on negative changes from a given level of income than they do on positive changes of equal dollar magnitude—they would prefer a job paying W' and offering H' hours with certainty to one paying W' and offering H' hours only on average. Thus, to compensate them for the loss in utility associated with *risk aversion*, they would require a wage above W' for the job offering H' hours only on average.

HE OBSERVED WAGE/LAYOFF RELATIONSHIP

The discussion above centered on worker preferences regarding layoffs. For compensating wage differentials to arise, of course, employers must be willing to pay them. That is, employers must profit from being able to lay off workers, and if we are to observe firms pursuing a high-wage/high-layoff strategy, their gains from layoff must exceed their costs of higher wages.

The discussion above also neglected unemployment insurance (UI) payments to laid-off workers. This topic is discussed in some detail in chapter 15. Here we need note only that if UI payments fully compensate laid-off workers for their lost utility, compensating wage differentials will not arise. Compensating wage differentials will arise only if UI payments do not fully compensate laid-off workers.

One study that looked very carefully at the relationship between wages and layoffs suggests that the compensating wage differential for an average probability of layoff is around 4 percent of wages, with over 80 percent of this differential related to the aversion to risk associated with the variability (uncertainty) in layoff rates facing workers over time. Workers in the high-layoff industries of automobile manufacturing and construction received estimated compensating wage differentials ranging over the early 1970s from 6 to 14 percent and 6 to 11 percent, respectively.[5] A study of farm workers around 1990 found that those who risked unemployment by working seasonally were paid from 9 to 12 percent more per hour than those who held permanent jobs in farming.[6]

[5]These estimates are from the Abowd and Ashenfelter article in footnote 1 of this appendix. Similar evidence for the late 1970s can be found in Robert H. Topel, "Equilibrium Earnings, Turnover, and Unemployment: New Evidence," *Journal of Labor Economics* 2, no. 4 (October 1984): 500–522. For those interested in how UI benefits affect wages, see David A. Anderson, "Compensating Wage Differentials and the Optimal Provision of Unemployment Insurance," *Southern Economic Journal* 60, no. 3 (January 1994): 644–656.

[6]Enrico Moretti, "Do Wages Compensate for Risk of Unemployment? Parametric and Semiparametric Evidence from Seasonal Jobs," *Journal of Risk and Uncertainty* 20, no. 1 (January 2000): 45–66.

9

INVESTMENTS IN HUMAN CAPITAL: Education and Training

Many labor supply choices require a substantial initial *investment* on the part of the worker. Recall that investments, by definition, entail an initial cost that one hopes to recoup over some period of time. Thus, for many labor supply decisions, *current* wages and working conditions are not the only deciding factors. Modeling investment decisions requires developing a framework that incorporates a *lifetime* perspective.

Workers undertake three major kinds of labor market investments: education and training, migration, and search for new jobs. All three investments involve an initial cost, and all three are made in the hope and expectation that the investment will pay off well into the future. To emphasize the essential similarity of these investments to other kinds of investments, economists refer to them as investments in *human capital*, a term that conceptualizes workers as embodying a set of skills that can be "rented out" to employers. The knowledge and skills a worker has—which come from education and training, including the learning that experience yields—generate a certain *stock* of productive capital. The *value* of this productive capital is derived from how much these skills can earn in the labor market. Job search and migration are activities that increase the value of one's human capital by increasing the price (wage) received for a given stock of skills.

EXAMPLE 9.1

War and Human Capital

We can illustrate the relative importance of physical and human capital by noting some interesting facts about severely war-damaged cities. The atomic attack on Hiroshima destroyed 70 percent of its buildings and killed about 30 percent of the population. Survivors fled the city in the aftermath of the bombing, but within three months two-thirds of the city's surviving population had returned. Because the air-burst bomb left the city's underground utility networks intact, power was restored to surviving areas in one day. Through railway service began again in two days, and telephone service was restarted in a week. Plants responsible for three-quarters of the city's industrial production (many were located on the outskirts of the city and undamaged) could have begun normal operations within 30 days.

In Hamburg, Germany, a city of around 1.5 million in the summer of 1943, Allied bombing raids over a ten-day period in July and August destroyed about half of the buildings in the city and killed about 3 percent of the city's population. Although there was considerable damage to the water supply system, electricity and gas service were adequate within a few days after the last attack, and within four days the telegraph system was again operating. The central bank was reopened and business had begun to function normally after one week, and postal service was resumed within twelve days of the attack. The Strategic Bombing Survey reported that within five months, Hamburg had recovered up to 80 percent of its former productivity.

The speed and success of recovery from these disasters has prompted one economist to offer the following two observations:

> (1) the fraction of the community's real wealth represented by visible material capital is small relative to the fraction represented by the accumulated knowledge and talents of the population, and (2) there are enormous reserves of energy and effort in the population not drawn upon in ordinary times but which can be utilized under special circumstances such as those prevailing in the aftermath of disaster.

Data from: Jack Hirshleifer, *Economic Behavior in Adversity* (Chicago: University of Chicago Press, 1987), pp. 12–14, 78–79.

Society's total wealth is a combination of human and nonhuman capital. Human capital includes accumulated investments in such activities as education, job training, and migration, whereas nonhuman capital includes society's stock of natural resources, buildings, and machinery. Total per capita wealth in North America, for example, was around $379,000 in 1994, 76 percent of which ($289,000) was in the form of human capital. Indeed, in worldwide regions outside the resource-rich Middle East, over 60 percent of estimated national wealth in 1994 was derived from investments in human capital.[1] (Example 9.1 illustrates the overall importance of human capital in another way.)

Investment in the knowledge and skills of workers takes place in three stages. First, in early childhood, the acquisition of human capital is largely determined by the decisions of others. Parental resources and guidance, plus our cultural environment

[1]World Bank, *Expanding the Measure of Wealth: Indicators of Environmentally Sustainable Development* (Washington, D.C.: World Bank, 1997), Table 3.3. The wealth estimates for 1994 are expressed in dollars as of the year 2000.

and early schooling experiences, help to influence basic language and mathematical skills, attitudes toward learning, and general health and life expectancy (which themselves affect the ability to work). Second, teenagers and young adults go through a stage in which they acquire knowledge and skills as full-time students in a high school, college, or vocational training program. Finally, after entering the labor market, workers' additions to their human capital generally take place on a part-time basis, through on-the-job training, night school, or participation in relatively short, formal training programs. In this chapter we focus on the latter two stages.

One of the challenges of any behavioral theory is to explain why people faced with what appears to be the same environment make different choices. We will see in this chapter that individuals' decisions about investing in human capital are affected by the ease and speed with which they learn, their aspirations and expectations about the future, and their access to financial resources.

HUMAN CAPITAL INVESTMENTS: THE BASIC MODEL

Like any other investment, an investment in human capital entails costs that are borne in the near term with the expectation that benefits will accrue in the future. Generally speaking, we can divide the *costs* of adding to human capital into three categories:

1. *Out-of-pocket* or *direct* expenses, including tuition costs and expenditures on books and other supplies.
2. *Forgone earnings* that arise because during the investment period it is usually impossible to work, at least not full-time.
3. *Psychic losses* that occur because learning is often difficult and tedious.

In the case of educational and training investments by workers, the expected *returns* are in the form of higher future earnings, increased job satisfaction over their lifetime, and a greater appreciation of nonmarket activities and interests. Calculating the benefits of an investment over time requires us to progressively discount benefits lying further into the future (see chapter 5). Benefits that are received in the future are worth less to us now than an equal amount of benefits received today, for two reasons. First, if people plan to consume their benefits, they prefer to consume earlier. (We are relatively sure of being able to enjoy such consumption now, for example, but the uncertainties of life make future enjoyment problematic.) Second, if people plan to invest the monetary benefits rather than use them for consumption, they can earn interest on the investment and enlarge their funds in the future. Thus, no matter how people intend to use their benefits, they will discount future receipts to some extent.

As chapter 5 explained, the present value of a stream of yearly benefits ($B_1, B_2, \ldots$) over time (T) can be calculated as follows:

$$\text{Present Value} = \frac{B_1}{1+r} + \frac{B_2}{(1+r)^2} + \frac{B_3}{(1+r)^3} + \cdots + \frac{B_T}{(1+r)^T} \qquad (9.1)$$

where the interest rate (or discount rate) is r. As long as r is positive, benefits into the future will be progressively discounted. For example, if $r = 0.06$, benefits payable in 30 years would receive a weight that is only 17 percent of the weight payable on benefits payable immediately ($1.06^{30} = 5.74$; $1/5.74 = 0.17$). The smaller r is, the greater the weight placed on future benefits; for example, if $r = 0.02$, a benefit payable in 30 years would receive a weight that is 55 percent of the weight given to an immediate benefit.

Our model of human capital investment assumes that people are utility maximizers and take a lifetime perspective when making choices about education and training. They are therefore assumed to compare the near-term investment costs (C) with the present value of expected future benefits when making a decision, say, about additional schooling. Investment in additional schooling is attractive if the present value of future benefits exceeds costs:

$$\frac{B_1}{1+r} + \frac{B_2}{(1+r)^2} + \cdots + \frac{B_T}{(1+r)^T} > C \qquad (9.2)$$

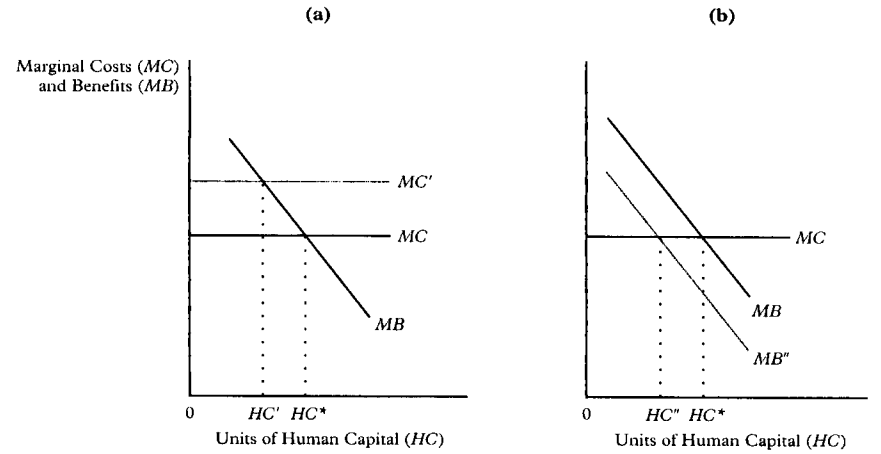
Utility maximization, of course, requires that people continue to make additional human capital investments as long as condition (9.2) is met, and that they stop only when the benefits of additional investment are equal to or less than the additional costs.

There are two ways we can measure whether the criterion in (9.2) is met. Using the *present-value method*, we can specify a value for the discount rate, r, and then determine how the present value of benefits compares to costs. Alternatively, we can adopt the *internal rate of return method*, which asks, "How large could the discount rate be and still render the investment profitable?" Clearly, if the benefits are so large that even a very high discount rate would render investment profitable, then the project is worthwhile. In practice, we calculate this internal rate of return by setting the present value of benefits equal to costs, solving for r and then comparing r to the rate of return on other investments.

Some basic implications of the model embedded in expression (9.2) are illustrated graphically in Figure 9.1, which depicts human capital decisions in terms of marginal costs and marginal benefits (focus for now on the black lines in the figure). The marginal costs, *MC*, of each additional unit of human capital (the tuition, supplies, forgone earnings, and psychic costs of an additional year of schooling, say) are assumed to be constant. The present value of the marginal benefits, *MB*, is shown as declining, because each added year of schooling means fewer years over which benefits can be collected. The utility-maximizing amount of human capital (*HC**) for any individual is shown as that amount for which $MC = MB$.

Those who find learning to be especially arduous will implicitly attach a higher marginal psychic cost to acquiring human capital. As shown by the green line, *MC'*, in Figure 9.1a, individuals with higher marginal costs will acquire lower levels of human capital (compare *HC'* with *HC**). Similarly, those who expect smaller future benefits from additional human capital investments (the green line, *MB"*, in Figure 9.1b) will acquire less human capital.

FIGURE 9.1
The Optimum Acquisition of Human Capital



This straightforward theory yields some interesting insights about the behavior and earnings of workers. Many of these insights can be discovered by analyzing the decision confronting young adults about whether to invest full-time in college after leaving high school.

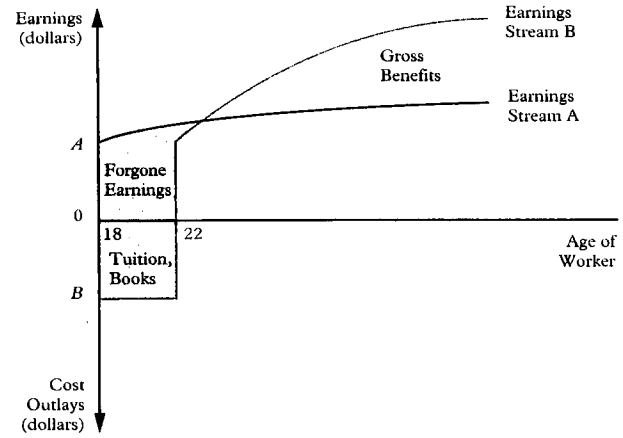
THE DEMAND FOR A COLLEGE EDUCATION

The demand for a college education, as measured by the percentage of graduating high school seniors who enroll in college, is surprisingly variable. For males, enrollment rates went from 55.2 percent in 1970, down to 46.7 percent in 1980, and back up to 61.4 percent by 1999. The comparable enrollment rates for women started lower, at 48.5 percent in 1970, and rose slowly during the 1970s, quickly during the 1980s, and again more slowly during the 1990s—reaching 64.4 percent in 1999. Why have enrollment rates followed these patterns?

Weighing the Costs and Benefits of College

Clearly, people attend college when they believe they will be better off by so doing. For some, at least part of the benefits may be short-term—they like the courses

FIGURE 9.2
Alternative Earnings Streams



or the lifestyle of a student—and to this extent college is at least partially a *consumption* good. The consumption benefits of college, however, are unlikely to change much over the course of a decade, so changes in college attendance rates over relatively short periods of time probably reflect changes in marginal costs or benefits associated with the *investment* aspects of college attendance.

A person considering college has, in some broad sense, a choice between two streams of earnings over his or her lifetime. Stream A begins immediately but does not rise very high; it is the earnings stream of a high school graduate. Stream B (the college graduate) has a negative income for the first four years (owing to college tuition costs), followed by a period when the salary may be less than the high school graduate makes, but then it takes off and rises above stream A. Both streams are illustrated in Figure 9.2. (Why these streams are differentially *curved* will be discussed later in this chapter.) The streams shown in the figure are stylized so that we can emphasize some basic points. Actual earnings streams will be shown in Figures 9.3 and 9.4.

Obviously, the earnings of the college graduate would have to rise above those of the high school graduate to induce someone to invest in a college education (unless, of course, the consumption-related returns were large). The gross benefits, the difference in earnings between the two streams, must total much more than the costs because such returns are in the future and are therefore discounted. For example, suppose it costs $25,000 per year to obtain a four-year college education and the real interest rate (the nominal rate less the rate of inflation) is 2 percent. The after-tax returns—if they were the same each year—must be $3,652

in constant-dollar terms (that is, after taking away the effects of inflation) each year for 40 years in order to justify the investment on purely monetary grounds. These returns must be $3,652 because $100,000 invested at a 2 percent interest rate can provide a payment (of interest and principal) totaling $3,652 a year for 40 years.[2]

Predictions of the Theory

In deciding whether to attend college, no doubt few students make the very precise calculations suggested in expression (9.2). Nevertheless, if they make less formal estimates that take into account the same factors, we can make four predictions concerning the demand for college education:

1. Present-oriented people are less likely to go to college than forward-looking people (other things equal).
2. Most college students will be young.
3. College attendance will decrease if the costs of college rise (other things equal).
4. College attendance will increase if the gap between the earnings of college graduates and high school graduates widens (again, other things equal).

Present-Orientedness Though we all discount the future somewhat with respect to the present, psychologists use the term *present-oriented* to describe people who do not weight future events or outcomes very heavily. In terms of expressions (9.1) and (9.2), a present-oriented person is one who uses a very high discount rate (r).

Suppose we were to calculate investment returns using the *present-value method*. If r is large, the present value of benefits associated with college will be lower than if r is smaller. Thus, a present-oriented person would impute smaller benefits to college attendance than one who is less present-oriented, and those who are more present-oriented are less likely to attend college. Using the *internal rate of return method* for evaluating the soundness of a college education, we would arrive at the same result. If a college education earns an 8 percent rate of return but the individuals in question are so present-oriented that they would insist on a 25 percent rate of return before investing, they would likewise decide not to attend.

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[2]This calculation is made using the annuity formula:

$$Y = X \frac{1 - [1/(1 + r)^n]}{r}$$

where Y = the total investment ($100,000 in our example), X = the yearly payment ($3,652), r = the rate of interest (0.02), and n = the number of years (40). In this example, we treat the costs of a college education as being incurred all in one year rather than being spread out over four, a simplification that does not alter the magnitude of required returns much at all.

The prediction that present-oriented people are less likely to attend college than forward-looking ones is difficult to substantiate because the rates of discount that people use in making investment decisions can rarely be quantified.[3] However, the model does suggest that people who have a high propensity to invest in education will also engage in other forward-looking behavior. Certain medical statistics tend to support this prediction.

In the United States there is a strong statistical correlation between education and health status.[4] People with more years of schooling have lower mortality rates, fewer symptoms of disease (such as high blood pressure, high cholesterol levels, abnormal X-rays), and a greater tendency to report themselves to be in good health. This effect of education on health is independent of income, which appears to have no effect of its own on health status except at the lowest poverty levels. Is this correlation between education and health a result of better use of medical resources by the well-educated? It appears not. Better-educated people undergoing surgery choose the same doctors, enter the hospital at the same stage of disease, and have the same length of stay as less-educated people of equal income.

What *may* cause this correlation is a more forward-looking attitude among those who have obtained more education. People with lower discount rates will be more likely to attend college, and they will *also* be more likely to adopt forward-looking habits of health. They may choose healthier diets, be more aware of health risks, and make more use of preventive medicine. This explanation for the correlation between education and health is not the only plausible one, but it receives some direct support from American data on cigarette smoking.[5] From 1966 to 1987, the proportion of male college graduates who smoked fell by 50 percent, while it was unchanged among male high school dropouts. It is unlikely that the less-educated group was uninformed of smoking dangers; it is more likely that they were less willing to give up a present source of pleasure for a distant benefit. Thus, we have at least some evidence that people who invest in education also engage in *other* forward-looking behavior.

Age Given similar *yearly* benefits of going to college, young people have a larger present value of *total* benefits than older workers simply because they have a longer

[3]A recent study infers personal discount rates from the choices of separation-pay options made by members of the military being separated for budget reasons. It finds that those officers with graduate degrees had lower discount rates than officers without, and that college-educated officers had lower discount rates than enlisted personnel (who generally do not have college educations). See John T. Warner and Saul Pleeter, "The Personal Discount Rate: Evidence from Military Downsizing Programs," *American Economic Review* 91, no. 1 (March 2001): 33–53.

[4]The analysis of the correlation between education and health status is taken from Victor Fuchs, "The Economics of Health in a Post-Industrial Society," *The Public Interest* (Summer 1979): 3–20.

[5]It could be, for example, that healthy people, with longer life spans, are more likely to invest in human capital because they expect to experience a longer payback period. Alternatively, we could argue that the higher incomes of college graduates later in life mean they have more to lose from illness than do non-college graduates. Data on smoking are from U.S. Department of Health and Human Services, Public Health Service, *Smoking Tobacco and Health*, DHHS publication no. (CDC)87–8397, October 1989, 5.

remaining work life ahead of them. In terms of expression (9.2), T is greater for younger people than for older ones. We would therefore expect younger people to have a greater propensity than older people to obtain a college education or engage in other forms of training activity. This prediction is parallel to the predictions in chapter 5 about which workers employers will decide to invest in when they make decisions about hiring or specific training.

Costs A third prediction of our model is that human capital investments are more likely when costs are lower. The major monetary costs of college attendance are forgone earnings and the direct costs of tuition, books, and fees. (Food and lodging are not always opportunity costs of going to college because some of these costs would have to be incurred in any event.) Thus, if forgone earnings or tuition costs fall, other things equal, we would expect a rise in college enrollments.[6]

The costs of college attendance are an additional reason why older people are less likely to attend than younger ones. As workers age, their greater experience and maturity result in higher wages and therefore greater opportunity costs of college attendance. Interestingly, however, as suggested by Example 9.2, college attendance by military veterans (who are older than the typical college student) has been responsive to the educational subsidies for which they are eligible.[7]

The subject of cost raises an interesting question: just who is *most* responsive to cost considerations? Economic theory postulates that, in any set of market transactions, some people are *at the margin*—meaning that they are close to the point of not transacting. Who are those for whom the decision to attend college is a close call? Our theoretical considerations suggest that, facing given monetary costs and post-college earnings, students with lower achievement levels (for whom learning is more difficult) or higher discount rates are more likely to be at the margin. Interestingly, studies looking at how the cost advantage of a hometown college affects college-attendance decisions find that the effects are largest for those who would be otherwise least likely to attend.[8]

Earnings Differentials The fourth prediction of human capital theory is that the demand for education is positively related to the increases in lifetime earnings that a college education allows. Strictly speaking, it is the benefits one *expects* to receive that are critical to this decision, and the expected benefits

[6]See Orley Ashelfelter and Cecilia Rouse, "Income, Schooling, and Ability: Evidence from a New Sample of Identical Twins," *Quarterly Journal of Economics* 113, no. 1 (February 1998): 253–284, for evidence that lower costs of schooling among abler students drive them to obtain more schooling.

[7]Also see Joshua D. Angrist, "The Effect of Veterans' Benefits on Education and Earnings," *Industrial and Labor Relations Review* 46, no. 4 (July 1993): 637–652.

[8]C. A. Anderson, M. J. Bowman, and B. Tinto, *Where Colleges Are and Who Attends* (New York: McGraw-Hill, 1972); and David Card, "Using Geographic Variation in College Proximity to Estimate the Return to Schooling," in *Aspects of Labour Market Behavior: Essays in Honour of John Vanderkamp*, ed. L. N. Christofides, E. K. Grant, and R. Swindinsky (Toronto: University of Toronto Press, 1995).

EXAMPLE 9.2

Did the G.I. Bill Increase Educational Attainment for Returning World War II Vets?

Veterans returning from service in World War II were eligible to receive unprecedented federal support through the G.I. Bill if they chose to attend college. Benefits under the G.I. Bill substantially subsidized the costs of a college education, covering the tuition charged by almost all private and public universities and providing monthly stipends ranging from roughly 50 to 70 percent of the median income in the United States at the time. After the war, many veterans enrolled in college—and total college enrollments jumped by more than 50 percent from their pre-war levels. Over 2.2 million veterans attended college under the bill, accounting for about 70 percent of the male student body at the peak of the bill's usage. Because of these effects, Senator Ralph Yarborough called the World War II G.I. Bill "one of the most beneficial, far-reaching programs ever instituted in American life."

Did the G.I. Bill really have a big effect, or did it merely subsidize returning veterans who would have gone to college anyway? A recent article helps to answer this question by comparing the college attendance of male veterans to otherwise similar individuals. It finds that among high school graduates, World War II veterans completed an average of about 0.3 more years of college than did non-veterans, and that they had a 6 percentage-point greater college completion rate. Similar estimates were obtained when comparing those eligible for war service and G.I. Bill subsidies with those born too late to serve in the war.

The conclusions of this study are that the responses of veterans to the G.I. Bill's subsidies were quite similar to the contemporary responses of students to changes in tuition costs. In both cases, a 10 percent reduction in the cost to students of attending college resulted in a 4 or 5 percent increase in college attendance and completion.

Data from: John Bound and Sarah Turner, "Going to War and Going to College: Did the G.I. Bill Increase Educational Attainment?" *Journal of Labor Economics*, forthcoming, and Keith W. Olson, *The G.I. Bill, the Veterans, and the Colleges* (Lexington: University Press of Kentucky, 1974).

for any individual are rather uncertain. Future earnings can never be perfectly foretold, and in addition, many students are uncertain about their later occupational choice.[9] As a first approximation, however, it is reasonable to conjecture that the *average* returns received by recent college graduates have an important influence on students' decisions.

Dramatic changes in the average monetary returns to a college education over the past three decades are at least partially, if not largely, responsible for the changes in college enrollment rates noted earlier. It can be seen from the first and third columns of Table 9.1, for example, that the decline in male enrollment rates during the 1970s was correlated with a decline in the college/high school earnings differential, while the higher enrollment rates after 1980 were associated with larger earnings differentials.

[9]For a study that incorporates uncertainty into the formal model of choice, see Joseph G. Altonji, "The Demand for and Return to Education When Education Outcomes Are Uncertain," *Journal of Labor Economics* 10 (January 1993): 48–83. For studies on the accuracy of students' knowledge about the salaries in various fields, or at various ages, see Julian R. Betts, "What Do Students Know about Wages? Evidence from a Survey of Undergraduates," and Jeff Dominitz and Charles F. Manski, "Eliciting Student Expectations of the Returns to Schooling," both in *Journal of Human Resources* 31, no. 1 (Winter 1996): 1–56.

TABLE 9.1 Changes in College Enrollments and the College/High School Earnings Differential, by Gender, 1970–1999

Year	*College Enrollment Rates of New High School Graduates*		*Ratios of Mean Earnings of College to High School Graduates, Ages 25–34, Prior Year*[a]	
	Male	*Female*	*Male*	*Female*
1970	55.2%	48.5%	1.38	1.42
1980	46.7	51.8	1.19	1.29
1990	57.8	62.0	1.48	1.59
1999	61.4	64.4	1.62	1.60

[a]For year-round, full-time workers. Data for the first two years are for personal income, not earnings; however, in the years for which both income and earnings are available, the ratios are essentially equal.

Sources: U.S. Department of Education, *Digest of Education Statistics 2000* (January 2001), Table 185; U.S. Bureau of the Census, *Money Income of Families and Persons in the United States*, Current Population Reports P-60, no. 66 (Table 41), no. 129 (Table 53), no. 174 (Table 29), no. 209 (Table 9).

The second and fourth columns of Table 9.1 document changes in enrollment rates and earnings differentials for women. Unlike enrollment rates for men, those for women rose throughout the three decades; however, it is notable that they rose most in the 1980s, when the college/high school earnings differential rose most sharply. Why did enrollment rates among women increase in the 1970s when the earnings differential fell? It is quite plausible that, despite the reduced earnings differential, the expected returns to education for women actually rose because of increases in their intended labor force attachment and hours of work outside the home (both of which increase the period over which the earnings differential will be received).[10]

While changes in average earnings differentials are a useful indicator of relative labor market conditions, individuals must assess their *own* probabilities of success in specific fields or occupations. Recent studies have pointed to the

[10]For evidence that women with "traditional" views of their economic roles receive lower rates of return on, and invest less in, human capital, see Francis Vella, "Gender Roles and Human Capital Investment: The Relationship between Traditional Attitudes and Female Labour Market Performance," *Economica* 61, no. 242 (May 1994): 191–211. For an interesting analysis of historical trends in female college attendance, see Claudia Goldin, "Career and Family: College Women Look to the Past," in *Gender and Family Issues in the Workplace*, ed. Francine D. Blau and Ronald G. Ehrenberg (New York: Russell Sage Foundation, 1997): 20–58.

importance of friends, ethnic affiliation, and neighborhoods in the human capital decisions of individuals, even after controlling for the effects of parental income or education.[11] The educational and occupational choices of friends and acquaintances appear to have a significant effect on an individual's human capital decisions, perhaps because the presence of role models helps to reduce the uncertainty that inevitably surrounds estimates of future success in specific areas.

Market Responses to Changes in College Attendance

Like other market prices, the returns to college attendance are determined by the forces of both employer demand and employee supply. If more high school students decide to attend college when presented with higher returns to such an investment, market forces are put into play that will tend to lower these returns in the future. Increased numbers of college graduates put downward pressure on the wages observed in labor markets for these graduates, other things equal, while a smaller number of high school graduates will tend to raise wages in markets for less-educated workers.

Thus, adding to uncertainties about expected payoffs to an investment in college is the fact that current returns may be an unreliable estimate of future returns. A high return now might motivate an individual to opt for college, but it will also cause many *others* to do likewise. An influx of college graduates in four years could put downward pressure on returns at that time, which reminds us that all investments—even human-capital ones—involve outlays now and uncertain returns in the future. (For an analysis of how the labor market might respond when workers behave as if the returns observed currently will persist into the future, see Appendix 9A.)

EDUCATION, EARNINGS, AND POSTSCHOOLING INVESTMENTS IN HUMAN CAPITAL

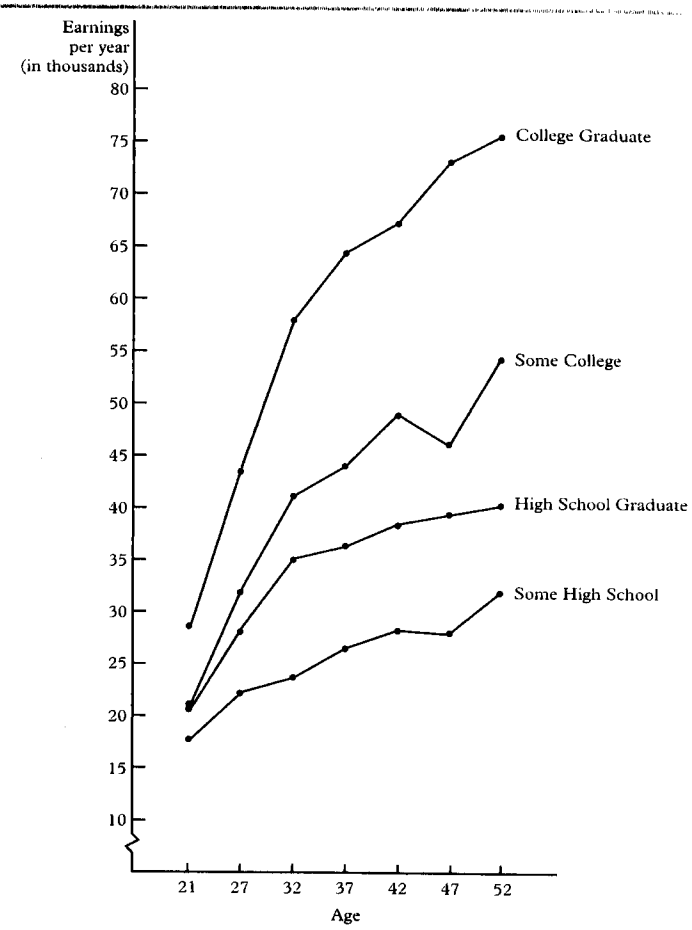
The preceding section used human capital theory to analyze the decision to undertake a formal educational program (college) on a full-time basis. We now turn to an analysis of workers' decisions to acquire training at work. The presence of on-the-job training is difficult for the economist to directly observe; much of it is informal and not publicly recorded. We can, however, use human capital theory and certain patterns in workers' lifetime earnings to draw inferences about their demand for this type of training.

Figures 9.3 and 9.4 graph the 1999 earnings of men and women of various ages with different levels of education. These figures reveal four notable characteristics:

1. Average earnings of full-time workers rise with the level of education.
2. The most rapid increase in earnings occurs early, thus giving a concave shape to the age/earnings profiles of both men and women.
3. Age/earnings profiles tend to fan out, so that education-related earnings differences later in workers' lives are greater than those early on.

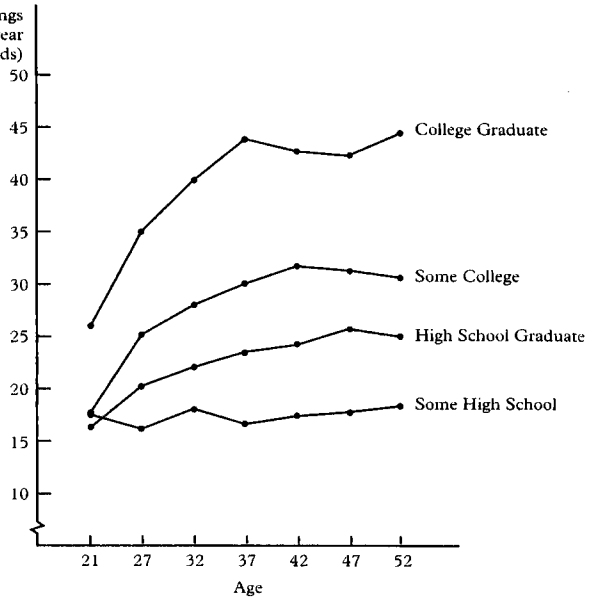
[11] For a recent study, see Ira N. Gang and Klaus F. Zimmermann, "Is Child Like Parent? Educational Attainment and Ethnic Origin," *Journal of Human Resources* 35, no. 3 (Summer 2000): 550–569.

FIGURE 9.3
Money Earnings (Mean), for Full-Time, Year-Round Male Workers, 1999



Source: See footnote 12.

FIGURE 9.4
Money Earnings (Mean), for Full-Time, Year-Round Female Workers, 1999



Source: See footnote 12.

4. The age/earnings profiles of men tend to be more concave and to fan out more than those for women.

Can human capital theory help explain the above empirical regularities?

Average Earnings and Educational Level

Our *investment* model of educational choice implies that earnings rise with the level of education, for if they did not, the incentives for students to invest in more education would disappear. It is thus not too surprising to see in Figures 9.3 and 9.4 that the average earnings of more-educated workers exceed those of less-educated workers.

Remember, however, that *earnings* are influenced by both wage rates and hours of work. Data on *wage rates* are probably most relevant when we look at the returns to an educational investment, because they indicate pay per unit of time at work. Wage data, however, are less widely available than earnings data. A crude, but readily available, way to control for working hours when using earnings data is to focus on full-time, year-round workers—which we do in Figures 9.3 and 9.4. More careful statistical analyses, however, which control for hours of work and factors other than education that can increase wage rates, come to the same conclusion suggested by Figures 9.3 and 9.4: namely, that more education is associated with higher pay. (A more rigorous theoretical analysis of the association between education and pay can be found in Appendix 9B, which presents the analysis in the context of hedonic wage theory.)

On-the-Job Training and the Concavity of Age/Earnings Profiles

The age/earnings profiles in Figures 9.3 and 9.4 typically rise steeply early on, then tend to flatten.[12] In fact, the early increases are so steep relative to those later on that a study of men's wage rates found that two-thirds of their *career* wage growth occurred in their first ten years of work![13] While in the next two chapters we will encounter other potential explanations for why earnings rise in this way with age, human capital theory explains the concavity of these profiles in terms of *on-the-job training*.[14]

Training Declines with Age Training on the job can occur through learning by doing (skills improving with practice), through formal training programs at or away from the workplace, or by informally working under the tutelage of a more experienced worker. All forms entail reduced productivity among trainees during the learning process, and both formal and informal training also involve a commitment of time by those who serve as trainers or mentors. Training costs are either shared by workers and the employer, as with specific training, or are borne mostly by the employee (in the case of general training).

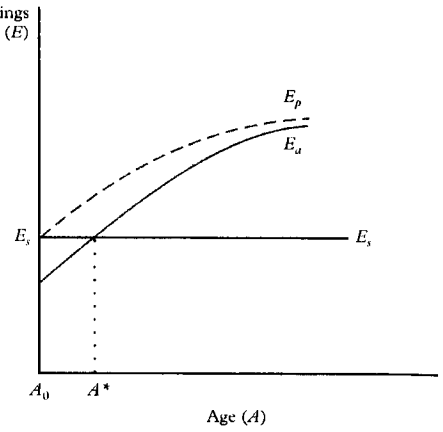
From the perspective of workers, training depresses wages during the learning period but allows them to rise with enhanced productivity afterwards. Thus, workers who opt for jobs that require a training investment are willing to accept

[12]Data in these figures are from U.S. Bureau of the Census, *Money Income in the United States*, Current Population Reports P-60, no. 209, Table 9; they match average earnings with age and education in a given year and do not follow individuals through time. For a study using longitudinal data on specific individuals, see Richard W. Johnson and David Neumark, "Wage Declines and Older Men," *Review of Economics and Statistics* 78, no. 4 (November 1996): 740–748.

[13]Kevin M. Murphy and Finis Welch, "Empirical Age–Earnings Profiles," *Journal of Labor Economics* 8 (April 1990): 202–229.

[14]For discussions of the relative importance of the human capital explanation for rising age/earnings profiles, see Ann P. Bartel, "Training, Wage Growth, and Job Performance: Evidence from a Company Database," *Journal of Labor Economics* 13, no. 3 (July 1995): 401–425; Charles Brown, "Empirical Evidence on Private Training," in *Research in Labor Economics*, vol. 11, ed. Lauri J. Bassi and David L. Crawford (Greenwich, Conn.: JAI Press, 1990), 97–114; and Jacob Mincer, "The Production of Human Capital and the Life Cycle of Earnings: Variations on a Theme," *Journal of Labor Economics* 15, no. 1, pt. 2 (January 1997): S26–S47.

FIGURE 9.5
Investment in On-the-Job Training over the Life Cycle



lower wages in the short run to get higher pay later on. As with other human-capital investments, returns are generally larger when the post-investment period is longer, so we would expect workers' investments in on-the-job training to be greatest at younger ages and to fall gradually as they grow older.

Figure 9.5 graphically depicts the life-cycle implications of human capital theory as it applies to on-the-job training. The individual depicted has completed full-time schooling and is able to earn E_s at age A_0. Without further training, if the knowledge and skills the worker possesses do not depreciate over time, earnings would remain at E_s over the life cycle. If the worker chooses to invest in on-the-job training, his or her future earnings potential can be enhanced, as shown by the (dashed) curve E_p in the figure. Investment in on-the-job training, however, has the near-term consequence that actual earnings are below potential; thus, in terms of Figure 9.5, actual earnings (E_a) lie below E_p as long as the worker is investing. In fact, the gap between E_p and E_a equals the worker's investment costs.

Figure 9.5 is drawn to reflect the theoretical implication, noted above, that human capital investments decline with age. With each succeeding year, actual earnings become closer to potential earnings; further, because workers become less willing to invest in human capital as they age, the yearly *increases* in potential earnings become smaller and smaller. Thus, curve E_p takes on a concave shape, quickly rising above E_s but flattening later in the life cycle. Curve E_a (which is what we observe in Figures 9.3 and 9.4) takes on its concave shape for the same reasons.

The "Overtaking" Age For those who invest in on-the-job training, actual earnings start below E_s, approach it near age A^*, and continue to rise above it afterwards. Age A^* is called the *overtaking age*, and it is the age at which workers with

the same level of schooling have equivalent earnings regardless of whether they have invested in on-the-job training. The concept of an overtaking age has an interesting empirical implication.

We can observe educational levels workers possess, but we cannot observe workers' E_p or the time they have spent in on-the-job training. Thus, when we use statistical methods to analyze earnings differences across individuals, the correlation between earnings and education will be strongest at A^*, where $E_a = E_s$. Why? The correlation between schooling and earnings is weakened both before and after A^* by the presence of on-the-job training, which we cannot measure and for which we cannot therefore statistically control. Interestingly, we find that educational and earnings levels correlate most strongly at about ten years after labor market entry.[15] This finding offers support for the human-capital explanation of age-earnings profiles based on job training.

The Fanning Out of Age/Earnings Profiles

Earnings differences across workers with different educational backgrounds tend to become more pronounced as they age. This phenomenon is also consistent with what human capital theory would predict.

Investments in human capital tend to be more likely when the expected earnings differentials are greater, when the initial investment costs are lower, and when the investor has either a longer time to recoup the returns or a lower discount rate. The same can be said of people who have the ability to learn more quickly. The ability to learn rapidly shortens the training period, and fast learners probably also experience lower psychic costs (lower levels of frustration) during training.

Thus, people who have the ability to learn quickly are those most likely to seek out, and be presented by employers with, training opportunities. But who are these fast learners? They are most likely the people who, because of their abilities, were best able to reap benefits from formal schooling! Thus, human capital theory leads us to expect that workers who invested more in schooling will also invest more in postschooling job training.[16]

The tendency of the better-educated workers to invest more in job training explains why their age/earnings profiles start low, rise quickly, and keep rising after the profiles of their less-educated counterparts have leveled off. Their earnings rise more quickly because they are investing more heavily in job training,

[15]See Jacob Mincer, *Schooling, Experience, and Earnings* (New York: Columbia University Press for National Bureau of Economic Research, 1974), 57. For other evidence consistent with the human capital model summarized in Figure 9.5, see David Neumark and Paul Taubman, "Why Do Wage Profiles Slope Upward? Tests of the General Human Capital Model," *Journal of Labor Economics* 13, no. 4 (October 1995): 736–761.

[16]For studies showing that on-the-job training is positively correlated with both educational level and ability, see Joseph G. Altonji and James R. Spletzer, "Worker Characteristics, Job Characteristics, and the Receipt of On-the-Job Training," *Industrial and Labor Relations Review* 45 (October 1991): 58–79; and Joseph Hight, "Younger Worker Participation in Post-School Education and Training," *Monthly Labor Review* 121, no. 6 (June 1998): 14–21.

and they rise for a longer time for the same reason. In other words, people with the ability to learn quickly select the ultimately high-paying jobs where much learning is required and thus put their abilities to greatest advantage.

Women and the Acquisition of Human Capital

A comparison of Figures 9.3 and 9.4 discloses immediately that the earnings of women who work full-time year-round are lower than for men of equivalent age and education, and that women's earnings within each educational group rise less steeply with age. The purpose of this section is to analyze these differences in the context of human capital theory (a more complete analysis of male/female wage differentials is presented in chapter 12).

A major difference in the incentives of men and women to make human capital investments has historically been in the length of work life over which the costs of a human capital investment can be recouped. Chapters 6 and 7 clearly showed how rapidly working for pay has increased among women in recent decades, and this fact obviously should have made human capital investments more lucrative for women. Nevertheless, Table 9.2 shows it is still the case that, on average, women can be expected to work (for pay) fewer years than men. In addition, Table 9.2 indicates that within the occupations shown—all of which require the acquisition of skills—women average fewer hours of work per week than do men.

To the extent that there is a shorter expected work life for women than for men, it is caused primarily by the role women have historically played in child-rearing and household production. This traditional role, while undergoing significant change, has caused many women to drop out of the labor market for a period of time in their childbearing years. Thus, female workers often have not had the continuity of experience that their male counterparts accumulate. If this historical experience causes younger women who are making important human capital decisions to expect a discontinuity in their own labor force participation, they might understandably avoid occupations or fields of study in which their skills depreciate during the period out of the labor market.[17] Moreover, historical experience could cause employers to avoid hiring women for jobs requiring much on-the-job training—a practice that itself will reduce the returns women can expect from a human capital investment. Human capital theory, however, *also* predicts that recent changes in the labor force participation of women, especially married women of childbearing age, are causing dramatic changes in the acquisition of schooling and training by women. We turn now to a discussion of recent changes in these two areas.

[17]For a discussion of the wage losses facing women who interrupt their labor force attachment at childbirth, see Jane Waldfogel, "Understanding the 'Family Gap' in Pay for Women with Children," *Journal of Economic Perspectives* 12, no. 1 (Winter 1998): 137–156. Losses were also suffered by men who involuntarily withdrew from their careers by being drafted into military service during the Vietnam War; see Joshua D. Angrist, "Lifetime Earnings and the Vietnam Era Draft Lottery: Evidence from Social Security Administrative Records," *American Economic Review* 80 (June 1990): 313–336.

TABLE 9.2 Average Work Life and Hours of Work, by Gender

Remaining Expected Years of Paid Work at Age 25[a]*:*	*Male*	*Female*
High school graduates	33.4 (years)	27.3 (years)
Some college	34.5	29.5
College graduates	35.8	31.7
Average Weekly Hours of Paid Work for Those Working Full-Time in 2000:		
Executive, administrative, managerial workers	47.7 (hours)	43.3 (hours)
Professional specialty workers	45.8	42.1
Technicians and related support workers	43.9	40.6
Sales workers	46.6	41.8
Precision production, craft, and repair workers	43.4	41.4

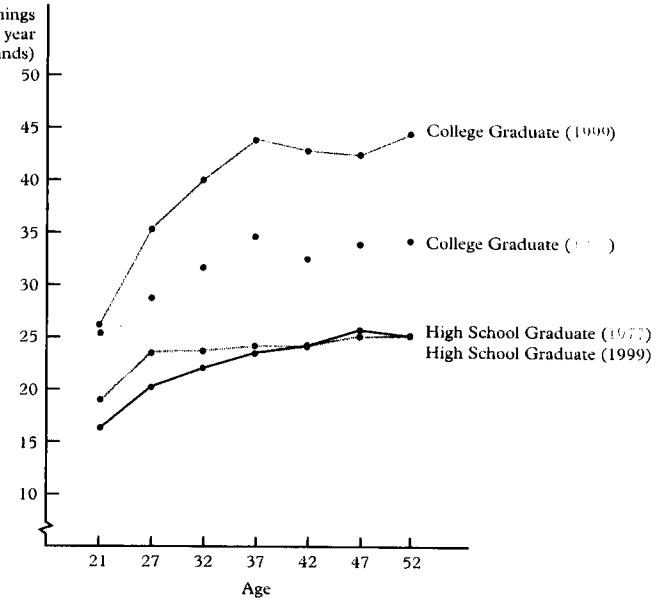
[a]Data relate to nondisabled individuals in 1994.
Sources: Anthony M. Gamboa, "The New Worklife Expectancy Tables," Vocational Econometrics, Louisville, Kentucky (1995); U.S. Bureau of Labor Statistics, *Employment and Earnings* 48 (January 2001), Table 23.

Women and Job Training There is little doubt that women receive less on-the-job training than men, although the gap is probably narrowing. The most recent survey of employer-provided training found that, during a six-month period in 1995, women reported receiving 41.5 hours of both formal and informal training, while men received 47.6 hours; differences were mainly in the area of informal training.[18] To the extent that on-the-job training causes age/earnings profiles to be concave, an explanation for the flatter age/earnings profiles of women may be rooted in their lower levels of such training.

This human capital explanation for the flatter age/earnings profiles among women does not directly address whether the lower levels of job training emanate from the employer or the employee side of the market, but both possibilities are theoretically plausible. If employers expect women workers to have shorter work

[18]H. Frazis, M. Gittleman, M. Horrigan, and M. Joyce, "Results from the 1995 Survey of Employer-Provided Training," *Monthly Labor Review* 121, no. 6 (June 1998): 3–13.

FIGURE 9.6
The Increased Concavity of Women's Age/Earnings Profiles



lives, they are less likely to provide training to them. Alternatively, if women themselves expect shorter work lives, they will be less inclined to seek out jobs requiring high levels of training. Finally, if women expect employers to bar them from occupations requiring a lot of training or experience, incentives to enter these occupations will be diminished.[19]

While human capital theory predicts that the traditional role of women in child-rearing will lead to reduced incentives for training investments, it also suggests that as this role changes, the incentives for women to acquire training will change. We should thus expect to observe a growing concavity in women's age/earnings profiles over the past decades, and Figure 9.6 indicates that this expectation is generally supported.

The darker lines in Figure 9.6 are the 1999 profiles for college and high school graduates that appeared in Figure 9.4. The lighter lines indicate the comparable

[19]Francine D. Blau and Marianne A. Ferber, "Career Plans and Expectations of Young Women and Men," *Journal of Human Resources* 26 (Fall 1991): 581–607, found that female college seniors, who expected starting salaries equal to those expected by men, expected much lower salaries later in their careers.

TABLE 9.3 **Percentages of Women among College and University Graduates, by Degree and Field of Study, 1971 and 1998**

Percentage of Women among:	*Bachelor's Degree*		*Master's Degree*	
	1971	*1998*	*1971*	*1998*
Total	43.4%	56.1%	40.1%	57.1%
Business majors	9.1	48.5	3.9	38.6
Computer science majors	13.6	26.7	10.3	29.0
Education majors	74.5	75.2	56.2	76.4
Engineering majors	0.8	18.5	1.1	19.8
English majors	66.7	66.8	61.0	66.1
Health professionals	77.1	82.1	55.9	77.7
First professional degree[a]			6.3	42.9

[a]Degrees in this category are largely doctor's degrees in law, medicine, and dentistry.
Sources: U.S. National Center for Education Statistics, *Digest of Education Statistics 1993* (1993), Tables 235, 269, 271–273, 275, 278; *Digest of Education Statistics 2000* (2001), Tables 266, 269, 274.

profiles for 1977 (adjusted to 1999 dollars using the Consumer Price Index). A visual comparison reveals that the earnings profiles for both high school and college graduates have become steeper for women in their 20s and 30s, especially among the college educated. This faster earnings growth among women at the early stages of their careers suggests that they may be receiving more on-the-job training than they did two decades ago.

Women and Formal Schooling As Table 9.1 suggested, there have been dramatic changes in the level of formal education received by women in recent years. Their fields of study have also changed markedly. These changes undoubtedly reflect the increased returns to human capital investments arising from women's increased attachment to the labor force and longer expected work lives. Table 9.3 outlines some of the magnitudes of these changes.

Women, who traditionally were less likely than men to graduate from college, now represent well over half of both bachelor's and master's graduates. There also have been dramatic shifts in the fields in which women major, most notably in the areas of business (graduate and undergraduate), law, and medicine—where women have gone from under 10 percent of all majors to roughly 40 percent or more. While still underrepresented in computer science and engineering, women have posted gains in these areas as well.[20] What the data in Table 9.3 suggest is that

[20]A study that measures gender changes in undergraduate majors differently, however, concludes that, aside from business majors, changes since the 1970s have not been dramatic. See Sarah E. Turner and William G. Bowen, "Choice of Major: The Changing (Unchanging) Gender Gap," *Industrial and Labor Relations Review* 52, no. 2 (January 1999): 289–313.

women's expected labor force attachment has grown so fast that investing in technical degrees has become more attractive over the last three decades.

IS EDUCATION A GOOD INVESTMENT?

The question whether more education would be a good investment is one that concerns both individuals and government policymakers. Individuals ask, "Will I increase my monetary and psychic income enough to justify the costs of additional education?" Governments must decide if the expected social benefits of enhanced productivity outweigh the opportunity costs of investing more social resources in the educational sector. We pointed out earlier that these questions can be answered using either the *present-value* method (an illustration of which is in Example 9.3) or the *internal rate of return* method. The latter is primarily used in the subsections that follow.

Is Education a Good Investment for Individuals?

Individuals about to make an investment in a college education are typically committing themselves to costs of at least $18,000 per year. Is there evidence that this investment pays off for the typical student? Several studies have tried to answer this question by calculating the internal rates of return to educational investments. While the methods and data used vary, these studies normally estimate benefits by calculating earnings differentials at each age from age/earnings profiles such as those in Figures 9.3 and 9.4. (*Earnings* are usually used to measure benefits because higher wages and more stable jobs are both payoffs to more education.) All such studies have analyzed only the monetary, not the psychic, costs of and returns on educational investments.

The rates of return to education typically estimated for the average American worker fall into the range of 5–12 percent (after adjusting for inflation), although they may vary across individuals with such factors as parental background, school quality, and even the level of education (as will be seen later in Example 9.4).[21] These findings are interesting because most other investments generate returns in the same range. Thus, it appears, at least at first glance, that an investment in education is about as good as an investment in stocks, bonds, or real estate. This conclusion must be qualified, however, by recognizing that there are potential biases in the estimated rates of return to education. These biases, which are of unknown size, work in opposite directions.

The Upward Bias The typical estimates of the rate of return on further schooling may overstate the gain an individual student could obtain by investing in education because they do not distinguish between the contribution that *ability* makes to higher earnings and the contribution made by *schooling*.[22] The problem is that (*a*) people who are smarter, harder-working, and more dynamic are likely to obtain more schooling, and (*b*) such people might be more productive, and hence earn higher-than-average wages, even if they did not complete more years of schooling than others. When measures of true ability are not observed or accounted for, the studies attribute *all* the earnings differentials associated with college to college itself and none to ability, even though *some* of the added

[21]See David Card, "The Causal Effect of Education on Earnings," in *Handbook of Labor Economics*, ed. Orley Ashenfelter and David Card (New York: Elsevier, 1999), pp. 1802–1863, for a comprehensive review of recent estimates of the rates of return to educational investments.

EXAMPLE 9.3

Valuing a Human Asset: The Case of the Divorcing Doctor

State divorce laws typically provide for the assets acquired during marriage to be divided in some equitable fashion. Among the assets to be divided is often the value of human capital investments made by either spouse during marriage. How these acquired human capital values are estimated can be illustrated by the following example.

Dr. Doe married right after he had acquired a license to practice as a general practitioner. Instead of opening a general (family) practice, however, Dr. Doe undertook specialized training to become a surgeon. During his training (residency) period, the income of Dr. Doe and his wife was much lower than it would have been had he been working as a general practitioner. Thus both spouses were investing, albeit to different degrees, in Dr. Doe's human capital.

Shortly after his residency was completed and he had acquired board certification as a general surgeon, Dr. Doe and his wife decided to divorce. She sued him for an equitable division of the asset value of his certification as a general surgeon. How can this asset value be estimated?

The asset value of Dr. Doe's certificate as a general surgeon is the present value of his estimated *increase in lifetime earnings* this certificate made possible. The most reasonable estimate of his increase in yearly earnings is calculated by subtracting from what the typical general surgeon earns the average earnings of general practitioners (which is an estimate of what Dr. Doe could have earned in the absence of his training as a surgeon).

In 1997, the median earnings of general surgeons were $217,000 and those of general practitioners were $132,000. Thus, assuming Dr. Doe is an "average" doctor, obtaining his certificate as a surgeon increased his earnings capacity by $85,000 per year in 1997 dollars.* Assuming a remaining work life of 25 years and a real interest rate (which takes account of what inflation will do to the earnings differential) of 2 percent, the present value of the asset Dr. Doe acquired as the result of his surgical training comes to $1,658,000. (It would then be up to the court to divide this asset equitably between the two divorcing spouses.)

*Earnings data are from U.S. Department of Labor, Bureau of Labor Statistics, *Occupational Outlook Handbook, 2000–01 Edition* (Government Printing Office, 2000), p. 195. The formula used to calculate present value is the one given in footnote 2 of this chapter, where $X = \$85{,}000$, $r = 0.02$, and $n = 25$.

[22]If investments in education have a rate of return comparable to alternative investments people could make, they will raise wages more than overall wealth—which (recalling chapters 6 and 7) should cause hours of work to rise. Thus, some of the increased earnings from more education could be associated with reduced leisure, which would constitute another source of upward bias. This point is made by C. M. Lindsay, "Measuring Human Capital Returns," *Journal of Political Economy* 79 (November/December 1971): 1195–1215.

earnings college graduates typically receive may have been received by an equally able high school graduate who did not attend college.

Recent studies that attempt to control for *ability bias* in estimating rates of return to schooling have utilized several strategies. Some have estimated the separate effects of schooling and aptitude-test scores on earnings. Others have estimated how much the earnings of people are affected when a random event, not ability, affects their level of schooling. Still others analyze differences among family members, who have the same family background, and even among identical twins, who share the same inherited characteristics. These studies generally conclude that the problem of ability bias in conventional estimates is small.[23]

The Downward Bias There are three reasons to believe that conventionally estimated rates of return to educational investments may be downward biased. First, some benefits of college attendance are not necessarily reflected in higher productivity, but rather in an increased ability to understand and appreciate the behavioral, historical, and philosophical foundations of human existence. Second, most rate-of-return studies fail to include employee benefits; they measure money earnings, not total compensation. Because employee benefits as a percentage of total compensation tend to rise as money earnings rise, ignoring benefits tends to create a downward bias in the estimation of rates of return to education.

Third, some of the job-related rewards of college are captured in the form of psychic or nonmonetary benefits. Jobs in the executive or professional occupations are probably more interesting and pleasant than the more routine jobs typically available to people with less education. While executive and professional jobs do pay more than others, the total benefits of these jobs may be understated when only earnings differences are analyzed.

Selection Bias A third source of bias in the standard estimates of rates of return on education arises from the *selectivity* problem. Briefly put, a person who decides to go to college and become a manager, rather than terminate schooling with high school and become a mechanic, may do so in part because he or she has very little mechanical aptitude; thus, becoming a mechanic might yield this person *less* income than is earned by those who actually become mechanics. Likewise, those who become mechanics rather than go to college and become managers might not have aptitudes that would allow them to earn much as managers.

To understand the potential selectivity biases in the conventionally calculated returns to a college education, keep in mind that these returns are usually based on differences between the actual earnings of college and high school graduates. For people who graduated from college, the rate-of-return calculation thus assumes that, in the absence of a college education, their earnings would have been equal to those of the average high school graduate. If, instead, their earnings would have been *less* than those of the high school graduate, the conventional calculation *understates* their gains from a college investment.

[23]See Card, "The Causal Effect of Education on Earnings," for a comprehensive review of studies that attempt to correct for ability bias.

Does the conventionally calculated rate of return to college indicate the yield mechanics would have obtained had they gone to college to become managers? It does not, because this calculation assumes that they would have been able to earn as much as the average manager. Thus, while the conventional calculations underestimate the returns for those who actually go to college, they overestimate the returns that would have been received by those who decided not to go.

Fortunately, the selectivity bias in estimated rates of return to schooling appears to be small.[24] Nevertheless, raising the selectivity issue does serve to remind us that the principle of comparative advantage is potentially important in making choices about schooling and occupations.

Is Education a Good Social Investment?

The issue of education as a social investment has been of heightened interest in the United States during the past decade, especially because of three related developments. First, product markets have become more global, increasing the elasticity of both product and labor demand. As a result, American workers are now facing more competition from workers in other countries. Second, the growing availability of high-technology capital has created new products and production systems that may require workers to have greater cognitive skills and to be more adaptable, efficient learners.[25] Third, American elementary and secondary school students have scored poorly relative to students elsewhere in language proficiency, scientific knowledge, and (especially) mathematical skills.[26]

The combination of these three developments has led to concern about the productivity of America's future workforce, relative to workers elsewhere, and to a series of questions about our educational system. Are we devoting enough resources to educating our current and future workforce? Should the resources we devote to education be reallocated in some way? Should we demand more of students in elementary and secondary schools?

[24]The discussion in this subsection is based on Robert J. Willis and Sherwin Rosen, "Education and Self-Selection," *Journal of Political Economy* 87 (October 1979): S7–S36. For discussion of how selectivity based on discount rate affects the measured rates of return to education, see David Card, "Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems," *Econometrica* 69, no. 5 (September 2001): 1127–1160.

[25]For recent studies on the earnings of those with greater cognitive skills, see Richard J. Murnane, John B. Willett, and Frank Levy, "The Growing Importance of Cognitive Skills in Wage Determination," *Review of Economics and Statistics* 77, no. 2 (May 1995): 251–266; and John Cawley, James Heckman, and Edward Vytlacil, "Understanding the Role of Cognitive Ability in Accounting for the Recent Rise in the Economic Return to Education," in *Meritocracy and Economic Inequality*, ed. Kenneth Arrow, Samuel Bowles, and Steven Durlauf (Princeton: Princeton University Press, 2000).

[26]National Center for Education Statistics, *The Condition of Education 1998* (NCES 98-013, October 1998), p. 76.

TABLE 9.4 **International Comparisons of Schooling, 1997–1998**

Country	Expenditures per Pupil, Secondary Level (in U.S. $)	% of Those, Ages 25–44, Who Have Completed: Secondary School	% of Those, Ages 25–44, Who Have Completed: University
France	6,564	75%	15%
Germany	6,149	88	14
Japan	5,917	94	24
United Kingdom	4,609	63	17
United States	7,230	88	28

Source: National Center for Education Statistics, *The Condition of Education 2001* (NCES 2001-072), pp. 52, 178.

The Social Cost As Table 9.4 indicates, the United States devotes at least as many resources to elementary and secondary education as do other developed countries. In terms of dollars per student, the United States ranks first among the five countries shown, and in terms of the percentages of the population completing secondary school, it ranks in the upper middle. Moreover, the percentage of the population completing college is higher than in every comparison country. Thus, with about 7 percent of its gross domestic product devoted to the direct costs of formal education (elementary, secondary, and college), and with forgone earnings (especially of college students) adding another 3 or 4 percent, the United States devotes a substantial fraction of its available resources to formal schooling.[27] Whether this huge social investment pays off and whether its returns can be enhanced are important questions. In beginning to answer them, we must try to understand how education and productivity are related.

The Social Benefit The view that increased educational investments increase worker productivity is a natural outgrowth of the observation that such investments enhance the earnings of individuals who undertake them. However, this view that the educational investment is what *causes* productivity to rise is not the only possible interpretation for the positive relationship between earnings and schooling. Another interpretation is that the educational system provides society with a screening device that sorts people by their (predetermined) ability. As discussed below, this alternative view, in its extreme form, sees the educational system as a means of *finding out* who is productive, not of enhancing worker productivity.

[27]The forgone earnings of high school and college students have been estimated to equal 60 percent of the *direct* cost outlays at those schooling levels. See Theodore Schultz, *The Economic Value of Education* (New York: Columbia University Press, 1963).

The Signaling Model An employer seeking to hire workers is never completely sure of the actual productivity of any applicant, and in many cases the employer may remain unsure long after an employee is hired. What an employer *can* observe are certain indicators that firms believe to be correlated with productivity: age, experience, education, and other personal characteristics. Some indicators, such as age, are immutable. Others, like formal education, can be *acquired* by workers. Indicators that can be acquired by individuals can be called *signals;* our analysis here will focus on the signaling aspect of formal education.

Let us suppose that firms wanting to hire new employees for particular jobs know that there are two groups of applicants that exist in roughly equal proportions. One group has a productivity of 2, let us say, and the other has a productivity of 1. Further, suppose that these productivity levels cannot be changed by education and that employers cannot readily distinguish which applicants are from which group. If they were unable to make such distinctions, firms would be forced to assume that all applicants are "average"; that is, they would have to assume that each had a productivity of 1.5 (and would offer them wages of up to 1.5).

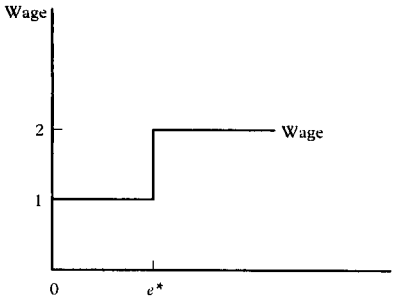
While workers in this simple example would be receiving what they were worth on *average*, any firm that could devise a way to distinguish between the two groups (at little or no cost) could enhance its profits. When wages equal 1.5, workers with productivities equal to 1 are receiving more than they are worth. If these applicants could be discovered, and either rejected or placed into lower-paying jobs, the firm could obviously increase its profits. It turns out that using educational attainment as a hiring standard can increase profits even if education does not enhance productivity. We can illustrate this with a simple example.

An Illustration of Signaling To illustrate the use of educational signaling, suppose that employers come to believe that applicants with at least e^* years of education beyond high school are the ones with productivity 2, and that those with less than e^* are in the lower-productivity group. With this belief, workers with less than e^* years would be rejected for any job paying a wage above 1, while those with at least e^* would find that competition among employers drives their wages up to 2. This simple wage structure is illustrated in Figure 9.7.[28] If additional schooling does not enhance productivity, can requiring the signal of e^* really distinguish between the two groups of applicants? The answer is yes *if the costs to the worker of acquiring the added schooling are negatively related to his or her on-the-job productivity.*

If workers with at least e^* years of education beyond high school can obtain a wage of 2, while those with less can earn a wage of only 1, all workers would want to acquire the signal of e^* if it were costless for them to do so. As we argued earlier, however, schooling costs are both large and different for different individuals. In particular, the psychic costs of education are probably inversely related to ability: those who learn easily can acquire the educational signal (of e^* in this case)

[28]This analysis is based on Michael Spence, "Job Market Signaling," *Quarterly Journal of Economics* 87 (August 1973): 205–221.

FIGURE 9.7
The Benefits to Workers of Educational Signaling



more cheaply than others. *If*—and this is critical—those who have *lower* costs of acquiring education are *also* more productive on the job, then requiring educational signals can be useful for employers.

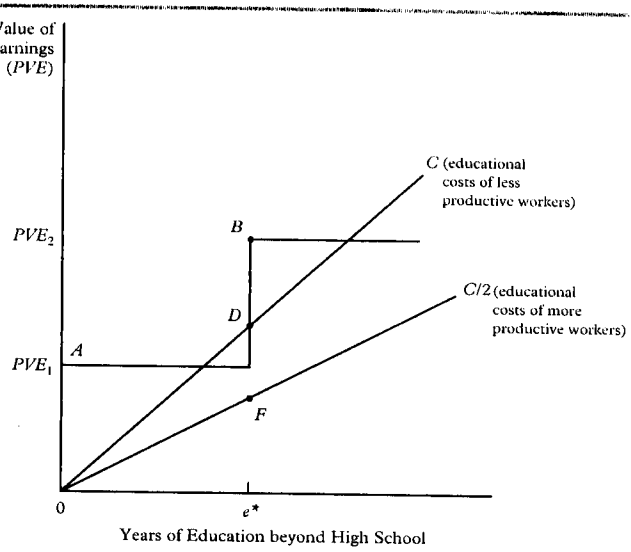
To understand the role of costs in signaling, refer to Figure 9.8, in which the reward structure from Figure 9.7 is expressed in terms of the present value of lifetime earnings (at a wage of 1 their discounted lifetime earnings sum to PVE_1, while at a wage of 2 they sum to PVE_2). Now assume that each year of education costs C for those with less productivity and $C/2$ for those with greater productivity.

Workers will choose the level of schooling at which the difference between their discounted lifetime earnings and their total educational costs is maximized. For those with yearly educational costs of C, the difference between lifetime earnings and total educational costs is maximized at zero years of education beyond high school. For these workers, the net benefit of an additional e^* years (distance BD) is less than the net benefit of zero additional years (distance $A0$). For them, the benefits of acquiring the signal of e^* years is not worth the added costs.

For those whose costs are $C/2$, it can be seen that the net benefits of investing in e^* (distance BF) exceed the net benefits of other schooling choices. Therefore, only those with costs of $C/2$—the workers with productivities of 2—find it advantageous to acquire e^* years of schooling. In this example, then, schooling attainment signals productivity.

Some Cautions about Signaling Our simple example demonstrated how education could have value even if it did not directly enhance worker productivity. It is necessary to stress, though, that for education to have signaling value in this case, on-the-job productivity and the costs of education must be *negatively* related. If the higher costs reflected along line C were associated with lower cognitive ability or a distaste for learning, then it is conceivable that these costs could be indicative of lower productivity. If, however, those with costs along C have higher costs only because of lower family wealth (and therefore smaller contributions from others

FIGURE 9.8
The Lifetime Benefits and Costs of Educational Signaling

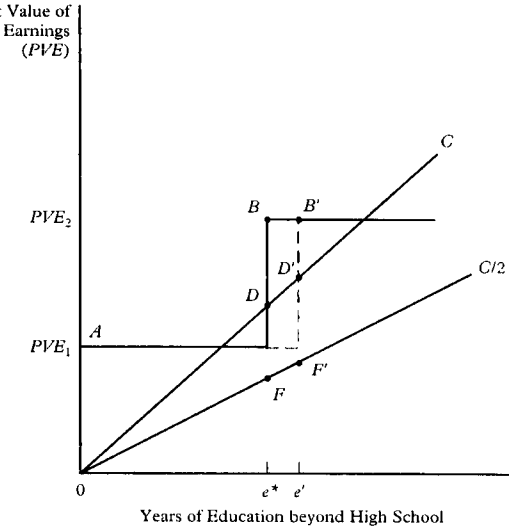


toward their schooling costs), then they may be no less productive on the job than those along line $C/2$. In this latter case, signaling would fail, because it would only indicate those with low family wealth, not lower productivity.

Even when educational signaling is a useful way to predict future productivity, there is an *optimum* signal beyond which society would not find it desirable to go. Suppose, for example, that employers now requiring e^* years for entry into jobs paying a wage of 2 were to raise their hiring standards to e' years, as shown in Figure 9.9. Those with educational costs along C would still find it in their best interests to remain at zero years of schooling beyond high school, and those with costs along $C/2$ would find it profitable to invest in the required signal of e' (because distance $B'F'$ is greater than $A0$). Requiring more schooling of those who are selected for high-wage jobs, however, is more costly for those workers (and thus for society as a whole). While the new required signal would distinguish between the two groups of workers, it would do so at increased (and unnecessary) costs to individuals, which cannot be socially optimal.

It clearly can be beneficial for individuals to invest in educational signals, but if schooling *only* has signaling value, is it a worthy investment for society to make? If the only purpose of schools is to provide signals, why encourage investments in the expansion or qualitative upgrading of schooling? If forty years ago being a high school graduate signaled above-average intelligence and work discipline, why

FIGURE 9.9
Requiring a Greater Signal May Have Costs without Benefits



incur the enormous costs of expanding college attendance only to find out that now these qualities are signaled by having a bachelor's degree? The issue is of even more importance in less-developed countries, where mistakes in allocating extremely scarce capital resources could be disastrous (see Example 9.4). Before attempting to decide if schooling has social value when all it produces are signals, let's first turn to the more basic question of whether we can figure out if schooling enhances, or merely signals, human capital.

Signaling or Human Capital? Direct evidence on the role schooling plays in society is difficult to obtain. Advocates of the signaling viewpoint, for example, might point to the higher rates of return for college graduates than for college dropouts as evidence that schooling is a signaling device.[29] They argue that what is learned in school is proportional to the time spent there and that an added bonus (rate of return) just for a diploma is proof of the signaling hypothesis. Advocates of the view that schooling enhances human capital would counter that those who

[29]Dropouts naturally have lower earnings than graduates, but because they have also invested less, it is not clear that their *rates of return* should be lower. For further discussion and evidence, see David A. Jaeger and Marianne E. Page, "Degrees Matter: New Evidence on Sheepskin Effects in the Returns to Education," *Review of Economics and Statistics* 78, no. 4 (November 1996): 733–740. Thomas J. Kane and Cecilia Elena Rouse, "Comment on W. Norton Grubb: 'The Varied Economic Returns to Postsecondary Education: New Evidence from the Class of 1972'," *Journal of Human Resources* 30, no. 1 (Winter 1995): 205–221, calls into question the benefits of graduation independent of the number of *credits* taken.

EXAMPLE 9.4

The Socially Optimal Level of Educational Investment

In addition to asking whether schooling is a good social investment, we could also ask: What is the socially optimal *level* of schooling? The general principle guiding our answer to this question is that society should increase or reduce its educational investments until the marginal rate of return (to society) equals the marginal rate of return on other forms of capital investment (investment in physical capital, for example).

The rationale for the above principle is that if society has some funds it wants to invest, it will desire to invest them in projects yielding the highest rates of return. If an investment in physical capital yields a 20 percent rate of return and the same funds invested in schooling yield (all things considered) only a 10 percent return, society will clearly prefer to invest in physical capital. As long as the two rates of return differ, society could be made better off by reducing its investments in low-yield projects and increasing them in those with higher rates of return.

The text has discussed many of the difficulties and biases inherent in estimating rates of return to schooling. However, the general principle of equating the rates of social return on all forms of investments is still a useful one to consider. It suggests, for example, that capital-poor countries should invest in additional schooling only if the returns are very high—higher, in all probability, than the rates of return required for optimality in more-capital-rich countries.

Indeed, the rates of return to both secondary schooling and higher education appear to be generally higher in less-developed countries than in developed countries. One review estimated that the rate of return on secondary schooling investment was 10 percent for a developed country (on average), while for a less-developed country it was 13 to 15 percent. Comparable rates of return on investments in higher education were 8 percent and 11 percent, respectively.

Data from: George Psacharopoulos, "Returns to Investment in Education: A Global Update," *World Development* 22, no. 9 (1994): 1325–1343.

graduate after four years have learned more than four times what the freshman dropout has learned. They argue that dropouts are more likely to be poorer students—the ones who overestimated their returns on schooling and quit when they discovered their mistake. Thus, their relatively low rate of return is associated not with their dropping out but with their *reason* for dropping out.

To take another example, proponents of the human capital view could argue that the fact that earnings differentials between college and high school graduates grow with age supports their view. If schooling were just a signaling device, employers would rely on it *initially*, but as they accumulated direct information from experience with their employees, schooling would play a smaller role in determining earnings. Signaling advocates could counter that continued growth in earnings differentials only illustrates that educational attainment was a *successful* signaling device.[30]

[30]Attempts to distinguish between the two views include Joseph Altonji, "The Effects of High School Curriculum on Education and Labor Market Outcomes," *Journal of Human Resources* 30, no. 3 (Summer 1995): 409–438; Andrew Weiss, "Human Capital vs. Signaling Explanations of Wages," *Journal of Economic Perspectives* 9, no. 4 (Fall 1995): 133–154; Wim Groot and Hessel Oosterbeek, "Earnings Effects of Different Components of Schooling: Human Capital versus Screening," *Review of Economics and Statistics* 76, no. 2 (May 1994): 317–321; and Kelly Bedard, "Human Capital versus Signaling Models: University Access and High School Dropouts," *Journal of Political Economy* 109, no. 4 (August 2001): 749–775.

School Quality Given the difficulty of generating predictions of labor market outcomes that can directly distinguish the signaling from the human capital hypothesis, you may wonder if there are other ways to resolve the debate. A research strategy with some potential grows out of issues related to school quality.

As mentioned earlier, concerns have been raised about the cognitive achievement of American students. If schooling performs primarily a signaling function, by helping to *discover* people's cognitive abilities, we would not necessarily look to the educational system to remedy the problem of low cognitive achievement. However, if schooling can enhance the kinds of skills that pay off in the labor market, then increased investment in the quality of the nation's schools could be warranted.

Proponents of the signaling and human capital views of education can agree that people of higher cognitive ability are likely to be more productive; where they disagree is on whether better schools can enhance worker productivity by improving cognitive skills. Advocates of the signaling viewpoint cite a substantial literature suggesting it is difficut to demonstrate a relationship between schooling expenditures and student performance on *tests of cognitive skill*.[31] Advocates of the human capital view, however, find support in studies of *earnings* and school quality. These studies generally indicate that students attending higher-quality schools (that is, ones with greater resources per student) have higher subsequent earnings, other things equal.[32]

Clearly, assessments of the social returns to schooling that examine the role of school quality have so far yielded somewhat ambiguous results. Better schools may enhance labor market earnings, but evidence that they enhance measured cognitive abilities is relatively weak. One possibility, of course, is that better schools enhance productivity by teaching useful problem-solving skills or better work habits—characteristics that may be valued in the labor market but not captured especially well by standardized tests of cognitive achievement. Another possibility, however, is that better schools give students better information about their own interests and abilities, thus helping them to make more successful career choices. Some important questions, then, remain unanswered.

Does the Debate Matter? In the end, perhaps the debate between advocates of the signaling and human capital views of schooling is not terribly important. The fact is that schooling investments offer *individuals* monetary rates of return that are comparable to those received from other forms of investment. For individuals to recoup their human capital investment costs requires willingness on the part of employers to pay higher wages to people with more schooling; and for

[31]Eric A. Hanushek and Dennis D. Kimko, "Schooling, Labor Force Quality, and the Growth of Nations," *American Economic Review* 90, no. 5 (December 2000): 1184–1208. For a dissenting view, see Alan B. Krueger and Diane M. Whitmore, "Would Smaller Classes Help Close the Black-White Achievement Gap?" working paper no. 451, Industrial Relations Section, Princeton University, March 2001.

[32]For summaries of the lively debate on the effects of school quality on both cognitive skills and earnings, see the following symposium issues: *Federal Reserve Bank of New York Economic Policy Review* 4, no. 1 (March 1998); *Journal of Economic Perspectives* 10, no. 4 (Fall 1996); and *Review of Economics and Statistics* 78, no. 4 (November 1996).

employers to be willing to do this, schools must be providing a service that they could not perform more cheaply themselves.

For example, we argued earlier that to profit from an investment of $100,000 in a college education, college graduates must be paid at least $3,652 more per year than they would have received otherwise. Naturally, this requires that they find employers who are willing to pay them the higher yearly wage. If college merely helps *reveal* who is more productive, employers who believe they could find this out for less than a yearly cost of $3,652 per worker would clearly have incentives to adopt their own methods of screening workers.

The fact that employers continue to emphasize (and pay for) educational requirements in the establishment of hiring standards suggests one of two things. Either more education *does* enhance worker productivity, or it is a *less expensive* screening tool than any other that firms could use. In either case, the fact that employers are willing to pay a high price for an educated workforce seems to suggest that education produces social benefits.[33]

Is Public Sector Training a Good Social Investment?

Policymakers should also ask whether government job training programs can be justified based on their returns. During the past four decades, the federal government has funded a variety of these programs that primarily targeted disadvantaged men, women, and youth. Some programs have served trainees who applied voluntarily, and others have been mandatory programs for public assistance recipients (who stood to lose benefits if they did not enroll). Some of these programs have provided relatively inexpensive help in searching for work, while others have directly provided work experience or (in the case of the Job Corps) comprehensive services associated with living away from home. Over these decades, however, roughly half of those enrolled received classroom training at vocational schools or community colleges, and another 15 percent received in-plant training. The per-student costs of these latter two types of programs have been in the range of $3,500 to $7,000 (in 2000 dollars).[34]

Evaluating these programs requires comparing their costs to an estimate of the present value of their benefits, which are measured by calculating the increase in wages made possible by the training program. Calculating the benefits involves estimating what trainees would have earned in the absence of training, and there are several thorny issues the researcher must successfully confront. Nevertheless, summaries of credible studies done to date have concluded that adult women are the only group among the disadvantaged that clearly benefits from these training programs; adult men and youth show no consistent earnings increases across studies. Moreover,

[33]Kevin Lang, "Does the Human Capital/Educational Sorting Debate Matter for Development Policy?" *American Economic Review* 84, no. 1 (March 1994): 353–358, comes to a similar conclusion through a more formal argument.

[34]Robert J. LaLonde, "The Promise of Public Sector–Sponsored Training Programs," *Journal of Economic Perspectives* 9, no. 2 (Spring 1995): 149–168, gives a brief history of federally sponsored training programs and summarizes several issues relevant to evaluating their efficacy.

the average increase in earnings for women in voluntary training programs is roughly $1,500 per year, while it is less than half that for the mandatory training associated with welfare programs.[35] Were these increases large enough to justify program costs?

The programs had direct costs of $3,500 to $7,000 per trainee, but they also had opportunity costs in the form of forgone output. The typical trainee was in her program for 16 weeks, and while many of the trainees had been on welfare prior to training, the opportunity costs of their time surely were not zero. Recall from chapter 7 that a person can be productive in the home as well as the workplace. If we place a value on time at home equal to $20,000 per year (see Example 7.3 in chapter 7), spending one-third of a year in training had opportunity costs of roughly $6,700. Thus, the total costs of training were probably in the range of $10,000 to $14,000 per woman.

If benefits of $1,500 per year were received annually for 20 years after *voluntary* training, and if the appropriate discount rate is 2 percent, the present value of benefits comes to $24,500. Benefits of this magnitude are clearly in excess of costs. Indeed, the present value of benefits for voluntary training would still be in excess of $14,000 even if the yearly earnings increases lasted for just more than 10 years. The returns to *mandatory* training for women, as noted above, are less than half of those for voluntary training, so even if benefits were to last for 20 years, they are not too likely to cover costs.[36]

[35]Daniel Friendlander, David H. Greenberg, and Philip K. Robins, "Evaluating Government Training Programs for the Economically Disadvantaged," *Journal of Economic Literature* 35, no. 4 (December 1997): 1809–1855, and Robert LaLonde, "The Promise of Public Sector–Sponsored Training Programs," Table 1.

[36]Paul Lengermann, "How Long Do the Benefits of Training Last? Evidence of Long Term Effects Across Current and Previous Employers," *Research in Labor Economics* 18 (1999): 439–461, found that the gains from formal and company training last at least nine years. For a discussion of the social returns to investments by the Job Corps, see Alan B. Krueger, "Economic Scene: A Study Backs Up What George Forman Already Said, the Job Corps Works," *New York Times* (March 30, 2000), p. C2. For reference to studies of vocational education, see Paul Ryan, "The School-to-Work Transition: A Cross-National Perspective," *Journal of Economic Literature* 29, no. 1 (March 2001): 34–92.

REVIEW QUESTIONS

1. Women receive lower wages, on average, than men of equal age. What concepts of human capital help to explain this phenomenon? Explain. Why does the discrepancy between earnings for men and women grow with age?
2. "The vigorous pursuit by a society of tax policies that tend to equalize wages across skill groups will frustrate the goal of optimum resource allocation." Comment.
3. A few years ago, a prominent medical college inadvertently accepted more applicants than it could accommodate in its first-year class. Not wanting to arbitrarily delay the entrance date of the students admitted, it offered them one year of free tuition if they would delay their medical studies by one year. Discuss the factors entering into a student's assessment of whether he or she should take this offer.

4. When Plant X closed, Employer Y (which offers no training to its workers) hired many of X's employees after they had completed a lengthy, full-time retraining program offered by a local agency. The city's Equal Opportunity Commission noticed that the workers Employer Y hired from X were all young, and it launched an age-discrimination investigation. During this investigation, Employer Y claimed that it hired *all* of the applicants from X who had successfully completed the retraining program, without regard to age. From what you know of human capital theory, does Y's claim sound credible? Explain.
5. Why do those who argue that more education "signals" greater ability believe that the most able people will obtain the most education?
6. Suppose that the government, in an effort to upgrade the quality of mechanics, promulgates legislation requiring all new mechanics to take three years of post–high school training and to pass a competency test. Those who are currently mechanics will not be subjected to these requirements. What are the likely labor market effects of this legislation? Which labor and consumer groups would gain and which would lose?
7. In many countries higher education is heavily subsidized by the government (that is, university students do not bear the full cost of their college education). While there may be good reasons for heavily subsidizing university education, there are also some dangers in it. Using human capital theory, explain what these dangers are.
8. Many crimes against property (burglary, for example) can be thought of as acts that have immediate gains but run the risk of long-run costs. If imprisoned, the criminal loses income from both criminal and noncriminal activities. Using the framework for occupational choice in the long run, analyze what kinds of people are most likely to engage in criminal activities. What can society do to reduce crime?

PROBLEMS

1. Becky works in sales but is considering quitting work for two years to earn an MBA. Her current job pays $40,000 per year (after taxes), but she could earn $55,000 per year (after taxes) if she had a master's degree in business administration. Tuition is $10,000 per year and the cost of an apartment near campus is equal to the $10,000 per year she is currently paying. Becky's discount rate is 6 percent per year. She just turned 48 and plans to retire when she turns 60, whether or not she gets her MBA. Based on this information, should she go to school to earn her MBA? Explain carefully.
2. (Appendix). Suppose that the supply curve for optometrists is given by $L_S = -6 + 0.6W$, while the demand curve is given by $L_D = 50 - W$, where W = annual earnings in thousands of dollars per year and L = thousands of optometrists.
   a. Find the equilibrium wage and employment levels.
   b. Now suppose that the demand for optometrists increases and the new demand curve is $L_{D'} = 66 - W$. Assume that this market is subject to cobwebs because it takes about three years to produce people who specialize in optometry. While this adjustment is taking place, the short-run supply of optometrists is fixed. Calculate the wage and employment levels in each of the first three rounds and find the new long-run equilibrium. Draw a graph to show these events.

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APPENDIX 9A

A "Cobweb" Model of Labor Market Adjustment

The adjustment of college enrollments to changes in the returns to education is not always smooth or rapid, particularly in special fields, like engineering and law, that are highly technical. The problem is that if engineering wages (say) were to go up suddenly in a given year, the supply of graduate engineers would not be affected until three or four years later (owing to the time it takes to learn the field). Likewise, if engineering wages were to fall, those students enrolled in an engineering curriculum would understandably be reluctant to immediately leave the field. They have already invested a lot of time and effort and may prefer to take chances in engineering rather than devote more time and money to learning a new field.

The failure of supply to respond immediately to changed market conditions can cause *boom-and-bust cycles* in the market for highly technical workers. If educational planners in government or the private sector are unaware of these cycles, they may seek to stimulate or reduce enrollments at times when they should be doing exactly the opposite, as illustrated below.

AN EXAMPLE OF "COBWEB" ADJUSTMENTS

Suppose the market for engineers is in equilibrium, where the wage is W_0 and the number of engineers is N_0 (see Figure 9A.1). Let us now assume that the demand curve for engineers shifts from D_0 to D_1. Initially, this increase in the demand for engineers does *not* induce the supply of engineers to increase beyond N_0, because it takes a long time to become an engineer once one has decided to do so. Thus, while the increased demand for engineers causes more people to decide to enter the field, the number available for employment *at the moment* is N_0. These N_0 engineers, therefore, can *currently* obtain a wage of W_1 (in effect, there is a vertical supply curve, at N_0, for a few years until the supply of engineering graduates is increased).