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Economic Development, Growth of Human Capital, and the Dynamics of the Wage Structure

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In this paper I elucidate the sources of growth of human capital in the course of economic development. On the supply side (Section 1) I include the growth of family income, urbanization, the demographic transition, and the rising cost of time.The supply side alone cannot explain the continuous growth of human capital as it implies a self limiting decline in rates of return below those in alternative investments. Such declines are offset by growing demands for human capital in the labor market. Growth of demand for labor skills is a function of capital accumulation and of technological changes. Evidence on this hypothesis is summarized in Section 2 and on supply responses to growing demand for human capital in Section 3. Changes in the skill and wage structures in the labor market are an important part of the evidence.The reciprocal relation between economic growth and the growth of human capital is likely to be an important key to sustained economic growth. A caveat applies to indirect effects of economic growth on family instability, which may lead to a deterioration of childhood human capital in some sectors of society.

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The concept of human capital plays a major role in modern treatments of growth theory and of labor economics. In one sense, the distinction between the two is in levels of aggregation. At the macroeconomic level the social stock of human capital and its growth are central to the process of economic growth; at the micro level differences in human capital stock and in their growth can explain much of the observed variation in the wage structure and in the wage distribution among individuals and groups. Although pursued independently, these applications view human capital and its growth as a cause of economic growth: of the economy as a whole in the theory of growth and of individuals in labor economics.

Human capital is implicated in the process of growth not merely as a cause but also as an effect of economic growth or of developments generated by economic growth. The reciprocal relation between economic growth and the growth of human capital is likely to be an important key to sustained economic growth.

It is my purpose, in this paper, to elucidate the sources of growth of human capital. I stress the role of the family and of the labor market, as revealed in research of labor economists, including my own.

1. Supply Side

The growth of human capital in twentieth-century economies has been spectacular—from low levels of schooling and a great deal of illiteracy even in advanced countries in the late nineteenth century to a large majority of high school graduates at the present time. The continuing growth of human capital is an integral part of several other profound social transformations experienced in this century. Table 1 shows the changes for the United States: (1) growth of education, from very small proportions of high school graduates to almost universal completion, (2) a sevenfold rise in per capita real incomes, (3) urbanization, from nearly half of the labor force in agriculture to less than 5 percent, (4) the demographic transition, from large and extended families with high fertility and mortality to nuclear and subnuclear families with much greater longevity and better health, and (5) increased female participation in the labor market, from a miniscule proportion of married women working outside their households in 1890 to nearly two-thirds at the end of the current century.

The developments in the United States are paralleled by the history of most currently advanced economies. Though more recent, these trends are unfolding as well in less developed countries where, as in most of them, income growth is positive. Table 2 shows the current differences between poor and advanced countries, which very much correspond to the trends shown for the United States in Table 1. The trends are strongly interrelated; all are generated by and feed back on economic growth.

In what follows I sketch the economic analysis that relates these trends to economic growth and points to the growth of human capital as their consequence.

1.1. Direct Effect of Income Growth on Educational Trends

Education is an asset that generates not only earnings but also a stream of nonmarket utilities involving learning and culture. As such, it may be viewed as a consumption good, which, therefore, is directly related to income. The positive income effects apply also to the acquisition of education as an investment good, to the extent that imperfect capital markets necessitate a degree of self-financing of education. The positive effect of parental income on school enrollment of their children is documented in many microeconomic studies. Intercountry comparisons (Table 3) show similar results. But as Table 3 shows, the effect of income is greatly reduced: the coefficient declines greatly when variables representing urbanization, demographic change, and women's labor force participation are included. The income coefficient is reduced because the additional variables are in part generated by income (wage) growth. Their effect on education can therefore be viewed as an indirect effect of economic growth.

1.2. Urbanization

Given low price and income elasticities of the demand for food, the growth of industrial productivity, whether or not agricultural productivity grows at the same or lesser rate, results in a reduced demand for farm labor and lower wages in agriculture than in industry.[1] The

Table 1. A Century of Social Change in the United States, 1890 to 1990.

Year	Completed High School at Age 18 (1)	Enrollment Rates in School Ages 5–19, (2)	Real[a] GNP (Per Capita) (3)	Percent of Labor in Agriculture (4)	Life Expectancy[b] (5)	Infant Mortality[c] (6)	Female Labor Force Participation Rates[d]			Household Size: Percent with Numbers	
							Single	Married	All	5 or more	2 or less
1890	3.5%	54%	$840	44%	44 yrs	16.3%	40.5%	4.6%	19%	50%	16.8%
1990	87.0%	92%	$5,600	4%	76 yrs	1.6%	55.0%	63.0%	60%	15%	47.6%

Sources: Historical Statistics of the U.S., Statistical Abstracts (1990–1993); UN Human Development Report (1993); Current Population Survey (1991).

a. In 1958 prices.
b. At birth.
c. In Massachusetts.
d. As percent of population age eighteen and over.

Table 2. Intercountry Comparisons of Growth Related Variables (1990 and before)[a] (by Level of Income)

Countries	High Income	Middle Income	Low Income	
			All	Excl India and China
	(1)	(2)	(3)	(4)
% postsecondary education[b]	11.4%	3.0%	.6%	.6%
Years of school, male[b]	10.9	6.1	4.3	3.1
Years of school, female[b]	10.7	5.0	2.2	1.5
Real GDP per capita[c]	$18,170	$4,830	$1,510	$1,320
Rate of growth (1965–1980)[d]	3.0%	3.1%	2.7%	1.9%
Rate of growth (1980–1990)[d]	2.4%	1.3%	4.6%	1.6%
% Urban population, 1990	78%	60%	29%	26%
% Urban population, 1960	69%	41%	17%	13%
Life expectancy, 1991	76.4	67.2	61.9	54.7
Life expectancy, 1960	69.6	54.1	44.2	41.0
Infant mortality[e]	1.4%	4.6%	7.7%	9.8%
Total fertility rate	1.8	3.3	3.8	5.5
Percent of women in labor force	42%	32%	33%	28%
Population growth:				
Rate 1960–1991	.8	2.0	2.2	2.6
Rate 1990–2000	.5	1.6	1.9	2.5

Source: U.N. Human Development Report (1993).

Notes

a. High income: GNP per capita < $6,000 (35 countries); middle income: GNP per capita > $500 to $6000 (92 countries); low income: GNP per capita < $500 (46 countries).

b. Population ages 25 +.

c. Purchasing power parity ($).

d. Rate of growth of GNP per capita.

e. Per thousand live births.

share of the agricultural labor force in the total labor force declines more rapidly than the share of food expenditures in consumer budgets as their incomes grow. Cities grow as a result of labor migration from farms in response to the urban-rural wage differential rather than from urban fertility alone. Urban fertility is historically lower than rural fertility as the net costs of raising children are lower on the farm. With smaller families in the city than on the farm and greater profitability of education in the urban environment, urban families devote more resources per child to their education. But as urbanization grows, expected migration flows of the young to the cities increase incentives for farm families to invest in their children's education as well as to reduce their number. At the same time technological changes in agriculture increase the importance of education and reduce the usefulness of experience, thereby reducing the power of the elders in the extended family. Both technology and migration contribute to the decline of the extended family.[2]

Table 3. Education and Factors Affecting It

a. Effects of Income: Simple Regression Coefficients of (log) Income[a] (OLS).

On Variable	Years of School		Enrollment	Percent	Infant	Life	Women's Labor
	Male	Female	Rate	Urban	Mortality	Expectancy	Force Rate[b]
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Coefficient	1.83	2.03	19.1	15.1	−32.4	6.9	5.8
T-ratio	(18.9)	(19.6)	(29.0)	(29.0)	(18.2)	(35.5)	(29.5)
R^2	.71	.71	.77	.68	.46	.76	.69

b. Factors Affecting Education[c]: Multiple regression (OLS)

Dependent Variable	ln Y	TFR[d]	L EXP[e]	UWLF[f]	MUS[g]	R^2
Male education	.53	−.33	.065	.0005	.21	.77
	(2.3)	(2.6)	(2.5)	(2.1)	(0.6)	
Female education	.52	−.28	.092	.0006	−0.90	.80
	(2.2)	(2.2)	(3.6)	(2.2)	(2.6)	
Secondary school enrollment rate	6.65	−5.16	.066	.0034	3.91	.85
	(4.8)	(6.0)	(3.5)	(2.3)	(1.7)	

Sources: U.N. Human Development Reports (1993–95).

Note: Sample = 83 countries with comparable data for years 1970 to 1990 in five-year intervals.

a. Log of GNP per capita = ln Y; intercepts not shown.
b. Ratio of women's urban labor force to population.
c. ln Y is lagged 10 years in rows (1) and (2); intercepts not shown.
d. Total fertility rate.
e. Life expectancy at birth.
f. Women's urban labor force rate.
g. Dummy for Muslim countries.

1.3. The Demographic Transition

The demographic transition is the long-term change from populations with high birth and death rates to much larger populations with low birth and death rates. Family size changes from large and extended households to small nuclear (even subnuclear) units. It is inextricably also a change from low to high levels of human capital per person. The long-term growth of human capital is intimately connected with the demographic transition both as a factor in it as well as an outcome of it. The changes in family size and in human capital during the transition are linked as an effective, though not necessarily direct, substitution of quality for quantity of children.

While Malthus was right in concluding that economic growth due to increases in productivity would support a larger population, his prediction that population growth would ultimately eliminate the income gains from productivity growth was incorrect. The error is due to his basically biological theory that fertility is limited mainly by fecundity and that therefore mortality is the ultimate factor that adjusts numbers of people to available resources.

Modern economists discard the Malthusian notion of the predominance of biologically conditioned fertility and substitute for it a demand function for children[3] that focuses on both their numbers and "quality," or their human capital. This leads to a better understanding of the actual dynamics of the demographic transition that was triggered by the Industrial Revolution in the West some two centuries ago and in the less developed world in the current century.

The starting point of the demographic transition analysis is the decline in mortality that set in with the growth of income[4] in Western Europe. After a rather long lag, fertility began to decline in response to the decline in mortality. This response, not anticipated by Malthus, reveals that fertility decisions were matters of choice rather than biology. If the family contemplates an optimal rather than maximal number of surviving children, the decline in mortality forces a revision in fertility behavior, since the same number of survivors can be produced with fewer births. Fertility may therefore decline, but as the cost of producing a survivor declines,[5] more surviving children are desired. Since the number of survivors represents the difference between births and deaths of children, if fertility declines while number of surviving children increases, fertility must decline less rapidly than mortality yielding positive and increasing rates of population growth.

A necessary condition for a reduction in mortality to produce a reduction in fertility is a price-inelastic demand for children (T. P. Schultz, 1981). To see this, define the cost of producing a surviving child as

$$\pi_s = \frac{c}{p(s)}, \tag{1}$$

where $p(s)$ is the probability of survival to adulthood, while c is the cost of raising a child, conditional on survival. A reduction in mortality increases $p(s)$, which reduces π_s and so increases the demand for surviving children. If b is births per family, the number of surviving children per family is given by

$$n_s = bp(s). \tag{2}$$

Using equations (1) and (2), and holding c constant, it can be shown that

$$e_{n,\pi} = e_{b,\pi} - 1, \tag{3}$$

where e stands for price elasticity. $e_{b,\pi}$ must be positive for births to decline, when an increase in $p(s)$ reduces π_s. Hence, only if $|e_{n,\pi}| < 1$ will a decline in births materialize, even if c does not grow. But since $e_{n,\pi} < 0$, n_s increases and the birth rate declines less rapidly than mortality.

The lag prior to the drop in fertility may be attributed to $|e_{n,\pi}| \geq 1$ initially. More likely the perceived need and practice of fertility control required a cultural adjustment that was protracted. Less of a lag can be expected and is observed in the current transtion in LDCs as the culture and technology of fertility control are transmitted from the advanced countries. Indeed, the total duration of transition is expected to be significantly shorter in the LDCs.[6]

The increases in rates of population growth ("population explosion") characteristic of this initial or first phase of the demographic transition did take place even when, after a lag, fertility was declining. But for population growth rates to decline, as they did in the later phase of the demographic transition, fertility had to decline more strongly than mortality. This happened progressively as costs of raising surviving children (the numerator c in π_s) began to outstrip the gains in survival ($p(s)$). But even without increases in c the reduction in mortality produced increased incentives to invest in human capital: increases in longevity and the improved health underlying them imply a greater profitability of investment in people as the effective payoff period lengthens.[7] With limited budgets, investments in health and education of children reduced fertility further. The initial phase of the demographic transition, when population growth increased merged into the next phase as fertility declines accelerated in consequence of growing costs (c) of raising children.

In addition to costs due to urban living, the growth of real wages in industry and services, the opportunity cost of time in raising children is another factor that leads to declines in population growth[8] and the ultimate completion of the demographic transition, all the while providing further incentives for investment in human capital, as the numbers of children decline and income per child grows.

1.4. Growth of the Female Labor Force

Growth of the female labor force is a feature of twentieth-century societies experiencing economic growth.[9] The basic analysis of this phenomenon recognizes the productive nonmarket activities of consumers that are combined with purchased market goods and services to create final objects of utility or "commodities" in Becker's terminology. These activities use time, and growth of real wages raises the opportunity cost of nonmarket time. Consequently inputs of nonmarket time—time spent in household production—are reduced in favor of substitute market inputs bought with increased market earnings. The transfer of time from household production to market earnings shows up in growing labor force participation of women whose household activities are curtailed in favor of earning activities. Another effect of the growing cost of time is the reduction of household demands for time-intensive "commodities" such as child raising, which accelerates the downward trend in fertility. Both consequences require an initially sharp division of labor between the sexes in market and household activities, which is clearly much greater at the outset of economic growth (or in less advanced economies) when wages are low and fertility is high, taking up much of the adult life of mothers. As a result, work of married women outside the household is infrequent at that stage.

Two qualifications to this analysis involve income effects.[10] If demand for household intensive commodities were income elastic ($\eta > 1$), the analysis may not hold. Also, if productivity growth in household activities were as (or more) rapid than in the market, relative price changes that generate the substitution from time intensive to other commodities would either not materialize or reverse. The answers to these possible objections are (1) relative price changes that create the proper substitution move in the proper direction so long as market productivity grows more rapidly than household productivity—a proposition acceptable on both logical and empirical grounds and (2) if productivity in nonmarket activities were to advance as rapidly as in market activities, relative prices for household (time)-intensive commodities would not change over time, eliminating the substitution effect. But income growth due to productivity growth would reduce the share of income spent on time-intensive commodities, hence of time spent in the household, provided the income elasticity of demand for time intensive commodities is less than for other commodities (less than unitary). This very plausibly applies to production of necessities that require a great deal of household time such as food, shelter, and other utilities including children.

Small income elasticities are, indeed, observed in empirical demand functions for numbers of children, but large ones are observed for expenditures on children's "quality."[11] Here both the substitution and income effects work in the same direction: Much of the expenditure on market goods substituted for nonmarket time as inputs to the raising of children are purchased educational inputs. And the income elasticity of demand for "quality" of children such as their education is much greater than the elasticity of demand for quantity, as the analogy with consumer durables would predict, and is indeed observed.

In sum, the growth of human capital of children is due to all three developments: relative price changes due to increases in the cost of time, standard income effects, and productivity effects.

I portrayed the growth of women's labor force and reductions in fertility as jointly dependent on economic or wage and income growth, and children's human capital growth as an outcome. Of course, labor-force growth and reduction of family size also exert direct negative effects on one another, thereby speeding the processes.

The growth of human capital as an outcome is not restricted to children; it also extends to women as they contemplate their future role in the market and in the family. Two considerations lead to incentives for women's expanded investment in themselves. First, as time spent in the workforce increases with improved health and longevity, and as time spent in child care decreases, the payoff to human capital investments at school and on the job grows since the payoff period is lengthened. Increases in school enrollment and in job training of women are indeed observed in correlation with labor-force growth, especially with the growing continuity of labor market activities (Mincer, 1993a). Second, the increasing marital separation and turnover may be related to the declining division of labor in the family and to reduced parental stakes in children as their number declines. Awareness of a high probability of divorce, which is likely to cause an income loss to the spouse without a market career, leads to a precautionary growth of market work activities to ensure economic independence (see Johnson and Skinner, 1986). Increased investments in education and training and delayed marriage and fertility are vital parts of this response to risk and more generally to the growing expectation of a long working life.

2. Demand Side

All the described effects of economic growth on human capital formation whether direct or indirect, generate continuously expanding supplies of human capital. Higher incomes, the increased cost of time, city living, the demographic transition, and changing roles of women in the market and in the family—all increase the motivation for human capital investment by individuals and families.

But this is not a complete explanation of the unceasing upward trend in human capital accumulation. Theoretically, a trend due to the expansion of supply is self-limiting: sooner or later such investments would be curtailed as the rate of return on human capital would decline and fall below the rates on alternative investments. In fact, rates of return to human capital have not declined over the past century, just as rates on physical capital remained trendless. In theory, the obvious inference is that secularly growing market demands for human capital lifted the rates of return upward as supply grew, in part as a response to rising demand. The net outcome was a fluctuating but trendless rate of return on human capital investments.

Industry demands for skilled, educated, labor increases either because demand for its services and products increases or because its productivity grows as a result of physical capital accumulation or of technological change.

When human capital is viewed as a factor of production, coordinate with physical capital and "raw" or unskilled labor, a hypothesis of complementarity between physical and human capital implies growth of demand for human capital as a consequence of physical capital accumulation (Griliches, 1969). Physical capital accumulation raises the marginal product of human capital more than that of raw labor, producing wage (profitability) incentives for the conversion of labor into human capital by means of training and education. The accumulation of physical capital is not exogenous, however. Indeed the demand for both physical and human capital responds to opportunities for profit that emerge from cost-reducing and product innovating changes in technology.

Secular growth of demand for human capital, resulting from skill-biased technological change (Nelson and Phelps, 1966) or from physical-human capital complementarities, offers a plausible resolution of the apparent puzzle of trendless rates of return on education in the face of continuous upward trends in education.

This is not to say that technological change is always skill biased or that it is completely exogenous to the formation of human capital. Indeed, some of the market responses to increased costs of skilled labor inputs are technologies that economize on skills. Responses of this sort have not yet become prominent in current labor markets, but historical examples, such as the assembly line, are not rare.

Thanks to the availability of rich microdata sets and some indexes of technological change at the sectoral level, it has become possible to test the hypothesis that the pace of technology affects the demand for human capital, using U.S. data covering the past two or three decades. Changes in technology are difficult to measure, so the tests are largely indirect. They use contributing factors such as R&D intensity or consequences such as growth of productivity as demand shifters.

Using a variety of microdata sets, Lillard and Tan (1986) as well as Bartel and Sicherman (1995) found a greater incidence of training in industries whose productivity growth was fastest. Bartel and Lichtenberg (1987) report that, based on census data, relatively more educated workers were employed in those manufacturing industries (in 1960, 1970, and 1980) where capital equipment was newer and research and development (R&D) expenditures were more intensive. Extending the census data to all broadly defined industries (eighteen sectors), Gill (1989) observed greater utilization of educated workers and steeper wage profiles in sectors with more rapid decade-long productivity growth.

I tested the hypothesis that recent technological change is biased toward human capital (Mincer, 1993b) on the eighteen U.S. industrial sectors, using annual PSID data of the male labor force in 1968 through 1987, and Jorgenson-Fraumeni productivity growth (PG) indexes[12] for the period 1960 through 1985. The use of decade long averages for the intersectoral cross-sections of these indexes reduces much of the year-to-year error typical of such residuals.

Consistent with the skill bias hypothesis, the PSID data show that a more rapid pace of technological change in a sector (indexed by PG) generates a greater demand for education and training of the sectoral workforce; as evidenced by the following:

- The share of educated workers and the use of training is greater in the sector.
- Educational wage differentials (in percent terms) are larger within sectors with rapid productivity growth.
- Mobility of educated and, especially of young, workers into these sectors is observable and appears to erode much of the educational wage gains over the course of a decade.
- Wage profiles are steeper in progressive sectors, as incidence of training is greater in them.
- Separation rates increase in the short run. They decline in the long run, presumably because training intensifies.

All these findings can be viewed as responses of firms and workers to skill-biased technological change. This is true of the utilization and wage effects and, with an additional assumption, of the turnover effects. That additional assumption is a degree of firm specificity in training investments necessitated by changing technology, or more precisely, significant employer investments in such training.

In another study (Mincer and Higuchi, 1988) we showed that the difference between the United States and Japan in rates of technological change (measured by sectoral and national Jorgenson type total productivity growth indexes) can explain why wage structures and turnover rates differ across sectors and between the two countries. The remarkably low turnover rate in Japan viewed as "lifetime employment" is frequently described as a reflection of a culture that puts great emphasis on group loyalty. Yet in the same culture, turnover rates were a great deal higher prior to World War II. The difference appears to be an effect of the remarkably rapid technological progress in Japan since 1950. This technological catch up required sizable investments in human capital, in schools, and in enterprises. The phenomenal growth of educational attainments in Japan in recent decades is well known. The even more intense effort to adapt, train, and retrain workers for continuous rapid technological changes is not visible in available data. However, effects of training on life-cycle wage growth and on turnover rates are visible in the negative relationship between the two within industrial sectors observed in Japan and in the United States. In both countries, industries with more rapid growth had both steeper wage profiles and lower turnover rates. Indeed, using the parameters of those relations, a rate of productivity growth in Japan that was four times that in the United States in the period from 1960 to 1980 predicted rather well the over threefold steeper wage profiles and the less than one-third frequency of firm separations in Japan. Somewhat weaker but quite pronounced differences of the same sort were observed in a comparison of American and Japanese plants in the United States—that is, in the same cultural environment. Here the much larger investments in training and screening of workers in the Japanese plants were more directly observable.

Positive cross-sectional associations between the pace of technological change in a sector and indexes of relative demand for human capital do not, by themselves, establish a causal relationship nor the direction of causality, as articulated in the hypothesis of skill-biased technology. To resolve the possible doubts that may attach to the interpretation based on cross-sections, a companion time-series analysis was undertaken as the next step.

The time-series analysis of annual aggregates over a recent twenty-five-year period is provided in Mincer (1993c). This study focuses on the dramatic changes in wage differentials by education and by experience during the period from 1963 through 1987. Both sets of differentials are, in part, indicators of the payoffs for skill, or of rates of return on human capital investments. Fluctuations in them are the outcome of changes in relative supplies of educated and experienced workers and in relative demands for them. Both relative supply and relative demand variables are brought to bear in equations that "explain" the time series of wage differentials. The findings shown in Table 4 substantially confirm the cross-sectional results:

- The year-to-year educational wage differentials (between college and high school graduates) are very closely tracked by relative supplies of graduates in (roughly) their first decade of work experience and by changes in demand for more educated workers. The latter is indexed by research and development expenditure per employee (RDE) as well as by trends in service employment (RSG) relative to goods producing employment. Of these, RDE accounts for most of the explanatory power.

- With the decline of average productivity growth and the near cessation of average real wage growth since the early 1970s, the skill-biased changes in demand took the form of increases in demand for workers with postsecondary education and decreases in demand for workers at lower education levels. The decline in demand for workers at lower educational levels is attributed by some analysts (see Murphy and Welch, 1989) to the growth of world trade: imports and exports in U.S. trade more than doubled as a percentage of GNP between 1960 and 1990. As import competing industries tend to be less skill intensive this may have led to a reduction in wages of less skilled workers.[13] In my regression findings (Table 4) the effect of the net balance of trade variable (RNE) on the skill wage gap is significant but quite small when substituted for research and development (RDE). It is not significant when added to the RDE variable.

- Changes in age distributions (cohort effects) account, in part, for the observed steepening of the experience profile of wages in the 1970s: increased proportions of young workers ("baby boomers") reduced their wages relative to older workers.[14] They do not account for the steepening of the high school profile in the 1980s or for the stabilization of the slope of the college profile between the 1970s and 1980s. A more complete explanation for the steepened profiles is provided by additional variables that reflect the growing profitability of human capital.

Table 4. Educational wage differentials (college—high school)[a] 1963–1987

Variables	Coefficients				
	(1)	(2)	(3)	(4)	(5)
Intercept	−0.09 (1.4)	−0.59 (3.4)	−0.41 (4.6)	0.06 (1.0)	−0.14 (3.5)
$RESY_{-2}$	−0.065 (2.2)	−0.086 (1.9)	−0.080 (3.0)	0.081 (1.1)	0.002 (0.2)
DR_{-2}		−0.20 (4.6)		−0.14 (2.7)	
PG	1.12 (2.2)	0.45 (1.00)		0.88 (1.9)	
RDE_{-2}			0.00024 (12.3)		0.00025 (9.0)
RNE	−0.011 (4.5)				
RSG		0.088 (4.1)	0.044 (3.5)		
EQ				0.000064 (3.4)	0.000028 (2.1)
R^2	0.69	0.80	0.91	0.75	0.89

Source: Mincer (1993c, Table 2).

Notes: t-values in parentheses. Excluded variables not significant.

Subscripts$_{-2}$ and $_{-3}$ denote a two-year and three-year lag.

RESY = Proportion of young college+graduates among young workers (experience 1–10 years).

DR = Ratio of young (experience less than or equal to ten years) to total workforce.

PG = Total factor productivity growth (Jorgenson measure).

RDE = Research and development expenditure per worker.

RNE = Merchandise trade balance as a ratio to GDP.

RSG = Ratio of service to goods producing employment.

EQ = Expenditure on new equipment per worker.

a. Percent wage differential between male college and high school graduates with 6–10 years of work experience.

- Capital-skill complementarity appears to be at work alongside skill-biased changes in technology: when new equipment per worker is used as the measure of capital intensity, the variable has a positive effect on the skill wage differential. It is not clear, however, whether the skill bias embodied in new equipment represents anything different than the effect of new technology.

The importance of skill-biased technological change in affecting relative demands for human capital is invoked in an indirect manner in a number of micro-level studies[15] that attempt to shed light on the dramatic changes in the U.S. wage structure in the past two decades. In these studies skill-biased technology is suggested as a hypothesis consistent with a variety of observed changes at the industry or plant level. These changes include increased utilization of skilled workers within a complete array of industries and plants whether or not they engage in or compete with internationally traded goods and services. The increase in (relative) utilization of skilled workers is positively correlated with the increase in skill wage gaps across industries and plants. This is evidence for a growing demand for skills. If the growth of international trade were the major factor in reducing the demand for unskilled labor in manufacturing wages of unskilled labor would fall, and its relative utilization in nonmanufacturing would have been positively correlated with the skill wage gap, but the opposite correlation is observed.

A natural corollary of the dramatic changes in the skill structure of wages in the 1970s and 1980s is in the substantial growth in wage (and income) inequality (as measured by, for example, the variance of log wage), especially in the latter period. The widening inequality is viewed by some—perhaps many—observers as an ominous reflection of a deteriorating economy and society. It has stimulated research by economists and sociologists.

The sense in which changes in wage inequality are a corollary of changes in skill differentials in wages (by education and age) is obvious: when these differentials change, total inequality changes in the same direction, unless within group differences move in an opposite direction. This proviso is intuitively implausible, yet it did emerge in the 1970s, as some observers report: residual (within education and age groups) inequality did not narrow, when educational differentials shrank. Since residual inequality is the larger part of total inequality, resolutions of puzzles about changes in residual inequality are a matter of some importance in the developing research effort (Levy and Murnane, 1992; Freeman, 1994).

3. Human Capital Supply Responses to Growth in Demand

A question of great interest is whether the growth of skill differentials in wages and more generally in wage inequality, now seen for close to two decades, can be expected to reverse itself, and if so, how fast. Changes in the age distribution might have some effect. As the baby boom that steepened the wage profile was followed by a baby bust, a flattening of age profiles might have been expected, and this in turn would have contributed to a reduction in equality. But this did not happen because the age profile of wages is affected not only by demographic change but also by skill premiums, which rose in the 1980s. The major question, therefore, is whether the supply of human capital can be expected to grow sufficiently in response to high rates of return so as to eventually reduce the rates of return to a normal level and so reduce inequality as well.

The supply responses are analyzed in my recent study "Investment in U.S. Education and Training" (Mincer, 1994). In analyzing supply responses it is important to distinguish between stocks and flows of human capital. The stock of human capital, such as educational attainment, exerts an effect on educational differentials in wages, while the flow, measured by enrollments responds to the wage differentials, or more precisely to rates of return. The rather lengthy lag of the build up in the stock of educational attainment following changes in the enrollment gives rise to apparent paradoxes such as the growth of educational supplies (attainment) in the 1970s when the rates of return were falling and the leveling of supply when the rates were rising steeply. Correctly understood, the 1970s' decline of rates is due to the effect of an increasing stock accumulated by growth of enrollment in the 1960s when rates were rising. Stocks leveled off in the 1980s as flows of enrollment declined in the 1970s in response to declining rates. Consequently the growth of rates of return in the 1980s was due to upward shifting demand, as is shown in Table 4.

According to human capital theory, investments in education (school enrollments and participation in training) respond positively to prospective rates of return as well as to parental education and income, and respond negatively to tuition costs. In Table 5 parental education was used to represent both informational and financial advantages facilitating the education of children. Since the measure of the educational wage differential, used in the empirical analysis is not a rate of return, it misses the direct (net tuition) costs of schooling as a factor which is included in Table 5. The prospective educational wage premia are pictured as the ratio (minus unity) of wages of college to high school graduates about a decade after graduation, which are currently observed by families and students. This is the "overtaking stage of experience," which is minimally affected by job training (Mincer, 1974).

At all stages—enrollment rates in October following high school graduation, enrollment rates of high school graduates aged eighteen to twenty-four, and enrollment rates of the population of those eighteen to twenty-four years old—the response to wage premia and to parental education was positive and significant, while tuition had a negative effect.

The educational pipeline from postsecondary enrollment to attainment implies a sizable lag. The optimal lag measured by the maximal correlation in the regression of attainment in the young population (Figure 1) on enrollment of roughly the same cohort was eight years. This regression yielded an $R^2 = 0.93$, when the proportion of college graduates in the twenty-five to twenty-nine age group was regressed on enrollment of these eighteen to twenty-four years old eight years before. Similarly, if the dependent variable is the cohort at six to ten years of working age (years since completion of schooling) the optimal lag is again eight years, and $R^2 = 0.89$. A slightly weaker correlation is obtained when the cohort aged twenty to twenty-nine is used as the relative supply (proportion with sixteen or more years of schooling) variable.

It is this relative supply variable which affects the rate of return negatively, holding the demand variable constant—as is shown in Table 4. Figure 1 shows how well the enrollment series (lagged eight years) fits relative supply, by shifting the attainment series of the young population eight years back. Enrollment growth in the 1960s produces the growth of attainment prior to 1975, while the declining enrollment rate in the 1970s leads to the stagnation in the supply in the 1980s. In turn, the growth of enrollment in the 1980s predicts an increasing relative supply in the 1990s among the young cohorts, as shown in the extrapolation of the lower graph in Figure 1. The predicted increase in attainment from 1991 to 2000 is, according to Figure 1, about 8 percentage points.

Parameter estimates of RESY (the effects of relative supply on the educational wage

Table 5. Enrollment rates, 1967–1990.

Variables	Percent of High School Graduates Enrolled Next October	Percent of High School Graduates Enrolled, Age 18–24		Percent of Population Age 18–24 Enrolled	
	(1)	(2)	(3)	(4)	(5)
College wage premium[a]	2.9	1.3	1.3	0.77	0.77
	(5.1)	(3.2)	(4.3)	(2.8)	(3.6)
	0.45	*0.31*	*0.31*	*0.23*	*0.23*
Parental education[b]	3.7	1.2	1.2	1.6	1.6
	(3.7)	(1.7)	(2.3)	(3.4)	(4.5)
	0.84	*0.42*	*0.43*	*0.73*	*0.74*
Tuition	−0.007	−0.002	−0.002	−0.0004	−0.0003
	(2.9)	(0.96)	(1.1)	(−0.3)	(−0.3)
	−0.81	*−0.29*	*−0.26*	*−0.08*	*−0.06*
Intercept	27.7	18.8	18.8	3.2	3.2
	(3.1)	(3.1)	(4.1)	(0.7)	(1.0)
Residual from first regression			0.46		0.32
			(3.9)		(3.9)
R^2	0.75	0.69	0.82	0.79	0.88

Sources: Mincer (1994, Table 6). Column (1): Condition of Education (U.S. Department of Education, National Center for Education Statistics: 1992, Table 7-1).
Columns (2–5): School Enrollment—Social and Economic Characteristics of Students (Current Population Survey: October, 1992, pp. 20–474).

Notes:
All variables are three-year moving averages. T-statistics in parentheses; elasticities in asterisks.
a. Percent wage differential of male college and high school graduates with 6–10 years of experience.
b. Average schooling of males with 26–30 years of experience.

differentials) in Table 4 imply an elasticity of −0.72 of the wage premium with respect to the relative supply. The predicted increase in attainment of 35 percent in the young population (8/23 in Figure 1) would therefore reduce the college premium by about 25 percent. If the current college premium is about double its usual (average) level, the supply response would return the college premium about half way toward its long-run average (1957 to 1990) a decade from 1993.

In this scenario over half of the skill shortages would be eliminated by the end of the decade following the year 1993. This prediction relies on supply effects alone and assumes a deceleration of growth in demand for human capital and in direct costs of schooling (such as net tuition) to their long-term levels. Clearly, the adjustment will be slower, if growth of demand does not decelerate, unless skill-saving technologies are implemented.

The response of job training to changing demand for human capital can be inferred indirectly from changing slopes of wage profiles and more directly from BLS surveys of the incidence of job training. The changing slopes of the wage profile are affected both

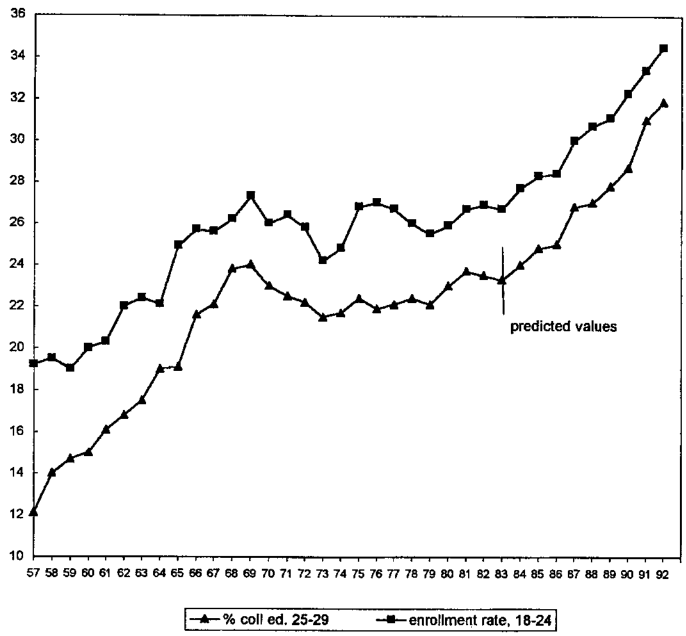

Figure 1. Percent of College Graduates in the 25–29 Population (shifted 8 year versus 18–24 enrollment rate). Source: Mincer (1994, Figure 4).

by changes in the profitability of training and of its volume or incidence. The slopes are also affected by demographic changes: the baby boom increased the relative supply of inexperienced workers and steepened the ratio of wages of older to younger workers given imperfect substitution between inexperienced and experienced workers. In Table 6, both the proportion of young workers in changing cohorts and the schooling wage premium are positive and significant in affecting the profile's slope.

In addition, information from 1983 and 1991 BLS surveys shows that the incidence of training increased in the 1980s when the profitability of education grew strongly (see Mincer, 1994, Table 11).

4. Prospects and Questions

The increasing human capital investments in the 1980s can be expected to produce higher stocks of human capital in the 1990s and beyond, which in turn could reverse the growth of rates of return and of wage inequality at a later date, provided the growth of demand for education and skilled workers decelerates. If so, estimates of the optimal lag between attainment and enrollment and of elasticities of rates of return with respect to the supply of human capital stocks, suggest a decline of rates of return half-way toward the "normal" long-run level in the next decade or so.

The suggested period of readjustment of supply and of the wage structure is expected to

Table 6. Slope of Wage Profile, 1967–1990

	High School	College
intercept	−0.0165	n.s.
	(−2.9)	
r_s	0.31	0.12
	(7.8)	(3.6)
	0.68	*0.27*
DR	0.06	0.06
	(5.1)	(6.0)
	0.61	*0.76*
u	0.0011	n.s.
	(5.2)	
	0.17	
R^2	0.91	0.60

Source: Mincer (1994, Table 10).
Notes: T-statistics in parentheses; elasticities in asterisks.
r_s = college wage premium.
DR = ratio of numbers of workers of 1–10 years experience to all workers with 1–40 years of experience.
u = unemployment rates for recent high school grads.
n.s. = not significant.

be longer than the decade-long fluctuations in the past because the skill-biased growth in demand, especially in the past decade, has been very strong, reflecting the birth of a new era of information and communication technology.

Looking to the future, a more basic question remains concerning the scope of possible supply responses to the growth in demand for skill. Skills acquired at school and on the job are a function of the quality of learning and not merely of the time spent in it. Therefore a bottleneck in the expansion of human capital supply may lie in the inadequate quality of learning absorbed by the workforce, especially at the elementary and secondary levels of schooling.

If this quality deteriorated or remained inadequate in the face of growing technological demands in the past decade or two, it may have been a factor in the widening and persistence of educational differentials and in inequality more generally. Evidence on trends in quality of learning is difficult to come by, but apprehension about quality levels appears to be justified by a variety of tests and international comparisons. At a deeper level quality problems are not restricted just to schooling. They start with childhood development before entering school. Human capital inadequacies at home and in early schooling are likely to affect the efficiency of human capital investments. Therefore, quality bottlenecks are not effictively overcome by the substitution of training for schooling: the needs for remediation increase the cost of training and are likely to reduce job training as well.

5. Childhood Human Capital: Progress or Impediment?

In the past the division of labor within the family made the family economically interdependent and therefore more stable. The growth of real wages, the decline of fertility, and the improvements in health and life expectancy are some of the factors generated by economic growth that led to the growth of women's labor market participation and market career orientation. The consequence is a considerable reduction in the division of labor within the family. The greater economic independence of spouses (current or prospective) may well generate increasing marital separation and turnover. I indicated before that this development in turn augments women's incentives, on precautionary or insurance grounds, to increase their investment in themselves. But the effects on the investment in the human capital of children are uncertain: even though greater human capital investments per child are the outcome of the demographic transition and continue to rise with growing technology, deterioration is likely to arise from growing family instability. The latter is reflected not only in high separation rates. Postponements of marriages and reduction of marriage rates as well as growing cohabitation and nonmarital births are other manifestations of profound changes in family structure experienced in the advanced countries of North America and Western Europe.

Do these new and growing family structures represent a viable adaptation to the consequences of economic growth, or are they symptoms of decay created by economic growth?

The implications for the human capital of the large proportion of children living with only one parent or only one biological parent are problematic. Recent studies (McLanahan and Sandefur, 1994) show that children growing up in single-parent households are twice as likely to drop out of high school, to be unemployed, and to become teenage parents themselves. After separation, the single parent household loses about 40 percent of family income, children lose most of their contact with fathers, while growing proportions of single mothers are away at work most of the day. Even when income and ethnicity are held constant, children in single-parent households are likely to suffer the consequences of a reduced human capital potential (Dawson, 1991).

Since human capital is a factor in producing additions to human capital (Ben-Porath, 1967; Becker 1975), the disadvantages of an impoverished early human capital stock accumulate over a lifetime.[16] Although the repercussions of family instability are most pronounced in the poor population, the proportion of population in poverty has not grown significantly in the past two or three decades, while the growth of family instability has been rapid in most of the advanced economies in that period.[17] Is there a danger that economic growth is carrying seeds of its own destruction? This Schumpeterian thought may be as wrong as its predecessor, but more research will be required to evaluate the nature and dimensions of the problem and some policies will be needed to deal with it.

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Notes

1. If agricultural productivity grows faster than industrial productivity, the demand for farm labor is still likely to decline, given the low income and price elasticities.
2. See Rosenzweig (1994) for an instructive analysis of the effects of the "green revolution" in India.
3. For a comprehensive synthesis see Becker (1981) and T. P. Schultz (1981).
4. Historians also stress the relevance of public health measures as a factor independent of income. This point is probably more applicable to the current experience of less developed countries.
5. Costs decline because fewer births are needed to produce a survivor.
6. Rates of population growth in LDCs began a decline as early as the 1960s. Fertility rates declined over 50 percent since then (T. P. Schultz, 1994).
7. This was first pointed out by O'Hara (1972).
8. This description of the demographic transition as a nonlinear effect of economic growth on population growth casts doubt on attempts to analyze economic growth as an effect of population growth: the same rate of population growth corresponds to low and high levels of income, depending on the state of the demographic transition.
9. The first analysis by Mincer (1962) used a price-theoretic approach and was applied to the U.S. experience. Becker (1965) contributed a theoretical framework that utilizes the concept of the "household production function." Goldin's book (1990) covers the U.S. history in great detail.
10. For a detailed analysis see Becker (1965) and Mincer (1962).
11. Voluminous evidence is cited in T. W. Schultz (1975b) and Becker (1981).
12. The Jorgenson-Fraumeni indexes contain measures of quantity and of "quality" of labor inputs. The latter are based on education, age, and sex of the workforce. The productivity growth residuals are, therefore, largely purged of human capital components. This ensures that there is no spurious correlation in the empirical relations between productivity growth and human capital.
13. See articles in Kosters (1994) and a review by Burtless (1995). Based on micro-level studies, described below, most economists doubt that the growth of trade had much of an effect, if any, on the decline of less skilled wages.
14. See Welch (1979) for the analysis of cohort effects.
15. For comprehensive reviews see Levy and Murnane (1992) and Freeman (1994). No direct measures of technology are available except for a study of computer use and its effects by Krueger (1993).
16. Lesser additions to human capital translate into flatter wage profiles.
17. If the welfare system is a factor in the disintegration of poor families, its contribution to the problem may have actually diminished in the past two decades as welfare benefits declined in the United States.

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