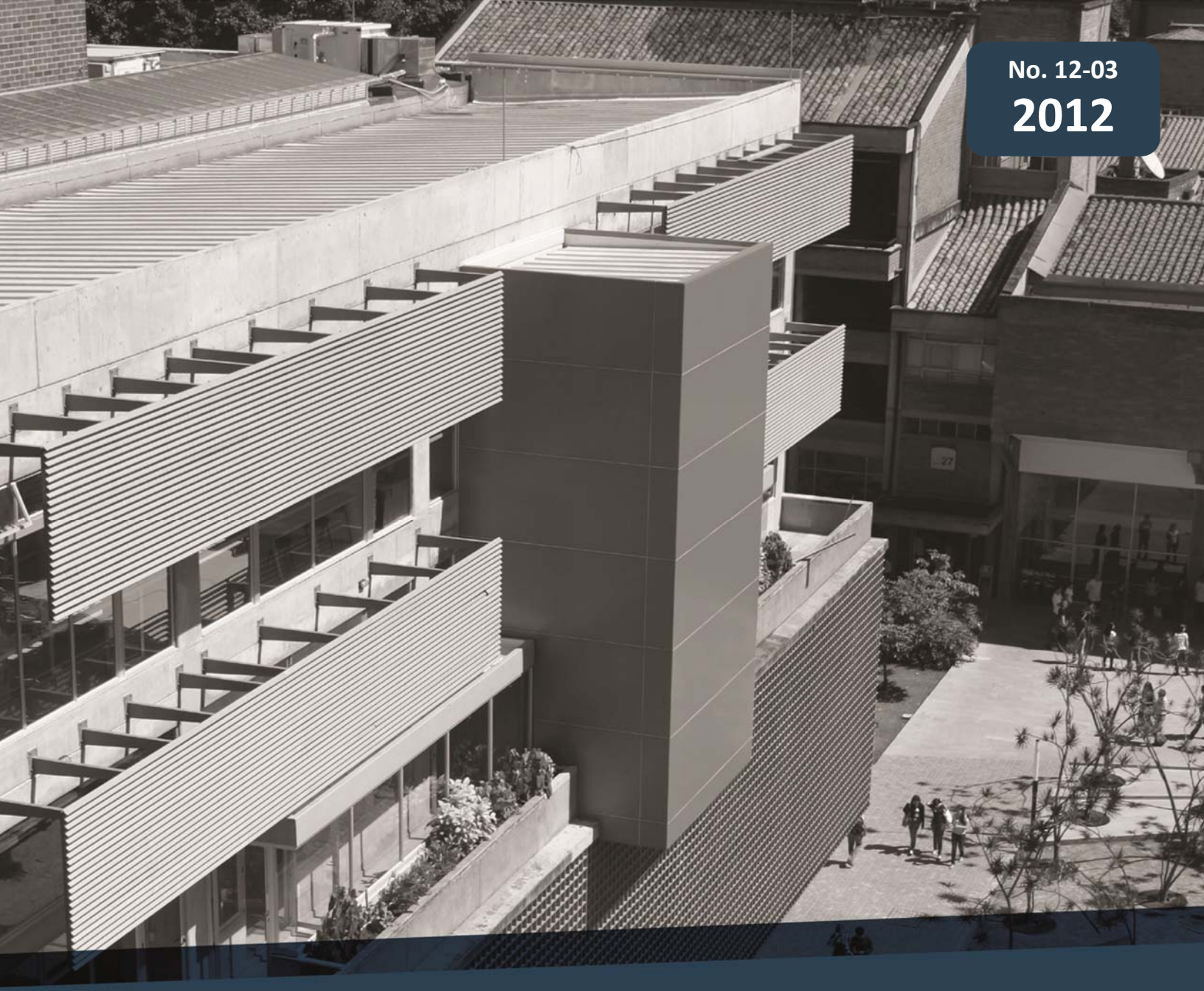


No. 12-03
2012

THE ROLE OF EDUCATION IN ECONOMIC GROWTH: THEORY, HISTORY, AND CURRENT RETURNS

Theodore R. Breton

Documentos de trabajo
Economía y Finanzas
Centro de Investigaciones Económicas y Financieras (CIEF)

UNIVERSIDAD EAFIT
Abierta al mundo

Foto: Juan Carlos Ramírez

The Role of Education in Economic Growth: Theory, History, and Current Returns

Theodore R. Breton

May 12, 2012

Abstract

Evidence is presented that economic development requires both human capital and physical capital and that historically human capital has been the limiting factor in national development. Education has direct and indirect effects on national income. Evidence is presented that the indirect effects are very large and larger than the direct effects in poor countries. The indirect effects are not very large and are smaller than the direct effects in rich countries. Investment in education has diminishing returns. Macro returns exceed 50 percent in poorly-educated countries and 12 percent in highly-educated countries.

Structured Abstract

Background

This paper was prepared to contribute to a special issue on the value of education.

Purpose

The paper examines the role of education in economic development from both a theoretical and a historic perspective, addresses why education has been the limiting factor determining development historically, discusses why certain countries have provided education to the masses and others have not, provides estimates of the quantitative importance of the direct and indirect effects of education on the economy, calculates the marginal macro return on investment for 61 countries, and examines the implications of these results for government policy.

Methodology

The paper presents the results from other studies and estimates the marginal product of education and of physical capital and the relative importance of post-secondary education in 2005 using cross-country estimates of national income and the stocks of human capital and physical capital. The estimates of the stocks of human capital were developed from historic rates of public and private investment in schooling, the cost of capital during schooling, and students' foregone earnings.

Results

The paper presents evidence that education has direct and indirect effects on national output. Educated workers raise national income directly because schooling raises their marginal productivity. The affect national income indirectly by increasing the marginal productivity of physical capital and of other workers. In highly-educated countries the spillover effect on other workers is minimal, but the effect on physical capital productivity is important. In less-educated countries the spillover effect on the productivity of other workers appears to be much larger. In all countries the positive effect of rising human capital on the productivity of physical capital is required to offset the diminishing returns to investment in physical capital and make rising investment in physical capital financially viable in the development process.

The empirical results indicate that investment in schooling is subject to diminishing returns, but that the macro marginal return is still considerable in highly-educated countries, over 12 percent in 2005. In less-educated countries the marginal macro returns are much

larger, in excess of 50 percent, but since most of this return is indirect, the magnitude of the marginal returns to education is not generally appreciated. The results also indicate that investment in post-secondary education does not provide any additional effect on national income beyond the effect of investment in education generally.

Conclusions

These very high macro marginal returns to education make it possible for poor countries to grow very rapidly if they make a major public commitment to raising the average level of schooling of the masses

.

I. Introduction

Economic development, defined here as the increase in national production of goods and services, is a complex process, and economists have had a difficult time identifying the factors that determine whether and how it occurs. At its core the process is one in which capital and labor are combined in ever more sophisticated and productive ways, but it has not been clear why certain countries advance in this process much more rapidly than others.

In *The Wealth of Nations*, Adam Smith [1776] identified "the acquired and useful abilities of all the inhabitants or members of the society," or what is now called "human capital," as one of the four types of fixed capital that contribute to production in a national economy.[1] But subsequently when factories replaced skilled artisans as the principal means of production, economists concentrated on the role of physical capital in development and forgot about human capital. In the 1920s Cobb and Douglas [1928] observed that economic growth in the U.S. could be explained by the growth of physical capital and labor and a productivity trend. So when National Accounts were created in the 1930s, the capital account included only physical capital.

After World War II the International Bank for Reconstruction and Development (IBRD) was created to facilitate the financing of physical capital projects in countries damaged by the war and in poor countries. At the time economists believed that countries were poor because they lacked physical capital. The presumption was that due to adverse institutional characteristics, private individuals in poor countries either did not have the wherewithal or lacked the confidence to invest in capital projects. The IBRD proceeded to provide financing for physical capital projects, but many of these projects were unsuccessful.

Some economists began to wonder if poor countries might be poor because they lacked human capital. Schultz [1961] observed that rich countries devastated in World War II were able to quickly employ massive amounts of new physical capital, while the poorest countries seemed unable to successfully utilize even small amounts. He theorized that a nation's capability to productively use physical capital is a function of its level of human capital and that if its human capital does not increase in conjunction with its physical capital, then it becomes the factor limiting economic development. Shultz further observed that human capital is more likely to be the factor constraining development because foreign investors are eager to invest in physical capital, but not in human capital.

[1] Smith, Adam, 1976 (1776), University of Chicago Press, p. 298

Economists now accept that investment in education, or human capital, is an important element in the economic development process. Econometric studies provide very strong and consistent evidence that more educated workers are more productive and that they earn higher salaries [Psacharopoulos and Patrinos, 2004]. These results support Adam Smith's view that acquired abilities are a form of capital.

There also is no doubt that average levels of education and national income rise simultaneously. But doubts remain as to whether they rise together because education drives development, or rather because people demand more education as they acquire more income. And some economists continue to question whether the very large effects of education on GDP found in some studies indicate that education has large indirect effects or that other factors affecting GDP were not included.

In the U.N.'s [2009] *System of National Accounts 2008* (SNA), education is identified as an asset in the broad sense of the term, but not as a fixed asset because it transfers rather than creates knowledge. Based on this logic the SNA classifies schooling as the consumption of education services, not as investment in human capital.

So the dilemma for public policy is clear. If education is primarily consumption, then public funds for education should be cut in difficult times. But if it is primarily investment, then any cuts could have serious future repercussions. And if it is THE primary determinant of economic development, then in poor countries particularly, expenditures on education should be increased even in difficult times.

In this paper I elaborate on Schultz's theory that education plays a large and critical role in the economic development process and that it most likely is the limiting factor in this process. I present evidence that supports this theory and I offer an explanation for why historically certain nations provided education to the masses much sooner than others. Subsequently I present the empirical results from a model of the direct and indirect effects of education on GDP that is consistent with Schultz's theories, and I show the quantitative importance of these different effects in rich and poor countries. I then use the estimated parameters from this model to estimate the marginal product of schooling in 61 countries in 2005 and investigate whether investment in post-secondary education has a larger effect on national income than investment in lower levels of schooling. Finally, I discuss the policy implications of these results.

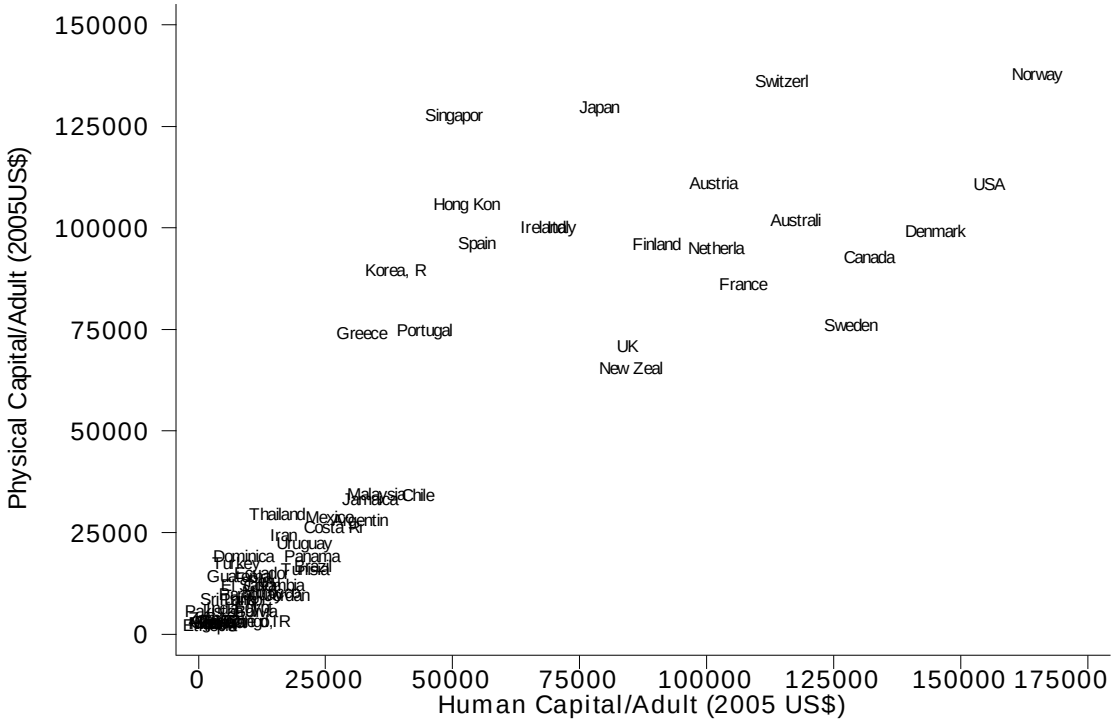
II. Evidence for Schultz's Theory of Economic Development

Figure 1 shows the stocks of human capital and physical capital in 2005 for 61 countries that historically had market economies and did not rely primarily on resource extraction to create income. I estimated these stocks using the standard OECD [2001] methodology, which

estimates each nation's cumulative investment in each type of capital and then depreciates this investment over its expected life.[2] In the case of human capital, the investment includes public and private expenditures on formal schooling, the implicit financing costs during students' schooling, and students' foregone earnings. As shown in the figure, the differences between rich and poor countries are enormous. Capital/adult differs by a factor of up to 100.

Figure 1

Stocks of Human Capital and Physical Capital in 2005



The observed relationship between the two capital stocks is consistent with Schultz's theory that human capital and physical capital are complementary. There is some variation in the relative amounts of the two types of capital, but no countries have high levels of only one type. For example, the U.S. has more human than physical capital, while Japan has more

[2] For physical capital the investment is for the period 1965 to 2004, while for the human capital the investment is for 1965 to 2000. Physical capital has an assumed geometric depreciation rate of 6 percent. Human capital has an assumed linear depreciation rate of 2.5%. Both stocks are calculated using economic data from Penn World Table (PWT) 6.3 [Heston, Summers, and Aten, 2009]. The methodology for the calculation of the human capital stock is presented in Breton [2012].

physical than human capital, but both countries have high levels of both. The correlation coefficient between the two kinds of capital in this data set is 0.87.

These data show that economic development does not occur automatically. If it did, there would not be such large differences in the magnitude of the capital stocks between countries. Clearly some characteristic(s) of the more developed countries, not present in the less developed countries, facilitated historic investment in both types of capital. It is also evident that whatever these characteristics are, they vary widely across countries because levels of capital/adult vary widely. If human capital and physical capital are complementary, then historically either type of capital or both could have been the factor limiting investment in the other type of capital.

All of the countries in Figure 1 historically have had a market economy, and national statistics show that investment has been flowing between these countries for some time [Obstfeld and Taylor, 2004]. So it is not *a priori* evident that a shortage of financial capital has limited economic development. Caselli and Feyrer [2007] show that the marginal product of reproducible physical capital in 1996 was very similar in 43 developed and undeveloped countries. Implicitly local and global private investors have provided financing for those capital projects that had attractive returns, so any recent failure to develop apparently has not been due to any shortage of financial capital.

But as Shultz [1961] observed years ago, there is no evidence that local and global investors provided financing for human capital in these countries. So even though human capital and physical capital appear to be similar in their effect on economic output, they apparently are not similar from a private investment standpoint. Why not?

These types of capital may appear similar to economists, but for accountants they are very different. In a poor country human capital is created by investing in the education of a child, which is very different from investing in a factory. The factory is a transferable fixed asset, and education is not. Centuries ago, private investors could and occasionally did invest in children's education, with a contractual guarantee of repayment through the indentured servitude of the child [Clark, 1977]. Today such arrangements typically are illegal, and without them the private financing of a poor child's education is not feasible.

Even if private financing were feasible, in a poor country the parents' incentives to finance their child's schooling are weak or even negative for several reasons. First, if the child is working, enrollment of the child in school immediately reduces the parents' income. Second, the period over which the parents would have to continually borrow is quite long, and the period they would have to carry the loan before it could be paid off would be considerably longer. Such long loan periods substantially increase the financing risk and cost. Third, if the

investment pays off in higher income for the child, the parents may not benefit, since they would have no legal right to this income after the child reaches maturity.

Precisely because the parents have no right to the future income from the investment in the child's schooling, they cannot collateralize the investment, so they would have to pay a very high rate of interest for a high-risk loan. For this reason Mincer [1984] argues that historically only the children of the rich have been educated in response to market forces.

III. History of Mass Schooling and Economic Development

So how have some countries managed to create a highly-educated population? Easterlin [1981] observes that historically the schooling of the masses has occurred only when ideological or political forces made it a priority.

The Jews appear to have been the first people to commit to mass schooling. After the destruction of the Temple in Jerusalem in 70 CE, religious leaders required every Jewish family to educate their male offspring to enable them to study the Torah. Botticini and Eckstein [2007] argue that this religious obligation created the first educated community, but the members of this community had to disperse to put their education to economic use. The Jews became a wealthy people, but no single country developed as a result.

The first national commitment to the schooling of the masses appears to have occurred in the Protestant Reformation in the 16th century. The leaders of the Protestant sects in northern Europe promoted literacy to enable their members to read the Bible and learn religious catechism. This religious obligation launched the first significant efforts to create schools for the poor [Bowen, 1981].

Numerous reports document the increase in literacy that accompanied the Protestant Reformation [Cipolla, 1969]. Competition between Protestant and Catholic religious groups to attract believers further spurred the provision of free or subsidized schooling for the poor in regions where both groups were active [Houston, 1988]. For the next three centuries literacy increased steadily in Europe, largely through the use of religious catechisms. By 1700 35-40 percent of the population in Protestant Europe could read, while in Southern Catholic Europe less than 20 percent were literate [Johannson, 1977].

During the course of the 19th century, nation-building became the dominant political ideology in Europe, and as part of this process the state increasingly imposed obligatory public schooling on the masses [Ramirez and Boli, 1987]. In the struggle over control of the educational system, Pope Pius IX issued an encyclical in 1864 in which he forbade Catholics from accepting civil education [Johnson, 1976].

The Catholic Church's opposition to public schooling slowed the provision of schooling to the poor in southern Catholic Europe and in the Iberian colonies. As national levels of education increased from 1850 to 1940, northern Protestant Europe maintained their historic advantage relative to southern Catholic Europe, with particularly large differences relative to Spain and Portugal [Benavot and Riddle, 1988]. In 1940 primary school enrollment ratios were about 70 percent in northern Europe and its settlements, 60 percent in Italy, and 35 percent in Iberia and its settlements.

No comparable commitment to mass schooling occurred outside of Europe and some of its settlements until much later [Craig, 1981]. Japan is the principal exception, in that it had levels of primary enrollment in 1870 that were comparable to those in southern Europe [Benavot and Riddle, 1988]. Subsequently, in the 20th century the European model of a national society, including state funding for mass schooling, spread throughout the world [Ramirez and Boli, 1987]. A review of the historical record shows that nations' cultural and political propensities to accept missionary schooling or to provide their own charitable or state funds for mass schooling have determined their average level of human capital today.

According to Schultz's theory, beginning in the 16th century as the stock of human capital increased in response to ideological and political developments, expected returns on investment in physical capital increased, and rising investment increased the stock of physical capital. As the stocks of human and physical capital increased, national income rose.

Anecdotal data suggest that economic development has been linked to literacy and schooling since the 16th century, but comprehensive data on national levels of education are only available for a subset of the more educated countries since the mid-19th century. Figure 2 shows the relationship between the average schooling attainment of the population age 15 to 64 and national income for 43 countries in 1910 and in 2000.[3] In 1910 the highest average level of schooling in any of these countries was less than eight years. In 2000 the highest average level of schooling had increased to 13 years. The trend lines in 1910 and 2000 show that over this period the relationship between average schooling and GDP/capita did not change for countries with average schooling levels below five years. At higher levels of schooling the associated level of GDP/capita increased substantially over this period.

[3] The schooling data are from Morrisson and Murtin [2009]. The GDP/capita data are from Maddisson [2003], but the units were converted from 1996 US$ to 2005$ using data from PWT 6.3.

Figure 2

Average Schooling and GDP/capita in 1910 and 2000

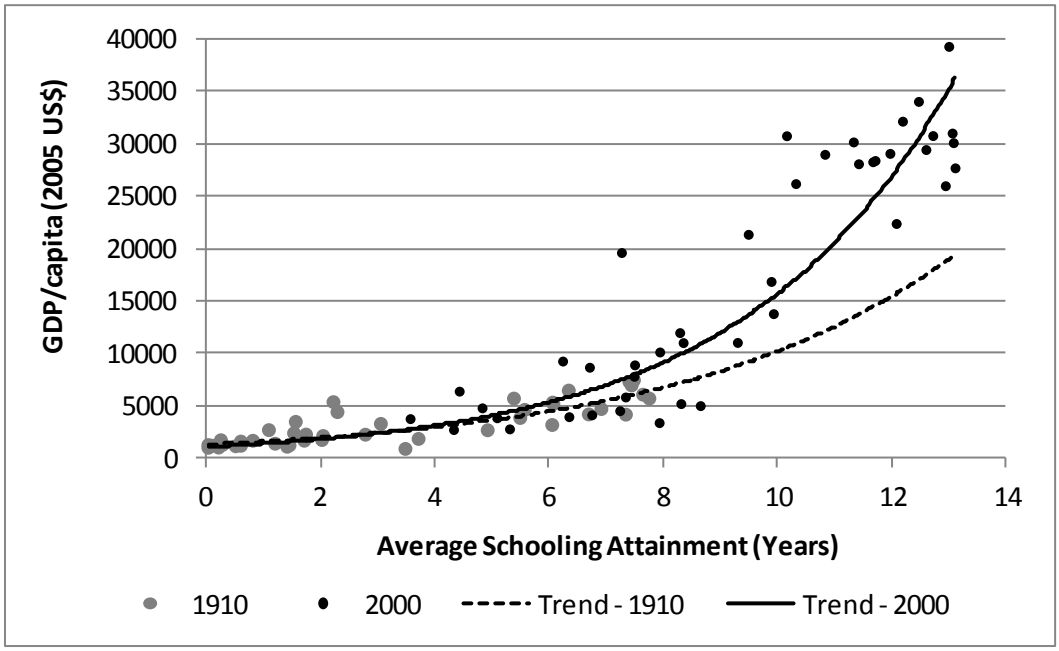


Figure 3 shows the relationship between human capital/adult and GDP/adult in 2005, using the same human capital data shown in Figure 1.[4] The strong relationship between these variables is evident. The higher levels of human capital in countries with greater Protestant affiliation is also evident.

IV. Methodology for Estimating the Returns to Education

If Schultz's theory that human capital and physical capital are complementary is correct, then education has both direct and indirect effects on national income, and an estimate of the returns to investment in education should take both into account. The standard methodologies widely used to estimate the returns to education include only the direct effect on workers' salaries. Estimation of the larger returns to the nation requires a model of the effect of education on national income that includes the direct and the indirect effects.

Mankiw, Romer, and Weil [1992] created a model of national income (Y) that is consistent with Schultz's theory of capital-skill complementarity. This model includes three factors of production, human capital (H), physical capital (K), and labor (L):

[4] The data for GDP/adult are from PWT 6.3, but they include my estimate of students' foregone earnings.

(1) $Y = K^{\alpha} H^{\beta} L^{1-\alpha-\beta}$

The model is a Cobb-Douglas production function, similar to the one Cobb and Douglas created in the 1920s, but with an additional factor for human capital. This model intrinsically includes a direct and two indirect effects for each factor of production [Breton, 2012]. In the case of human capital, it has a direct effect on the salary received by the educated worker and indirect effects on the productivity of physical capital and on the productivity of other workers (labor).

Figure 3

Human Capital/Adult and GDP/Adult in 2005

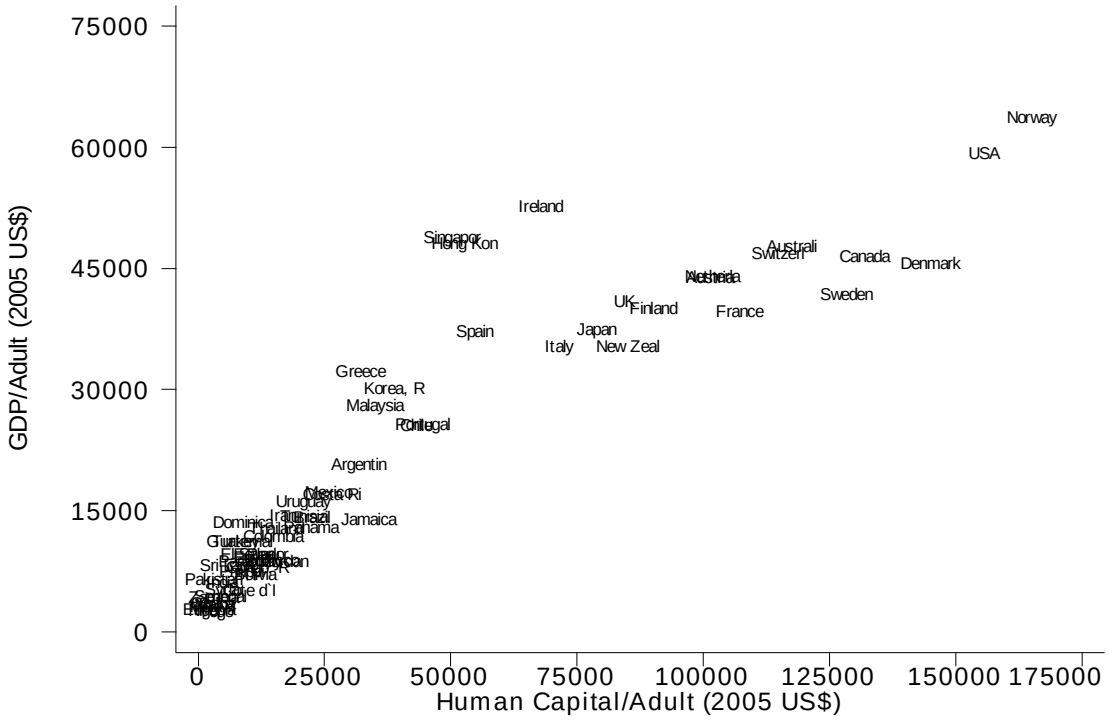
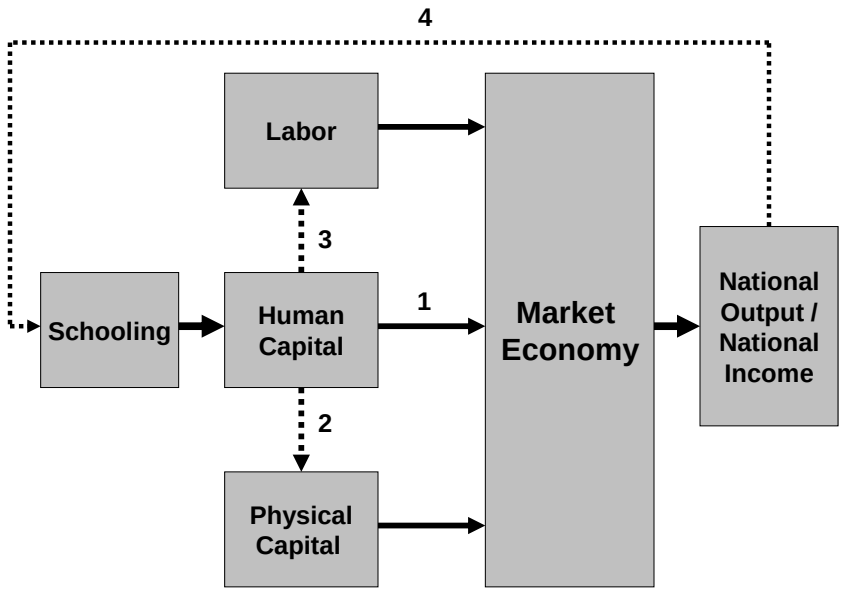


Figure 4 shows the dynamics of this model in response to an increase in schooling. The increase in schooling increases the nation's human capital. Human capital then has a direct effect on national income (the solid line) and indirect effects on the productivity of the other two factors (the dotted lines). The figure also shows a third indirect effect (labeled "4"), which is the positive feedback that rising income has on the society's demand for education.

Figure 4: Effect of Schooling on National Income in a Market Economy



When connected to the global financial capital market, this model simulates the effect on physical capital that follows a national decision to increase the level of schooling. After a lag the increase in schooling increases the stock of human capital in the work force, which raises the marginal productivity of physical capital and the expected return on investment. Private investors then increase their investment in physical capital, which has a direct effect on national income and an indirect effect on the productivity of human capital and labor. As these various effects work their way through the economy, economic output rises and national income increases along with it.

Conveniently, the marginal product of human capital in this model (i.e., the increase in national income associated with an increase in human capital) provides an estimate of the full macro marginal return on investment in schooling, including the direct and the two indirect effects:

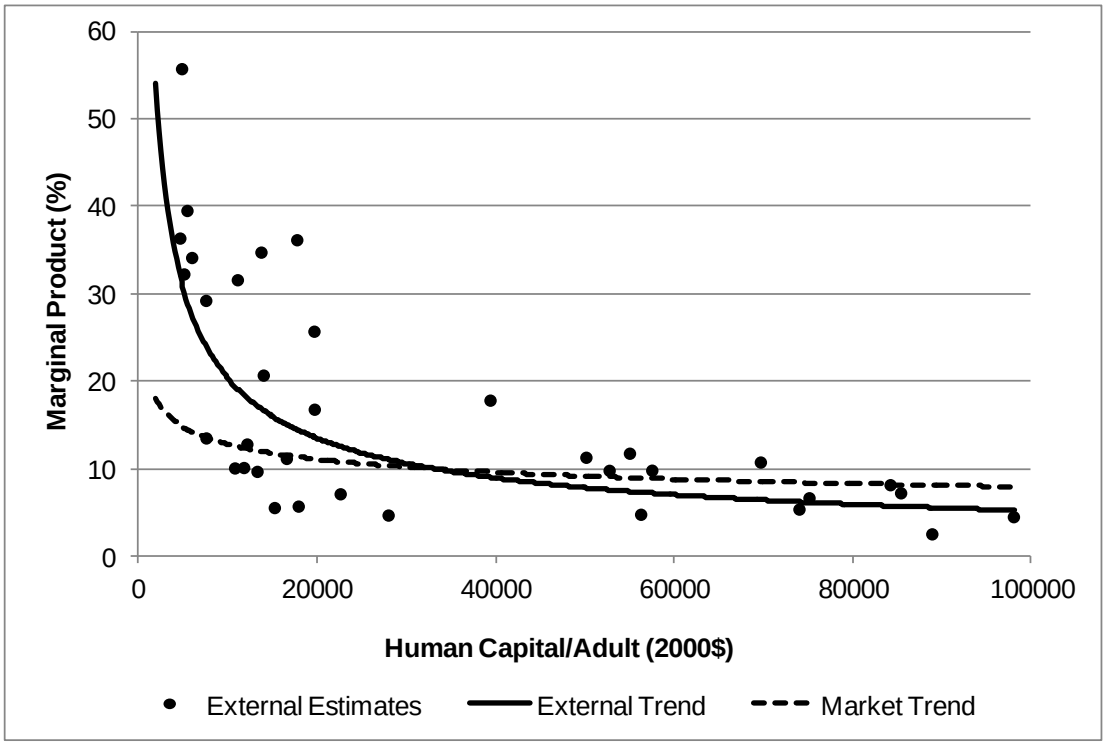
(2) $MPH = \delta Y/\delta H = \beta Y/H$

Given an estimate of β for the model in equation (1) and estimates of GDP/adult and human capital/adult, the marginal return on investment in schooling can be estimated for any country. In addition, when combined with an estimate of α and information on the direct marginal effect of education on salaries from micro studies, the two indirect effects of human capital can be estimated [Breton, 2012].

V. Estimates of Macro Returns to Education

Breton [2012] shows that this model provides estimates of the macro effect of schooling on income that are consistent with micro studies of the direct effect of schooling on workers' salaries in 36 countries. The trends in these direct and indirect (external) effects are shown in Figure 5. They show that in 1990 the marginal product of schooling estimated in workers' earnings studies varied from 8 percent in the most educated countries to 13 percent in the least educated countries. The external marginal product varied from 6 percent in the most educated countries to 40 percent in the least educated countries. These results indicate that the indirect effects of education are less than the direct effects in highly-educated countries, but they are much larger than the direct effects in countries with low average levels of education. The combined direct and indirect return to education in the countries with the lowest educational levels was over 50 percent.

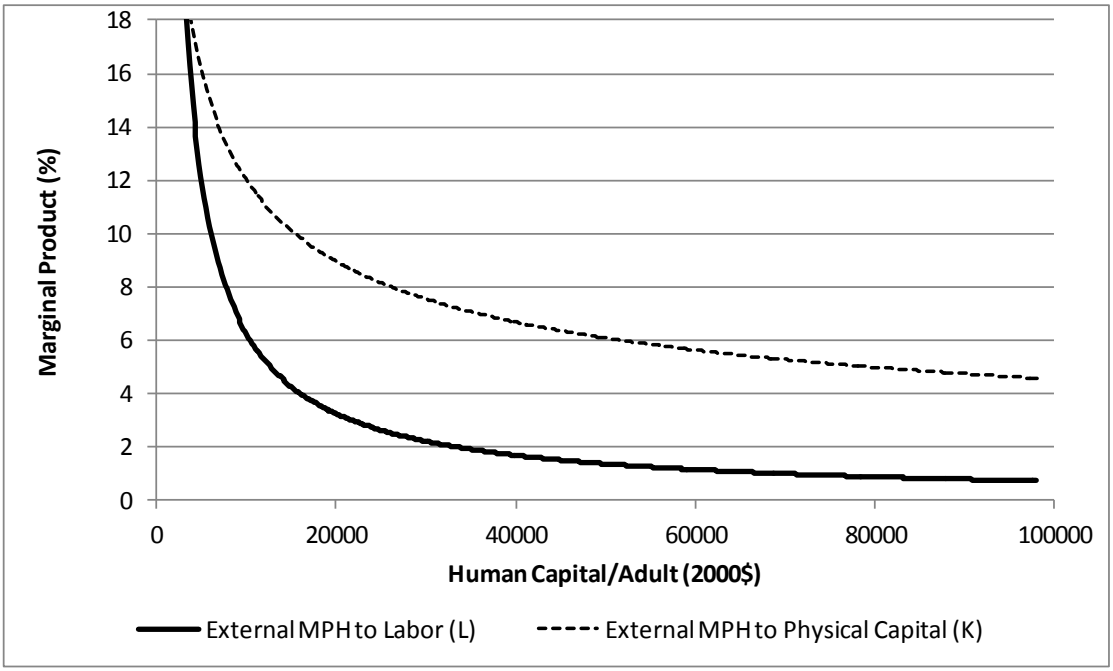
Figure 5: Direct (Market) and External Returns to Education in 1990



The estimates of the total external benefits of schooling in Figure 5 can be allocated to physical capital and labor using the data provided in Breton's [2012] study. This allocation is shown in Figure 6. The implication is that the spillover effect of a more educated individual on

the productivity of others in a highly-educated work force is very small, but it is considerably larger in countries where the work force is less educated. These results are consistent with the few micro studies that estimate the external effect of more educated workers on the wages of other workers in countries with different average levels of schooling [Breton, 2012].

Figure 6: External Returns to Education in 1990



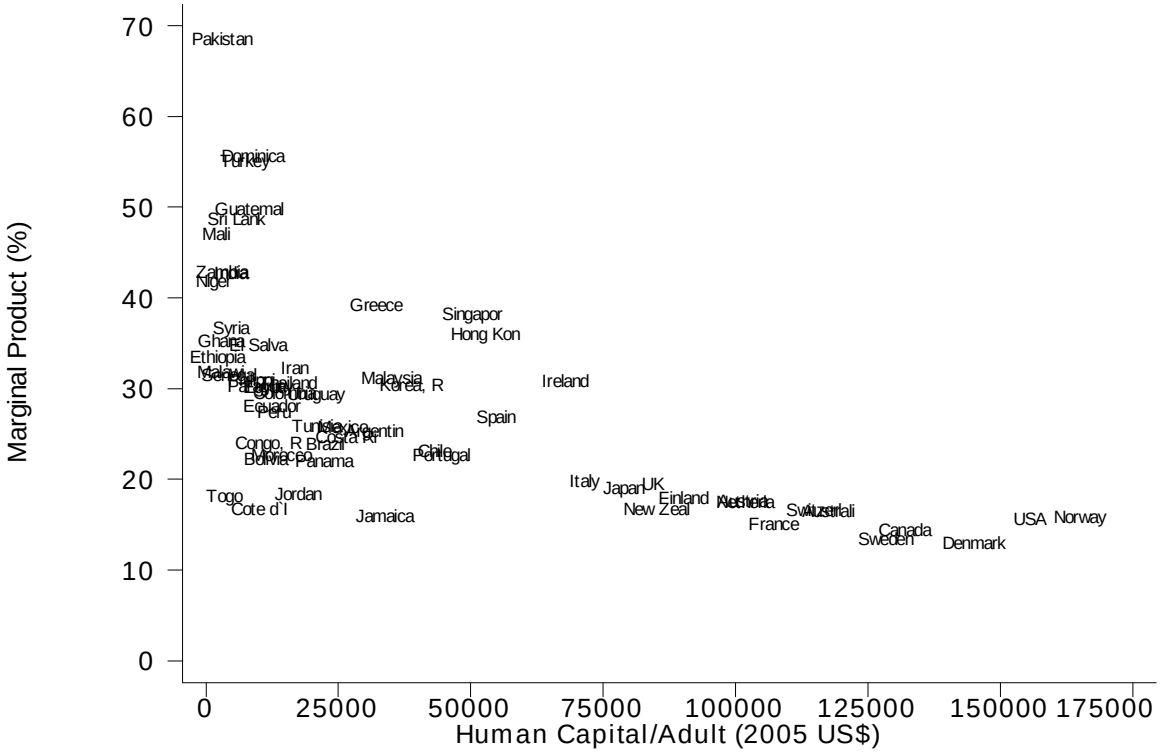
The estimates in Figure 6 indicate that the marginal external effect of human capital on the productivity of physical capital is substantial in highly-educated countries, but it diminishes noticeably as the level of human capital rises. The diminishing return evident in all of these marginal products indicates that it will be increasingly difficult for highly educated countries to increase national income by investing more resources in schooling.

Most countries have substantially increased their level of human capital since 1990, and in this model these increases reduce the marginal return to investment in education. Figure 7 shows the total macro returns in 2005, which are analogous to the sum of the direct and the external returns shown in Figure 5. In this set of estimates, Denmark has the lowest marginal product, which is 12.2 percent. This return compares to Denmark's estimated marginal product of 13.5 percent in 1990 [Breton, 2012].

VI. Relative Macro Returns at Different Schooling Levels

These estimates measure marginal returns to investment in education in the aggregate, but not for different levels of schooling. In highly educated countries primary and secondary schooling is virtually universal, so incremental investment is more likely to occur at the post-secondary level. But it also could be increased at lower levels of schooling in an attempt to raise the quality of schooling.

Figure 7: Marginal Product of Human Capital (Macro) in 2005



In countries with low average levels of education, schooling is not universal at the primary level and is infrequent at the secondary level. Governments must make choices with respect to funding priorities. Should incremental funds go to expanding university opportunities, or to improving either coverage or quality at lower levels of schooling? This is a complex issue, which has serious implications for income inequality, social mobility, and political stability.

Numerous studies have focused on the direct returns to investment in education at different levels of schooling. Older studies have found that the direct returns to education are

higher at lower levels of schooling [Psacharopoulos and Patrinos, 2004]. Recent studies provide data showing that the salary premium for post-secondary education has been rising since 1997 in real terms in most OECD countries [Psacharopoulos, 2009]. These data may indicate that direct returns have risen for post-secondary education compared to lower levels of schooling.

Estimates of returns based on workers' salaries ignore the external effects of schooling, which according to Figure 5, are very large in poor countries. Implicitly these very large external returns are associated with increases in schooling at lower levels since this is where most schooling occurred in these countries prior to 1990. Macro returns may be larger for investment at lower levels of schooling even if the direct returns are larger for post-secondary schooling.

I examine this issue by estimating the effect of the share of the population with some post-secondary schooling on national income in 48 countries, controlling for the level of human capital/adult in 2005. I exclude the sub-Saharan African countries in this analysis, since they have virtually no post-secondary schooling. Although the post-secondary share and the level of human capital/adult are positively correlated in these countries ($\rho = 0.60$), the post-secondary share varies substantially in countries with similar levels of human capital/adult. Figure 8 shows these data.

The share of the population with post-secondary education is from a data set for the population over 25, which is documented in Cohen and Soto [2007]. These data are not ideal since the population includes adults over 65. I use the estimate in 2010 to represent the share of the working population (over 20) with post-secondary education in 2005.

I estimate two permutations of the Mankiw, Romer, and Weil model in log form:

(3) $\log(Y/L) = c + \alpha \log(K/L) + \beta \log(H/L)$

(4) $\log(Y/L) = c + (\alpha/1-\alpha-\beta) \log(K/Y) + (\beta/1-\alpha-\beta) \log(H/Y)$

I estimate the model in 2005 with and without physical capital because the complementary nature of the two forms of capital implicitly makes physical capital an endogenous variable that is affected by the level of human capital.

The bidirectional causality between schooling and income could bias OLS estimates of the effect of these variables on national income, so I use the Protestant share of the population in 1980 from Barrett [1982] as an instrument for the education variables. Breton [2012] uses this instrument and provides a detailed rationale for its validity. As described earlier, there is

considerable evidence that Protestant affiliation has an exogenous effect on a nation's willingness to support schooling for the masses.

Figure 8

Population Share with Post-Secondary Education vs. Human Capital/Adult in 2005

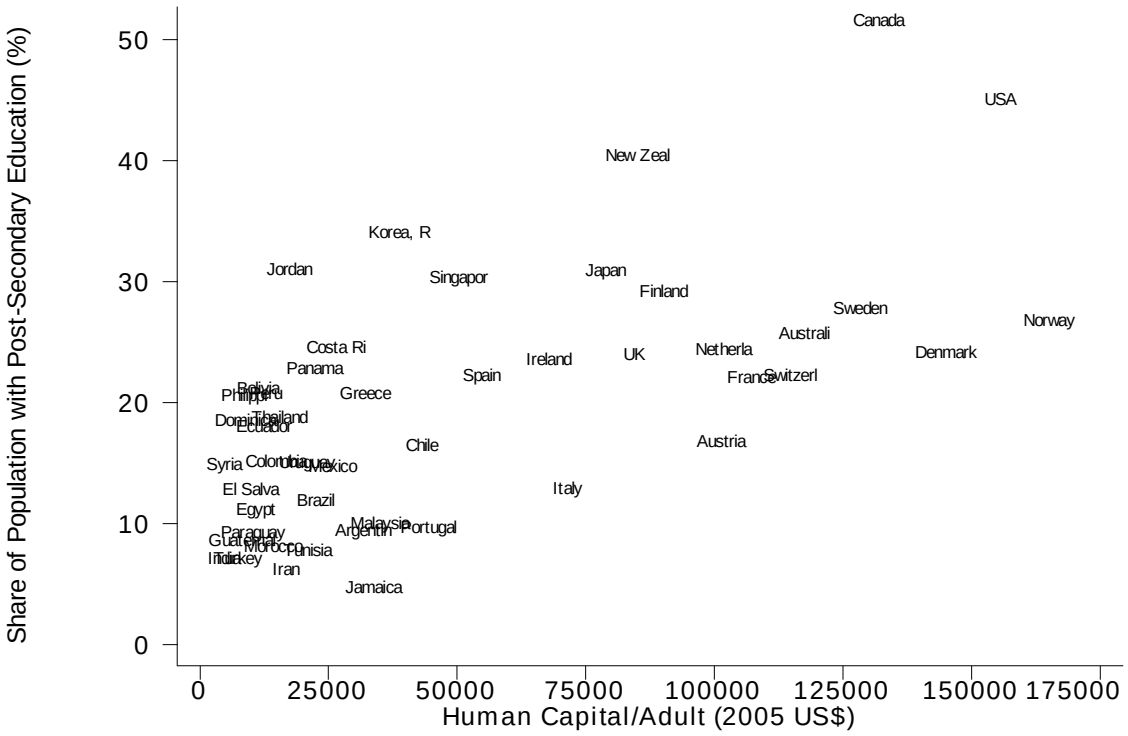


Table 1 presents the results. Column 1 shows the OLS statistical results for the model in equation (3) with human capital/adult alone, which explains 90% of the variation in log (Y/adult). Column 2 shows that when the post-secondary share is added, it has no effect on national income. This test could be unfair because the human capital variable is estimated using education's historic shares of national income, which are highly correlated with current income.

Columns 3 and 4 show the same results for the model in equation (4) that uses log(H/Y) as the dependent variable. In this model (column 4) the post-secondary share has a highly statistically-significant, positive effect on national income. But the estimated coefficients in these models may be biased because while education affects national income, national income also affects a nation's level of education.

Table 1
Effect of Human Capital and Post-Secondary Schooling on National Income
Dependent variable is log(national income/adult)

	1	2	3	4	5	6	7	8
	OLS	**OLS**	**OLS**	**OLS**	**2SLS**	**2SLS**	**2SLS**	**2SLS**
Log (H/adult)	0.69* (.03)	0.71* (.04)						
Log(H/Y)			1.09* (.18)	0.75* (.24)	1.63* (.30)	1.50 (.70)	0.94* (.30)	0.88 (.48)
Post-Secondary Share		-0.11 (.45)		2.77* (.84)		0.80 (3.74)		0.52 (2.18)
Log(K/Y)							0.98* (.18)	0.98* (.17)
R^2	.90	.91	.33	.43	.25	.31	.66	.69

Note: Robust standard errors in parentheses
*Significant at one percent level

Columns 5 and 6 show the results for the same model using the Protestant share of the population in 1980 and the log of this share as instruments for the education variables.[5] With these instruments the effect of human capital/adult is larger and the effect of the post-secondary share is smaller and not statistically significant. Although not shown, the results are similar if the sample is limited to the more educated countries. Columns 7 and 8 show the 2SLS results when physical capital is included in the model. Again the estimated coefficient on the post-secondary share is small and not statistically significant.

The implication of the different outcomes using OLS and 2SLS estimates is that a nation's cumulative investment in education raises national income and this increase in income raises the demand for post-secondary education. The small, statistically-insignificant coefficient on the post-secondary share indicates that post-secondary investment has no incremental effect on national income beyond the effect from investment in education generally. Implicitly there is no loss in national income if the government chooses to extend

[5] The first stage regressions are: $\underset{(.15)}{\text{Log(H/Y)} = 0.56^*} + \underset{(.03)}{0.05 \log(\text{ProtSh})} + \underset{(.24)}{0.65^* \text{ ProtSh}} \quad R^2 = .38$

$\underset{(.04)\ (.007)\ (.05)}{\text{PostSecSh} = 0.28^* + 0.023^* \log(\text{ProtSh}) - 0.01\text{ProtSh})} \quad R^2 = .27$

primary and secondary schooling to more of the population instead of increasing post-secondary schooling for those that already have secondary schooling.

VII. Implications for Public Policy

The empirical evidence indicates that the macro marginal returns to investment in education are very large in countries with less-educated populations but are much lower in countries with highly-educated populations. What are the implications of this evidence for government policy related to public the funding of education?

Given the obstacles to private financing at the primary and secondary levels of schooling, state support at these levels need to be very substantial to achieve an optimal level of national education. All countries with high levels of human capital provide free, obligatory public schooling or public funds for private schooling through the secondary level. The evidence indicates that if poor countries wish to develop, they also must provide this financial support for primary and secondary schooling.

At the post-secondary level the optimal level of state support is less obvious because this education can be privately financed to some degree. In countries with low average levels of education, the external benefits of incremental schooling are so great that government support for post-secondary education is justified. However, in the event that public funds are limited, the empirical results indicate that these funds are best spent providing primary and secondary education for all. Once students have achieved this level of schooling, those that wish to continue their education may be able to privately finance these studies. In contrast, if government support is not forthcoming at lower levels of schooling, it is unlikely that poor students will continue in school.

Some highly-educated countries currently provide very substantial subsidies for post-secondary education. Given the diminishing returns from investment in human capital, are these subsidies too extensive? Should governments reduce these subsidies and require students to finance a larger share of their education themselves?

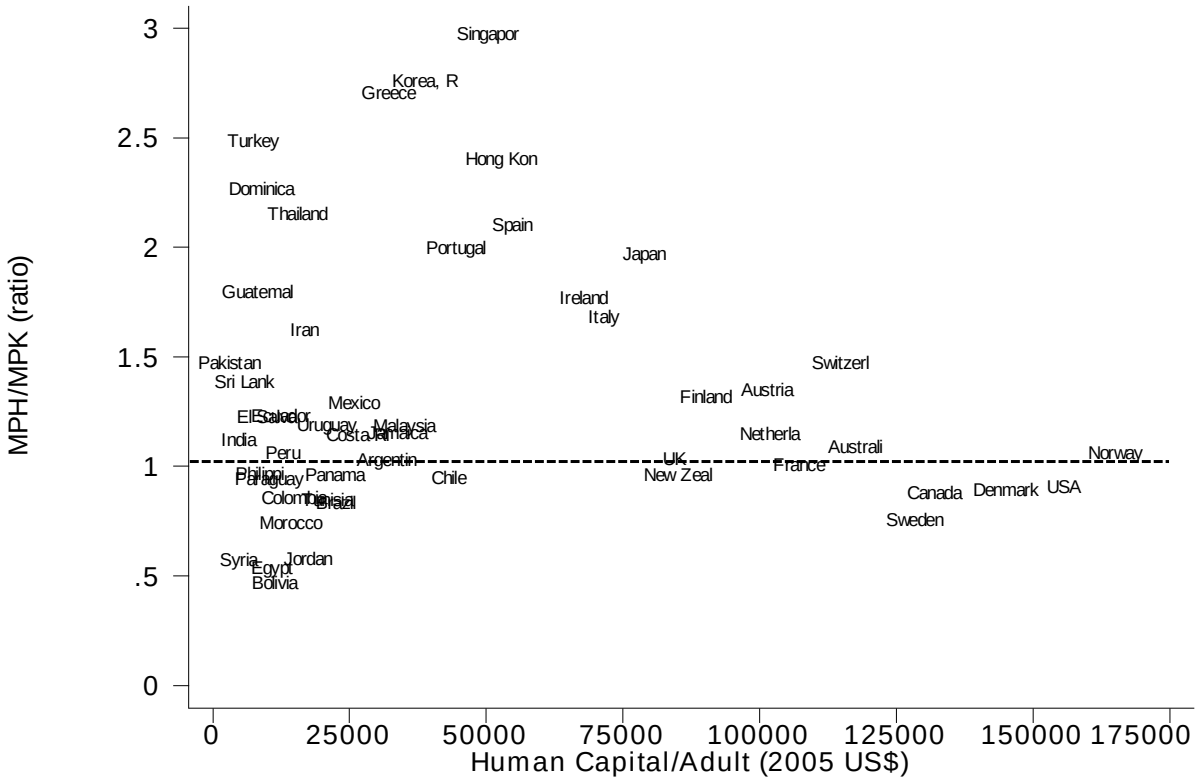
At the macro level this question has two aspects. The first is whether the relative subsidies (or taxes) for human capital and physical capital are optimal. Both types of capital are required for income growth, and the rate of growth will be suboptimal if government policies result in very different marginal returns for the two types of capital. The second question is, how low does the macro marginal return have to fall before government support is no longer justified?

The Mankiw, Romer, and Weil model provides information useful for answering the first question, because it provides estimates of the marginal product of both human capital and

physical capital for each country. If the marginal product of human capital is less than the marginal product of physical capital, then the nation may be overinvesting in human capital and vice-versa.

Figure 9 shows the ratio of the marginal products MPH/MPK for 48 countries in 2005. This analysis shows that the marginal returns to education are equal or greater than the returns to physical capital for most countries. Some countries with low levels of human capital apparently have higher returns on physical capital, but this indicates either that their macro data are not accurate or that they are under-investing in both kinds of capital.

Figure 9
Relative Returns to Human Capital and Physical Capital in 2005



A few countries with high levels of human capital (above $125,000/adult) also have returns to physical capital that exceed the returns to human capital. The implication is that tax and subsidy policies in these countries are not optimal in their encouragement of investment in the two kinds of capital. As the marginal returns to education continue to decline, these

countries should reexamine their policies for promoting investment in these two kinds of capital.

Assuming the aggregate marginal returns are similar for both kinds of capital, is there a marginal return below which investment is counterproductive? Implicitly, yes, but that point does not appear to have been reached in any country. Denmark has the lowest estimated return on investment in human capital in 2005, and this return is 12.2 percent. This return still substantially exceeds the cost of financial capital. But this is an aggregate return, and returns on particular types of education are undoubtedly more and less than this rate. As the aggregate return continues to fall, investment in more types of education are likely to fall below the cost of financial capital. Optimal policy requires that subsidies for education be increasingly targeted on those types of education that offer the higher returns.

VIII. Conclusions

This paper presents evidence that human capital and physical capital are both required for economic development and that each has a positive external effect on the productivity of the other. The evidence also indicates that human capital is more likely to be the limiting factor in economic development.

Human capital is created initially by providing children with primary and secondary schooling. Private financing of this type of investment is not feasible for poor children. Countries that are highly developed today have a long history of providing free or highly-subsidized education to the poor. A review of their history suggests that the initial impetus for this schooling had a religious basis, but that as the public's level of education and income rose, their demand for schooling rose, and the financial support from private donors was replaced or greatly augmented by public funds from the state. If poor countries wish to achieve high levels of national income, they need to provide public funding for the education of the poor, at least at the primary and secondary levels of schooling.

The evidence on returns to education indicates that investment in schooling is subject to diminishing returns, but that the macro marginal return on all education is still considerable in highly-educated countries, over 12 percent in 2005. In less-educated countries the marginal macro returns are much larger, in excess of 50 percent, but since most of this return is indirect, the magnitude of the marginal returns to education is not generally appreciated. These very high macro marginal returns to education make it possible for poor countries to grow very rapidly if they make a major commitment to raising the average level of schooling.

The evidence also indicates that educated workers raise the marginal productivity of physical capital and of other workers. In the highly educated countries the spillover effect on other workers is very small, but un less-educated countries this effect appears to be much

larger. In all countries the positive effect of rising human capital on the productivity of physical capital is required to offset the diminishing returns to investment and make rising investment in physical capital financially viable in the development process.

References

Barrett, David B., 1982, *The World Christian Encyclopedia*, Oxford University Press, New York

Benavot, Aaron, and Riddle, Phyllis, 1988, "The Expansion of Primary Education, 1870-1940: Trends and Issues, *Sociology of Education*, v61, n3, 191-210

Botticini and Eckstein, 2007, "From Farmers to Merchants, Conversions and Diaspora: Human Capital and Jewish History, *Journal of the European Economic Association* 5 (5), 885-926

Bowen, James, 1981, *A History of Western Education; Volume III: The Modern West*, Methuen & Co. Ltd, London

Breton, Theodore R., 2012, "Were Mankiw, Romer, and Weil Right? A Reconcilation of the Marginal Product of Human Capital with Micro Returns on Investment in Schooling" *Macroeconomic Dynamics*, forthcoming

Caselli, Francesco, and Feyrer, James, 2007, "The Marginal Product of Capital," *Quarterly Journal of Economics*, v122, n2, 535-568

Cipolla, Carlo M., 1969, *Literacy and Development in the West*, Pelican Books, Baltimore

Clark, Dennis, 1977, "Babes in Bondage: Indentured Irish Children in Philadelphia in the Nineteenth Century, The Pennsylvania Magazine of History and Biography, v101, n4, 475-486

Cobb, Charles W., and Douglas, Paul H., 1928, "A Theory of Production," *The American Economic Review*, Vol. 18, No. 1, Supplement, Papers and Proceedings of the Fortieth Annual Meeting of the American Economic Association (Mar., 1928), pp. 139-165

Cohen, Daniel, and Soto, Marcelo, 2007, "Growth and Human Capital: Good Data, Good Results," *Journal of Economic Growth*, v12, n1, 51-76

Craig, John E., 1981, "The Expansion of Education," *Review of Research in Education*, v9, 151-213

Easterlin, Richard A., 1981, "Why Isn't the Whole World Developed?" *The Journal of Economic History*, v41, n1, 1-19

Heston, Alan, Summers, Robert, and Aten, Bettina, 2009, *Penn World Table Version 6.3*, Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania (CICUP)

Houston, R. A., 1988, *Literacy in Early Modern Europe; Culture and Education 1500-1800*, Longman, New York

Johansson, Egil, 1977, "The History of Literacy in Sweden in Comparison with Some Other Countries," in Graff, Harvey J., 1981, *Literacy and Social Development in the West: A Reader*, Cambridge University Press, New York, 151-182

Johnson, Paul, 1976, *A History of Christianity*, MacMillan Publishing, New York

Maddison, Angus, 2003, *The World Economy: Historical Statistics,* Development Centre of the Organisation for Economic Co-operation and Development, Paris, France

Mankiw, N. Gregory, Romer, David, and Weil, David N., 1992, "A Contribution to the Empirics of Economic Growth," *Quarterly Journal of Economics*, v107, Issue 2, 407-437

Mincer, Jacob, 1984, "Human Capital and Economic Growth," *Economics of Education Review*, v3, n3, 195-205

Morrisson, Christian, and Murtin, Fabrice, 2009, "The Century of Education," *Journal of Human Capital*, v3, n1, 1-42

Obstfeld, Maurice, and Taylor, Alan, 2004, *Global Capital Markets: Integration, Crisis, and Growth*, Cambridge University Press, Cambridge

OECD, 2001, "Measuring Capital; OECD Manual: Measurement of Capital Stocks, Consumption of Fixed Capital, and Capital Services," *OECD Publication Services*, www.SourceOECD.org

Psacharopoulos, George, 2009, "Returns to Investment in Higher Education: a European Survey," A Contribution to the Higher Education Funding Reform Project, unpublished

Psacharopoulos, George and Patrinos, Harry, 2004, "Returns to Investment in Education: A Further Update," *Education Economics,* v12, n2, 111-134

Ramirez, Francisco O., and Boli, John, 1987, "The Political Construction of Mass Schooling: European Origins and Worldwide Institutionalization," *Sociology of Education*, v60, n1, 2-17

Schultz, Theodore W., 1961, "Investment in Human Capital," *American Economic Review*, v51, n1, 1-17

Smith, Adam, 1776 (1977), *An Inquiry into the Nature and Causes of the Wealth of Nations*, University of Chicago Press, Chicago

United Nations, 2009, *System of National Accounts 2008*, document symbol ST/ESA/STAT/SER.F/2/Rev.5, New York,