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An Economy at Risk? The Social Costs of School Inefficiency

Many economists have studied the public school system of the United States, and most of them have reached the same conclusion: reducing expenditures would not reduce student achievement. Eric Hanushek (1986) analyzed sixty-five studies that examined the relationship between expenditures per pupil and student achievement on standardized tests. Only thirteen of the sixty-five studies indicated that lower expenditures produced significantly lower student achievement. (For an explanation, see the box entitled "You Get What You Pay For.")

If we assume, as do most economists, that a school system's primary objective is to produce measurable academic skills, then this economic evidence suggests that the U.S. public school system is inefficient. The inefficiency could arise from an inappropriate mix of inputs, a less effective use of resources than otherwise comparable schools, or the pursuit of unmeasured objectives (such as drug education) that consume school resources.[1] Inefficiency could be caused by regulatory constraints, a lack of competitive pressures, or incomplete information on the part of the producers and consumers of educational services.

School system inefficiency could be more than an academic concern. Edward Denison (1979) attributes 11 percent of U.S. economic growth over the years 1948–73 to increases in the educational attainment of the labor force. John Bishop (1989) estimates that gross national product would now be at least 2 percent higher if student test scores had continued to rise during the 1970s instead of experiencing their well-documented decline.

Few researchers, however, have directly examined the economic consequences of school inefficiency. I find that although school inefficiency can crowd out consumption and investment in the remainder of the economy and can reduce the rate of return to investments in education, it has only a limited impact on economic activity. I estimate that, even compounded over twenty-five years, plausible degrees of school inefficiency reduce consumption and potential GDP by less than 1 percent. As such, the social costs of school inefficiency are similar in magnitude to the social costs of the corporate income tax (Feldstein 1979) or of monopoly (Harberger 1954).

The degree of school inefficiency

Although the production-function studies described by Hanushek (1986) indicate that the typical U.S. school is inefficient, they are not designed to quantify that inefficiency. Thus, while they indicate that the typical school could cut spending without harming achievement, they do not indicate *how much* the school could cut spending without doing so. To measure the degree of educational inefficiency (how much could be cut), I turn to another form of research—frontier analysis.

Frontier analyses measure school inefficiency by identifying the most efficient schools in a study

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[1] *While society may value these objectives highly, they are difficult to quantify and have an uncertain relationship with our measures of economic output. Therefore, the economics literature has generally relied on standardized tests to measure the outputs of the educational process.*

You Get What You Pay For

To a large extent, reducing educational expenditures would not reduce student achievement because the primary determinants of educational expenditures—teacher salaries and pupil–teacher ratios—are uncorrelated with student achievement. Hanushek's (1986) survey of the literature identifies sixty studies that analyze the relationship between student achievement and teacher salaries and 112 studies that analyze the relationship between student achievement and class size. In both cases, only nine studies suggest that higher salaries or smaller classes have a positive effect on learning. The vast majority of studies indicate that small changes in salary or class size would have no systematic effect on student achievement.

The survey evidence does not imply that teachers are unimportant to learning. Economic research and basic common sense indicate that teachers are very important. (For an example of research on the question, see Hanushek 1971.) However, the analysis does indicate that teachers who earn higher salaries are generally no more effective than teachers who learn lower salaries.

One reason for the missing link between a teacher's ability and salary is that the observable characteristics for which teachers are commonly compensated—their educational background and experience—are uncorrelated or only weakly correlated with student achievement. Hanushek (1986) found only six studies indicating that teachers with advanced degrees are more effective than teachers with less education. He found five studies indicating that highly educated teachers are less effective in the classroom and ninety-five studies indicating no effect from the teacher's educational background. Similarly, only one-third of the relevant studies in Hanushek's survey indicate a positive effect from teacher experience; more than two-thirds of the studies found no such relationship. Furthermore, some of the studies indicating a positive correlation between teacher experience and student achievement may simply reflect the ability of experienced teachers to avoid students who are difficult to teach.

Intuitively, it is not surprising that researchers find no systematic relationship between student achievement and teacher characteristics like educational attainment and experience. After all, a person with a doctorate in mathematics may know more about the subject than a person with a bachelor's degree, but that does not mean that the Ph.D. is any more (or less) able to communicate that knowledge to students. Similarly, experience could help teachers hone their skills, but it could also cause them to burn out and become less effective.

and using their characteristics to define a production possibilities frontier against which the remaining schools are measured.[2] The most efficient schools are the schools that either need the fewest resources to produce a given level of student achievement or that produce the most student achievement with a given level of resources. The remaining schools are deemed inefficient because they use more resources or produce less achievement than comparable frontier schools. Researchers quantify that inefficiency by measuring the distance between the school's output and the production possibilities frontier.

Figure 1 illustrates a production possibilities frontier for schools that produce two outputs (y_1 and y_2).[3] Schools T and S help define the educational frontier. School A is inefficient. If school A behaved like school T, it could produce more of both outputs without any additional resources. Ratio *OT/OA* represents the proportion by which school A could expand both outputs. If *OT/OA* equals 1.1, then school A could expand both outputs by 10 percent if it used its resources efficiently. Thus, in this example, school A is 10 percent inefficient.

Most researchers use linear programming techniques to construct the educational frontier. Linear programming (LP) is a mathematical optimization strategy that finds the frontier by repeatedly solving a system of linear equations.[4]

[2] *By this methodology, virtually every industry will show some degree of inefficiency.*

[3] *This example, drawn from Grosskopf et al. (1994), measures inefficiency along a ray from the origin. Other studies use different measures of distance from the frontier.*

[4] *For more information on LP, see Chiang (1984).*

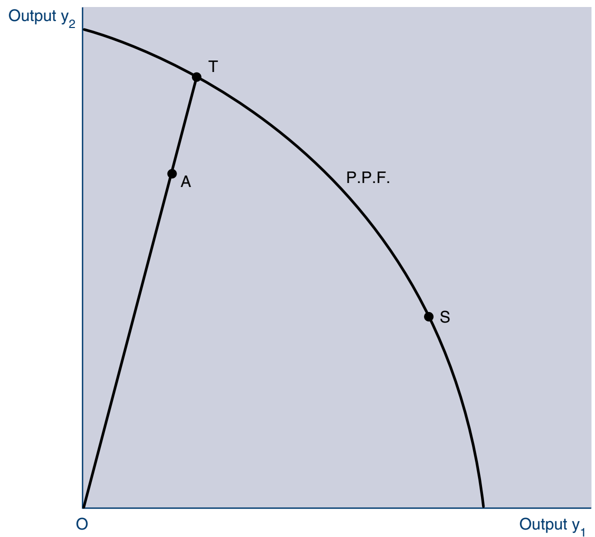
Because the technique is mathematical rather than statistical, LP is especially vulnerable to omitted-variables bias and measurement errors.

A few researchers use statistical estimation techniques to define the educational frontier. Steven Deller and Edward Rudnicki (1993) make strong assumptions about the distribution of inefficiency that allow them to use a maximum likelihood function to estimate the frontier.[5] Subhash Ray (1991) and Therese McCarty and Suthathip Yaisawarng (1993) use a two-step procedure that combines LP and regression analysis. In the first step, they use LP to construct an educational frontier that does not control for student and family characteristics. In the second step, they use regression techniques to adjust for the demographic characteristics that were omitted from the first step. The two-step procedure reduces problems associated with mismeasurement and outliers in the data, but it could yield biased measures of efficiency if the omitted student and family characteristics influence the optimal allocation of school resources.[6]

Most studies of the educational frontier in the United States suggest that primary and secondary schools are less than 15 percent inefficient, on average.[7] Four studies find school inefficiency of less than 5 percent (Bessent and Bessent 1980; Bessent et al. 1982, 1984; and Färe et al. 1989). Another four studies find inefficiency in the 5-percent to 10-percent range (Bessent et al. 1984, Sengupta and Sfeir 1988, Deller and Rudnicki 1993, and Grosskopf et al. 1994).[8] Ray (1991) finds an average inefficiency of 13 percent. The remaining study by McCarty and Yaisawarng (1993) suggests an average inefficiency of 77 percent, but the sample of schools is deliberately unrepresentative, making their extreme results a questionable indicator of the typical U.S. experience.[9]

It is important to remember that all of these studies base their description of the educational frontier on the "best practice" observed in the data. Thus, they yield relative, rather than absolute, estimates of inefficiency. It is possible that schools judged relatively efficient in these analyses are not reaching their full potential. Therefore, these estimates of inefficiency should be considered lower bounds on the absolute inefficiency in the public school system.

Figure 1
Production Possibilities Frontier



[5] Specifically, Deller and Rudnicki argue that OLS estimates of the production function have a compound error term ($\nu - \epsilon$), where ν represents production inefficiency and ϵ represents noise. They generate a conditional expected value for ν by using maximum likelihood estimation and assuming a normal distribution for ϵ and a half-normal distribution for ν.

[6] McCarty and Yaisawarng find that their two-step procedure yields efficiency estimates that are statistically similar to those produced by an LP model that incorporates demographics but treats them as exogenous inputs that schools cannot control.

[7] To be included in this discussion, a study of the educational frontier must have used data on primary or secondary schools in the United States, have attempted to control for student and family characteristics, and have reported its findings in such a way that a measure of technical inefficiency could be inferred.

[8] Bessent et al. (1984) is cited twice because it reports separately on school efficiency in 1981 and 1983. The higher inefficiency estimate reflects their study of 1981 data.

[9] Inefficiency for the two-step McCarty and Yaisawarng analysis is inferred relative to the most efficient school in their sample by adding a constant (the absolute value of the most negative residual) to their measure of "pure" technical efficiency ($\hat{u}_k$). Their LP calculations indicate an average inefficiency of 39 percent.

The economic impact of school inefficiency

School inefficiency can influence the economy in two ways. First, it can reduce the resources available for consumption and investment in the noneducational sector of the economy.[10] Second, school inefficiency can reduce the return to investments in the educational sector of the economy. It probably has both effects in unknown proportion. However, by estimating how much faster the economy could have grown if all of the resources lost through school inefficiency had instead been allocated to the noneducational sector (the pure first effect), and estimating how much faster the economy could have grown if the resource allocation had remained unchanged but inefficiency had not reduced the rate of return to education (the pure second effect), one can set bounds on the estimates of economic impact. As demonstrated below, using these two estimation approaches leads to very similar results and a reasonably narrow range for the estimated effect.

Although the two approaches attack the measurement problem from different directions, they both rely on the concept of social rates of return. The first estimation approach, which assumes that school inefficiency crowds out other productive activities, relies on estimates of the social rate of return to investments in physical capital. The second estimation approach, which assumes that school inefficiency reduces the rate of return to investments in education, relies primarily on estimates of the social rate of return to investments in primary and secondary education in the United States, although the return to physical capital also plays a role.

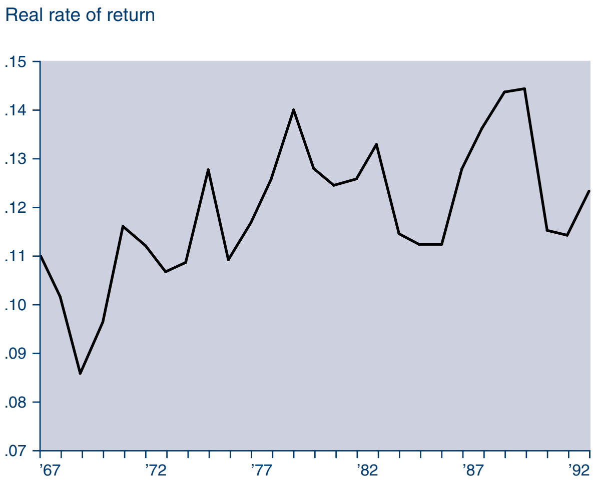
The social rate of return to any investment is the interest rate at which the present value of social benefits from an investment exactly equals the present value of social costs of that investment. The social benefits and costs equal the private benefits and costs plus any measurable benefits or costs to society in general. For example, public high school students do not pay tuition or for books, so their private cost of education is essentially the opportunity cost of their time. However, the government does pay the teachers and buy the books, so the social cost of an investment in education equals the private costs of the students' time plus the government's expenditures on education. Similarly, any tax revenues generated by an investment are a benefit to government and thus a part of the social benefits of that investment.

The social rate of return to physical capital. Considerable economic research suggests that the social rate of return to physical capital (that is, the rate of return gross of taxes and investment subsidies) is between 6 and 12 percent. Edwin Mills (1989) uses payments to capital, imputed rents, and capital gains to estimate rates of return to housing and nonhousing physical capital in the United States. He finds that since the 1950s, private, nonhousing capital (equipment and business structures) has earned a social rate of return (15 percent) that is roughly triple the social rate of return to housing (5 percent). Given the relative shares of housing and nonhousing capital investment since 1967, Mills' estimates imply an average return to physical capital of 12 percent. Cross-country analysis by J. Bradford De Long and Lawrence Summers (1991) suggests that the social rate of return to investments in manufacturing equipment exceeds 30 percent but that the social rate of return to investments in structures is negligible. Because their data indicate that equipment represents only 36 percent of U.S. investment, the De Long and Summers estimates would also be consistent with a 12-percent return to physical capital.[11] Psacharopoulos (1981) notes that 10 percent is a common rule of thumb for the opportunity cost of capital. However, some economists use a rate of return as low as 6.5 percent (for example, see King, Plosser, and Rebelo 1988).

[10] I define the noneducational sector as gross domestic product excluding the public primary and secondary educational sector. Because the national income and product accounts use educational expenditures to represent the output of the education sector, this approach is equivalent to subtracting public expenditures on primary and secondary education from gross domestic product.

[11] Let r_T be the rate of return to noneducational investment. Then, $r_T = r_E S_E + r_{NE}(1 - S_E)$, where r_E is the rate of return on equipment investment, r_{NE} is the rate of return on nonequipment investment, and S_E is equipment's share of total investment.

Figure 2
Annual Rates of Return to Secondary Education



The social rate of return to education. Research suggests that the social rate of return to primary and secondary education is comparable to the social rate of return to physical capital. Walter McMahon (1991) calculates internal rates of return to education over time and finds that the real social rate of return to investments in secondary education averaged 12.8 percent over the period 1967–88.[12] Using the same approach, I find that the rate of return to education for males averaged 11.9 percent over the period 1967–92 (*Figure 2*). (For a description of the data and the internal rate of return methodology, see Appendix A.) The most recent estimates of the internal, social rate of return for countries in the Organization for Economic Cooperation and Development (OECD) indicate an average rate of return to secondary schooling of 10.2 percent (Psacharopoulos 1993).

Most other estimates of the rate of return to education in the United States follow an estimation relationship developed by Jacob Mincer (1979). However, Mincerian rates of return equal social rates of return only when the social costs of an additional year of schooling equal one year of potential earnings for the person receiving the education.[13] If social costs exceed potential earnings, then the Mincerian rate of return exceeds the social rate of return. Similarly, if potential earnings exceed social costs, then the social rate of return exceeds the Mincerian rate of return. Over the last twenty-five years, the social costs of secondary education have averaged 1.2 percent of potential earnings, suggesting that researchers using Mincerian rates of return overestimate the social rate of return by 20 percent.[14] On the other hand, because investments in education exhibit diminishing returns and Mincerian rates of return seldom distinguish between secondary and post-secondary education, the Mincerian approach tends to underestimate the rate of return to secondary education.[15]

In general, Mincerian rates of return fall between 7 and 11 percent (for example, see Mincer 1979, Izraeli 1983, Angrist and Krueger 1991, and Card and Krueger 1992), although recent estimates have ranged as low as 2 percent (Low and Ormiston 1991) and as high as 16 percent (Ashenfelter and Krueger 1992). Correcting for the measurement of social costs (but not for the problem of diminishing returns) suggests a social rate of return to secondary education of between 6 and 10 percent. Thus, adjusted estimates of the Mincerian rate of return and direct estimates of the internal rate of return suggest that the social rate of return to

[12] *Because so few Americans have less than a primary school education, it is not possible to estimate the rate of return to primary education. International analyses suggest that the rate of return to primary education exceeds the rate of return to secondary education (Psacharopoulos 1984, 1993).*

[13] *In a Mincerian estimation equation, the coefficient on years of schooling equals* $r_s k_t$ *where* r_s *is the rate of return to schooling, and* k_t *is the ratio of total educational costs in period* t *divided by potential earnings in period* t *(Mincer 1979). Because cost information can be difficult to acquire, most researchers assume (as did Mincer) that* $k_t = 1$ *and interpret the coefficient on years of schooling as the rate of return* (r_s). *However, if* $k_t > 1$ *then the Mincerian rate of return* ($r_s k_t$) *overestimates the true rate of return* (r_s), *and vice versa.*

[14] *Potential earnings and social costs are derived as in Appendix A.*

[15] *The Mincerian approach does not yield credible estimates of the rate of return to primary education in the United States because potential earnings are zero for this group (see note 12).*

Table 1
The Resource Value of School Inefficiency

Year	Real expenditures (billions)	Resources available for reallocation — Inefficiency (billions): 5 percent	10 percent	15 percent
1965	$ 92.42	$4.6	$9.2	$13.9
1970	129.63	6.5	13.0	19.4
1975	143.50	7.2	14.3	21.5
1980	145.22	7.3	14.5	21.8
1985	157.42	7.9	15.7	23.6
1990	202.24	10.1	20.2	30.3

primary and secondary education lies between 6 and 13 percent.

In deriving these estimates, economists generally presume that wages reflect all of the benefits to education. If there are other benefits, such as the externality effects described in Lucas' (1988) model of economic growth, then researchers will underestimate the true rate of return. Similarly, if the wage increases that are associated with more education reflect greater innate abilities in addition to school effects, then researchers will overestimate.[16]

The costs of crowding-out. Assuming that school inefficiency crowds out investment and consumption in the noneducational sector, one can use estimates of the social rate of return to physical capital to estimate the growth consequences of school inefficiency. Because the educational frontier research suggests that U.S. public schools are less than 15 percent inefficient, I consider three cases—5-percent inefficiency, 10-percent inefficiency, and 15-percent inefficiency.

As Table 1 indicates, billions of dollars could be lost through school inefficiency. If those resources were allocated instead to the noneducational sector, then both consumption and investment could increase substantially. On average, investments in physical capital account for 16 percent of spending in the noneducational sector. Assuming that this tendency persists, each dollar reallocated from primary and secondary education would increase investment in physical capital by 16 cents. If such a reallocation had begun in 1967, and school inefficiency were 5 percent, then by 1992 the U.S. capital stock would have been between $34 billion and $38 billion greater than it actually was, depending on the rate of return to physical capital (see Appendix B).

In turn, any increase in the capital stock would have augmented future economic output. Given the range of estimates for social rates of return, each $1 increase in capital investment would have increased GDP by 6 cents to 12 cents per year. By 1992, a persistent 5-percent inefficiency in the school system would have reduced GDP by $2 billion to $5 billion per year, depending on the presumed rate of return (*Table 2*). A persistent 15-percent inefficiency would have reduced GDP by up to $13.8 billion.

Higher output and the redistribution of resources away from education would translate into higher consumption. Assuming that consumption's share of noneducational output remains unchanged, I estimate that consumption in 1992 would have been between $9 billion and $32 billion higher if the school system had been efficient (*Table 3*). Because consumption is a rough proxy for welfare, I estimate that persistent school

[16] *For a further discussion of biases in estimates of the rate of return to education, see Weale (1993).*

inefficiency reduced economic well-being in 1992 by between 0.3 and 1 percent.[17]

The costs of a lower rate of return to education. Rather than thinking of school inefficiency as crowding out other productive activities, one can think of it as reducing the social rate of return to education. After all, economists calculate social rates of return to education using the opportunity costs of student time plus actual expenditures on education as the measure of social costs and increased future wages as the measure of social benefits. However, an efficient school system would have spent less than the actual system spent. If the actual system were 5 percent inefficient, then an efficient system would have spent 5 percent less. Reducing expenditures by 5 percent reduces social costs by 2 percent, on average. In turn, lower social costs lead to higher rates of return. I estimate that the efficiency-adjusted rate of return to education is between 1.4 and 4.3 percent higher than the observed rate of return (see Appendix A).

To measure how much faster the economy would grow if investments in primary and secondary education earned a higher rate of return, I calculate annual returns to educational investments using a plausible range of values from the literature on social rates of return to education (6–13 percent). I then compare those returns to annual returns calculations that use the efficiency-adjusted rates of return in Table 4. The difference between the two calculations represents most of the additional output that could have been produced each year if the school system were efficient and therefore earning the higher rate of return (see Appendix B).

For example, the United States spent $109 billion on primary and secondary education in 1967. Together with the opportunity costs of the students' time, this represents an educational investment of $206 billion. Assuming a 13-percent rate of return, such an investment would add $26.8 billion to GDP each year. However, if the school system were 5 percent inefficient, then the

Table 3

The Annual Welfare Loss After Twenty-Five Years of School Inefficiency (Billions of dollars)

Social rate of return	Welfare loss — Assuming inefficiency of 5 percent	10 percent	15 percent
Method 1:			
12 percent	$10.7	$21.3	$32.0
6 percent	8.9	17.8	26.7
Method 2:			
12 percent	$9.8	$19.6	$30.1
6 percent	4.3	8.7	13.4

NOTES: Method 1 measures potential GDP through reallocating resources to the noneducational sector. Method 2 measures potential GDP through improved efficiency in primary and secondary education.

Table 2

The GDP Effect of Twenty-Five Years of School Inefficiency (Billions of dollars)

Social rate of return	GDP loss — Assuming inefficiency of 5 percent	10 percent	15 percent
Method 1:			
12 percent	$4.6	$9.2	$13.8
6 percent	2.0	4.1	6.1
Method 2:			
13 percent	$14.6	$29.2	$44.8
6 percent	6.5	13.0	19.9

NOTES: Method 1 measures potential GDP through reallocating resources to the noneducational sector. Method 2 measures potential GDP through improved efficiency in primary and secondary education.

[17] *Real consumption for 1992 was $3,342 billion (Council of Economic Advisers 1994).*

Table 4
Efficiency-Adjusted Rates Of Return to Secondary Education (Average rate for the period 1967–92)

	Efficiency-adjusted rate of return		
	Assuming inefficiency of		
Observed rate of return	5 percent	10 percent	15 percent
13 percent	13.2%	13.4%	13.6%
6 percent	6.1	6.2	6.3

rate of return could have been 1.4 percent higher. With a higher rate of return, the original $206 billion investment would have added $27.1 billion to GDP each year. Thus, assuming that the students in 1967 have an average working life of forty years, a 5-percent inefficiency in 1967 alone would reduce GDP by more than $300 million each year until 2007.

If all investments in primary and secondary education since 1967 had earned a higher, efficiency-adjusted rate of return, and the proceeds of those higher returns had been reinvested according to historical experience, then by 1992 GDP would have been between $6.5 billion and $44.8 billion higher, depending on the degree of educational inefficiency and the social rate of return to education (*Table 2*). Consumption, and therefore welfare, would have been up to $30 billion higher (*Table 3*).

Conclusions

A preponderance of the economic evidence demonstrates that the public school system in the United States is inefficient. Studies of the educational frontier quantify that inefficiency and suggest that the U.S. system is up to 15 percent inefficient, on average.

As demonstrated above, school inefficiency in the 5-percent to 15-percent range costs billions of dollars per year in foregone output. I calculate that twenty-five years of 5-percent inefficiency in primary and secondary education would have reduced GDP by between $2 billion and $15 billion. A persistent 15-percent inefficiency would have reduced GDP by between $6 billion and $45 billion. I find the lower bound on these ranges by assuming that school inefficiency crowds out other productive activities. I find the upper bound on this range by assuming that school inefficiency reduces the rate of return to investment in primary and secondary education.

The impact of such losses on a $5 trillion economy with nearly $3.4 trillion in consumption would seem rather minimal. By my calculations, twenty-five years of school inefficiency would have reduced annual output and consumption by less than 1 percent. However, Arnold Harberger (1954) found that the distortions induced by monopolies amounted to only 0.1 percent of output, and Martin Feldstein (1979) found that the distortions induced by the corporate income tax amounted to approximately 1 percent of output. The social costs of school inefficiency, therefore, cannot be dismissed.

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Appendix A
Rate of Return Calculations

The internal, social rate of return to education is the interest rate at which the present value of the social benefits from education equals the present value of the social costs. In general, economists use earnings differentials at age t (E_t) to measure the social benefits. Per-pupil expenditures plus the opportunity cost of student time equal the social costs (C_t). Therefore, the social rate of return is the interest rate (r) that solves equation A.1,

$$\text{(A.1)} \qquad \sum_{t=1}^{T} \frac{E_t}{(1+r)^t} = \sum_{t=1}^{T} \frac{C_t}{(1+r)^t},$$

where T is retirement age (65).[1]

Population surveys provide data on the annual earnings of males according to education levels and age groups (U.S. Bureau of the Census, 1968–93). For example, the survey of current population for 1992 indicates that men ages 18–24 years old who had a secondary school education earned $11,805 on average, while men in the same age group who had a primary school education earned $8,447 on average. The difference ($3,358) approximates the social benefit of education (E_t) because it represents the additional earnings associated with additional education.

The social cost of education (C_t) has two components. *The Digest of Education Statistics* (U.S. Department of Education 1993) provides annual information on enrollments and expenditures for public primary and secondary education. As in McMahon (1991), I approximate the opportunity costs of student time as 75 percent of the annual earnings of an 18-year-old male with a primary school education.

I find that the social rate of return to secondary education for males averaged 11.9 percent over the period 1967–92. As Figure 2 in the text illustrates, higher earnings differentials in the 1980s more than compensated for the increased expenditures on education and led to increasing returns to education over the period.

Equation A.1 can also produce efficiency-adjusted rates of return. For example, suppose that the public school system is 5 percent inefficient. Then the per-pupil expenditures could have been 5 percent lower without having any negative effect on the benefits of education. To estimate the efficiency adjusted rate of return, I reduce C_t by 5 percent of expenditures and recalculate. If school inefficiency is 10 percent, then I reduce per-pupil expenditure by 10 percent before calculating r. Thus, the efficiency-adjusted rate of return is the interest rate at which the present value of social benefits equals the present value of efficiency-adjusted social costs.

I find that over the period 1967–92, the efficiency-adjusted rate of return is between 1.4 and 4.3 percent higher than the observed rate of return, depending on the degree of inefficiency. Because expenditures' share of education costs has been rising, I also find that the gap between observed rates of return and efficiency-adjusted rates of return has been rising.

[1] For a further discussion, see McMahon (1991).

Appendix B
Calculating Inefficiency's Effect on GDP

Method 1

Each year, school inefficiency crowds out consumption and investment in the noneducational sectors of the economy. If E_0 is school spending in the initial period, and υ is the degree of inefficiency, then υE_0 represents the resources available for redistribution in that period. Let S_0 represent investment's share of the noneducational economy in the initial period. Thus, $S_0 \upsilon E_0$ is the increase in investment that results from the initial redistribution. The increased investment means that the capital stock in the next period will also increase ($\Delta k_1 = S_0 \upsilon E_0$). If the social rate of return to physical capital is r, then output in the next period (period 1) increases by $r\Delta k_1$.[1]

Table B1
Data for Method 1
(Inefficiency = 0.05, r_k = 0.12)

Year	School spending ($)	Investment share (%)	ΔCapital stock ($)	ΔGDP ($)
1967	108.8	.15	—	—
	116.2	.16	.83	.10
	122.2	.16	1.74	.21
	129.6	.15	2.75	.33
	129.9	.16	3.80	.46
1972	133.6	.17	4.92	.59
	137.9	.18	6.16	.74
	144.4	.16	7.51	.90
	143.5	.15	8.85	1.06
	141.9	.15	10.06	1.21
1977	144.6	.17	11.33	1.36
	143.8	.18	12.77	1.53
	146.5	.18	14.30	1.72
	145.2	.17	15.93	1.91
	140.9	.16	17.45	2.09
1982	141.3	.15	18.95	2.27
	146.2	.16	20.39	2.45
	150.6	.17	21.93	2.63
	157.4	.18	23.69	2.84
	166.0	.17	25.57	3.07
1987	172.7	.17	27.52	3.30
	185.7	.17	29.49	3.54
	195.5	.17	31.62	3.79
	202.2	.16	33.83	4.06
	206.7	.15	36.07	4.33
1992	213.0	.15	38.22	4.59

NOTE: All monetary values are in billions of dollars.

In subsequent periods, any additional output is available for consumption and investment, and any additional capital created in the previous period continues to generate returns.[2] Thus, in period t,

$$\Delta k_t = S_{t-1}(\upsilon E_{t-1} + r\Delta k_{t-1}) + \Delta k_{t-1},$$

and

$$\Delta GDP_t = r\Delta k_t.$$

For example, consider the data in Table B1, and let 1967 be the initial period. In 1967, real expenditures for public primary and secondary schools totaled nearly $109 billion (U.S. Department of Education 1993). Assuming that the school system was 5 percent inefficient, $5.4 billion could have been redistributed to the noneducational sector without reducing future GDP. Because investment's share of noneducational spending was 15 percent (Council of Economic Advisers 1994), investment would have increased by approximately $0.8 billion. Thus, at the beginning of 1968, the U.S. capital stock could have been $0.8 billion greater than it actually was. Assuming that the rate of return to capital was 12 percent, the additional $0.8 billion in capital would have added $0.1 billion to GDP in 1968.

In 1968, school spending totaled $116.2 billion, and the resources available for redistribution would have been $5.9 billion (.05 · $116.2 billion + $0.1 billion). Because 16 percent of noneducational resources were allocated to investment, investment in 1968 would have been $0.9 billion greater. By the beginning of 1969, the additional investments in 1967 ($0.8 billion) and 1968 ($0.9 billion) would have added $1.7 billion to the capital stock. Thus, GDP would have been $0.2 billion higher in 1969. If the pattern of inefficiency persisted for twenty-five years, then in 1992 the capital stock would have been $38.2 billion higher and GDP would have been $4.6 billion higher.

[1] I assume that most government spending is not investment spending so that the return on government spending (excluding primary and secondary education) is negligible.

[2] These calculations are gross of depreciation and do not include any costs imposed by distortionary school taxes. If depreciation were included, the estimates of social costs to inefficiency would be somewhat smaller. If tax distortions were included, the estimates of social cost would be somewhat larger.

(Continued on the next page)

Appendix B
Calculating Inefficiency's Effect on GDP—*Continued*

Method 2

School inefficiency can also reduce GDP by reducing the rate of return to investments in education. To measure this effect, I calculate the annual return to investments in education using credible bounds on the observed rate of return (6 percent and 13 percent) and compare them with the annual return implied by the corresponding efficiency-adjusted rates of return in Table 4. The difference represents part of the losses in GDP that can be attributed to school inefficiency. To be complete, I also consider the fact that some of the additional returns to education would have been invested in either physical capital or additional education and that any such investments would also augment GDP.[3]

In each time period, investments in primary and secondary education (I_t) represent the sum of actual expenditures and the opportunity costs of student time. *The Digest of Education Statistics 1993* provides annual information on total expenditures for public primary and secondary education. As in the calculations for the internal rate of return to education, I approximate the opportunity cost of time for secondary school students as 75 percent of the annual earnings of an 18-year-old male with a primary school education. Because they are generally too young to work legally, I assume that the opportunity cost of time is zero for primary school students. I use the GDP deflator to adjust for inflation. The data on real opportunity costs, real expenditures, and total costs can be found in Table B2.

To illustrate, consider the data in Table B2, let 1967 be the initial period, and let the observed return on investments in primary and secondary education (r_e) be 13 percent. In 1967, real expenditures were $109 billion, the total opportunity cost of the students' time was $97 billion, and total educational investment was $206 billion. In 1968, that $206 billion investment would have earned $27.1 billion if schools were efficient but only $26.8 billion if schools were 5 percent inefficient. The difference ($0.37 billion) represents the additional output that could have been produced in 1968. Assuming that expenditure shares were stable, that additional output would have produced an additional $0.01 billion in educational investment and an additional $0.06 billion in physical capital investment.

Assuming no change in educational efficiency, educational investments since the initial period (1967) would earn an annual return of

$$\hat{y}_{r_e,T} = \sum_{t=1}^{T} r_e I_{t-1}.$$

In 1969, $\hat{y}_{r_e T}$ = $55.6 billion ($r_e$ · ($206 billion + $222 billion)).

However, if the system were efficient, then output and investments in previous periods would have been greater, and the annual return would have been

$$\hat{y}_{r_e^*,T} = \sum_{t=1}^{T} r_{e^*}\left(I_{t-1} + S_{e,t-1}\Delta GDP_{t-1}\right) + r_k S_{k,t-1}\Delta GDP_{t-1},$$

where r_{e^*} is the efficiency-adjusted rate of return, $S_{e,t-1}$ is education's share in output, ΔGDP_{t-1} is the additional output in period t–1, r_k is the return to physical capital and $S_{k,t-1}$ is capital's share in output. If the school system were 5 percent inefficient, then in 1969, $\hat{y}_{r_e^*,T}$ = $56.4 billion ($r_{e^*}$ · ($206 billion + $222 billion + $0.01 billion) + r_k · ($.06 billion)). The additional output in period t would be

$$\Delta GDP_t = \hat{y}_{r_e^*,T} - \hat{y}_{r_e,T}\ .$$

If the school system were 5 percent inefficient and the social rate of return to education were 13 percent, then ΔGDP_t = $0.8 billion in 1969 and ΔGDP_t = $14.6 billion in 1992.

[3] I assume that investments in physical capital earn a 12-percent rate of return and that noneducational government expenditures earn a negligible rate of return.

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Appendix B
Calculating Inefficiency's Effect on GDP—*Continued*

Table B2

Data for Method 2

(Inefficiency = .05, r_k = .12, r_e = .13)

Year	Opportunity cost ($)	School spending ($)	I_e ($)	S_e (%)	S_k (%)	Y_{re} ($)	Y_{re^*} ($)	ΔGDP ($)
1967	96.95	108.8	205.8	.00	.00	—	—	—
	105.52	116.2	221.7	.04	.15	26.75	27.13	.37
	120.03	122.2	242.2	.04	.15	55.57	56.35	.79
	113.98	129.6	243.6	.05	.15	87.06	88.31	1.25
	107.05	129.9	236.9	.04	.15	118.73	120.45	1.72
1972	112.93	133.6	246.6	.04	.16	149.53	151.72	2.19
	138.47	137.9	276.4	.04	.17	181.58	184.28	2.70
	113.64	144.4	258.1	.04	.16	217.51	220.78	3.27
	90.83	143.5	234.3	.04	.14	251.06	254.88	3.82
	98.47	141.9	240.3	.04	.15	281.52	285.86	4.33
1977	94.57	144.6	239.2	.04	.16	312.77	317.64	4.87
	95.25	143.8	239.1	.04	.17	343.86	349.29	5.43
	85.52	146.5	232.0	.04	.17	374.94	380.94	6.00
	81.91	145.2	227.1	.04	.16	405.10	411.68	6.58
	71.89	140.9	212.8	.04	.16	434.63	441.78	7.15
1982	66.60	141.3	207.9	.04	.15	462.30	470.00	7.71
	61.45	146.2	207.7	.04	.15	489.33	497.59	8.26
	73.18	150.5	223.7	.04	.17	516.32	525.15	8.83
	71.84	157.4	229.2	.04	.17	545.41	554.86	9.46
	68.53	166.0	234.6	.04	.16	575.21	585.32	10.11
1987	62.52	172.7	235.2	.04	.16	605.70	616.49	10.79
	64.26	185.7	250.0	.04	.16	636.28	647.76	11.48
	60.90	195.5	256.4	.04	.16	668.78	680.99	12.21
	66.11	202.2	268.3	.04	.15	702.11	715.08	12.97
	65.78	206.7	272.5	.04	.14	737.00	750.76	13.76
1992	61.25	213.0	274.2	.04	.15	772.41	786.99	14.57

NOTE: All monetary values are in billions of dollars.