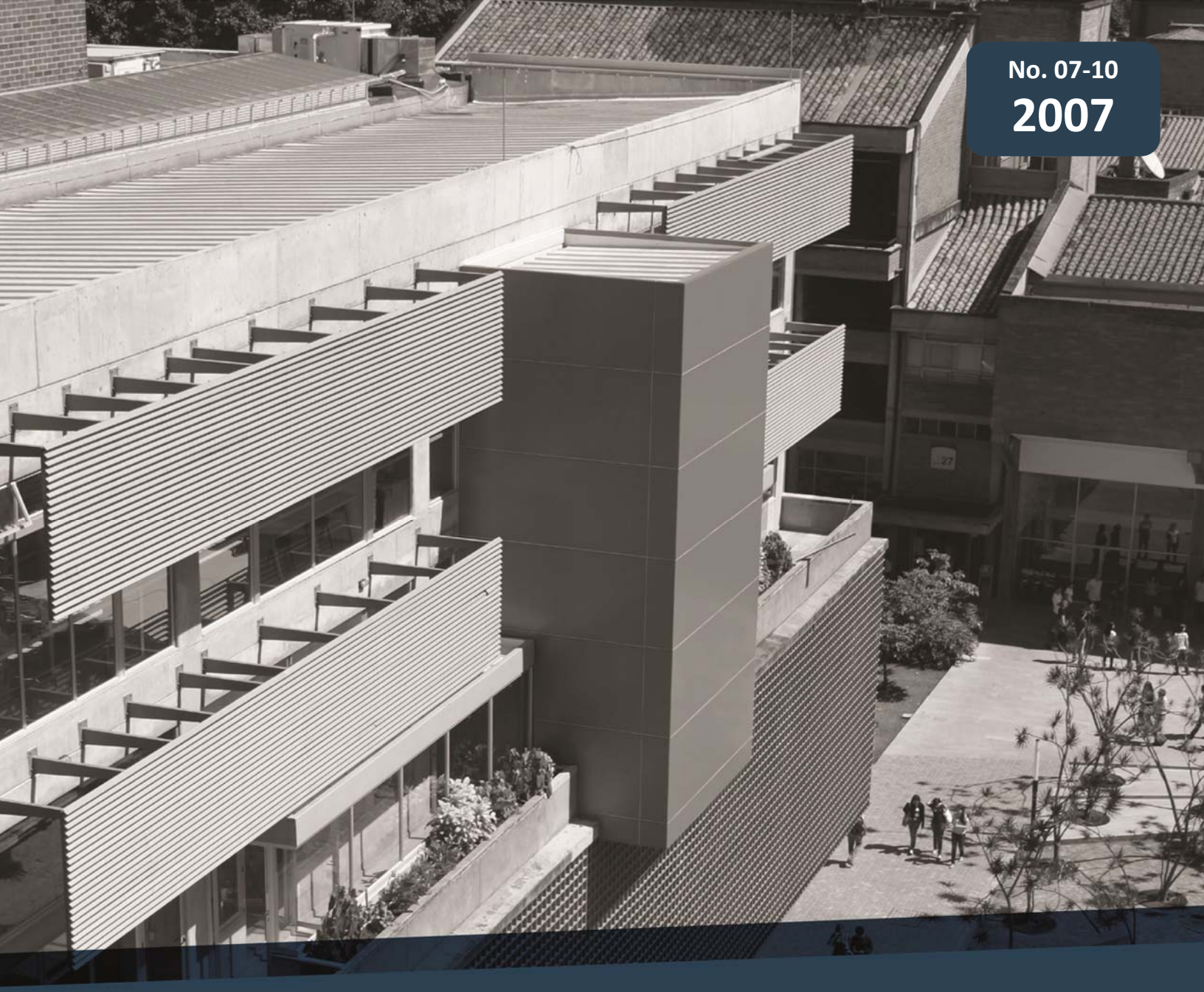

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SCHOOLING AND NATIONAL INCOME: HOW LARGE ARETHE EXTERNALITIES?

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Schooling and National Income: How Large Are the Externalities?

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Abstract

This paper uses a new data set for cumulative national investment in formal schooling and a new instrument for schooling to estimate the national return on investment in 61 countries. These estimates are combined with data on the private rate of return on investment in schooling to estimate the external rate of return. In 1990 the external rate of return ranged from 10 percent in high-income countries to over 50 percent in the lowest-income countries. The external benefits of schooling are about equal to the private benefits in high-income countries and three times the private benefits in the lowest-income countries.

JEL Codes: E13, I21, O11, O15, O41

Key Words: Human Capital, Education, Economic Growth, External Benefits

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Throughout the world formal schooling is funded primarily by the state, in part because education is believed to have external benefits. And yet the empirical support for this belief is relatively meager. Lucas [1990] and Moretti [2004] hypothesize that a worker's productivity on the job is enhanced when other workers are more educated, but knowledge "spill-over" potentially could improve a nation's productivity and thereby its level of income in many other ways. The mechanisms could include a longer working life for the labor force, better national policies, superior national institutions, or the more extensive use of new technology.

Moretti [2004] finds evidence for external benefits from schooling in the United States by examining the effect of a higher share of workers with university education on the wages of workers with less education. He estimated that a one percent increase in the share of U.S. college graduates in a city raised high school graduates' wages by 1.6 percent. While these effects are substantial, they include only the external effects that are limited to the cities where the more educated workers reside. Additional external benefits might accrue to the nation as a whole.

Moretti's evidence that schooling has external benefits appears to be contradicted by the empirical results from cross-country studies. Pritchett [2001] compared the direct return on investment in schooling to workers with the (macro) return to the nation for an array of countries and concluded that investment in schooling had negative externalities. He cited numerous other cross-country studies that find little effect from changes in schooling on national income, which implicitly support his conclusions.

Krueger and Lindahl [2001] argue that the low estimates of the effect of changes in schooling on national income are due to attenuation bias. They find that the measurement error in the cross-country schooling attainment data is so large that these data have almost no signal over short periods of time. As a result, statistical estimates of the effect of changes in schooling attainment fail to find any effect, which then leads to negative estimates of the external effect of schooling. Cohen and Soto [2001] corroborate this measurement problem with schooling data. They compare two sets of cross-country educational attainment data for the OECD and find that the high correlation (0.9) between these data sets declines to less than 0.1 when the data are compared in first differences. When they adjust these data to eliminate

measurement errors, they find that the estimated effect of schooling on national income becomes much larger.

But these analyses focus on only one type of measurement error. Greene [2000] observes that the "years-of-schooling" variable suffers from two types of measurement error; the error from misreporting the years of schooling completed, described above, and the error arising because "years-of-schooling" is a poor proxy for the true variable, education. The cross-country educational attainment data suffer badly from both types of error. Because a year of schooling varies so substantially in terms of the quality of education provided across levels of schooling, over time, and across countries, a year of schooling is not an accurate proxy for educational achievement even if it is measured accurately. When used as a proxy for cross-country levels of education, the measurement error caused by differences in schooling quality is likely to be even larger than the error due to misreporting.

Additional bias in the estimates of the effect of education on national income occurs because the level of schooling is likely to be endogenous in the economic growth process. Kim [1988], Bils and Klenow [2000], and Glewwe and Jacoby [2004] present evidence that the demand for schooling rises with income. Many cross-country studies of the effect of education on income do not control for endogeneity. Caselli, Esquivel, and Lefort [1996] used lagged educational attainment as an instrument to control for endogeneity, but this instrument is invalid because lagged attainment is likely to affect income directly. Psacharopoulos and Layard [1979] find a positive relationship between the level of formal education and the rate of increase in worker earnings, which is evidence of this lagged effect.

Clearly the problem of accurately estimating the effect of schooling on national income is a difficult one. Indeed, many researchers have become skeptical of any results from cross-country studies, since Levine and Renelt [1992] illustrated the sensitivity of cross-country model results to the conditioning variables included in the model. Unfortunately, the only way to estimate the external benefits of a nation's investment in schooling is to compare estimates of the national and the private benefits of schooling, and the national benefits are difficult to quantify other than through cross-country studies.

This paper estimates the magnitude of the external benefits of schooling, using a methodology designed to reduce several sources of estimation bias that have plagued earlier cross-country studies. First, the schooling data measurement problem is addressed with a new data set for cumulative investment in schooling that implicitly accounts for education quality across time and across countries. Second, attenuation bias and endogeneity bias are addressed by using the Protestant share of the population as an instrument for cumulative investment in schooling. Third, the potential bias due to the lag between investment in schooling and the effect on national income is minimized by estimating the long-run effect of schooling across 61 countries, rather than the short-run effect measured in many other studies. Fourth, the external benefits of schooling are estimated by calculating the national rate of return on schooling and comparing them to the private rates of return in low and high-income countries. This paper's contribution to the literature is the new cross-country data set on levels of schooling, the analysis and use of the Protestant share variable as an instrument for schooling, the estimate of the (marginal) national rate of return on schooling in 61 countries, and the estimate of the external rate of return in 20 countries.

The results from this approach indicate that the external rate of return from investment in schooling ranges from about 10 percent in the highest-income country to over 50 percent in the lowest-income countries. These results provide evidence that the external benefits from schooling are particularly large in countries with low levels of schooling. These results indicate that the external rate return is about three times the private rate of return in the lowest-income countries and about equal to the private rate of return in the high-income countries.

The paper is organized into six sections. Section I of the paper examines the education data quality issue and presents the new data set. Section II examines the suitability of the Protestant share of the population as an instrument for schooling. Section III presents the national income model used to estimate the effect of schooling. Section IV presents the estimates of the effect of schooling on national income using the new cumulative investment data. Section V presents the estimates of the external benefits of schooling. Section VI concludes.

I. Data on Investment in Schooling

Barro and Lee's [2001] cross-country data on the average years of schooling of the population over 15 and 25 years of age appear to be a standardized time-series data set for educational attainment. They are used in most cross-country studies that examine the effect of schooling on national income. But the reality is that the data are only comparable within countries over short periods of time when differences in the quality of schooling are minimal. Lee and Barro [2001] confirm that the average attainment data do not properly account for the quality differences in a year of schooling. Schooling quality varies across schooling levels within a country, across countries, and over time. And changes in schooling quality can be dramatic over any of these parameters.

The potential magnitude of the quality differences across schooling levels is evident in the available national data on public expenditures per year of schooling. Table 1 presents these data for eight high-income countries for primary, secondary, and university schooling. The average public expenditure

Table 1
High-Income Countries Public Education Expenditures Per Pupil

		Expenditures*			Ratio of University Expenditures		
Country	**Year**	**Primary**	**Secondary**	**University**	**Primary**	**Secondary**	**University**
USA[1]	1956	327**	425**	1168	0.28	0.36	1.00
USA[2]	1985	4294**	5401**	8600	0.50	0.63	1.00
Canada[2]	1985	4044	5391	13104	0.31	0.41	1.00
Australia[2]	1985	3117	4376	14284	0.22	0.31	1.00
Denmark[2]	1985	4305	6076	9917	0.43	0.61	1.00
Germany[2]	1985	3358	3676	8085	0.42	0.45	1.00
Italy[2]	1985	3011	3870	5438	0.55	0.71	1.00
Spain[2]	1985	1505	2078	2160	0.70	0.96	1.00
UK[2]	1985	2698	3807	15045	0.18	0.25	1.00
Average					**0.40**	**0.52**	**1.00**

*Numbers are annual expenditures in each country's currency.
**Average expenditures for elementary school split between primary and secondary based on the relative unit cost ratio of 1.3 in the 1960s cited in Hines, Tweeten, and Redfern, [1970].

Sources:
[1]Schultz [1960]
[2]OECD [2001]

per pupil for a year of university schooling in these countries is 2.5 times the expenditure per pupil at the primary level.

Table 2 presents similar data for 13 lower-income countries. The rising level of public expenditures per pupil is again evident by level of schooling, but in these countries the public expenditures for a year of university schooling are eight times the amount at the primary level. There are

Table 2
Annual Public Education Expenditures Per Pupil in Lower-Income Countries

		Expenditures*			Ratio of University Expenditures		
Country	**Year**	**Primary**	**Secondary**	**University**	**Primary**	**Secondary**	**University**
Uruguay[1]	1989	155	185	372	0.42	0.50	1.00
Chile[2]	1982	5.2	8.3	33.7	0.15	0.25	1.00
Chile[2]	1960	5	10.2	49.4	0.10	0.21	1.00
Greece[3]	1961	1290	2504	7618	0.17	0.33	1.00
Ecuador[4]	1987	16500	37200	111200	0.15	0.33	1.00
Papua N.Guinea[5]	1986	316	1803	8622	0.04	0.21	1.00
Philippines[6]	1985	630	952	7928	0.08	0.12	1.00
Venezuela[7]	1984	2169	3908	27624	0.08	0.14	1.00
Paraguay[8]	1983	12	27.4	146.6	0.08	0.19	1.00
Brazil[9]	1980	811	1316	13842	0.06	0.10	1.00
Venezuela[7]	1975	1235	3045	16562	0.07	0.18	1.00
India[10]	1976	113	242	1550	0.07	0.16	1.00
Sri Lanka[11]	1978	15	21.7	45.2	0.33	0.48	1.00
Mexico[12]	1963	414	2082	3720	0.11	0.56	1.00
Colombia[13]	1962	278	1489	11199	0.02	0.13	1.00
Average					**0.13**	**0.26**	**1.00**

*Numbers are annual expenditures in each country's currency.

Sources:
[1]Psacharopoulos and Velez [1994]
[2]Riveros [1990]
[3]Psacharopoulos [1970]
[4]Gomez-Castellanos and Psacharopoulos [1990]
[5]McGavin [1991]
[6]Tan and Paqueo [1989]
[7]Psacharopoulos and Steier [1988]
[8]Psacharopoulos, Velez, and Patrinos [1994]
[9]Dougherty and Jimenez [1991]
[10]Tilak [1988]
[11]Tilak [1984]
[12]Carnoy [1967]
[13]Schultz [1968]

no issues related to purchasing power parity with these data because each comparison is made for a single country in the same year. The clear implication is that a year of primary school and a year of university

represent very different amounts (or qualities) of schooling and the ratio between these amounts may be very different in high and low-income countries. In addition, the quality of a year of schooling at the same level of schooling can change dramatically across countries or in a particular country over 20-30 years. In countries that have not provided public education for very long, the quality of teachers and schools is likely to improve greatly as the level of educational attainment in the country rises. Initially the level of teacher training may be very low by necessity, but standards for teachers can rise substantially over a relatively short period of time.

The amount expended on a year of schooling certainly is not an exact indicator of the amount or quality of the education provided, but many studies indicate that quality is positively related to expenditures [Lee and Barro, 2001]. If total expenditures are adjusted for purchasing power parity across countries and over time, cumulative national expenditures on the formal education of the work force may provide a valid measure of the relative level of education of the work force across countries. In theory it should be a more accurate indicator than the cumulative years of vastly different qualities of schooling.[1]

This paper presents and makes use of a set of data for cumulative national investment in the formal schooling of the work force for 61 countries in 1990, 1995, and 2000. The amount of this investment is estimated under the assumption that all residents of a country complete formal schooling and then contribute to national income for a period of 40 years. The amount of this investment is approximated using historic data on public expenditures, private expenditures and students' foregone earnings (FE) as follows:

$$(1) \qquad H_{it} = (FE+TotExp)/TotExp) * (TotExp/PubExp)_i * 5 * \sum_{j=1}^{8} [(PubExp/Y)_{it-5j} * Y_{it-5j}]$$

The key data driving these estimates are the ratios of public expenditures for schooling divided by national income (PubExp/Y), which are available from UNESCO for most countries for the years

[1] Hanushek and Kimko [2000] suggest that test scores on standard tests may be a more accurate indicator of relative levels of education than expenditures, but test scores are not available for low-income countries and may not be representative of all students in a country.

divisible by five over the 1950-1995 period. This ratio was multiplied by estimates of national income adjusted for cross-country purchasing power differences to provide comparable estimates of total national public expenditures on formal schooling in each country. The sum of the eight years divisible by five was multiplied by five to account for the other years of investment. This estimate of total public expenditures was multiplied by the estimated ratio of total direct (public + private) expenditures to public expenditures (TotExp/PubExp) in each country and a single ratio of total investment to total expenditures (FE+TotExp)/TotExp) that accounts for students" foregone earnings.[2] The four-year lag is included to account for the average (weighted) delay between the nation's investment in formal schooling and the entry of a student into the work force. Appendix 1 documents the methodology used to estimate the cumulative investment in more detail. Although no prior studies have used this data set, Judson [1995] and Breton [2004] used the UNESCO public expenditure data and the PWT income data for an earlier part of this period as a component of their indices for cross-country levels of human capital.

The 61 countries in the data set were chosen because they met several criteria. First, they had relatively complete UNESCO public expenditures data over the 1950-95 time period [UNESCO, 1969, 1980, 1998a]. Second, their national income was not predominantly due to oil exports. Third, they were not planned socialist economies during the 1950-95 period. These criteria were adopted to ensure that the income produced in each country was due primarily to the employment of capital, education, and labor and that markets predominantly determined the allocation of resources, the return on investment, and the production and value of goods and services.

These data on cumulative investment can be combined with the Barro and Lee [2001] data on the average years of schooling in the population over 15 years of age to estimate each country's cumulative investment per year of schooling. The results are shown in Figure 1 for 1990. Since the Barro and Lee data are for the population over 15, while the cumulative investment is per adult of working age, these two sets of data are not strictly comparable. Nevertheless, they provide an indication of the pattern of

[2]This ratio of 1.7 does not affect the coefficient on schooling in the log-linear national income model estimated in section III, but it affects the national marginal return on investment in schooling estimated in section IV.

national investment per year of schooling attainment as total schooling increases. The results indicate that the cumulative investment per year of schooling (adjusted for purchasing power) is higher in countries that provide more schooling and in countries with higher income per adult. The data indicate that countries with an average attainment of ten years of schooling invest more than twice as much per year of schooling as countries with an average population attainment of only five years of schooling[3]. These data indicate that Barro and Lee's data on average years-of-schooling attainment systematically underestimate the relative level of education in higher-income countries.

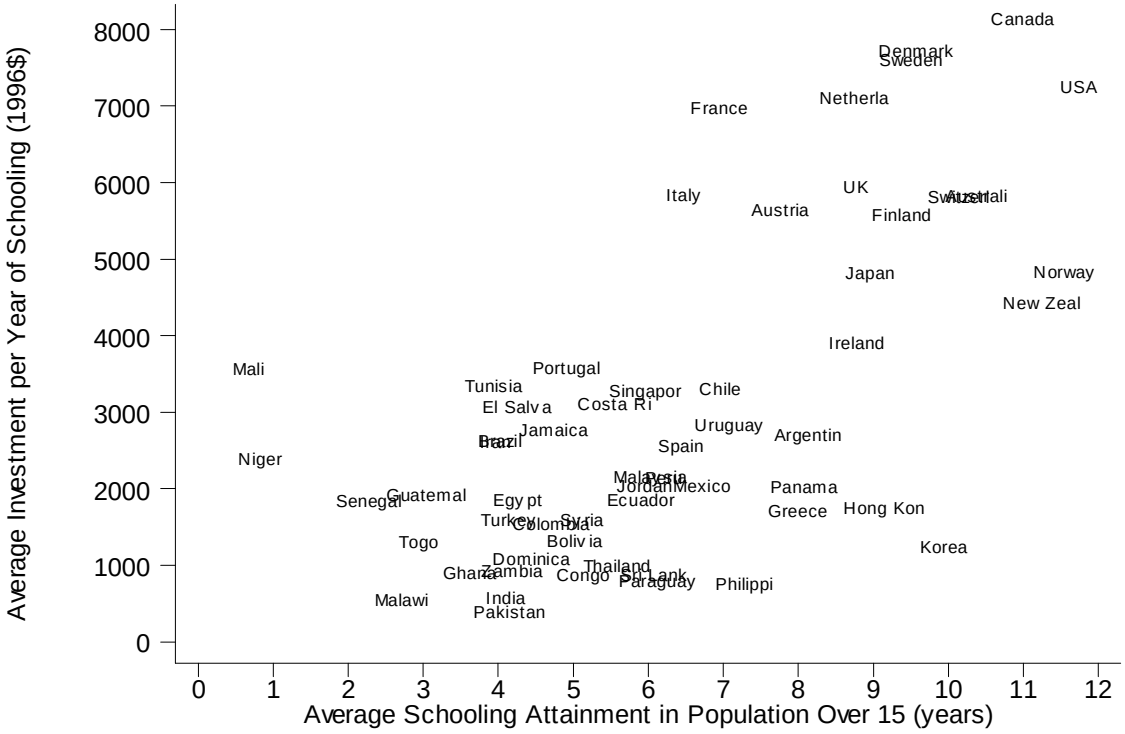

Figure 1
Investment in Education per Adult per Year of Schooling in 1990

Critics might argue that these estimates of cumulative investment per year of schooling only indicate that higher-income countries pay more for the same amount of education. But the data in Tables 1 and 2 show that public expenditures per year of schooling rise with the average level of schooling

[3]The data shown in Figure 1 exaggerate the upward trend in investment per year of schooling as a nation's level of schooling rises because the countries with higher levels of schooling have older populations that include more

within countries and that these expenditures rise much more in lower-income countries. In addition, since these estimates are adjusted for purchasing power differences, a large share of the differences in cumulative investment per year of schooling across countries in Figure 1 is likely to represent differences in the quality of the education provided per year of schooling.

An examination of the data in the figure also indicates that there may be substantial random measurement error in the educational attainment and expenditure data. It is surprising to observe that some of the OECD countries have average levels of educational attainment that are below the levels in lower-income countries. It is also surprising to see the substantial range of estimated costs for a year of schooling across countries at relatively similar stages of development. These data patterns suggest that there could be serious problems with the purchasing power adjustments, the attainment estimates, the expenditures on education reported by UNESCO, or all of the above. It highlights the importance of selecting statistical techniques for estimating the effect of schooling on national income that are not dependent on highly accurate data to provide valid results.

II. The Protestant Share Instrumental Variable

Given the evidence that education is endogenous in the economic growth process and that the measurement error in the schooling data is very large, a valid instrumental variable for education is required to accurately estimate the effect of schooling on national income. The problem is that most variables are endogenous in the economic growth process, so it is difficult to find one that can serve as an appropriate instrument for a nation's level of education.

Measures of religious affiliation are potentially attractive instruments for cross-country economic variables because religious preference is measured worldwide. The minimal variation over time precludes the use of these measures in country fixed-effects models, but makes them potentially suitable for analyzing economic differences across countries.

Means [1966] reports that historically many social scientists hypothesized that the higher income in Protestant countries during the 18th and 19th centuries was due to the Protestants' unusually strong

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retired members with low average levels of schooling. The data in the figure are not used in the empirical analysis.

support for literacy and schooling. Prior to the Protestant Reformation in 1500 there was little difference in income between European countries [Maddison, 1995]. And at that time the European population was largely illiterate everywhere. Johansson [1977] and Cipolla [1969] document the increase in literacy that accompanied the Protestant Reformation due to the Protestant's emphasis on personal study of the Bible. And when public schooling was promoted as part of nation-building in the 19th century, the Catholic church actively and often successfully opposed it in countries with a large Catholic population [Johnson, 1976]. As a result, in 1940 primary school enrollment ratios were about 70 percent in northern Europe and its settlements and 35 percent in Iberia and its settlements [Benavot and Riddle, 1988].

Research at the sub-national level also consistently shows that a higher share of Protestants is correlated with higher levels of schooling. Goldin and Katz [1999] found that the amount of public secondary schooling in Midwestern towns in the early part of the 20th century was highly correlated with the share of Protestants in the town.

Of course, social scientists have long debated whether a nation's level of Protestant affiliation may have affected its level of economic activity through mechanisms other than its level of schooling. In 1905 Weber [2000] suggested that nations with a high share of Protestant affiliation may have had a "Protestant Ethic" that caused economic levels to rise through such mechanisms as a higher savings rate or a greater work effort. If Weber's thesis were correct, then the Protestant share variable would be correlated with the error term in a national income model and could not be used as an instrument for schooling. Critics of the use of the Protestant share variable as an instrument for schooling invariably cite the Protestant Ethic thesis to reject the validity of this instrument.

Implicitly addressing these critics, Innnacone [1998] reports that "…the most noteworthy feature of the Protestant Ethic thesis is its absence of empirical support." He cites an array of studies that have rejected "Weber's myth." Nevertheless, many of the studies he cites are dated and are not as satistically rigorous as more recent social science research. To remedy this situation Becker and Wössmann [2007] have recently completed a comprehensive statistical study of the determinants of Protestant economic success in 19th century Prussia using data from the 1871 Population Census. They find that in 453

counties in Prussia the Protestants had a higher level of income than the Catholics, as postulated by Weber, but that their higher level of literacy entirely explained these higher incomes. They state, "When Protestantism and literacy are entered jointly in a 'horse race' to explain economic prosperity, the association between Protestantism and economic outcomes vanishes, and the whole effect is absorbed by a significant association between literacy and economic outcomes." They also find that the same pattern between religious denomination, education, and income was still prevalent in Germany in 1997. These studies provide support for the validity of the Protestant share of the population as an instrument for schooling.

Conveniently, Christian groups have collected comprehensive worldwide data on national religious affiliation for over a century, as a part of their effort to spread the Christian religion. Barrett [1982] provides estimates of the share of each country's population that professed to be Protestant in 1970, 1975, and 1980. These are ideal dates for an instrument for the cumulative investment in schooling in this study, because these dates occur at the approximate midpoint of the periods over which each nation invested in the schooling of the members that were active in its work force in 1990, 1995, and 2000.

Consistent with the results from earlier studies, controlling for income, the Protestant share of the population over the 1970-80 period is a highly statistically-significant determinant ($t = 8.4$) of a nation's cumulative national investment in schooling per adult (as a share of national income) over the 1990-2000 period:

$$(2) \qquad \ln(H/YL)_{it} = -0.63 + .045 \ln(Y/L)_{it} + .85 \text{ Protestant share} \quad R^2 = 0.25$$
$$(0.29) \quad (.032) \qquad\qquad (.10)$$

Of course, the concern that the Protestant share of the population may affect national income indirectly or may be endogenous can never be entirely dismissed. But as will be shown in section IV, there is no indication in the statistical results that Protestant affiliation affects national income other than through its effect on a nation's level of schooling. In addition, the historic data on religious affiliation in Barrett [1982] indicate that the Protestant share of the population is extremely stable and is not affected in any consistent way by changes in national income over time.

Another concern with the use of this variable as an instrument is that the Protestant share could be a proxy for high-income countries with a European culture. Figure 2 shows the share of Protestants in 1990 in the 61 countries used in this study. About one quarter (14) of the countries had a Protestant share above 20 percent in 1990, and about one half (32) had a Protestant share above two percent. Importantly, since there is considerable variation in the share of Protestants residing in countries at different levels of national income and in different regions, the Protestant share in this data set is not just a proxy for high-income or European countries. Nevertheless, the Scandinavian countries are outliers in their very high levels of Protestant affiliation. If there is some cultural element in Scandinavian countries that causes economic success, the Protestant share IV could bias the estimate of the effect of schooling on national income. In section IV the income model is estimated with and without the four Scandinavian countries to examine whether the high level of Protestant affiliation in these countries could bias the results.

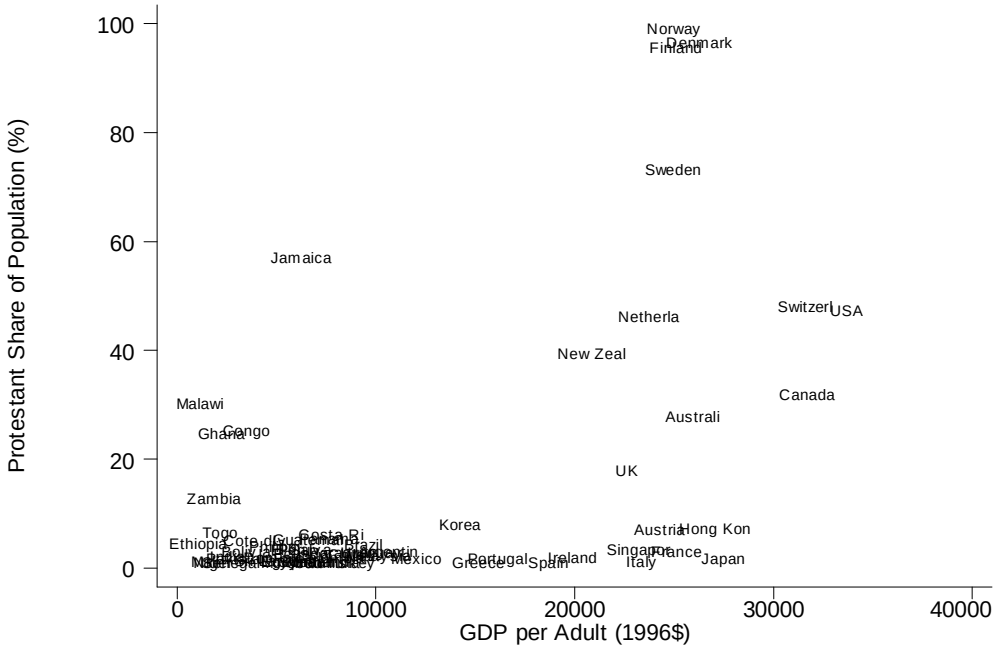

Figure 2
Protestant Share of Population in 1990

III. The National Income Model

Several models have been used in the literature to estimate the effect of schooling on national income. Many researchers have used a Solow growth model augmented with human capital, and some have included other conditioning variables that affect total factor productivity (TFP). The Solow model is a conceptually desirable model because it includes a Cobb-Douglas production function that exhibits constant returns to scale and diminishing returns to factor inputs. These assumptions are consistent with the observed characteristics of national economies and with the observed private rate of return on investment in schooling, which declines with increases in schooling [Psacharopolous and Patrinos, 2004].

One potentially confusing finding in the micro studies is that the return on incremental *years of schooling* (the Mincerian return) is not subject to decreasing returns [Psacharopolous and Patrinos, 2004]. The data in Tables 1 and 2 show why this is the case. Since the annual investment per pupil increases with years of schooling, the rising investment per year offsets the diminishing returns per unit of investment. The assumption of diminishing returns used in this study is consistent with the findings from micro studies for the measure of schooling used in this study (cumulative investment, not years of schooling).

The income model used in this paper is an augmented Solow model that is similar to the model used in Breton [2004]:

(3) $$Y/L_{it} = K/L_{it}^{\alpha} \, H/L_{it}^{\beta} \, GC/Y_{it}^{\gamma} \, e^{\delta \, sSAfr_i} \, [A_0 \, e^{gt}]$$

This model includes the most important known factors affecting national income across countries. The level of income per worker in country i at time t (Y/L_{it}) is a function of the physical capital per worker (K/L_{it}), the formal education per worker (H/L_{it}), the government's share of consumption (GC/Y_{it}), a dummy variable for countries in sub-Saharan Africa, and any trends due to omitted factors, such as technological progress ($A_t = A_0 \, e^{gt}$).

The government's share of national consumption is included to control for national productivity differences due to differences in the market share of economic activity. Levine and Renelt [1992] identify this variable as one of the few that has a consistently negative sign in a growth model regardless

of the other variables included in the model. Breton [2004] suggests that this variable may capture the effect of cross-country differences in the share of GDP that is unreported, since GC/Y is larger if underground private activity in not included in official statistics and GC/Y is high in poor countries known to have large underground economies.

The dummy variable for the sub-Saharan African countries is a proxy for the omitted variables that would be required to fully characterize income production in the sub-Saharan region. As shown in Appendix 1, life expectancy is much shorter there than elsewhere, which reduces the income obtained from investment in schooling. High levels of morbidity and civil unrest also reduce national TFP and income in this region relative to other parts of the world.

Since omitted variables bias is a particular concern in cross-country studies, are any theoretically-important variables missing from the national income model in (3)? One potential concern is that a nation's cumulative investment in formal schooling is only an approximate measure of a nation's human capital stock because it does not include any human capital depreciation due to obsolescence nor any appreciation due to learning on the job. Hopefully these missing elements are proportional to each nation's level of cumulative investment in formal schooling and do not bias the estimated coefficients if the model is estimated in log form.

One variable that is not included in (3) is any measure of a nation's institutional capacity, such as its degree of adherence to the rule of law. This variable is purposely excluded from the model because it is endogenous, highly correlated with national income, difficult to measure accurately, and difficult to instrument properly. But since numerous studies have included institutional variables in growth models and found empirical support for them, the exclusion of this variable could be viewed as a serious deficiency.

Glaeser, La Porta, Lopez-de-Silanes, and Shleifer [2004] performed a thorough evaluation of the studies providing empirical evidence that institutions affect national income and concluded that these studies are seriously flawed. They showed that the commonly-used measures for a nation's institutional characteristics, such as indices for the rule of law and expropriation risk, are unstable and actually

measure the effect of short-run government policies rather than the characteristics of a nation's institutions. When they used other more stable measures of a nation's institutions, they found no evidence that institutions affect national income. They also reexamined the Acemoglu, Johnson, and Robinson [2001] analysis that used European mortality rates as an instrument to show that institutions affect national income. They show that when a schooling variable is added to Acemoglu et.al.'s national income model and a valid proxy is used to represent institutions, the effect of schooling on national income is statistically significant and the effect of institutions is not. While the importance of institutions in the determination of national income has not been entirely rejected by this study, it does indicate that the exclusion of institutions from an income model may not constitute mis-specification.

Aside from the data on cumulative investment described in section I and the Protestant share data described in section II, the data used in the model were obtained or derived from the Penn World Table 6.1 (PWT) data set [Heston, Summers, and Aten, 2002]. The number of adults in each country is used to represent the number of workers (L), and these data are calculated from the PWT data on income per capita and income per equivalent adult. The government share of consumption is the constant price average share for the five years preceding the year t and is also obtained from the PWT data. This estimate does not include the year t to avoid potential endogeneity bias due to cyclical changes in income.

A data set on the national stock of physical capital was not available for the 1990-2000 period, so a simplified approach was used to estimate this variable. De Long and Summers [1991] present evidence that the physical capital stock that generates income is predominantly the stock of equipment rather than the stock of structures. Since Fraumeni [1997] shows that equipment has a useful life of 10-15 years in the U.S., each country's capital stock K in year t was estimated as the sum of the fifteen years of investment prior to t. No depreciation was applied to this sum since available depreciation rates measure the *financial* depreciation of the capital (due primarily to the decline in the equipment's remaining useful life), not the decline in the productivity of the equipment. With a 15-year life and no physical depreciation prior to retirement, the relevant capital stock in place across countries in year t is approximately the sum of the expenditures on physical capital made during the prior 15 years. The PWT

constant price investment rate and national income data are used to develop this estimate. Since the income model is estimated in log form, the physical capital stock measure is suitable as long as it provides a data set that is proportional to the true level of the physical capital stock.[4]

In the income model in (3), Y/L, K/L, and H/L are highly correlated because K/L and H/L rise almost linearly with the level of income. In this study the income model is estimated in a reduced form in which the physical and human capital stocks are represented as a share of national income to preclude low estimates of statistical significance for these variables due to multicollinearity:

(4) $\ln(Y/L)_{it} = \alpha/(1-\alpha-\beta)\ln(K/Y)_{it} + \beta/(1-\alpha-\beta)\ln(H/Y)_{it} + \varepsilon \ln(GC/Y)_{it} + \theta\, sSAfr_i + g/(1-\alpha-\beta)\, t + c$

IV. The Effect of Schooling on National Income

Table 3 presents the empirical results from the estimation of the model in (4). The table also presents the implied estimates of α and β calculated from the reduced form model results. The determination that the implied estimates are statistically significant at the 1% level was made using the Delta method.

Column 1 presents the OLS results using the new data set. If the augmented Solow model is a valid income model, the estimate of α should be consistent with independent estimates of physical capital's share of national income. Caselli and Feyrer [2006] estimate the value of α (for reproducible physical capital) for 40 of the 61 countries in the data set. The average value of α is 0.34, which is very close to the 0.33 estimated in the model. Additionally, the estimates of α and β are highly statistically significant. The estimate of β (.18) is plausible, but it may suffer from attenuation or endogeneity bias.

As discussed earlier, the Protestant share of the population could be a valid instrument for schooling if it does not affect national income other than through the schooling variable. Column 2 tests the effect of including the Protestant share variable in the income model. The results indicate that the Protestant share variable does not raise the explanatory power of the model, so it does not clearly affect income other than through the variables already in the base model. In addition, its inclusion has no effect

[4] Estimates of the income models using ten years instead of fifteen years of expenditures for the physical capital variable provided similar empirical results.

on the estimate of α, indicating that it is relatively independent of investment in physical capital. The principal effect of adding the Protestant share is to reduce the coefficient on the schooling variable, which is expected given the high correlation (0.50) between investment in schooling and the Protestant share of the population.

Table 3
Effect of Cumulative Investment in Education on National Income
[Dependent Variable is Ln(Income/Adult)]

	1	2	3	4	5	6	7	8	9
Sample Size	183	183	87	183	183	171	153	183	183
Countries	61	61	29	61	61	57	51	61	61
Technique	OLS	OLS	OLS	IV	OLS	IV	IV	IV	IV
Ln(K/Y)	0.67* (.08)	0.63* (.08)	0.65* (.11)	0.57* (.09)	0.57* (.09)	0..53* (.11)	0.64* (.10)	0.57* (.09)	0.89* (.11)
Ln(H/Y)	0.37* (.07)	0.30* (.07)	0.33* (.10)	0.64* (.14)	0.30* (.07)	0.77* (.23)	0.59* (.13)		075* (.17)
Est Ln(H/Y)					0.34 (.15)				
Ln(Pub H/Y)								0.55* (.12)	
Ln (GC/Y)	-0.62* (.06)	-0.61* (.06)	-0.54* (.07)	-0.64* (.06)	-0.64* (.06)	-0.68* (.07)	-0.64* (.7)	-063* (.06)	
Time	0.002 (.007)	0.003 (.007)	0.010 (.010)	-0.002 (.008)	-0.002 (.008)	-0.004 (.009)	-0.001 (.008)	-0.001 (.008)	0.014 (.010)
Sub-Saharan Africa	-1.02* (.10)	-1.04* (.10)	-0.96* (.15)	-1.11* (.11)	-1.11* (.11)	-1.14* (.13)		-1.14* (.12)	-1.16* (.14)
Protestant Share 20 years before		0.28 (.14)							
R^2	.85	.85	.80	.83	.85	.80	.72	.84	.73
Implied α	.33*	.33*	.33*	.26*	.26*	.23*	.29*	.27*	.34*
Implied β	.18*	.16*	.17*	.29*	.29*	.33*	.26*	.26*	.28*

Note: White-adjusted standard errors in parentheses
*Significant at one percent level

Column 3 presents the estimated model when countries with a Protestant share of the population greater than two percent are eliminated from the data set. If the Protestant share were an important omitted variable in the model, the coefficients on physical capital and investment in schooling in a model without the Protestant countries would be different. But the estimated coefficients are the same. These results provide additional evidence that the Protestant share of the population does not affect national income other than through its effect on schooling.

Column 4 presents the estimated coefficients for the base model when the Protestant share is used as an instrument for the ratio of cumulative investment in schooling to national income. The estimated value of β (0.29) with the IV remains statistically significant but is about 50 percent larger than the OLS estimate, indicating that the OLS estimate may be biased downward.

Column 5 presents the results of a Hausman test for endogeneity, in which the estimated schooling variable (Est Ln(H/Y)) from the first stage of the two-stage IV regression process is included in the model. In this model if the coefficient on the estimated schooling variable is zero, then the schooling variable is not endogenous in this data set. But the estimated coefficient is statistically different from zero, with statistical significance at the four percent level, indicating that the education variable is endogenous. Additionally, the high statistical significance of the coefficient on the Protestant share variable in the first stage regression indicates that it is a valid instrument to control for endogeneity:

(5) Est. Ln(H/Y) = .196 ln(K/Y)+.087 ln(GC)+.196 sSAfr + .017 t +.845 Protest - .152
(.087) (.065) (.102) (.007) (.097) (.213)

These empirical results provide strong evidence that the OLS estimates of the effect of schooling on national income in columns 1, 2, and 3 are biased downward and that the larger IV estimate in column 4 is a superior estimate.

Column 6 provides the IV results when the four Scandinavian countries, with very high Protestant shares of the population, are excluded from the data set. The estimated effect of schooling on income is higher in this model, indicating that the effect of schooling in the base model results is not biased upward.

Column 7 tests whether the effect of investment in physical capital and schooling may be different in the ten sub-Saharan African countries than elsewhere, due either to the conditions in those countries or to measurement error in the data . When these countries are removed from the data set, the effect of schooling on national income declines slightly, yielding an estimate of $\beta = 0.26$.

In all of these results, the estimated coefficient on time is negative. If this variable is presumed to measure world technological progress, then even though the coefficient is statistically insignificant, it casts doubt on the validity of the model results. But the coefficient on time in this model is the "Solow residual," which is just the trend in income changes due to factors not explicitly modeled. The negative

coefficient in the empirical results could indicate that technological progress over the 1990-2000 time period only benefited countries that were increasing their cumulative investment in schooling per worker. The larger negative coefficient when the sub-Saharan African countries were included in the data set implies that income per adult was declining due to non-modeled factors in those countries. Adverse trends in morbidity (due, for example to the HIV epidemic) or political violence over this period could have this effect.

One critic of the results in these models argued that errors in the estimates of private expenditures may bias the results upward. Column 8 presents the model results when private expenditures on schooling are excluded from total investment. The estimated effect of public investment in schooling on national income is slightly lower ($\beta = 0.26$) but similar to the effect estimated with total investment.

Another critic argued that the validity of the government share of consumption variable in the income model is not well-supported and that its inclusion may be biasing the results. Column 9 presents the results when this variable is removed from the base model. While the effect of schooling on income is essentially unchanged ($\beta = 0.28$), the coefficient on physical capital in this model is more consistent with the independent estimates cited above and the coefficient on time becomes positive.

These model results provide substantial evidence that cumulative investment in schooling has a large effect on national income. The implied value of β is robust and highly statistically significant in all of the models using the Protestant share as an instrument. These estimates of β in the 0.26 to 0.29 range are similar to the estimates obtained by Mankiw, Romer, and Weil [1992] and Breton [2004].

V. The External Benefits of Education

The magnitude of the external benefits from additional investment in schooling can be calculated by subtracting the private rate of return estimated in micro studies from the national rate of return on investment in schooling. As the national rate of return on investment in schooling is the marginal product of schooling (MPH) in the augmented Solow model in (3), it can be calculated using the estimates of β obtained in section IV. First, however, it is necessary to examine the relationship between changes in the level of physical capital to changes in the nation's level of schooling, since the national return on

investment in schooling depends in part on this indirect effect. This relationship can be estimated by examining the effect of changes in schooling on national income in the model in (3):

(7) $MPH_{it} = dY_{it} / dH_{it} = \beta (Y/H)_{it} + [\alpha (Y/K)_{it} * \delta K/\delta H_{it}]$

In the augmented Solow model framework, the level of physical capital rises when the level of schooling rises because an increase in the level of schooling has a positive effect on the rate of return on investment in physical capital:

(8) $MPK_{it} = \alpha K^{\alpha-1} H^{\beta}$

In the augmented Solow model, the change in the physical capital stock associated with a change in the level of schooling is fully determined by the coefficients on physical and human capital and the stocks of these two types of capital:

(9) $\delta K/\delta H_{it} = \delta K/\delta Y_{it} * \delta Y/\delta H_{it} = \beta / \alpha * (K/H)_{it}$

Substituting (9) into (7) reveals that the total national return on the investment in schooling is double the partial return on investment since the direct and indirect effects have the same magnitude.

(10) $MPH_{it} = 2\beta (Y/H)_{it}$

The empirical results in section IV indicate that over the 1990-2000 time period a reasonable estimate of β is 0.27. The estimated marginal national returns on investment in schooling in 1990 for the 61 countries in the data set using this value of β are shown in Figure 3. The rates of return range from 19 percent in Sweden to 126 percent in Pakistan. The marginal return on investment in education is generally lower for countries with a higher level of schooling due to the diminishing return to factor inputs that is inherent in the Solow model structure.

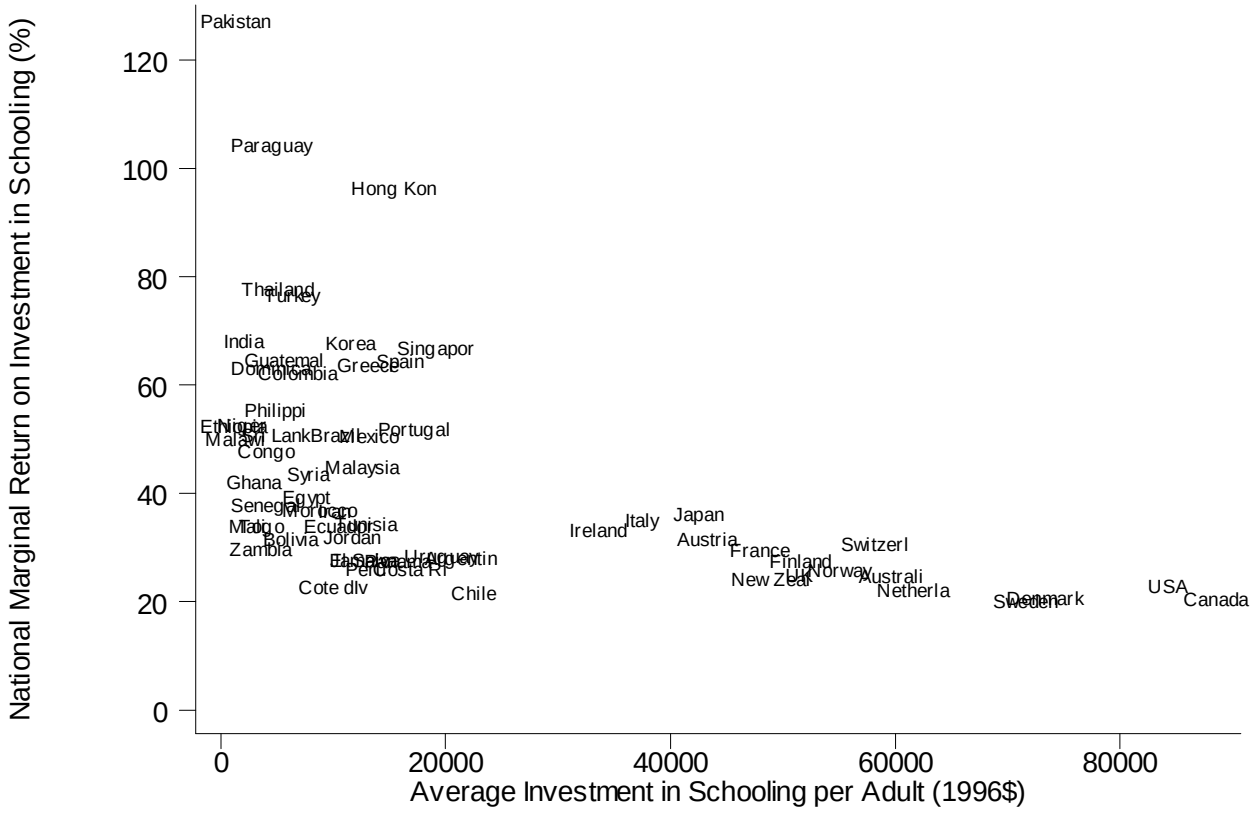

Figure 3
National Return on Investment in Schooling in 1990

Due to the rapidly rising level of investment in schooling worldwide over the 1950-95 period, the average cumulative investment in schooling per adult of working age was much higher in all countries in 2000 than in 1990. Figure 4 shows the national marginal return on investment in schooling in 2000. The estimated rates of return in 2000 are noticeably lower than in 1990, ranging from 16 percent in Sweden to 84 percent in Pakistan. The average national marginal rate of return for the 61 countries declined from 42 percent in 1990 to 36 percent in 2000, as investment in schooling grew faster than national income.

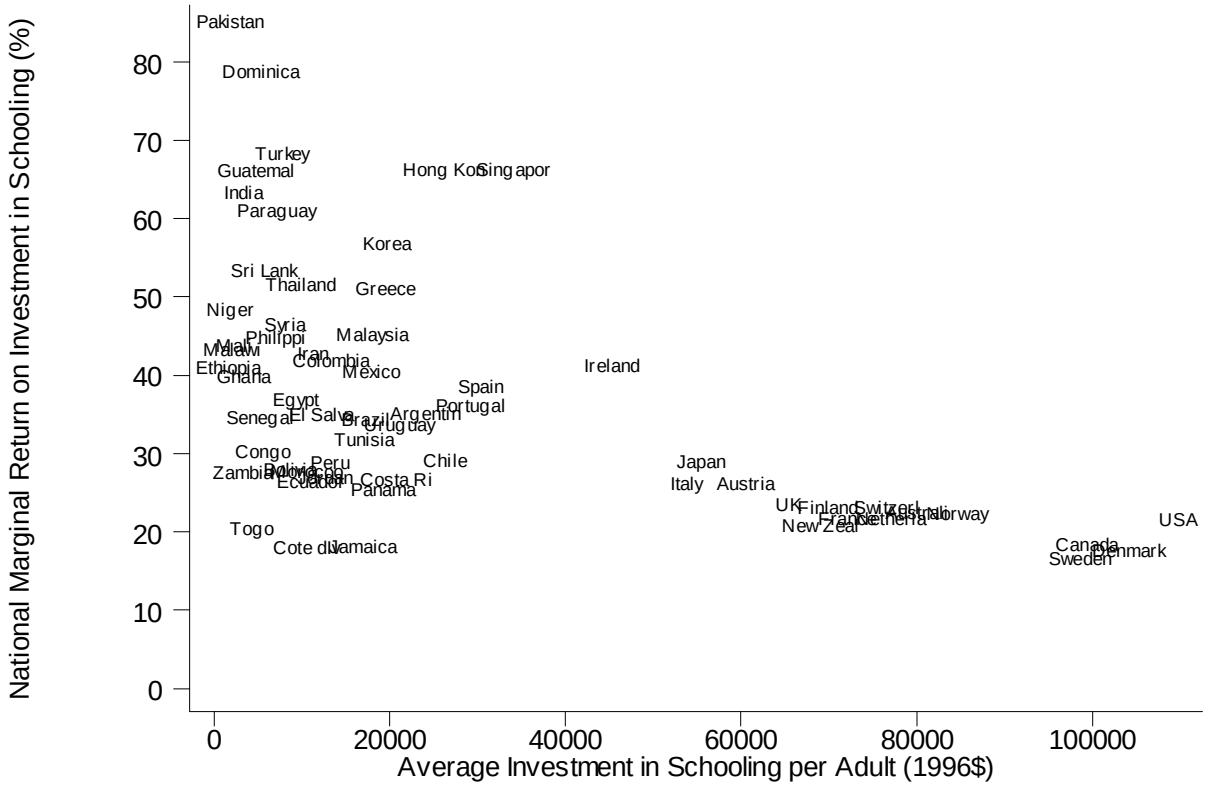

Figure 4
National Return on Investment in Schooling in 2000

These rates of return are quite large even in the countries with the lowest return on investment. They raise the question as to why such high returns did not attract more investment, particularly in the lowest-income countries where the estimated rates of return are enormous. The answer appears to be that a very large share of these returns on investment accrued as external benefits to the nations making the investment in schooling, as Lucas [1990] hypothesized. Since these external benefits accrued relatively steadily over time, they were attributed to technological progress, rather than to the rising levels of schooling that were occurring in all countries over this period.

Psacharopoulos and Patrinos [2004] summarize the estimated private[5] rates of return on investment in schooling at the primary, secondary, and university levels for a large number of countries. Many of their estimates are quite dated or do not cover all levels of schooling, but they provide estimates for all levels of schooling during the late 1980s and early 1990s for 20 of the 61 countries included in the cross-country data set. The average private return on investment in these countries can be estimated by weighting the rates of return at each level of schooling by the share of national investment at each level. Given the vintage of the private rate of return estimates, they are most comparable to the estimated national rates of return on investment in schooling in 1990.

As shown in Appendix II, for the 20 countries for which private returns were available, the average private return on national investment in schooling in 1990 was 13 percent, the average national return was 43 percent, and the average external rate of return (national return – private return) was 29 percent. In 1990 the external rate of return ranged from a low of about 10 percent in the nations with the most educated workers to over 50 percent in the nations with the least educated workers. Appendix II describes the methodology used to estimate the average private rates of return and shows the private, national, and external rates of return for each country. Although the sample size is small, these data can be used to estimate the return on investment as a function of a nation's cumulative investment in schooling per adult. Figure 5 shows these relationships for the private rate of return on investment and the external rate of return.

These relationships reveal why the rate of private investment in schooling is limited in a market economy. At low levels of schooling, the national return on investment in schooling is extremely high, but only a small part of this return accrues directly to the educated worker in the form of wages. Even at very low levels of schooling, the private rate of return is only 15 percent. While a rate of return of 15 percent appears attractive for an investment in schooling, this return accrues over a 45-year period and is

[5]Psacharpoulos and Patrinos denote the return to the worker from the worker's own investment the "private return" and the return to the worker from the nation's total investment in their education the "social return." The rates of return designated the private rate of return in this article are their social returns.

not collateralized. So the risk associated with private investment in a poor child's education is too large relative to the potential return to interest a private investor. The net effect is that absent charitable assistance from individuals with financial means or the state, only those families with their own financial assets can provide a private education for their children [Mincer, 1984].

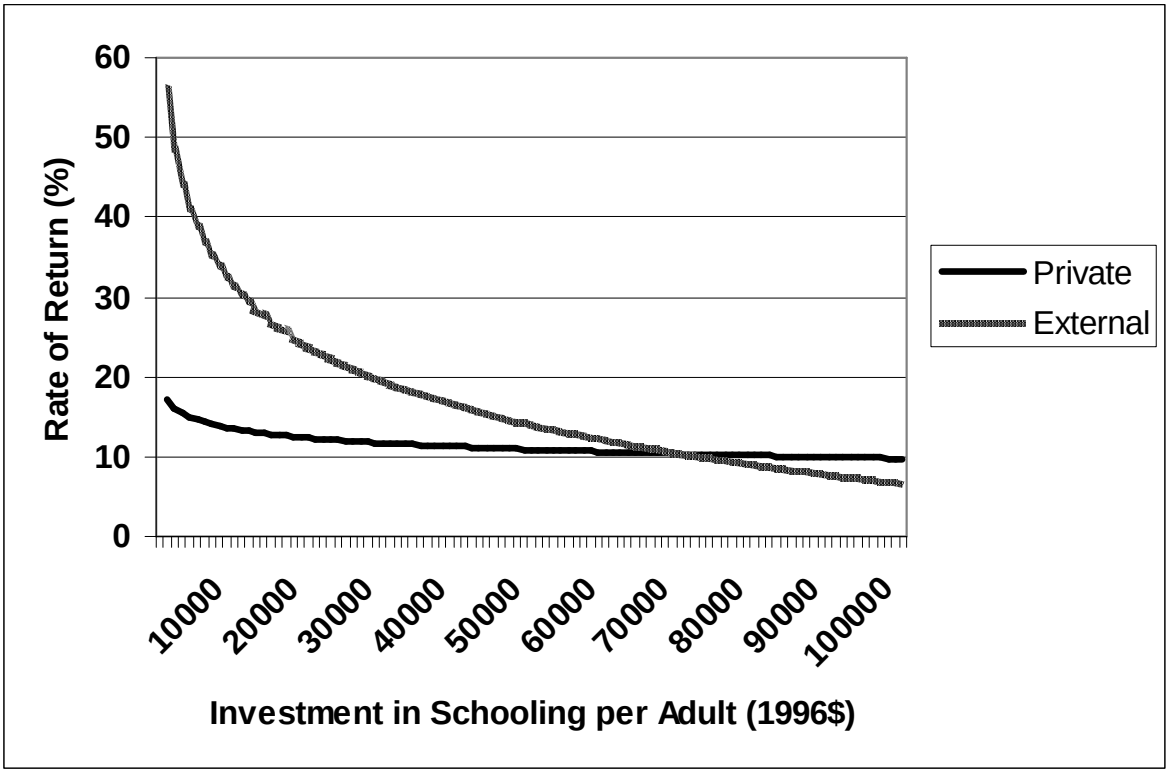

Figure 5
Private and External Rates of Return on Investment in Schooling in 1990

The estimates of the external rate of return on investment in schooling indicate that formal schooling is in large part a public good, a good whose benefits accrue to the nation as a whole rather than to the individual obtaining the schooling. This is especially the case for the poorest countries. The external rate of return on investment in schooling in the poorest countries is over 50 percent, while the total return is over 65 percent. The empirical results indicate that the external rate of return declines with the level of schooling of the adult population, dropping to 10 percent when the national investment in formal schooling exceeds $70,000 (1996$) per adult. The share of the total benefits of schooling that is external also falls as the level of schooling rises.

In 1990 the national rate of return on investment in schooling (private + external) in the countries with the most educated workers appears to have been over 15 percent. Caselli and Freyer [2006] estimate that the average return on reproducible physical capital was below 9 percent across 53 countries. So there is no indication that countries with the most educated work forces have over-invested in formal schooling. Quite the contrary, these empirical results indicate that the countries with high incomes today are prosperous precisely because they have provided their populations with very large public subsidies for schooling for a very long period of time.

VI. Conclusions

Supporters of public education have argued for centuries that investment in education has large external benefits for society, but the empirical support for this belief is relatively meager. Most cross-country studies have found that the effect of schooling on national income is small and that there are no positive externalities. But recent studies indicate that the failure to find external benefits from schooling may be due to downward bias in the statistical estimates.

This paper presents two innovations that address the sources of downward estimation bias in the existing studies. The first innovation is a new data set for the cumulative investment in the formal schooling of the work force in 61 countries in 1990, 1995, and 2000. By implicitly accounting for differences in the quality of education across schooling levels, across countries, and over time, these data may have less measurement error than the data used in earlier studies. The second innovation is the use of the Protestant share of the population as an instrumental variable for a nation's cumulative investment in formal schooling. The use of this instrument controls for the endogeneity of the level of schooling in the economic growth process and also may reduce the attenuation bias caused by data measurement error in OLS estimation.

Empirical estimation of an augmented Solow model with these innovations yields estimates of the effect of schooling on national income that are larger than in many earlier studies and highly statistically significant. These estimates indicate that the national rate of return on investment in schooling is much

larger than the private return in low-income countries and that it is similar in magnitude to the private return in high-income countries.

These empirical results provide evidence that schooling is in large part a public good. At the level of schooling that characterizes low-income countries, there appear to be substantial external benefits from investment in formal schooling, and these external benefits far exceed the private benefits. As is normal with public goods, these external benefits often are not realized unless private charities or the state provide a subsidy for schooling. Although investment in schooling does provide a substantial private return to the educated individual through increases in wages, this return accrues over a 45-year period. Given the lack of collateral for schooling loans, the financing of schooling for children is not attractive to private investors. The net result is that without external assistance the children of the poor remain unschooled.

The total rate of return on investment in schooling in the lowest-income countries in 1990 is estimated to have been over 65 percent. It is unlikely that any other public investment could provide a higher return. Even in high-income countries where the state provides enormous subsidies for schooling, the national rate of return on investment in formal schooling appears to be higher than the market return on investment in physical capital. These results indicate that from a cost-benefit standpoint, increased government subsidies for schooling are justified in all countries, but particularly in the lowest-income countries.

Appendix I
Data on National Investment in Schooling for 61 Countries

A nation's cumulative investment in formal schooling is the sum of three components; public expenditures, private expenditures, and students' foregone earnings. This appendix documents the methodology used to estimate the cumulative national investment in adults likely to be contributing to national income in 1990, 1995, and 2000 in 61 countries. The 61 countries in the data set were chosen because they met several criteria. First, they had relatively complete UNESCO public expenditures (percent of GDP) data over the 1950-95 time period. Second, their national income was not predominantly due to oil exports. Third, they were not planned socialist economies during the 1950-95 period.[6]

Cumulative investment in schooling is estimated at time t as the total public expenditures on formal schooling over the 40-year period ending four years earlier multiplied by national factors that account for private expenditures and foregone earnings (FE):

$$(1) \qquad H_{it} = (FE+TotExp)/TotExp) * (TotExp/PubExp)_i * 5 * \sum_{j=1}^{8} [(PubExp/Y)_{it-5j} * Y_{it-5j}]$$

The four-year lag is included because when nations invest in schooling, the effect on national income does not occur until the student enters the work force. The average delay depends on a nation's enrollment pattern, the pattern of expenditures per pupil across levels of schooling, and the delay between when the investment is made and when the student becomes an effective worker. Since the cost of a year of schooling rises with the level of schooling, the weighted average time lag between the investment in schooling and the entry of an educated student into the work force is less than half the average number of years that students spend in school. In developing this data set, this lag is assumed to be four years. In countries that provide relatively little schooling, the lag between the investment in schooling and the

[6] Israel was not included because the unusually high levels of immigration and emigration over the 1950-95 period made the cumulative investment in education unrepresentative of the educational level of the work force.

completion of schooling is likely to be shorter, but the students entering the work force are still children, so some additional time lag is likely before these young workers are effective on the job.

Although the length of a working life varies across countries, 40 years appears to be a reasonable estimate for most countries. The life expectancy of the population at age five is an indicator of the potential length of a working life for those receiving schooling. Figure A-1 shows the life expectancy at age five in 1960 for the 61 countries used in the data set. This life expectancy was calculated from data on life expectancy at birth and infant and child mortality rates in World Bank [1983]. Excluding the sub-Saharan African countries, life expectancy at age five in 1960 varied from 52 years in Guatemala to 74 years in Norway.[7] Workers live longer in the higher-income countries, but they also enter the work force later and have longer periods of retirement.[8] In the sub-Saharan African countries, in 1960 the average life expectancy at age five was only 46 years, which indicates that a working life was less than 40 years and that work force productivity likely suffered from high rates of morbidity.

A. Public Expenditures

With the assumed four-year lag and 40-year working life, the cumulative investment in formal schooling over the 1946-95 period determines a nation's human capital stock over the 1990-2000 period. UNESCO [1969, 1980, 1998a] has collected and published data on public expenditures on schooling since 1960 for most countries and since 1950 for a large subset of these countries. These data typically are available for years divisible by five. The sum of the eight years divisible by five within each 40-year period (multiplied by five) is used to estimate the cumulative investment.

[7] The members of the population with the lowest life expectancy are likely to have the least schooling and start working at an early age, so even in Guatemala the working life of an educated worker is likely to be 40 years.

[8] The average retirement age in the U.S. over the 1990-2000 period was 62.5 years [Murray, 2001].

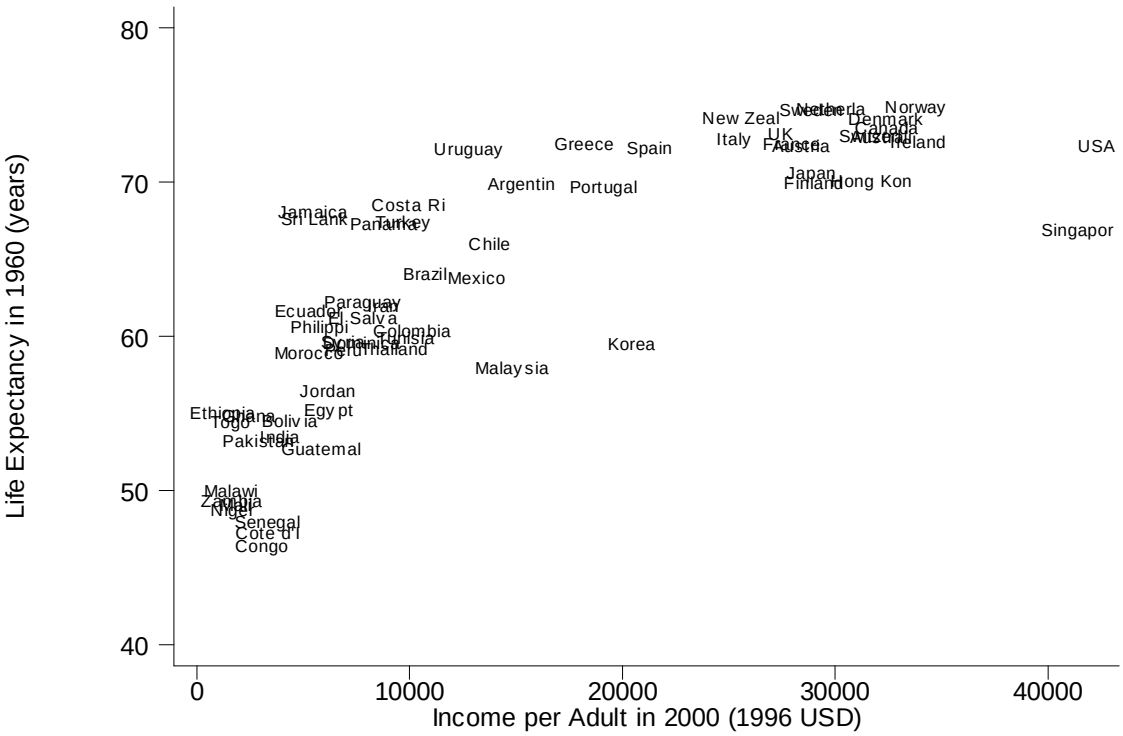

Figure A-1
Life Expectancy at Age 5 in 1960

Some sub-Saharan African countries without data for 1950 or 1955 were included in the data set to make the countries in the sample more representative of the world's distribution of national income. Missing data on public expenditures for 1950 and less frequently for 1955 were estimated from trends in UNESCO enrollment data over the 1950-60 period and from trends in the rate of public expenditures for the next available years. These expenditures generally were very small in these countries in those years.

Data on income per capita (constant price: Laspeyres in 1996 $) and population were obtained from version 6.1 of the Penn World Tables (PWT) [Heston, Summers, and Aten, 2002]. Missing data on population for 1950 and 1955 were obtained from United Nations [2001]. Missing income per capita data for 1950 and 1955 were estimated using income per capita growth rates from the next available five-year period.

The UNESCO rates of public expenditures in schooling are the share of GDP, not adjusted for cross-country differences in purchasing power (PP). These rates were multiplied times income adjusted for PP to estimate a nation's relative investment in schooling. A key assumption is that the nominal share of GDP expended on schooling and the PP-adjusted share are similar. While schooling is likely to be somewhat more labor-intensive than a nation's average economic activity, labor income accounts for about 2/3 of national income, so any differences between the nominal and PP-adjusted shares of national expenditures should be small.

The income model estimated in this paper is specified as income per adult. The number of adults in each year was estimated from the PWT 6.1 data on income per capita and income per equivalent adult. The resulting data on cumulative public expenditures per adult are shown in Table A-1.

Table A-1
Cumulative Public Expenditures in Formal Schooling of the Work Force

Country	**Public Expenditures (% of GDP)**										**Cumulative/Adult (1996$)**		
	1950	1955	1960	1965	1970	1975	1980	1985	1990	1995	1990	1995	2000
Argentina	1.4	3.2	2	3.3	3.3	2.5	2.7	2	3.4	3.6	9489	9769	10665
Australia	1.8	2.8	3.6	3.5	4.3	6.5	5.9	5.9	5.4	5.5	25426	29727	34103
Austria	3	4	3.7	3.7	4.6	5.7	5.6	5.9	5.4	5.6	24122	28449	33742
Bolivia	0.7	0.8	1.7	4.3	3.3	3	3.5	3.7	4	4.9	2769	3382	3904
Brazil	2.5	2.2	2.3	1.4	2.7	3	3.5	3.7	4.6	5.1	4886	6565	8238
Canada	3.1	3.9	6.1	8.5	8.5	7.6	7.3	7	6.8	6.9	43200	44146	48479
Chile	2.7	2.7	3.5	4.4	5.1	4.1	4.6	4.4	2.7	3.1	7020	7353	8201
Colombia	1.4	1.4	3	2.6	1.6	2.2	1.9	2.8	2.8	4	2906	4352	5639
Congo	1	1	1.2	2.4	6	8.1	7.1	5.1	5.9	6.1	2383	2954	3281
Costa Rica	1.7	2	4	4.7	5.2	6.8	7.8	4.5	4.5	4.6	8022	9487	9887
Cote d'Ivoire	1.2	1.6	4.7	5.9	6.7	6.6	7.2	7.4	7.7	5.3	4872	5478	5187
Denmark	3.1	3.8	3.9	5.7	6.8	7.8	6.9	6.3	7.5	7.7	38828	46880	55174
Dominican Rep	0.6	1.6	1.6	2.8	2.9	1.9	2.1	1.8	1.8	1.9	1770	1899	2144
Ecuador	1.4	1.6	2	3.5	4.3	3.1	5.6	3.7	2.6	3.4	4306	4273	4538
Egypt	2.3	2.3	5.2	4.8	4.8	5.1	5.7	6.3	4.9	4.8	4039	4477	4971
El Salvador	1.2	2.7	2.7	3.2	2.9	3.4	3.9	3	2	2.2	5504	5525	5334
Ethiopia	0.4	0.6	1	1.2	2.8	3.3	3.3	4.3	4.9	4	603	803	873
Finland	4.8	6.6	6.6	6	6.2	6.3	5.5	5.8	5.7	7.5	29516	34500	39962
France	2.4	2.4	3.2	4	4.7	5.2	5	5.8	5.4	6.1	23180	28719	34868
Ghana	1.5	2.5	4.5	4.6	4.3	5.3	3.1	2.6	3.1	4.8	1629	1694	1880
Greece	1.7	1.7	1.8	2.3	2	2	2.2	2.9	3.1	2.9	7308	9166	10888
Guatemala	1.8	1.5	1.5	2.3	2	1.6	1.9	1.8	1.4	1.7	2403	2000	2068
Hong Kong	1.3	1.5	2.4	2.4	2.9	2.7	2.5	2.8	2.8	2.9	7268	9763	12387
India	0.8	2	2.5	2.6	2.8	2.7	2.8	3.3	3.9	3.3	1082	1495	1768
Iran	2.6	2.6	2.6	3.2	2.9	4.6	7.2	3.6	4.1	4	5663	5922	6342

Ireland	2.7	3.4	4	4.2	4.9	6.1	6.6	6.7	5.7	6	19378	22426	26130
Italy	2.4	2.7	4.6	5.2	4.3	4.1	4.4	5	5.1	4.7	20135	24653	28905
Jamaica	2.4	2.5	2.9	3.1	3.6	5.9	6.9	5.7	5.5	6.4	6606	7732	8745
Japan	4.8	6.1	5.1	4.4	3.9	5.5	5.8	5.1	3.6	3.6	21136	24266	27568
Jordan	4.8	1.7	3.5	3	3.9	5.1	6.5	6.9	6.4	8.7	5925	5028	6415
Korea	5	5.6	5.6	2	3.7	2.4	3.7	4.5	3.5	3.7	5299	6700	9021
Malawi	1.5	2.2	2.9	5.1	4.1	2.4	3.3	3.5	3.4	5.4	700	847	1113
Malaysia	1	2	4.8	4.2	4.4	6	6	6.6	5.5	4.7	6833	8351	9815
Mali	0.9	1	1.5	4.5	4	4.7	3.7	3.7	3	2.2	1300	1290	1278
Mexico	0.8	0.9	1.4	2.1	2.6	3.6	4.2	3.9	4	4.9	7144	8043	9691
Morocco	1.5	3	4.4	4.2	3.7	5.1	6.1	7.4	5.5	5.8	4847	5246	5867
Netherlands	3.5	4.6	5.9	6.3	7.7	8.2	7.9	6.8	6	5.2	34860	39747	43601
New Zealand	2.4	3.5	3.8	3.8	4.9	6.1	6.1	4.8	6.5	7.5	26059	31146	36746
Niger	1.2	1.2	1	1.6	2	2.4	3.1	3	3	2.9	1070	1088	1066
Norway	3.2	4	5.4	5.3	5.9	7.1	7.2	6.5	7.3	8.1	31557	39117	48539
Pakistan	0.4	0.5	1	1.7	1.7	2.2	2	2.7	2.6	2.8	763	849	1077
Panama	3.6	3.9	4.2	4.8	5.4	5.7	5	5.2	5.4	5.2	7493	8327	9184
Paraguay	1.2	1.3	1.5	1.9	2.2	1.6	1.5	1.5	1.5	3.4	1998	2265	3202
Peru	2	2.1	3.1	4	3.8	3.3	3.1	2.7	3.3	2.9	5188	5250	5353
Philippines	2.4	2.5	3	2.5	2.6	1.9	1.7	1.4	2.9	3	1902	2382	2742
Portugal	1.4	1.8	2.2	1.7	1.6	4	4.4	5	5.1	5.3	9370	12440	15908
Senegal	0.9	1.2	2.2	2.8	3.8	3.5	3.7	3.8	4	4	1947	2465	2585
Singapore	0.5	1.5	3	4	3.1	2.9	2.8	4.4	3.1	3	7761	9800	13848
Spain	0.9	1.1	1.5	1.6	2.1	1.8	2.6	3.3	4.4	4.9	7889	11074	14995
Sri Lanka	3	3.1	4.9	4.5	4.3	2.8	3.1	3	2.7	3	2756	3006	3270
Sweden	3.5	4.8	5.3	6.2	7.7	7.3	9	7.7	7.7	8.1	41194	49043	56722
Switzerland	2	2.7	3.7	4.2	4.2	5.1	5	4.8	5	5.4	32837	37896	43213
Syria	2.3	2.3	5.2	4.1	4	3.9	4.6	6.1	4.3	3.3	4200	4271	4385
Thailand	0.6	2.9	2.8	3	3.5	3.5	3.4	3.9	3.6	4.1	2544	3372	4963
Togo	1.9	1.9	1.9	2	2.2	3.5	5.6	5	5.6	4.5	1681	1923	2020
Tunisia	3	5.8	5.8	8.3	7	5.2	5.4	5.9	6.2	6.8	7249	8323	9610
Turkey	2.3	1.5	2.9	3.8	2.9	2.8	2.6	2.3	2.8	2.2	3646	4180	4520
UK	3	4.1	5.3	5.1	5.2	6.6	5.6	4.9	4.9	5.3	27836	31674	35416
Uruguay	3	3	3	4.2	3.6	2.9	2.2	2.6	3.1	2.8	8749	9090	9415
USA	3.1	4	4.8	6.5	6.4	6.2	5.4	4.9	5.3	5.4	36222	41802	47196
Zambia	0.3	1	2	5	4.5	6.7	4.5	4.7	2.7	2.2	1990	1940	1851

B. Private Expenditures

Data on private expenditures for schooling are available for most countries but only for a few years, so private expenditures for schooling must be estimated using their ratio to public expenditures in these years. A single, non-varying ratio of total expenditures/public expenditures was created for each country by first estimating the share of private enrollment at each level of schooling and then weighting these shares by the relative cost of schooling at each level using the data in Tables 1 and 2. The starting

point was UNESCO [1980] data on gross enrollment in 1970 by level of schooling. 1970 was selected as a representative date for the 1945-95 period of investment. For primary and secondary school the share of private schooling was estimated using UNESCO [1998b] data on each country's private enrollment as a share of total enrollment in 1985. As UNESCO did not provide this data for university schooling, several other sources were used to estimate this share. OECD [2001] and OECD [2005] data on the shares of public and private expenditures at the university level during the 1990-2002 period were used for OECD countries and for seven other countries for which data were provided. A 50 percent private share was used for the Latin American countries for which OECD did not have data, as this was the average private share in the Latin American countries for which data were provided. A 15 percent private share was used for Islamic countries based on information in Sedgwick [2004]. For the few remaining countries, shares were assumed based on shares in culturally similar countries or set equal to the share at the secondary level. The overall private share was not very sensitive to these assumptions because these countries had very little enrollment at the university level. The data used to develop these ratios are presented in Table A-2. On average public expenditures were 84 percent of total expenditures on schooling. The ratios of total to public expenditures are not correlated with income/adult (r = -0.03), so no clear bias is created if cumulative public expenditures rather than cumulative total expenditures are used to estimate the effect of schooling on income.

Table A-2
Private National Investment in Formal Schooling

Country	Private % of Enrollment			Weighted Share			Ratio
	Primary	Secondary	University	Primary	Secondary	University	Total/public
Argentina	19	30	35	0.28	0.11	0.09	1.33
Australia	23	29	35	0.21	0.20	0.09	1.38
Austria	4	7	4	0.22	0.20	0.06	1.06
Bolivia	8	8	50	0.09	0.06	0.09	1.31
Brazil	12	12	50	0.10	0.04	0.03	1.23
Canada	3	7	43	0.20	0.17	0.17	1.21
Chile	32	39	76	0.09	0.07	0.06	1.89
Colombia	13	42	50	0.10	0.05	0.04	1.39
Congo	0	0	0	0.11	0.03	0.01	1.00
Costa Rica	3	9	50	0.10	0.04	0.07	1.24
Cote d'Ivoire	11	29	29	0.11	0.03	0.01	1.19
Denmark	9	14	1	0.18	0.23	0.09	1.11

Dominican Republic	24	30	50	0.10	0.04	0.05	1.47
Ecuador	16	34	50	0.10	0.05	0.06	1.43
Egypt	5	8	15	0.08	0.08	0.07	1.10
El Salvador	8	51	50	0.10	0.05	0.03	1.36
Ethiopia	11	6	10	0.10	0.05	0.00	1.10
Finland	0	5	4	0.21	0.22	0.07	1.03
France	15	22	16	0.22	0.18	0.09	1.22
Ghana	6	5	10	0.11	0.05	0.01	1.06
Greece	6	3	7	0.08	0.09	0.08	1.05
Guatemala	14	38	50	0.11	0.04	0.04	1.37
Hong Kong	10	12	50	0.10	0.06	0.04	1.24
India	5	5	22	0.09	0.06	0.07	1.12
Iran	2	3	15	0.09	0.07	0.03	1.05
Ireland	0	0	14	0.21	0.21	0.07	1.02
Italy	7	6	17	0.23	0.17	0.09	1.09
Jamaica	3	4	60	0.09	0.07	0.03	1.14
Japan	0	13	58	0.20	0.22	0.08	1.18
Jordan	8	19	19	0.09	0.08	0.02	1.16
Korea	1	39	85	0.27	0.14	0.05	1.28
Malawi	6	14	14	0.12	0.01	0.00	1.07
Malaysia	8	5	16	0.09	0.07	0.02	1.08
Mali	4	9	9	0.11	0.04	0.00	1.06
Mexico	3	4	23	0.10	0.04	0.05	1.09
Morocco	3	6	15	0.10	0.05	0.03	1.06
Netherlands	0	0	19	0.21	0.20	0.10	1.04
New Zealand	2	5	38	0.21	0.20	0.09	1.11
Niger	3	11	11	0.12	0.02	0.00	1.04
Norway	0	3	6	0.19	0.23	0.09	1.02
Pakistan	0	0	6	0.09	0.06	0.05	1.01
Panama	7	14	50	0.09	0.07	0.05	1.24
Paraguay	14	23	54	0.11	0.03	0.03	1.30
Peru	14	15	64	0.09	0.05	0.08	1.46
Philippines	6	41	50	0.08	0.07	0.11	1.51
Portugal	7	9	4	0.24	0.18	0.05	1.08
Senegal	9	29	29	0.10	0.05	0.02	1.21
Singapore	24	28	50	0.09	0.08	0.04	1.45
Spain	34	35	26	0.26	0.15	0.05	1.50
Sri Lanka	1	2	22	0.09	0.08	0.01	1.02
Sweden	0	0	10	0.20	0.20	0.11	1.02
Switzerland	2	6	6	0.23	0.18	0.07	1.04
Syria	4	6	15	0.08	0.08	0.07	1.09
Thailand	9	12	50	0.11	0.04	0.02	1.17
Togo	23	13	13	0.12	0.02	0.01	1.26
Tunisia	0	9	15	0.10	0.05	0.02	1.05
Turkey	0	3	3	0.10	0.05	0.04	1.01
UK	4	8	20	0.22	0.20	0.07	1.09
Uruguay	15	15	50	0.08	0.08	0.06	1.31
USA	12	12	55	0.16	0.21	0.20	1.37
Zambia	0	20	20	0.11	0.03	0.00	1.05

C. Foregone Earnings

Students' foregone earnings must be imputed, and these analyses are only available for a few countries. Estimates of the magnitude of foregone earnings relative to total expenditures are available for India and the United States from different studies for certain years during the period 1960 to 1979. A comparison of these estimates in these two countries is useful since arguably they represent both ends of the national income scale. Table A-3 presents the expenditures data, as a percent of GDP and as ratios of each component to total investment. While the estimates from the different studies vary substantially, foregone earnings appear to be approximately 70 percent of total direct expenditures on schooling in both countries. Since most of the expenditures on education are labor costs, as are the foregone earnings, it is plausible that foregone student earnings are a similar ratio of the direct costs of education across countries. At a minimum the results for India and the U.S. provide no indication that this ratio varies by national income level in any systematic way that might make differences in total expenditures a biased indicator of differences in the total investment in formal education. Foregone earnings are estimated to be 70 percent of total expenditures on schooling in all countries.

Table A-3
Annual Investment in Education in India and the United States

	Percent of GDP				**Ratio to Total Direct Costs**			
	India		**U.S.**		**India**		**U.S.**	
Year	**1960**	**1978-79**	**1960**	**1969**	**1960**	**1978-79**	**1960**	**1969**
Institutional Costs-Public	2.5	3.9	4.8	6.4	0.6	0.5-0.7	0.7	0.8
Institutional Costs-Private	-	0.2	1.3	-	-	0.1	0.2	-
Other Private Costs	1.7[1]	-	0.3[2]	-	0.4	0.2-0.4	0.1	-
Total Private Costs	1.7	1.9-3.5	1.6	1.7	0.4	0.3-0.5	0.3	0.2
Total Direct Costs	4.2	5.8-7.4	6.4	8.1	1.0	1.0	1.0	1.0
Foregone Earnings	2.2-3.6	4.2	2.0-4.9	7.3	0.5-0.9	0.6-0.7	0.3-0.8	0.9
Total Annual Costs	6.4-7.8	10.0-11.6	8.4-11.3	15.4	1.5-1.9	1.6-1.7	1.3-1.8	1.9
Sources	[1]Gounden [1967] & Kothari in Tilak [1988]	Tilak [1988]	[2]Schultz [1960] & Solmon [1971]	Kendrick [1976]				

Appendix II
Private vs. National Returns on Investment in Schooling in 1990

The average private return on investment (in percent) for 20 countries by level of schooling reported by Psacharopoulos and Patrinos [2004] in certain years is shown in Table A-4. The countries were selected because they had estimates for all levels of schooling for years close to 1990. These returns are estimated from the increase in worker earnings and the total investment in the schooling (private and public) of the worker. The overall private rate of return for each country was estimated as the weighted average of the private returns at each level of education, weighted by the share of the adult population whose education terminated at that level of education in 1970 and the relative public expenditures per pupil for that level of schooling in Tables 1 and 2. The external rate of return was calculated by subtracting the private rate of return from the national marginal rate of return on investment in 1990 estimated from the cross-country national income model.

Table A-4
Rate of Return on Investment in Schooling in 1990

	Private Rate of Return (%)				Share of Adult Population			Rate of Return (%)		
Country	Year	Prim	Second	Higher	Primary	Second	Tertiary	Private	National	External
Argentina	1989	8.4	7.1	7.6	0.42	0.44	0.14	7.7	26.9	19.2
Bolivia	1990	13	6	13	0.66	0.24	0.10	11.3	30.4	19.1
Brazil	1989	35.6	5.1	21.4	0.69	0.26	0.05	26.9	49.5	22.6
Chile	1993	8.1	11.1	14	0.52	0.39	0.09	9.8	20.4	10.6
Colombia	1989	20	11.4	14	0.70	0.25	0.05	17.6	61	43.4
Costa Rica	1989	11.2	14.4	9	0.61	0.28	0.11	11.9	24.8	12.9
Ecuador	1989	14.7	12.7	9.9	0.70	0.22	0.08	13.9	32.7	18.8
El Salvador	1990	16.4	13.1	8	0.75	0.22	0.03	15.4	26.5	11.1
Ethiopia	1996	14.9	14.4	11.9	0.96	0.04	0.00	14.9	62.6	47.7
Jamaica	1989	17.7	7.9	7.9	0.49	0.46	0.06	12.7	26.4	13.7
Malawi	1982	14.7	15.2	11.5	0.97	0.03	0.00	14.7	59.7	45
Mexico	1992	11.8	14.6	11.1	0.72	0.22	0.06	12.4	49.3	36.9
New Zealand	1991	12.4	12.4	9.5	0.05	0.77	0.18	11.9	23	11.1
Paraguay	1990	20.3	12.7	10.8	0.79	0.17	0.04	18.6	103	84.4
Philippines	1988	13.3	8.9	10.5	0.34	0.46	0.20	10.7	54.2	43.5
Singapore	1998	16.7	10.1	13.9	0.47	0.46	0.07	13.5	65.5	52
Spain	1991	7.4	8.5	13.5	0.35	0.56	0.09	8.6	63.2	54.6
UK	1986	8.6	7.5	6.5	0.13	0.73	0.14	7.5	23.7	16.2
Uruguay	1989	21.6	8.1	10.3	0.30	0.59	0.11	12.4	27.2	14.8
USA	1987	10	10	12	0.00	0.51	0.49	11	21.6	10.6
Average								13.2	42.6	29.4

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