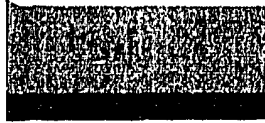


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HUMAN CAPITAL INVESTMENT IN WOMEN AND MEN

Micro and Macro Evidence
of Economic Returns

T. Paul Schultz

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T. Paul Schultz



An International Center for Economic Growth Publication

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This Occasional Paper draws upon two studies originally prepared by the author as a senior research fellow of the Institute for Policy Reform and distributed under IPR's Working Paper Series, to a readership distinct from the individuals and organizations who receive ICEG publications. Research fellows and policy practitioners are engaged by IPR to expand the analytical core of the reform process. IPR recognizes cultural, political, economic, and environmental elements as crucial dimensions of societies.

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PREFACE

We are pleased to publish *Human Capital Investments in Women and Men: Micro and Macro Evidence of Economic Returns* as the forty-fourth in our series of Occasional Papers, which present perspectives on development issues by noted scholars and policy makers.

In their attempts to quantify the role of human capital in economic growth, economists have focused mainly on education, which increases the skill level of the work force in addition to its ability to adapt to new technology. In this paper, T. Paul Schultz summarizes recent research and its limitations in order to assess the private and social rates of return to human capital investments in women and men. He examines relative investments in the education, health, and nutrition of women and men, as well as the effects of traditional social roles of men and women. Trends in education and health, and changes in the role of women profoundly affect not only women's earning power in relation to that of men, but also their mortality and fertility.

The benefits of investment in women's health and education are clear—benefits to society and to women themselves. The explanation for differential investments in women and men are difficult to quantify, however. Dr. Schultz hypothesizes that they are most likely imbedded in the family decision-making process that attaches less value to the productivity of daughters than to that of sons. Dr. Schultz leaves us with these questions: why does this occur, and what can public policy do to encourage greater equality in the allocation of resources? Although these questions have only begun to be addressed—and this issue recognized—Dr. Schultz provides a thorough overview and analysis of the related studies currently available.

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Professor Schultz is Director of Yale University's Economic Growth Center and is a noted scholar who has made theoretical and empirical contributions to our understanding of the role of human capital for economic growth and for human welfare. Dr. Schultz wrote this paper as a senior research fellow of the Institute for Policy Reform, which was established to enhance the scholarly foundation for broad-based economic growth in developing countries. Through its research, education, and training activities, IPR encourages active participation in the dialogue on policy reform, focusing on changes that stimulate and sustain economic development.

Economists, policy makers, and leadership groups everywhere will benefit from the analysis of differing human capital investments in women and men presented in this paper. Dr. Schultz's work represents an important contribution to ICEG's mission to promote reforms that will advance human welfare and help support emerging democracies throughout the world.

Nicholas Ardito-Barletta
General Director
International Center for Economic Growth

November 1993



ABOUT THE AUTHOR

T. Paul Schultz is Malcolm K. Brachman Professor of Economics at Yale University and director of the Economic Growth Center. He has previously been on the faculty at the University of Minnesota and before that director and founder of the Population Research Program at Rand Corporation. He received his Ph.D. from MIT in 1966 and has studied and taught economics of individual and family behavior, including time allocation to the labor force, wage determination, migration, marriage, fertility, schooling, and health, particularly as related to modern economic growth in low income countries. He has published articles on these subjects, a textbook entitled *Economics of Population*, edited *The State of Development Economics* (Blackwell, 1988), and *Research in Population Economics* (JAI, 1985, 1988, 1991), and participated on two National Academy of Sciences studies of population growth and development (1971, 1986). The causes and consequences of increased human capital investment in women and the economic consequences of improvements in adult health are his current research interests.

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T. Paul Schultz

Human Capital Investment in Women and Men

Micro and Macro Evidence of Economic Returns

Economists have sought for several decades to quantify the role of human capital in determining the pace and structure of modern economic growth. Most attention has been paid to education, which provides workers with productive skills and the ability to modify their routines in response to changing opportunities in a dynamic environment (Denison 1967; Welch 1970; T. W. Schultz 1975). Microeconomists have studied extensively the productivity of individual workers, whereas macroeconomists have analyzed aggregate output and the growth experience of nation states. With time, a consensus was forged that "modern economic growth," or what Kuznets described as "sustained periods of growth in total factor productivity," critically depends on improvement in a population's education and health.

Recent research and its limitations are summarized in this paper, which compares evidence on the private and social rates of return to

This paper draws upon two studies originally prepared for the Institute for Policy Reform. The author appreciates the comments on an earlier version of these papers from J. Heckman, B. Herz, Y. Mundlak, T. W. Schultz, D. Thomas, B. Torrey, and R. Willis. One paper is being published by the Kiel Institut für Weltwirtschaft, in a volume *Economic Growth in the World Economy*, and the other in a forthcoming symposium issue on "Women's Human Capital in Low Income Countries," of the *Journal of Human Resources*. Economic Growth Center, Yale University, P.O. Box 1987, Yale Station, New Haven, CT 06520.

the education and health of men and women. In the twentieth century a trend is evident for the "years of education" received by women to increase more rapidly than that received by men. In the high income industrially advanced countries this trend has proceeded a long way toward rough equality, although the metric "years of education" does not reveal that those years may prepare women for different occupations (for example, school teaching and nursing for women versus engineering and medicine for men). This conceals not only heterogeneity but systematic differences in quality reflected in the public and private resources actually invested in a year of schooling obtained by men and women.

Among low income countries the relative standing of women and men in terms of educational attainment differs substantially. Latin America has followed Western Europe, with the differences in years of education of men and women gradually narrowing. Southeast and East Asia have, following the path taken by Japan, increased the number of years of schooling received by women more rapidly than they have for men, closing the wide gap that historically separated them, for example, in the traditional Chinese family. In sub-Saharan Africa there is much variation in the form of the family, but throughout the region women play a major part in the labor force outside of the family in addition to performing the childrearing. In most countries of sub-Saharan Africa, however, women have only about half as much education as men do, though there are exceptions to this pattern in some countries in Southern Africa, such as Botswana and, to a lesser degree, Zimbabwe. North Africa and West and South Asia exhibit large differences in the education of men and women, and in this region the gender gap is only closing slowly.

Data from all regions from 1950 to 1990 suggest that the ratio of educational attainment of women to men is increasing. China after 1980 may be an exception, where the return to the "household responsibility system" for women may have been associated with some setbacks in secondary education of girls compared with that of boys in rural areas, where families now bear most of the opportunity costs of sending their children to school. Quantifying the economic payoff to educating women and men is a challenge discussed in this paper, in which I also accumulate evidence of differential returns, both private

returns to the individual and social returns to the society. Private and social returns to education generally appear to be higher in low income countries than in high income countries. There are reasons to anticipate, therefore, a convergence in per capita income levels across countries, holding constant for initial levels of human capital, if the growth in educational investments in low income countries continues to exceed that in high income countries.

Health investments are the second major category of human capital accumulation, but one about which our economic knowledge is much more limited. One class of studies has documented that improved nutrition in combination with a reduced burden of disease lead to increased adult height, which can be predicted on the basis of a child's height before age four. Early childhood diseases and nutrition, combined with a continuing adequate diet in adulthood, should allow adults to be more productive workers. The increase in average height of men and women in the last few centuries is documented in Western Europe and North America. There is a widespread belief that the same growth in stature is under way today in the low income world as incomes rise, real food prices fall, per capita calorie consumption increases, and major infectious and parasitic diseases are progressively curbed. Research by microeconometricians studying household surveys from a growing number of low income countries confirms the anticipated relationship between household allocations of nutrition and health inputs and the production of healthy children, and the links between well nourished and healthy adults and their productivity in the labor force.

From quite different data sources we also know that age specific death rates have declined much more rapidly in the low income countries since 1950 than they ever did in the high income countries. The resulting increase in life expectancy at birth for the low income world has been about two years with each passing decade, whereas in the nineteenth century the gains in life expectancy in Western Europe rarely reached one year per decade. This decline in mortality is of course the proximate cause of the acceleration of population growth from less than 1 percent per year in the low income countries at the start of this century to a peak of 2.5 percent per year in the 1960s.

In the area of health investments in men and women the comparisons must be more circumstantial, for the inputs to nutrition and health

are not as readily measured as years of school enrollment. The output of longevity, however, is estimated for most countries since 1950, although with substantial uncertainty given the incomplete registration of mortality. Longevity appears to have increased substantially more for females than for males in the industrially advanced countries, but this occurred largely in the twentieth century. A similar pattern seems to be occurring in low income countries, but again regions of the less developed world differ in this regard. If we can interpret increased longevity as associated with increased vitality and capacity for productive work, then most women have, for some economic or biological reason, gained a perceptible advantage in this century.

Labor market evidence of returns to schooling and health has its limitations. For example, fewer women than men report wage rates from which the researcher can infer their labor productivity. But given the statistical methods recently developed for dealing with these problems of sample selection and simultaneous determination of productivity and human capital investments, there is accumulating empirical evidence that private returns for men and women are not different within a country. Moreover, social returns, to the extent they can be measured, if not monetized, almost always favor investments in women.

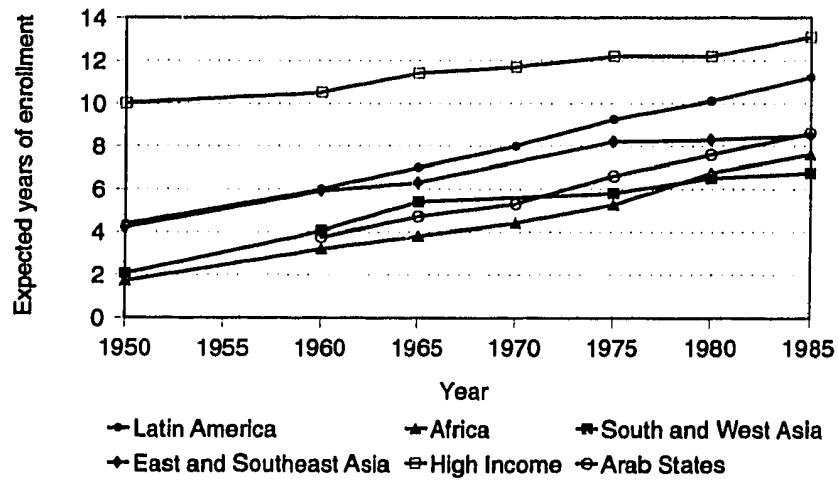
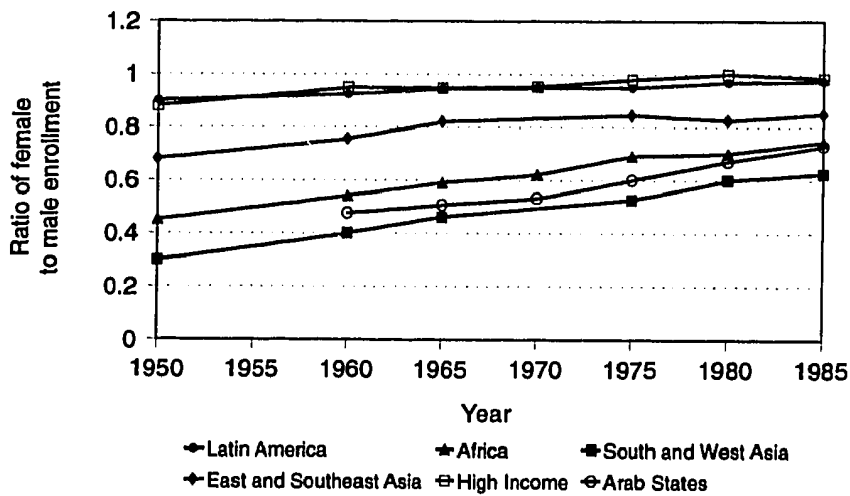
Another way to assess the importance of such difficult-to-evaluate social returns and externalities associated with human capital investments is to analyze aggregate growth performance in countries. Modern growth theory provides a new rationale for not only including human capital in standard neoclassical production functions, but also for looking for a context in which human capital might be a source of social externalities that could explain the general puzzle of increasing returns to conventionally measured inputs. As the empirical measures of human capital used in these aggregate studies of modern economic growth become more refined, it is expected that educational capital in the form of men and women will be disaggregated. These data, despite problems of collinearity, will likely suggest that the marginal social product of female schooling exceeds male schooling, and that those countries that have closed the gap between women and men in terms of their educational investments are also the same countries that have generally experienced the most rapid and consistent growth in the last half of the twentieth century.

Improving our knowledge about these processes is a challenge being taken on today by academic researchers and the donor community concerned with development of the third world. But with the unusual agreement emerging between the existing evidence derived from micro and macro analyses, policymakers would be prudent to weigh the current knowledge carefully. The neglect of social and private investments in education, nutrition, and health of both females and males is not likely to foster rapid economic development effectively. As yet very little work has focused on how public resources can be utilized to efficiently channel private resources into such high return schooling and educational investments. To progress with this work we must know much more about how families work and how public policies affect family opportunities, for this remains an area of decision making dominated by the family.

This paper is organized as follows. The first section following the introduction presents patterns in school investments in men and women across regions and across birth cohorts within countries. The second section reviews gender differences in mortality and nutritional status. The third section describes how market failure could be responsible for families investing less than the socially efficient amount in girls, and the problems of measuring without bias the resulting private and social returns. Gender differences in estimated returns to schooling are estimated in the fourth section. The fifth section reviews macroeconomic evidence of social returns to schooling. I conclude by posing questions for further research.

Investment in the Schooling of Women and Men

The average number of years of schooling completed by men and women in various age groups can be derived from some population censuses, but these estimates of stocks of education in the population are available from only a few low income countries over time. School enrollment rates by sex are published in the *UNESCO Statistical Yearbook* for most countries annually over the last several decades. A single measure of the flow of investment in education for a cohort is the "expected years of school enrollment" (Schultz 1987). It is

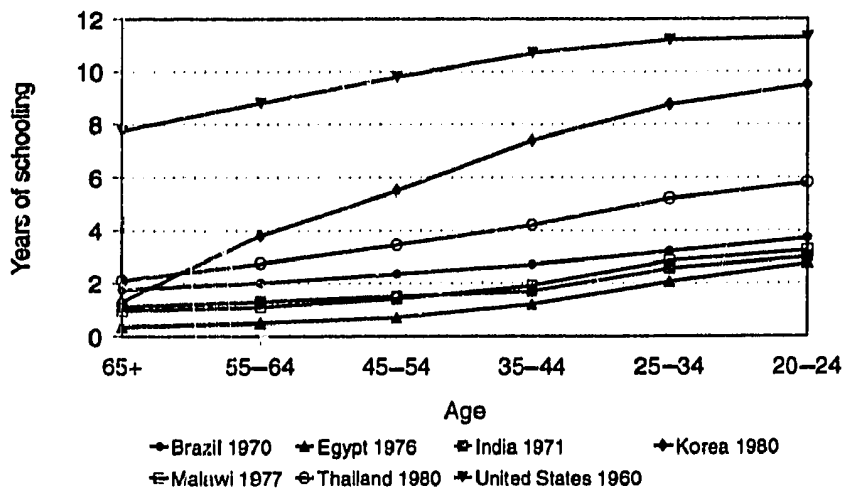
FIGURE 1 Expected Years of Enrollment by Region, 1950 to 1985

FIGURE 2 Ratio of Female to Male Expected Years of Enrollment by Region, 1950 to 1985


constructed by multiplying the gross enrollment rates at each school level (or age) by the number of years of study at that level (or age bracket), and summing over levels. There are, of course, many limitations to this single synthetic measure of educational investment in a cohort: (1) it ignores repetition of grades and partial attendance; (2) it is not adjusted for the length of daily school hours or of the school year; (3) it neglects quality of the schooling, which might be related to resources available per student; and (4) it combines different levels of education indiscriminately, whereas each year of schooling increases the value of the child's time in the next level of education, as does the child's maturing. All of these factors may contribute to overstating the value of education acquired at earlier years compared with later years, and to overstating the value of the same level of education in lower compared with higher income countries. This crude physical measure of expected years of enrollment will be subsequently refined with data on public expenditures per student per year by school level.¹

Expected years of school enrollment is converging between low and high income countries, as is evident from Figure 1, where the gap is shown to have closed from about seven years in 1950 to five years in 1985. In addition, figure 2 shows that women today are enrolled for nearly as many years of schooling as men are in industrially advanced,

DATA NOTES TO FIGURES 1 AND 2: The expected years of enrollment are based on the gross enrollment rates for three age (or school level) groups multiplied by the number of years in the age (school level) group. For example in the 1984 *UNESCO Statistical Yearbook*, Table 2.11 provides the age specific enrollment rates for designated regions. In this case the three age specific enrollment rates are each for six year brackets (age 6-11, 12-17, and 18-23), and thus is each multiplied by six and summed for a measure of "expected years of enrollment." To obtain disaggregated estimates for South and West Asia and for East and Southeast Asia, enrollment rates for individual countries were aggregated by school level and weighted by the population in the age groups conventionally attending that school level. Table 3.2 provides the primary, secondary, and tertiary enrollment rates, whereas the conventional duration of each nation's school system's levels is reported in table 3.1. In the earlier years, some countries do not report enrollment rates in Asia, such as in North Korea and Afghanistan. These countries do not represent a significant share of the Asian regions reported here, and for simplicity enrollment rates are assumed not to have changed in these countries from 1950 to the first year for which figures are reported, usually 1960, whereas U.N. population estimates by age are available for all countries to weight the enrollment rates. The figures for China are more unstable, and probably are subject to more error, despite the fact that they are derived from time series on enrollments that are consolidated into standard Chinese yearbooks on education. But these estimates for China are not necessarily the same as those implicitly used by UNESCO.

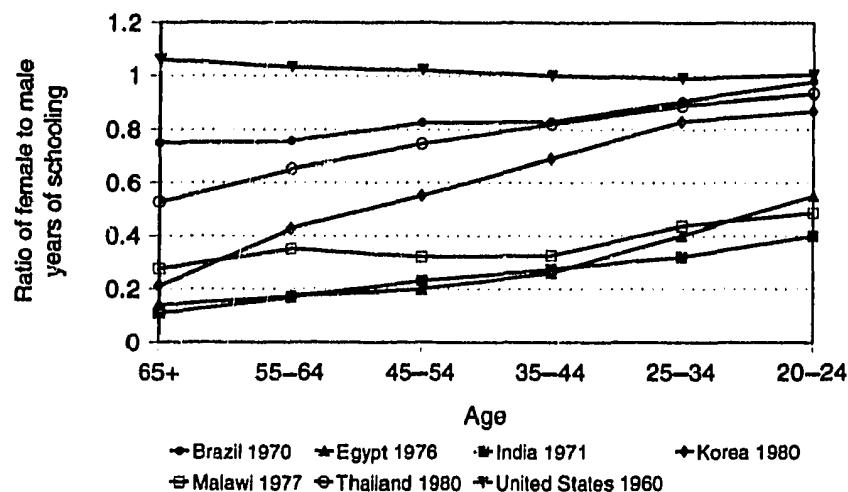
FIGURE 3 Years of Schooling Completed by Age, for Selected Countries



high income countries. Latin America and, to a lesser extent, South-east and East Asia, are relatively similar to the high income countries. At the other extreme are most of the countries of South and West Asia and North and sub-Saharan Africa, in which women receive about two-fifths to three-fourths the number of years of schooling men receive. This pattern for Latin America, Africa, and the high income countries is based on United Nations Educational, Scientific and Cultural Organization (UNESCO) regional estimates representing all countries of these regions. I have computed my own estimates separately for the subregions of Asia from individual country enrollment figures because of the noted differences in levels and trends among them. In every region distinguished in Figure 2, however, the ratio of female to male expected years of enrollment increases from 1950 to 1985.

From the alternative source of data on educational attainment—population censuses—years of schooling completed by age for seven selected countries are shown in Figure 3. The ratio of female to male educational attainment is then plotted in Figure 4. As the age cohorts

FIGURE 4 Female to Male Years of Schooling Completed by Age, from Selected Countries



advance in years, the relative gap between men and women in educational attainment is substantially larger, with the exception of the United States (see also Goldin 1992). School attainment and enrollment data, which typically come from independent statistical sources, imply similar estimates of years of educational investment for recent birth cohorts within this group of countries. The more widely available school system data on enrollments, thus, do not appear to be misleading indicators of the years of education that cohorts eventually complete who are currently matriculating in the system. But enrollment rates describe only current investment flows and do not describe directly the stocks of human capital available to the economy or labor force at any particular point in time. It is often difficult to estimate enrollment rates in low income countries before about 1960. For this reason, estimation of educational attainment among older cohorts, derived from historic enrollment trends, is uncertain but probably not too misleading for the entire labor force, because of its youthfulness (World Bank 1992). From both sources of data women's years of schooling are more nearly equal to that of men's in countries with

higher per capita income; over time women are making relative gains in those countries that achieved more rapid economic growth in the period 1960–1980 (Schultz 1989b).²

Public expenditures on education are reported for at least five years in forty-seven countries in real local currency units. These expenditures are converted according to 1969–71 foreign exchange rates into 1970 dollars. Averages of expenditures per student in these countries are reported in Table 1 for one-hundred and forty country-year observations, included at five year intervals. These estimates should be treated with caution, because this small sample of countries may not be representative of the regions I have grouped them into, or of the world as a whole.

Expenditures per student increase across regions with increasing income, with the exception of South and West Asia, which spend more per student than do Latin America and Southeast and East Asia. This anomaly can be traced to the higher relative cost of teachers in South and West Asia (Schultz 1987). In each country, however, public expenditures per student increase markedly at the secondary and higher educational levels compared to those at the primary level, particularly in low income countries and especially in Africa and South Asia (Psacharopoulos and Woodhall 1985).

Although public expenditures on education cannot be disaggregated into that which is spent on educating boys and that spent on girls, the expected years of enrollment, which are available by sex, can be weighted in these forty-seven countries for differences in average (boys and girls combined) public expenditure per student at the three levels of schooling. This adjustment incorporates the tendency for the fraction of female students to decline at higher levels in the school system, and for public subsidies per student to increase at these levels. Any differences in expenditures on male and female students within a given schooling level is neglected by this procedure, although it may be particularly important at higher levels of education, such as between teacher colleges for women and technical universities for men. No data could be found for most countries on the costs of educational sub-systems and their gender composition.

In most countries, relatively few youths attend school beyond the secondary level. Nonetheless, the inclusion of the higher level of

TABLE 1: Expected Years of School Enrollment and Annual Public Expenditures per School-aged Child, 1960s and 1970s

Region (number of countries observed) ^a	Expected enrollment per child ^b (years)	Annual public expenditure per child ^c (1970 U.S. \$)	Ratio of female to male	
			Years enrolled	Public expenditures
World (47)	8.9	2878.0	0.91	0.76
Africa (13)	5.7	455.0	0.73	0.50
Latin America (8)	8.0	801.0	1.03	0.83
East and Southeast Asia (6)	9.4	913.0	1.00	0.86
West and South Asia (5)	7.3	1234.0	0.59	0.52
High income countries (15)	12.0	6854.0	1.02	0.93

a. A country is included if *UNESCO Statistical Yearbooks* report for at least five years the required data on enrollments by sex, and on public expenditures by three levels of schooling. Countries included in sample (and span of years) are: Malawi (1965–1980); Mauritius (1965–1975); Rwanda (1970–1980); Tanzania (1965–1975); Zambia (1970–1980); Congo Republic (1970–1975); Algeria (1970–1980); Morocco (1965–1975); Tunisia (1975–1980); Ghana (1965–1980); Niger (1975–1980); Senegal (1970–1980); Burkina Faso (1975–1980); Trinidad/Tobago (1965–1980); Guatemala (1965–1975); Honduras (1965–1980); Mexico (1965–1975); Panama (1960–1980); Colombia (1965–1980); Paraguay (1960–1970); Venezuela (1965–1970); Japan (1965–1975); Hong Kong (1970–1980); South Korea (1960–1965); Malaysia (1975–1980); Philippines (1970–1980); Singapore (1970–1980); Thailand (1960–1975); Afghanistan (1970–1975); Iran (1970–1975); Iraq (1965–1970); Kuwait (1975–1980); Syria (1970–1980); Israel (1965–1980); Finland (1960–1975); Ireland (1960–1980); Norway (1960–1970); Sweden (1975–1980); United Kingdom (1970–1980); Greece (1970–1975); Italy (1960–1970); Portugal (1975–1980); Spain (1965–1975); Yugoslavia (1960–1970); France (1970–1980); West Germany (1960–1980); Netherlands (1960–1965).

b. Expected enrollments are derived by summing the weighted gross enrollment rates for the three school levels, where the weight is the reported duration of the school level in years.

c. Public expenditures for each school level include the current expenditures and a share of capital expenditures. Capital expenditures are smoothed by a five year moving average and interpolated in a few cases. Because capital expenditures are not allocated by level, they are divided among levels in the same proportion as that level's current expenditures are to all current school expenditures. Female and male students are assumed to receive the same expenditures on their education within the same school level.

NOTE: Data are averages for a sample of countries reporting time series on schooling expenditures by levels.

SOURCE: *UNESCO Statistical Yearbook*, various years.

education increases by 26 percent the total public outlays on education in this sample. Because women receive an especially small fraction of these opportunities for higher education in many countries, the ratio of female to male public expenditures on education is .76 for the full sample (that is, for the world), although women receive 91 percent as many years of education as men do. In Africa, the female to male ratio of years of enrollment is .73, while the ratio of public school expenditures is only .50. Even in Latin America, East Asia, and the high income countries, where the ratio of enrollments approaches parity, the ratio of expenditure on women relative to men declines to .83, .86, and .93, respectively. In South and West Asia the ratio of female to male enrollments starts at .59 and declines further in terms of public expenditures to .52. In sum, there is today a noted division in the developing world between those countries that are approaching parity in educational expenditures on women and men ($>.83$) and those that are not ($<.52$). Are these regional divisions closing over time, and are human capital investments in women catching up to those in men, in terms of education?

Rates of growth over time in the educational attainment level and gender composition of school enrollments and public expenditures on education can also be calculated for the same sample of forty-seven countries. These annual percentage growth rates are reported in Table 2. Expenditures have increased twice as rapidly in these countries as enrollments have in the world. The exception to this pattern is Africa, where enrollments increased nearly as rapidly as expenditures. African school systems have reduced their costs per enrolled student; this has been accomplished through a reduction in the relative cost of teachers associated in part with replacing expatriates with natives, and reducing the relative wages of teachers as the available native supply of potential teachers increased (Schultz 1987). Salaries of teachers accounted for 90 percent of public expenditures on education in low income countries in 1981—as they did in the last half of the nineteenth century in the United States (World Bank 1981; Fuchs 1968). The capacity of an educational system to reduce the cost of teachers—the dominant input to education—can contribute importantly to the rate of expansion in enrollments and alleviate the requirements for public education resources during the early stages of expansion of the national school

TABLE 2: Annual Growth Rates in Expected Years of School Enrollments and Public Expenditures per School Aged Child, 1960s and 1970s (Percentage)

Region (number of countries observed) ^a	Expected enrollment per child ^b (years)	Public expenditure per child ^c (1970 U.S. \$)	Ratio of female to male	
			Years enrolled	Public expenditures
World (47)	2.0	5.4	0.74	0.85
Africa (13)	3.3	3.7	1.6	0.70
Latin America (8)	2.3	5.2	0.07	1.2
East and Southeast Asia (6)	1.1	3.3	0.81	1.8
West and South Asia (5)	2.8	7.7	1.5	0.45
High income countries (15)	0.95	7.2	0.10	0.52

NOTES and SOURCES: See Table 1.

system. There are dynamic external economies of scale in education, because increases in output contribute to reducing the cost of the main input of schools: teachers. Expansion of the school system is often implicated in the compression of wages, a perception that contributes to a reduction in the returns to education (Knight and Sabot 1987; Lam and Levison 1991; Almeida and Barros 1991; Londoño 1990).

Every region in Table 2 shows a tendency for the ratio of female to male enrollments and the ratio of female to male school expenditures to increase. The increase varies substantially across regions, however, as does the gap to be closed between total human capital investments in men and women. The slowest rate of increase of female to male expenditures on schooling is in South and West Asia—.45 percent per year—and this slow advance is based on the initially low level of the female to male expenditure ratio of .52 (Table 1).³ Thus, the low income region that currently invests the least in the education of women compared to men is closing this gap in expenditures more

slowly than other regions, or falling further behind. Why are these regional differences so substantial and persistent?

There are two plausible reasons parents in low income countries do not invest more in the schooling of their children: the low returns on schooling and their own low income. Parents may see the expected private rate of return to schooling of their children as low relative to the alternative investment opportunities. Even when expected returns are competitive, parents may not invest an efficient amount in the education of their children because of their aversion to the associated risks or because of credit constraints that limit their ability to borrow funds to invest in the future productivity of their children. Both risk aversion and credit constraints are likely to be more important among the poor who have fewer opportunities to diversify such risks in their portfolio or offer other collateral for borrowing to finance investment in education.

Education can also be viewed by parents partly as a normal consumption good for which their demand increases with their income, holding constant the return (or inverse of the net price) of education. Parents may be called altruistic if they derive utility from increasing their children's future consumption by educating them. From either perspective, parent income moderates the effect on the demand for the investment good of risk aversion and credit constraints, or parent income increases the demand for education as a consumption good. Clearly, it is difficult to distinguish between these alternative explanations for the relationship between parent income and child education. From either viewpoint, parent demand for schooling is expected to increase with their income, and as the price decreases, even though schooling is considered mainly as an investment good, at least by economists.

Based on cross country comparisons from 1950 to 1980, school enrollment rates increase with national income per adult and decrease with the relative cost of teacher salaries. The estimated positive income and negative price elasticities of school enrollment are both larger in absolute value for female enrollment rates than for male enrollment rates (Schultz 1987). The larger response of female enrollment rates (than those of males) to income and prices are also observed within countries over time during the 1960s and 1970s (Schultz 1989b). Per

capita income increases and the relative price of teachers decreases with economic development, and according to these estimates both changes reduce the relative and absolute gap between enrollment rates for women and men. Family level studies have also found that the household income elasticity of the school enrollment rate of daughters exceeds that of sons, and distance from residence to school is a greater deterrent to enrollment for girls than for boys (Lavy 1992; Tansel 1993; Deolalikar 1993).

Public expenditures on education are not commonly disaggregated by sex of student. It is not possible, therefore, to estimate how public sector expenditures on female and male schooling respond distinctly to income and prices, but the income elasticity of total public expenditures on schooling clearly exceeds one, and not surprisingly. The income elasticity is higher at higher levels of education when estimated from cross sectional or time series variation at the national level (Schultz 1987, 1989b).

A question that has not been pursued is whether gender differences in educational investments across countries and within countries over time are a response to gender differences in private and social returns to schooling. If enrollment does not respond positively to returns, then are we to conclude that the distribution of schooling is misallocated as an investment? Does the allocation of human capital between the sexes affect the differentials in returns to schooling and lead men and women with comparable skills to perform different tasks in the economy? This set of issues is clearly difficult to pursue and not attempted here.

Investments in Health and Nutrition

Much less is known about the differential nutritional and health-related inputs invested in men and women than about the gender allocation of educational investments. Biological relationships are postulated between human nutritional inputs, physical growth, metabolic requirements for body maintenance, and finally an energy "excess" that can be allocated to productive and leisure activities. The efficiency of this energy conversion system, however, is affected by exposure to

disease, and the immune system itself draws on nutrition inputs to fight infections and parasites. Given the complexity of these processes and the long lags between inputs and outcomes, research on nutrition has sought indicators of the net (or final) outcomes—such as height—rather than trying to quantify all of the inputs and production functions that underlie human growth and health status. Moreover, as long as health and nutrition inputs are themselves allocated within families and societies in response to unobserved (by researchers) healthiness of individuals, direct estimates of health technology, or of the effects of inputs on health outcomes, can be quite misleading. This heterogeneity bias will be present even if all inputs are accounted for and functional forms of the health production process are known (Rosenzweig and Schultz 1983).

Most analyses of health technology have focused on the least ambiguous (and most final) outcome: mortality. Anthropometric indicators of health, such as birthweight, height for age, body-mass-index (defined as weight divided by height squared), and skinfold thickness, are justified as readily measured proxies for cumulative health status by the strength of their correlations with age-specific mortality (Fogel 1990). There is, however, a view that too much emphasis has been given to mortality, and conversely that measures of morbidity, such as limitations on physical functioning, should be consulted to assess the health of the living. For this view to carry weight, different health investments and behavior must be effective in modifying morbidity and mortality, and these two measures of health do not always have the same consequences (see Strauss et al. 1993).

Under the conditions prevailing today, females appear to live longer than males, given apparently equivalent diet and medical care. In the industrially advanced countries of Europe, European settlement, and Japan, females at birth are today expected to live four to eight years longer than males (United Nations 1982). The mortality advantage of women seems to be a recent development, however. Before the twentieth century, male mortality appears to have been infrequently higher than female mortality, and sometimes lower (Preston 1976; Fogel 1986; Pope 1992). Some countries in South and West Asia—such as India, Pakistan, Bangladesh and Nepal—continue to report more males than females in their population; this can be attributed to

the higher mortality rate among females than males from birth until at least the end of childbearing or age forty-five (see, for example, Visaria 1971). In general, where the overall level of mortality is lower and life expectancy at birth is longer, the relative mortality advantage of women compared with that of men is larger (Stolnitz 1956; Preston 1976).

Three hypotheses for this change in sex differences in mortality are that (1) the causes of death have changed, probably due to the introduction of medical treatments for infectious and parasitic diseases; (2) the diet or medical care of females compared with that of males improved; or (3) differences in occupations have changed, and the health risks associated with these roles differ, with the new outcome favoring women. Data on cause of death are not particularly reliable historically, and are often of uncertain quality even today in many low income countries. Most cause-of-death rates disaggregated by sex indicate more frequent male than female deaths within most cause-specific categories, with a few notable exceptions. The shift in the cause-of-death composition with rising incomes does not, however, according to Preston (1976), explain the increasing female advantage of survival over males in the twentieth century. Only a small part of this change, for example, can be explained by the decline in fertility and reduced risk of immediate maternal mortality.

Confronted by this puzzle, Preston disaggregated age-standardized death differentials between males and females into thirteen causes of death. He finds that the increase in male relative to female mortality associated across countries with rising average income is explained mostly by cardiovascular disease: neoplasms, tuberculosis, and influenza, pneumonia, and bronchitis. Family and social allocations of health investments may play some role in some of these sex differences in mortality by cause, but the evolving exposure of men and women through occupational roles determined by technological change and urbanization, as well as possible biological differences in their vulnerability to specific diseases, cannot be ruled out as the originating factor for these patterns. For example, diarrheal diseases and other infectious and parasitic diseases that are a major cause of high mortality at low income levels, and which might be expected to respond noticeably to intrahousehold resource allocations of food and health care, are not

quantitatively important to the changes in the gender balance of mortality that occur with development (Preston 1976).

If the decomposition of death rates by cause does not generate any salient hypotheses for why female mortality declines more than male mortality in this century and with development, several characteristics of the environment do. Problems of multicollinearity among explanatory variables at the national unit of observation limit the confidence we can attach to such estimated relationships, but they are a useful source of hypotheses that may be refined at the micro level. Agricultural populations have higher female relative to male mortality rates and higher overall death rates. Cardiovascular and neoplasm deaths and those related to respiratory diseases become relatively more important in urban areas and take a disproportionate toll of males (Preston 1976).

Preston then considers another variable that is more difficult to interpret, because it is a product of two functionally dissimilar variables: the grams of animal protein consumed per capita and the female to male ratio of primary school enrollments. This hybrid variable, holding constant for metropolitanization and agricultural employment share, is associated with greater male relative to female mortality through its correlation with deaths due to cardiovascular disease and violence other than automobile accidents, and because of declining maternal mortality due to lower fertility. Other than this single study by Preston (1976) and Preston and Weed (1976), there are few multivariate explanations for the recent marked changes or variation in the gender balance of mortality. All that is known, then, is that with metropolitanization and a shift of employment out of agriculture, mortality declines more rapidly for females than for males.⁴ It is possible that this is related to increasing returns to health investments in women in urban areas where women have increased their schooling and entered the labor force as their wage opportunities have improved relative to those of men. Alternatively, other changes in the rural-urban composition of endemic diseases and the greater availability of public and private health services in urban locations may have favored the health of urban women independently of their economic productivity.

Adequacy of diet increases adult height and alters the age pattern of growth and timing of sexual maturation, all of which is presumably

also affected by diseases and behavior (Falkner and Tanner 1986, volume 3). Historical analyses of the change in height in Western European populations in recent centuries has documented substantial growth in the stature of men and women (Tanner 1981; Fogel 1986); but relatively little attention has been paid to measuring differences in adult male and adult female height, or to analyzing the origins of changes, if any, in these sex differences. Some have argued that females, compared with males, "are more readily thrown off their growth pathway by environmental adversities, such as malnutrition and disease, and that they respond more dramatically to environmental improvement" (Bielicki 1986; p. 298), but the evidence is weak. Sexual dimorphism in regard to human growth may not, however, all be biological in origin, but rather it could be a response to cultural and economic factors filtered through household allocations (van Wieringen 1986; Waldron 1983, 1986). How surpluses and shortfalls in food supplies are shared in the family and society is affected by what roles men and women undertake and the physical claims that these work activities place on their dietary intakes (see Pitt et al. 1990).

There are few studies that separately assess how the height of men and women varies with economic conditions and how their height affects mortality, morbidity, and economic functioning.⁵ There is little evidence that adult height has increased relatively more for females than for males in the nineteenth and twentieth centuries in Western European populations, although the adolescent growth spurt may have shifted more sharply to a younger age for girls than it did for boys (Bielicki 1986).⁶ There is also evidence that height increased more rapidly in urban than in surrounding rural areas in several European populations, but sex differentials in these gains or how they contributed to improved adult health or economic functioning is not discussed.

In sum, there has been a dramatic, but largely unexplained, advance in female longevity relative to that of males in the twentieth century that is evident in most countries, with the exception of certain countries in South Asia. This development is associated with the shift of populations from dependence on agriculture to working in urban areas. Height, because of dietary improvements and disease control, has been increasing for as long as two hundred years in some Western

European populations. New studies are needed to assess the conditions under which gains in stature differ for women and men with distinct consequences for their economic functioning and welfare. Have health inputs for women increased relatively more than they have for men in their families or in the society at large? The gains in longevity and stature have not yet been analyzed in conjunction with women's schooling and labor force participation, inside and outside of the family, to assess whether these factors account for the increasing productivity of females relative to males. These changes are a major source of decreasing inequality within and between countries in this century (Rosenzweig and Schultz 1982; Schultz 1990).

Micro Evidence of Individual and Social Returns

Returns of individuals, families, and society. Returns to education are calculated from information on the benefits and costs, and can be reckoned from three perspectives: that of the individual student, the student's parents, or the society. The private individual's projected net gains in productivity associated with schooling are offset by private opportunity costs—that is, time lost to the family—and direct private costs. Individuals are assumed to maximize their lifetime wealth by investing first in forms of human and physical capital that earn them the highest internal private rates of return.

In reckoning education's costs from the perspective of the society, public sector subsidies to education are included with the private costs of education. In addition, there may be social benefits from the educated individual's increased future productivity and altered behavior that are not captured by the individual.⁷ More educated workers tend to work more outside the home in taxable activities. Taxable labor supply tends to increase with the education of women, but the wives of more educated men supply fewer hours of labor in taxed activities. Moreover, men's market or wage labor supply tends to be relatively unresponsive to increases in their education (Schultz 1981).

Education of women influences their health, longevity, and welfare and that of their children, and perhaps of other members of their family (see, for example, Cochrane et al. 1980; Schultz and Tansel

1992; Strauss et al. 1993). Education of women also influences family size. If these effects embody social as well as private benefits, they are externalities of women's education that should be taken into account in setting public sector priorities. Indeed, public subsidies are already provided to improve child health, nutrition, and schooling, and, through family planning programs, to help couples avoid unwanted births. In the literature on educational returns, however, social externalities are neglected in practice, because their quantification is controversial and there is no agreement on how to value them equivalently to the opportunity costs and market production gains of education. Most estimates of social returns to education therefore simply adjust the private individual returns downward by adding into the computation the public subsidies for education (Psacharopoulos and Woodhall 1985). Despite the measurement difficulties, the difference between social and private returns is the relevant criterion for allocating public resources (including education) among competing programs to maximize social welfare. If private resources were initially allocated efficiently to activities generating the highest individual returns, social subsidies should supplement private resources only in those activities where social returns exceed private returns.

Between the individual and the society there exists a fuzzier intermediate level of aggregation—the family, or, more specifically, parents who have some interests in and responsibility for their children. Educational decisions for children are undoubtedly influenced by the willingness of parents to sacrifice their current consumption for the schooling of their offspring. How are the motivations of parents to be characterized? One view of the family is that it provides a context for people to transfer resources over time.⁸ The inability to internalize in the family all of the individual private returns to human capital investments in children because credit markets facing parents are imperfect could explain the common practice of public subsidies for education and other interventions to help investors in human capital, such as need-based scholarships and student loans.

In their investments in and transfers to children, parents need not treat all of their children equally. The private returns to schooling for different children may differ. The family must then consider whether to be guided only by efficiency, in other words maximizing total

private returns, or whether to also assign a value to equalizing consumption opportunities among their offspring.⁹

With these distinctions in mind, the educational investments in men and women can now be considered as a potential instance of market failure. Three factors might motivate parents to invest systematically more in the health or education of boys than of girls (Gertler and Alderman 1989). First, private individual returns to education for women may be lower than for men, possibly because the technologically derived demands for female labor do not assign as large a relative premium to educated female labor as to educated male labor. This line of reasoning presumes that the labor of males and females is technically different in the sense that they are imperfect substitutes for each other in some activities. These female and male market returns to more educated workers are estimated later in this paper to assess whether they commonly diverge.

Second, remittances to parents may be smaller from daughters than sons. Third, for reasons unrelated to the individual private returns or to rates of remittances, parents may derive more satisfaction from the economic success of their sons than of their daughters. If the second and third sources of intrafamily gender differences in human capital investment are important, parental allocations of these human capital investments will not be productively efficient. Subsidized loans for female education could, under these conditions, promote a socially more efficient pattern of investment that would maximize economic growth. Social external returns to women's schooling provide a further rationale to subsidize female education more than male education.

There are three limitations in our capacity to measure the economic returns to education. Comparative studies of worker productivity cannot, in most cases, be based on experimentally controlled variation in human capital investment across a sample of people. Thus, those who acquire more education than others may differ in many ways that could influence their productivity, whether or not they are educated (Griliches 1977). Controls for ability and other characteristics of the worker may reduce omitted variable bias in estimates of the returns to education, but the introduction of these controls into the wage function also increases errors in the measurement of schooling, with the consequence of adding a downward bias to the estimated returns to education (Griliches 1977;

Lam and Schoeni 1991). Evidence that additional controls for ability appreciably alter male–female comparisons of the private individual's returns to education has not been advanced, and I expect whatever bias is present will be similar for both sexes.

Second, labor productivity of the individual is inferred readily only if the worker is paid wages; it is substantially more complex to measure the product of an individual who is self-employed or works without a wage in a family enterprise. Moreover, studies of self-employed men and women in a variety of countries, including Thailand, Colombia, and Israel, have not detected major differences in the monetary returns to schooling associated with working in wage and nonwage sectors (Chiswick 1979; Fields and Schultz 1982; Ben-Porath 1986); Thomas and Strauss (1993) report similar evidence for urban Brazil. Again, this problem is difficult to resolve entirely, but whatever biases it may exert on estimates of the returns to education, they have not yet been shown to differ systematically for men and women.

Third, many individuals at the time of a survey are not in the labor force. Rates of return to education can typically be estimated only for those who are “self-selected” into the labor force, and often only for those in the wage labor force. Are these estimates applicable to the average or representative person for whom schooling investment decisions are intended to be applicable? This statistical problem of “sample-selection” is common to much of nonexperimental social science (Heckman 1979, 1987); statistical methods are required to explain first the reason some people are “selected” into the wage labor force; this information is then used to eliminate potential bias in the estimation of the private returns to schooling arising from unobserved factors that affect the marginal productivity of labor—such as wage rate—and also affect the probability that the person is a wage earner.¹⁰ Because the proportion of women working in the labor force is substantially smaller than the proportion of men in most countries (Schultz 1990), this source of sample selection could be a more serious source of bias in estimating educational returns for women. Selection-corrected estimates of returns may be sensitive to the choice of assumptions underlying the statistical approach. There is, however, some theoretical basis for the statistical identification of the sample selection model subsequently proposed for estimating wage functions.

Productive benefits from health and nutrition can be estimated by including health characteristics of the worker in the wage function, just as current schooling and post-school experience are included (Mincer 1974). If earnings are used partly to improve health or nutrition, then the impact of nutrition and health on wage rates must be estimated by simultaneous equation methods to disentangle only one direction in the causal system. Parameter bias due to errors in the measurement of health and nutritional status may be an even more serious problem than an error in measuring schooling, biasing down the directly estimated—that is, ordinary least square (OLS)—effects of health and nutrition on productivity. Estimating the effects of health or nutrition on wages without bias from errors in measurement and simultaneity generally requires the specification of a valid instrumental variable or an exclusion restriction. Food prices and health programs are candidates for exclusion from the wage functions. These variables are then assumed to influence the household's demand for nutrition and health inputs and consequent labor productivity. Food prices and health programs thereby affect labor productivity only through their predicted impact on nutritional status and health, but do not shift community labor supply, which would affect wage levels. The wage is measured in real terms, deflated for the local price level, but this requires that the relative prices of food items do not affect labor supply. This approach was proposed by Strauss (1986) in a study of family farm labor productivity as a function of predicted caloric availability in Sierra Leone, and employed to analyze height and weight by Deolalikar (1988) in India, Sahn and Alderman (1988) in Sri Lanka, Bouis and Haddad (1990) in the Philippines, and to analyze adult disability days by Schultz and Tansel (1992) in Côte d'Ivoire and Ghana. These estimates of the benefits of increased calorie intake, height, and a reduction in morbidity have not yet been combined with the costs of investments required to improve nutrition and health status, as will eventually be necessary to derive private or social rates of return to investments in health that are commensurate with those for schooling. There is insufficient evidence as yet to assess whether private productive returns to investments in health and nutrition differ for men and women. A study of the intrahousehold allocation of nutrition, time, and productivity in Bangladesh provides a broader family context in which to analyze these interdependent decisions (Pitt et al. 1990).¹¹

Social externalities and home productivity. Because of the difficulty of measuring and valuing nonmarket production, economists focus on the marketable component of the income of families and individuals. In principle, personal and national income should include the market value of home-produced and -consumed goods—such as the production and preparation of food and fuel, the fetching of water, and maintenance of housing—for which there are sometimes market-priced equivalents. But in practice, the complexity of imputing a value to goods one produces and then consumes leads to their frequent omission. Moreover, untradable home production activities, such as child rearing, are ignored entirely, although they are economically valued outputs of society. By omitting these nonmarket components of personal income, economists understate sources of income that are of relatively greater importance to poor families. Within families these conventions of economic measurement understate women's economic contribution relative to men's.

The distinctive role of women in managing patterns of consumption in the family, and hence investment in the health, nutrition, and schooling of children, is a major reason for social intervention to increase women's capabilities and control over resources. Improving the productivity of women through human capital investments directly advances economic development and the growth of measured output. Human and nonhuman capital controlled by women appears to channel associated new streams of income and resources toward particular ends: consumption and investment in food, medical care, and schooling of children (Schultz 1989a; Thomas 1991).¹²

The effects of male and female human capital investments on fertility have been frequently studied (Schultz 1993). In most societies, fertility is lower among women who are better educated and can therefore expect to be offered a higher wage. Education thus increases a woman's potential income, but also increases what she must give up in order to bear and rear an additional child. The latter price effect on fertility invariably outweighs the former income effect in empirical studies, and fertility tends to decline as women's market wage opportunities rise. Increases in the labor productivity and wage rates of men, on the other hand, do not appear deter larger families and are often associated with higher levels of fertility, consistently so in low-income

agricultural societies. As a consequence, a redistribution in the balance of education from men to women, if the number of places in school were fixed, should have the unambiguous effect of reducing fertility and thus slowing population growth.

Although male education is not held constant, the tabulation of fertility in Table 3 by women's education in the thirty-eight countries where the World Fertility Surveys (WFS) were conducted during the 1970s illustrates the widely observed pattern just mentioned. In all of the regions distinguished, women at age forty to forty-nine with seven or more years of schooling have 1.6 to 2.9 fewer births over their lifetime, on average, than women with no schooling (column 1). The measure of recent total fertility rates, based on reproductive rates in the five years before the survey, reflects a larger educational differential of 2.0 to 3.6 fewer births for this more educated group of women (column 2). The difference between children ever born to women now aged forty to forty-nine (column 1) and desired family size (column 3) (across women of all ages) is a rough indicator of the recent change in the latent demand for birth control among women of childbearing age. This measure of latent demand for more effective birth control than that used in the past by women now aged forty to forty-nine is concentrated in Asia and Latin America within the least educated strata of women. Education of women is thus associated with a reduction both in desired fertility and in unwanted fertility.¹³

Overall levels and trends in estimated returns. As noted earlier, estimates of the returns to human capital investments have their limitations, but the accumulating evidence from studies in many countries, based on a wide variety of working assumptions and sources of data, imply that private and social returns to primary and secondary education are substantial, ranging between 5 percent and 40 percent per year. One survey of empirical studies in African, Asian, and Latin American countries concluded that the average social returns to investment in primary, secondary, and higher education were 27 percent, 16 percent and 13 percent per year, respectively (Psacharopoulos and Woodhall 1985, p. 58). The returns to education within a level of schooling tend to be lower in high income countries than in low income countries, but the relationship is not always monotonic. Middle income

TABLE 3: Total Children Born, Recent Total Fertility Rate, and Desired Family Size, 1970s

Regions (number of countries observed) and years of schooling completed by women	Total children born ^a	Total fertility rate ^b	Desired family size ^c
Africa (8 to 10)			
0	6.4	7.0	6.9
1-3	6.5	7.2	6.4
4-6	6.1	6.2	5.9
7 or more	4.8	5.0	5.0
Difference (0-7+)	-1.6	-2.0	-1.9
Latin America (13)			
0	7.1	6.8	4.8
1-3	6.8	6.2	4.7
4-6	6.0	4.8	4.2
7 or more	4.2	3.2	3.7
Difference (0-7+)	-2.9	-3.6	-1.1
Asia and Oceania (9 to 13)			
0	6.7	7.0	5.4
1-3	6.7	6.4	4.3
4-6	6.4	5.8	4.2
7 or more	4.9	3.9	4.0
Difference (0-7+)	-1.8	-3.1	-1.4

a. Women aged forty to forty-nine years.

b. The average number of children that would be born alive to a woman during her lifetime, if during her childbearing years she were to bear children at each age in accord with the estimated age-specific birth rates in the five years before the survey.

c. Means are adjusted for the effects of age differences between educational groups. National age composition used to compare means.

NOTES: Figures are averages for countries with World Fertility Surveys in the 1970s, by region and education of women.

SOURCE: Summary of data collected in thirty-eight U.N. World Fertility Surveys around 1975. United Nations, 1987, tables 112 and 115.

countries often appear to have higher returns to secondary and higher education than do the lowest income countries (Jain 1991).

In a growing number of countries it is possible to follow wage differentials over time by education, and thereby estimate a time series on the returns to education in a particular country. The majority of

such studies confirm that private returns tend to decrease over time, although perturbed from a smooth path by business and trade cycles (Schultz 1988; Psacharopoulos 1989; Jain 1991). The slope of the education-earnings profile associated with the private returns to schooling is decreasing over the long run and is an important factor reducing income inequality in some Latin American countries, as well as Kenya, and Korea in the 1980s (Almeida and Barros 1991; Londoño 1990; Knight and Sabot 1987; Choi 1991). Secondary schooling has become a bottleneck in some countries where enrollments have not kept up with labor market demands; the private returns are consequently substantially higher at the secondary level than at the primary level (Schultz 1988). Within countries, the general rule is for the social rate of return to decline at higher levels of education, most noticeably at the university level, where public subsidies are often relatively large. This is particularly evident in Africa (Psacharopoulos and Woodhall 1985).

As already noted, the majority of studies of returns to education are limited to wage earners. To estimate the returns to education among self-employed workers more data and different analytical methods are required. In agriculture, the education of the (male) family head is associated with significantly higher farm profit; but returns to the education of other family workers, such as women, are generally ignored in these studies (see, for example, Jamison and Lau 1982).

Analogous private returns on physical capital investments in factories, equipment, inventories, and infrastructure are generally lower than estimates of the private returns to primary and secondary education. The marked increase in investment in education in low income countries in the last fifty years can be interpreted, on the basis of these microeconomic studies, as a monetarily justified investment of individuals and governments compared to the returns on alternative non-human forms of private and social investment (Schultz 1988).

With the routinization of labor force surveys and censuses that collect information on earnings and hours worked, it is possible to compare wage differentials by educational attainment at several points in time. This is now possible for a substantial number of countries in Latin America and Asia, and for a few in Africa. The common pattern is for these indicators of private returns to education to increase as the

national economy grows rapidly and becomes more integrated into the world economy; only then, after a lag of one or two decades, does the expansion of the educational system begin to catch up to the derived demands for educated labor. Only then do very high educational returns, in excess say of 15 percent, begin to diminish as noted earlier.

Brazil in the 1960s and 1970s experienced a sharp increase in the relative wage gap between secondary and primary educated workers and between university and secondary school graduates (Langoni 1977). Public education in Brazil may have lagged behind the demand for educated workers, for private returns to education remained high and began to decline in Brazil by the 1980s from roughly 25 percent to 15 percent; they remain about constant, however, at all levels of schooling (Lam and Levison 1989; Lam and Schoeni 1991; Strauss and Thomas 1991). Within Brazil, the higher income regions, such as São Paulo and Rio de Janeiro, report the smallest educational wage differentials and the best educated workforce, whereas the low income northeastern region reports the highest differentials (Reis and Barros 1991). Because wage differentials by education tend to be smaller where the supply of more educated workers is larger, it may be concluded that regional differences in the relative demands for educated labor are less important than supply differences. Wage differentials driven by labor supply may also be understood in terms of capital mobility exceeding labor mobility, at least within a single country, common market, or custom union. Alternatively it may suggest that differences in culture and customs raise the costs of interregional migration in such large and heterogeneous populations as those of Brazil or India, for example. Regional wage inequality within education groups is larger in Brazil than it is in high income countries, and in most low income ones, which is also consistent with the immobility of labor. Simple Mincerian earnings functions account for about half of the variance in the log of wages in Brazil, whereas these specifications of wage functions account for only a quarter of the variance in the United States (Mincer 1974, 1981). These large educational wage differentials are not apparently caused by segmentation of the labor force into formal and informal sectors (Barros et al. 1992), and are not diminished by more than a few percent after controlling for parent education and region (Lam and Schoeni 1991).

From 1937 to 1951 educational wage differentials widened in Colombia, continuing to expand during the 1960s, and then declining slowly thereafter. The recent decline in schooling returns from 20 percent to 12 percent can be followed through a series of national household surveys (Londoño 1990). Rural to urban wage differentials have also closed, and migration to the largest cities has diminished. As in Brazil, regional relative differentials in wages are largest for the least educated, and for the rural born a large share of the returns to obtaining an education is recouped through migration (Schultz 1982, 1988). Because the labor market for college educated workers is more nearly national in scope, relative differences in wage rates across regions for these more highly educated workers tend to be narrower than the relative differences in wage rates across regions for the least educated. The same pattern of educational to wage differentials by region is noted in 1961 in Venezuela, and is consistent with the greater responsiveness of interregional migration among the more educated (Schultz 1982; Schwartz 1971).

Countries that have protected their domestic economy from competitive pressures of international trade have tended toward slower growth and lower returns to education (Harrison 1991; World Bank 1991). Peru, for example, as the military managed the economy during the 1970s and aggressively pursued import substitution policies, recorded a steady decline in its social returns to secondary schooling from nearly 20 percent to about 7 percent (Schultz 1988).

Korea, which has sustained one of the most rapid expansions of its educational system in the last thirty years, experienced a marked increase in returns in the late 1960s as export-led growth in light industry developed. Returns to college education have only begun to decline markedly at the end of the 1980s, despite the several-fold increase in the number of high school and college graduates (Choi 1991; Topel and Kim 1992). Korean estimates of returns to schooling may, however, be somewhat distorted, because the primary source of data is the Occupational-Wage Survey collected only from nonagricultural private firms with at least ten employees. Taiwan has also reported stable high returns to schooling in the 1970s and 1980s. As with Korea, Taiwan had initially rationed excess demand for higher education with university entrance examinations, and thereby

undoubtedly sustained the relative wages of university graduates (Deaton and Paxson 1992).

Wage differentials associated with education are surveyed in Thailand since the early 1970s. They evidence some decline in returns at the primary level, as virtually all Thais were completing primary school by the 1960s. A relatively slow expansion of secondary education, particularly for girls, contributed to the rise in private returns associated with secondary schooling, peaking from 1975 to 1985 at 30 percent per year for females and 20 percent for males. Returns to higher education appear to be more moderate in Thailand, and the corresponding proportion of the population studying at this level is also relatively large compared to neighboring countries with similar levels of per capita income (Sussangkarn 1988; Schultz 1991).

Africa also provides a number of comparisons of different educational policies and growth experiences, but less in the way of time series on wage differentials. Kenya rapidly expanded its public and private secondary school systems in the 1960s and 1970s in response to popular demand, using public school fees to finance part of the growth. Tanzania, in contrast, relied upon an entrance exam to ration excess demand for relatively fewer places in its fully subsidized public secondary school system. On the demand side, the Kenyan economy has been more open to trade and investment, and growth has proceeded more rapidly than it has in the state-dominated Tanzanian economy. Growth in per capita GDP has been 1.7 percent per year in Kenya from 1965 to 1987, while it has been negative in Tanzania. Private wage returns to secondary education in Kenya have declined. The relative returns to secondary schooling have also decreased in the stagnant Tanzanian setting, but so has the absolute level of wages (Knight and Sabot 1987).

Ghana followed Kenya in its educational *laissez-faire* policy, achieving shortly after independence in 1965 enrollments of about 70 percent at the primary school level, and by 1975 enrollments of 36 percent at the secondary level. But the subsequent declines in national output that occurred during the 1970s halted any further expansion of schools in Ghana and probably contributed to a decline in educational returns. By 1985, as the economy began to revive, private returns to primary education were nil, and an additional year of middle

or secondary schooling earned a modest ten percent premium in wage employment.

By way of comparison, Côte d'Ivoire grew many times faster than Ghana from 1960 to 1980 and expanded its primary school system to Ghana's level by 1975, but restricted the enrollment rate at the secondary level to about 20 percent, and maintained its French Lycée-type examination system. Although it is not clear whether the demand or supply conditions are responsible, private returns to primary schooling in Côte d'Ivoire were about 10 percent in 1987, whereas at the middle and secondary school levels they exceeded 20 percent (Vijverberg 1993; Tansel 1993).

Private wage returns should be accounted for within a model that combines evidence, on the one hand, on population growth and capital investment, which determine the derived relative demands for educated labor, with evidence, on the other hand, of the human capital investments expanding the relative supply of educated labor. However, only a few case studies such as those cited have been undertaken. Simulations of computable general equilibrium models are moving in this direction, but they are based on assumed values of critical elasticities of substitution among the factors of production, including educated and uneducated labor (Londoño 1990). This is another instance where macroeconomic evidence of the role of human capital in growth and the consequences of educational policies that favor price over quantity rationing of education could better inform policy makers about the trade-off between different forms of public investment, growth, and the resulting personal distribution of income.

Gender Differences in Returns: Examples from Four Countries

The primary problem emphasized here with extending the empirical analysis to gender differences in returns to schooling is the need to incorporate the nonmarket returns to education of women. Because nonmarket output cannot be comprehensively evaluated in monetary terms, it is unavoidable that quantitative analyses deal only with the wage rates of wage earners. There is no a priori reason to expect the sample selection bias in this case to understate or overstate the true

return to education evident in accepted market wage offers for all women or all men, or to affect differentially this bias between women and men. The direction and origins of such a bias is an open issue in need of more empirical research. The composition of output and employment (Fuchs 1968), the capital intensity of production (Griliches 1969), the rate of technical change (Schultz 1975), and perhaps measures of sex segregation in employment by industry and occupation (Boserup 1970) might all plausibly affect which males and females are selected to be wage earners and thus bias estimates of schooling returns.¹⁴

It may be useful to consider several hypothetical sources of sample selection that illustrate how bias in estimating returns to schooling might arise. In the first case, assume that virtually all women with higher education work for wages, but that only half of those who have only a secondary education work for wages. Suppose further that the half of the secondary educated persons who work for wages are not a representative sample of this population, but for some unobserved reason they are more (or less) productive workers. The difference between the wages received by wage earners with only a secondary education and those with a higher education will, in this case, understate (or overstate) the productivity gain an average person could expect to receive by studying to obtain a higher education.

To correct for sample selection bias in estimating the returns to education, some specific variable must be known that affects the probability that a person works for wages, but this variable cannot affect the worker's productivity as a wage earner or her market wage offer.¹⁵ I will assume that this identifying variable is the individual's ownership of land and other assets that yield nonearned income; this asset or income stream is expected to raise the individual's shadow value of time in nonwage activities, and thereby reduce the likelihood that the individual will be a wage earner. But this asset or nonearned income variable is assumed not to influence what an employer would offer her as a market wage.¹⁶

A second source of selection bias might arise in a modern welfare state that could be most pronounced among the least educated. Suppose, for example, that persons in this low education group who decide not to engage in wage employment are the least productive workers.

This alternative pattern of selection could be reinforced either by public assistance programs that provide workers with welfare support if they do not accept a wage job or by minimum-wage legislation that discourages employers from hiring workers whose productivity is below the minimum wage floor. This form of sample selection bias might become important when unemployment, welfare, and disability insurance benefits are set at relatively generous levels, or where legislation sets the minimum wage high enough to reduce the number of job offers for less productive workers (Schultz 1990). In this case, the wage earner sample of the lowest education group is made up of only the most productive members of the group.

The estimation sample of wage earners becomes more representative of the entire population as a group's level of education increases. According to this second hypothetical source of sample selection bias, standard estimates of private wage returns to relatively low levels of education would be biased downward. Identification of the selection equation might be possible in this case if welfare legislation or its implementation differed randomly across regions of the sample and induced variations in the wage labor force participation rate.

Some recent studies of wage structures of males in the United States are consistent with this second hypothesized source of sample selection bias, but they have not been extended to a comparison of the wages of men and women. At the low end of the distribution of educational attainment in the United States, in each age cohort by state of birth, there is a threshold below which the returns to education for men appear to fall off markedly to approximately zero. Card and Krueger (1992) estimate this threshold at the two percentile level, whereas other empirical studies often omit the lowest educational group—made up of people with less than eight years of education—to smooth out patterns in the low end of the education distribution (Murphy and Welch 1990). If the minimum wage floors applied to male and female workers are the same, and welfare support programs are more generous (relative to the distribution of their wage opportunities) for women than they are for men, one might expect the downward bias in estimated returns to schooling caused by this source of sample selection to extend further up the distribution of educational attainments for women than for that of men.

Several empirical examples are presented in this section to illustrate how private returns to schooling at the primary, secondary, and higher education levels can vary for women and men. These returns are first calculated as conventionally reported by OLS for wage earners. Then these estimates are corrected for sample selection bias where property income and assets, such as land ownership, are used to identify the selection correction procedure. Notes to each table describe other included variables and estimation methods.

Thailand has grown rapidly for the last several decades. Women have historically played a major role in the market economy, both in traditional agricultural pursuits and in more modern labor force activities. Thailand instituted universal primary education in the 1930s, and by the 1970s nearly all boys and girls completed primary school. The difference in education received by men and women remains substantial at the secondary school level, but has narrowed recently at the university level. Private returns to schooling are estimated in Table 4 from the two most recent rounds of the Socio Economic Survey (SES) collected in 1985–86 and 1988–89. Estimates of returns to schooling based on similar assumptions from earlier rounds of this survey in 1975–76 and 1980–81 are reported elsewhere (Schultz 1989a). By 1988–89 the selection-corrected returns to schooling in Thailand do not differ substantially from the direct OLS estimates for either women or men. By comparison, in 1985–86 (and in earlier surveys) primary schooling returns are higher when sample selection is taken into account, whereas secondary schooling returns are lower, again for both men and women. After secondary school, the correction for sample selection increases the returns for women and decreases them for men until the most recent survey in 1988–89. Corrected returns are generally highest for women at the secondary level, whereas they peak at the primary level for males. At the primary school level men have slightly higher returns than women do (17 percent versus 13 percent), whereas women receive higher corrected returns at the secondary school level (25 percent versus 7 percent in 1985–86), and still markedly higher returns than men in 1988–89 (20 percent versus 12 percent).

Wage ratios associated with each year of primary schooling, corrected for sample selection, have been of similar magnitude in

TABLE 4: Estimates of Private Wage Return to Schooling in Thailand by Sex and School Levels, 1985 and 1988 (without and with Statistical Correction for Sample Selection Bias)^a

Year and monthly earnings (sample of wage earners/ population)	Without correction (OLS)			With correction (ML)		
	Primary	Secondary	Higher	Primary	Secondary	Higher
1985-86						
Female (2,709/8,606)	8.2 (4.75) ^b	31.0 (18.7)	9.5 (4.31)	13.0 (7.00) ^c	25.0 (9.84)	18.0 (5.45)
Male (4,199/7,685)	14.0 (9.40)	18.0 (14.4)	12.0 (6.81)	17.0 (11.3)	6.8 (5.34)	7.8 (4.61)
1988-89						
Female (2,222/8,924)	13.5 (8.53)	20.8 (16.5)	9.0 (5.79)	13.8 (9.24)	19.8 (10.2)	8.2 (3.14)
Male (3,362/7,733)	15.6 (13.8)	12.9 (15.2)	11.8 (10.4)	15.5 (14.3)	12.4 (12.7)	11.3 (7.31)

a. The coefficients reported are those on the variable years of education completed at each school level, in a logarithmic monthly wage function, which also includes experience (e.g., age-schooling-7), experience squared, and several regional dummy variables (Bangkok, municipal, sanitary district—i.e. suburban—and Northeast region). The estimation sample is restricted to wage and salary earners between the ages of twenty-five and fifty-four. The OLS estimates of the education coefficients are reported in the first three columns, whereas the last three columns report the ML estimates of the joint probit model for participation as a wage or salary worker and the log wage function. The probability of participation as a wage or salary earner is assumed to be affected by hectares of irrigated and dry land owned and by nonearned income. These identifying variables are assumed to be exogenous to the wage function, and thus do not affect the wage offered to the individual. See Schultz 1989a for a further discussion of model specification and full ML estimates and parallel estimates for 1980-81 and 1975-76 based on the same socioeconomic survey in these earlier years.

b. The absolute value of the *t* statistic is reported in parentheses beneath each OLS regression coefficient on years of education.

c. The absolute value of the asymptotic *t* statistic is reported in parentheses beneath each ML coefficient estimate on years of education.

NOTE: OLS = ordinary least squares. ML = maximum likelihood.

Thailand for men as for women, as have enrollment rates. But where women have received only two-thirds the number of years of secondary education compared with men, their wage returns have been consistently higher, though falling gradually in recent years from 31 percent in 1975-76 to 20 percent in 1988-89. Only about one tenth of the Thai survey populations has any higher education, but by 1988-89

the SES reports women with 85 percent as many years of higher education as men compared to about half as many in 1975. Women's returns to higher education greatly exceeded men's until 1988–89, when this pattern reversed. Under conditions of rapid economic growth in Thailand, returns to schooling for men and women appear to be of similar magnitude, with the exception of secondary school, where the supply of educated Thai females relative to males is lowest, and returns to women have greatly exceeded those to men for the last fifteen years.

Private returns are uniformly higher for *Côte d'Ivoire* than for *Ghana*. Table 5 reports estimates from the Living Standards Measurement Surveys of private returns to schooling from *Côte d'Ivoire* in 1985, 1986, and 1987, and from *Ghana* in 1987–88 and 1988–89 (Ainsworth and Muñoz 1986). Economic growth until the late 1970s was sustained and rapid in *Côte d'Ivoire*, whereas economic output per capita declined in *Ghana* during the 1970s. Over the previous twenty-five years, national income per capita grew by 70 percent in *Ghana*, whereas it more than quadrupled in *Côte d'Ivoire* (World Bank 1991).

The correction for sample selection in *Côte d'Ivoire*, where only 18 percent of men and 5 percent of the women age 15 to 65 are wage earners, lowers marginally the estimated private returns to schooling. Although women have obtained only half as many years of schooling as men, the private returns are similar for men and women. In Thailand, the labor of more educated men and that of women do not appear to be reasonable substitutes for each other, and the gender balance of labor supplies by education level seems to have influenced returns at the secondary level. The evidence from *Côte d'Ivoire*, on the other hand, is consistent with the interpretation that male and female educated labor are reasonable substitutes for each other in this economy. Other investigations of wage determinants in *Côte d'Ivoire* also find few indications of gender differentials between observationally similar workers (Van der Gaag and Vijverberg 1987, 1993).

Ghana began the 1960s with more widespread education than *Côte d'Ivoire*, but *Ghanaian* women also receive only half the number of years of education as men do. There are relatively few students who exit the school system before completing nine years; for those few who stay only for the first six years of primary schooling, there are no

TABLE 5: Estimates of Private Wage Return to Schooling in Côte d'Ivoire and Ghana by Sex and School Level, 1985 through 1989 (without and with statistical correction for sample-selection bias)^a

Year and Sample (sample of wage earners/ population)	Without correction (OLS)			With correction (ML)		
	Primary	Middle	Secondary	Primary	Middle	Secondary
Côte d'Ivoire						
1985-87						
Female (376/9,099)	10.9 (4.08) ^b	24.3 (7.45)	22.4 (9.95)	7.8 (1.26) ^c	20.9 (2.71)	20.2 (4.22)
Male (1,452/7,832)	14.0 (11.5)	27.4 (15.3)	22.4 (18.0)	11.6 (7.03)	24.1 (10.3)	20.0 (11.5)
Ghana						
1987-88; 1988-89						
Female (454/6,067)	-1.0 (.34)	14.5 (3.95)	10.4 (8.30)	-1.2 (.31)	14.2 (2.97)	10.1 (2.07)
Male (1,471/5,605)	-1.3 (.72)	7.0 (3.15)	11.8 (15.1)	-1.3 (.78)	7.9 (2.73)	12.3 (9.27)

a. The coefficients reported are those on the variable years of education completed at each school level, in a logarithmic hourly wage function, which also includes experience (age-schooling-7), experience squared, and several regional dummy variables (capital city, north, central, south, and other urban). The estimation sample is restricted to wage and salary earners between the ages of fifteen and sixty-five. The OLS estimates of the education coefficients are reported in the first three columns, whereas the last three columns report the ML estimates of the joint probit model for participation as a wage or salary worker and the log wage function. The probability of participation as a wage or salary worker is assumed to be affected by various forms of financial and business assets, including land. These identifying variables are assumed to be exogenous to the wage function, and thus do not affect the wage rate offered to the individual. See Schultz and Tansel 1992 for further discussion of the Living Standards Measurement Surveys on which these estimates are based and a complete reporting of parallel ML estimations with the inclusion of adult health and disability variables.

b. The absolute value of the *t* statistic is reported in parentheses beneath each OLS regression coefficient on years of education.

c. The absolute value of the asymptotic *t* statistic is reported in parentheses beneath each ML coefficient estimate on years of education.

SOURCE: Ainsworth and Muñoz 1986 and Schultz and Tansel 1992.

private returns for either sex. At the middle level, where women have obtained 61 percent as many years of schooling as men, the relative wage gain for more educated women is almost twice as large as for

men—14 percent versus 8 percent, respectively. These higher private returns for women are not evident at the secondary school level and beyond, where women have obtained only 40 percent as many years of schooling as men. Many college graduates in Ghana migrated abroad during the 1970s and 1980s in search of jobs, and may make the observed sample that stayed at home unrepresentative of all those who received educations at the secondary and higher levels.

The *United States* is examined in Table 6, as an example of a high income country where wage earners are a large fraction of the labor force, and education is more equally distributed between men and women (Schultz 1993). The state level duration of unemployment benefits and the value of AFDC benefits in cash and food stamps for a mother and child are added to the individual's property income as identifiers of the wage earner sample selection model. Not surprisingly, the sample selection procedure indicates that the nonrandom selection of wage earners is a less important source of parameter bias in the United States than in Thailand or Ghana. But there is, nonetheless, a tendency, when sample selection bias is corrected, for women's private returns to increase more than male returns do, and they exceed male returns among both blacks and whites. Only at the higher education level do U.S. women receive a smaller number of years of schooling than men. One interpretation of this pattern is that the derived demand of firms for workers with a college education in the U.S. economy treats men and women as imperfect substitutes. Contrary to our hypothetical example, correcting for sample selection bias does not raise the low returns to the lowest levels of schooling in the U.S. labor market, although the unemployment and welfare benefits have the theoretically expected effect of reducing wage participation, as does nonearned income, assets, and land in the three studies previously reported.

There are relatively few studies of the returns to schooling for men and women that have corrected estimates for sample selection, but the number is growing rapidly. The findings from several other studies are summarized in Table 7, and others could be consulted (for example, Deolalikar 1993; Vijverberg 1993; Thomas and Strauss 1993). Because men and women in Latin America receive similar levels of education (Figure 1), I do not expect gender differences in returns to

TABLE 6: Estimates of Private Wage Returns to Schooling in the United States, by Sex, Race, and School Level 1980 (without and with statistical correction for sample-selection bias).^a

Sex (sample of wage earners/ population)	Without correction (OLS)			With correction (ML)		
	Primary	Middle	Secondary	Primary	Middle	Secondary
White females (5,909/9,752)	.18 (.11) ^b	5.1 (5.72)	10.4 (21.5)	.11 (.09) ^c	5.6 (1.66)	10.6 (13.9)
White males (7,430/9,334)	3.3 (2.66)	7.1 (9.13)	7.0 (17.2)	3.3 (3.02)	7.6 (5.22)	7.0 (16.8)
Black females (5,213/9,075)	-2.2 (1.20)	9.6 (8.71)	9.8 (12.9)	-2.4 (1.35)	11.2 (4.46)	10.6 (7.47)
Black males (5,334/7,762)	1.5 (1.10)	7.4 (7.15)	7.0 (8.56)	1.3 (1.02)	7.9 (2.63)	7.2 (6.21)

a. The coefficients reported are those on the variable years of education completed at each school level, in a logarithmic hourly wage function, which also includes experience (age-schooling-7), experience squared, urban (i.e., SMSA) resident dummy, and hispanic origin. The estimation sample is restricted to wage and salary earners between the ages of fifteen and sixty-four, reporting weeks worked and usual hours worked per week in 1979, so that an hourly wage could be defined as annual earnings divided by the product of weeks worked and usual hours worked in the previous year. The sample includes all blacks and one in ten white persons from the 1 in 1000 public use sample A of the U.S. Census. The OLS estimates of the education coefficients are reported in the first three columns, whereas the last three columns report the ML estimates of the joint probit model for participation as a wage or salary worker and the log wage function. The probability of participation as a wage or salary worker is assumed to be affected by an individual's receipt of income in 1979 from dividends, interest, and rentals (in linear and quadratic form), the duration of unemployment benefits in the state of residence, and the maximum aid to families with dependent children (AFDC) cash or food stamp benefit level paid to a single mother and one child in the state of residence. These identifying variables are assumed to be exogenous to the wage function and thus do not affect the wage an individual is offered. See Schultz 1991 for a more extensive discussion of the specification of the model and the full ML estimates.

b. The absolute value of the *t* statistic is reported in parentheses beneath each OLS regression coefficient on years of education.

c. The absolute value of the asymptotic *t* statistic is reported in parentheses beneath each ML coefficient estimate on years of education.

schooling would be particularly sensitive to sample selection bias in this low income region. The 1985 estimates of male and female returns to schooling for Peru, for example, were not greatly affected by sample selection correction based on land and wealth variables, although women's returns at the secondary level noticeably exceed those of men

TABLE 7: Estimates of Private Wage Return to Schooling of Women and Men from Selected Studies, 1970s and 1980s (percentage)

Country, city or regional coverage, and school level	Year	Women	Men
Argentina	1980	6.6	9.3
Buenos Aires			
Bolivia	1980	11.0	9.8
La Paz			
Brazil	1971	6.3	5.4
São Paulo			
Colombia	1973	18.0	18.0
National			
Paraguay	1979	8.0	11.0
Asunción			
Peru	1974	14.0	14.0
National			
India	1981	14.9 ^a	15.8 ^a
Madras			
Thailand	1980-81	20.1 ^a	11.3 ^a
National			
Côte d'Ivoire	1985	28.7 ^a	17.0 ^a
Urban			
Secondary school			
Peru	1985	14.6 ^a	8.8 ^a
National			
Secondary school			
Indonesia	1986	9.6 ^b	6.2 ^b
National			
General high school			

a. Sample selection is corrected based on land or nonearned income included in the selection equation, but not in the wage function.

b. Fixed effect for family included, which, however, does not correct for problems associated only with selected families in which both a male and a female earn wages.

NOTE: The coefficients reported are those on the variable years of education completed (on school level if indicated or if not, all levels combined), in a logarithmic wage function, which also includes experience (e.g., age-schooling-7), experience squared, and regional and rural/urban dummy variables if a national sample. Samples tend to be at least a thousand, and often much larger, including all wage and salary workers between the ages of twenty-five and sixty-four. The coefficients on the education variable are all statistically significant at conventional levels. In several cases age is used in place of experience.

SOURCES: For Peru, see Khandker 1989; for India, see Malathy 1989; for others, see sources in T. Paul Schultz 1989a.

(Khandker 1989). The first six studies in Table 7 for Latin American countries are reported, therefore, with the expectation that they are not seriously distorted by their neglect of the sample-selection problem. No evidence emerges from these studies that individual private rates of return to schooling among wage earners are systematically lower for women than for men in Latin America. Indeed, they tend to be somewhat higher, on average.

Estimates of the returns to women's schooling are more difficult to infer in regions where women have not yet received more than a primary level of schooling and where women are an especially small part of the wage labor force. These conditions hold in most of rural South and West Asia and much of rural Africa. Analysis in these regions could be particularly valuable for understanding why parents in these regions tend to also invest more in the schooling of their sons than their daughters.

To estimate with more confidence the returns to schooling, it is necessary that our models account for the individual's allocation of time, particularly to wage employment. This knowledge of how to model wage participation decisions motivates the identification of these sample-selection corrections. Understanding how resources are pooled and labor market behavior is coordinated within the family may be critical to this process. The appropriate theory of family labor supply is therefore important to estimating without bias wage functions. More comparative research is needed to assess whether variations in the specification of models of labor supply behavior, such as by treating it as a cooperative bargaining process (see, for example, Schultz 1990; Thomas 1990), alter importantly the parameter estimates of the private returns to schooling of women and men. This matter promises to be more important in low income than on high income countries, but there are as yet too few studies of even high income countries on which to base any generalizations.

Macro Evidence of Social Returns and Modern Growth Theory

Both macro- and microeconomists have sought to understand the role of human capital in the pace and structure of modern economic growth.

Each has its own theoretical approaches, simplifying assumptions, and data for disentangling how education and analogous activities increase total factor productivity. Juxtaposing these literatures may help focus attention on the areas of agreement and areas where further research could reconcile differences of viewpoint or lead to the construction of improved data for advancing our knowledge.

In the 1950s it became clear that the concept of an aggregate production function relating the input of labor hours and the services of land and capital to national output failed to account for modern economic growth in the United States since 1870 (Kuznets 1952). Historical time series assembled by Kuznets (1966, 1971) for other industrially advanced countries reconfirmed that modern economic growth was not explained by the growth in physical units of traditional inputs. Solow (1957) made the point graphically by fitting a regression in logarithms of private nonfarm output per man-hour to employed capital per man-hour, and by then showing that most of the growth in output was accounted for by a linear trend in time, which he named "technical change." Possibly a more suitable name for this trend had been proposed by Abramowitz (1956), when he called it an "index of our ignorance," or the more neutral term in growth accounting of "the residual" (Nelson and Phelps 1966). Empirical and theoretical work formulating and testing hypotheses for explaining this residual have stressed four factors: the quality of nonhuman capital, represented perhaps by its vintage (Solow 1960); the quality of labor represented by human capital (T. W. Schultz 1960); an accumulation through research and development of a base of productive knowledge (Griliches 1973; Nelson and Phelps 1966); and organizational innovations possibly induced by relative factor scarcities (Hayami and Ruttan 1971).

The recrudescence of interest in growth theory may be linked to the work of Lucas (1988) and Romer (1986), who proposed an endogenous mechanism for the generation of economic growth, a source of increasing returns associated in Lucas's view with the accumulation of human capital. A novelty of their work was the idea that in the long run output per unit of input could increase, even when inputs were exhaustively accounted for. Synergies between highly skilled workers or particular forms of capital investment were credited with producing

these increasing returns; technically advanced human capital and the growth in knowledge base also appear to be part of this wellspring of growth. Constant returns to scale technology at the level of the firm are retained as an approximate basis for achieving a perfectly competitive equilibrium, but at some level higher than the firm; nonappropriable increasing returns are attributed to this factor of production. Subsidization of this factor, perhaps human capital formation, might therefore be desirable.

One implication of Lucas's hypothesis was that human capital should be factored back into aggregate production functions, an empirical practice that was never fully accepted in the growth theory literature of the 1960s. Nor was much attention directed at that time to the empirical implications of growth models. A property of convergence implied by these models was then explored, in which countries moving toward a common steady-state growth path would grow more rapidly the further they were from their path. Countries with low income per capita (and low capital per capita) would tend to converge to high income per capita countries, or catch up, under suitable assumptions. But as noted by various authors (for example, Barro 1992), a regression of per capita growth rates among countries from 1960 to 1985 on initial levels of income per capita did not show the predicted negative relationship. But convergence conditional on initial human capital stocks, crudely approximated by literacy or contemporaneous primary and secondary enrollment rates, did suggest the expected pattern of convergence among countries.

Another approach to conditional convergence was to examine subunits in larger, more integrated economic units, where it might be more defensible to assume that the subeconomies shared the same technological opportunities, economic institutions, savings propensities, and capital mobility. Following this approach, it was shown that convergence has occurred across the forty-eight states of the United States from 1888 to 1988, the forty-six prefectures of Japan from 1930 to 1987, the seventy-three administrative regions of Western Europe from 1950 to 1985, and the OECD countries from 1960 to 1985, (Barro and Sala-i-Martin 1992).

Other implications of the growth process follow from the reestimated parameters of this human capital-augmented, but nonetheless

neoclassical, constant-returns-to-scale Solow growth model. The share of income attributed to nonhuman capital is awkwardly large, on the order of 60 percent, in the simple Solow model, whereas the human capital, nonhuman capital, and labor shares of income appear to be more reasonably estimated as about one-third each in the augmented Solow model (Mankiw, Romer, and Weil 1992). The elasticity of income per worker with respect to population growth increases from $-1/2$ to -2 , with the augmentation of the growth model to include human capital measured approximately as secondary school enrollments as a share of population (Mankiw, Romer, and Weil 1992). Although population continues to be treated as exogenous, it becomes quantitatively more important in the augmented model. The next step is to incorporate fertility as endogenous to the human capital formation process (Becker, Murphy, and Tamura 1990), and possibly making fertility eventually responsive to the gender composition of that human capital as noted earlier (Schultz 1973, 1981). Similarly, the elasticity of the income per worker with respect to the physical savings rate is substantially larger, increasing in one set of regressions from $+1/2$ to 1. The convergence among countries with the same population growth, technologies, and capital accumulation propensities is also slower and more nearly compatible with the slow conditional convergence previously estimated (Mankiw, Romer, and Weil 1992).

However, none of these plausible empirical patterns seems to depend on an externality or source of increasing returns as postulated by Lucas and Romer. Indeed, there is little concrete guidance in this literature on where precisely to look for this externality, if it exists. Should it occur across production units of cities (Jacobs 1984), or industries (Jaffe 1992), or nation-states? Without a more empirically tractable description of the mechanism and the relevant unit of observation, it may be some time before a convincing empirical test is mounted for the notion of an aggregate externality caused by human capital. But even if the externality associated with human capital is not confirmed, we can expect to see more study of international time series for clues on their determinants. Casual empiricism had previously explained the resurgence of Western Europe and Japan after the Second World War as being due to the highly skilled and disciplined labor forces of these countries. The mobility of physical capital quickly

returned these war-damaged economies to their steady-state growth paths once institutional stability was reestablished and property rights clarified. The establishment of property rights and institutions to achieve capital mobility appear to be more serious problems ahead for Eastern Europe today, although again countries in this region start relatively well-endowed with human capital.

This economic growth literature may now begin to go beyond intercountry regression coefficients on educational enrollment and literacy rates. Growth models call for a variable representing the level of, or increments to, the *stock* of human capital. These are not provided by any existing international agencies, such as UNESCO.¹⁷ Capital stocks can be constructed in terms of the historical (or replacement) cost of production, or according to their current productive value. These two measures may diverge substantially in a long-lived human capital stock, producing quasi rents for the owners of human capital. A distinctive feature of human capital is that it is not bought or sold, but only hired from workers in exchange for wages. Consequently, most analysis of human capital is based on wage structures for individuals with different amounts of human capital, and these microeconomic differences in wages are interpreted as being due to the workers having invested in observable skills, training, or health. How these inferences may be biased is discussed in previous sections of this paper. However, it may be useful to consider here how human capital stock series might be constructed and used in future empirical work in this reinvigorated field of economic growth studies (see also Denison 1967; Maddison 1975; Jorgenson, Gallop, and Fraumeni 1989; Eisner 1989).

From the social cost accounting side, the stock of human capital investment made during a year in country j — I_j —might be defined as follows:

$$I_j = \sum_{i=7}^n S_{ji} C_{ji} P_{ji}$$

where S_{ji} is the enrollment rate of individual students in a specific i^{th} age cohort for a given number of days each year; C_{ji} is the social daily cost of educating them; and P_{ji} is the population in that i^{th} age group. The social cost of education has three components: the opportunity cost

of the student's time or the foregone production which is approximated by the market wage for comparable individuals who do not attend school for a year, W_i ; the private direct costs borne by the family, such as books, transportation, and school fees, P_i ; and the public expenditures for a student-year of education, G_i . Gross domestic product as conventionally measured must then be augmented by the opportunity cost of the time of students. The investment share of this augmented income invested in human capital can then be properly calculated (Eisner 1989).

Because the dominant cost of most public education is the foregone wages of students, the percentage increase in the market wage resulting from an additional year of schooling is approximately equal to the private internal rate of return to these schooling investments by families (Becker 1964; T. W. Schultz 1967; Mincer 1974). Few studies include estimates of the private direct costs of education to families— P_i —because even consumer expenditure surveys rarely relate family expenditures on education to the amounts spent on each particular individual in the family who attends school. Calculations of social returns to schooling vary a great deal in methodology, but generally include public expenditure on each level of schooling, at least at the central governmental level.

The majority of microeconomic studies of wage structures find that private returns to schooling vary by level, whereas aggregate growth studies assume that returns are constant across levels of schooling. Although the predominant tendency may be for the social returns to schooling to be higher in low income countries than in high income countries, and to decrease at more advanced levels of schooling within either class of country (Psacharopoulos and Woodhall 1985), there is no shortage of short-run exceptions.¹⁸ In linking macroeconomic studies to micro evidence, it would be useful to compare how a particular country compares to other countries. Are those countries with relatively low levels of human capital investment in macro models the *same* countries that exhibit lower than average private or social rates of return to schooling as measured from independent micro wage studies? If not, then are other institutions dissimilar across these countries? Does effective protection of an economy from competitive pressures of foreign trade or the domination of sectors by public and private monopolies or unions lead to less demand for educated workers and hence

lower private returns to schooling? There are surprisingly few studies that combine macro and micro evidence of this form on human capital and growth. Integration of the two approaches could also more plausibly identify macroeconomic models.

Improved measures of the heterogeneity in human capital stocks should help in the assessment of human capital's contribution to macroeconomic growth. But there is no consensus on how human capital should enter the production function. One strategy is to disaggregate labor into more homogeneous types, and introduce them as separate factors in the production function—that is, skilled and unskilled labor. A second-order approximation of the production function would additionally imply the elasticity of substitution between the various forms of labor and other factors (Fuss and McFadden 1978). A second strategy would aggregate heterogeneous labor into "efficiency units," which are often assumed to be perfect substitutes for each other (Welch 1969; Griliches 1970). A third strategy would allow the more educated worker to provide more efficiency units of labor in routinized static production and also facilitate the borrowing and adapting of the best technology for local use in a technologically dynamic world (Nelson and Phelps 1966; Welch 1970). According to this approach, increasing the number of educated workers can contribute to closing the gap in incomes and technologies between those who create new technologies in the highly educated countries and those who adapt them in the follower countries (Kim and Lau 1992). In this catching-up framework, static neoclassical gains accrue to human capital in less developed countries as a result of augmenting the relatively scarce factor input. Dynamic gains are achieved by lowering the cost of adapting advanced technologies (Benhabib and Spiegel 1992).¹⁹ These static and dynamic sources of higher returns to education in less educated countries have not yet been documented in macroeconomic growth studies; they have been confirmed from microeconomic studies of private wage returns to education, but largely in agriculture.

Conclusions and Unresolved Issues

Schooling for women may be justified in terms of efficiency (high individual private market returns), social externalities (for example,

reduced child mortality and fertility), intergenerational redistribution (such as better health and education of children and a slower growth in population), and equity (an increase in the productive capability of poorer individuals relative to richer individuals). This paper has concluded by estimating for several countries the private efficiency of women's and men's schooling, while observing that health and nutritional investments may be equally important and involve similar issues. Aspects of social externalities and intergenerational redistribution are difficult to quantitatively assess, but social returns that can be measured favor social subsidies for investments in women. Others have discussed the justification for making transfers to women on the grounds of equity (see, for example, Tinker 1990).

During this century, human capital investment in women has increased relative to that made in men, at least as measured by either years of schooling or years of longevity.²⁰ These shifts in the gender composition of human capital formation have occurred at about the same time that women have entered in increasing numbers into the market labor force, particularly in employment outside of the family for wages (Schultz 1990). The coincidence of these trends in female participation in the labor force and their schooling support the conjecture that women realize more returns to their education through their work in the market labor force.

Most studies of labor force participation of women confirm that women with more education supply more of their time to market work, and more specifically to wage employment, holding constant male education or wages and nonhuman wealth. This is true in each of the four countries analyzed in this paper, and is notable in many studies of Latin America in recent decades (ECIEL 1982). The release of time from childbearing and childrearing activities is also associated with women leaving home for market employment in the higher income countries (Mincer 1985). Which comes first, the market labor force commitment, the decline in fertility, or the educational attainment of women? Education is often treated as being determined first, based on an individual's expected returns to education and on parents' endowments, both educational and financial, that allow parents to contribute to their children's schooling. By this reasoning, fertility and specialization between home and market labor force skills are modified by

prior educational attainment. To disentangle with greater rigor this lifecycle causal chain (or system), a suitable source of variation in schooling is needed that is independent of the child's (or parent's) preferences for adult careers of childbearing or market employment. This source of variation in education may then be used to identify the effect of education on individual productivity and behavior. It should then be possible to infer how variation in women's education affects their wage opportunities as well as their fertility and labor force behavior and other choices involving migration and sector of employment (see Vijverberg 1993; Thomas and Strauss 1993).

The returns to education and health investments may interact and partially account for the shifting emphasis toward women's human capital. Medical knowledge appears to have contributed little to the decline in mortality before the twentieth century (McKeown and Record 1962; Preston and Haines 1991). And yet, the creation and spread of public health and medical technologies are believed to be important factors in the demographic transition in this century. Have these new technologies given educated persons a new survival advantage? And in the case of women, the health advantage has been effectively extended to their children. If this is a relatively recent phenomenon, then it might help explain the shift of resources toward women's education, even when women in low income countries are still primarily engaged in household production tasks within the family. Increased nutrition and health status of populations may also reinforce the rising productivity of more educated workers. Were this true, the contribution of education to labor productivity as estimated in wage functions could overstate the returns to schooling because of the failure to hold nutritional status constant. Thomas and Strauss (1993) support this hypothesis in urban Brazil.

Studies of human capital have emphasized the heterogeneity of labor as a productive factor, and the substantial share of that heterogeneity that is a produced means of production, created by the secularly rising investment of families and society in the nutrition, health, and schooling of people. How are we to explain that a widening circle of countries, indeed those that have been more successful in stimulating modern economic growth, are also tending to invest an increasing share of their human capital in women? With all the limitations of

current data and statistical methods, this paper has reported for several countries estimates of private market returns to schooling that are of a similar magnitude for men and women. In some countries educated male and female labor appear to be imperfect substitutes, and their relative supplies are inversely associated with the returns they receive on their skills. Specifically, when women have received a small fraction of the secondary or higher education in a society, women with these more scarce skills tend to receive a larger relative wage premium than men do. Although the relative wage returns to schooling for women and men may be of a similar magnitude, as in the United States, this does not imply, as we all know, that the *level* of women's wages is equal to men's. Private returns are approximated by the *ratio* of the wage of the more educated worker to that of a worker (of the same sex) with less education, divided by the years a student must forego employment to acquire this extra education (Mincer 1974). Both the wage gains and the opportunity costs of schooling are generally lower for women than for men, but roughly in the same proportion, implying comparable internal private rates of return.

Future research should estimate the effects of relative supplies of sex-specific educated labor on the level of and differentials in wages, holding constant for the effect of the composition of aggregate demand on these wage structures. That objective is beyond the scope of this paper, for it will require consistent compilation of microdata across many countries, and perhaps within them, over time. But no evidence has emerged in this study that supports the view that educating more women, even if it involved educating fewer men, would lower potential aggregate output.

Beyond the market productivity of workers that should be captured by private individual returns flowing to those who invest in their own schooling, there are palpable external benefits to society, as measured by reduced child mortality, improved child nutrition and schooling, and decreased fertility and population growth. These social externalities of education are primarily associated with the education of women. Thus, there is a microeconomic case for society to subsidize investments in women's schooling by a greater amount than men's.

Estimates of aggregate production functions from intercountry data and indications of convergence across countries and regions in

economic growth have contributed to speculations that human capital is an important determinant in modern economic growth and a central factor in explaining differences in per capita income across countries. For this literature to shed more empirical light on the contribution of education and other forms of human capital to growth, measures of the stock of human capital must be improved and disaggregated, and in particular with respect to women and men. A year of educational attainment or enrollment in a school does not generally cost the same amount to produce or have the same productive value for the labor force (and home workers) at the primary, secondary, and tertiary levels. Nor are the private and social returns to educating women and men identical everywhere.

We have not found a satisfactory economic explanation for the shortfall in female education and health relative to male education and health, particularly in South and West Asia, but also in schooling in much of Africa. The answer would seem to lie in the family decision-making process and parent's own traditionally defined interests, which may attach less value to the future productivity of daughters than to the productivity of sons. Parental claims on the adult productivity of sons may be more secure in custom and law in some family-cultural systems than their claims on daughters. If the allocation of private investments by parents between the schooling for boys and girls does not lead to the socially most productive pattern of investment in some countries, what should public policy do? Can the judicious application of the tools of public finance—taxes and subsidies—improve the allocation of these resources? Where does policy exert the most leverage to increase female enrollment rates or longevity? Research has only begun to squarely address these issues.

END NOTES

1. For example, in Thailand in 1975 this measure suggests that women could expect to be enrolled for about seven years if they experienced the age specific enrollment rates prevailing in 1975 from age 7 on (that is, $.81 \times 7 \text{ years} + .23 \times 5 \text{ years} + .027 \times 5 \text{ years} = 6.96 \text{ years}$). A ratio of this summary measure of schooling investment for women relative to men in Thailand in 1975 is .91. But this female to male ratio of enrollment rates declines from near parity at the primary school level to .82 at the secondary level to .68 at the post secondary school level. Clearly, this synthetic measure of per child investment in schooling is not adjusted for the repetition rates, and should therefore be viewed as years of exposure to schooling rather than years completed (as typically measured in censuses) to approximate a stock of human capital.

2. Another interpretation is that the higher levels of investment in women's schooling contribute to greater social product and income. In this case, ignoring nonlabor inputs, one might fit an aggregate production function by regressing the logarithm of GNP ($\ln y$) per adult (potential workers over age fifteen) on the expected years of male (S_m) and female (S_f) school enrollments (lagged a decade to better correspond with the stock of schooling in the labor force). These regressions for sixty-five countries, for which all three levels of enrollment rates are available back to 1960, yield the following estimates for 1970 and 1980:

$$(1) \text{ For 1970} \quad \ln y = 5.02 + .098S_m + .169S_f \quad R^2 = .85$$

(35.2) (2.02) (4.18)

$$(2) \text{ For 1980} \quad \ln y = 4.63 + .110S_m + .182S_f \quad R^2 = .78$$

(21.6) (1.45) (2.81)

where absolute values of the t ratios are reported in parentheses beneath the OLS coefficients. For details on the composition of the sample and sources of data, see Schultz (1987, 1989b). This cross sectional evidence of production suggests that the return on female schooling is substantially higher than that on male schooling. Identifying the aggregate production function parameters from the parameters of household demand functions is not currently feasible. Only these partial correlations between

schooling and income are available, which require more structure than is commonly provided in either the literature on aggregate growth models with human capital inputs or in private or social demand models for schooling.

3. Preston (1976; table 6.10) reports relationships between the difference in age-standardized male and female mortality and country characteristics based on data drawn from the 1960s. Although I did not compile the cause-specific mortality rates examined by Preston, the aggregate mortality levels for males and females were consulted to ascertain whether the gender differences in overall mortality (measured by the sex difference in life expectancy at birth) continue to be related in the 1980s to the same variables found to be important by Preston, and whether changes within countries also confirmed the causal relevance of the same variables in explaining changes occurring over time. In the case of the share of agricultural employment (measured among males, to reduce the cultural variations across countries in whether women are counted as being active in agriculture), there continues to be greater female than male mortality in populations more dependent on agriculture; the relationship is also evident in changes over time and is particularly strong among children less than five years of age. Urbanization performs as an alternative proxy for agriculture, but the two variables are highly correlated and thus cannot always be used together as explanatory variables. Education of women relative to men reduces female mortality relative to male in the 1980s (and in the 1960s) and in the change relationship from the 1960s to the 1980s. One relationship that Preston noted, but that is absent in the 1980s and in the time series changes, is the proportion of the population in large cities (over a million), after holding constant for agriculture share. The interaction of animal fat in the diet and gender differences in schooling that Preston considered performs more poorly in predicting overall gender differences in mortality in 1980 than the two variables considered separately. If the ratio of female to male education is summarized, more plausibly, by the entire span of schooling (i.e. expected years enrolled), and is not to be limited, as in Preston's study, to Level I (primary), the explanation of the female to male ratio of longevity is substantially more significant.

4. Most comparisons that document the growth in stature over decades of centuries within a population are derived from administrative records of the military, and thus pertain only to males. By the nineteenth century, school studies of physical growth of male and female children had become common, but they were most useful in confirming changes in the timing of the adolescent growth spurt and the onset of puberty. They are much less useful for documenting change in the adult height for men and women over time. Relatively few males and far fewer females were still in educational systems by age eighteen. This well educated population is not likely to be representative of the entire population (Tanner 1981; Falkner and Tanner 1986).

5. The association between height and mortality of male and female adult slaves in Trinidad during the nineteenth century was found by John (1984) to be significant only for male adults, whereas child mortality is several times more responsive to height fluctuations in the population than adults. Friedman (1984), on the contrary found significantly higher survival rates for both males and females who were taller, controlling for origins, occupation, and other factors. See also the summary by Fogel (1986).

6. See Note 4.

7. The increased taxes that the more educated individual pays back to the state can be viewed as an externality, if the added taxes contribute to a reduction in tax rates that reduces the distortionary burden imposed on resource allocation. The returns to human capital can be effectively taxed only when educated persons hold jobs where their productivity is readily monitored by the state, such as in wage employment.

8. A child implicitly borrows from her or his parents to invest in schooling and is thereby obliged to support the parents in the future when parent productivity may be lower. Repayment could take alternative forms, such as supporting younger siblings through their schooling, marriage, or borrowing requirements (see, for example, Parish and Willis 1993). Thus, the family may smooth consumption as would a credit market, because of the distinct life cycle phases of investment, production, and consumption that individuals experience. Even when financial markets and government social insurance schemes provide for old age support without relying on children, the young may still be credit constrained, and their educational investments may depend in part on the altruistic behavior of their parents. Extreme forms of "dynastic altruism" that assign equal weight to one's own consumption and that of one's offspring may be unrealistic. A gap between the parental-private return to investment in the schooling of their children and the child's individual private return could arise from credit market constraints, and would suggest arrangements outside of the family are needed to allow children to invest optimally in their own education.

9. This consideration of equity might lead parents to invest more than the efficient amount in the children whose educational investments yield lower returns, or parents might consider transferring to these children nonhuman capital assets from which competitive returns would presumably be earned (Becker and Tomes 1979). This is, however, little evidence that this pattern of portfolio balancing behavior is empirically common even within rich families.

10. The exclusion restriction that secures identification depends on the researcher knowing some information that influences the probability of sample selection, but does not affect the market wage offer. Functional form assumptions regarding the selection equation—for example, normal errors in a probit equation—can provide formal identification, but not a particularly strong theoretical or empirical basis for identification.

11. But education and health are themselves interdependent. The connections between education and health are not yet clearly documented, in part because mortality or morbidity rates are not often available for analysis by educational attainment. Recent research has linked mothers' education to the survival of their children in low income countries (Cochrane, Leslie, and O'Hara 1980), whereas other studies have suggested that nutrition and health of children can affect their school achievement (Moock and Leslie 1986). Height is believed to be largely determined by nutritional status of the individual before reaching age four (Fogel 1990). Height can then be viewed as an indicator of long-run nutritional status that is essentially fixed in early childhood and may therefore be assumed to be exogenous in an adult's wage function in the same way that education is. Weight or a body-mass-index, current caloric intake, or acute illness, on the other hand, are more reasonably viewed as simultaneously determined with current productivity and income. Calorie consumption as an indicator of short-run nutritional status can be estimated as a determinant of productivity by instrumental

variable methods, but may only be a quantitatively important determinant of labor productivity and wages at very low levels of income or calorie intake (Strauss 1986). See also Thomas and Strauss 1993.

12. Increases in a mother's schooling decrease mortality of her children. This pattern is widely replicated in surveys from countries in every region of the world. An added year of mother's education is associated with a 5 to 10 percent reduction in child mortality (Cochrane et al. 1980). Levels of mortality tend to be higher in rural than in urban populations of low income countries, but the proportionate reduction in child mortality associated with an additional year of mother's schooling is of about the same magnitude in both urban and rural areas of the same country. Although fathers' education in years is also correlated with lower child mortality, it has a smaller coefficient than mothers' education. The correlation between women's schooling and lower child mortality across low income countries is also robust to the inclusion of income per adult, men's schooling, caloric consumption, and other factors.

13. The less educated are most likely to benefit from a family planning information campaign and by subsidized birth control and the supply of associated services. It may be noted, however, that these data from the 1970s do not yet reveal much latent demand to restrict traditional fertility levels among African women, among those with either high or low educational levels, perhaps because of the high overall levels of child mortality in Africa (Okojie 1991). The Demographic Health Surveys from the late 1980s document regions in Africa where demands are beginning to change, but these surveys lack economic information to facilitate analyses of the economic determinants of fertility or the independent effects of health and family planning programs.

14. Most research on the scoring of students by ability and its effects on estimated wage returns to schooling has analyzed these relationships for males, and then mostly in the United States. It is possible that the investments of families in the schooling of daughters is more (or less) responsive to the ability of the girls than in the case of boys (see, for example, Parrish and Willis 1993). Alternative hypotheses regarding the family's objective in educating sons and daughters will need to be rigorously formulated and tested. We may expect then to be able to reject in some settings the simplified wealth-maximizing model of the family that is assumed to treat boys and girls as identical.

15. The probability of participating as a wage earner can then be estimated as a probit model jointly with the wage equation for the censored sample of wage earners. Maximum likelihood methods, where the covariance (ρ) between the errors in the two equations is estimated, is the standard means of estimation, although the two-stage method (if the standard errors are adjusted) is also consistent although less efficient than the joint procedure (Heckman 1987).

16. The sample selection correction can be statistically identified from the non-linearity of the probit wage earner selection equation with its normally distributed error (Heckman 1987). In most economic contexts, however, it is desirable to have a stronger basis for identifying the model than only a relatively arbitrary assumption as to functional form. Exclusion restrictions based on a theoretical framework are the preferred estimation strategy. Asset income may not in all contexts be independent of the wage rate, however, if for example the assets represent accumulated savings that are a positive function of past wages, or if asset income encourages more investment

(consumption) in unobserved health and nutritional inputs that augment labor productivity. Land may also have relatively little value for self-employment in some parts of the world. Land per household may be allocated in some regions of Africa by the community in proportion to the number of unskilled workers in the household, and may not be a good indicator of wealth per person or per adult, for example, in Côte d'Ivoire or Uganda.

The return coefficient on education in the wage function could be biased by multiple sources of sample selection. For example, suppose the multiple choices that determine sample selection involve different processes of, say, migration from rural to urban labor markets, working in the paid labor force, and working as a wage earner. This chain of decisions often appears to be sensitive to the educational attainment of the individual (Schultz 1988). If unobserved factors related to wages and schooling are associated differentially with the probabilities of each choice in the chain occurring, the procedure to correct for selection bias requires the covariance between the errors in each choice process and the wage function to be estimated. Vijverberg (1993) proposes such an approach in this paper on Côte d'Ivoire, and Thomas and Strauss (1993) implement a similar scheme in their analysis of urban Brazil.

17. In the *World Bank Development Report for 1991* human capital stocks were created by projecting enrollment rates backward to the start of this century. The stock of labor force educational attainment was then constructed for intermediate years. Where these figures can be checked against census cross tabulations of the population by educational attainment, it seems clear that the trend extrapolation of enrollments may need to be revised and refined. Investigators are also exploring other methods for estimating educational stocks as a factor in explaining economic growth, but it is too early to determine how their findings are influenced by their shift from investment to the services of a capital stock.

18. When about 95 percent of an age cohort has completed a given level of education, it may prove difficult to estimate the return with any reasonable confidence. Comparisons of the wage received for persons with only that level of education compared to the wage received by the fewer than 5 percent with less education may be volatile, and frequently not statistically different from zero. (See, for example, Murphy and Welch 1990; Card and Krueger 1992). Hypotheses regarding the self-selection process can be used to explain this pattern, but this finding is probably better viewed as a clue about the limitations of the approach. For this reason, estimates of the private returns to primary education in high income countries where virtually all persons (except immigrants) have completed primary schooling are not meaningful. It is also often the case that where national economies have grown rapidly, a bottleneck may emerge at the secondary level, and for some years the private returns to secondary schooling will exceed those at the primary level (as they did in Thailand). This may also be the case where the tertiary level of education is controlled by the public sector and entry is rationed by national entrance examinations (as in Taiwan and Korea until the 1980s).

19. There are, nonetheless, substantial costs involved in efficiently adapting the borrowed technology to a new production environment. For example, factor proportions would have to be modified in response to different local relative factor prices in the countries creating technology and those borrowing.

20. Most indicators of adult health status or morbidity are based on self-

evaluations of a survey population and are criticized as being excessively subjective. Consequently, comparisons of the health status of men and women across cultures based on these indicators are controversial (Schultz and Tansel 1992). Height and body-mass-index appear to predict mortality and the onset by middle age of chronic diseases (Fogel 1990; Costa 1992). But these anthropometric indicators of adult health have not yet been systematically collected for women as they have been for men, to assess how sex differences in these indicators vary across groups in a society, across populations at different stages in the development process, or over time within a population. More research is therefore required to systemically describe the inputs of nutrition and health investments, and their consequences on adult health for females and males separately. It is conjectured that because the declines in mortality have been generally more favorable for females than for males, that other objective indicators of health will confirm a similar pattern. The empirical basis for this presumption is currently limited.

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