

AN ABSTRACT OF THE THESIS OF

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Title: Toward a New Methodology for Estimating the Marginal Social Rate of Return to Public Investments in Higher Education

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The United States invests tens of billions of dollars in higher education each year. This had led many researchers to estimate the marginal and average rates of return to these expenditures. Past works, however, have been partial in scope. That is, they have counted only the benefits of higher education which result from the increased earnings of college graduates over people with only a high school diploma. Additional benefits, such as lower consumer prices which result from a more productive work force, have not been considered previously and empirically estimated.

The purpose of the present study was to use the techniques of applied welfare analysis to develop a new approach to estimating the marginal social rate of return to investments in higher education. The annual economic benefits to society from increased levels of public support for higher education are estimated by changes in areas of consumer and producer surplus associated with the general equilibrium supply and demand curves for college educated labor. These benefits are then equated with the increased expenditures using a

standard discount formula, and a marginal social rate of return is calculated.

Data for this study come from the Bureau of the Census and the National Center for Educational Statistics. The supply and demand curves for the labor of college graduates are estimated by ordinary least squares regression treating each state as a separate labor market.

Our analysis suggests that further increases in the level of public expenditures for higher education may not be justified using cost benefit analysis techniques. The weakness of the statistical properties associated with our empirical results, however, indicates considerable additional research is necessary prior to making a policy recommendation on the issue.

Toward a New Methodology for Estimating  
The Marginal Social Rate of Return  
to Public Investments in Higher Education

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TOWARD A NEW METHODOLOGY FOR ESTIMATING  
THE MARGINAL SOCIAL RATE OF RETURN  
TO PUBLIC INVESTMENTS IN HIGHER EDUCATION

CHAPTER I

INTRODUCTION

1.1 Objective and Justification

Over the last three decades numerous studies have analyzed the private and social rates of return to investments in education. Conceptually, such calculations are straightforward. Using a standard rate of return formula (see equation 1.1) one first subtracts the costs from the appropriate returns occurring in each time period under consideration. The rate of return is then defined as the discount rate which equates the sum of these values with zero. In practice, however, the application of this technique is not so simple. Serious problems arise when we try to measure the returns to investments in education; this is particularly true when the investing agent is the collective whole acting through government. Thus, despite the abundance of work already published, there is still much debate regarding what society receives for its investments in education.

The present study seeks to extend the current body of knowledge by examining one aspect of the subject; specifically, our objective is to estimate the marginal social rate of return to public expenditures for higher education.

This research is important for two reasons. First, decision makers in the public sector are having to operate with fewer

resources than in the past. This trend will likely continue for the foreseeable future. As resources dwindle so competition increases for them from alternative uses. If public decisionmakers are to make intelligent allocation decisions some idea as to each alternative's payoff is needed. Second, there are justifiable grounds on which to question the social rates of return to investments in higher education published thus far. Past studies, by their own admission, have been very partial in scope.

One use for society's resources is the education of people, or as is common usage in the literature, investments in "human capital." A few statistics will illustrate the scope of American education in general and higher education in particular. In the fall of 1979 nearly three out of every ten Americans were directly involved in the educational process (N.C.E.S., 1980).<sup>1/</sup> Our nation's 2871 colleges and universities employed an instructional staff of 820,000 to teach 11.5 million students (N.C.E.S., 1980). Nor does the demand for college training appear to be diminishing. Of the people currently under age 18, 45 percent will enroll in a degree-credit program at an institution of higher education (N.C.E.S., 1980). Twenty-three percent of the population now in their late teens will earn a bachelors degree, eight percent a masters, and one percent a doctorate (N.C.E.S., 1980). If viewed in dollar terms, the statistics are just as impressive. During the 1978-79 school year total expenditures for education in the U.S. amounted to 152 billion dollars (N.C.E.S., 1980). Fifty-four

billion of this was spent on higher education of which 9.4 billion represented federal grants (N.C.E.S., 1980). In 1979-80, total expenditures climbed to 166 billion dollars or 7 percent of the gross national product (N.C.E.S., 1980).

Clearly, higher education employs a great deal of our nation's resources. The question before us is what do we as a society realize from this investment? Also, at the college level are we now spending too much, too little, or the correct amount improving and maintaining our human capital stock relative to other possible public investments?

The work of past researchers suggests that we may have over-invested in higher education. Since the next chapter reviews the literature to date, the findings of other researchers will not be detailed here. For present purposes, it will suffice to state that many reported estimates of the social rate of return to investments in higher education fall around 10 and 11 percent. How does this compare to returns reported on alternative uses? Mansfield (1965) has calculated social rates of return to investments in research and development in the chemical and petroleum industries at 30 and 40 percent, respectively. Minasian (1969) puts the figure for the chemical industry at 50 percent. Evenson, Waggon and Ruttan (1979) have estimated returns between 45 and 130 percent to society on investments in agriculture. Becker (1964) reports a 12 percent social rate of return to investments in physical capital. Thus, evidence exists to suggest society may be better off allocating to

other uses some of the resources now employed in higher education (i.e., assuming society's investment funds are limited).

As stated above, however, past studies which have estimated the marginal social rate of return to investments in higher education have been very partial in scope. A brief examination of their methodology reveals why. Exploiting data from various sources, previous researchers have calculated both private and social rates of return ( $r$ ) to investments in higher education using some variation of the formula:

$$0 = \sum_{i=1}^n \frac{B_i - C_i}{(1+r)^i} \quad (1.1)$$

where:

- $B_i$  = the benefits realized in time period  $i$  from a college degree;
- $C_i$  = the costs in time period  $i$  of obtaining a college degree;
- $r$  = the marginal rate of return to investment in a college education (i.e., that discount rate which sets the right-hand side of equation 1.2 equal to zero);
- $n$  = the number of time periods from the start of college training to the end of the individual's working lifetime.

Private costs have been defined as the sum of foregone earnings while in school, tuition, and other school related expenses (e.g., books, travel, supplies, etc.). Social costs have been derived by adding to this figure any additional expenses incurred by society (e.g., teacher salaries, financial aid, depreciation on capital,

etc.). Benefits, on the other hand, have been defined as the additional average annual earnings of people with a college degree over those with only a high school diploma, regardless of whether the focus has been on the individual (i.e., the marginal private rate of return) or society (i.e., the marginal social rate of return). Not surprisingly, previous researchers have unanimously reported that society receives less from investments in higher education than individuals do. Given their approach, this result is predetermined because benefits are measured the same regardless of whether one is estimating the private or social rate of return while costs are, by definition, larger when the focus is on society (in fact, private costs are treated as a component of social expenditures).

While it has long been recognized that college graduates average substantially higher earnings than people who have only completed high school (Houthakker, 1959 and Miller, 1960), there are other benefits that a college education produces. These include many spillover economic returns - benefits that accrue to people other than the degree holder. Many firms, for example, benefit from reduced training costs and an efficient system for screening potential employees. Society as a whole gains from increased scientific and technological breakthroughs as well as lower retraining costs for displaced workers. If increased numbers of degree holders lead to lower prices for the products of educated labor, then consumers also gain. On the other hand, if these additional college graduates merely take over positions now occupied by non-degree holders, then society loses since it is paying more than it must to

get a job done. Clearly, then, there are many economic benefits that should be considered (other than just the increased earnings of college graduates over those with only a high school diploma) when estimating the social rate of return to investments in higher education.

A college degree also produces many non-pecuniary benefits and, like the economic returns, these also accrue to both degree and non-degree holders. Degree holders may obtain such things as increased prestige, enhanced job security and a heightened sense of culture. Non-degree holders may benefit from the discovery and cultivation of talent and a more law abiding society. Theoretically, these non-pecuniary returns do have a monetary value. That is, we can imagine a process that solicits from each person the dollar value that individual places on the non-pecuniary benefits of higher education he/she receives. The summation of these values across all people would then give the total value to society of the non-pecuniary benefits of higher education. In practice, however, such a process would be very complicated to design and prohibitively expensive to implement. Hence, from the standpoint of society, the data needed to put a monetary value on the non-pecuniary benefits of higher education are unavailable. This problem has led previous researchers to ignore these benefits altogether. While the methodology of the present study does not pretend to account for all the non-pecuniary returns to higher education, we do make a first step in this direction. This is done by including in our analysis the

influences of variables whose correlation with benefits should be relatively high.

## 1.2 Approach Overview

To estimate the marginal social rate of return to public investments in higher education we utilize the techniques of applied welfare analysis. Our methodology is based on the work of Just, Hueth and Schmitz (1982) and consists of the following three steps. First, we estimate the ordinary supply and demand curves that describe the labor market for college graduates.<sup>2/</sup> Following standard economic practice, the areas of consumer and producer surplus associated with these curves are used to approximate the economic benefits that accrue to buyers and sellers (respectively) of educated labor. Similarly, when the implementation of a specific policy shifts either of the above curves the changes in these areas are used to estimate the economic impact of that policy on the participants in this market.

It is important to note that ordinary supply and demand curves are derived assuming prices remain constant in all other markets. In general, however, this is unrealistic because changes in the price of one good usually trigger changes in the prices of related goods. Since the ordinary supply and demand curves do not reflect these latter price changes they show only part of the adjustment process that occurs when an exogenous force temporarily causes disequilibrium in a given market. Hence, when referring to the market



described by the ordinary supply and demand curves for educated labor we will use the terms ordinary and partial equilibrium interchangeably.

In the second step we follow a procedure laid out by Just, Hueth and Schmitz (1982) and expand the relationships estimated above to include general equilibrium considerations.<sup>3/</sup> General equilibrium supply and demand curves have the property of allowing for price adjustments among related goods that result from price movements of the primary good being analyzed. Hence, when a policy is implemented in a given market the changes in areas of consumer and producer surplus associated with these curves reflect surplus changes in markets related to the one being modeled. This implies we can estimate the aggregate economic benefits to society of a change in the level of public expenditures for higher education by measuring how such increases or decreases change the areas of consumer and producer surplus associated with the general equilibrium relationships for educated labor.

In the final step we estimated the marginal social rate of return to public investments in higher education. This is done by hypothetically increasing the level of expenditures for higher education and calculating the resulting changes in areas of consumer and producer surplus associated with the relationships developed in step two. We then assume society receives similar returns annually for a period of 43 years (i.e., the average working lifetime of a college graduate, see Endnote 19, Chapter III).

The marginal social rate of return is that discount rate which equates this stream of benefits with the amount of increased expenditures in the following formula:

$$\Delta INV = \sum_{i=4}^{47} \frac{Y}{(1+r)^i} \quad (1.2)$$

where:

- $\Delta INV$  = the change in expenditures for higher education;
- $Y$  = the annual social benefits derived from INV.  $Y$  is assumed to be constant over the period of analysis and is measured as the sum of changes in areas of consumer and producer surplus associated with the general equilibrium supply and demand curves for educated labor;
- $r$  = the discount rate, the rate of return being that value of  $r$  that makes equation 1.1 an equality;
- $i$  = an index of years over which society receives benefits from  $\Delta INV$ .

The research presented here examines society's marginal rate of return to investments in higher education. It differs from past works in that its methodology measures all the benefits of higher education simultaneously rather than trying to quantify each independently. The specifics of this methodology, along with its underlying theoretical framework, are laid out in Chapter III. Chapter IV develops the empirical model and presents our results. The conclusions of the study are contained in Chapter V. Chapter II,

to which we now turn, reviews and critiques the work that has been published to date.

ENDNOTES

- 1/ National Center for Education Statistics (N.C.E.S.).
- 2/ Throughout this paper, the terms college graduates, degree holders and educated labor are used interchangeably. So, too, are the terms high school graduates, non-degree holders and uneducated labor.
- 3/ Both general equilibrium and the procedures referred to here are discussed in Section 3.3.

## CHAPTER II

## LITERATURE REVIEW

## 2.1 Previous Studies Reviewed

Literature dealing with the private and social rates of return to investments in education began appearing in abundance during the late 1950s. The topics subsequently became the subject of numerous books and articles. This Chapter examines the work done to date. Because of the focus of this study, primary emphasis is given to the findings which concern society's rate of return to expenditures for higher education. For the reader's convenience, a summary table (Table 1) of these results, by author, has been included at the end of the Chapter.

Before delving into this literature, however, a cornerstone should be set. In 1958, Zvi Griliches (1958) published an article in which he examined the returns to society from its investment in hybrid corn research. The work was of major importance because of the methodology it employed. Using supply and demand analysis, Griliches estimated the social benefits from hybrid corn by calculating the changes in areas of producer and consumer surplus that would have occurred in the corn market had hybrids not been developed. The above figures were then combined with an estimate of the total cost of developing these varieties. The results indicated an annual rate of return to society between 35 and 40 percent for each dollar that had been invested in this research.<sup>1/</sup>

It may seem logical to move from one form of public investment to another. Yet, when economists began to seriously examine the returns to expenditures in education, some in the profession were against it. They maintained it was beyond the scope of rigorous economic analysis. Vaisey (1962) argued that it was impossible to identify that portion of an individual's earnings attributable to educational attainment and that part attributable to other, highly correlated, factors (e.g., family wealth, socio-demographic group, personal ability, etc.). Similar objections were voiced by Balogh and Streeten (1968). These authors went on to suggest this interdependency with other variables rendered the derivation of functional relationships between education's inputs and outputs impossible. This, they argued, precluded rate of return analysis because the relationships are essential to the methodology. A final criticism came from Shaffer (1968) who pointed out that in such an analysis the identification of all relevant variables was a futile undertaking.

Defense for the approach came from Schultz (1963), Hansen (1963), Becker (1964), and Blaug (1968). Schultz (1963) noted that expenditures for education in 1963 totaled about \$30 billion. Since economics studies how society allocates scarce resources among competing wants, its role analyzing education was valid. Blaug (1968) argued that social projects frequently include factors whose influences cannot be measured as well as costs and benefits which cannot be quantified. Hence, it was inconsistent to dismiss rate of return analysis when looking at expenditures for education and then employ it when reviewing many other social projects. With

education, the best one could do was admit to a partial analysis and consider only the measurable economic effects.

In the first works to actually estimate the economic returns to education three systems of measurement appeared. These were as follows:

- 1) comparing lifetime earnings of people with different levels of schooling,
- 2) comparing the present values of the above figures,
- 3) comparing the present values of the costs versus the benefits of obtaining different levels of schooling.

The first approach was taken by Miller (1960) and the second by Houthakker (1959). In 1963, W. Lee Hansen (1963) laid out the third method. Hansen argued that neither of the other approaches was appropriate for analyzing the returns to education because each ignored the costs students incur while attending school; Miller's framework suffered the additional drawback of weighing all returns to education equally regardless of the time periods in which they accrue. He then proposed a methodology whereby the cost-streams of acquiring different amounts of schooling are calculated, as well as the larger life cycle income streams each successive level of schooling is expected to yield. The present values of the additional income flows and the cost outlays are then equated with an appropriate discount rate called the internal rate of return. This he did using the formula:

$$\sum_{i=1}^n \frac{B_i - C_i}{(1+r)^i} = 0 \quad (2.1)$$

where:

- $B_i$  = the benefits accruing to education in time period  $i$ ;
- $C_i$  = the costs of schooling in period  $i$ ;
- $n$  = the number of time periods from the start of the level of schooling being considered to the end of the individual's working lifetime;
- $r$  = the internal rate of return to schooling.

Hansen used equation 2.1 to calculate both private and social marginal rates of return to investments in education.<sup>2/</sup> Of key importance is how these concepts were defined.

To derive the marginal social rate of return to a particular level of schooling,  $B_i$  was taken as the difference in median income, in time period  $i$ , between people with that level of schooling and those with the next lowest level.  $C_i$  was defined to be the sum, in period  $i$ , of (1) the direct costs of education to society (e.g., teachers' salaries, supplies, interest and depreciation on capital, etc.), (2) the opportunity costs incurred by students (i.e., income foregone while enrolled in school), and (3) personal expenses incidental to school (e.g., books, travel, etc.). To calculate the corresponding private rates of return,  $B_i$  was defined as before.  $C_i$  included both (2) and (3) from above, but (1) was changed to tuition and fees paid by the individual. It is important to note that direct individual costs are included in the direct social costs. This is because schools use the tuition and fees they collect to help pay their operating expenses.



Data for Hansen's study came from several different sources. Income distributions for males in 1949, by age and years of schooling completed, were obtained from the 1950 Census of Population. Lifetime income flows to people with different levels of education were derived from this source. The opportunity costs of attending various levels of school were then calculated from the income flows. They were estimated by adding the average annual incomes received by working males the same age as the student while the student was in school. Data on tuition and fees for 1949-1950 were derived from the Biennial Survey of Education, 1955-56. Estimates of incidental school expenses and total resource costs to society were borrowed from an earlier work by Schultz.<sup>3/</sup>

Hansen explicitly stated that his calculations reflected only money returns and that other costs and benefits associated with education had been excluded from his analysis. Rates of return, both social and private, were estimated for investments in seven different levels of schooling across seven different student age groups. Of primary interest to us are the marginal returns to society from 12 and 16 years of education (i.e., high school and college graduates). These were estimated to be 11.4 and 10.2 percent, respectively. The probability of society's returns being diminished by the premature death of the degree holder was incorporated but found to have only negligible effects. Calculations of similar returns to private investment were 15.3 and 11.6 percent, respectively.

Hansen admitted to several drawbacks in his data. These problems will be elaborated here because much of the subsequent research is aimed at correcting them. First, the Census data reflected income not earnings. This lumped money earned at work with receipts from other assets. Second, no attention was given to the effects of socio-demographic variables. As mentioned earlier, many of these variables are highly correlated with educational attainment. Third, no allowance was made for ability. Since smarter people tend to complete more schooling, some of the extra earnings displayed by the more educated would have accrued to them anyway. Fourth, all the costs of education were considered as investment. Some argue that students derive considerable consumption benefits from schooling.<sup>4/</sup> Fifth, because the results relied on cross-sectional cost-income relationships future shifts in these relationships were not allowed. Finally, a hodge-podge of omitted factors that could have affected the analysis (e.g., measurement error, aggregation bias, etc.).

Considerable attention has been accorded Hansen's work. This is because it laid the foundation on which many of the subsequent studies were built.

In 1964, Gary Becker published Human Capital (1964). It is perhaps the single most cited reference in the economics of education literature. The book's focus is primarily on the individual; the treatment of education with respect to society is very limited. Still, several aspects of Becker's study are important to this discussion.

Like Hansen, Becker employed the population Census, but his work covered both the 1940 and 1950 editions. To solve many of the socio-demographic biases present in Hansen's results, Becker disaggregated the data by age, sex and race. This created a more homogeneous data set and the technique became standard practice in subsequent research. Another aspect of Becker's work that gained wide acceptance was his calculation of the opportunity cost of acquiring a year of college training. This he estimated at 75 percent of the average annual earnings of similar aged high school graduates participating full time in the labor force.<sup>5/</sup> The problem of correlation between years of schooling and ability was handled less satisfactorily; it was assumed to be relatively small.

In a brief section Becker did address the social rate of return to investments in higher education. For a lower bound he obtained estimates of 13 and 12.5 percent for white male graduates in 1939 and 1949, respectively. Although Becker used Hansen's procedure to calculate rates of return (i.e., selecting  $r$  that sets equation 2.1 equal to zero), his estimates were higher. This was due to two factors. First, the opportunity cost of a year of college used by Becker was 75 percent of the figure used by Hansen (that is for 1949). Also, Becker subtracted the money colleges and universities spend on noneducational activities from their current expenditures. This resulted in a lower estimate of the direct costs to society of higher education than was used by Hansen.

Becker emphasized that the above rates of return reflected only monetary costs and benefits. For a more encompassing measure, he

utilized the work of Denison (1962). Using regression analysis, Denison calculated the effects of many variables on economic growth (e.g., labor, physical capital, increasing returns, etc.). The residual he credited to "advancements in knowledge." By attributing the entire residual to education, Becker estimated an upper limit of 25 percent for the true social rate of return to investments in higher education.

The next major study appeared in 1970 and was coauthored by Hines, Tweeten and Redfern (1970). In many ways it combined the methodologies of Hansen and Becker. Income data came from the One in One Thousand Sample of the 1960 Census of Population; direct cost data were obtained from the Statistical Abstract of the United States. The data were disaggregated to reflect seven educational levels in each of four race-sex groups over four U.S. census regions.

The private and social benefits attributable to a particular level of education were defined as the difference in mean earnings between people in a given race-sex group with that level of schooling and people in the same group with the next lowest level. The private costs of acquiring a college degree were, again, taken as the sum of tuition, fees, opportunity costs, and incidental expenses; social costs were obtained by adding to this figure any additional public expenditures incurred by society operating its post secondary schools. The social rate of return to investments in higher education, for any given race-sex group, was defined by choosing  $r$  such that:

$$\sum_{n=b}^{75} \frac{P_n (NB_n)}{(1+r)^{n-b}} = 0$$

where:

$n$  = age;

$b$  = age when student enrolled in college ( $n > b$ );

$P_n$  = total number of people age  $n$  enrolled in college;

$NB_n$  = net social benefits accruing to all people, age  $n$ , enrolled in college where costs are treated as negative benefits, and positive benefits are the additional earnings of people with a college degree over those with only a high school diploma.

The results Hines, Tweeten and Redfern reported were as follows. The marginal social rate of return to white males from obtaining a college degree (over a high school diploma) was 9.7 percent. For white females, other males and other females this return was 4.2, 3.0 and 11.0 percent, respectively. The private rates corresponding to the above groups were 13.6, 9.98, 6.0 and 29.1 percent, respectively. In addition, a weighted social rate of return to all males of 9.0 percent was computed.

The returns to white males were investigated further to examine the effects of secular growth in earnings, mortality, ability and interest on property.<sup>6/</sup> Allowing for secular growth in incomes boosted the social rate of return from a college degree to 12.1 percent. Further adjustments for mortality, ability and interest on property, performed in that order, altered this figure to 12.0, 9.9, and 9.7 percent.

The studies reviewed so far have dealt with returns to quantity of schooling. Implicit has been the assumption that a unit of schooling, at any given level, is a homogeneous commodity. Obviously, it is not. In 1973, Johnson and Stafford (1973) addressed the substitutability between quantity and quality of education. Their data came from a 1965 study done by the Survey Research Center of the University of Michigan. The data allowed identification of where each respondent obtained his/her elementary, high school and college education as well as their 1964 income. After eliminating all observations representing females, blacks, retired farmers, the self-employed and people outside the labor force, Johnson and Stafford were left with a data set consisting of 1039 income earning family heads. Quality was defined as the average annual expenditure per student through grade 12 (EXP from now on). Examining this variable in each state during three different time periods identified 150 quality observations. Quantity was taken as years of schooling completed.

Like Hansen, Johnson and Stafford used equation 2.1 to estimate marginal social rates of return to investments in education. The manner in which they applied this formula, however, was considerably different in that social costs were measured starting in grade 1. To calculate rates of return to years of schooling, the data were partitioned into three groups based on different levels of EXP; these were \$150, \$300, and \$425. For each level, lifetime income streams were derived according to how much education was obtained.<sup>7/</sup> The net social benefits attributable to a specific amount of

schooling were measured by the difference in income between people in a given EXP level with that amount of schooling and people in the same EXP level with the next lowest amount of education. Annual per pupil costs to society, for each group, were defined as EXP for grades 1-8,  $1.73 \times \text{EXP}$  for grades 9-12, and \$1,636 plus opportunity costs for college.<sup>8/</sup>

To estimate the rates of return to quality of education, the data were separated into groups of people who had completed 8, 12, and 16 years of schooling. For these groups, lifetime income streams were calculated for three levels of EXP; these were \$125-\$150, \$275-\$300, and \$400-\$425. Social costs and benefits were defined as before, except that benefits were calculated for different levels of EXP given quantity of education.

The results showed positive but diminishing returns to expenditures per pupil. Grades 1-12 displayed high degrees of substitution between quantity and quality; in college, this substitutability was much less pronounced. Holding expenditures per student constant at \$150, \$300, and \$425, Johnson and Stafford reported a marginal social rate of return to investments in higher education of 8.5, 8.8 and 9.0 percent, respectively. Holding quantity constant at 16 years of schooling, they report returns of 14.1, 11.9 and 11.6 percent to expenditures per pupil of \$125-\$150, \$275-\$300, and \$400-\$425, respectively.

In 1972, Griliches and Mason (1972) examined the already discussed problem of correlation between ability, education and income. The study utilized a 1964 sample of military veterans who had been

tested for ability upon entering the service. Incomes were regressed on the variable, incremental schooling obtained during or after military service. The coefficient was then compared to the coefficient of the same variable with ability and background added to the model. Griliches and Mason reported the contribution of education to income is overstated about 12 percent when ability and background are not accounted for.

The relationship between these variables was analyzed again in 1974 by Taubman and Wales (1974). They employed a data set called the NBER-TH sample.<sup>9/</sup> These data represented some 4400 men. Each had been given 17 different ability tests in 1943 as a screening procedure for specialized army training; the same men were later the subject of a 1955 follow-up survey by Thorndike and Hagen (1959) who were seeing how well the original tests predicted vocational success.

Using regression analysis, Taubman and Wales found only the omission of mathematical ability significantly biased the effects of education on earnings. The magnitude of the bias across educational levels and occupations averaged about 25 percent in 1955 and 15 percent in 1969. Several socio-demographic and background variables (e.g., father's educational attainment and marital status) were also examined and found to have an aggregate effect on earnings similar to that of mathematical ability.

With the data adjusted for inflation, ability, and background biases, Taubman and Wales report a social rate of return to obtaining a bachelors degree (over a high school diploma) of 7.6



percent. If inflation is ignored, the return jumps to 10.0 percent, and when no adjustments are incorporated the return increases to 12.2 percent.

In 1975, the results of three more studies on the private and social rates of return to investments in education were published. Though these works differed in focus, they all employed the methodology first suggested by Hansen (1963) and Becker (1964). That is, social/private rates of return to specific levels of schooling were calculated by equating the benefits (defined as before) of that level of education with its costs (defined as before) to society/the individual. This was done by choosing  $r$  such that equation 2.1 would equal zero.

Raymond and Sesnowitz (1975) addressed only the returns to higher education. Their data came from the 1970 Census of Population but were adjusted for growth in incomes, ability, part-time workers and taxes.<sup>10/</sup> Results were reported with both a 15 and 25 percent ability adjustment; this reflecting the works of Griliches and Mason, and Taubman and Wales.

Like Hansen, Raymond and Sesnowitz restricted their study to the male population. They reported a social rate of return to investments in higher education of either 14.3 or 15.3 percent, depending on whether a 25 percent or a 15 percent ability adjustment was used; the corresponding private rates were 15.7 and 16.4 percent.

Carnoy and Marenbach (1975) examined the trends in returns to different levels of schooling over time. This was done using

Census data from 1940, 1950, 1960 and 1970. Following Becker and Hines, et al., the data were disaggregated into race-sex groups. For each group, private and social marginal rates of return were calculated across three levels of schooling (i.e., elementary, high school and college). A summary of their reported social rates of return to higher education is presented in Table 1.

For all people, across all educational levels, Carnoy and Marenbach concluded the social rate of return to investments in education had declined from about 13 to 14 percent in 1939 to about 9 percent in 1969. The bulk of this decline occurred at the primary and secondary levels. As shown in Table 1, the social returns to a college degree remained fairly constant within each race-sex group over the period analyzed. This study made no adjustments for non-schooling factors (e.g., ability, background, etc.). The authors defended this omission on the grounds that such factors are too intimately connected with the function and expansion of schooling to be measured separately. In closing, Carnoy and Marenbach noted that the supply of college graduates seemed to be growing faster than the demand for them. They speculated this would lead to a decreasing marginal social rate of return to investments in higher education within ten years (i.e., 1985). Private returns were predicted to remain high, or even increase, due to a preference by employers for college graduates.

Like Raymond and Sesnowitz, Richard Freeman (1975) dealt with the returns to a college education for males. Like Carnoy and Marenbach, he was interested in the trends these rates displayed

over time; the span, however, was much shorter, 1959-1974. Freeman used 1960 and 1970 Census data. Figures for the 1972 and 1974 earnings of recently graduated men were estimated by applying the rates of change in starting salaries of these people (published in the Current Population Reports) to the 1970 Census data. His results are summarized also in Table 1.

Freeman's chief finding was that from 1959-1975 both the social and private rates of return to investments in college training declined. These trends were predicted to continue since the supply of college graduates was growing faster than the demand for them.

The work of Russell Rumberger (1981) supports the findings of Carnoy and Marenbach. Rumberger has not actually calculated rates of return. He argues, however, that society is getting less from its investment in higher education because college graduates are now doing many jobs once done by people with only a high school diploma. Contrary to Freeman, he maintains the earnings difference between these two groups has not diminished in recent years. From this, he concludes the private rate of return to a college degree has not declined and may have actually increased.

Freeman also has been challenged by Witmer (1980) Using income data from the Current Population Reports, Series P-60, Witmer computed a social rate of return to investments in higher education for each year over the period 1961-1975. To facilitate

comparisons, only his calculations for 1961, 1969, 1972, 1974, and 1975 will be mentioned here. For men, these figures were 13.5, 12.5, 13.6, 15.8, and 16.7 percent, respectively; for all people they were 14.2, 13.4, 14.0, 14.7 and 15.1 percent. Witmer's position is that society's return to its investments in higher education has been increasing, not decreasing, in recent years.

## 2.2 Previous Studies Critiqued

Section 2.1 reviewed two and a half decades of literature dealing with the social rate of return to investments in higher education. Although data sets, groups focused on, periods of analysis, and even some definitions, varied from one study to another, two common threads stand out. First, the methodologies employed were generally quite similar. Most authors, following Hansen (1963), calculated rates of return using equation 2.1 (or some closely related formula). Second, virtually all studies used the same components to define the costs and benefits associated with higher education. That is, the benefits, both social and private, were taken as the difference in average annual incomes between college graduates and people with only a high school diploma. Private costs were defined as the sum of tuition, fees, opportunity costs, and incidental school related expenses; social costs were derived by adding to this figure any additional higher education expenses incurred by society.

When these threads are woven together two peculiar results emerge. Consider Figure 1, which is a simplification of the market for college graduates implicit in past studies.

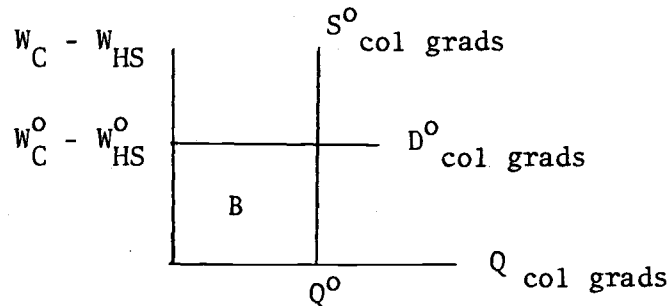


Figure 1.

The Labor Market for College Graduates  
Implicit in Past Studies

Let  $W_C$  and  $W_{HS}$  be the average wages paid college and high school graduates, respectively. Further, assume the initial supply of degree holders is  $Q^0$ . Note the assumption that demand is perfectly elastic and supply perfectly inelastic. These results follow from setting, in turn, net social benefits equal to net private benefits and net private benefits equal to the additional earnings of college graduates over people with only a high school diploma. Dividing total net benefits ( $B$ ) by the total educated work force ( $Q^0$ ) yields, by definition, average net benefits per educated worker. This is equal to  $W_C^0 - W_{HS}^0$  which, by inspection, is also equal to the marginal benefits (social or private) realized by

any new graduates upon entering the labor market. Hence, past researchers have made no distinction between the average and marginal returns, and thus the corresponding rates of return, to investments in higher education. What society obtains from each individual who has already received a college degree (the average social rate of return) is the same as what it will realize from any additional graduates its colleges and universities turn out (the marginal social rate of return).<sup>11/</sup>

A second peculiar result of past studies is the relationship between the estimated social and private rates of return to investments in higher education. In all works, the latter exceeds the former. This result, however, is predetermined. It follows from using the same measure to define both the social and private benefits associated with schooling while including private expenditures for higher education in the estimate of social costs. Hence, in equation 2.1 the numerators (the  $B_i - C_i$ 's) are smaller when one is calculating rates of return to society's, as opposed to the individual's, investment. In fairness, this is a criticism to which past researchers admit; most explicitly state their treatment of social returns is very limited.

Although ignored in empirical sections, virtually all previous works allude to relatively large spillover economic benefits produced by an educated work force. These are benefits captured by people other than degree holders. For example, many employers view

a college degree as a sign of a person's ability to do a good job. For firms that use this criteria to screen job applicants, there are considerable savings in the hiring process. Additionally, a large number of firms greatly reduce their training costs when they hire college graduates over people with lesser amounts of schooling. Here degree holders may already possess skills desired by the firm, or the firm's training programs may cost less to operate because the people in them are proven learners.

The last two paragraphs suggest past authors would acknowledge Figure 2 as a more accurate presentation of the market for college graduates.

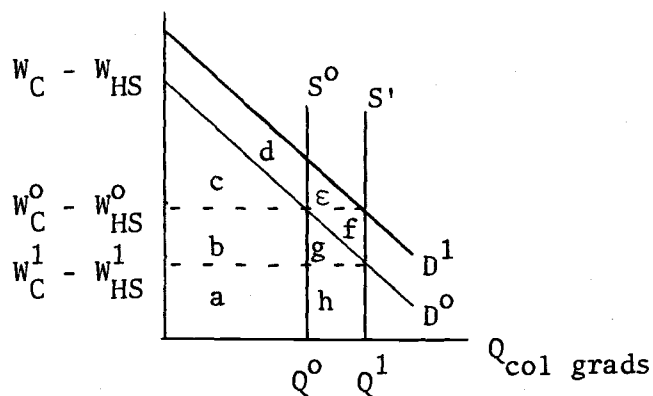


Figure 2.

The Labor Market for College Graduates  
as Acknowledged in Past Studies

As in Figure 1, the net benefits realized by degree holders are taken as the additional earnings of college graduates over people with only a high school diploma; hence, supply is again perfectly

inelastic. Demand, however, is now downward sloping; this reflecting the existence of economic benefits captured by people other than degree holders. Let the initial supply of educated workers be given by  $Q^0$  and the initial demand for them by  $D^0$ . To start, then, the total net benefits realized by society from its educated work force are given by area  $a+b+c$ ; of this, area  $a+b$  represents benefits that accrue directly to degree holders. Dividing each area by  $Q^0$  yields, respectively, the average social and private benefits per educated worker. Assuming these measures remain fairly constant over time, they can then be used in the following formulas to estimate the average social and private rates of return to investments in higher education:

Average Social Rate of Return

$$0 = -\bar{C}_S + \sum_{i=1}^n \frac{(a+b+c)/Q^0}{(1+r)^i} \quad (2.3)$$

Average Private Rate of Return

$$0 = -\bar{C}_P + \sum_{i=1}^n \frac{(a+b)/Q^0}{(1+r)^i} \quad (2.4)$$

where:

$\bar{C}_S$  = the average social cost (i.e., both private and public expenditures) of equipping each member of the educated work force with a college degree;

$\bar{C}_P$  = the average private cost incurred by educated workers obtaining a college degree;



$n$  = the number of time periods in which these benefits are realized;

$r$  = the internal rate of return (i.e., that discount rate which sets the right-hand side equal to zero).

Assume now a new class graduates and the number of degree holders in the labor force increases to  $Q^1$ . Figure 2 illustrates two possibilities with respect to demand. Consider first the case where demand does not shift. Society gains benefits equal to area  $g+h$ , while college graduates gain benefits equal to  $h-b$  (this may or may not be positive). Using equations 2.5 and 2.6, these marginal gains can be combined with the social and private costs of shifting supply from  $Q^0$  to  $Q^1$  to yield, respectively, estimates of the marginal social and private rates of return to investments in higher education.

Marginal Social Rate of Return

$$0 = -C_S + \sum_{j=1}^I \frac{(g+h)}{(1+r)^j} \quad (2.5)$$

Marginal Private Rate of Return

$$0 = -C_P + \sum_{j=1}^I \frac{(h-b)}{(1+r)^j} \quad (2.6)$$

where:

$C_S$  = the cost to society of shifting the supply of educated labor from  $Q^0$  to  $Q^1$ ;

$C_P$  = the costs incurred by degree holders shifting supply from  $Q^0$  to  $Q^1$ ;

$I$  = the number of periods these benefits will be realized.

Assuming ways can be found to estimate areas  $c$  and  $g$  in Figure 2 (to be dealt with in Chapter III), rates of return calculated with equations 2.3 to 2.6 eliminate the peculiarities of past studies. That is, the average and marginal returns to investments in higher education are no longer equivalent since  $2.3 \neq 2.5$  and  $2.4 \neq 2.6$ . Also, it is not predetermined that private rates of return will exceed those to society; equation 2.3 is not clearly less than 2.4, and 2.5 is not clearly less than 2.6.

Returning to Figure 2, consider now the case where demand shifts to  $D^1$ . This more accurately reflects past researchers' views of the educated labor market since they assumed wage differential between people with various levels of schooling to be fairly constant over time.<sup>12/</sup> The benefits gained by society are now given by area  $d+e+f+g+h$ , of which area  $f+g+h$  accrues to degree holders. As before, equations 2.3 to 2.6 can be used to combine these benefits with the social and private costs of the shift from  $Q^0$  to  $Q^1$  to obtain estimates of marginal and average rates of return to investments in higher education. Again, no special relationship exists between 2.3 and 2.4 or 2.5 and 2.6. Note, however, one result is predetermined; the private rates of return, average and marginal, are now equivalent and given by  $W_C^0 - W_{HS}^0$ .

This chapter has reviewed and critiqued two and a half decades of literature dealing with the social rate of return to investments in higher education. It has hinted at how a more encompassing estimate of this measurement might be obtained. The specifics of

this new approach and its theoretical justification are the subject of the next chapter.

Table 1. Marginal Social Rates of Return (MSSR) to Investments in Secondary and Post Secondary Education as Reported by Past Researchers

Researcher	Year Published	Year(s) Analyzed	MSSR (in percent)		Group Analyzed	Adjustments to the Data
			12 years <u>a/</u>	16 years <u>b/</u>		
Hansen	1963	1949	11.4	10.2	Males	None
Becker	1964	1939	NA	13.0-25.0	White Males	None
		1949	NA	12.5-25.0	White Males	None
Hines et al.	1970	1959	14.0	9.7	White Males	None
			17.8	12.1	White Males	Secular growth in incomes (SGI)
			17.8	12.0	White Males	SGI + Mortality (M)
			10.5	9.9	White Males	SGI + Ability (A)
			9.9	9.7	White Males	SGI + M + A + inter- on property
			13.0	4.3	White Females	None
			16.7	3.0	Other Males	None
			16.4	11.0	Other Females	None
Johnson and Stafford	1973	1965	11.5	8.5	White Males	<u>c/</u> Expenditure/Student = \$150
			10.9	8.8	White Males	= \$300
			10.5	9.0	White Males	= \$400
			16.6	14.1	White Males	<u>d/</u> = \$125-\$150
			13.6	11.9	White Males	= \$275-\$300
Taubman and Wales	1974	1955-59	13.4	11.6	White Males	= \$400-\$425
			NA	12.2	White Males	None
			NA	7.6	White Males	Ability, Background, Inflation
Raymond & Sesnowitz	1975	1969	NA	14.3	Males	15% for ability, growth in incomes, part-time workers
			NA	15.3	Males	25% for ability, growth in incomes, part-time workers
Carroy and Marenbach	1975	1959	10.2	10.7	White Males	None
			10.4	6.5	Black Males	None
			12.7	9.8	White Females	None
			4.8	11.1	Black Females	None
			14.2	10.6	White Males	None
			9.1	4.6	Black Males	None
		1949	11.5	7.0	White Females	None
			8.7	9.2	Black Females	None
			10.1	11.3	White Males	None
			8.3	7.2	Black Males	None
		1959	9.3	6.6	White Females	None
			8.2	8.8	Black Females	None
			10.7	10.9	White Males	None
			9.0	8.0	Black Males	None

Table 1. Marginal Social Rates of Return (MSSR) to Investments in Secondary and Post Secondary Education as Reported by Past Researchers

Researcher	Year Published	Year(s) Analyzed	MSSR (in percent)		Group Analyzed	Adjustments to the Data
			12 years a/	16 years b/		
			8.3	9.4	White Females	None
			6.9	10.5	Black Females	None
			9.0	11.0	White Males	Earnings only
			11.2	7.7	Black Males	None
			7.4	7.9	White Females	None
			10.3	10.6	Black Females	None
Freeaan	1975	1959	NA	10.5	Males	None
		1969	NA	11.1	Males	None
		1972	NA	9.5	Males	None
		1974	NA	7.5	Males	None
		1980	NA	13.5	Males	None
Witmer	1980	1961	NA	13.1	Males	None
		1962	NA	13.0	Males	None
		1963	NA	12.9	Males	None
		1964	NA	12.7	Males	None
		1965	NA	11.8	Males	None
		1966	NA	11.4	Males	None
		1967	NA	11.8	Males	None
		1968	NA	12.5	Males	None
		1969	NA	12.7	Males	None
		1970	NA	13.1	Males	None
		1971	NA	13.6	Males	None
		1972	NA	13.9	Males	None
		1973	NA	15.8	Males	None
		1974	NA	16.7	Males	None
		1975	NA	15.1	Females	None
		1961	NA	15.5	Females	None
		1962	NA	15.7	Females	None
		1963	NA	16.4	Females	None
		1964	NA	17.0	Females	None
		1965	NA	16.0	Females	None
		1966	NA	15.6	Females	None
1967	NA	14.9	Females	None		
1968	NA	14.5	Females	None		
1969	NA	14.3	Females	None		
1970	NA	14.2	Females	None		
1971	NA	14.5	Females	None		
1972	NA	13.9	Females	None		
1973	NA	13.5	Females	None		
1974	NA	13.3	Females	None		
1975	NA					

a/ High school over elementary school

b/ College over high school

c/ Expenditures held constant

d/ Years of schooling held constant

NA = not applicable.

Table 2. Marginal Private Rates of Return (MPRR) to Investments in Secondary and Post Secondary Education as Reported by Past Researchers

Researcher	Year Published	Year(s) Analyzed	MPRR (in percent)		Group Analyzed	Adjustments to the Data
			12 years a/	16 years b/		
Hansen	1963	1949			Males	None
Becker	1964	1939	16.0	14.5	White Males	None
		1949	20.0	13.4	White Males	None
Hines et al.	1970	1959	19.5	13.6	White Males	None
			22.1	16.2	White Males	Secular growth in incomes (SGI)
					White Males	SGI + Mortality (M)
			22.1	16.2	White Males	SGI + M + Ability (A)
			15.8	13.2	White Males	SGI + M + A + Taxes
			15.8	13.2	White Males	None
			39.8	9.9	White Females	None
			27.3	6.0	Other Males	None
Johnson and Stafford			57.7	29.1	Other Females	None
			NA	NA		
Taubman and Wales	1974	1955-69	NA	9.7	White Males	After tax (AT)
			NA	10.7	White Males	Before tax (BT)
			NA	7.3	White Males	AT, ability, background, inflation
			NA	8.2	White Males	BT, ability, background, inflation
Raymond and Sesnowitz	1975	1969	NA	15.7	Males	25% for ability, growth in incomes, taxes
			NA	15.5	Males	Same as above plus part time workers
			NA	16.8	Males	15% for ability, growth in incomes, taxes
				16.4	Males	Same as above plus part time workers
				17.9	Males	Growth in incomes, taxes
				17.4	Males	Growth in incomes, taxes, part time workers
Carnoy and Marenbach	1975	1939	49.1	21.4	White Males	None
			27.1	14.6	Black Males	None
			25.2	18.4	White Females	None
			10.0	30.0	Black Females	None
		1949	22.7	13.2	White Males	None
			14.7	7.7	Black Males	None
			20.0	11.0	White Females	None

Table 2. Marginal Private Rates of Return (MPRR) to Investments in Secondary and Post Secondary Education as Reported by Past Researchers

Researcher	Year Published	Year(s) Analyzed	MPRR (in percent)		Group Analyzed	Adjustments to the Data
			12 years <sup>a/</sup>	16 years <sup>b/</sup>		
			15.2	17.0	Black Females	None
		1959	14.6	17.6	White Males	None
			13.1	13.9	Black Males	None
			14.8	12.2	White Females	None
			12.9	19.1	Black Females	None
		1969	18.8	15.4	White Males	None
			16.1	14.3	Black Males	None
			19.2	17.0	White Females	None
			11.6	19.6	Black Females	None
			14.0	16.2	White Males	Earnings only
			19.9	13.6	Black Males	Earnings only
			15.1	14.6	White Females	Earnings only
			19.1	9.4	Black Females	Earnings only
Freeman	1975	1959	NA	11.0	Males	None
		1969	NA	11.5	Males	None
		1972	NA	18.5	Males	None
		1974	NA	8.5	Males	None
Witmer			NA	NA		

a/ High school over elementary school

b/ College over high school

NA = not applicable.

Table 3. Social Rates of Return Reported by Past Researchers to Investments other than Higher Education

Author	Investment	Social Rate of Return (%)
Griliches (1958)	Hybrid corn development	35-40
Becker (1964)	Investments in physical capital	12
Mansfield (1965)	R&D in the chemical industry	30
	R&D in the chemical industry	40
Minasian (1969)	R&D in the chemical industry	50
Mansfield <u>et al.</u> (1977)	Primary metals innovation	17
	Machine tool innovation	83
	Component for control system	29
	Construction material	96
	Drilling material	54
	Drafting innovation	92
	Paper innovation	82
	Thread innovation	307
	Door control innovation	27
	Chemical product innovation	71
	Chemical process innovation	32
	Chemical process innovation	13
	Household cleaning device	209
Evenson <u>et al.</u> (1979)	Investments in agriculture	45-130

Sources: See Bibliography.



ENDNOTES

- 1/ It should be noted that Griliches calculated an average, not a marginal, rate of return. The distinction between these two concepts will be dealt with in Section 2.2
- 2/ Hansen used the wording "total resource" instead of "social" when referring to society's investments in and returns to education. His terminology has been changed to be consistent with similar concepts in other works.
- 3/ See T.W. Schultz, "Capital Formation by Education," Journal of Political Economy, LXVIII (Dec. 1960), pp. 571-83.
- 4/ See T.W. Schultz, The Economic Value of Education, Columbia University Press, NY, 1963.
- 5/ Becker used 75 percent because he assumed college students could work full time during summer vacation (which lasts about three months or one-fourth of the year).
- 6/ For a discussion of how these adjustment were incorporated, see Hines, Tweeten and Stafford (1970), pp. 331-36.
- 7/ For a discussion of how this was done see Johnson and Stafford (1973), pp. 142-50.
- 8/ Opportunity costs were taken to be 75 percent of the earnings of a 19 year old high school graduate working full time. \$1,636 was an estimate of the direct per pupil cost to society of higher education. It was the same value Hansen used adjusted for 1964 prices.
- 9/ National Bureau of Economic Research. Thorndike-Hagen.
- 10/ For a discussion of how these adjustments were made, see Raymond and Sesnowitz (1975), pp. 141-147.
- 11/ Defining the additional earnings of college graduates over people with only a high school diploma as the sole measure of social benefits derived from investments in higher education implies such investments produce no economic returns that accrue to people outside the educated labor market. This assumption allows one to use the ordinary supply and demand curves for college graduates to assess the economic impact on society of policies implemented in this market.

12/ This assumption is implicit when past wage differentials between people with different levels of schooling are used to estimate future wage differentials.

## CHAPTER III

## THEORETICAL CONSIDERATIONS AND METHODOLOGY

Chapter II showed that past studies have generally estimated the social rate of return to investments in higher education using some version of the internal rate of return formula (i.e., equation 2.1). Although the approach is theoretically sound, a major problem occurs in the transition from conceptual to empirical analysis.

The problem is that many of the social costs and benefits derived from an educated labor force are difficult to quantify. For example, many employers substantially reduce their training costs when they hire a college graduate versus someone with a lesser amount of schooling.<sup>1/</sup> Measuring these savings across all firms in the economy, however, is virtually impossible. Unable to solve this problem, previous researchers have opted to do a partial analysis by ignoring all benefits associated with higher education except the increased earnings of degree holders over high school graduates. But if we are not concerned with the magnitude or distribution of specific benefits, we can estimate rates of return to investments in higher education using more justifiable applied welfare analysis techniques. The key here is that we utilize a methodology which captures benefits in their aggregate rather than trying to quantify each independently. As suggested by Griliches (1958), the success of this approach hinges on reasonably specifying the supply and demand relationships for educated labor. The theoretical considerations behind these curves are the subjects of Sections 3.1

and 3.2. Section 3.3 joins supply and demand together in a market for college graduates and outlines the procedure for calculating rates of return. It also deals with the conditions which must hold in this market in order to obtain meaningful welfare results.

### 3.1 The Demand for Educated Labor

The market wage paid by college graduates results from the interaction between buyers and sellers. For the most part, buyers are private firms and so the main force motivating the demand for educated labor is profit maximization. Consider a representative firm from the economy. If we think in general terms of its production process, that is requiring simply capital, labor, energy and material inputs, we can write the firm's production function as:

$$Q = f(K, L_E, L_U, E, M) \quad (3.1)$$

where:

$Q$  = output;

$K$  = a composite good representing all capital goods;

$L_E$  = the quantity of educated labor used by the firm;

$L_U$  = the quantity of uneducated labor used by the firm;

$E$  = the firm's energy requirements;

$M$  = a composite good representing all material inputs.

From here we can incorporate prices and define the following profit function:

$$\pi(P, W_K, W_{L_E}, W_{L_U}, W_E, W_M) =$$

$$\text{Max}[P \cdot Q - W_K K - W_{L_E} L_E - W_{L_U} L_U - W_E E - W_M M] \quad Q = f(K, L_E, L_U, E, M)$$

where:

$(\pi)$  = profit;

$P$  = the market price of the firm's output;

$W_K$  = the cost of a unit of capital;

$W_{LE}$  = the wage paid college graduates;

$W_{LU}$  = the wage paid non-college graduates;

$W_E$  = the cost of a unit of energy;

$W_M$  = the cost of a unit of materials.

By Hotelling's Lemma, we obtain the firm's demand for any input by differentiating 3.2 with respect to that input's price and multiplying by negative one. Doing this for educated labor yields:

$$D_{LE}^* = D_{LE}^* (P, W_K, W_E, W_M, W_{LE}, W_{LU}) \quad (3.3)$$

This says the number of college graduates demanded by a firm will depend on the price of its output, the prices of its capital, energy, and material inputs as well as what it has to pay both degree and non-degree holders. Unfortunately, equation 3.3 is likely to encounter two severe problems in empirical work of the type undertaken in this study. First, in cross sectional data individual commodities often display little to no price variation. For such commodities, then, it is impossible to estimate how own price changes affect the demand for the good being analyzed. Second, equations like 3.3 become harder to estimate as the number of input and output prices that must be accounted for increase. At more aggregate levels, this problem can render estimation of demand functions intractable.

Hence, to simplify the present analysis the firm's profit function is assumed to be additive with respect to labor and other inputs.<sup>2/</sup>

The above additivity assumption proves very convenient for it allows equation 3.3 to be rewritten as:<sup>3/</sup>

$$D_{LE}^* = D_{LE}^* (P, W_{LE}, W_{LU}) \quad (3.4)$$

Now the firm's demand for college graduates depends only on the price of its output and the prices it must pay both degree and non-degree holders.<sup>4/</sup> It has been shown that over a working lifetime college graduates average substantially higher earnings than people with less education (Houthakker [1959], Miller [1960], U.S. Bureau of the Census [1979]). Furthermore, allowing non-degree holders four additional years of employment (i.e., the average time needed to obtain a bachelors degree) suggests that, in general, the market wage for educated labor ( $W_{LE}$ ) exceeds that paid uneducated workers ( $W_{LU}$ ).<sup>5/</sup> Assume for simplicity that all people either graduate from college or end their formal schooling upon completion of the 12th grade. Now consider a firm deciding between two job applicants similar in all respects except one is a college graduate and the other is not. Hiring the educated workers entails a larger increase in costs, so the firm will choose him only if it feels he is more productive. But how much more productive must he be?

With respect to labor, the first order conditions of problem 3.2 for profit maximization are:

$$Pf'_{LE} = W_{LE} \quad (3.5a)$$

$$Pf'_{LU} = W_{LU} \quad (3.5b)$$

This says the firm will employ educated (uneducated) labor up to the point where the value of its marginal product equals the salary it must pay degree (non-degree) holders. Manipulating these relationships obtains the following profit maximizing decision rule with respect to the level of education a firm should pay for when filling a given position.

$$\frac{MP_{LE}}{W_{LE}} \geq \frac{MP_{LU}}{W_{LU}} \quad (3.6)$$

Hence, in the choice being faced above, the firm will hire the college graduate if it thinks the marginal product per dollar spent for the educated worker equals or exceeds the marginal product per dollar spent for the uneducated worker.

A key concept underlying equation 3.6 is the direct elasticity of substitution (denoted  $\phi$ ) between degree and non-degree holders in the production process of the firm.<sup>6/</sup> This elasticity is defined as the proportionate change in the ratio of educated to uneducated workers divided by the proportionate change in the ratio of each one's respective wage rate. That is:

$$\phi = \frac{\partial \left( \frac{L_E}{L_U} \right)}{\frac{L_E}{L_U}} \div \frac{\partial \left( \frac{W_{LE}}{W_{LU}} \right)}{\frac{W_{LE}}{W_{LU}}} \quad (3.7)$$

To see how equations 3.6 and 3.7 are related, consider two extreme cases. First, suppose the firm is trying to fill a position which requires skills that take years of specialized training (i.e., beyond the high school level) to acquire (e.g., an engineer, a chemist, a computer accountant). In such jobs, college graduates will be more productive than non-degree holders so that regardless of the difference in wage rates the firm will have little choice but to hire educated workers. In the context of equation 3.7, this implies that no matter how much the denominator changes the numerator (and thus also  $\phi$ ) will be 0, and the two types of labor will not be considered substitutes. Clearly, the more such jobs a firm has the greater will be its demand for degree holders. The second extreme case involves jobs which require relatively little formal schooling (e.g., a janitor or farm laborer). Here employers will be adverse to paying any additional money to attract college graduates even if the amount needed is very small. This implies that, in the limit, equation 3.7 will approach infinity and the two types of labor will be considered perfect substitutes. Clearly, the proportion of these jobs in a firm is negatively related to its demand for educated labor.

Between the two extremes described above are a multitude of positions for which  $0 < \phi < \infty$  (i.e., educated and uneducated workers are, to varying degrees, substitutes for each other). In filling such positions, the firm faces a choice of whether or not to pay the higher wage needed to attract degree holders. While no hard rules exist to tell when equation 3.6 favors educated workers, the



decision of who gets hired will, in general, depend on the technical production process of the firm. Since this process embodies the many factors that influence the elasticity of substitution between college and non-college graduates it indicates to the employer each applicant's potential productivity which must then be balanced against the wage he commands. Conceptually, then, we can define a vector ( $\bar{\delta}$ ) consisting of job characteristics that decrease  $\phi$  (i.e., that favor hiring educated workers). Some elements of  $\bar{\delta}$  will be sufficient in and of themselves to ensure a position is filled with a degree holder (e.g., an advanced knowledge of chemistry), while others will only increase this probability (e.g., considerable on the job training).<sup>7/</sup>

The preceding discussion suggests equation 3.4, the firm's demand for educated labor, can be written as a function of output price, wage rates and the shift variables contained in  $\bar{\delta}$ . That is,

$$D_{LE}^* = h(P, W_{LE}, W_{LU}, \bar{\delta}) \quad (3.8)$$

where:

$$\frac{\partial D_{LE}^*}{\partial \bar{\delta}} > 0$$

Our goal, however, is to specify the aggregate demand for educated labor, not the demand for these people by any single firm. The transition from individual firm/consumer behavior to group behavior is called the aggregation problem. It is brought about because microeconomic theory generally relates to the actions of individual units while statistical data usually reflect groups of

firms or people. Currently, two schools of thought exist with regard to how this problem should be approached. The first, supported by Deaton and Muellbauer (1980, pp. 80-81), advocates one start with the theory as it relates to the firm/consumer and proceed to investigate the conditions under which that theory holds for larger groups. The second is to simply ignore the problem and assume all firms/consumers can be modeled as a "representative" single unit. This viewpoint is supported by Hicks (1956, p. 55), Houthakker (1970, p. 200) and Philips (1974, pp. 98-100) and is the approach adopted in this study.

Following the above discussion, equation 3.8 can be reinterpreted as the aggregate demand for educated labor. Unfortunately, it is impossible to observe how all the elements of  $\bar{\delta}$  are distributed throughout the economy. Hence, if equation 3.8 is to be made empirically operational proxy variables must be found that reflect their influence. In 1970, George Johnson published a paper titled "The Demand for Labor by Educational Category." In it he argued that the best proxies for  $\bar{\delta}$  were industry mix variables. Johnson used two such variables in specifying the demand curve for college graduates. The first was the proportion of the experienced male work force in industries that used educated labor intensively (SK from now on). This group consisted of finance, insurance, real estate, professional and related services and public administration. The second proxy was the proportion of the experienced male workers in industries that employ uneducated labor intensively (AG from now on).<sup>8/</sup> This group included fisheries,

agriculture and forestry. The complete specification of the demand for college graduates was:

$$\ln k = \alpha_0 + \alpha_1 \ln R + \alpha_2 SK + \alpha_3 AG \quad (3.9)$$

where:

$k$  = the proportion of all males over 25 who have four or more years of college;

$R$  = the difference in median income of people with four or more years of college and people with years of high school divided by the latter.

To estimate equation 3.9 Johnson used cross sectional data from the Census of the Population, 1960. In his framework, each state was treated as a separate labor market. Equation 3.9 was estimated by both ordinary least squares (OLS) and two-stage least squares (2SLS). These results are presented in Table 4. Table 4 suggests equation 3.8 can be empirically estimated.

Although the omission of output price is a theoretical shortcoming, each coefficient has its anticipated sign and is statistically significant at the 20 percent level. In addition, the  $R^2$  of .78 for the OLS formulation indicates the model has a high degree of explanatory power.

The model used in the present study draws heavily on Johnson's work but does incorporate a number of changes. These changes, along with a critique of Johnson's methodology, will be presented in Section 3.3. But first, we must add the supply of educated labor to the model. It is to the forces that underlie this curve that we now turn.

Table 4. The Demand for Educated Labor as Estimated by George Johnson

Estimation Technique	OLS		2SLS	
Constant	-3.21	(.13)	-3.42	(.13)
ln R	-.111	(.081)	-.333	(.096)
SK	5.56	(.59)	5.64	(.54)
AG	-.976	(.269)	-1.171	(.250)
R <sup>2</sup>	.777			

Estimated standard errors in parentheses.

Source: Johnson (1970).

### 3.2 The Supply of Educated Labor

The total stock of college graduates is, by definition, the summation of all people who have obtained a college degree. Clearly, then, the supply of educated labor is influenced by the same forces that underlie the individual's decision to pursue college training. From the individual's perspective, the decision of how much education to obtain (past the compulsory level) is a problem of choice. Each level of schooling has associated with it a stream of costs and benefits and each person must decide which level will yield him/her the most satisfaction. This implies people who undertake college training do so thinking, in some sense, it will make them better off.

The anticipated gains from a college education can be either pecuniary or non-pecuniary. The latter may be viewed as consumption benefits.<sup>9/</sup> Some people, for instance, enjoy learning or like the social life around a campus. Hence, the process of attending college produces immediate satisfaction, at least for some students. Other psychic returns accrue in the future. For any given individual, these may include access to more interesting jobs and an increased level of prestige. Clearly, the importance given non-pecuniary benefits will vary from one person to another, although there is little hope of directly measuring their total effect since doing so would involve aggregating utility across people.

In the past, researchers have sidestepped this problem by treating the decision to pursue a college education solely from the standpoint of an investment (i.e., by ignoring all but the

financial costs and benefits associated with obtaining a degree). This approach assumes people choose the number of years of schooling to complete so as to maximize the net present value of their lifetime earnings. Formally:

$$\text{Max PV} = W - A = \sum_{t=1}^T \frac{y_t(S)}{(1+r)^t} \quad (3.10)$$

where:

- PV = the present value of net lifetime earnings;
- W = net lifetime wealth;
- A = initial endowment of assets;
- r = the constant real interest rate;
- $Y_t(S)$  = the real income in year t for people with S years of schooling;
- S = years of schooling;
- t = time;
- T = year of retirement.

But equation 3.10 embodies a long list of questionable assumptions.<sup>10/</sup> It assumes people derive no consumption benefits from education, that all people can borrow at a given real interest rate, that labor markets clear instantly, that people know what their future earnings will be, and that while attending college leisure time is fixed. In addition, models derived from equation 3.10 which seek to explain earnings as a function of schooling have not performed too satisfactorily. Specifically, Mincer (1976) fit the following regressions to U.S. earnings and schooling data from the 1960 Census:

$$\log y_t (S) = \beta_0 + \beta_1 S + u_1 \quad (3.11)$$

$$\begin{aligned} \log y_t (S) = \beta_0 + \beta_1 S + \beta_2(t-S) \\ + \beta_3(t-S)^2 + u_2 \end{aligned} \quad (3.12)$$

where:

(t-S) is interpreted as on the job training past school investment.<sup>11/</sup>

The reported  $R^2$ 's for equations 3.11 and 3.12 were .067 and .285, respectively. Psacharopoulos and Layard (1979) fit the same regression to British data and got  $R^2$ 's of .031 and .316, respectively. Clearly, there is more to the decision to obtain a college degree than can be explained by the financial returns alone.

This is not to imply the investment aspect of higher education is not important. Quite the contrary. In 1980, the money costs of a year of college (i.e., direct expenses plus foregone earnings) ranged between \$10 and \$15 thousand (Ehrenberg and Smith, 1982). Consider someone who spends \$48,000 obtaining a degree (i.e., \$12,000 each of four years), faces an interest rate of six percent and has a post schooling working lifetime of 40 years. From an investment viewpoint, he must earn at least \$3,200 a year more, on average, than a contemporary with only a high school diploma in order to economically justify his college education (since \$48,000 invested at a six percent interest rate yields annual payments of \$3,200 over 40 years).<sup>12/</sup> Therefore, efforts to model the decision to pursue college training which ignore the investment aspect of obtaining a

degree weigh very heavily the non-pecuniary benefits discussed earlier.

The preceding discussion suggests that any attempt to formally model the total stock of educated labor should be conditioned on both the financial and the consumption benefits attributable to a college degree. In this vein, Deaton and Muellbauer (1980) have proposed treating education as a good available in several varieties. They define higher levels of schooling as higher quality (and more expensive) goods with each person selecting the level that maximizes his/her total satisfaction. Each amount of schooling has associated with it a stream of financial and psychic rewards. As mentioned earlier, the latter group cannot be directly measured. What does seem plausible, though, is that the value any given individual places on the consumption aspects of schooling is largely a function of personal background variables (e.g., ability, parents' educational attainment, family socioeconomic group, past school performance, etc.). Hence, for any individual  $i$ , we can conceive of a function ( $f_i$ ) which, for that person, places a dollar value on obtaining  $j$  years of schooling. This function is conditioned on both the financial and non-pecuniary benefits of  $j$  years of education, as well as the background variables that person possesses. More formally:

$$\beta_{ij} = f_i(\bar{\phi}_j, \bar{a}_i) \quad (3.13)$$

where:

$\beta_{ij}$  = the dollar value individual  $i$  places on the benefits of  $j$  years of schooling;



$\bar{\phi}_j$  = a vector of financial and non-pecuniary rewards derived from j years of schooling;

$\bar{a}_i$  = a vector of personal background variables that influence the level of utility individual i receives from education;

$f_i$  = the function that combines the elements of  $\bar{\phi}_j$  and  $\bar{a}_i$  to derive the dollar value of j years of schooling to individual i.

If we further specify the costs of obtaining the jth level of schooling as  $P_j$  then a person will pursue a college degree if:<sup>13/</sup>

$$f_i(\bar{\phi}_C, \bar{a}_i) - P_C > f_i(\bar{\phi}_{HS}, \bar{a}_i) - P_{HS} \quad (3.14)$$

where:

C = college; and

H = high school.

Although equation 3.14 models a discreet choice on the part of a particular person (i.e., get a degree or not), it provides insights as to how we can obtain the aggregate supply function for educated workers. Consider a randomly selected individual. The probability that he/she will pursue a degree ( $Pr_i$ ) can be written:

$$\begin{aligned} Pr_i &= Pr_i[f_i(\bar{\phi}_C, \bar{a}_i) - P_C \\ &> f_i(\bar{\phi}_{HS}, \bar{a}_i) - P_{HS}] \end{aligned} \quad (3.15a)$$

$$= y_i(\bar{\phi}_{C-HS}, \bar{a}_i) \quad (3.15b)$$

where:

$\bar{\phi}_{C-HS}$  = the financial and non-pecuniary benefits of obtaining a college education over and above those of a high school diploma.

Consider next a group of  $N$  people, each member of which has probability  $Pr_g$  of obtaining a degree. The expected number of educated workers,  $E(L_E)$ , in this group (i.e., the supply) is given by:

$$E(L_E) = \sum_g n_g Pr_g = \sum_g n_g y_g(\bar{\phi}_C^*, \bar{a}_g) \quad (3.16)$$

Define now a vector,  $\bar{A}$ , that includes all elements found in any  $\bar{a}_i$  (i.e.,  $a_i \in A$ , for all  $i$ ) and substitute it for  $\bar{a}_g$ . This allows equation 3.16 to be rewritten:

$$\begin{aligned} E(L_E) &= \sum_g n_g y_g(\bar{\phi}_C^*, \bar{A}) \\ &= b(\bar{\phi}_C^*, \bar{A}) \end{aligned} \quad (3.17)$$

This says the supply of educated workers in a population depends on the financial and non-pecuniary returns associated with a college degree and the distribution of background characteristics that influence the level of utility people derive from education. But while equations 3.14 to 3.17 tell us what factors affect the supply of college graduates they reveal no clues as to the properties such a supply function should possess to be consistent with utility maximization. This shortcoming, however, is common to all models which seek to explain the overall quantity of a given type of human capital skill. It is, unfortunately, an area in which to date little work

has been done. With respect to the supply of educated labor, then, any model that is conditioned on both the financial and psychic returns to obtaining a degree is, at present, preferable to one which ignores the psychic returns altogether.

Still, the success of making equation 3.17 empirically operational depends on correctly identifying how the elements of  $\bar{A}$  are distributed throughout the population. Since many of these elements are unobservable, it becomes necessary to find proxy variables that reflect their influence. Again, we draw on the work of George Johnson (1970). Johnson estimated the following specification for the supply of college graduates; his results are presented in Table 5.

$$\ln k = \beta_0 + \beta_1 \ln R + \beta_2 \text{Urb} + \beta_3 \text{Age} + \beta_4 \text{Neg} \\ + \beta_5 \text{Pub} \quad (3.18)$$

where:

- k = the proportion of all males over 25 who have four or more years of college;
- R = the difference in median income of people with four or more years of college and people with four years of high school divided by the latter;
- Age = the median age of employed males;
- Neg = the proportion of male workers who are black;
- Pub = state and local funds spent for higher education (including scholarships) per population age 18-24 in 1957;

Table 5. The Supply of Educated Labor as Estimated by George Johnson

Estimation Technique	OLS		2SLS	
Constant	-1.448	(.862)	-.706	(.927)
ln R	.316	(.121)	.784	(.266)
Urb	1.046	(.134)	.859	(.162)
Age	-.034	(.021)	-.040	(.020)
Neg	-.662	(.263)	-1.077	(.334)
Pub	.128	(.057)	.254	(.085)
R <sup>2</sup>	.745			

Estimated standard errors in parentheses.

Source: Johnson (1970).

Urb = the proportion of all males, age 25 and over, who live in urban areas.

Table 5 suggests the best proxies for  $\bar{A}$  are socio-demographic variables (e.g., Urb, Age and Neg in equation 3.18). But this is not surprising. Such variables measure the relative importance of people with a particular background trait in the overall population. If this trait affects one's choice about obtaining a degree, or is correlated with other unobserved characteristics affecting this decision, we would expect it to be helpful in explaining the overall stock of college graduates. With respect to equation 3.18, the linkages between the socio-demographic variables used and (at least some of) the elements of  $\bar{A}$  are intuitively straightforward. Minority families generally have less income than white families and so financing a college education is often more of an economic burden to them. But parents of minority children are also less likely to have obtained degrees themselves. The combination of these influences may lead minority children to put less emphasis on obtaining a degree. Similarly, since most colleges are in cities, people who live in urban areas can often lower the costs of college by residing at home. But growing up near a university also exposes a person to the atmosphere around a college and thus makes becoming a student easier. Finally, Age gives marginal consideration to the fact younger people have more years in which to realize the benefits of education and so will be more likely to undertake college training.

The investment aspect of obtaining a degree is captured primarily by  $R$  and  $Pub$ .  $R$  reflects the additional annual earnings of college graduates (on average) over people with only a high school diploma. Although the decision to attend college is made in anticipation of financial rewards accruing over a period of many years, any variable reflecting such a stream will be highly correlated with  $R$ .  $Pub$  enters the investment aspect of obtaining a degree because it is a public subsidy to higher education. It thus represents a lowering of the costs to students of getting a college education.

As mentioned at the end of Section 3.1, the current study borrows substantially from Johnson's work, though this is more true of the demand for educated labor than the supply. But before presenting the alternative model and its empirical results we must first join Sections 3.1 and 3.2 together and form a market for college graduates. This is done in the next section, which also critiques Johnson's study.

### 3.3 The Market for Educated Labor

Sections 3.1 and 3.2, respectively, looked at the theoretical considerations which underlie the demand for and supply of educated labor. We now join these relationships together and consider the market for college graduates. Our first objective is to examine how this market can be specified if it is to be used to estimate the social rate of return to investments in higher education. We then outline the procedure that will be employed in the next chapter

to calculate this rate of return. Finally, the previously discussed work of Johnson (1970) is critiqued with the goal of making it more theoretically appealing.

Economists have long estimated the economic benefits that accrue to buyers and sellers in a given market with, respectively, the areas of consumer and producer surplus associated with the Marshallian supply and demand curves.<sup>14/</sup> Similarly, changes in these areas have traditionally been used to measure the change in each group's welfare resulting from the implementation of a given policy. Unfortunately, the scope of this technique generally does not allow one to estimate how society gains or loses from a particular action. The reason is markets are usually specified in a partial equilibrium framework. That is, the supply and demand curves are formulated, holding constant the prices of all other goods. But markets are frequently interrelated. Changes in the supply and/or demand of one good often trigger repercussions in the price and/or quantity offered of other goods. To see how this affects social welfare measurement consider Figures 3a and 3b, which we will assume represent the markets for college and high school graduates, respectively.

Initially consider just the market for degree holders and let it be described by  $S_{LE}$  and  $D_{LE}^0$  in Figure 3a. Equilibrium occurs where  $Q_{LE}^0$  graduates are employed at a wage of  $W_{LE}^0$ . By inspection, those people who supply educated labor realize benefits equal to area c; those who purchase it get benefits amounting to area a+b. Assume now there is a change in one of the exogenous forces affecting this market (say several firms in this market decide to enter high

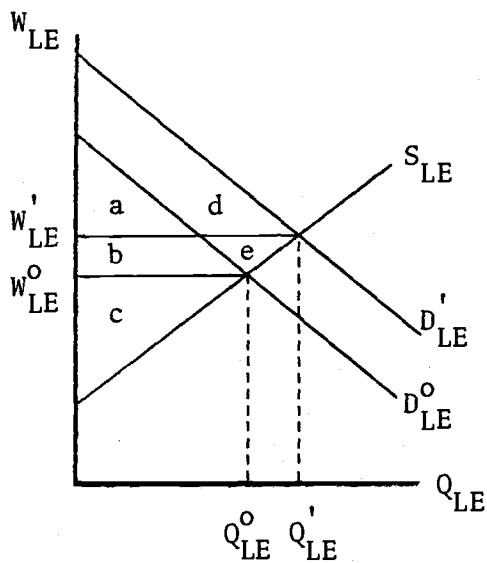


Figure 3a.

A Hypothetical Representation  
of the Labor Market for  
College Graduates

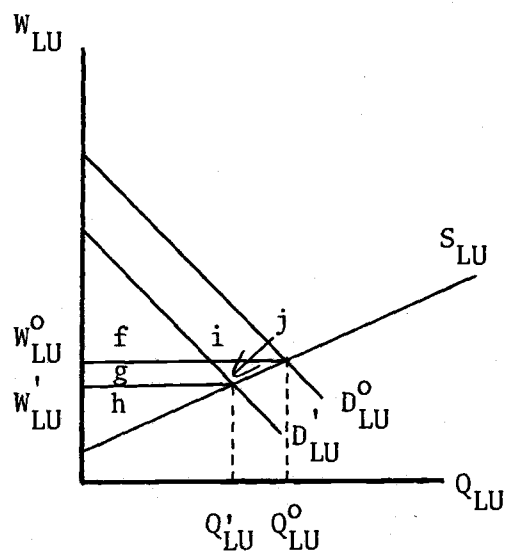


Figure 3b.

A Hypothetical Representation  
of the Labor Market for High  
School Graduates

technology fields) and as a result demand for college graduates shifts upward to  $D_{LE}^1$ . Equilibrium now occurs at employment level  $Q_{LE}^1$  and wage rate  $W_{LE}^1$ . Sellers of educated labor now receive benefits totaling areas  $c+b+e$  (for a gain of  $b+e$ ); buyers now realize benefits equal to area  $a+d$  (a gain of  $d-b$ ). Clearly, the shift in demand has resulted in an economic gain to the participants in this market of area  $d+e$ .

But does  $d+e$  reflect the net gain to society as a whole from the shift in demand? It does, if changes in the supply of and/or demand for college graduates do not trigger price and/or quantity changes in any other market. But what if the increased demand for degree holders effects a change in the market for uneducated workers. Say, for instance, the market for high school graduates is initially



described by  $S_{LU}$  and  $D_{LU}^0$  in Figure 3b. Equilibrium is at employment level  $Q_{LU}^0$  and wage rate  $W_{LU}^0$ . As Figure 3b demonstrates, sellers of uneducated labor initially receive benefits equal to areas  $g+h+j$ ; buyers get benefits totaling areas  $f+i$ . Now assume as a result of the increase in demand for college graduates demand for uneducated workers shifts downward from  $D_{LU}^0$  to  $D_{LU}'$ . A new equilibrium is reached at employment level  $Q_{LU}'$  and wage rate  $W_{LU}'$ . By inspection, the benefits accruing to sellers of uneducated labor now amount to area  $h$  (a loss of  $g+j$ ); purchasers now receive benefits equaling areas  $f+g$  (a loss of  $i-g$ ). Therefore, the increase in demand for college graduates results in an economic loss of area  $i+j$  to participants in the market for non-degree holders. Hence, the change in welfare to society as a whole is given by area  $d+e-i-j$ .

The preceding discussion suggests that if we wish to estimate the total economic impact on society of a policy implemented in a particular market we must not only model that market but also all related markets. If the number of related goods is large, this approach can get prohibitively complicated. Fortunately, an alternative often exists and this is to model the market of interest with general (rather than partial) equilibrium supply and demand curves. These curves have the property of allowing for equilibrium price and quantity adjustments in related markets that result from equilibrium price and quantity shifts in the primary market being analyzed.<sup>15/</sup> With respect to the present study, this means specifying the market for college graduates with supply and demand curves that take into account the movement from  $W_{LU}^0, Q_{LU}^0$

to  $W'_{LU}Q'_{LU}$  (i.e., the loss of area i+j) as the market for educated labor adjusts from  $W_{LE}^0Q_{LE}^0$  to  $Q'_{LE}Q'_{LE}$  (i.e., gains area d+e).

To estimate the market for college graduates in general equilibrium form we employ a methodology suggested by Just, Hueth and Schmitz (1982).<sup>16/</sup> This methodology is outlined here because its understanding is crucial to understanding the empirical model presented in the next chapter. Consider Figure 4 in which we will assume  $Dq_{LE}$  and  $Dq_{LE}^E$  describe, respectively, the ordinary and equilibrium demand for educated workers.

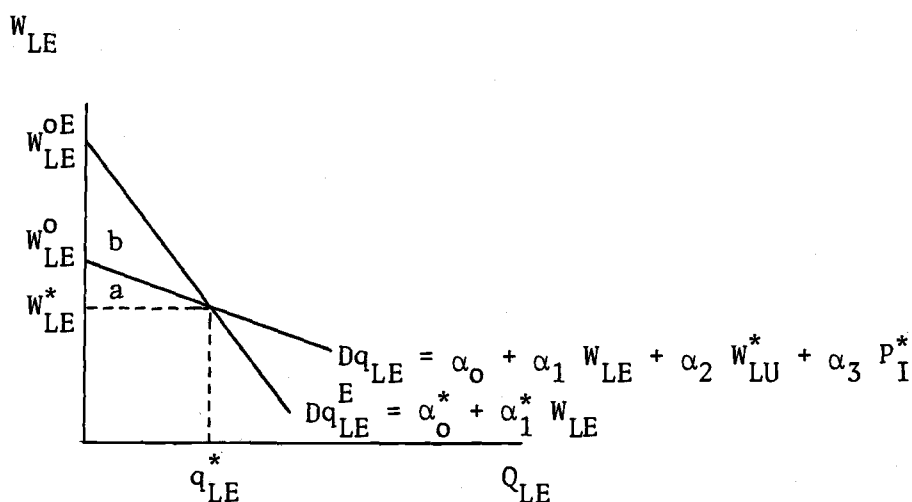


Figure 4.

A Hypothetical Representation of the Marshallian and General Equilibrium Demand Curves for College Educated Labor

The considerations of Section 3.1 suggest the ordinary demand curve for college graduates can be written as a function of the wage rates paid both degree and non-degree holders and the prices

of goods for which educated labor is an input. Assume, for simplicity, this function has the following specification:

$$Dq_{LE} = \alpha_0 + \alpha_1 W_{LE} + \alpha_2 W_{LU} + \alpha_3 P_I \quad (3.19)$$

where:

$P_I$  = an index of prices for outputs that employ educated labor in their production;

and we expect:

$\alpha_1 < 0$  (demand is downward sloping,  $\alpha_2 > 0$  (if the price of a substitute input rises, so too will the demand for the input being analyzed), and  $\alpha_3 > 0$  (if output price rises, so too will input prices via increased derived demand).

To obtain the (ordinary) demand curve  $Dq_{LE}$  shown in Figure 4 set  $W_{LU} = W_{LU}^*$  and  $P_I = P_I^*$ . Further, fixing  $W_{LE} = W_{LE}^*$  implies  $Dq_{LE} = q_{LE}^*$ . To determine the ordinary consumer surplus (CS) associated with  $(W_{LE}^*, q_{LE}^*)$  first set  $Dq_{LE} = 0$  and solve for  $W_{LE}$ . This solution is represented by  $W_{LE}^0$  in Figure 4 and is the minimum wage at which no educated labor is demanded given  $W_{LU} = W_{LU}^*$  and  $P_I = P_I^*$ . More formally:

$$W_{LE}^0 = - \frac{\alpha_0 + \alpha_2 W_{LU}^* + \alpha_3 P_I^*}{\alpha_1} \quad (3.20)$$

With  $W_{LE}^0$  known, the ordinary consumer surplus associated with  $(W_{LE}^*, q_{LE}^*)$  can be calculated from geometry and is given by:

$$\begin{aligned} CS &= \text{area a} \\ &= 1/2 (W_{LE}^0 - W_{LE}^*) q_{LE}^* \end{aligned} \quad (3.21)$$

But now suppose changes in the equilibrium wage of college graduates trigger price changes in the uneducated labor market as well as the market for the products of educated labor. Suppose, also, that these relationships can be written:

$$W_{LU} = \beta_0 + \beta_1 W_{LE} \quad (3.22)$$

$$P_I = C_0 + C_1 W_{LE} \quad (3.23)$$

Substituting equations 3.22 and 3.23 into equations 3.19 obtains a demand curve that not only models price changes in the market for degree holders but also takes account of price adjustments in related markets that occur in response to movements in the wage paid educated workers. In other words, we obtain the following general equilibrium demand curve for college graduates.

$$\begin{aligned} Dq_{LE}^E &= \alpha_0 + \alpha_1 W_{LE} + \alpha_2(\beta_0 + \beta_1 W_{LE}) + \alpha_3(C_0 + C_1 W_{LE}) \\ &= \alpha_0^* + \alpha_1^* W_{LE} \end{aligned} \quad (3.24)$$

where:

$$\alpha_0^* = \alpha_0 + \alpha_2\beta_0 + \alpha_3C_0$$

$$\alpha_1^* = \alpha_1 + \alpha_2\beta_1 + \alpha_3C_1$$

and we expect  $\alpha_1^* < 0$  (i.e., the equilibrium demand curve is downward sloping).

Setting  $Dq_{LE}^E = 0$  and solving for  $W_{LE}$  yields the wage intercept of the equilibrium demand curve. By inspection, this value equals

$-\alpha_0^*/\alpha_1^*$ ; it is shown as  $W_{LE}^{OE}$  in Figure 4. With  $W_{LE}^{OE}$  known, the equilibrium consumer surplus ( $CS^E$ ) associated with  $(W_{LE}^*, q_{LE}^*)$  can be estimated, using geometry, as follows:

$$\begin{aligned} CS^E &= \text{area } a+b \\ &= 1/2 (W_{LE}^{OE} - W_{LE}^*) q_{LE}^* \end{aligned} \quad (3.25)$$

Before proceeding, three points should be made. First, the demand for college graduates depicted in Figure 4 shows net economic gains to consumers outside the market for educated labor. This is reflected by the slope of  $Dq_{LE}^E$  being greater (in absolute value) than that of  $Dq_{LE}$ . Whether or not this is actually the case is an empirical question that will be addressed in the next chapter. For now, the relationships shown in Figure 4 should be viewed as being presented for illustrative purposes only. Second, the above discussion dealt only with identifying an equilibrium demand curve. Generally speaking, symmetrical arguments can be developed that allow construction of equilibrium supply curves as well.<sup>17/</sup>

Finally, in equations 3.22 and 3.23 the uneducated wage and output prices were assumed to be functions of  $W_{LE}$  alone. In reality, both  $W_{LU}$  and  $P_I$  are likely to be influenced by other exogenous factors in the economy. The wage paid non-degree holders, for example, will likely be higher in areas where labor unions exercise a lot of power than in areas where they do not. Similarly, output prices are likely to be increased by the imposition of a tax on producers or quotas on imported substitutes. Suppose we define the

exogenous forces that influence the uneducated wage by the variable  $Z$  and those that influence output prices by the variable  $Y$ . Equations 3.22 and 3.23 then become:

$$W_{LU} = \beta_0 + \beta_1 W_{LE} + \beta_2 Z \quad (3.26)$$

$$P_I = C_0 + C_1 W_{LE} + C_2 Y \quad (3.27)$$

The appropriate equilibrium demand curve for educated labor is now constructed by substituting equations 3.26 and 3.27 into equation 3.19, yielding:

$$\begin{aligned} Dq_{LE}^E &= \alpha_0 + \alpha_1 W_{LE} + \alpha_2(\beta_0 + \beta_1 W_{LE} + \beta_2 Z) \\ &\quad + \alpha_3(C_0 + C_1 W_{LE} + C_2 Y) \\ &= \alpha_0^* + \alpha_1^* W_{LE} + \alpha_2^* Z + \alpha_3^* Y \end{aligned} \quad (3.28)$$

where:

$$\alpha_0^* = \alpha_0 + \alpha_2\beta_0 + \alpha_3C_0, \quad \alpha_1^* = \alpha_1 + \alpha_2\beta_1 + \alpha_3C_1$$

$$\alpha_2^* = \alpha_2\beta_2, \quad \alpha_3^* = \alpha_3C_2$$

If the just described general equilibrium framework is to be made operational, it will have to be embodied in an empirical model. We will shortly construct such a model but for the moment assume the equilibrium supply and demand curves have been identified. The next question of concern is, how can these curves be used to estimate the marginal social rate of return to investments in higher education? To illustrate the procedure this study will employ

consider the hypothetical market for degree holders depicted in Figure 5.

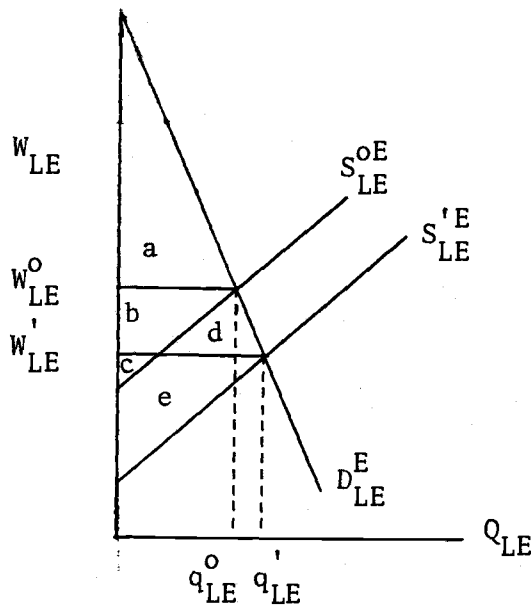


Figure 5.

A Hypothetical Representation of the General  
Equilibrium Labor Market for College Graduates

Let  $S_{LE}^{OE}$  and  $D_{LE}^E$  represent the initial (general equilibrium) supply and demand relationships. Equilibrium occurs at  $(w_{LE}^O, q_{LE}^O)$ , and society receives benefits totaling areas  $a+b+c$ . Since public expenditures for higher education act to lower the cost to students of obtaining a degree, they impact primarily on the supply of college graduates. Hence, by specifying the supply of degree holders as a function of public investment in higher education we can examine how shifts in such expenditures would affect the educated labor market.<sup>18/</sup> Assume we do exactly this. That is, let us suppose public investment in higher education is increased by some amount  $k$  and as a result supply shifts to  $S_{LE}'^E$ . By

inspection, the (marginal) gain to society from  $k$  is given by area  $d+e$ . But, as specified in Figure 5, this is the gain which accrues in one time period, say a year. To estimate a stream of returns resulting from the increased expenditure assume society receives similar benefits in each of the next  $T$  years. This stream can then be combined with the cost  $k$  in equation 3.22 to calculate a marginal social rate of return to the investment.

$$0 = -k + \sum_{i=1}^T \frac{d+e}{(1+r)^i} \quad (3.22)$$

By definition, the rate of return we seek is the value of  $r$  that sets equation 3.22 equal to zero.

In Sections 3.1 and 3.2, a paper by George Johnson (1970) was cited to illustrate the possibilities of empirically estimating the demand for and supply of educated labor. That work lends much to the empirical analysis of the present study. Hence, we now critique Johnson's model with an eye toward making it more theoretically appealing.

Theory tells us that any ordinary demand function should have as an argument output price. As noted earlier, the absence of such a price is a shortcoming in Johnson's model (see equation 3.9). But, as also noted previously, this shortcoming is likely to occur in demand equations estimated with cross sectional data, particularly at more aggregate levels. The reason is cross sectional data reflecting price variations for a given good (set of goods) across states is extremely hard to find. Johnson found no such data set



for the products of educated labor and so had to omit output price from his model. When analyzing the aggregate demand for a factor of production an additional problem can occur, that of defining the output for which to measure a price. Many industries, for example, employ educated labor in their production process. Clearly, including the prices of all goods produced by these industries is empirically impossible. Defining an output price, then, becomes somewhat arbitrary and even if accomplished may not solve the (no) price variation problem. Hence, when dealing with cross sectional data it may often be necessary to drop output price from the demand equation and admit to a shortcoming in one's model.

Turning to the supply of college graduates (see equation 3.18), Johnson's model may be made more appealing in a couple of respects. First, the independent variables  $R$  (the proportionate difference in median incomes between degree and non-degree holders in 1960) and  $Pub$  (the sum of state and local funds spent for higher education in 1957) can be redefined. As measured, their relationship to the dependent variable is conceptually weak. Recall the dependent variable in the study was the proportion of all males in 1960, age 25 and over, who had completed four or more years of college. Included in this group were people who received their degrees between 1917 and 1960.<sup>19/</sup> The expenditures represented by  $Pub$ , however, could not have affected any degree holders who received their diplomas prior to 1957. Of course, one can argue that funding patterns do not change dramatically from one year to the next. Even so, it is unrealistic to use 1957 data to model the education

decision of people all the way back to 1917. Additionally, Pub ignores federal funds going to higher education. From the standpoint of colleges and universities, this is a major source of public money.

Similarly, the effect of R on the education decision of people in 1920, 1930, 1940 and 1950 is nonexistent. That is, people who chose to pursue college graining between 1920 and 1950 could not possibly have based their decision on the wage rates of degree and non-degree holders in 1960. One could even argue that R has no influence on the number of college graduates in 1960. This is because the decision to obtain a degree is made with information available at the time of enrollment. Hence, R's impact would not be felt until 1964.<sup>20/</sup>

The preceding discussion suggests the following alteration to Johnson's model that would make it more appealing. Consider the total stock of college graduates at any time  $t$  to be conditioned on past, not present, wage differentials between degree and non-degree holders.<sup>21/ 22/</sup> That is, assume people base their education choice on knowledge they have at the time of enrollment. In time  $t$  wage-quantity space, then, the supply of educated labor is perfectly inelastic (or fixed) and the wage paid college graduates is determined by the demand for their services. This implies the market for degree holders can be modeled as in Figure 6a; Johnson's framework is presented in Figure 6b.

In addition to being more consistent with the forces that influence the schooling decision, the model depicted in Figure 6a

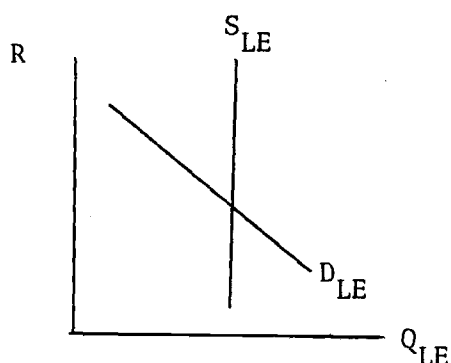


Figure 6a.

The Educated Labor Market  
as Presented in This Study

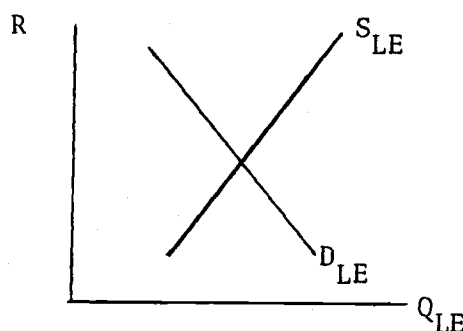


Figure 6b.

The Educated Labor Market  
as Presented in Johnson's Study

has two other advantages over Johnson's framework. First, it is intuitively more plausible. A college education takes years to acquire. Thus, in a given state, an increase (decrease) in the earnings of graduates relative to non-degree holders can only increase (decrease) the number of people who pursue higher education; it cannot affect the number of people who already have degrees (i.e., ignoring migration, see footnote 22). Second, the model presented in Figure 6a can be estimated by ordinary least squares (OLS) without incurring simultaneous equation bias. This is because we assume supply fixed at its observed quantity and no explanatory variable is endogenously determined. Johnson's framework requires the use of a simultaneous equation technique, since  $R$  is jointly determined by supply and demand. From an empirical standpoint, it is better if the use of OLS can be justified because the data can then be more thoroughly analyzed for econometric problems.<sup>23/</sup>

This chapter has examined the theoretical considerations behind the supply of and demand for educated labor. It has discussed how this market can be specified in order to obtain an estimate of the marginal social rate of return to investments in higher education. The time has now come to put the theory into practice; the empirical analysis, to which we now turn, is the subject of the next chapter.

ENDNOTES

1/ See Ehrenberg and Smith (pp. 254-55).

2/ That is, we assume the firm's profit function ( ) can be written as:

$$\pi = \pi_1(P, W_{LE}, W_{LU}) + \pi_2(P, W_K, W_E, W_M)$$

3/ Proof:

The firm's problem:

$$\begin{aligned} \text{Max } \pi = & [Pf_1(L_E, L_U) - W_{LE}L_E - W_{LU}L_U] \\ & + [Pf_2(K, E, M) - W_KK - W_EE - W_MM] \end{aligned} \quad (1)$$

The first order conditions (F.O.C.) for profit maximization are:

$$\frac{\partial \pi}{\partial L_E} = P \frac{\partial f_1(L_E, L_U)}{\partial L_E} - W_{LE} = 0 \quad (2)$$

$$\frac{\partial \pi}{\partial L_U} = P \frac{\partial f_1(L_E, L_U)}{\partial L_U} - W_{LU} = 0 \quad (3)$$

$$\frac{\partial \pi}{\partial K} = P \frac{\partial f_2(K, E, M)}{\partial K} - W_K = 0 \quad (4)$$

$$\frac{\partial \pi}{\partial E} = P \frac{\partial f_2(K, E, M)}{\partial E} - W_E = 0 \quad (5)$$

$$\frac{\partial \pi}{\partial M} = P \frac{\partial f_2(K, E, M)}{\partial M} - W_M = 0 \quad (6)$$

Solving equations (2) through (6) for the profit maximizing input level wage given any set of input and output prices yields:

$$L_E^* = L_E^*(W_{LE}, W_{LU}, P)$$

$$L_U^* = L_U^*(W_{LE}, W_{LU}, P)$$

$$K^* = K^*(W_K, W_E, W_M, P)$$

$$E^* = E^*(W_K, W_E, W_M, P)$$

$$M^* = M^*(W_K, W_E, W_M, P)$$

Substituting  $L_E^*$ ,  $L_U^*$ ,  $K^*$ ,  $E^*$ , and  $M^*$  into (1) yields the maximum value of profits for any set of input and output prices.

That is,

$$\begin{aligned} \pi^* &= [Pf_1(L_E^*, L_U^*) - W_{LE}L_E^* - W_{LU}L_U^*] \\ &\quad + [Pf_2(K^*, E^*, M^*) - W_KK^* - W_EE^* - W_MM^*] \\ &= \pi_1(P, W_{LE}, W_{LU}) + \pi_2(P, W_K, W_E, W_M) \end{aligned}$$

By Hotelling's Lemma:  $\frac{\partial \pi^*}{\partial W_i} = -q_i$

$$\begin{aligned} \frac{\partial \pi^*}{\partial W_{LE}} &= P \frac{\partial f_1}{\partial L_E^*} \frac{\partial L_E^*}{\partial W_{LE}} + P \frac{\partial f_1}{\partial L_U^*} \frac{\partial L_U^*}{\partial W_{LE}} - L_E^* - W_{LE} \frac{\partial L_E^*}{\partial W_{LE}} \\ &\quad - W_{LU} \frac{\partial L_U^*}{\partial W_{LE}} \end{aligned}$$

(Note:  $\frac{\partial \pi_2}{\partial W_{LE}} = 0$ )

Rearranging

$$\begin{aligned} \frac{\partial \pi^*}{\partial W_{LE}} &= \underbrace{\left( P \frac{\partial f_1}{\partial L_E^*} - W_{LE} \right)}_{= 0 \text{ by F.O.C.}} \left( \frac{\partial L_E^*}{\partial W_{LE}} \right) + \underbrace{\left( P \frac{\partial f_1}{\partial L_U^*} - W_{LU} \right)}_{= 0 \text{ by F.O.C.}} \left( \frac{\partial L_U^*}{\partial W_{LE}} \right) - L_E^* \end{aligned}$$

$$= - L_E^*$$

$$= - L_E^*(P, W_{LE}, W_{LU})$$

⇒ if the firm's profit function is additive with respect to labor and other inputs, then its demand for educated labor can be written as a function of  $W_{LE}$ ,  $W_{LU}$  and  $P$ .

Q.E.D.

Admittedly, the assumption of an additive profit function is very restrictive. It implies that the marginal product of labor (educated or uneducated) does not change with changes in the amounts of capital, energy or materials employed by the firm. It also assumes that the firm's total profit (and production) is made up of two distinct and separate components-- that attributable to labor and that attributable to capital, energy, and materials. Clearly, neither of these assumptions is very realistic. Unfortunately, we were unable to identify any weaker set of assumptions that would allow the firm's demand curve to be specified as functions of  $P$ ,  $W_{LE}$ , and  $W_{LU}$  alone.

- 4/ Not explicitly accounted for here is the demand for the firm's product, which clearly underlies its demand for all input. Changes in this underlying demand, however, are generally mirrored (at least in a competitive economy) by changes in  $P$ .
- 5/ This also assumes non-degree holders do not generally retire at an earlier age than college graduates.
- 6/ The term "direct" is used here to differentiate  $\phi$  from the Allen elasticity of substitution.
- 7/ The correlation between on the job training and employer preference for educated workers was first shown by Mincer (1962). More recently, Rumberger (1981) has demonstrated that these are the jobs in which college graduates have slowly been replacing non-degree holders.

- 8/ Actually, this variable reflects jobs possessing few, if any, elements of  $\bar{\delta}$ . Hence,

$$\frac{\partial D_{LE}^*}{\partial AG} < 0$$

- 9/ Non-pecuniary, consumption and psychic benefits are used interchangeably.
- 10/ For a complete critique of the present value maximization approach to the choice of schooling and income distribution see Deaton and Muellbauer, pp. 294-301.
- 11/ To see how equations 3.11 and 3.12 follow from equation 3.10, see Deaton and Muellbauer, pp. 294-301.
- 12/ These calculations are borrowed from Ehrenberg and Smith, p. 232.
- 13/  $P_j$  here represents only the direct costs of schooling. Actually, these costs vary from one individual to another since different people have different opportunity costs and face different interest rates. These factors, however, can be viewed as elements of  $\phi_i$  or  $\bar{a}_i$ ; that is, they either increase or decrease the benefits individual  $i$  attributes to getting a degree.
- 14/ These results are laid out in Just, Hueth and Schmitz, Applied Welfare Analysis and Public Policy, 1982; see Chapter 5 for a single producer, Chapter 6 for a single consumer, and Chapters 8 and 9 for aggregations across people and firms. Also, consumer results are rigorously proved in Appendix B.
- 15/ Ibid., Chapter 9 and Appendix D for a proof of the theoretical equivalence of these two approaches.
- 16/ Ibid., see Chapter 9.5.
- 17/ For a similar development of an equilibrium supply curve see Ibid., Section 9.5.
- 18/ For simplicity, we are ignoring the lagged nature of these expenditures here. This will be dealt with in Chapter IV.



- 19/ Assuming people receive their diploma at age 22 and retire at age 65, individuals who graduated in 1917 would be included in Johnson's dependent variable.
- 20/ Still from an empirical standpoint, R would probably perform fairly well in modeling the education decision of the most recent graduates in 1960 since income (at this level of aggregation) changes slowly over time.
- 21/ Assuming people require four years to obtain a degree, the influence of wage differentials in years  $t-i$  ( $i = 1,2,3$ ) would be zero.
- 22/ It should be noted that we are ignoring migration of educated workers between states. While the decision to move is undoubtedly conditioned on current wage information, the effect of migration on the size of the educated work force of a state (at least in most cases) is relatively small compared to the effect of annual graduation. Further, including both past and current wage differentials in a model would undoubtedly create problems with multicollinearity.
- 23/ With 2SLS one cannot check for multicollinearity, heteroscedasticity or autocorrelation.

## CHAPTER IV

## THE MODEL AND EMPIRICAL RESULTS

This chapter presents the empirical analysis of our study. The model used to estimate the marginal social rate of return to investments in higher education is developed in Section 4.1. Section 4.2 describes the data set to which we fit this model, and Section 4.3 details the empirical results.

## 4.1 The Model

Sections 3.1 and 3.2 developed, respectively, the following partial equilibrium demand and supply relationships for educated labor.

Demand (see equation 3.8):

$$D_{LE} = h(P, W_{LE}, W_{LU}, \bar{\delta}) \quad (4.1)$$

where:

- $P$  = the price of goods for which educated labor is an input;
- $W_{LE}$  = the wage paid degree holders;
- $W_{LU}$  = the wage paid non-degree holders;
- $\bar{\delta}$  = a vector of job characteristics that define the elasticity of substitution between educated and uneducated labor.

Supply (see equation 3.17):

$$S_{LE} = b(\bar{\phi}_{C-HS}, \bar{A}) \quad (4.2)$$

where:

$\bar{\phi}_{C-HS}$  = a vector containing the financial and non-pecuniary benefits of obtaining a college degree over and above those of a high school diploma;

$\bar{A}$  = a vector of background variables that influence the level of utility people receive from higher education.

These sections also noted that many elements of  $\bar{\delta}$  and  $\bar{A}$  are unobservable and, hence, the prospects for making equations 4.1 and 4.2 empirically operational depend on finding proxy variables that reflect the influence of these vectors. Towards this objective a model developed by George Johnson (1970) was presented and discussed. This work contributes to the empirical analysis of the present study. Therefore, to assist the reader in comparing Johnson's model with ours we restate his supply and demand relationships for educated labor.

Johnson's Demand Curve for Educated Labor:

$$\ln k = \alpha_0 + \alpha_1 \ln R + \alpha_2 SK + \alpha_3 AG \quad (4.3)$$

where:

$k$  = the proportion of all males, 25 and over, who have completed four or more years of college;

$R$  = the difference in median income of people with four or more years of college and people with four years of high school divided by the latter;

$SK$  = the proportion of the experienced male work force in finance, real estate, insurance, professional and related services and public administration;

AG = the proportion of experienced male workers in fisheries, agriculture and forestry.

Johnson's Supply Curve for Educated Labor:

$$\ln k = \beta_0 + \beta_1 \ln R + \beta_2 \text{URB} + \beta_3 \text{AGE} + \beta_4 \text{NEG} + \beta_5 \text{PUB} \quad (4.4)$$

where:

R and k are as in equation 4.3;

URB = the porportion of all males, 25 and over, who live in urban areas;

AGE = the median age of employed males;

NEG = the proportion of male workers who are black;

PUB = state and local funds spent for higher education (including scholarships) per population age 18-24 in 1957.

Section 3.3 critiqued the above model. It was argued there that in Johnson's supply curve (equation 4.4) the linkages between the dependent variable,  $\ln k$ , and the independent variables  $\ln R$  and PUB were weak. This was because, as measured, the latter two variables could only have influenced a very small proportion of the people included in  $k$ . We then argued that people base their decision to obtain a degree on information available to them at the time of enrollment. This suggests the current stock of educated labor is a function of past, not present, forces. In time  $t$  wage-quantity space, then, the supply of college graduates can be treated as fixed.

Modifying equations 4.3 and 4.4 to reflect the criticisms of Sections 3.3 we hypothesize the following model to describe the (partial equilibrium) market for college graduates.

Demand:

$$k = f(\text{Re}1W, \text{SK}, \text{UNSK}) \quad (4.5)$$

where:

$k$  = the proportion of the male work force who have completed four or more years of college;

$\text{Re}1W = W_{LE}/W_{LU}$  = the median incomes of people who have completed four years of college divided by the median income of people who have completed four years of high school;

$\text{SK}$  = the proportion of the experienced male work force in finance, real estate, insurance, professional and related services and public administration;

$\text{UNSK}$  = the proportion of the experienced male work force in fisheries, agriculture, forestry and mining.

Supply:

$$\text{DH}_t = \text{DH}_{t-1} + h(\text{Re}1W_{(t-4)}, \text{URB}, \text{INV}_{(t-4)}) \quad (4.6)$$

where:

$\text{DH}_t$  = the number of degree holders in year  $t$ ;

$\text{Re}1W$  = defined as in equation 4.5 but lagged four years;

$\text{URB}$  = the proportion of males, age 25-30 in year  $t$ , who reside in urban areas;

INV = expenditures per student (measured as the sum of government appropriations, endowment income, private gifts, sponsored research, and student aid all divided by total enrollment) in thousands of dollars, by colleges and universities. Again, this variable is lagged four years.

The reader will note equations 4.5 and 4.6 are completely general; neither implies any particular mathematical relationship between its dependent and independent variables. Such relationships are, in large part, the subject of empirical investigation.<sup>1/</sup> Hence, we defer questions regarding the functional forms of the supply and demand curves until Section 4.3 (i.e., the empirical results section). Prior to estimation, however, the supply curve was modified to reflect the degree decisions of only the most recent graduates (i.e., the degree holders most like those people who would be effected by changes in the level of public investment in higher education). This was done by subtracting  $DH_{(t-1)}$  from both sides of equation 4.6. Therefore, the version of our model on which we carry out the empirical analysis is:

Demand:

$$k = f(\text{Re}1W, SK, \text{UNSK}) \quad (4.7)$$

Supply:

$$\text{Dif} = h(\text{Re}1W_{(t-4)}, \text{URB}, \text{INV}_{(t-4)}) \quad (4.8)$$

where  $\text{Dif} = DH_t - DH_{t-1}$ .

It is easy to see that output price has been omitted from equation 4.7. In this respect, our demand relationship has the same theoretical shortcoming that Johnson's (see equation 4.3) did and for the same reason; we were unable to locate any cross-sectional data reflecting price variations in the products of educated labor across states. This is not the only similarity our demand equation shares with Johnson's. In both studies, the influence of  $\bar{\delta}$  (the vector of job characteristics defining the elasticity of substitution between educated and uneducated workers) is measured using two proxy variables; one reflecting the proportion of the experienced male work force in professions that are college graduate intensive and the other reflecting the proportion in industries which employ primarily non-degree holders. The former group Johnson defined as finance, real estate, insurance, professional and related services and public administration. In the latter, he put fisheries, agriculture and forestry. Our study borrows Johnson's measure of skilled jobs directly (we acknowledge this by using his terminology, SK, for the variable). For unskilled professions we expand Johnson's measure by adding to it males employed in mining (we denote this variable UNSK, whereas Johnson used AG). Finally, in both demand equations the wages paid degree and non-degree holders (i.e.,  $W_{LE}$  and  $W_{LU}$ , respectively) are included in such a way as to represent the additional cost of hiring a college graduate over someone with just a high school diploma. This is because the two types of labor are substitute inputs and with such inputs it is the relative costs versus relative productivity firms consider in making their employment decision.

Turning to the supply of educated labor, the reader will note few similarities between the model developed by Johnson and the one used in the present study. Johnson assumes the supply of college graduates, in any individual state at any time  $t$ , to be a function of the current wage differential (in that state) between degree and non-degree holders. This implies an upward sloping supply curve in current wage-quantity space. Such a supply curve might be justified by the migration of educated workers between states; assuming this migration is the result of people searching for higher wages.

While we acknowledge the existence of inter-state migration by degree holders our model does not allow for it. Although this simplification eases our analysis (since supply can then be treated as fixed), it requires some further explanation. Suppose we separate the college graduates in a given state in year  $t$  into two groups, one containing the people who received their diplomas prior to year  $t$  and the other containing those individuals who obtained their degree in year  $t$  (i.e., those who just graduated from college). The first group consists of people who, by and large, have settled into the labor force. For these individuals moving to another state entails both financial and psychic costs (often quite large); thus, those contemplating such a move may do so only after much thought and preparation. Additionally, the knowledge of wage rate changes in a particular area generally takes time to disseminate to other parts of the country, and people must have this information before they can act on it. Hence, it seems plausible to assume that there



would be little immediate impact on those already in the work force from changes in the wages paid degree and non-degree holders in other states.

For the second group (recent graduates) this assumption may be less realistic. Many new graduates take jobs outside the state in which they earned their degree. Undoubtedly, a major reason for this is people going where they can make the most money. Unfortunately, we were unable to locate data reflecting the net migration of new graduates by state, and so could not incorporate this variable in our model.<sup>2/</sup>

In our framework, people decide to obtain a college degree (or not) based on information available to them at the time of enrollment. This implies a perfectly inelastic supply curve for college graduates in current wage-quantity space. We focus on the forces affecting the education decision of only the most recent graduates; the degree holders most like those people who would be affected by changes in the level of public expenditures for higher education. This is done by modeling a state's supply of degree holders in year  $t$  ( $DH_t$ ) as a function of the quantity of degree holders that state had in year  $t-1$  ( $DH_{t-1}$ ) and variables influencing the degree decision of the most recent graduates (see equation 4.6). Subtracting  $DH_{t-1}$  from both sides of this supply curve yields an equation describing how a state's educated labor force changes from year to year (i.e., equation 4.8). Since a college degree generally takes four years to acquire, the independent variables of this equation are lagged similarly. In equation 4.8  $RelW_{t-4}$

and  $INV_{t-4}$  measure the investment aspect of obtaining a degree ( $RelW_{t-4}$  because it tells how much more college graduates earned over individuals with only a high school diploma in the year those people included in Dif decided to pursue higher education and  $INV_{t-4}$  because it shows the costs of their college training the people in Dif were not called on to pay). Background variables affecting the level of utility students derive from college training are reflected in URB. While URB, clearly, does not measure all such variables the formulation of our supply curve greatly reduces the importance of the problem. That is, since we assume supply fixed and are interested only in how supply shifts with changes in the level of public expenditures for higher education the only coefficient of real interest to us is the one associated with INV (i.e.,  $d_3$  in equation 4.8).

To convert the model presented in equations 4.7 and 4.8 from a partial to a general equilibrium framework, we follow the procedure laid out by Just, Hueth and Schmitz (1982) (and described in Section 3.3). That is, we first consider the wage paid uneducated workers ( $W_{LU}$ ) as a function of the wage paid college graduates ( $W_{LE}$ ) as well as relevant exogenous forces in the economy (i.e., the forces represented by Z in equation 3.26). Once estimated, this equation is used to obtain a fitted value for  $W_{LU}$  ( $\hat{W}_{LU}$ ) in each state. Equation 4.7, the ordinary demand curve, is then reestimated with these fitted values taking the place of  $W_{LU}$ . The result is a model of the educated labor market that allows for price adjustments in the market for non-degree holders brought on by changes

in the wage paid college graduates (i.e., a general equilibrium model of the educated labor market). It is important to note that no similar substitution is necessary in the supply relationship. This is because we assume the quantities of educated and uneducated labor available today (in a given state) to be functions of past, not present, wage levels. Hence, changes in the current wage rates paid degree and non-degree holders can only lead to changes in the future supplies of these types of labor.

Developing an equation that includes exogenous forces in the economy as explanatory variables for the wage paid uneducated workers requires some approximation. Clearly, there are many such determinants, and it is doubtful all could even be identified let alone included in a workable model.<sup>3/</sup> It is, therefore, necessary to focus on a subset of these forces; a subset that provides fitted values of  $W_{LU}$  which, when substituted into equation 4.7, yield acceptable empirical results.

Our selection of exogenous determinants of  $W_{LU}$  is based on three well documented socio-economic phenomena.<sup>4/</sup> First, over the last several decades wages have been observed to be generally inflexible in a downward direction.<sup>5/</sup> This suggests including some measure of past earnings when trying to model current wage rates. Second, at all levels of educational attainment blacks and hispanics earn substantially less (on average) than whites with similar amounts of schooling.<sup>6/</sup> Since these minorities are made up predominantly of non-degree holders we would expect  $W_{LU}$  to be lower in states with large black and/or hispanic populations. Finally, for people with

similar years of education, those residing in urban communities average considerably higher earnings than those living in rural areas.<sup>7/</sup> Hence, we include a measure of urbanization as the final exogenous determinant of the wage paid uneducated workers. The preceding discussion suggests the following relationship:

$$W_{LU} = j(W_{LE}(t), INC_{(t-2)}, URBT(t), MIN(t)) \quad (4.9)$$

where:

$W_{LU}$  = the median annual income of male workers (18 years and older) with four years of high school;

$W_{LE}$  = the median annual income of male workers (18 years and older) with four years of college;

INC = per capita income;

URBT = the proportion of the male work force (18 years and older) who reside in urban areas;

MIN = the proportion of the male work force (18 years and older) who are black or hispanic.

Replacing  $W_{LU}$  in equation 4.7 with the fitted values obtained from equation 4.9 yields the following general equilibrium demand curve for college educated labor:

$$k_t = g(\widehat{Re1W}_t, SK_t, UNSK_t) \quad (4.10)$$

where:

$k$ ,  $SK$ ,  $UNSK$  are defined as in equations 4.5 and 4.7;

$\widehat{Re1W} = W_{LE}/W_{LU}$  = the median annual income of male workers (18 years and older) with four years of college ( $W_{LE}$ ) divided

by the fitted value for the median annual income for male workers (18 years and older) with four years of high school ( $W_{LU}$ ).

This section has developed a model of the educated labor market (in both partial and general equilibrium) that can be empirically estimated. But before doing so we must first describe the data set to which it will be fit. This is the subject of the next section.

#### 4.2 The Data

Our model (equations 4.7 - 4.10) is estimated such that it describes the market for college trained male workers in 1970 (i.e.,  $t = 1970$ ). As in many past works (see Tables 1 and 2) women are excluded from the study in order to create a more homogeneous data set. We employ cross sectional data and treat each state in the U.S. as a separate labor market. To eliminate the effects of inflation, all money variables are expressed in 1970 dollars.

The primary source of data is the Census of Population: 1970. Additional data come from the Census of Population: 1960; The Statistical Abstract of the United States: 1970; Financial Statistics of Institutions of Higher Education: 1966-67; and Opening Fall Enrollments; Higher Education: 1966.

In what follows we define precisely how each variable was measured and give the source(s) from where its observations were obtained. In some cases, direct observation was impossible. For these variables we describe the nature of the measurement problem encountered and detail the remedial procedure used. For the

reader's convenience, each equation is restated prior to discussing the variables in it.

Demand (partial equilibrium):

$$k_t = f(\text{Re}1W_{(t)}, SK_{(t)}, \text{UNSK}_{(t)})$$

$$t = 1970$$

k: Defined as the total male work force (18 years and over) with four or more years of college divided by the total male work force (18 years and over).

Source: Census of the Population: 1970, table 197.

Re1W: Defined as the median annual income of male workers (18 years and over) with four years of college divided by the median annual income of male workers (18 years and over) with four years of high school.

Source: Census of the Population: 1970, table 197.

SK: Defined as the experienced male work force in finance, insurance, real estate, professional and related services and public administration divided by the total experienced male work force.

Source: Census of the Population: 1970, table 183.

UNSK: Defined as the experienced male work force in forestry, fisheries, mining and agriculture divided by the total experienced male work force.

Source: Census of the Population: 1970, table 183.

$\hat{W}_{LU}$  (the fitted value for the wage paid uneducated workers):

$$W_{LU}(t) = j(W_{LE}(t), INC(t-2), URBT(t), MIN(t)) \quad (4.9)$$

$t = 1970, \quad t-2 = 1968$

$W_{LU}$ : Defined as the median annual income of male workers (18 years and over) with four years of high school.

Source: Census of the Population: 1970, table 197.

$W_{LE}$ : Defined as the median annual income of male workers (18 years and over) with four years of college.

Source: Census of the Population: 1970, table 197.

INC: Defined as per capita income (here measured in 1968 since this variable is lagged two years).

Source: Statistical Abstract of the United States: 1970, table 483.

URBT: Defined as the proportion of the male work force (18 years and over) who reside in urban areas.

Source: Census of the Population: 1970, table 197.

MIN: Defined as the proportion of the male work force (18 years and over) who are black or hispanic.

Source: Census of the Population: 1970, table 197.

Demand (general equilibrium):

$$k_t = g(\widehat{\text{Re}1W}_{(t)}, \text{SK}_{(t)}, \text{UNSK}_{(t)})$$

$$t = 1970$$

$k$ ,  $\text{SK}$  and  $\text{UNSK}$ : Defined as in the partial equilibrium demand equation, sources detailed there.

$\widehat{\text{Re}1W}$ : Defined as the median annual income of male workers (18 years and over) with four or more years of college ( $W_{LE}$ ) divided by the fitted value for the median annual income for male workers (18 years and over) with four years of high school ( $\widehat{W}_{LU}$ ).

Sources:  $W_{LE}$ , Census of the Population: 1970, table 197.

$\widehat{W}_{LU}$ , the fitted value from equation 4.9.

Supply:

$$\text{Dif} = h(\text{Re}1W_{(t-4)}, \text{URB}, \text{INV}_{(t-4)})$$

$$t = 1970, \quad t-4 = 1966$$

$\text{Dif}$ : Defined as the difference in the number of males (18 years and over) who have completed four or more years of college between years  $t$  and  $t-1$  (i.e., between 1970 and 1969).

Sources: Census of the Population: 1970, table 197, and

Census of the Population: 1960, table 138.

Problems: Data, by state, on the number of males who have completed four or more years of college are available for



Census years only. Hence, observations on this variable for 1969 had to be estimated. For each state this was done using straight line interpolation between the 1960 and 1970 Census values.

RelW: Defined as the median annual income of male workers (18 years and over) with four years of college ( $W_{LE}$ ) divided by the median annual income of male workers (18 years and over) with four years of high school. Here, however,  $W_{LE}$  and  $W_{LU}$  are lagged four years to reflect the wage rates of educated and uneducated workers in 1966; the year when the people measured by Dif decided to obtain a college degree.

Sources: Census of the Population: 1970, table 197, and  
Census of the Population: 1960, table 138.

Problems: Data, by state, for  $W_{LE}$  and  $W_{LU}$  are available for Census years only. Hence, observations on these variables for 1966 had to be estimated. For each state this was done using straight line interpolation between the 1960 and 1970 Census values.  $RelW_{(t-4)}$  was then obtained by dividing the estimated value for  $W_{LE}$  in 1966 by the estimated 1966 value of  $W_{LU}$ . To correct for inflation both  $W_{LE}$  and  $W_{LU}$  (i.e., the estimated 1966 values) were converted to 1970 dollars prior to forming  $RelW_{(1966)}$ .

URB: Defined as the proportion of the male work force, age 25-29, who lived in urban areas.

Source: Census of the Population: 1970, table 193.

Problems: Ideally, we wanted the proportion of males, age 18-22 in 1966 (i.e., the age most degree holders start their college education) who lived in urban areas. Census data, however, restricted this proportion to a choice between males age 18-24 (14-20) and 25-29 (21-25) in 1970 (1966). As would be expected, the ratios constructed for each group were very similar; we arbitrarily selected the latter to form URB.

INV: Defined as the sum of government appropriations, private gifts, sponsored research, other sponsored programs, student aid and endowment income of four year colleges and universities (in thousands of dollars) divided by the total enrollment of these institutions. Again, the data for this variable reflect the year 1966 but are corrected for inflation by converting the observations to 1970 dollars.

Sources: Financial Statistics of Institutions of Higher Education: 1966-67, table 5, and Opening Fall Enrollment; Higher Education: 1966, table 7.

### 4.3 Empirical Results

This section contains the results of our empirical analysis. We first estimate both the ordinary and general equilibrium supply and demand curves for educated labor. Next, these curves are used to estimate the annual benefits that would accrue, respectively, to the participants in this market and society as a whole from increases in the level of public expenditures for higher education. Annual benefits are calculated under various assumptions regarding the level of increase in expenditures and the degree of substitutability between educated and uneducated workers. Finally, we employ a version of the rate of return formula with the benefits and expenditures referred to above to estimate the marginal social rate of return to investments in higher education. For purposes of comparison, we also present calculations of the marginal rate of return realized by the participants in the labor market for college graduates.

The model developed in Section 4.1 (i.e., equations 4.7 - 4.10) was fit to the data described in Section 4.2 using ordinary least squares regression (OLS). For each equation, a variety of functional forms were examined to see which specification best fit the data. We focus here on the linear, double log and semi-logarithmic functional forms. This is because each of these formulations proved the most satisfactory in estimating some part of the model.

In describing the empirical results, the following format will be adhered to. For each equation (i.e., 4.7 - 4.10) we will state the general form, briefly define the variables in it (for complete

variable definitions see Section 4.2), list the functional forms for which empirical results are given and present and discuss the empirical results. The discussions will cover the hypotheses that were being tested in each equation and the economic problems that were checked for.

#### Equation 4.7: The Ordinary Demand Curve for Educated Labor

General Form:  $k = f(\text{Re}1W, \text{SK}, \text{UNSK})$

where:

$k$  = the proportion of the male work force possessing a college degree;

$\text{Re}1W$  = the wage paid college graduates divided by the wage paid those who have completed only high school;

$\text{SK}$  = the proportion of the male work force in skilled professions;

$\text{UNSK}$  = the proportion of the male work force in unskilled professions.

#### Functional Forms Reported:

linear:  $k = \alpha_0 + \alpha_1 \text{Re}1W + \alpha_2 \text{SK} + \alpha_3 \text{UNSK}$

double log:  $\ln k = \alpha_0 + \alpha_1 \ln \text{Re}1W + \alpha_2 \ln \text{SK} + \alpha_3 \ln \text{UNSK}$

semi-log:  $k = \alpha_0 + \alpha_1 \ln \text{Re}1W + \alpha_2 \ln \text{SK} + \alpha_3 \ln \text{UNSK}$

Discussion:

The empirical results of equation 4.7 were used to test the following three hypotheses.

- 1)  $\alpha_1 < 0$  , or, the demand curve is downward sloping;
- 2)  $\alpha_2 > 0$  , or, the demand for educated labor is an increasing function of the number of firms that employ educated labor intensively;
- 3)  $\alpha_3 < 0$  , or, the demand for educated labor is a decreasing function of the number of firms that employ uneducated labor intensively.

Consider now the results presented in Table 6. As is evident there the industry shift variables, SK and UNSK, have their anticipated signs and are statistically significant at the 5 percent level in all three specifications of the demand curve (compare the t statistics given in Table 6 with a critical value of about 2.01). RelW, however, is not significant at this level in any formulation but does, in all cases, have its expected sign. Hence, with respect to the hypotheses being tested, we accept all but the first (i.e., at the 5 percent level we cannot conclude  $\alpha_1 < 0$ ).

The failure to obtain statistically significant results for RelW (i.e., at the 5, or even the 10 percent level) is unfortunate. This is because RelW's coefficient determines the slope of the demand curve in wage-quantity space. It is this curve we will (later) integrate to estimate the annual benefits realized by the

Table 6. OLS Estimation of the Ordinary Demand Curve for Educated Labor.

## Part A:

Functional Form: Linear

Dependent Variable: k

 $R^2 = .59$ 

Independent Variable	Estimated Coefficient	t-statistic
C	.090	2.584
Re1W	-.028	-1.262
SK	.393	7.143
UNSK	-.097	-2.897

## Part B:

Functional Form: Double Log

Dependent Variable:  $\ln k$  $R^2 = .65$ 

Independent Variable	Estimated Coefficient	t-statistic
C	-.999	-5.042
$\ln \text{Re1W}$	-.406	-1.572
$\ln \text{SK}$	.758	7.972
$\ln \text{UNSK}$	-.089	-3.558

## Part C:

Functional Form: Semi-log

Dependent Variable: k

 $R^2 = .66$ 

Independent Variable	Estimated Coefficient	t-statistic
C	.247	10.926
$\ln \text{Re1W}$	-.040	-1.358
$\ln \text{SK}$	.087	7.993
$\ln \text{UNSK}$	-.010	-3.681

participants in the educated labor market from increases in the level of public expenditures for higher education. The insignificance of ReIW's coefficients, however, reduces confidence in the slope of our ordinary demand curve which, in turn, casts doubts on the validity of the benefit estimates derived from it. To help the reader determine how much confidence one can have in the results that follow from Table 6, we note that the critical t value for the 20 percent significance level is about 1.30. Two of the coefficients for ReIW listed in Table 6 have t statistics higher than this, and the third's is just marginally below it.

Equation 4.7 was tested for both multicollinearity and heteroscedasticity. Multicollinearity refers to the existence of a linear relationship between the independent variables of a function. In regression analysis, its presence leads to indeterminate coefficient estimates and large standard errors.<sup>8/</sup> To check for this problem we employed the Farrar-Glauber test. This is a three step procedure in which the explanatory variables of interest are first examined for the presence and severity of multicollinearity using a chi square test. Next, an F test locates the specific variables which are collinear. Finally, a t test is used to determine the degree of multicollinearity between each pair of affected variables.<sup>9/</sup> In all three stages of the procedure the null hypothesis is that multicollinearity is not present.

The first step yielded a chi square statistic of 10.463; this compared to a critical value of 9.348. Thus, we rejected the hypothesis that multicollinearity did not exist among the explanatory

variables of equation 4.7. The second step revealed the affected variables to be RelW and UNSK; the t test, however, indicated that the degree of collinearity was not very severe (the t statistic from the test was -2.922, which compared to a critical value of about 02.000).

There are several procedures which can be used to correct for multicollinearity. These include dropping one or more collinear variables from one's model, using principle components and ridge regression. Unfortunately, each of these remedies has serious drawbacks when applied to equation 4.7.

Assuming a model has been well thought out and the independent variables really do explain variation in the dependent variable, then the technique of dropping explanatory variables introduces specification (omitted variable) bias. At present, it is unclear which is less damaging to a model, specification bias or the presence of multicollinearity. Principle components and ridge regression both obscure the meaning of individual parameter estimates.<sup>10/</sup> Since our methodology requires knowledge of the coefficients associated with the explanatory variables (particularly that associated with RelW), neither of these remedies was considered feasible.<sup>11/</sup>

Given that the degree of multicollinearity in equation 4.7 was not severe and considering the drawbacks of correcting for it, we decided to just accept its presence. We note two consequences of this decision. First, further doubt is cast on the validity of the estimated coefficients of RelW listed in Table 6;



second, the  $t$  statistics associated with these estimates are biased downward.<sup>12/</sup>

Heteroscedasticity refers to the violation of homoscedasticity, the econometric assumption of constant variance of the error term.<sup>13/</sup> In regression analysis the presence of heteroscedasticity has two consequences. First, it invalidates the formula by which the variances of the coefficients are computed (hence one cannot construct confidence intervals or perform tests of significance). Second, it renders OLS parameter estimates inefficient (although they are still unbiased and consistent). To check equation 4.7 for this problem, we utilized the Goldfeld-Quandt test. In this procedure one first orders the observations according to the magnitude of the explanatory variable thought to be causing the heteroscedasticity. Next, an arbitrary number of central observations (generally about one quarter of the total) are deleted. The remaining observations are then grouped into two equal sized subsamples; one containing the smaller values of the variable being analyzed and the other the larger values. Finally, separate regressions are performed using the data in each group. A ratio is then constructed using the error sum of squares obtained from these runs. This ratio has an  $F$  distribution and its value is close to one if heteroscedasticity is not present.

We applied the Goldfeld-Quandt test to each variable in all three specifications of equation 4.7. The critical value of  $F$  at the 95 percent level was 2.463 (we had 14 degrees of freedom in both

the numerator and denominator). Only one test statistic (that for RelW in the linear formulation) exceeded this value, and it was only marginally over (its F statistic was 3.000). Hence, we concluded heteroscedasticity was not a problem in our demand for educated labor.

Equation 4.9. The Fitted Value for the Wage Paid Uneducated Workers ( $\hat{W}_{LU}$ ):

$$\text{General Form: } W_{LU(t)} = j(W_{LE(t)}, INC_{(t-2)}, URBT_{(t)}, MIN_{(t)})$$

where:

$W_{LU}$  = the wage paid workers who have completed only high school;

$W_{LE}$  = the wage paid college graduates;

INC = per capita income;

URBT = the proportion of the male work force living in urban areas;

MIN = the proportion of the male work force who are black or hispanic.

Functional Forms Reported:

$$\begin{aligned} \text{semi-} & W_{LU} = \beta_0 + \beta_1 \ln W_{LE} = \beta_2 \ln INC + \beta_3 \ln URBT \\ \text{log:} & \\ & + \beta_4 \ln MIN \end{aligned}$$

Discussion:

Recall that the purpose of equation 4.9 was to convert equation 4.7 from an ordinary to a general equilibrium demand curve. In

estimating equation 4.9, then, the only criteria by which the results were judged was how well it performed this task. Because we were not interested in the parameter estimates of this equation, it was not checked for any econometric problems (i.e., multicollinearity and heteroscedasticity).

As is evident in Table 7, we report only the results for the semi-logarithmic specification. This is because the general equilibrium demand curves derived using the fitted values of  $W_{LU}$  from both the linear and double log functional forms of equation 4.9 had positive signs on the wage (i.e., price) variable. This would seem to contradict theory for it suggests the wage firms pay college graduates is an increasing function of the number of degree holders in the labor market (i.e., the equilibrium demand curve for educated labor is upward sloping).<sup>14/</sup> While the results obtained using the fitted values from the semi-log formulation are not (statistically) very good, they were the only usable results we could get. As will be seen shortly, these fitted values at least yielded coefficient estimates in the equilibrium demand curve whose signs were as expected.

Equation 4.10: The General Equilibrium Demand Curve for Educated Labor

$$\text{General Form: } k = g(\widehat{\text{Rel}W}, \text{SK}, \text{UNSK})$$

where:

$$\widehat{\text{Rel}W} = W_{LE} / \widehat{W}_{LU} = \text{the wage paid college graduates divided by the fitted value for the wage paid workers with only a high school diploma;}$$

Table 7. OLS Estimation of the Fitted Value of  $W_{LU}$ 

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Functional Form: Semi-Log  
Dependent Variable:  $W_{LU}$   
 $R^2 = .78$

Independent Variable	Estimated Coefficient	t-statistic
C	-4.404	-2.876
$\ln W_{LE}$	3.891	3.911
$\ln INC$	1.602	1.533
$\ln URBT$	.772	1.809
$\ln MIN$	-.222	-2.526

---

k, SK and UNSK are defined as in the ordinary demand curve for educated labor.

Functional Forms Reported:

$$\text{linear: } k = C_0 + C_1 \widehat{\text{Rel}W} + C_2 \text{SK} + C_3 \text{UNSK}$$

$$\text{double log: } \ln k = C_0 + C_1 \ln \widehat{\text{Rel}W} + C_2 \ln \text{SK} + C_3 \ln \text{UNSK}$$

$$\text{semi-log: } k = C_0 + C_1 \ln \widehat{\text{Rel}W} + C_2 \ln \text{SK} + C_3 \ln \text{UNSK}$$

Discussion:

The empirical results of equation 4.10 were used to test the following three hypotheses.

- 1)  $C_1 < 0$  , or, the general equilibrium demand curve is downward sloping;
- 2)  $C_2 > 0$  , or, the equilibrium demand for educated labor is an increasing function of the number of firms that employ educated labor intensively;
- 3)  $C_3 < 0$  , or, the equilibrium demand for educated labor is a decreasing function of the number of firms that employ uneducated labor intensively.

As is evident in Table 8, SK and UNSK have their anticipated signs and are statistically significant at the 5 percent level in all three specifications of the general equilibrium demand curve for

## Empirical Results:

Table 8. OLS Estimation of the General Equilibrium Demand Curve for Educated Labor

## Part A:

Functional Form: Linear

Dependent Variable:  $k$  $R^2 = .57$ 

Independent Variable	Estimated Coefficient	t-statistic
$\widehat{C}$	.083	1.501
ReIW	-.021	-.633
SK	.378	6.706
UNSK	-.094	-2.499

## Part B:

Functional Form: Double Log

Dependent Variable:  $\ln k$  $R^2 = .64$ 

Independent Variable	Estimated Coefficient	t-statistic
$\widehat{C}$	-1.098	-5.595
$\ln \widehat{ReIW}$	-.215	-.576
$\ln SK$	.732	7.395
$\ln UNSK$	-.082	-3.062

## Part C:

Functional Form: Semi-Log

Dependent Variable:  $k$  $R^2 = .64$ 

Independent Variable	Estimated Coefficient	t-statistic
$\widehat{C}$	.235	10.499
$\ln \widehat{ReIW}$	-.007	-.164
$\ln SK$	.085	7.544
$\ln UNSK$	-.009	-3.073

educated labor (compare the  $t$  statistics listed in Table 8 with a critical value of about 2.01).  $\widehat{Re}lW$ , however, is not significant at this level in any formulation but does, in each case, have its expected sign. Hence, with respect to the hypotheses being tested we accept all but the first (i.e., at the 5 percent level of significance we cannot include  $C_1 < 0$ ).

The failure to obtain statistically significant coefficients for the wage variable was a problem encountered when we estimated equation 4.7 (the ordinary demand curve for educated labor). Here, however, the associated  $t$  statistics are much lower. Recall in equation 4.7  $ReIw$  was (for the most part), significant at the 20 percent level; in equation 4.10  $\widehat{Re}lW$  is not significant at even the 50 percent level (compare the  $t$  statistics in Table 8 with a critical value of .68). This means we cannot be very certain about the slope of our general equilibrium demand curve, which, in turn, implies we cannot have much confidence in the benefit estimates (i.e., benefit to society) obtained using it.

The reader will note the results presented in Table 7 parallel those given in Table 5. But this is not surprising since equation 4.10 is derived by making a variable substitution in equation 4.7. Because of the similarities in both the construction and empirical results of these equations, we assume the equilibrium demand curve for educated labor to be free of heteroscedasticity (i.e., we did not test for it). Multicollinearity, however, was checked for because of the possibility of a linear relationship between either

SK or UNSK and the explanatory variables used to obtain the fitted values of  $W_{LU}$ .

The first stage of a Farrar-Glauber test performed on  $\widehat{RelW}$ , SK and UNSK yielded a chi-square statistics of 12.530. This compared to a critical value of 9.348, and so we concluded some multicollinearity was present in equation 4.10. The second step of the procedure showed the affected variables to be  $\widehat{RelW}$  and UNSK, but the following t test revealed the degree of collinearity to be small (the test t statistic was -3.536, which compared to a critical value of about -2.000). Hence, for the reasons described in the discussion of equation 4.7, we decided not to correct for this problem.

Equation 4.8: The Supply Curve for Educated Laobr

$$\text{General Form: } Dif = h(\text{RelW}_{(t-4)}, \text{URB}, \text{INV}_{(t-4)})$$

where:

Dif = the number of degree holders in year t minus the number of degree holders in year t-1;

URB = the proportion of the male work force, age 21 to 25 in year t-4, who lived in urban areas;

INV = expenditures for higher education;

RelW is defined as before.

Functional Forms Reported:

$$\text{linear: } Dif = d_0 + d_1 \text{RelW}_{(t-4)} + d_2 \text{URB} + d_3 \text{INV}_{(t-4)}$$



## Discussion:

Recall that our model assumes the number of degree holders in any given state at any time  $t$  to be perfectly inelastic (i.e., fixed) in current wage-quantity space (see Section 4.1 for the rationale behind this assumption). This assumption has two consequences for our analysis. First, it implies that equation 4.6 (obtained by adding the number of degree holders in year  $t-1$  to both sides of equation 4.8) is both the ordinary and general equilibrium supply curve for educated labor. Recall that general equilibrium curves allow for price changes in related markets that result from price changes in the primary market being analyzed. But note equations 4.6 and 4.8 are not conditioned on time  $t$  wage levels; this says the supply of educated labor is not affected by changes in current wage rates. Second, with the above inelasticity assumption, we need not worry about locating the supply curve of college graduates. For each state, we know how many degree holders there are and the supply curve is just a vertical line at this point. Given a vertical supply curve at a known point, the problem of estimating the effect of changes in the level of public expenditures for higher education on the number (or, more precisely, the future number) of college graduates reduces to estimating the coefficient associated with the variable  $INV_{(t-4)}$  in equation 4.8. Hence, in estimating equation 4.8, it is this parameter in which we are most interested.

The reader will note Table 9 presents empirical results for just the linear functional form of the supply curve. This is because

it was the only specification where results did not imply negative rates of return.<sup>15/</sup> In the double log formulation the sign associated with  $INV_{(t-4)}$  was negative. This would appear to contradict theory for it implies more students would pursue a degree if the private costs of college increase (i.e., the future supply of degree holders could be increased by reducing public expenditures for higher education). Although the sign of  $INV_{(t-4)}$ 's coefficient was positive in the semi-logarithmic formulation its magnitude, .369, was so small that any rates of return based on it would have been negative.

The above findings cast some doubt on the validity of the results detailed in Table 9. The linear, double log and semi-logarithmic functional forms of equation 4.8 were all estimated by OLS using the same data (albeit each specification transformed the data somewhat differently). Hence, with respect to the statistical properties of  $INV_{(t-4)}$ 's coefficient, we expected more uniform results. Speculation as to why this was not the case is deferred until Section 4.4. We proceed now to evaluate the results presented in Table 9 on their own merits.

The empirical results for the linear formulation of equation 4.8 were used to examine the following hypothesis.

- 1)  $d_1 > 0$  , or, the number of new graduates entering the educated labor market in year  $t$  is an increasing function of the wage paid college graduates relative to that paid non-degree holders in year  $t-4$ .

Table 9. OLS Estimation of the Supply Curve of Educated Labor

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Functional Form: Linear  
Dependent Variable: Dif  
 $R^2 = .376$

Independent Variable	Estimated Coefficient	t-statistic
C	-31.782	-2.569
RelW <sub>(t-4)</sub>	10.200	1.285
URB	24.225	3.715
EXP <sub>(t-4)</sub>	2.961	2.224

---

- 2)  $d_2 > 0$  , or, the number of new graduates entering the educated labor market in year  $t$  is an increasing function of the proportion of college age people living in urban areas.
- 3)  $d_3 > 0$  , or, the number of new graduates entering the educated labor market in year  $t$  is an increasing function of per student expenditure for higher education in year  $t-4$ .

As is evident in Table 9, all coefficients have their anticipated signs. Additionally, URB and  $INV_{(t-4)}$  appear to be statistically significant at the 5 percent level while  $RelW_{(t-4)}$  does not (compare the  $t$  statistics listed in Table 9 with a critical value of about 2.01). Unfortunately, in a Goldfeld-Quandt test for heteroscedasticity the  $F$  statistics for  $INV_{(t-4)}$ ,  $RelW_{(t-4)}$  and URB were, respectively, 4.965, 6.119 and 30.302. All exceed the 5 percent critical value of 2.463 (there were 14 degrees of freedom in both the numerator and denominator). Thus, we concluded heteroscedasticity was present. Because of the magnitude of its  $F$  statistic, URB was considered to be the main cause of the problem. Recall that one of the consequences of heteroscedasticity is that it invalidates the formula for computing standard errors. This, in turn, makes it impossible to perform a test of significance, and so we were unable to accept or reject any of the three hypotheses listed above.

Although heteroscedasticity is not, in general, difficult to correct for in OLS regression, we decided not to try to remove it. Our decision was based on the following three factors. First, when heteroscedasticity is present OLS parameter estimates lose only their

efficiency property; they remain both unbiased and consistent. Second, the procedure to remove heteroscedasticity usually obscures the meaning of individual coefficients.<sup>16/</sup> For our purposes, this was considered unsatisfactory since our methodology hinges on the coefficient associated with  $INV_{(t-4)}$ . Finally, in an unreported run DIF was regressed against  $INV_{(t-4)}$  alone. Not only was this regression free from heteroscedasticity, but the empirical results were very similar to those appearing in Table 9 (the estimated coefficient for  $INV_{(t-4)}$  was 2.888 and its t statistic was 2.875).

Equation 4.8 also was tested for multicollinearity using the Farrar-Glauber test. In the first stage, a chi square statistic of 4.548 was obtained. This compared to a critical value (at the 5 percent significance level) of 9.348. Thus, we concluded multicollinearity was not a problem.

#### Annual Benefits

We have just presented the empirical results obtained from fitting equations 4.7 - 4.10 (i.e., our model) to the data described in Section 4.2. Unfortunately, the statistical properties associated with these results do not allow us to put much confidence in our findings. The wage variables, for example, in both the ordinary and general equilibrium demand curves ( $RelW$  and  $\widehat{RelW}$ , respectively) were insignificant at the 10 percent level. Recall the coefficients of these variables determined the slopes of their respective demand curves. Recall, also, that we reported results for only the linear version of the supply curve for educated labor. This was because in

the double and semi-logarithmic formulations the coefficients of the expenditures variable (i.e.,  $INV_{(t-4)}$ ) were both highly insignificant (their t statistics were barely above zero) and so low in magnitude that they implied negative rates of return. Finally, the sign of the wage variable in the general equilibrium demand curve (i.e.,  $\widehat{Re}W = W_{LE}/\widehat{W}_{LU}$ ) varied with the functional form of the equation used to obtain the fitted values for the wage paid non-degree holders ( $\widehat{W}_{LU}$ ).

Because the empirical results of our model were so inconclusive, we cannot be very confident in any findings they suggest. That is, by the methodology developed in Chapter III the general equilibrium supply and demand curves for educated labor are used to estimate the social benefits derived from increased levels of public expenditures for higher education. These benefits are then used to estimate the marginal social rate of return to public investments in higher education. But since we cannot have much confidence in the model for educated labor we have estimated, neither can we have much confidence in the benefit and rate of return estimates obtained using it. As a result, the reader is cautioned to view what follows as largely a numerical example of how the methodology developed in Chapter III can be used to estimate the marginal social rate of return to investments in higher education rather than an attempt to actually estimate the rate of return.

With this caution in mind, we now use the results listed in Tables 6 through 9 to estimate the annual benefits that would accrue to both the participants in the market for educated labor and society as a whole from various increases in the level of public expenditures

for higher education. For the former group these benefits are measured using the changes in areas of consumer and producer surplus associated with the ordinary supply and demand curves for educated labor (i.e., equations 4.7 and 4.8); for the latter group they are measured using similar area changes associated with the equilibrium relationships (i.e., equations 4.10 and 4.8). But, regardless of which set of curves is being considered, the procedure for estimating benefits is the same.

We start by putting the ordinary and general equilibrium demand curves for college graduates into wage-quantity space. This is done by fixing the values of SK and UNSK at specific levels, thereby eliminating them as variables in equations 4.7 and 4.10. These levels are chosen to reflect three different degrees of substitutability between educated and uneducated workers. The degrees of substitutability, along with the levels of SK and UNSK that describe them, are as follows:

<u>To reflect:</u>	=	<u>We set:</u>
1) An average degree of substitutability	=	both SK and UNSK at their national average;
2) A high degree of substitutability	=	SK at its national minimum and UNSK at its national maximum;
3) A low degree of substitutability	=	SK at its national maximum and UNSK at its national minimum.

The reader will note there are now 18 different demand curves for educated labor to consider. That is, we started by constructing equations 4.7 and 4.10 (the general formulations of the ordinary and

equilibrium demand curves). These were then estimated using the linear, double log and semi-logarithmic functional forms. Now each functional form has been put into wage-quantity space under three different assumptions regarding the substitutability between educated and uneducated workers.

As a final manipulation, the demand curves are rearranged so that the quantity variable,  $k$ , appears on the right-hand side, while the price variable,  $ReIW$ , is moved to the left-hand side. This is done because the methodology of calculating annual benefits involves integrating the demand curves over different values of  $k$ .

Next, the supply of educated labor is defined in terms of the proportion of the male work force with a college degree (i.e.,  $k$ ). Since we are interested in how changes in the level of public expenditures for higher education shift this curve, it must be assigned an initial position. In estimating both annual benefits and rates of return, it often will be necessary to assign specific values to certain variables. When this is the case, we will employ the framework of an "average" state and select the mean value of the variable in question. Hence, the initial position of  $k$  is set at .118, its national average in 1970.

Having specified the market for college graduates, we can now estimate the annual benefits that would result from various increases in the level of public expenditures for higher education. It should be kept in mind, however, that the increases we simulate cannot actually be observed since  $INV$  is lagged four years. That is, our



analysis compares the actual market for educated labor in 1970 with the market as it would have been had expenditures for higher education in 1966 occurred at different levels.

Expenditures are measured in thousands of dollars per student. Because we are interested in how various increased in this variable shift the supply of educated labor, it must be given an initial value. As before, this value is chosen to be the mean of  $INV_{1966}$  among all states (i.e.,  $\overline{INV}$ ). In 1966,  $\overline{INV}$  equaled 1.609 (i.e., \$1,609 per student). Thus, using 1.609 as a starting point, we increase expenditures by 10, 20, 40, 50 and 100 percent. Each successive increase implies a greater number of (hypothetical) college graduates entering the work force in 1970. Recalling that DIF is defined in terms of thousands of degree holders, Table 9 estimates the magnitude of the increase in college graduates (i.e., the coefficient associated with  $INV$ ) to be three times that of the increase in expenditures.

To estimate how the supply curve shifts in response to each increase in  $INV_{1966}$  we first define the numerator and denominator of  $\bar{k}$  in terms of their national means. In 1970, an "average" state had about 147.5 thousand male college graduates (the numerator) in a total male labor force (the denominator) of 1,250 thousand workers (i.e.,  $147.5/1250 = .118 = \bar{k}$ ). Next, for each increase in expenditures, we add to the numerator of  $\bar{k}$  (i.e., 147.5) the number of additional college graduates obtained from equation 4.8 (i.e., as estimated in Table 9). The addition of these "new" graduates implies

a rightward shift in the supply curve of educated labor, say to  $\tilde{k}$  which, in turn, implies a change in the areas of consumer and producer surplus in the market for educated labor. The magnitude of these surplus changes is calculated by integrating the relevant demand curve from  $\bar{k}$  to  $\tilde{k}$ .

Finally, we note that, as formulated, the above changes in areas of consumer and producer surplus do not reflect the aggregate benefits resulting from our simulated increases in  $INV_{1966}$ . This is because to assess the economic impact of a policy in a given market one usually integrates the demand curve over different values of quantity. But in our analysis quantity, the number of male graduates, is divided by the entire male labor force.<sup>17/</sup> Hence, to estimate the total annual benefits derived from increases in  $INV_{1966}$  we multiply the area under the demand curve from  $\bar{k}$  to  $\tilde{k}$  by 1250, the number (in thousands) of male workers in an average state.

Table 10 lists our estimates of the annual benefits realized by society from increases in the level of public expenditures for higher education of 10, 20, 40, 60 and 100 percent. Benefits are calculated under the assumptions of a linear, double log and semi-logarithmic demand curve as well as a high, low and average degree of substitutability between educated and uneducated workers. Table 11 gives similar estimates for the returns realized by just the participants in the educated labor market. Note that in both tables there are specifications of the demand curve for which no benefits are presented; in these specifications, the estimated benefits implied negative rates of return.<sup>18/</sup>

Table 10. Estimated Marginal Social Rates of Return to Expenditures for Higher Education.

## Part A:

Functional Form of Equilibrium Demand Curve; Linear

Exogenous Forces; SK: Average, UNSK: Average

Percent Increase in Expenditures	Cost (in thousands of dollars)	Annual Benefits (in thousands of dollars)	Marginal Rate of Return
10	16.09	.812	3.4
20	32.18	1.559	3.2
40	64.36	2.845	2.8
60	96.54	4.278	2.8
100	160.90	7.031	2.7

Exogenous Forces; SK: High, UNSK: Low

10	16.09	2.010	9.0
20	32.18	3.995	8.7
40	64.36	7.447	8.3
60	96.54	11.357	8.3
100	160.90	19.061	8.3

Exogenous Forces; SK: Low, UNSK: High

(rates of return negative to all increases in expenditures)

## Part B:

Functional Form of Equilibrium Demand Curve; Double Log

Exogenous Forces; SK: Average, UNSK: Average

(rates of return negative to all increases in expenditures)

Exogenous Forces; SK: High, UNSK: Low

Percent Increase in Expenditures	Cost (in thousands of dollars)	Annual Benefits (in thousands of dollars)	Marginal Rate of Return
10	16.09	1.242	5.7
20	32.18	2.500	5.7
40	64.36	4.683	5.4
60	96.54	7.148	5.4
100	160.90	11.986	5.4

Exogenous Forces; SK: Low, UNSK: High

(rates of return negative to all increases in expenditures)

Table 10. Estimated Marginal Social Rates of Return to Expenditures for Higher Education.  
(Cont.)

Part C:

Functional Form of Equilibrium Demand Curve; Semi-Log

Exogenous Forces; SK: Average, UNSK: Average

(rates of return negative to all increases in expenditures)

Exogenous Forces; SK: High, UNSK: Low

Percent Increase in Expenditures	Cost (in thousands of dollars)	Annual Benefits (in thousands of dollars)	Marginal Rate of Return
10	15.09	4.083	14.6
20	32.18	8.150	14.6
40	64.36	15.198	14.1
60	96.54	23.145	14.1
100	160.90	38.697	14.1

Exogenous Forces; SK: Low, UNSK: High

(rates of return negative to all increases in expenditures)

Table 11. Estimated Marginal Rates of Return to Participants in the Market for Educated Labor from Expenditures for Higher Education

Part A:

Functional Form of Ordinary Demand Curve; Linear

Exogenous Forces; SK: Average, UNSK: Average

Percent Increase in Expenditures	Cost (in thousands of dollars)	Annual Benefits (in thousands of dollars)	Marginal Rate of Return
10	16.09	.750	3.0
20	32.18	1.500	3.0
40	64.36	2.750	2.6
60	96.54	4.125	2.6
100	160.90	6.875	2.6

Exogenous Forces; SK: High, UNSK: Low

10	16.09	1.752	7.6
20	32.18	3.456	7.7
40	64.36	6.420	7.3
60	96.54	9.781	7.3
100	160.90	16.417	7.3

Exogenous Forces; SK: Low, UNSK: High

(rates of return negative to all increases in expenditures)

Part B:

Functional Form of Ordinary Demand Curve; Double Log

Exogenous Forces; SK: Average, UNSK: Average

(rates of return negative to all increases in expenditures)

Exogenous Forces; SK: High, UNSK: Low

Percent Increase in Expenditures	Cost (in thousands of dollars)	Annual Benefits (in thousands of dollars)	Marginal Rate of Return
10	16.09	.773	3.2
20	32.18	1.550	3.2
40	64.36	2.900	2.9
60	96.54	4.427	2.9
100	160.90	7.433	2.9

Exogenous Forces; SK: Low, UNSK: High

(rates of return negative to all increases in expenditures)

Table 11. Estimated Marginal Rates of Return to Participants in the Market for Educated Labor from Expenditures for Higher Education (cont.)

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Part C:

Functional Form of Ordinary Demand Curve; Semi-Log

Exogenous Forces; SK: Average, UNSK: Average

(rates of return negative to all increases in expenditures)

Exogenous Forces; SK: High, UNSK: Low

Percent Increase in Expenditures	Cost (in thousands of dollars)	Annual Benefits (in thousands of dollars)	Marginal Rate of Return
10	16.09	.865	3.8
20	32.18	1.750	3.8
40	64.36	3.287	3.6
60	96.54	5.024	3.6
100	160.90	8.439	3.6

Exogenous Forces; SK: Low, UNSK: High

(rates of return negative to all increases in expenditures)

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### Rates of Return

The annual benefits listed in Tables 10 and 11 are used now to estimate, respectively, the marginal rate of return to investments in higher education for society as a whole and the participants in the market for educated labor. For these calculations we employ the following formula:

$$C = \sum_{i=4}^{47} \frac{\beta_i}{(1+r)^i} \quad (4.11)$$

where:

- C = the total dollar amount of the percentage increase in  $EXP_{1966}$ ;
- $\beta_i$  = the annual benefits realized in year  $i$  from  $C$ ;
- $i$  = an index of years spanning the average working lifetime of a college graduate (i.e., ages 22 to 65);
- $r$  = the rate of return (i.e., that discount rate which makes equation 4.11 an equality).

But before applying equation 4.11 we need both an estimate of  $C$  and an assumption regarding the annual benefits derived from investments in higher education. To estimate  $C$  each increase in  $INV_{1966}$  (which is measured in 1,000s of dollars) was multiplied by the number of students enrolled in a college or university in an "average" state during 1966 (this number was 100,000). The total cost of each percentage increase in expenditures per student is given in Tables 10 and 11. Although these costs do not vary from one specification

to another, we list them with each formulation for which rates of return are presented.

The assumption regarding benefits is that, for each increase in expenditures, society (the participants in the educated labor market) realizes returns equal to those listed in Table 10 (11) annually for a period of 43 years. That is, we have estimated the marginal returns in 1970 to (hypothetical) increases in expenditures for higher education in 1966. But the working lifetime of most degree holders spans several decades which implies investments in higher education produce a stream of benefits that accrue over a period of many years. This stream is assumed to run the average working lifetime of a college graduate, 43 years.<sup>19/</sup> It is further assumed that once a degree holder has started working any increases in productivity are attributable to some factor other than college training (e.g., on the job training or experience).

Table 10 presents our estimates of the marginal social rate of return to increases in public expenditures for higher education of 10, 20, 40, 60 and 100 percent. Rates of return are calculated assuming a linear, double log and semi-logarithmic demand curve as well as a high, low and average degree of substitutability between degree and non-degree holders. Table 11 details similar rate of return estimates for the participants in the educated labor market. In both tables the reader may assume rate of return estimates were negative for those specifications in which none is listed.



#### 4.4 Interpreting the Results

This section interprets the results presented in Section 4.3. But before doing so, the reader again is reminded that our empirical work must be viewed primarily as a numerical example of how one would estimate the marginal social rate of return to investments in higher education using the methodology developed in Section 3.3. This is because the statistical properties associated with our estimated model of the educated labor market are such that one cannot put much confidence in any findings that follow from it. Later in the section some possible explanations as to why the empirical work was not more conclusive are discussed. For the moment, however, assume the rates of return presented in Tables 10 and 11 are valid. If so, then the following conclusions would be suggested by the study.

First, our research suggests that additional increases in the level of public expenditures for higher education would be an uneconomical social investment. This is an important result for it addresses one of the main justifications for undertaking the project; that being the question of whether society is investing too much, too little or the correct amount maintaining and improving its human capital stock. The social rates of return listed in Table 10 generally fall far below those calculated by other researchers to various alternative investments (see Table 3). Hence, with the possible exception of one formulation of the demand curve for college graduates (i.e., the semi-logarithmic functional form; high SK, low UNSK), it appears society could benefit by holding constant,

and in some cases even reducing, its level of support for higher education and increasing the resources it allocates to other, more productive, uses (e.g., those listed in Table 3). This conclusion agrees with the work of Freeman (1975) and Rumberger (1981). These authors have argued strongly that society has over-invested in higher education. To support their position they point out that college graduates have started recently to dominate many occupations traditionally filled by workers with only a high school diploma. From a social perspective, this represents an over-investment since society is paying more than it must to get certain jobs done. Because of the unreliability of our results, however, we cannot advocate a shift of public resources away from higher education. We only note that for some states (e.g., those whose economy is comprised largely of industries that employ uneducated labor intensively: i.e., low SK, high UNSK) our work suggests such a shift would produce potential net economic gains.

Another important finding indicated by this research is that states should consider the industrial mix of their economies when deciding how much public support to give higher education. Referring to Table 10 note that, regardless of functional form, all specifications of the general equilibrium demand curve for college graduates with high SK and low UNSK have positive marginal social rates of return to investments in higher education. These rates vary from 5.4 to 14.6 percent. On the other hand, all

specifications with low SK and high UNSK have negative rates of return. Hence, it would appear increases in the level of public expenditures for higher education are economically more justifiable in states having a proportionally high number of industries that employ college graduates intensively than in states where economies are based largely on industries that use mainly uneducated labor. One possible interpretation of this result is that a state, looking to establish a high technology sector, should first try to attract these firms and then, if successful, consider increasing its educated work force via public support for higher education.

A third conclusion suggested by this study is that there would be positive net economic gains to people outside the educated labor market from increased levels of public expenditures for higher education. Comparing Tables 10 and 11, note that for all specifications of the demand curve (i.e., with positive rates of return), and all levels of increased expenditures, the rate of return to society (i.e., Table 9) exceeds the rate of return to just the participants in the educated labor market (i.e., Table 10).

In itself, this result is completely plausible. Past studies generally have acknowledged the existence of spillover economic effects from investments in higher education, although they have ignored them in their empirical work. It was argued in Section 2.2 that this omission is a major weakness in the approach used by previous researchers to estimate the social rate of return to expenditures for higher education. Unfortunately, the degree to which

our model captures the above spillover effects is somewhat unclear. Theory tells us that the price of an output is a function of the prices of the inputs that go into its production. This suggests the price of the products of educated labor ( $P$ ) is a function of the wages paid degree ( $W_{LE}$ ) and non-degree ( $W_{LU}$ ) holders (recall these are substitute inputs).<sup>20/</sup> Consider now the following specification of the ordinary demand curve for educated labor ( $D_{LE}$ ):

$$D_{LE} = \alpha_0 + \alpha_1 \frac{W_{LE}}{W_{LU}} + \alpha_2 P + \alpha_3 SK + \alpha_4 UNSK \quad (4.11)$$

Note, if output price is a function of  $W_{LE}/W_{LU}$  (i.e.,  $P = f[\frac{W_{LE}}{W_{LU}}]$ ), then a substitution can be made for  $P$ , and equation 4.11 can be rewritten

$$D_{LE} = b_0 + b_1 \frac{W_{LE}}{W_{LU}} + b_2 SK + b_3 UNSK \quad (4.12)$$

Clearly, equation 4.12 is equivalent to the linear form of equation 4.7 (the ordinary demand curve for educated labor in our model). Hence, if the price of the products of educated labor is a function of the relative wage rates of degree and non-degree holders, then equations 4.9 and 4.10 model the general equilibrium market for college graduates. That is, when a policy is implemented in this market the changes in areas of consumer and producer surplus reflect the economic effects of that policy on the participants in both the markets for non-college graduates and the products of educated labor.

On the other hand, if some other mathematical construction describes the relationship between  $P$  and  $W_{LE}$  and  $W_{LU}$  (i.e.,  $P \neq f[\frac{W_{LE}}{W_{LU}}]$ ) then equation 4.11 cannot be rewritten in the form of equation 4.12. In this case, our model does not reflect the economic effects of policies implemented in the market for degree holders on the participants in the market for the products of educated labor.

Since we were unable to find any data reflecting price variations in the products of educated labor across states in 1970, the relationship between  $P$  and  $W_{LE}$  and  $W_{LU}$  could not be determined. As a result, some ambiguity exists with respect to the number of markets, and hence the number of spillover economic effects reflected in our general equilibrium model of the educated labor market.

Finally, our research indicates that past works may have overestimated the marginal social rate of return to investments in higher education. Below are listed the findings reported by other researchers (excerpted from Table 1) for males for 1969-70, the same group and general time period this study considers.

Referring to Table 10, the reader can see our estimated marginal social rates of return fall within the range of the figures below only for states in which the economy is dominated by industries that employ educated labor intensively (i.e., high SK, low UNSK) and, then, only where the general equilibrium demand curve for college graduates is assumed to have a linear or semi-logarithmic functional form. For all other specifications of the demand curve, our estimated marginal social rates of return are considerably less than those listed below.

<u>Researcher</u>	<u>Estimated Marginal Social Rate of Return (for males)</u>
* Taubman and Wales	7.6 - 12.2
Raymond and Sesnowtiz	14.3 - 15.3
* Carnoy and Marenbach	10.9
Freeman	11.1
Witmer	12.5 - 12.7

\* = white males only

But because of data and methodological differences with past researchers, as well as the low statistical significance of our empirical results, this finding is the one which we are least comfortable with.

On several occasions now the reader has been cautioned against putting much confidence in the empirical results of this study. It even has been suggested that the empirical analysis be viewed only as a numerical example illustrating how the methodology developed in Chapter III can be applied to estimate the marginal social rate of return to investments in higher education. Considered next are some possible explanations as to why the empirical work was not more conclusive.

Undoubtedly, one problem undermining our analysis was the level of generality with which some key concepts were dealt. College degrees, for example were considered to be a homogeneous commodity. In reality this is not so. By and large, a bachelors degree in chemistry or engineering today has a far greater market value than does a similar degree in history or philosophy. Even within a particular field, the value (and cost) of a given degree can vary considerably with the institution from which it was obtained. Hence,

while it could be the case that further increases in the level of public support for higher education are economically unjustifiable when all degrees are considered equally there may well be some fields in which the social returns are large enough to warrant more public investment.

The same problem occurs in our treatment of expenditures. Recall the expenditures variable ( $INV_{t-4}$ ) was defined as the sum of government appropriations, private gifts, sponsored research, sponsored programs and student aid, all divided by total enrollment. That is, the monies colleges and universities receive from these sources were treated as if each affected enrollment and graduation rates equally. In reality, however, some of these areas (e.g., sponsored research and sponsored programs) have relatively little to do with undergraduate programs. Including them in  $INV_{(t-4)}$ , thus, biases downward the influences of expenditures that do bear more on the number of undergraduates a school turns out (e.g., student aid and classroom related expenses).

Another potential problem with our empirical analysis was specification error (i.e., the omission of relevant explanatory variables from the regressions in one's model).<sup>21/</sup> In our model there were several possible sources of this problem. First, if the price of educated labor's outputs is not a function of the relative wage rates of degree and non-degree holders (i.e.,  $P \neq f[\frac{W_{LE}}{W_{LU}}]$ ) then our formulation of the general equilibrium market for college graduates cannot capture welfare effects in the market

for the products of educated labor. Also, in the supply relationship, URB (an indicator of the degree of urbanization among college age males) reflects only a portion of the non-pecuniary aspects of pursuing a college degree. Finally, it can be argued that people choose the level of schooling to obtain based on the effect they perceive increased amounts of education having on their future earnings. In the supply equation, then, a more justifiable wage variable may have been a formulation of anticipated future salaries (i.e., rather than  $RelW_{(t-4)}$ ).

Specification error is a problem shared by many econometric works. Unfortunately, it can be difficult to correct for. This is because it is usually impossible (or impractical) to determine all the forces influencing a given dependent variable; and even if accomplished, the inclusion of all such forces in a regression often creates problems with multicollinearity and/or degrees of freedom.<sup>22/</sup> If specification error is a serious problem in our model, then the coefficient estimates are biased, and their associated t statistics are understated.

A third problem undermining our empirical work stems from defining each state as a separate labor market. At this level of aggregation, many variables affecting the supply of and demand for educated labor in an area become diluted, or average out. For example, the firms employing college graduates intensively may tend to locate in clusters (as in eastern Massachusetts or southern California). In some states, then, expenditures for higher education



may be a poor social investment in general and yet be very justifiable in some localized areas. This suggests standard metropolitan statistical areas (SMSA's) may better define individual labor markets. This point, however, can only be noted since most of our data (including income by educational category and expenditures for higher education) were available for states only.

Finally, there is the possibility of measurement error in our data.<sup>23/</sup> Measurement error occurs when the observed values of one or more of the explanatory variables in a regression are incorrect. The data used in this study were susceptible to the problem for two reasons. First, we employed several proxy variables. These variables, by definition, are substitutes for influences that cannot be measured directly; hence, their use implies the existence of some measurement error. Second, we relied heavily on state data that were generated from substate samples. When this is done, errors in sampling and extrapolation are difficult to avoid.

The presence of measurement error, however, is not always cause for concern in regression analysis. If decisionmakers base their actions on observed values of the variables under consideration then there is no problem with the use of OLS. If, instead, decisionmakers base their actions on the true values of these variables, OLS coefficient estimates will be both biased and inconsistent.<sup>24/</sup> The degree to which our results are affected by measurement error is debatable. But regardless of the degree, there was little choice

but to live with the problem, since we had no control over how the data were collected or what it was designed to measure.

This chapter developed and estimated an empirical model of both the ordinary and general equilibrium labor markets for college graduates based on the theoretical framework of Chapter III. Unfortunately, the weakness of the statistical properties associated with these empirical results did not allow us to put much confidence in either the model or any further results that were obtained using it. Hence, the reader was cautioned to view the empirical work as only a numerical example of how the methodology developed in Chapter III could be applied. With this caution in mind, the model was used to estimate the marginal rates of return to both society in general and the participants in the educated labor market from various increases in the level of public investment in higher education. The implications of these rates of return were then discussed (i.e., under the assumption that they were valid). Finally, we considered several possible explanations as to why our empirical work was not more conclusive.

## ENDNOTES

- 1/ Theory does impose some restrictions on these relationships such as the (ordinary) demand curve must be homogeneous of degree 0 in prices.
- 2/ It should be noted, however, that even if such data were available there would be other factors to consider. For example, some people go out of state to obtain their degree and return home after graduation. For these graduates the migration decision may well be based more on psychic than monetary considerations.
- 3/ One determinant, for example, that would be very difficult to put into an empirical model would be the effect of labor laws (such as those regarding child labor, minimum wage, take home work, illegal immigrants, etc.) in a given state. Another would be the influence of government assistance to key industries in a state (such as subsidies, price supports or protection from outside competition).
- 4/ We note that intuition and past research must guide the selection of which exogenous forces to include in equations of the type being discussed here. This is because rigorous demand theory says little about such determinants and relying on it would also create severe estimation problems. Remember a firm's demand for input  $q_i$  can be written as a function of input and output prices. That is:

$$Dq_i = h(W_1, \dots, W_i, \dots, W_n, P) \quad (A)$$

where:  $Dq_i$  = demand for input  $q_i$ ;  
 $W_j$  = the price of input  $j$ ;  
 $P$  = output price.

But this implies

$$W_i = g(Dq_i, W_1, \dots, W_{i-1}, W_{i+1}, \dots, W_n, P) \quad (B)$$

Substituting equation B into equation A (in place of  $W_i$ ) yields a function in which the dependent variable appears as an explanatory variable. Also, we can see by inspection that if equation A were estimated after making the substitution there would be problems with multicollinearity.

- 5/ See Statistical Abstract of the United States: 1970, table 347, p. 234.
- 6/ See 1) Ibid., table 494, p. 325.  
2) Census of the Population: 1970, table 197.
- 7/ See Statistical Abstract of the United States: 1970, table 347, p. 234.
- 8/ For a complete discussion of multicollinearity (its causes, consequences and corrective procedures), see Koutsoyiannis (1977), Chapter 11.
- 9/ For a description of the Farrar-Glauber Test see ibid., p. 242-249.
- 10/ For principle components see ibid., p. 251-52. For ridge regression see Johnston (1984), p. 252.
- 11/ An additional problem associated with principle components is that the method requires a large number of explanatory variables.
- 12/ In a regression, the presence of multicollinearity leads to large standard errors. This, in turn, biases downward the t statistics since they are formed by dividing the coefficient estimate by its standard error.
- 13/ For a complete discussion of heteroscedasticity (its causes, consequences and corrective procedures) see Koutsoyiannis (1977), Chapter 9.
- 14/ We acknowledge that equation 4.9 does not reflect all the exogenous determinants of the wage paid non-degree holders. Hence, one reason the fitted values of  $W_{LU}$  did not yield better empirical results could be that equation 4.9 was specified incorrectly. Time constraints, however, did not allow this relationship to be investigated any further.
- 15/ That is with the double and semi-logarithmic specifications of the supply curve a negative marginal social rate of return to investments in higher education was predetermined. In some states this rate of return may, in fact, be negative but it seems unlikely (and we had no reason to believe) that this would be the case in all states.

16/ To correct for heteroscedasticity one must first find its pattern (i.e., do the variances of the error terms increase or decrease as the magnitude of the heteroscedastic variable increases). Typically, econometricians assume heteroscedasticity takes the form:

$$E(U_i)^2 = \sigma_{U_i}^2 = k^2 X_i^2$$

where:

$U_i$  = the error term of the  $i$ th observation;

$k$  = some constant;

$X_i$  = the  $i$ th observation of the variables ( $X$ ) causing the heteroscedasticity.

Once the pattern is identified, the problem is corrected by dividing the equation through by 1 over the square root of that pattern (i.e.,  $1/X_i$  above). In our case, we have the following regression in which URB is causing heteroscedasticity.

$$DIF = \alpha_1 + \alpha_2 \text{RelW}_{(t-4)} + \alpha_3 \text{URB} + \alpha_4 \text{EXP}_{(t-4)}$$

We found the pattern of heteroscedasticity to be one of increasing variance of the error term as URB increases in value. Dividing through by  $\text{URB}^2$  corrects for the problem. But, note the implications for the OLS coefficients. The new (weighted) regression is:

$$\begin{aligned} DIF/\text{URB}^2 = & \alpha_0 (1/\text{URB}^2) + \alpha_2 \left( \frac{\text{RelW}_{t-4}}{\text{URB}^2} \right) + \alpha_3 \left( \frac{1}{\text{URB}^2} \right) \\ & + \alpha_4 \left( \frac{\text{EXP}_{(t-4)}}{\text{URB}^2} \right) \end{aligned}$$

Clearly,  $\alpha_4$  is no longer an estimate of the marginal change in DIF brought on by a one unit change in  $\text{EXP}_{(t-4)}$  (which is what we need to calculate rates of return to expenditures for higher education).

- 17/ We used the proportion of the male work force with a college degree rather than just the number of degree holders as our quantity variable because of population differences among the states. That is to say the number of college graduates in a state is 150,000 has two different implications with respect to the demand for educated labor if one is talking about a state like Maine or California.
- 18/ From an investment viewpoint, any project with a negative marginal rate of return is not worth further investment; how negative this rate is is not important (except perhaps as an indicator of how much disinvestment should be undertaken). Hence, rates of return were not calculated for specifications of the educated labor market that implied a negative marginal social rate of return to investments in higher education.
- 19/ It is assumed here that most college graduates start work at age 22 and retire at age 65.
- 20/ When we say "the price" of educated labor's outputs we mean a price index for these products.
- 21/ For a discussion of specification bias, its causes and consequences, see Koutsoyiannis (1977), pp. 253-6.
- 22/ In fact, the problem of multicollinearity in a regression is often treated by dropping one (or more) of the collinear variables from one's model. But if the dropped variable(s) really belongs in the model this procedure guarantees the introduction of some specification bias.
- 23/ For a discussion of measurement error, its causes and consequences, see Koutsoyiannis (1977), pp. 258-79.
- 24/ For a proof of the consequences, see ibid., pp. 261-63.

## CHAPTER V

## CONCLUSIONS

This study has examined the marginal social rate of return to investments in higher education. Although the subject has been addressed frequently (see Chapter II) our work was justified because of the partial scope of the methodologies employed by previous researchers. That is, in the past, researchers have defined the social benefits of higher education to be the increased earnings of degree holders over people with only a high school diploma. Completely ignored have been the economic effects investments in higher education have on people other than college graduates and the possibility of an interrelationship between the wages paid degree and non-degree holders.

Drawing on the work of Just, Hueth and Schmitz (1982), we utilized the techniques of applied welfare analysis to develop a new methodology for estimating the marginal social rate of return to investments in higher education. This approach (developed in Chapter III) required identifying the general equilibrium supply and demand curves for college graduates. The areas of consumer and producer surplus associated with these curves were used to estimate the aggregate benefits to society from its educated work force. The supply relationship was conditioned on the level of expenditures for higher education so that changes in this variable would alter

the above surplus areas; that is, so the marginal benefits to society from changes in the level of support for higher education could be estimated. Finally, using benefit estimates obtained in this manner, marginal social rates of return were calculated under various assumptions regarding the industrial mix of an economy, the functional form of the demand curve for college graduates, and the level of increase in expenditures. Under most scenarios, our model indicated further increases in the level of public support for higher education to be an uneconomical social investment.

Unfortunately, the empirical work (the subject of Chapter IV) had to be interpreted primarily as a numerical example of how our methodology could be applied to estimate the marginal social rate of return to investments in higher education rather than an attempt to actually estimate this rate of return. This was due to the overall weakness of the statistical results. In both the ordinary and general equilibrium demand curves key parameters (i.e., the coefficients of  $ReIW$  and  $\widehat{ReIW}$ , respectively) were statistically insignificant at the 10 percent level. The coefficient of the expenditures variable (i.e.,  $INV_{(t-4)}$ ) varied in sign and significance with the functional form used to estimate the supply curve. The sign of  $\widehat{ReIW}$ , in the general equilibrium demand curve, varied with the functional form of the equation used to obtain the fitted values of the wage paid non-degree holders (i.e.,  $\widehat{W}_{LU}$ ). Finally, it was ambiguous whether or not our general equilibrium market for college graduates reflected welfare changes in the market for the products of educated labor.



While our results do not allow us to say much about the true marginal social rate of return to investments in higher education, the problems we encountered in this study do permit the following conclusions. First, the empirical identification of supply and demand curves, both ordinary and general equilibrium, is not a simple matter. Major difficulties can arise due to either gaps in theory or deficiencies in data. Both of these difficulties created problems with our analysis. In estimating the ordinary demand curve for college graduates the transition from theory to empirical application was incomplete due to the unavailability of output price data. The lack of these data also made it impossible to verify if welfare changes in the market for the products of educated labor were reflected in our general equilibrium model. The theoretical development of the supply curve for degree holders was undermined by the absence of a theory rigorously tying personal education decisions to utility maximization. The empirical identification of this curve was hurt by the lack of data regarding migration between states of new college graduates. Clearly, when supply and demand curves cannot be estimated accurately the methodology of this study will be of little applied value.

A second conclusion of this work is that our approach to estimating the marginal social rate of return to investments in higher education has several conceptual strengths over the methodologies employed by previous researchers. First, the theory on which our approach was built is sound. That is, if the general equilibrium supply and demand curves for college graduates can be correctly specified, the marginal social rate of return to investments in

higher education can be estimated using the methodology developed in this study. Defining the benefits of a college degree solely as the earnings difference between degree and non-degree holders, however, will always yield rate of return estimates that are partial in scope. Second, our approach reflects the spillover economic benefits produced by expenditures for higher education without having to identify and measure each such benefit individually (again assuming the general equilibrium curves are correctly specified). Finally, our methodology acknowledges the very real possibility that there may not be one marginal social rate of return to investments in higher education. That is, this rate of return may vary from one area to another.

The last conclusion drawn from this study is that more work is needed before our methodology can be used to make policy recommendations regarding public investment in higher education. Discussed now are some areas in which future research could help eliminate the problems encountered in this analysis.

First the methodology of this study would benefit from the development of a price index, by state, for the products of educated labor. Output price could then be included as an argument in the ordinary demand curve for college graduates, thus eliminating a major theoretical shortcoming in our empirical model. Additionally, the relationship between output price and the wages paid degree and non-degree holders could then be investigated to see if our general equilibrium model reflects welfare changes in the market for the products of educated labor.

Second, any work relating utility maximization to the decision to acquire a particular type of education would be a major contribution to both the theory behind our supply curve and economics in general. As noted earlier, past researchers have given this subject only the most cursory attention. Although Chapter III makes a start at understanding this relationship, there is much to be done before the supply of individual human capital skills is rigorously tied to utility maximization.

We also suggest that the methodology developed here be applied to degrees in specific fields. That is, our approach could be used to estimate the marginal social rate of return to investments in higher education in the fields of engineering, accounting, economics or history. This would address our unrealistic assumption that all college degrees are a homogeneous commodity. In addition, it would allow for the possibility that some degrees are a good social investment while others are not.

Finally, we suggest that our methodology be applied to the 1980 Census of Population data. Unfortunately, this data was not available in time to allow its use in this study. Hence, it must be kept in mind that even if we had been very confident in our results their meaning for today's world would have been quite limited.

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