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## The Output of the Education Sector

Dale W. Jorgenson and Barbara M. Fraumeni

In recent years educational expenditures have averaged around 7 percent of the national product. This percentage doubled between 1950 and 1970 and has remained stable since then. Obviously, education is a very important economic activity. Excellent statistics exist on all aspects of education, except the one most fundamental from the economic point of view, namely, the output of the educational system. We need a measure of output to put the education industry on par with other industries producing goods and services. The purpose of this paper is to present a new approach to measuring the output of the education sector.

Our point of departure is that, although education is a service industry, its product is investment in human capital. The effects of formal schooling on income endure throughout the lifetime of an educated individual. Accordingly, we employ the effect of education on an individual's lifetime income as a measure of educational output. A second important idea is that the benefits of schooling are not limited to time spent at work. Education also enhances the value of activities outside the labor market, such as parenting and the enjoyment of leisure time. Our estimates of the output of the education sector incorporate the value of time spent outside the labor market.

Beginning with the seminal contributions of Becker (1964), Mincer (1974), and Schultz (1961), economists have found it useful to characterize the benefits of education by means of the notion of investment in human capital.<sup>1</sup> This

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1. Rates of return to investment in human capital are discussed by Becker (1975) and Mincer (1974). Welch (1979) presents estimates of relative rates of return for different age cohorts of the U.S. population. Murphy and Welch (1989) give estimates of rates of return for higher education. Surveys of different aspects of the literature are provided by Griliches (1977) and Rosen (1977).

idea captures the fact that investment in human beings, like investment in tangible forms of capital such as buildings and industrial equipment, generates a stream of future benefits. Education is regarded as an investment in human capital because benefits accrue to an educated individual over a lifetime of activities. Of course, investment in education is only one of many forms of investment in human capital. Important investments are made by families in the rearing of their children and by employers and workers in on-the-job training.

The most common approach to compiling data on education investment is to measure the inputs, rather than the output, of the educational system.<sup>2</sup> Data on the expenditures of educational institutions for teachers and other personnel, buildings and equipment, and materials can be compiled from accounting records. This information can be supplemented by estimates of the value of time spent by students (and their parents) as part of the educational process. Costs of schooling and the value of the time spent by students can be used to measure the flow of resources into schools and universities.

Although the costs of education are highly significant in economic terms, the cost-based approach to measurement of educational investment ignores a fundamental feature of the process of education, the lengthy gestation period between the application of educational inputs—mainly the services of teachers and the time of their students—and the emergence of human capital embodied in the graduates of educational institutions. Furthermore, some of the benefits of investment in education, such as greater earning power, are reflected in transactions in the labor market; others—such as better parenting and more rewarding enjoyment of leisure—remain unrecorded.<sup>3</sup>

In measuring the output of the educational system our first step is to compile data on the economic value of market labor activities. In section 8.1 we show that the constant dollar value of time spent working has doubled in the postwar United States. The growth of this value has been greater—or the decline has been less—for women than for men at all levels of educational attainment and reflects the rapid increase in labor force participation by women relative to men. The proportional increase in the value of market labor time has been greatest for college-educated men and women and corresponds to the substantial growth in levels of educational attainment.

Our second step in measuring the output of the education sector is to estimate the value of nonmarket labor activities. These activities include both time spent in investment in education and time spent in the consumption of leisure. We infer rates of compensation for nonmarket activities from market wage rates. The value of nonmarket activities, measured in this way, exceeds

2. In this context we employ the notion of output as the economic value produced within the educational sector. Outputs of the educational system can also be defined in terms of measures of educational achievement, such as performance on standardized tests. This definition is the basis for the literature on educational production functions reviewed by Hanushek (1986, 1989).

3. Nonmarket benefits of education are discussed by Haveman and Wolfe (1984) and Michael (1982).

the value of market activities, primarily because nonmarket time exceeds time in the labor market. However, the value of nonmarket labor activities has grown more slowly. The expansion of the value of nonmarket time has been more rapid for men than for women. We discuss these findings at greater length in section 8.1.

In section 8.2 we estimate lifetime labor incomes for all individuals in the U.S. population. These incomes include the value of both market and nonmarket labor time. We then estimate the effect of increases in educational attainment on the lifetime incomes of all individuals enrolled in school. We find that investment in education, measured in this way, is greater in magnitude than the value of working time for all individuals in the labor force. Furthermore, the growth of investment in education has exceeded the growth of market labor activities. Investment in education has increased much more rapidly for women than for men, especially at the college level.

We present the conclusions of our study in section 8.3. One of the most attractive aspects of cost-based estimates of investment in education from the accounting viewpoint is that these estimates can be derived primarily or even entirely from data on market transactions. Unfortunately, it is precisely this feature that leads to the undeserved neglect of nonmarket activities. The lifetime-income approach presented in this paper easily encompasses the value of time spent outside the labor market. When applied to education, this approach yields far greater estimates of the output of the education sector than do those approaches based on costs of inputs.

## 8.1 Market and Nonmarket Labor Incomes

In order to measure investment in human capital as an output of the educational system we have constructed a new data base for measuring lifetime labor incomes for all individuals in the U.S. population. This data base includes demographic accounts for the population in each year, cross-classified by sex, age, and year of highest educational attainment. Our demographic accounts include data on the number of individuals enrolled in formal schooling and on the number employed. These demographic accounts are based on annual population data from the U.S. Bureau of the Census.<sup>4</sup>

Table 8.1 presents our estimates of numbers of students between 5 and 34 years old enrolled in school, cross-classified by sex and level of education.<sup>5</sup> Enrollments in grades 1–8 and high school peaked during the late 1960s or the 1970s and have gradually drifted downward through 1986, the last year for which our data are available. Enrollments in college flattened in the 1980s for both men and women and have begun to decline. Enrollments in primary

4. See, e.g., Bureau of the Census (1985). We employ a system of demographic accounts for the United States constructed by Land and McMillen (1981). Demographic accounting is discussed by Stone (1981).

5. See, e.g., National Center for Education Statistics (1988). A compendium of educational statistics is given by O'Neill and Sepielli (1985).

schools have increased over the period 1947–86 as a whole; enrollments in secondary schools have nearly doubled. Enrollments in higher education have risen very dramatically, especially for women.

To measure lifetime labor incomes for all individuals in the U.S. population we begin with a data base on market activities constructed by Gollop and Jorgenson (1980, 1983). We derive estimates of hours worked and labor compensation for each sex by 61 age groups and 18 education groups for a total of 2,196 groups for each year. Table 8.2 presents our estimates of the value of time spent working, cross-classified by sex and educational attainment, for all individuals in the U.S. economy from 1948 to 1987. In this table we give estimates of the value of labor time in current prices. The corresponding estimates in constant prices are given for 1949–87 in table 8.3.

Labor time in constant prices is a quantity-index number, defined in terms of annual hours worked for individuals cross-classified by age, sex, and educational attainment. To construct a quantity index of labor time, we weight these hours worked by average compensation per hour. We assume that labor time can be expressed as a translog function of its 2,196 components. The growth rate of the corresponding quantity index is a weighted average of growth rates of these components. The weights are given by the shares of each component in the value of market labor time. A quantity index of labor input is unaffected by inflation in rates of labor compensation; the current market value obviously reflects this inflation.

The current dollar value of market labor activities has increased 17-fold over the postwar period. The proportional increases were greatest for college-educated workers—almost 40 times for men and 65 times for women. The proportional increase for women exceeds that for men for all levels of educational attainment. For the population as a whole the growth of labor compensation is due to a rise in employment and very substantial increases in rates of labor compensation per hour worked. The contrasting trends for men and women are due to a modest rise in employment for men and much greater increase in employment for women. Hours worked per employed person have declined for both sexes.

The constant dollar value of market labor activities has more than doubled over the postwar period. However, the quantity index for workers with eight or fewer years of educational attainment has declined substantially. For high-school-educated workers quantity peaks in 1979 for males and rises throughout the period for females. Finally, working time in constant prices increases by more than four and a half times for college-educated males and almost seven times for college-educated females. The constant dollar value of working time for males with a college education exceeds that for high-school-educated males, beginning in 1980; the value for college-educated females exceeds that for females with a high school education at the end of the period in 1987.

Turning next to the task of evaluating labor time spent in nonmarket activities, we consider activities, such as formal schooling, that enter into investment in human capital and activities that result in consumption. The importance of evaluating time spent in nonmarket activities is widely recognized.<sup>6</sup> For example, Nordhaus and Tobin (1972) have incorporated measures of the value of these activities into their measure of economic welfare. Kendrick (1976) and Eisner (1989) have also imputed values for time spent outside the labor market. Five types of nonmarket activities are commonly distinguished in studies of time allocation—household work, human capital investment, travel, leisure, and maintenance—the satisfaction of physical needs such as eating and sleeping.<sup>7</sup>

We allocate the total time available for all individuals in the population among maintenance, work, school, and household production and leisure. Studies of time allocation show that maintenance time per capita has changed very little during the postwar period. We estimate that time spent in maintenance is ten hours per day per person and exclude this time from our measure of the value of nonmarket activities. We estimate the time spent in formal education for all individuals enrolled in school and allocate this time to investment. Finally, we allocate the time that is not spent on maintenance, work, or school to consumption. We impute rates of labor compensation for nonmarket activities from wage rates for employed individuals with the same age, sex, and educational attainment. Market wage rates are reduced by taxes on labor incomes estimated by Jorgenson and Yun (1990).

Table 8.4 gives the value of nonmarket activities in current prices, cross-classified by sex and educational attainment, for all individuals in the U.S. population for the period 1948–1987. The corresponding estimates in constant prices are given for 1949–87 in table 8.5. As before, nonmarket time in constant prices is a quantity-index number, defined in terms of hours of nonmarket time for all 2,196 categories of workers. Although nonmarket time in current prices reflects inflation in imputed rates of compensation, the quantity-index number is unaffected by inflation.

The value of nonmarket activities in either current or constant prices exceeds the value of market activities by a factor of two. This is due to the fact that nonmarket time, as we measure it, is greater than time spent at work. For the population as a whole the growth of the value of nonmarket time is roughly comparable to the growth of the value of work time; however, the distribution of this growth is considerably different. Because each individual has a fixed time budget of 14 hours per day, allocated between market and nonmarket

6. An economic theory of time allocation is presented by Becker (1965). Detailed references to the literature are given by Murphy (1980). Gates and Murphy (1982) present time use accounts for the United States for 1975–76, based on data collected by the Survey Research Center of the University of Michigan. A survey of time allocation is given by Juster and Stafford (1991).

7. See, e.g., Gates and Murphy (1982) and Juster, Courant, and Dow (1981).

activities, the general pattern for nonmarket time is a mirror image of that for work time. For both men and women the value of nonmarket activities has grown considerably more slowly than the value of time spent working.

Given increased rates of labor force participation for women, the value of work time has grown more rapidly for women than for men. With fixed time budgets for both men and women, the value of nonmarket time has increased faster for men. For example, the value of nonmarket time for college-educated men has increased by 42 times, whereas the value for college-educated women has grown by a factor of 38. The relative increase in the value of nonmarket time is greater for individuals of both sexes with higher education than for individuals with only secondary education. This increase is greater for individuals with secondary education than for those with only primary education. These trends reflect increases in levels of educational attainment for both men and women.

Our final step in measuring lifetime labor incomes for all individuals in the U.S. population is to project incomes for future years, discount these incomes back to the present, and weight income for each individual by the probability of survival.<sup>8</sup> We obtain these probabilities by sex from life tables published by the National Center for Health Statistics.<sup>9</sup> We combine estimates of lifetime labor incomes by sex, age, and educational attainment with demographic accounts for the numbers of individuals to obtain estimates of human capital, investment in this capital, and the flow of human capital services. The value of the services of human capital is, of course, equal to the sum of the values of market and nonmarket time presented in tables 8.2–8.5 above.

In estimating lifetime labor incomes we distinguish among five stages of the life cycle. We assume that all individuals 75 or older are retired, so that the value of current labor time is set equal to zero. Lifetime labor income for these individuals is zero.<sup>10</sup> We assume that individuals between 35 and 74 may work but do not attend school. Lifetime labor income is the discounted sum of future labor incomes through age 74, so that the level of educational attainment is held constant. We project future labor incomes for a person of given sex and educational attainment by taking these incomes equal to the current average for all individuals with the same age, sex, and educational attainment, increased by 1.32 percent per year to reflect future increases in real incomes.<sup>11</sup>

For example, we project future labor incomes for a male with a high school education at age 35 by first considering current labor incomes for males with

8. Estimates of lifetime labor incomes for men based on market labor activities are presented by Weisbrod (1961), Miller (1965), and Graham and Webb (1979).

9. See National Center for Health Statistics (various annual issues).

10. The proportion of the U.S. population 75 and over has risen from 2.4 percent in 1948 to 5 percent in 1987, so that omissions of lifetime labor incomes for this part of the population imparts a small but slowly increasing bias to our estimates of human wealth for the population as a whole.

11. Our estimate of the growth rate of real incomes is based on the rate of Harrod-neutral productivity growth for the United States estimated by Jorgenson and Yun (1990).

high school education at ages 35, 36, and so on, up to age 74. We increase the labor income for a 36-year-old individual by 1.32 percent to reflect increase in real income. We increase labor income for an individual aged 37 by a further 1.32 percent, and so on. We then multiply labor incomes for ages 35–74 by the probabilities that the individual will survive to each of these ages, given that he or she has already reached the age of 35. Finally, we discount the labor incomes at 4.58 percent per year back to the present.<sup>12</sup>

For individuals between 14 and 34, we assume that an individual may work as well as enroll in school. For an individual of a given age and sex enrolled in the highest level of formal schooling, which is the 17th year of school or higher, lifetime labor income is the discounted value of labor incomes for a person with 17 years or more of education. For an individual enrolled in the 16th year of school, lifetime labor income includes the discounted value of labor incomes for a person with 17 years of formal education or more, multiplied by the probability of enrolling in the 17th year of school, given enrollment in the 16th year. This income includes the time not spent in school during the 17th year. It also includes the discounted value of labor incomes for a person with 16 years of education, multiplied by one minus this probability, which is the likelihood of terminating formal schooling at 16 years.

By working backward from the lifetime incomes of individuals with the highest level of education we can derive the lifetime labor incomes for all individuals enrolled in school. At each level of formal education this is the lifetime labor income of an individual who terminates formal schooling at the end of the current level, multiplied by the probability of terminating at that level, plus the lifetime income of an individual with the next higher level of formal education, multiplied by one minus this probability, which is the likelihood of completing an additional year of schooling. In addition, lifetime labor income for each individual enrolled in school includes the value of time not spent in school.

Individuals between 5 and 13 years old are not permitted to participate in the labor market, so that the value of time not spent in school is set equal to zero. However, lifetime labor incomes for these individuals are affected by formal schooling and are calculated in the same way as for individuals between 14 and 35 who are enrolled in school. Because the probabilities of continuing in school are very close to unity for people below the minimum age for leaving school, differences in lifetime labor incomes by age primarily reflect greater discounting of future labor incomes for younger individuals. For people younger than 5 years old lifetime labor incomes are well defined but are not affected by school enrollment. A summary of our methodology in algebraic form is presented in the appendix.

12. Our estimate of the discount rate is based on the long run rate of return for the private sector of the U.S. economy estimated by Jorgenson and Yun (1990).

## 8.2 Investment in Education

To estimate investment in education we employ data on lifetime labor incomes, cross-classified by sex, single age, and single grade of highest educational attainment. We use increments in lifetime labor incomes and estimates of the number of individuals enrolled in school presented in table 8.1 above to measure the value of investment in education.<sup>13</sup> At this point our approach to measuring investment in education incorporates the crucial time dimension of the educational process. Lifetime incomes reflect the effect of educational attainment on the values of future market and nonmarket labor activities over the whole lifetime of an educated individual. These values are discounted back to the present in order to reflect the time value of money.

The gestation periods between educational outlays and the final emergence of human capital embodied in the graduates of educational institutions are very lengthy—8 years for individuals completing primary education, 12 years for secondary education, and 16 or more years for higher education. These long gestation periods imply that educational investment must reflect the increase in the value of previous investments in education that are due to the time value of money as well as to the current outlays of educational institutions. In measuring investment in education we focus on increments in lifetime labor incomes that are due to increases in educational attainment. These increments incorporate the time value of money for investments in education in earlier time periods. Of course, increments in lifetime labor incomes, as we define them, incorporate the effects of enhanced earning power on the values of both work time and nonmarket time.

In table 8.6 we present estimates of the value of educational investment in current prices for 1947–86. We give the corresponding estimates in constant prices for 1948–86 in table 8.7. Our most remarkable finding is that the value of investment in education is considerably greater in magnitude than the value of time spent at work, presented in table 8.2 above. The value of investment in education, as we measure it, accrues in the form of increments to the lifetime incomes of individuals enrolled in school. This value is greater than the value of the time spent at work by the whole labor force. However, the growth in the value of educational investment is almost 21 times the initial level, whereas the increase in the value of work is only 17 times the initial level. This growth reflects the investment associated with rising levels of educational attainment.

The growth of investment in education is greater in relative terms for women than for men. Although the value of market activities for college-educated women has increased 65 times, the value of investment in higher education for women has grown by a factor of 74. The corresponding growth in the value of market activities for college-educated men is 40 times the ini-

13. Details are discussed in Jorgenson and Fraumeni (1989).

tial level, and investment in higher education for men has increased by 51 times. The massive rise in investment in education by women is associated with the costs of substantially higher levels of educational attainment. These costs have preceded the entry of more highly educated women into the labor force.

Our estimates of investment in education incorporate a number of critical assumptions. We have assumed that the future growth of real incomes is constant at 1.32 percent per year. We have discounted future incomes by 4.58 percent per year to reflect the time value of money. Finally, we have estimated the value of nonmarket labor activities by subtracting time spent in market activities from a total time budget of 14 hours per day for both men and women. We obtain this time budget by allocating 10 hour per day to maintenance for each individual. In order to assess the sensitivity of our estimates to these assumptions, we present a series of alternative estimates of investment in education in table 8.8.

In giving investment in education in current prices, we assume in the first panel of table 8.8, that real incomes grow at 2 percent per year and future incomes are discounted at 4 percent per year. We have used these assumptions in earlier estimates of investment in human capital, for example, in Jorgenson and Fraumeni (1989). Because the difference between the discount factor and the growth rate of real income is reduced from 3.26 for the estimates given in table 8.6 to only 2 percent for those in the first panel of table 8.8, we expect the resulting values of investment in education to be substantially larger. The differences decline from 43 percent in 1947 to 33 percent in 1986. These differences are greatest for primary education and reflect the longer gestation period between the investments and the resulting future incomes.

To consider the effect of an increase in the difference between the discount factor and the growth rate of real income, we present investment in education in the second panel of table 8.8 under the assumptions that real incomes grow at only 1 percent per year and future incomes are discounted at 6 percent per year. The difference between the discount factor and the growth rate is 5 percent by contrast with 3.26 percent in table 8.6. We anticipate a substantial reduction in the value of investment in education. The difference declines from 36 percent in 1947 to 29 percent in 1986. As in the first panel of table 8.8, estimates of investment in primary education are more strongly affected by this change in assumptions. Although our estimates of investment in education are affected by these assumptions, the qualitative features of the estimates remain the same.

An important feature of our estimates of investment in education is that they incorporate the values of both market and nonmarket labor activities. Whereas hours worked in the labor market can be measured directly, hours allocated to nonmarket activities depend on our assumption about the total time available. In the third panel of table 8.8 we reduce our estimate of maintenance time from ten to eight hours per day and thereby increase the time allocated to

nonmarket activities by two hours per day. In the fourth panel of table 8.8 we increase the estimate of daily maintenance to twelve hours, reducing our estimate of nonmarket time by two hours. These alternative assumptions produce relatively modest changes in our estimates of investment in education. As before, the qualitative features of the estimates are unaffected.

Investment in education in constant prices is a quantity-index number, based on the school enrollments presented in table 8.1 above. The numbers of individuals in school are weighted by increments in lifetime labor incomes, cross-classified by age, sex, and level of schooling. Investment closely parallels school enrollments for each level of education. However, there are important differences for different levels of schooling. To analyze these differences in greater detail we present investment in education per student in current prices for 1947–86 in table 8.9 and constant prices for 1948–86 in table 8.10. These estimates make it possible to separate trends in the number of students from trends in per-capita levels of educational investment.

The value of educational investment per student is far greater than per capita income from market activities. This difference reflects the fact that investment in education includes the effect of formal schooling on the value of nonmarket as well as market activities.<sup>14</sup> For most of the period the values of investment for men and women are similar at all levels of education, despite differences in labor compensation between the sexes. For men the value of investment per student in higher education considerably exceeds that for secondary education, which exceeds in turn the value for primary education. These relationships also hold for women for most of the period. They reflect the lower differentials between wages of workers with secondary and primary education and the greater importance of time discounting for investments in primary education.

Investment per student in constant prices increases steadily throughout the period, reflecting the rising enrollments in secondary and higher education for both men and women. Although for men the values of investments in primary and secondary education are relatively constant throughout the period, the value of investment in higher education rises steadily. For women the value of investment in primary education increases, the value in secondary education rises and then falls, and the value in higher education remains almost the same throughout the period. The values of investment in primary and secondary education are higher for women than for men throughout the period, and the value of investment in higher education is greater for women than for men until 1979.

We have emphasized that our estimates of investment in education incorporate the value of nonmarket labor activities. Estimates implicit in the rate of return calculations reported, for example, by Becker (1964) and Mincer (1974) exclude the value of nonmarket time. In order to bring out the signifi-

14. Kroch and Sjoblom (1986) give estimates of investment in education based on lifetime labor incomes from market activities for men and women.

cance of nonmarket time, we find it useful to consider estimates based on market time alone. To do so requires that we re-estimate lifetime incomes for all individuals in the U.S. population. For this purpose we include the values of work time given in table 8.2 above but exclude the values of nonmarket time presented in table 8.4.

Investment in education including only market time is given as a percentage of investment also including nonmarket time in table 8.11. This percentage rises rapidly over the period 1948–52, reflecting increases in labor-force participation during this period. Since 1952 the percentage has varied around 40 percent of the estimates we present in table 8.6 and is higher for men than for women at every level of education. This percentage is rising for women and falling for men. We conclude that the magnitude of this bias is changing for both men and women. In order to capture trends accurately, both market and nonmarket activities must be included in estimates of the value of investment in education. Excluding nonmarket activities from these estimates produces a much more substantial downward bias for women than for men.

Human wealth is the sum of lifetime labor incomes for all individuals in the U.S. population. Table 8.12 presents estimates of human wealth in current prices by sex and level of educational attainment for 1947–86. The corresponding estimates in constant prices are given for 1948–86 in table 8.13. These estimates are obtained by multiplying lifetime labor incomes by numbers of individuals in the population, cross-classified by sex, age, and education. The totals presented in tables 8.12 and 8.13 are obtained by summing over age groups. The value of human wealth reflects the value of market and nonmarket activities given in tables 8.2–8.5 above. However, our estimates of human wealth incorporate not only investment in education but also all forms of investment in human capital including, for example, investments in child rearing and the value of new individuals added to the population.

In table 8.14 we present the average values of human wealth per person in current prices for individuals cross-classified by sex and educational attainment for 1947–86. We give the average values in constant prices for 1948–86 in table 8.15. These values have increased slightly for primary and higher education throughout the postwar period, but the relative values for men and women have remained fairly stable. By contrast human wealth per person in constant prices for secondary education has declined slightly for both men and women. Growth in human wealth for the population as a whole results from the increase in the population, the rise in average levels of educational attainment, and the growth in rates of labor compensation. Growth in compensation rates is by far the most important component of the increase in human wealth.

Our estimates of the value of human wealth, like our estimates of investment in education, are based on lifetime labor incomes that include both market and nonmarket activities. In table 8.16 we present measures of human wealth that exclude nonmarket time as a percentage of the estimates given in table 8.14. For the population as a whole the percentage of human wealth

based on market labor activities alone is fairly stable, varying from 29.5 percent in 1947 to 32.5 percent from 1979 to 1986. However, this percentage has fallen slightly for men from the values of the 1960s. By contrast the percentage has grown very rapidly for women. The omission of nonmarket activities produces a downward bias for women that greatly exceeds the downward bias for men.

### 8.3 Conclusion

Our new estimates of investment in education help to bring the role of human capital in the process of economic growth into proper perspective.<sup>15</sup> Economic growth is measured through increments in the national product, as recorded in the U.S. National Income and Product Accounts.<sup>16</sup> These accounts are compiled by the Bureau of Economic Analysis of the U.S. Department of Commerce. The accumulation of human and nonhuman capital accounts for the predominant share of economic growth.<sup>17</sup>

Although both human and nonhuman capital accumulation are important sources of economic growth, the information required to measure investment in human capital is not available in standard data sources like the U.S. national accounts. For example, the Bureau of Economic Analysis publishes a great deal of valuable information on investment in nonhuman capital.<sup>18</sup> The national accounts provide nothing on investment in human capital.<sup>19</sup> The primary reason for this fact is that the accounts are limited to market transactions. Although there have been numerous attempts to augment the U.S. national accounts to incorporate human capital, none of them measures investment in education as an output of the education sector.<sup>20</sup>

Investment in education, which is a major portion of investment in human capital, is produced almost entirely outside the business sector of the econ-

15. Jorgenson, Gollop, and Fraumeni (1987), especially chap. 8, present estimates of the contribution of education to U.S. economic growth. In Jorgenson and Fraumeni (1989) we give a complete set of U.S. national accounts, incorporating the estimates of market and nonmarket labor time, investment in education, and human wealth given above. Surveys of the contribution of education to economic growth are presented by Dean (1984), Mincer (1984), and Murnane (1988).

16. See, e.g., Bureau of Economic Analysis (1986).

17. See Jorgenson, Gollop, and Fraumeni (1987), especially chaps. 1 and 9.

18. See Bureau of Economic Analysis (1987), which gives investment and capital stocks for 61 industries broken down by 72 categories of physical assets.

19. Gates (1982) provides time-series estimates of education and training costs for 1965–79. The compendium edited by Peskin (1982) includes other studies of nonmarket activities at the Bureau of Economic Analysis. Unfortunately, the bureau has discontinued this line of investigation.

20. The cost-based approach to measuring investment in human capital was originated by Machlup (1962) and Schultz (1961). Campbell and Peskin (1979) and Eisner (1988) survey augmented accounting systems, including those containing cost-based estimates of investment in human capital. Kendrick's (1976) accounting system is also discussed by Engerman and Rosen (1980).

omy.<sup>21</sup> Transmission of education from schools and universities to their students involves increases in educational attainment that are not evaluated in the marketplace, at least not initially. However, the economic value of these increases can be traced through their impact on the lifetime incomes of individuals enrolled in school. Fortunately, participation in schooling is recorded in enrollment statistics. Furthermore, levels of educational attainment are routinely collected for individuals as part of the census of population.

We have emphasized the critical importance of including both market and nonmarket incomes in estimating the value of investment in education. In section A of table 8.17 we present a comparison between our estimates of the value of nonmarket activities and the well-known estimates of Nordhaus and Tobin (1972). Their estimates are derived from rates of labor compensation before taxes; our estimates employ after-tax wage rates. The use of before-tax wage rates imparts a substantial upward bias to the estimates of Nordhaus and Tobin; however, the trend in these estimates is nearly identical to that in the estimates we have presented in table 8.4.

We have pointed out that existing estimates of the value of human wealth are based on the costs of education. Estimates of this type have been constructed by Kendrick (1976) for an augmented system of U.S. national accounts. We present a comparison of our estimates with those of Kendrick for the period 1948–69 in section B of table 8.17. The ratio of our estimates in current prices to Kendrick's varies from 17.47 to 18.75 with very little trend from 1948 to 1969. The corresponding ratio for the two constant-price estimates declines from 20.31 in 1948 to 14.29 in 1969. We conclude that Kendrick's cost-based estimates differ from our lifetime labor income-based estimates by more than an order of magnitude.<sup>22</sup> The trends in the two sets of estimates are broadly similar, but far from identical.

It is important to note that Kendrick's cost-based estimates of human capital include the accumulated costs of rearing within the family as well as the costs of formal schooling. However, our lifetime income-based estimates include all sources of lifetime labor income, including investment in education, the value of rearing—which is partly offset by depreciation of human capital with aging—and the lifetime incomes of individuals added to the population, prior to any investment in education or rearing. Nonetheless, the disparities between the two sets of estimates of human capital are very striking. These disparities provide a graphic demonstration of the conceptual differences between the cost-based approach and the income-based approach to the measurement of investment in human capital.

21. The educational sector is discussed from the economic point of view in the collection of papers by Froomkin, Jamison, and Radner (1976).

22. Graham and Webb (1979) compare Kendrick's estimate of human wealth for 1969 with estimates based on lifetime labor incomes for males, excluding the value of nonmarket activities. Kroch and Sjoblom (1986) compare their estimates of human capital accumulated through education, on the basis of lifetime labor incomes from market activities for men and women, with Kendrick's estimates, based on costs of education and training.

Although cost-based estimates of investment in education reflect the current flow of resources into educational institutions, they do not capture the crucial time dimension of educational investment. There is a lengthy gestation period between the current outlays of educational institutions and the emergence of human capital embodied in their graduates. A very substantial proportion of educational investment is attributable to the time value of money, applied to previous investments in the education of individuals who are still enrolled in school. This feature of investment in education is entirely disregarded in estimates limited to current educational outlays.

The availability of estimates of the output of the education sector has created an opportunity for important new research on educational productivity. By combining cost-based estimates of educational inputs with our estimates of educational output, it is possible to measure the productivity of the educational sector. A productivity measure for this sector requires estimates of capital, labor, and intermediate inputs in current and constant prices like those compiled by Jorgenson, Gollop, and Fraumeni (1987) for all the other industries that make up the U.S. economy. An important issue that remains to be resolved is the appropriate valuation of the time spent in educational institutions by students. This time is an important input into the educational sector.

We conclude that the time scale for measuring human capital formation is given by the life span of an educated individual. The appropriate value of investment in education is given by its effect on the individual's lifetime income. The relevant concept of income must not be limited to market activities alone, because many of the benefits of education accrue in the form of enhanced value to nonmarket activities. Our estimates of investment in education incorporate the effect of higher educational attainment on the value of nonmarket activities such as parenting or enjoyment of leisure as well as the effect of increased education on earning power in the labor market.

Our estimates of investment in education are based on very detailed information on the value of working time. However, we have based our estimates of the value of nonmarket labor time on market wage rates. The valuation of nonmarket activities could be refined considerably, especially for individuals not in the labor force. An alternative approach is to infer the value of nonmarket time from labor supply behavior. Second, we have estimated the value of increments in lifetime incomes as a result of increases in educational attainment by comparing the incomes of individuals of the same age and sex with different levels of education. An important further refinement would base estimates of differences on lifetime incomes on the determinants of educational attainment for a given individual. These limitations of our existing estimates suggest opportunities for significant new research on the benefits of education.

Finally, another important source of new research opportunities is the extension of our methods to encompass other forms of investment in human capital. We have already mentioned three extensions of this type. First, fertil-

ity behavior is influenced by the lifetime incomes of children added to the population and by the effects of childbearing on the lifetime incomes of parents. Second, investment in child rearing is an important component of investment in human capital and can be measured on the basis of its effect on lifetime incomes of children. Third, the value of on-the-job training can be appraised by employers and workers in terms of its effect on lifetime labor incomes.<sup>23</sup>

## Appendix

In this appendix we outline the methodology for measuring the output of the educational sector in algebraic form. To represent the use of time and the corresponding labor income we require the following notation:

$y = 1947, 1948, \dots, 1987$ —calendar year.

$s = 1, 2$ —sex, male or female.

$a = 0, 1, \dots, 74, 75, 75+$ —age.

$e = 1, 2, \dots, 18$ —educational attainment, none or less than grade one, grade one, . . . , five years of college or more.

The variables required for estimates of the output of the educational sector are denoted as follows:

com—hourly compensation, net of taxes on labor income.

empr—employment rate.

life—lifetime labor income per capita.

mhrs—market labor time per capita.

mi—lifetime market labor income per capita.

nmhrs—nonmarket labor time per capita.

nmi—lifetime nonmarket labor income per capita.

senr—school enrollment rate, the probability that an individual with educational attainment  $e$  is enrolled in educational level  $e + 1$ .

shrs—school hours per capita; enrolled individuals are assumed to be in school 1300 hours per year.

si—investment in education per capita.

23. A survey of recent research on the prevalence and impact of on-the-job training is presented by Mincer (1989a). Mincer (1989b) presents estimates of the annual costs of training in the United States for 1958, 1976, and 1987. For 1976 these costs amount to half the costs of formal schooling.

sr—probability of survival, specific to the year of birth.

tax—average tax rate on labor income.

taxam—average marginal tax rate on labor income.

whrs—annual market hours worked per person employed.

ymi—annual market income per capita, net of tax on labor compensation.

ynmi—annual nonmarket income per capita, net of tax on labor compensation, where the tax is calculated at the average marginal rate.

Our first set of equations provides estimates of annual hours of market and nonmarket components of labor time. The first equation gives school hours per capita:

$$shrs_{y,s,a,e} = senr_{y,s,a,e} * 1300.$$

The second equation gives market hours per capita:

$$mhrs_{y,s,a,e} = whrs_{y,s,a,e} * empr_{y,s,a,e}.$$

Our third through eighth equations give nonmarket hours per capita for each of the five stages of the life cycle described in section 8.2. Stage 1 includes ages 0–4; stage 2 includes ages 5–13; stage 3 includes ages 14–34; stage 4 includes ages 35–74; stage 5 includes ages 75 and over. Maintenance time per capita is 10 hours per day, leaving 14 hours per day to be allocated between market and nonmarket time. The first stage is no school and no work:

$$nmhrs_{y,s,a,e} = 14 * 7 * 52.$$

The second stage is school but no work:

$$nmhrs_{y,s,a,e} = 14 * 7 * 52 - shrs_{y,s,a,e}.$$

The third stage is school and work:

$$nmhrs_{y,s,a,e} = 14 * 7 * 52 - shrs_{y,s,a,e} - mhrs_{y,s,a,e}.$$

The fourth stage is work but no school:

$$nmhrs_{y,s,a,e} = 14 * 7 * 52 - mhrs_{y,s,a,e}.$$

The fifth and final stage is retirement or no school or work:

$$nmhrs_{y,s,a,e} = 14 * 7 * 52.$$

Our second set of equations provides estimates of market labor income. The first equation gives annual market labor income per capita:

$$ymi_{y,s,a,e} = mhrs_{y,s,a,e} * com_{y,s,a,e}.$$

The second equation gives annual nonmarket labor income per capita:

$$ynmi_{y,s,a,e} = nmhrs_{y,s,a,e} * com_{y,s,a,e} * (1 + tax_y) * (1 - taxam_y).$$

Our third through eighth equations give lifetime market labor income per capita at the five stages of the life cycle described in section 8.2. Lifetime incomes are calculated by a backward recursion, starting with age 74, which is the oldest age before retirement. Future incomes are discounted back to the current age of the individual. The first stage is no school and no work:

$$mi_{y,s,a,e} = sr_{y,s,a+1} * mi_{y,s,a+1,e} * \frac{1.0132}{1.0458}$$

The second stage is school but no work:

$$mi_{y,s,a,e} = [senr_{y+1,s,a,e} * sr_{y,s,a+1} * mi_{y,s,a+1,e+1} + (1 - senr_{y+1,s,a,e}) * sr_{y,s,a+1} * mi_{y,s,a+1,e}] * \frac{1.0132}{1.0458}$$

The third stage is school and work:

$$mi_{y,s,a,e} = ymi_{y+1,s,a,e} + [senr_{y+1,s,a,e} * sr_{y,s,a+1} * mi_{y,s,a+1,e+1} + (1 - senr_{y+1,s,a,e}) * sr_{y,s,a+1} * mi_{y,s,a+1,e}] * \frac{1.0132}{1.0458}$$

The fourth stage is work but no school:

$$mi_{y,s,a,e} = ymi_{y+1,s,a,e} + sr_{y,s,a+1} * mi_{y,s,a+1,e} * \frac{1.0132}{1.0458}$$

The fifth and final stage is retirement or no school or work:

$$mi_{y,s,a,e} = 0$$

Our third set of equations gives estimates of nonmarket labor income. The first through fifth equations give lifetime nonmarket labor income for the five stages of the life cycle described in section 8.2. The first stage is no school or work:

$$nmi_{y,s,a,e} = sr_{y,s,a+1} * nmi_{y,s,a+1,e} * \frac{1.0132}{1.0458}$$

The second stage is school but no work:

$$nmi_{y,s,a,e} = [senr_{y+1,s,a,e} * sr_{y,s,a+1} * nmi_{y,s,a+1,e+1} + (1 - senr_{y+1,s,a,e}) * sr_{y,s,a+1} * nmi_{y,s,a+1,e}] * \frac{1.0132}{1.0458}$$

The third stage is school and work:

$$nmi_{y,s,a,e} = ynmi_{y+1,s,a,e} + [senr_{y+1,s,a,e} * sr_{y,s,a+1} * nmi_{y,s,a+1,e+1} + (1 - senr_{y+1,s,a,e}) * sr_{y,s,a+1} * nmi_{y,s,a+1,e}] * \frac{1.0132}{1.0458}$$

The fourth stage is work but no school:

$$nmi_{y,s,a,e} = ynm i_{y+1,s,a,e} + sr_{y,s,a+1} * nmi_{y,s,a+1,e} * \frac{1.0132}{1.0458}$$

The fifth and final stage is retirement or no school or work:

$$nmi_{y,s,a,e} = 0$$

Total lifetime labor income per capita, including market and nonmarket components is

$$life_{y,s,a,e} = mi_{y,s,a,e} + nmi_{y,s,a,e}$$

Investment in education per capita is:

$$si_{y,s,a,e} = senr_{y,s,a,e} * (life_{y,s,a,e+1} - life_{y,s,a,e})$$

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**Table 8.1** School Enrollment by Sex and Level, United States, 1947–86 (thousands)

Year	Total	Male			Female		
		Grades 1–8	High School	College	Grades 1–8	High School	College
1947	28,411	9,871	3,593	1,663	9,142	3,378	764
1948	28,876	10,120	3,570	1,694	9,387	3,341	764
1949	29,581	10,485	3,555	1,719	9,731	3,324	767
1950	30,318	10,840	3,562	1,741	10,069	3,333	773
1951	30,980	11,120	3,623	1,702	10,352	3,403	780
1952	31,721	11,407	3,712	1,669	10,639	3,503	791
1953	33,011	11,954	3,810	1,648	11,177	3,611	811
1954	34,433	12,545	3,922	1,644	11,751	3,731	840
1955	35,791	13,072	4,055	1,655	12,259	3,873	877
1956	37,166	13,551	4,232	1,685	12,718	4,055	925
1957	38,577	13,954	4,493	1,730	13,097	4,324	979
1958	40,028	14,368	4,756	1,788	13,497	4,579	1,040
1959	41,492	14,819	4,969	1,870	13,950	4,771	1,113
1960	43,198	15,382	5,157	1,999	14,497	4,943	1,220
1961	44,643	15,683	5,442	2,164	14,767	5,238	1,349
1962	46,121	15,929	5,797	2,335	15,002	5,588	1,470
1963	47,645	16,203	6,154	2,498	15,283	5,927	1,580
1964	49,140	16,496	6,475	2,668	15,580	6,229	1,692
1965	50,432	16,759	6,636	2,950	15,838	6,347	1,902
1966	51,665	16,991	6,756	3,271	16,072	6,458	2,117
1967	52,894	17,206	6,901	3,582	16,276	6,607	2,322
1968	54,068	17,358	7,080	3,899	16,417	6,788	2,526
1969	55,102	17,421	7,268	4,218	16,511	6,966	2,718
1970	55,907	17,392	7,434	4,567	16,450	7,130	2,934
1971	56,447	17,282	7,616	4,764	16,352	7,300	3,133
1972	56,717	17,048	7,783	4,957	16,129	7,451	3,349
1973	56,736	16,739	7,908	5,129	15,833	7,562	3,565
1974	56,554	16,389	7,989	5,273	15,503	7,638	3,762
1975	56,301	16,037	8,037	5,401	15,171	7,679	3,976
1976	55,996	15,723	8,048	5,499	14,878	7,677	4,171
1977	55,680	15,476	8,017	5,562	14,647	7,635	4,343
1978	55,200	15,202	7,968	5,577	14,381	7,565	4,507
1979	54,437	14,863	7,843	5,563	14,062	7,427	4,679
1980	53,552	14,560	7,644	5,511	13,775	7,214	4,848
1981	52,696	14,098	7,425	5,879	13,359	7,118	4,817
1982	52,648	13,989	7,361	5,940	13,308	7,088	4,962
1983	51,980	13,832	7,178	6,063	13,174	6,843	4,890
1984	51,664	13,722	7,149	6,058	13,005	6,757	4,973
1985	51,037	13,577	7,064	5,855	12,869	6,673	4,999
1986	51,110	13,612	7,177	5,744	12,908	6,779	4,890

**Table 8.2** Value of Market Activities by Sex and Educational Attainment, 1948–87 (billions of current dollars)

Year	Total	Male			Female		
		Grades 1–8*	High School	College	Grades 1–8*	High School	College
1948	147.3	44.2	51.6	24.1	7.9	13.6	5.9
1949	151.2	44.1	52.6	25.6	8.2	14.3	6.5
1950	164.5	47.6	56.0	29.2	8.7	15.1	7.9
1951	187.5	51.8	65.2	35.4	9.2	17.2	8.7
1952	201.4	53.6	70.5	40.0	9.5	18.6	9.3
1953	215.2	55.8	76.1	43.9	9.7	19.8	9.8
1954	220.6	54.3	79.1	47.3	9.4	20.3	10.2
1955	229.4	54.4	83.1	49.7	9.8	21.6	10.8
1956	245.6	56.4	89.6	54.3	10.2	23.5	11.7
1957	262.8	58.0	96.6	60.0	10.4	25.2	12.6
1958	274.1	56.9	101.9	65.4	10.5	26.1	13.5
1959	285.4	57.2	107.5	68.7	10.6	27.3	14.1
1960	299.4	58.4	113.8	70.8	11.0	30.2	15.3
1961	311.4	55.9	118.3	76.5	10.5	32.9	17.3
1962	328.8	55.8	125.2	81.7	10.5	36.3	19.3
1963	340.8	55.8	131.1	85.3	10.8	38.6	19.1
1964	365.9	56.6	141.5	92.2	11.3	43.2	21.0
1965	388.4	58.3	151.2	97.1	11.6	47.5	22.7
1966	429.1	62.4	167.5	106.8	12.5	54.4	25.6
1967	460.4	63.1	178.2	118.5	13.2	58.8	28.6
1968	504.2	65.4	195.5	131.0	13.8	65.6	32.8
1969	548.7	67.2	211.7	144.0	14.7	74.8	36.3
1970	602.3	68.1	230.2	160.3	15.4	85.5	42.7
1971	651.4	66.4	247.6	181.5	15.5	90.8	49.5
1972	701.5	66.0	267.3	201.7	15.3	97.9	53.4
1973	797.8	69.1	301.7	236.8	15.8	111.0	63.3
1974	870.1	71.5	323.5	262.7	16.2	121.0	75.3
1975	941.7	65.9	341.4	298.4	16.5	132.1	87.4
1976	1,036.0	67.8	370.5	335.3	17.3	145.0	100.1
1977	1,132.4	70.1	399.1	371.3	17.5	161.6	112.9
1978	1,273.4	74.8	441.6	423.5	19.8	183.7	130.0
1979	1,429.1	77.6	490.0	485.0	20.2	204.8	151.6
1980	1,560.8	77.6	518.8	533.8	21.4	231.4	177.8
1981	1,690.3	76.8	553.4	586.0	21.6	253.1	199.5
1982	1,757.6	69.2	554.1	617.7	21.1	268.9	226.5
1983	1,869.8	66.4	561.4	683.3	20.9	281.6	256.2
1984	2,047.3	69.2	620.7	752.2	21.6	303.9	279.6
1985	2,190.2	70.8	654.5	809.8	21.5	320.1	313.5
1986	2,350.9	71.5	686.5	875.6	22.3	347.6	347.4
1987	2,519.6	72.0	722.5	946.8	22.4	371.0	384.9

\*The grades 1–8 column includes persons who have completed less than the first grade.

**Table 8.3** Value of Market Labor Activities by Sex and Educational Attainment, 1949-87 (billions of constant dollars)

Year	Total	Male			Female		
		Grades 1-8*	High School	College	Grades 1-8*	High School	College
1949	981.8	308.8	336.4	163.0	59.9	91.8	43.6
1950	1,021.1	318.1	343.8	176.8	60.8	93.2	50.5
1951	1,105.3	326.7	383.8	200.1	61.5	102.6	52.5
1952	1,134.8	324.9	399.6	212.2	60.0	106.2	53.1
1953	1,154.6	323.1	411.8	219.9	58.3	108.8	53.1
1954	1,130.1	302.6	409.4	223.2	54.1	106.9	52.0
1955	1,163.6	301.5	423.1	232.2	56.3	113.9	54.3
1956	1,187.3	297.5	434.3	240.3	56.5	119.4	56.2
1957	1,191.5	287.0	439.9	246.2	55.0	121.8	57.0
1958	1,169.2	267.8	436.5	248.2	52.6	120.3	56.9
1959	1,207.4	268.6	454.6	259.8	53.1	125.2	58.2
1960	1,221.2	259.8	464.6	266.9	52.0	129.0	59.6
1961	1,231.1	239.8	470.6	280.2	47.9	134.6	65.5
1962	1,268.1	231.4	487.3	295.3	45.9	142.7	71.1
1963	1,285.0	225.0	497.9	305.7	45.5	146.9	68.7
1964	1,312.8	214.4	510.7	318.6	44.4	155.6	72.5
1965	1,352.8	212.1	528.2	329.8	43.9	165.0	76.5
1966	1,399.6	208.6	549.2	342.5	43.5	176.9	81.1
1967	1,419.8	198.2	554.5	362.7	42.2	179.2	84.7
1968	1,450.2	190.2	569.1	375.2	40.7	185.6	90.7
1969	1,487.3	182.2	580.8	392.0	40.0	198.5	94.7
1970	1,467.9	164.4	571.1	393.0	37.3	204.6	97.9
1971	1,466.2	149.1	564.6	406.7	34.8	204.5	106.7
1972	1,508.1	142.2	579.2	432.1	33.0	211.4	110.2
1973	1,564.2	135.0	593.3	462.1	31.8	220.6	121.2
1974	1,568.1	127.7	583.4	471.0	29.9	221.5	134.0
1975	1,544.0	107.5	560.9	484.9	27.9	220.3	141.8
1976	1,587.7	103.0	568.2	510.5	27.0	225.8	152.3
1977	1,640.2	100.2	577.3	536.1	25.8	237.2	162.7
1978	1,713.2	98.6	593.2	570.0	26.9	249.2	174.5
1979	1,772.3	93.8	605.9	599.8	25.2	257.5	189.6
1980	1,764.8	86.1	587.0	601.7	23.9	263.7	202.2
1981	1,782.8	79.9	584.3	616.0	22.6	268.2	211.7
1982	1,757.6	69.2	554.1	617.7	21.1	268.9	226.5
1983	1,799.9	64.3	546.9	654.3	20.1	269.5	244.6
1984	1,897.8	64.9	583.4	693.4	19.9	279.9	256.1
1985	1,937.5	63.3	590.8	711.1	18.7	280.3	272.9
1986	1,953.2	60.1	584.0	718.9	18.3	286.1	284.9
1987	2,013.4	58.3	594.3	744.9	17.8	294.1	302.8

\*The grades 1-8 column includes persons who have completed less than the first grade.

**Table 8.4** Value of Nonmarket Activities by Sex and Educational Attainment, 1948–87 (billions of current dollars)

Year	Total	Male			Female		
		Grades 1–8*	High School	College	Grades 1–8*	High School	College
1948	376.4	78.0	75.7	37.5	68.5	87.4	29.4
1949	401.7	80.8	84.1	41.8	69.3	93.8	32.0
1950	415.4	80.4	89.4	43.8	69.6	98.7	33.6
1951	425.3	81.5	89.4	45.8	70.3	102.3	36.0
1952	441.4	82.2	92.5	48.9	71.7	107.4	38.7
1953	465.6	84.4	98.2	53.4	73.9	114.0	41.8
1954	512.7	91.4	109.5	60.9	78.5	125.2	47.1
1955	519.1	90.2	113.3	63.3	76.5	127.3	48.3
1956	546.9	93.5	121.3	68.8	77.7	134.1	51.4
1957	590.8	100.0	132.7	76.8	80.8	144.4	56.1
1958	638.7	106.2	146.5	86.4	83.2	155.1	61.4
1959	644.4	102.9	149.8	88.1	80.8	159.0	63.8
1960	693.3	108.3	161.1	92.5	85.0	176.6	69.9
1961	739.5	116.0	170.4	99.5	90.7	188.4	74.5
1962	778.4	119.6	178.1	105.1	95.3	201.1	79.3
1963	804.2	118.4	184.4	109.4	96.6	210.7	84.7
1964	878.8	126.7	202.8	120.1	103.5	232.3	93.4
1965	953.7	132.6	220.9	131.9	110.6	255.0	102.6
1966	1,038.8	141.6	239.8	146.6	118.8	278.0	114.1
1967	1,127.4	148.2	260.8	158.4	127.5	305.5	126.9
1968	1,218.1	154.0	281.6	174.9	135.4	332.8	139.3
1969	1,317.7	160.7	306.5	190.9	143.9	361.6	154.1
1970	1,517.4	177.7	357.0	226.3	159.7	413.3	183.5
1971	1,676.3	190.8	397.9	261.0	173.9	448.6	204.1
1972	1,788.1	195.0	424.6	287.3	178.7	475.8	226.8
1973	1,937.9	206.8	463.7	322.6	181.8	511.9	251.1
1974	2,147.4	219.2	518.6	373.6	192.1	563.1	280.8
1975	2,365.3	234.6	575.7	426.1	201.3	612.5	315.2
1976	2,559.9	241.6	622.2	473.8	211.4	661.2	349.7
1977	2,725.3	243.7	661.8	519.1	216.7	701.1	382.8
1978	2,993.3	255.7	724.8	583.8	228.5	768.3	432.2
1979	3,294.1	270.0	795.6	665.0	243.3	837.5	482.7
1980	3,629.3	277.2	877.5	764.9	255.2	912.7	541.8
1981	3,930.1	287.8	972.4	832.6	271.9	987.1	578.2
1982	4,372.8	300.1	1,089.6	961.2	282.6	1,093.0	646.3
1983	4,706.9	309.1	1,145.9	1,071.8	287.6	1,149.6	742.8
1984	4,942.2	315.6	1,188.6	1,127.3	300.4	1,209.3	801.1
1985	5,346.6	343.6	1,259.9	1,242.9	323.7	1,281.8	894.7
1986	5,774.8	358.1	1,369.2	1,373.7	331.7	1,367.8	974.4
1987	6,536.0	381.4	1,557.8	1,583.9	356.0	1,525.5	1,131.3

\*The grades 1–8 column includes persons who have completed less than the first grade.

**Table 8.5** Value of Nonmarket Labor Activities by Sex and Educational Attainment, 1949–87 (billions of constant dollars)

Year	Total	Male			Female		
		Grades 1–8*	High School	College	Grades 1–8*	High School	College
1949	2,438.5	524.2	484.4	238.0	508.6	554.5	191.4
1950	2,457.0	505.1	502.1	241.9	500.1	571.3	194.7
1951	2,434.7	489.5	489.3	239.2	493.2	579.6	200.2
1952	2,456.9	481.9	496.1	244.9	488.3	593.0	206.4
1953	2,484.0	473.6	504.7	253.8	483.0	607.2	212.8
1954	2,551.5	480.7	526.3	266.9	479.4	624.9	220.2
1955	2,570.6	471.5	535.2	275.0	470.4	636.5	224.5
1956	2,599.5	465.2	546.9	284.4	463.4	649.3	229.6
1957	2,647.5	465.4	563.2	295.2	458.1	666.1	235.6
1958	2,713.6	468.8	587.2	308.7	451.7	686.3	242.6
1959	2,730.0	455.9	594.9	314.9	441.5	701.8	248.0
1960	2,784.0	452.3	613.7	327.1	434.4	723.6	255.4
1961	2,849.9	461.3	630.7	340.9	434.6	738.4	263.5
1962	2,888.7	454.4	642.1	354.1	427.9	753.6	272.5
1963	2,942.6	442.9	659.4	370.9	417.7	773.7	288.5
1964	2,988.3	435.1	675.6	385.9	408.1	790.6	299.8
1965	3,030.0	421.6	689.5	403.2	398.7	808.8	311.7
1966	3,070.5	409.0	700.9	422.6	389.8	824.7	325.4
1967	3,136.1	402.1	725.2	437.6	381.4	849.1	340.6
1968	3,195.6	392.4	743.8	459.0	373.2	871.8	354.6
1969	3,250.5	382.2	766.1	477.5	363.8	890.0	370.3
1970	3,351.4	378.2	805.6	509.6	355.6	914.8	387.8
1971	3,447.7	380.1	830.8	542.0	352.5	934.7	407.9
1972	3,513.3	374.3	840.4	567.9	348.1	949.6	433.4
1973	3,563.8	367.4	849.2	591.0	341.5	961.5	453.2
1974	3,659.8	360.5	877.5	633.1	335.3	980.2	473.0
1975	3,782.8	364.1	916.3	673.6	329.4	1,000.5	498.1
1976	3,855.2	354.6	932.1	707.6	321.8	1,015.5	522.4
1977	3,921.5	343.0	946.2	743.9	313.8	1,025.4	547.7
1978	3,975.8	330.3	955.9	776.1	303.9	1,034.8	573.6
1979	4,040.4	319.1	967.6	813.8	295.2	1,046.1	598.0
1980	4,153.4	308.8	1,002.3	875.1	284.8	1,057.5	625.0
1981	4,240.0	305.6	1,045.6	897.0	290.5	1,073.2	628.1
1982	4,372.8	300.1	1,089.6	961.2	282.6	1,093.0	646.3
1983	4,468.1	295.3	1,094.6	1,016.0	271.8	1,086.6	703.3
1984	4,503.7	292.3	1,092.1	1,028.1	270.2	1,095.4	725.1
1985	4,578.9	295.2	1,096.5	1,067.2	268.9	1,090.4	760.0
1986	4,663.8	288.2	1,123.7	1,108.0	262.2	1,098.6	782.7
1987	4,731.4	274.9	1,151.5	1,140.4	252.5	1,099.7	812.4

\*The grades 1–8 column includes persons who have completed less than the first grade.

**Table 8.6 Investment in Formal Education by Sex and Level of Environment, 1947–86 (billions of current dollars)**

Year	Total	Male			Female		
		Grades 1–8	High School	College	Grades 1–8	High School	College
1947	181.1	66.7	32.0	21.4	33.3	18.0	9.7
1948	214.3	71.0	42.6	30.5	35.5	21.7	13.0
1949	231.6	76.2	44.4	33.6	39.6	23.1	14.8
1950	257.2	84.7	46.9	39.7	44.4	24.4	17.2
1951	293.2	98.5	51.2	43.0	53.7	27.4	19.3
1952	323.4	108.2	55.0	47.0	61.1	30.2	22.0
1953	372.7	123.2	62.1	52.7	73.2	35.3	26.2
1954	390.2	126.4	63.9	53.5	79.8	38.2	28.4
1955	433.8	139.4	69.5	57.9	92.2	42.7	32.2
1956	495.8	158.8	78.4	65.1	107.7	48.9	36.8
1957	570.8	182.8	90.7	73.7	125.0	56.4	42.1
1958	603.5	185.2	93.1	74.6	139.8	63.3	47.3
1959	616.9	177.9	93.3	72.1	151.1	72.0	50.5
1960	650.9	185.8	101.4	77.1	157.6	78.4	50.6
1961	678.3	185.4	107.4	81.4	163.8	84.4	55.8
1962	695.3	184.1	108.1	84.3	169.7	86.0	63.0
1963	738.6	186.4	113.7	90.3	181.5	95.5	71.2
1964	768.2	185.3	118.3	94.1	190.3	104.2	76.0
1965	832.3	193.3	129.4	101.1	207.1	118.0	83.4
1966	903.5	199.8	140.4	107.9	228.4	134.2	92.7
1967	985.3	209.6	151.0	125.9	244.7	143.0	111.0
1968	1,039.4	208.1	154.1	140.5	259.1	152.5	125.1
1969	1,252.5	232.1	176.9	169.0	323.4	191.4	159.6
1970	1,383.7	250.3	201.9	192.4	352.6	210.3	176.3
1971	1,458.4	252.5	210.0	206.9	374.2	227.1	187.8
1972	1,521.7	261.8	221.9	234.9	375.4	231.6	196.0
1973	1,594.5	265.5	237.1	265.2	373.1	241.5	212.1
1974	1,719.2	279.4	261.5	310.7	373.4	256.4	237.8
1975	1,792.7	284.5	276.0	342.7	360.5	262.8	266.2
1976	1,825.5	281.0	282.2	367.6	340.5	263.1	291.2
1977	1,883.6	278.7	294.7	405.4	319.9	263.4	321.5
1978	1,991.9	282.3	314.5	464.7	307.4	267.6	355.5
1979	2,113.1	283.1	330.5	525.3	304.2	275.2	394.8
1980	2,346.6	311.1	360.9	584.3	338.3	304.9	447.1
1981	2,515.9	355.0	374.9	601.0	383.7	341.0	480.3
1982	2,834.9	342.5	421.1	725.1	421.6	373.5	551.1
1983	2,975.4	360.3	419.2	800.3	422.1	371.2	602.3
1984	3,171.2	384.1	448.9	885.0	433.7	384.3	635.2
1985	3,359.3	413.4	487.6	981.2	435.2	382.6	659.4
1986	3,779.0	461.3	546.5	1,096.6	510.6	442.6	721.4

**Table 8.7 Investment in Formal Education by Sex and Level of Enrollment, 1948–86 (billions of constant dollars)**

Year	Total	Male			Female		
		Grades 1–8	High School	College	Grades 1–8	High School	College
1948	1,073.9	272.7	175.0	131.9	262.8	144.4	69.6
1949	1,087.6	278.6	174.5	133.6	270.9	143.3	69.9
1950	1,105.7	287.3	173.1	134.9	281.9	141.9	70.4
1951	1,128.2	300.5	171.7	132.0	297.9	142.0	70.3
1952	1,139.5	302.8	171.4	135.1	301.8	141.5	72.8
1953	1,153.0	305.3	171.5	138.2	305.5	142.7	75.4
1954	1,168.0	306.9	174.0	141.5	308.0	145.2	77.9
1955	1,204.2	316.3	176.8	146.3	320.7	148.4	81.2
1956	1,241.4	324.8	180.6	151.8	331.8	152.8	85.1
1957	1,281.3	333.2	185.6	158.0	342.4	158.1	89.5
1958	1,320.2	339.3	192.2	165.2	350.2	164.5	94.3
1959	1,360.6	342.2	202.6	172.7	354.9	175.4	99.1
1960	1,403.2	345.2	213.9	181.0	360.8	185.2	104.3
1961	1,481.5	351.0	234.4	195.8	369.6	195.5	123.1
1962	1,566.8	364.9	246.3	213.4	386.8	201.3	142.6
1963	1,642.8	372.8	261.0	230.7	396.0	214.4	157.9
1964	1,714.2	380.1	277.7	245.1	406.0	229.3	167.6
1965	1,788.9	387.6	298.3	256.3	417.9	246.1	175.2
1966	1,868.9	395.8	320.2	269.0	430.4	263.1	184.1
1967	1,967.9	403.5	335.3	301.6	442.3	268.8	214.1
1968	2,057.8	411.8	346.7	336.5	452.8	276.4	235.4
1969	2,129.5	417.5	360.9	358.1	462.7	286.1	248.6
1970	2,200.6	421.3	378.1	379.3	471.3	297.6	260.3
1971	2,246.1	422.2	382.2	401.1	476.8	306.7	266.5
1972	2,292.1	423.9	385.8	429.9	480.8	308.5	277.0
1973	2,363.0	422.5	399.9	456.5	480.5	323.7	296.2
1974	2,430.7	418.5	412.5	484.7	476.7	337.3	319.6
1975	2,504.4	413.6	421.4	509.6	471.6	349.6	357.1
1976	2,567.2	406.8	429.0	533.3	464.9	360.4	391.0
1977	2,627.7	398.2	434.2	556.9	457.1	369.8	427.7
1978	2,652.7	384.6	433.3	581.2	450.6	379.0	437.8
1979	2,707.1	378.0	431.5	606.8	445.7	385.0	468.3
1980	2,742.6	368.9	428.9	623.9	437.8	389.0	497.9
1981	2,720.7	359.2	418.8	640.4	429.1	380.5	494.5
1982	2,834.9	342.5	421.1	725.1	421.6	373.5	551.1
1983	2,861.7	337.2	402.4	767.6	416.4	365.0	572.9
1984	2,859.4	333.5	394.7	780.5	410.6	361.7	578.1
1985	2,833.5	331.4	394.1	785.4	403.8	350.1	566.9
1986	2,834.6	331.2	394.5	788.3	399.4	349.5	569.4

**Table 8.8** Investment in Formal Education by Sex and Level of Enrollment, 1947-86 (billions of current dollars)

Year	Total	Male			Female		
		Grades 1-8	High School	College	Grades 1-8	High School	College
Real Income Growth Rate = 2%; Discount Rate = 4%							
1947	259.0	99.6	45.3	28.4	48.4	24.3	13.0
1953	529.3	186.1	86.5	68.6	106.7	47.2	34.3
1957	811.1	276.3	125.9	95.6	182.9	75.6	54.9
1960	918.0	278.2	139.8	99.4	230.0	105.0	65.6
1966	1,262.7	295.8	190.0	138.8	336.3	181.5	120.3
1969	1,743.2	346.9	238.9	217.0	475.5	258.5	206.3
1973	2,209.6	399.8	320.2	340.7	550.0	326.5	272.5
1979	2,845.9	420.4	443.5	676.2	442.5	362.7	500.6
1986	5,030.2	682.6	726.6	1,387.7	744.3	582.0	907.0
Real Income Growth Rate = 1%; Discount Rate = 6%							
1947	116.3	40.4	20.7	15.1	20.9	12.6	6.8
1953	241.9	73.0	41.0	38.2	45.9	24.9	18.9
1957	370.4	108.0	60.3	53.7	78.0	39.8	30.6
1960	427.2	111.7	68.2	56.6	98.6	55.2	36.9
1966	599.9	122.1	97.0	79.5	140.8	93.0	67.6
1969	835.5	139.2	122.5	124.7	199.4	132.7	117.1
1973	1,070.2	157.5	164.5	195.3	229.0	167.1	156.8
1979	1,474.3	172.6	231.9	385.6	190.3	197.7	296.2
1986	2,676.9	281.9	387.6	823.5	318.1	318.6	547.3
8 Hours of Maintenance per Day							
1947	206.2	76.0	36.4	24.3	37.9	20.5	11.1
1953	423.2	139.6	70.4	59.8	83.4	40.2	29.9
1957	648.1	207.0	102.8	83.5	142.4	64.3	48.0
1960	739.1	210.5	114.9	87.3	179.6	89.3	57.6
1966	1,026.7	226.4	159.0	122.2	260.5	153.0	105.6
1969	1,422.0	262.4	199.7	191.2	368.8	218.0	181.9
1973	1,802.5	298.4	266.5	299.1	423.7	274.0	240.8
1979	2,373.4	315.9	368.8	590.0	342.6	309.5	446.6
1986	4,269.2	518.5	614.8	1,238.7	578.5	500.2	818.6
12 Hours of Maintenance per Day							
1947	156.0	57.5	27.5	18.5	28.7	15.5	8.3
1953	322.1	106.7	53.7	45.7	63.0	30.4	22.5
1957	493.5	158.5	78.6	64.0	107.6	48.6	36.3
1960	562.7	161.2	88.0	67.0	135.5	67.4	43.5
1966	780.3	173.3	121.8	93.7	196.3	115.4	79.8
1969	1,083.1	201.9	154.1	146.8	278.1	164.8	137.4
1973	1,386.4	232.6	207.8	231.2	322.4	208.9	183.5
1979	1,852.9	250.3	292.2	460.7	265.8	241.0	343.0
1986	3,288.8	404.2	478.3	954.4	442.8	385.0	624.2

**Table 8.9 Investment per Student by Sex and Level of Enrollment, 1947–86**  
(thousands of current dollars)

Year	Total	Male			Female		
		Grades 1–8	High School	College	Grades 1–8	High School	College
1947	8.6	8.8	11.6	16.4	5.2	7.7	15.3
1948	10.5	10.2	13.1	19.0	6.6	8.8	16.4
1949	11.1	10.7	13.7	20.5	7.2	9.4	18.5
1950	12.1	11.5	14.5	23.9	7.7	10.0	21.2
1951	13.4	12.8	15.9	26.2	8.9	11.1	23.8
1952	14.7	14.0	17.2	27.9	10.0	12.4	26.2
1953	16.8	15.8	19.4	30.5	11.9	14.4	30.1
1954	17.4	16.1	19.8	30.2	12.9	15.4	31.6
1955	18.8	17.2	21.2	31.7	14.4	16.9	34.5
1956	20.9	19.1	23.5	34.4	16.3	18.9	37.9
1957	23.4	21.5	26.5	37.4	18.3	21.1	41.6
1958	24.1	21.5	26.2	36.4	20.1	22.6	44.6
1959	24.0	20.4	25.0	33.8	21.4	24.3	45.5
1960	24.7	21.1	26.0	34.5	21.9	25.3	43.5
1961	24.8	20.7	25.3	34.6	22.7	26.0	42.2
1962	24.4	20.0	23.9	33.3	23.0	25.6	41.5
1963	25.0	19.9	23.7	33.2	24.2	26.9	43.3
1964	25.0	19.4	23.1	32.4	24.8	27.7	43.2
1965	26.1	19.9	23.7	32.8	26.4	29.6	44.8
1966	27.2	20.1	24.2	33.0	28.6	31.9	47.1
1967	28.7	20.8	24.8	35.2	30.0	33.1	51.1
1968	29.2	20.4	24.3	35.7	31.3	34.1	52.5
1969	34.1	22.5	26.6	39.8	38.6	41.4	62.5
1970	36.6	24.1	28.9	42.5	41.8	43.9	64.9
1971	37.9	24.3	29.9	43.3	44.1	46.7	64.2
1972	38.9	25.2	31.3	46.5	44.0	47.2	62.9
1973	39.8	25.6	32.3	50.0	43.8	46.1	63.7
1974	41.9	27.3	34.6	55.8	44.1	46.1	66.0
1975	42.9	28.2	35.8	59.2	43.0	44.8	68.2
1976	43.1	28.3	36.0	61.2	41.3	43.0	69.0
1977	43.9	28.6	37.2	65.2	39.5	41.4	70.8
1978	46.0	29.5	39.7	72.3	38.5	40.5	73.6
1979	48.4	30.0	41.9	79.9	38.6	40.6	77.7
1980	53.7	33.7	46.3	87.1	43.8	44.2	83.4
1981	57.9	37.1	49.3	85.0	50.8	50.9	87.0
1982	64.5	39.8	55.1	92.5	58.2	56.4	92.2
1983	68.2	42.5	57.4	99.9	58.7	57.1	98.4
1984	72.5	45.7	62.2	107.6	61.4	58.8	100.9
1985	77.8	49.5	68.0	118.8	62.6	60.5	107.9
1986	87.1	55.5	75.6	131.8	74.1	70.0	113.9

**Table 8.10** Investment per Student by Sex and Level of Enrollment, Market and Nonmarket Labor Activities, 1948–86 (thousands of constant dollars)

Year	Total	Male			Female		
		Grades 1–8	High School	College	Grades 1–8	High School	College
1948	52.4	39.1	53.7	82.1	48.9	58.4	88.1
1949	52.2	39.0	53.7	81.6	48.9	58.4	87.5
1950	51.9	38.9	53.6	81.2	48.9	58.2	86.9
1951	51.6	39.2	53.3	80.5	49.3	57.6	86.5
1952	51.8	39.2	53.5	80.3	49.5	57.9	86.5
1953	52.0	39.2	53.5	80.0	49.7	58.3	86.7
1954	52.1	39.1	53.8	79.8	49.7	58.6	86.7
1955	52.2	39.0	53.9	80.0	49.9	58.9	87.1
1956	52.4	39.1	54.1	80.2	50.1	59.1	87.7
1957	52.5	39.2	54.2	80.3	50.2	59.1	88.4
1958	52.7	39.3	54.2	80.6	50.3	58.8	88.9
1959	52.9	39.3	54.4	80.8	50.3	59.3	89.3
1960	53.1	39.1	54.8	81.1	50.2	59.7	89.6
1961	54.2	39.2	55.2	83.2	51.3	60.1	93.1
1962	55.0	39.7	54.6	84.4	52.5	60.0	93.9
1963	55.5	39.8	54.3	84.9	52.7	60.4	96.0
1964	55.8	39.8	54.3	84.4	53.0	61.0	95.3
1965	56.0	39.8	54.7	83.3	53.3	61.7	94.1
1966	56.4	39.9	55.1	82.4	53.9	62.6	93.5
1967	57.3	40.0	55.1	84.3	54.3	62.2	98.6
1968	57.8	40.3	54.6	85.6	54.8	61.9	98.9
1969	57.9	40.4	54.3	84.4	55.3	61.8	97.3
1970	58.2	40.6	54.2	83.8	55.9	62.2	95.8
1971	58.4	40.7	54.4	83.9	56.2	63.1	91.1
1972	58.6	40.8	54.5	85.0	56.4	62.9	88.8
1973	59.0	40.8	54.5	86.1	56.4	61.8	88.9
1974	59.3	40.9	54.5	87.0	56.3	60.6	88.7
1975	60.0	40.9	54.6	88.1	56.3	59.6	91.4
1976	60.6	40.9	54.7	88.8	56.4	58.8	92.7
1977	61.3	40.9	54.8	89.6	56.4	58.1	94.2
1978	61.2	40.2	54.6	90.5	56.5	57.3	90.6
1979	62.1	40.1	54.7	92.3	56.6	56.8	92.1
1980	62.8	40.0	55.0	93.0	56.7	56.4	92.9
1981	62.6	39.8	55.1	90.5	56.8	56.8	89.6
1982	64.5	39.8	55.1	92.5	58.2	56.4	92.2
1983	65.6	39.8	55.1	95.8	57.9	56.1	93.6
1984	65.4	39.7	54.7	94.9	58.1	55.3	91.8
1985	65.6	39.7	55.0	95.1	58.1	55.3	92.8
1986	65.3	39.8	54.6	94.7	58.0	55.3	89.9

**Table 8.11** Percentage of Investment Based on Market Activities to Total Educational Investment, 1947–86

Year	Total	Male			Female		
		Grades 1–8	High School	College	Grades 1–8	High School	College
1947	33.7	36.4	36.2	32.3	28.8	28.6	30.1
1953	40.5	46.8	48.5	45.2	29.4	27.8	29.9
1957	38.5	44.7	45.7	42.8	29.0	27.5	29.8
1960	37.7	44.5	46.9	42.6	29.2	28.9	29.0
1966	35.7	38.8	42.1	40.6	30.8	30.7	31.2
1969	31.1	32.4	39.5	35.4	27.2	28.3	25.6
1973	38.7	40.6	46.1	39.6	35.8	36.0	33.1
1979	42.6	46.0	49.9	47.3	37.6	37.4	32.4
1986	41.2	41.8	46.0	43.9	40.9	40.4	33.6

**Table 8.12 Human Wealth by Sex and Educational Attainment, 1947–86**  
(billions of current dollars)

Year	Total	Male			Female		
		Grades 1–8*	High School	College	Grades 1–8*	High School	College
1947	15,082	4,780	3,133	1,382	2,842	2,232	711
1948	16,081	5,052	3,344	1,517	3,000	2,388	778
1949	16,957	5,323	3,532	1,646	3,129	2,490	835
1950	18,055	5,660	3,780	1,832	3,271	2,607	902
1951	19,178	5,989	3,998	2,009	3,464	2,743	972
1952	20,513	6,403	4,270	2,193	3,693	2,905	1,046
1953	22,433	6,964	4,631	2,443	4,056	3,171	1,167
1954	23,176	7,237	4,790	2,537	4,174	3,234	1,202
1955	24,805	7,779	5,131	2,749	4,441	3,418	1,285
1956	27,105	8,515	5,626	3,066	4,803	3,688	1,404
1957	29,570	9,294	6,168	3,431	5,160	3,978	1,536
1958	30,492	9,527	6,383	3,505	5,348	4,122	1,604
1959	32,457	9,923	6,771	3,611	5,824	4,582	1,745
1960	34,672	10,521	7,214	3,851	6,258	4,969	1,857
1961	36,788	11,042	7,573	4,090	6,742	5,325	2,014
1962	38,067	11,249	7,855	4,273	6,967	5,587	2,134
1963	41,145	11,932	8,535	4,647	7,505	6,160	2,363
1964	44,096	12,524	9,198	5,014	8,032	6,734	2,591
1965	48,087	13,402	10,129	5,560	8,668	7,427	2,899
1966	51,788	14,062	10,911	6,107	9,309	8,132	3,264
1967	56,099	14,901	11,900	6,857	9,905	8,874	3,658
1968	60,327	15,606	12,876	7,555	10,511	9,696	4,081
1969	68,923	17,270	14,733	8,884	11,884	11,220	4,928
1970	75,554	18,487	16,544	10,266	12,427	12,271	5,558
1971	80,601	19,271	17,827	11,353	12,836	13,114	6,196
1972	88,245	20,642	19,855	13,011	13,415	14,337	6,984
1973	96,651	21,953	21,993	14,818	14,189	15,794	7,901
1974	106,010	23,271	24,296	16,988	15,051	17,389	9,012
1975	114,568	24,289	26,328	18,964	15,886	18,965	10,135
1976	121,760	24,939	28,074	20,777	16,455	20,330	11,182
1977	133,148	26,300	30,733	23,464	17,517	22,468	12,664
1978	146,260	27,992	33,898	26,888	18,547	24,605	14,327
1979	159,836	29,515	36,836	30,408	19,785	27,024	16,265
1980	171,254	30,877	39,317	33,759	20,492	28,762	18,043
1981	186,814	32,980	43,442	36,355	22,293	31,892	19,850
1982	198,951	34,558	45,827	39,518	23,707	33,724	21,615
1983	210,240	35,859	47,239	43,472	24,641	34,793	24,233
1984	225,320	38,203	50,255	47,162	26,036	37,222	26,439
1985	242,713	40,996	53,548	52,120	27,493	38,993	29,559
1986	268,567	44,683	58,966	58,215	30,229	43,206	33,265

\*The grades 1–8 column includes persons who have completed less than the first grade.

**Table 8.13 Human Wealth by Sex and Educational Attainment, 1948–86**  
(billions of constant dollars)

Year	Total	Male			Female		
		Grade 1–8*	High School	College	Grade 1–8*	High School	College
1948	112,520	35,318	22,297	9,625	23,618	16,853	5,390
1949	114,719	35,758	22,756	10,021	23,931	17,233	5,578
1950	116,858	36,184	23,213	10,410	24,227	17,591	5,757
1951	119,151	36,733	23,641	10,815	24,621	17,932	5,905
1952	121,505	37,326	24,075	11,199	25,045	18,290	6,045
1953	123,879	37,942	24,522	11,572	25,474	18,663	6,176
1954	126,564	38,653	25,041	11,962	25,959	19,079	6,313
1955	129,203	39,355	25,557	12,345	26,433	19,492	6,451
1956	131,854	40,021	26,115	12,729	26,888	19,926	6,583
1957	134,705	40,714	26,752	13,120	27,347	20,437	6,731
1958	137,904	41,371	27,575	13,539	27,822	21,088	6,894
1959	140,923	41,934	28,432	13,963	28,172	21,740	7,056
1960	143,941	42,478	29,264	14,388	28,562	22,376	7,232
1961	147,149	43,073	29,883	15,071	29,021	22,813	7,596
1962	150,478	43,405	30,762	15,841	29,260	23,463	8,008
1963	153,503	43,488	31,720	16,604	29,346	24,166	8,417
1964	156,537	43,549	32,707	17,372	29,424	24,874	8,827
1965	159,346	43,491	33,685	18,155	29,432	25,565	9,241
1966	162,066	43,307	34,554	19,117	29,353	26,177	9,777
1967	164,712	43,016	35,390	20,177	29,195	26,802	10,354
1968	167,288	42,621	36,287	21,247	28,968	27,483	10,935
1969	169,624	42,097	37,211	22,283	28,677	28,149	11,490
1970	172,301	41,596	38,248	23,408	28,356	28,908	12,099
1971	175,200	41,341	39,044	24,630	28,190	29,464	12,827
1972	177,591	40,795	39,805	25,882	27,816	30,003	13,572
1973	179,806	40,111	40,561	27,181	27,343	30,521	14,338
1974	181,960	39,351	41,282	28,542	26,826	31,023	15,144
1975	184,167	38,618	41,958	29,955	26,326	31,495	15,983
1976	186,354	37,829	42,610	31,436	25,789	31,947	16,871
1977	188,420	37,047	43,168	32,959	25,257	32,337	17,753
1978	190,380	36,269	43,636	34,490	24,731	32,661	18,663
1979	192,372	35,540	44,042	36,068	24,244	32,927	19,589
1980	194,591	34,970	44,363	37,704	23,870	33,136	20,554
1981	196,836	34,834	45,569	38,070	23,799	33,732	20,838
1982	198,951	34,558	45,827	39,518	23,707	33,724	21,615
1983	201,208	34,346	45,299	41,646	23,547	33,225	23,133
1984	203,319	34,497	45,589	42,539	23,480	33,441	23,758
1985	205,415	34,622	45,538	43,717	23,483	33,006	25,023
1986	207,234	34,505	45,995	44,464	23,390	33,199	25,651

\*The grades 1–8 column includes persons who have completed less than the first grade.

**Table 8.14 Human Wealth per Person by Sex and Educational Attainment, 1947–86 (thousands of current dollars)**

Year	Total	Male			Female		
		Grades 1–8*	High School	College	Grades 1–8*	High School	College
1947	101.1	102.3	148.4	195.7	65.6	90.7	111.8
1948	106.0	107.3	154.7	206.2	68.5	94.6	117.7
1949	110.0	112.2	159.7	215.0	70.8	96.2	121.7
1950	115.2	118.4	167.0	230.4	73.3	98.3	126.9
1951	120.4	124.0	173.1	243.5	76.7	101.2	133.0
1952	126.7	131.2	181.2	256.9	80.7	104.8	139.2
1953	136.4	141.3	192.6	277.0	87.6	111.8	151.5
1954	138.5	145.3	195.0	278.5	89.0	111.4	152.1
1955	145.7	154.4	204.3	292.3	93.6	114.9	158.5
1956	156.5	167.3	218.9	315.8	100.0	121.0	168.9
1957	167.8	180.8	234.1	342.6	106.2	127.1	180.0
1958	170.2	184.1	235.9	339.9	109.0	128.0	183.3
1959	178.3	190.6	243.3	339.8	118.0	138.3	194.4
1960	186.7	200.0	251.2	350.1	125.3	145.2	200.6
1961	194.9	208.9	257.6	355.3	134.0	152.0	208.1
1962	198.6	212.9	259.7	354.2	138.4	155.0	210.6
1963	211.6	226.7	273.8	368.3	149.3	165.9	223.1
1964	223.7	239.1	286.4	380.6	160.3	176.2	234.4
1965	241.0	257.6	306.5	404.5	173.8	188.9	251.5
1966	256.6	273.0	321.6	423.2	188.1	201.5	269.6
1967	275.0	292.8	341.9	452.0	202.2	214.1	287.7
1968	292.8	311.2	360.5	475.0	217.4	227.6	306.2
1969	331.2	349.9	401.7	533.9	249.1	256.4	353.6
1970	359.4	380.8	439.0	589.8	264.3	272.8	381.1
1971	379.5	401.4	464.8	620.7	275.7	286.4	402.5
1972	411.9	437.1	508.5	677.1	292.5	307.3	430.1
1973	447.9	474.2	553.6	734.9	315.1	332.6	462.1
1974	487.8	513.6	601.4	803.0	341.0	359.9	500.7
1975	523.1	547.2	641.2	854.6	366.9	386.0	535.1
1976	551.9	574.4	673.3	893.2	388.1	407.2	561.2
1977	598.7	618.7	726.6	962.5	421.4	443.1	605.1
1978	652.3	672.3	790.6	1,053.4	455.0	478.2	651.9
1979	706.8	723.0	848.6	1,138.8	494.5	518.4	705.8
1980	750.7	769.5	896.5	1,210.1	520.4	545.5	747.6
1981	810.4	825.9	969.0	1,283.9	562.0	597.9	812.1
1982	853.7	873.3	1,012.8	1,339.0	602.7	624.0	853.6
1983	893.4	911.5	1,048.9	1,398.1	634.6	647.7	887.8
1984	948.4	971.9	1,103.3	1,484.6	672.4	687.3	942.2
1985	1,011.5	1,038.0	1,173.2	1,593.4	711.6	722.7	1,001.8
1986	1,108.3	1,137.5	1,276.6	1,734.0	785.4	794.0	1,095.3

\*The grades 1–8 column includes persons who have completed less than the first grade.

**Table 8.15 Human Wealth per Person by Sex and Educational Attainment, 1948–86 (thousands of constant dollars)**

Year	Total	Male			Female		
		Grades 1–8*	High School	College	Grades 1–8*	High School	College
1948	741.8	750.4	1,031.2	1,307.4	539.5	667.5	815.0
1949	743.9	753.5	1,028.6	1,308.7	541.0	665.8	812.4
1950	745.8	745.6	1,025.3	1,308.9	542.6	663.5	809.5
1951	748.2	760.6	1,023.4	1,310.9	544.8	661.5	807.4
1952	750.4	764.9	1,021.3	1,311.1	547.4	659.5	804.6
1953	752.9	769.9	1,019.9	1,312.0	550.2	657.9	801.4
1954	756.3	775.8	1,019.3	1,312.7	553.7	656.9	798.4
1955	759.0	781.3	1,017.7	1,312.3	556.8	655.3	795.4
1956	761.4	786.3	1,015.9	1,310.8	559.8	653.4	791.2
1957	764.4	791.9	1,015.3	1,310.0	562.7	652.7	788.3
1958	769.7	799.3	1,019.0	1,312.7	567.0	654.7	787.5
1959	774.3	805.3	1,021.8	1,313.9	570.6	656.1	785.8
1960	775.0	807.6	1,018.9	1,308.1	571.9	653.9	781.2
1961	779.4	814.8	1,016.2	1,309.0	576.9	651.2	784.6
1962	785.0	821.4	1,016.9	1,313.0	581.1	651.1	790.1
1963	789.5	826.2	1,017.5	1,315.7	583.9	650.8	794.3
1964	794.2	831.2	1,018.5	1,318.3	587.1	650.6	798.3
1965	798.6	836.1	1,019.2	1,320.5	590.2	650.1	801.5
1966	803.0	840.8	1,018.3	1,324.6	593.2	648.4	807.6
1967	807.3	845.2	1,016.8	1,330.0	596.0	646.5	814.1
1968	811.8	849.9	1,016.0	1,335.7	599.0	645.2	820.3
1969	815.1	853.0	1,014.4	1,339.0	601.0	643.3	824.2
1970	819.6	856.8	1,014.9	1,344.7	603.2	642.7	829.6
1971	824.9	861.1	1,017.9	1,346.5	605.5	643.4	833.2
1972	828.9	863.9	1,019.4	1,346.9	606.4	643.1	835.9
1973	833.2	866.4	1,020.9	1,348.0	607.2	642.7	838.5
1974	837.3	868.5	1,021.8	1,349.1	607.8	642.1	841.3
1975	840.9	870.0	1,021.9	1,350.0	608.0	641.0	843.8
1976	844.6	871.3	1,021.9	1,351.4	608.2	639.8	846.6
1977	847.3	871.6	1,020.5	1,351.9	607.6	637.8	848.2
1978	849.0	871.1	1,017.7	1,351.2	606.6	634.8	849.1
1979	850.7	870.6	1,014.5	1,350.8	605.9	631.6	850.1
1980	853.0	871.5	1,011.6	1,351.5	606.2	628.4	851.6
1981	853.9	872.3	1,016.5	1,344.5	600.0	632.4	852.6
1982	853.7	873.2	1,012.8	1,339.0	602.6	624.0	853.5
1983	855.1	873.0	1,005.8	1,339.4	606.4	618.5	847.5
1984	855.8	877.6	1,000.9	1,339.0	606.4	617.5	846.6
1985	856.1	876.6	997.7	1,336.5	607.8	611.7	848.0
1986	855.2	878.4	995.8	1,324.4	607.7	610.0	844.6

\*The grades 1–8 column includes persons who have completed less than the first grade.

**Table 8.16** Percentage of Human Wealth Based on Market Labor Activities to Total Human Wealth by Sex and Educational Attainment, 1947–86

Year	Total	Male			Female		
		Grades 1–8*	High School	College	Grades 1–8*	High School	College
1947	29.5	38.4	40.5	39.7	13.3	13.4	16.9
1953	30.8	40.9	41.8	43.5	14.6	14.6	19.2
1957	31.6	41.1	42.2	43.9	15.2	15.2	19.3
1960	31.9	41.1	42.3	43.9	15.6	15.6	19.5
1966	32.3	41.0	42.7	43.9	16.5	16.7	20.2
1969	32.4	40.9	42.7	43.9	17.0	17.3	20.5
1973	32.4	40.5	42.2	43.1	17.5	17.9	20.7
1979	32.5	40.1	41.4	42.2	18.9	19.2	21.9
1986	32.5	39.0	39.2	40.1	20.6	20.5	23.3

\*The grades 1–8 column includes persons who have completed less than the first grade.

**Table 8.17** Comparison with Other Results

A. Value of Nonmarket Activities, Selected Years, (billions of current dollars)

Year	Current Dollars		
	J-F	Nordhaus-Tobin	Ratio
1954	512.7	637.0	0.805
1958	638.7	794.6	0.804
1965	953.7	1,096.9	0.869

B. Private National Human Wealth, 1948–69 (billions of dollars)

Year	Current Dollars			1958 Dollars		
	J-F	Kendrick	Ratio	J-F	Kendrick	Ratio
1948	16,081.4	908.8	17.70	24,505.0	1,206.3	20.31
1949	16,957.9	938.9	18.06	25,156.1	1,242.9	20.24
1950	18,055.8	991.3	18.21	25,598.1	1,280.5	19.99
1951	19,178.6	1,097.7	17.47	26,036.4	1,322.2	19.69
1952	20,513.8	1,172.6	17.49	26,715.6	1,366.9	19.54
1953	22,433.3	1,236.8	18.14	27,310.1	1,413.3	19.32
1954	23,176.5	1,294.4	17.91	27,911.5	1,460.0	19.12
1955	24,805.7	1,364.2	18.18	28,494.8	1,509.9	18.87
1956	27,105.4	1,462.7	18.53	29,190.4	1,565.6	18.64
1957	29,570.6	1,576.8	18.75	29,837.0	1,623.7	18.38
1958	30,492.0	1,682.6	18.12	30,492.0	1,682.6	18.12
1959	32,457.5	1,786.9	18.16	31,203.8	1,744.7	17.88
1960	34,672.6	1,901.4	18.24	31,961.6	1,615.1	19.79
1961	36,788.8	2,012.8	18.28	32,701.2	1,888.4	17.32
1962	38,068.0	2,137.4	17.81	33,440.1	1,962.5	17.04
1963	41,145.1	2,273.0	18.10	34,262.1	2,041.9	16.78
1964	44,096.6	2,423.9	18.19	34,903.3	2,126.8	16.41
1965	48,087.5	2,594.4	18.54	35,667.5	2,218.8	16.08
1966	51,788.3	2,818.7	18.37	36,365.5	2,323.4	15.65
1967	56,099.5	3,049.7	18.40	36,959.7	2,434.0	15.18
1968	60,327.7	3,344.4	18.04	37,641.8	2,550.1	14.76
1969	68,923.4	3,699.9	18.63	38,215.0	2,674.4	14.29

## Comment Michael Rothschild

Comparative advantage dictates a focus on theory rather than data. I applaud Dale W. Jorgenson and Barbara M. Fraumeni's general framework. The most important output of education is human capital. The value of human capital is the discounted value of its services. I quarrel with one important modeling choice Jorgenson and Fraumeni make. The authors assert that human capital raises the productivity of time spent at leisure by the same amount that it does time spent working. Little evidence is offered for this assertion. My empirical work, which consists of introspection, does not resolve the issue. I would like to believe that Ph.D.'s make better lovers; I can believe that education is complementary to such leisure-time activities as operating a VCR; I doubt that within the audience at a football game (or an opera) the quality of the experience varies directly with the market wage.<sup>1</sup>

Noting that the market wage is the opportunity cost of leisure does not resolve this issue. Consider two simple variants of the standard time-allocation problem. Utility derives from goods,  $g$ , and leisure or recreation,  $r$ , and is calibrated by the utility function  $U(g, r)$ . Goods are bought with wage income paid at the rate of  $w$  per unit of time worked. The individual must divide his or her time between working and leisure. Choose units so that the total amount of time available for working and leisure is one. Let  $h$  (for hours) be the fraction of time spent working. Thus  $(1 - h)$  is the fraction of time spent at leisure. As human capital increases so does the wage per unit time. For simplicity measure human capital in units of wage income. Thus the consumer's budget constraint is  $g = hw$ , or

$$(1) \quad g + (1 - h)w = w; 0 \leq h \leq 1.$$

If human capital does not augment the ability to enjoy leisure, then the amount of leisure consumed is just the amount of time spent not working or

$$(2) \quad r = (1 - h).$$

If human capital does augment the ability to enjoy leisure, then

$$(3) \quad r = (1 - h)f(w),$$

where  $f(\bullet)$  is some increasing function. Jorgenson and Fraumeni focus on the case where  $f(\bullet)$  is the identity function. Thus in their world

$$(4) \quad r = (1 - h)w.$$

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1. This issue is not new; for one earlier discussion see Donald V. T. Bear, *The University as a Multi-Product Firm*, in *Efficiency in Universities: The La Paz Papers*, ed. Keith G. Lumsden (New York: Elsevier, 1974), 85 n.6. Bear attributes the distinction made here to comments by Arrow and Brainard.

The time-allocation problem is then a matter of choosing the fraction  $h$ , which maximizes  $U(g, r)$  subject to (1) and either (2) or (4). These two problems share the budget constraint (1). The right-hand side of equation (1) is often called full income. Clearly full income is a linear function of the level of human capital. If human capital doubles so does full income.

I understand national income accounting as a kind of cardinal welfare economics. Full income is an accounting concept. The question then is, Under what conditions is full income a reasonable measure of welfare? In order for the Jorgenson-Fraumeni procedure (which is linear) to have a chance, it is necessary to suppose that the utility function,  $U(g, r)$ , exhibits constant returns to scale; this form of the hypothesis that the marginal utility of income is constant is appropriate for this example.

Define

$$(5) \quad V(w) = \max U(g, r), \text{ subject to (1).}$$

Then  $V(w)$  is the value of human capital and is a good measure of national income. Consider the particular utility function

$$(6) \quad U(g, r) = U(g^\alpha r^{(1-\alpha)}).$$

The utility maximizing hours of work,  $h^*$ , is equal to  $(1 - \alpha)$ , and the utility maximizing  $g^* = \alpha w$ , when either (2) or (4) holds. If (2) describes the leisure technology, total utility is

$$V_R(w) = w^\alpha K,$$

where  $K = \alpha^\alpha (1 - \alpha)^{(1-\alpha)}$ . National income is *not* a linear function of  $w$ . In the Jorgenson-Fraumeni case total utility is

$$V_{JF}(w) = wK.$$

This argument generalizes somewhat. As long as the utility function is homothetic, the choice of hours of work is independent of the level of human capital. This pattern is true even if there are taxes on wage income. If  $\tau$  is the tax rate, then in the Jorgenson-Fraumeni world the allocation of time problem reduces to the problem of choosing  $h$  to maximize  $U[h(1 - \tau)w, (1 - h)w]$ . Because  $U(\bullet, \bullet)$  is homothetic, the optimal  $h$  is independent of  $w$ . Because the utility function is homogeneous of degree one, the indirect utility function  $V_{JF}(w)$  always has the form  $V_{JF}(w) = wK$ , where  $K$  is some constant.

If human capital does not increase the efficiency of leisure the allocation of time problem reduces to choosing  $h$  to maximize  $U[h(1 - \tau)w, (1 - h)]$ . In general the optimal  $h$  is a function of  $w$ ; because  $U(g, r)$  is homothetic, hours worked increase as  $w$  increases if and only if the elasticity of substitution between  $g$  and  $r$  is greater than one. Whatever the elasticity of substitution,  $V(w)$  is not a linear function of  $w$ . It is of some interest to note that  $V_R(w)$

can be either concave or convex. In the Cobb-Douglas case we saw that  $V_R(w)$  is concave. If  $U(g, r) = g + r$ , then  $V_R(w) = \max [1, w]$ , which is convex.

It is natural to ask whether it is possible to test the specification (4). At first sight it would seem that the Jorgenson-Fraumeni hypothesis has the strong implication that, if utility is homothetic, then hours worked are independent of the level of human capital. Unfortunately this prediction of the theory vanishes when the consumer has nonlabor income.