitive labor market and grow according to the sectoral rate of productivity growth:

$$w = ce^{rt} , \tag{17}$$

where c is a constant.

Prices in the two sectors are assumed to be set in competitive markets where price (p) must equal marginal cost. With only one input, marginal cost is defined by the wage divided by the physical marginal product of labor (*mpl*). The physical marginal product is given by the derivative of the production function with respect to labor, hence the relative price of schooling follows as

$$p_S / p_R = (w/mpl_S)/(w/mpl_R) = (b/a)e^{r \cdot t}\ , \qquad (18)$$

which demonstrates that the relative price of the constant-productivity sector rises over time in proportion to the exogenous rate of sectoral productivity growth *r* (Inman (1985)). Thus, whenever the relative price of that sector rises by more than *r*, its productivity must have declined.

To use the model for an empirical analysis of changes in the productivity of schooling, two auxiliary assumptions can be introduced. Assumption 1 is that schooling as well as all other service industries exhibit zero productivity growth. If so, an estimate of productivity growth in the non-service sector establishes a benchmark for the change in the relative price of schooling that would be compatible with an efficient allocation of resources. Assumption 2 is that comparing the change in the price of schooling with changes in the prices of other services allows for an implicit assessment of changes in productivity between schooling and other services. Such a comparison would show how schooling performed relative to, say, government services or community, social, and personal services, which are likely to display stagnant or near-stagnant productivity.

Under assumption 1, the economy-wide growth rate of productivity *g* is given by

$$g = r\frac{Y_R}{Y} + r_S\frac{Y_S}{Y} \text{ and hence} \qquad (19)$$

$$r = g/(Y_R/Y) \qquad (20)$$

if productivity growth in services r_S (including schooling) is zero, with Y_S/Y as the output share of services and Y_R/Y as the output share of the residual non-service sector. With the price level of economy-wide output (GDP) written as

$$p_{GDP} = p_S^{(Y_S/Y)} \cdot p_R^{(Y_R/Y)}\ , \qquad (21)$$

it follows that

$$\Delta p_S - \Delta p_{GDP} = \Delta p_S - \left(\frac{Y_S}{Y}\right)\Delta p_S - \left(\frac{Y_R}{Y}\right)\Delta p_R \text{ and hence} \qquad (22)$$

$$\Delta p_S - \Delta p_R = \frac{\Delta p_S - \Delta p_{GDP}}{Y_R/Y} = r\ , \qquad (23)$$

where Δ indicates an annual rate of change.

Equation (23) clarifies that the true change in the relative price of schooling (and other services) will be underestimated if changes in the nominal price of schooling are simply deflated by a general price index such as the GDP deflator or the CPI deflator (Hanushek and Rivkin (1997)). A GDP-deflated change in the price of schooling has to be divided by the output share of the residual non-service sector of the economy before it can be compared with the rate of productivity growth in the non-service sector.

Alternatively, a GDP-deflated change in the price of schooling could be directly compared with the economy-wide growth rate of productivity, since inserting (20) into (23) gives

$$\Delta p_S - \Delta p_{GDP} = g \ , \qquad (24)$$

which shows that changes in the GDP-deflated price of schooling should equal the growth rate of productivity for an efficient allocation of schooling resources under assumption 1.

Under assumption 2, the model would be applied only to the service sector. In this interpretation, S would indicate schooling as before and R would indicate remaining other service sectors. Except for this change in scope, all equations could be used as before, with g as the weighted growth rate of the productivity of schooling and other services. If productivity is constant for all service industries ($r = 0$), the price of schooling relative to other services should not change over time since Equation (18) would read

$$p_S / p_R = (w / mpl_S)/(w / mpl_R) = (b / a) \ . \qquad (18.1')$$

All results derived so far under assumptions 1 and 2 depend on a fixed relation between schooling output and schooling input. If schooling productivity were not constant but rising, the growth rate of productivity would exceed the increase in the GDP-deflated price of schooling. By contrast, if schooling productivity were declining, the GDP-deflated price of schooling should exceed the economy-wide rate of productivity growth. And if the increase in the relative price of schooling exceeds the increase in the relative price of other services, productivity growth in schooling would lag behind the typically low rate of productivity growth of other service sectors.

2. Productivity Growth in Schooling: Empirical Evidence

The main problem with an empirical estimation of the predicted effects lies with a measurement of schooling output over time. Measurement of output in service sectors is notoriously difficult because observed expenditure figures are difficult to disentangle into price and quality-adjusted quantity components. In this regard, measuring schooling output is easier because there are regular external measures of schooling output such as student achievement tests that do not rely on observed expenditures. However, the available measures of student achievement for selected countries have to be transformed into a common format before they can be compared over time.

Consistent time-series data on the cognitive achievement of pupils in standardized tests are available only for the case of the United States. The National Assessment of Educational Progress (NAEP) began to monitor the performance of pupils aged 9, 13 and 17 years in mathematics and science in the early 1970s. The NAEP has used the same assessment content and the same administration procedures over time, so the reported average test scores of US pupils are intertemporally comparable. The US evidence suggests that there has been no substantial change in the average performance of US pupils in 1980-1994 (Hanushek (1997)).

In addition to the time series US evidence, test scores in various subjects are available for pupils of different age from a number of countries in selected years. However, these studies differ with regard to the inclusion of subtests for pupils at different ages and they also differ with regard to the sample of countries. In addition, direct comparisons of the results of the early 1980s with the results of the mid-1990s are not possible because the design of test questions, the distribution of difficult and easy questions within a test, and the format in which test results are reported has changed. Nevertheless, it is possible to calculate changes in the performance of pupils for each country over time subject to specific assumptions about the mean and the standard deviation of the reported test results because the intertemporally constant performance of US pupils can be used as a benchmark in each case.[5]

Tables 2 and 3 provide results for the calculated *changes* in the performance of pupils from a number of developed and developing countries in natural science and in mathematics relative to the constant performance of US pupils. These changes in performance were calculated under different statistical assumptions about the mean and the standard deviation of the underlying test results in an attempt to account for the heterogeneity of tests. The overall impression from these calculations is that the performance of pupils in other countries than the US has by and large also remained constant because the estimated index for 1994 does not differ substantially from the base index which was set to 100. A possible exception is the Philippines (Table 3), where the drop in the index between 1980 and 1994 is substantial.

Table 2 Changes in the Performance of Pupils in OECD Countries, 1970-1994[a]

	H1		H2		H3	
	Science (1)	Ma&Sc (2)	Science (3)	Ma&Sc (4)	Science (5)	Ma&Sc (6)
Australia	94.3	97.7	94.4	97.8	94.9	98.1
Belgium	95.8	95.3	95.7	95.4	95.5	96.7
France	88.2	93.4	87.9	93.4	86.6	93.6
Germany	96.0	95.2	96.2	95.4	97.8	97.1
Italy	99.7	101.3	99.7	101.3	100.1	101.4
Japan	97.2	98.1	97.3	98.3	97.5	99.3
Netherlands	103.5	101.7	103.7	101.9	105.7	103.5
New Zealand	87.9	90.3	87.8	90.3	87.7	90.5

5. For details of the calculations, see Gundlach *et al.* (2001) and Gundlach and Wößmann (2001).

Table 2 (Continued)

	H1		H2		H3	
	Science (1)	Ma&Sc (2)	Science (3)	Ma&Sc (4)	Science (5)	Ma&Sc (6)
Sweden	104.3	104.3	104.5	104.5	105.9	105.6
United Kingdom	94.3	91.8	94.4	92.1	95.1	93.6
United States	100.0	100.0	100.0	100.0	100.0	100.0

[a] Index based on the performance of pupils in standardized international achievement tests relative to the performance of US pupils; 1970=100; H1-H3 report calculations for different assumptions about the mean and the standard deviation of the achievement test results.

Source: Gundlach *et al.* (2001).

Table 3 Changes in the Performance of Pupils in East Asia, 1980-1994[a]

	H1			H2			H3		
	Science (1)	Math (2)	Average (3)	Science (4)	Math (5)	Average (6)	Science (7)	Math (8)	Average (9)
Hong Kong	92.6	96.0	94.4	92.6	96.7	94.8	94.6	101.5	98.2
Japan	95.5	94.1	94.7	96.0	94.7	95.3	97.5	98.7	98.1
Philippines	78.6	n.a.	78.6	76.8	n.a.	76.8	78.3	n.a.	78.3
Singapore	101.7	n.a.	101.7	101.9	n.a.	101.9	104.5	n.a.	104.5
South Korea	101.9	n.a.	101.9	102.4	n.a.	102.4	102.2	n.a.	102.2
Thailand	88.6	103.1	95.7	88.1	102.8	95.3	90.5	101.0	95.7

[a] Index based on the performance of pupils in standardized international achievement tests relative to the performance of US pupils; 1970=100; H1-H3 report calculations for different assumptions about the mean and the standard deviation of the achievement test results.

Source: Gundlach and Wößmann (1999).

Overall, these findings tends to suggest that existing international differences in the performance pupils did not change by much over the last 20 years or so. But they of course do not mean that that there are no differences in the performance of pupils across countries. For instance, Japanese and Korean pupils scored much higher in mathematics and in science in the recent international achievement test than US or German pupils (TIMSS (1996)). But according to the results presented in Tables 2 and 3 their performance relative to US pupils was by and large constant over time, which means that Japanese and Korean pupils also scored higher than US pupils in the past.

Given that schooling output as measured by the performance of pupils did not change (by much), as was assumed by the model presented in the previous subsection, it remains to be seen whether the actual spending on schooling inputs would be compatible with zero productivity growth. Put differently, the question is whether observed changes in the relative price of schooling are compatible with the model's theoretical base line of zero productivity growth in schooling as discussed in Equation (18).

Since total expenditure equals price times quantity, dividing total current expenditure on primary and secondary education by the number of pupils enrolled equals the nominal price of schooling for a given quality of schooling output. To derive a measure of the change in the relative price of schooling, several deflators can be used. One possibility to assess productivity change in schooling is to compare measures of productivity growth with the GDP-deflated increase in the price of schooling (see Equation (24)), where measures of g can be approximated by measures of total factor productivity (TFP) growth. Using estimates of TFP-growth from a number of different sources that match the relevant time periods as closely as possible, the general finding is that the increase in the GDP-deflated price of schooling exceeds the estimated TFP-growth rates by an order of magnitude in all cases except for the Philippines (Tables 4 and 5, column (5)). Given that schooling output by and large remained constant but fell in the Philippines, this result is inconsistent with an efficient allocation of schooling resources in the countries considered.

Table 4 Schooling Productivity Growth in OECD Countries, 1973-1989

	Δp_S (1)	g (2)	$\Delta p_S - \Delta p_{GDP}$ (3)	$\Delta p_{PGS,CSPS}$ (4)	Change in Schooling Productivity 1 (5)=(2)-(3)	Change in Schooling Productivity 2 (6)=(4)-(1)
Canada	9.2	0.3	3.4	7.6	3.1	1.6
France	12.1	1.4	5.0	7.2	3.6	4.9
Germany	8.1	0.9	4.2	5.0	3.3	3.1
Italy	16.3	0.6	5.0	12.9	4.4	3.4
Japan	9.3	1.1	5.2	6.4	4.1	2.9
United Kingdom	12.5	0.7	3.5	-	2.8	-
United States	7.8	0.3	2.5	6.6	2.2	1.2

Source: Gundlach *et al*. (2001).

Table 5 Schooling Productivity Growth in East Asia, 1980-1994

	Δp_S (1)	g (2)	$\Delta p_S - \Delta p_{GDP}$ (3)	$\Delta p_{PGS,CSPS}$ (4)	Change in Schooling Productivity 1 (5)=(2)-(3)	Change in Schooling Productivity 2 (6)=(4)-(1)
Hong Kong	15.4	1.7	7.1	10.2	5.4	5.2
Japan	6.1	0.9	4.5	3.1	3.6	3.0
Philippines	13.8	0.8	0.8	14.1	1.6	0.3
Singapore	9.2	2.2	6.1	5.0	3.9	4.2
South Korea	18.0	2.3	11.0	10.8	8.7	7.2
Thailand	13.3	2.0	8.8	5.7	6.8	7.6

Source: Gundlach and Wößmann (2001).

A second possibility to assess productivity change in schooling is to compare the increase in the price of schooling with the increase in the price of comparable services. This approach has the advantage that no estimates of total factor productivity growth are needed, which are inherently unreliable (as shown in Section III). The difference between the increase in the price of schooling and the averaged increase in the PGS- and the

CSPS-deflator is shown in column (6) of Tables 4 and 5. Again except for the Philippines, all other countries experienced a substantial rise in the price of schooling relative to the price of other services.

The structure of these results across countries is basically the same under both measures of productivity change in schooling. The figures imply that it does not matter much whether changes in the GDP-deflated price of schooling are compared with the growth rate of TFP or whether changes in the price of schooling are compared with changes in other services prices. On both counts, there is a huge increase in the relative price of schooling which cannot be reconciled with an efficient allocation of schooling resources. Hence schooling productivity seems to have declined substantially in most countries, and in many countries the decline of schooling seems to be much larger than the so-called productivity collapse (Hanushek 1997) of US schools.

V. Where Do We Stand?

The idea that education is one of the crucial determinants of growth and development appears to be almost self-evident. However, there is surprisingly little macroeconomic empirical research which would support this claim. Moreover, most recent studies tend to find that there is no large macroeconomic productivity effect of education.

On balance, up to now the econometric results do not allow for a clear-cut assessment of the macroeconomic role of education in growth. The results that come close to a priori expectations of production elasticities share two properties. First, a specification of the underlying regression equation that is rigorously based on production theory and, second, a functional form of the regression equation that tends to reduce econometric problems. Nevertheless, most findings reported for the production elasticity of human capital tend to be on the low side. Measurement bias is an apparent reason for this result. Development accounting exercises confirm that alternative measures of human capital can produce an astounding range of estimates.

The more or less unconvincing evidence on the macroeconomic productivity of education is somewhat at odds with the strong microeconomic evidence in favor of a positive link from education to income. Griliches (1996) provides the most plausible economic explanation for the missing macroeconomic link from investment in education to growth. He notes that most of the increase in better-educated workers has been absorbed by the government sector, especially in developing countries. The problem is that the government sector, like other sub-sectors of services, belongs to that part of the economy where output is by and large immeasurable. In fact, output growth in the service sectors is often calculated as input growth plus a presumed (low) rate of productivity change.

That does not mean that government workers and other service sector workers do not contribute to overall productivity growth. But it does mean that their true contribution to overall productivity growth is unlikely to be reflected by conventionally measured GDP data, except for their possible second order effects. Second order effects could result from positive spillover effects of better-educated government workers who contribute to a more effective functioning of the economy in many areas. However, second order effects are unlikely to outweigh first order effects.

Another reason for disappointing macroeconomic productivity effects of education could be that the schooling sector is unlikely to allocate resources efficiently. At least over the last 25 years, the productivity of public schooling in several developed and developing countries has declined. The observed productivity decline of schooling seems to result from a government decision to increase the amount of schooling inputs without controlling for improved schooling output. Class sizes have been reduced by increasing the number of teachers employed, but the performance of pupils has largely stayed constant (or even declined). With inefficient spending, lacking macroeconomic effects of a reallocation of resources towards schooling do not come as a surprise.

These findings tend to confirm the positive theory of education expenditure by Pritchett and Filmer (1999), who claim that resource allocation in the education sector does not follow a constrained output-maximizing rule. They develop a behavioral theory of expenditure allocation where educational resource allocation is mainly determined through rent seeking, and not through competitive markets. With regard to educational policies, this theory and the presented international evidence implies that instead of further increasing the level of spending on education, the structure of decision making and the incentives within the education sector have to be changed in order to improve the productivity of schooling.

The most pressing question for further research regards the very existence and the actual size of positive externalities of education, which are emphasized by many new growth theories. The fact that all countries choose to subsidize education seems to support the idea that education does generate positive externalities. But the question remains whether present subsidies to education are too high, too low, or just right. The large microeconometric literature on private and social rates of return to education cannot answer the question how large education externalities actually may be. Macroeconomic research on this issue is just beginning (Heckman and Klenow (1997)). So my best summary is that we do not know as much as we need to know to identify the macroeconomic productivity of education, not to speak of the macroeconomic productivity of the broader concept of human capital. Only within the education sector, the picture appears to be more clear-cut: it seems that allowing for more competition at all levels of education could help to avoid declining productivity of schooling.

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