CHAPTER II

The Theoretical Model

The model used in this thesis is based on the human capital model developed in the 1960's by Schultz, Mincer, Becker and Ben-Porath to explain earnings differentials. The model has previously been employed to explain racial discrimination, sex discrimination, occupational discrimination, job mobility, and other labor market phenomenon.[1] This thesis extends the human capital model to explain wage differentials between disabled and non-disabled workers.

The human capital model offers a theoretic method to analyze wage differentials observed in the labor market. The model is based on the dynamic maximization of the present value of one's earnings. Maximization of earnings occurs by optimal investment in human capital over time, given constraints such as the human capital production function, the amount of time available for investment, and the span of one's lifetime.

The basic approach to determining optimal human capital investment entails the maximization of the present value of earnings:

$$\text{Present value of earnings} = \int_0^T W_t \ (1 - S_t) \ K_t \ e^{-\gamma t} \, dt$$

$$\text{with respect to } \dot{K} = f\ (S_t \ , K_t)$$

where:

S_t = Proportion of time spent investing in human capital

K_t = Human capital stock at time t

$e^{-\gamma t}$ = Discounting term where γ is the discount rate

W_t = Rate of remuneration per unit of human capital at time t

$\dot{K}$ = Addition to human capital stock

This model yields earnings functions of the following form [2]:

$$\ln Y_t = \ln E_0 + \sum_{i=0}^{t-1} rS_i + \ln (1 - S_t)$$

or:

$$\ln Y_t = \ln E_0 + r_s S + ar_e e + \frac{b}{2} r_e e^2 + \ln (1 - S_t)$$

where:

Y_t = Income at time t

E_0 = Innate human capital or earnings potential prior to investing

S = Schooling

e = Experience (post school investment)

r_s = Rate of return to schooling

r_e = Rate of return to post school investment

a = Parameter of parabolic estimating function = K_0

b = Parameter of parabolic estimating function = $K_0/2T$

Thus one's earning potential at any time period depends on the individual's human capital stock, including schooling and experience (such as on-the-job training and other forms of post school investment). Actual income depends on the earning potential and the amount of investment during that period. The quadratic terms on experience allow for diminishing rates of investment, due to decreasing marginal revenue as time passes and the expected future lifetime declines.

Certainly schooling and experience are not the only elements of human capital; nor are they the only determinants of income. Health capital has been recognized as a determinant of earnings [3] and of one's human capital stock. Health capital is embodied in one's human capital; without good health it is difficult to realize the returns on one's schooling and post school investments. Disability, in particular, can limit the amount or kind of work one can do, or it may curtail labor force participation entirely. No matter how much is invested in schooling or post school investment, a disability can render a person unable to work. For this reason it is important to design a human capital model which accounts for disability.

This new model will include a parameter to measure the amount of the human capital stock which is dysfunctional due to disability. Over the lifetime the present value of earnings depends not only on the stock of human capital and its rate of return, but also on the severity of disability or ill health. Disability limits the amount of human capital which can be employed in the earnings function at any point in time. The disability measure (δ) represents the portion of one's human capital which is dysfunctional due to the disability. Thus δ is measured such that $0 \leq \delta \leq 1$; if $\delta = 0$ the individual has no dysfunction or if $\delta = 1$ the individual has no functional human capital (i.e. he is 100 percent disabled). The measure $1 - \delta$ will represent the total amount of functional human capital.

Since the magnitude of a disability changes over time, it is necessary to allow δ to change. A subscript t denotes the time period corresponding to the disability level. Thus a 50 percent disability at time period t ($\delta_t = .50$) will result in the ability to employ only 50 percent of one's schooling and post school investment, while the other 50 percent is dysfunctional due to disability.

The disability measure, δ_t, is determined by a number of factors, some endogenous and some exogenous. Some exogenous factors are the number and kinds of limitations caused by the disability, the availability of health care including rehabilitation centers, and the availability of jobs in the location of the disabled person. Endogenous determinants of the disability measure include occupation, earnings prior to and after the disability (this will affect the individual's access to medical care), outside income and welfare or other transfers (these may be to an extent exogenous), and the availability of other family members for employment. For simplicity, disability will be assumed to be exogenous; endogenous aspects of disability will be ignored.

An important feature of the human capital model is the investment process. Persons acquire additional human capital through on-the-job training or, more generally, post school investment. Individuals combine their time with their previously acquired human capital to produce additional units of human capital; these additional units will yield returns in the future.[4] If one becomes disabled he loses some of his functional human capital and investment becomes more expensive. This is likely to reduce investment and lower future earnings further, relative to a non-disabled individual who continues investing at higher rates.

Past studies have shown that labor force participation may change with the onset of disability so that work time is not constant. The present model must provide for this reduction in labor force participation.

Taking these changes into consideration the disability model entails the maximization of:

$$\text{Present value of earnings} = \int_0^T W_t \, (N_t - S_t) \, (1 - \delta_t) \, K_t \, e^{-\gamma t} \, dt$$

$$\text{with respect to } \dot{K} = f\,(S_t \, , \, (1 - \delta_t) \, K_t)$$

where:

N_t = Proportion of normal time working and investing after disability

$$\frac{\text{time working post-disability}}{\text{time working pre-disability}}$$

(1 = fully participating)
(0 = not participating)

δ_t = Proportion of human capital disabled at time t

$(1-\delta_t)$ = Proportion of human capital not disabled at time t

γ = Discount rate

W_t = Rate of remuneration per unit of functional human capital

The theoretic model allows for two effects. First, the time spent working or investing can change with disability. Second, the amount of functional human capital can decline according to the severity of the disability.

From this model two key relationships are developed.

First:

$$E_t = (1 - \delta_t) \, E_t^*$$

where:

E_t = Actual earnings at time t

E_t^* = Potential earnings at time t (based on schooling and post schooling investment, independent of disability)

δ_t = Level of disability at time t

Actual earnings depend solely on one's level of disability and potential earnings as determined by schooling and experience. Secondly, potential earnings in the t + 1 period depend on investment in the previous time period plus the potential earnings from the previous period. Thus:

$$E_{t+1}^* = E_t^* + rS_t E_t$$

where:

E_{t+1}^* = Potential earnings in period t + 1

E_t^* = Potential earnings in period t

r = Rate of return to investment

S_t = Amount of time spent investing

E_t = Actual earnings at time t

One will note that investment can only be done with one's actual earnings in the previous time period.

The general form of the earnings function then becomes (See Appendix A-1 for derivation):

$$\ln Y_t = \ln E_0^* + \ln (1 - \delta_t) + \sum_{i=0}^{t-1} (1 - \delta_i) rS_i + \ln (1 - S_t)$$

where:

Y_t = Income at time t

E_0^* = Earnings potential prior to investment (innate stock of human capital)

S_t = Amount of time spent investing

δ_t = Proportion of human capital disabled

$1-\delta_t$ = Proportion of human capital not disabled

K_t = Human capital stock at time t

r = Rate of return to human capital

This function exhibits certain desirable properties; if $\delta_t = 0$, one has the normal earnings function developed by Mincer.[5] If $\delta_t = 1$ (total disability), earnings for that period will be zero. If $0 < \delta_t < 1$ then some disability exists and earnings will be less than pre-disability earnings, ceteris paribus. This coincides with empirical work in the area of disability which has shown that 81.7 percent of persons reporting a disability suffered a reduction of income while only 1.5 percent reported an increase in their income.[7]

Since disability is generally not an innate condition, at many points in time δ_t will be equal to zero. This permits the simplification of the earnings function by segmentation [8] into non-disabled and disabled periods. The appropriate segmented earnings function then becomes (See Appendix A-2 for derivation):

$$\ln Y_t = \ln E_0^* + \ln (1 - \delta_t) + \sum_{i=0}^{d-1} rS_i + \sum_{i=0}^{t-1} (1 - \delta_i)\, rS_i + \ln (1 - S_t)$$

This holds for persons who became disabled at time d and have not completely recovered from the disability by period t. Additional segmentation would be necessary to deal with recovered persons or persons who became disabled a second time.

To eliminate participation effects, the dependent variable in this research will be the wage rate; and N_t, work time, will be normalized to one (being one hour's time). The analysis will measure pure wage loss effects due to disability. Errors in reporting of asset income, transfer income, and other participation determinants make this method preferable.

The Wage Model

It is possible to derive an estimatable wage function from the segmented theoretic model, as was done by Mincer for the basic human capital model. Under the assumption of a fixed level of disability [9], this model becomes (See Appendix A-3 for derivation):

$$\ln Y_t = \alpha_0 + \alpha_1 X + \alpha_2 S + \alpha_3 exp_1 + \alpha_4 exp_1^2 + \alpha_5 exp_2 + \alpha_6 exp_2^2$$

where:

X = Measure of level of disability

S = Schooling

exp_1 = Pre-disability experience

exp_2 = Post-disability experience

Given a large number of observations on individuals, this regression could be run in a time series analysis for each individual. Large numbers of observations are seldom available for individuals, and consequently it is necessary to run the regressions cross-sectionally.

Cross-sectional data has a fundamental defect in human capital analysis. Unless the rate of return to schooling, innate ability, and investment rates are identical for members of the same age/schooling/disability cohort, the results of the analysis will be biased. This equality is assumed in most cross-sectional analyses of earnings.[10]

A priori one would expect α_0, the constant representing innate ability, and α_1, the constant representing the index of health (the inverse of disability) to have positive signs. As in the normal human capital model, α_2 is the rate of return to schooling and is expected to be positive. Based on past research it is expected to be in the range of .05 to .10 . The coefficients on experience and experience squared normally are positive and negative, respectively. However, due to the age of the individuals in this particular sample, the signs may not follow this pattern. If depreciation is greater than investment, the return to experience may be negative since experience will pick up aging effects rather than investment effects. The coefficients on post-disability experience and on that term squared should be of lesser magnitude than the coefficients on experience, since the rate of return is adjusted for disability (i.e. $\alpha_5 = \alpha_3 (1 - \delta)$; $\alpha_6 = \alpha_4 (1 - \delta)^2$).

The Wage Growth Model

Recently the testing of human capital theory has expanded its scope to explicitly measure wage growth.[11] Wage growth (or decline) is an important concept in the analysis presented here. The prediction of the wage after disability is not the only aspect to be considered. It is important to also consider the impact of disability as one becomes disabled, as the disability worsens, or as the disability reduces investment. By taking the first difference of the wage equation at time t and t - 1, we arrive at the wage growth equation (See Appendix A-4 for derivation):

$$\Delta \ln Y = \Delta \ln (1 - \delta) + rK (1 - \delta) + \Delta \ln (1 - S)$$

The equation can be expanded to:

$$\Delta \ln Y = \Delta \ln (1 - \delta) + rK - rK\delta + \Delta \ln (1 - S)$$

The final term cannot be assumed to be a random error. Mincer, however, has shown that investment levels are a function of a number of observable variables (e.g. schooling, level of experience, etc.), which can be used as a proxy for this term.

The estimatable model becomes:

$$\Delta \ln Y = \beta_0 + \beta_1 X + \beta_2 K + \beta_3 K\chi + \beta_4 S + \beta_5 exp + \beta_6 MS$$

where:

X = Measure of change in level of disability

K = Investment during time period from t - 1 to t

$K\chi$ = Investment • a dummy variable representing disability ($\chi = 1$ if disabled, 0 otherwise)

S = Schooling

exp = Total life cycle experience

MS = Marital status

One would expect the coefficient on the measure of disability, β_1, to be negative, indicating that becoming disabled or having one's condition deteriorate further will slow one's wage growth. β_2, the coefficient on investment during the period, should be positive, if during the period net investment was positive. β_3 is expected to be negative, since disability reduces the amount of investment due to the smaller inputs of human capital for use in the production of additional units of human capital.

Human capital theory states that the marginal revenue of investments in human capital falls over the life cycle since the time remaining prior to death or retirement is declining.[12] As the marginal revenue falls so does the amount of investment and it would seem that wage growth would decline with increasing age. On the other hand, as investment declines the time spent investing may now be spent working and the realized wage may grow, giving a larger wage growth with age. Thus β_5, the coefficient on life cycle experience is of indeterminate sign.

The coefficient on schooling is also indeterminate. Higher levels of schooling will increase one's efficiency in producing additional units of human capital and may lower the time input required. This might be expected to increase investment and increase one's growth in wages. At the same time, however, schooling raises one's wage rate making investment costlier in terms of time input. Finally, an additional year of schooling will, assuming a fixed retirement age, reduce the prospective years of work time by one. This lowers the marginal revenue from investment in human capital, which will reduce investment at each age. Specific assumptions about the nature of the human capital production function would be necessary to determine the sign of β_4, the coefficient on schooling. Rather than suffer a loss of generality, this will be determined empirically.

The sign of the coefficient on marital status is similarly indeterminate. A wife's human capital stock may be substituted for the husband's in the production of human capital, or they may act as complements, increasing the efficiency of the production function, which will, in either case, reduce investment costs. On the other hand, the husband's home productivity levels may increase while married, causing him to spend less time working or investing, and more time at home. This coefficient will also be left to empirical examination.

FOOTNOTES TO CHAPTER II

1) The human capital model has been applied to the following topics:

Sex Discrimination: Jacob Mincer and Solomon Polachek, "Family Investments in Human Capital: Earnings of Women," Journal of Political Economy, March/April, 1974, pp. S76 - S108.

Racial Discrimination: Barry Chiswick, "Income Inequality," NBER publication, 1974.

Occupational Segregation: Solomon Polachek, "Occupational Segregation Among Women: A Human Capital Approach," Paper presented at the Third World Congress of the Econometric Society, August, 1975.

Job Mobility: M. Kuratani, "A Theory of Training, Earnings and Employment: An Application to Japan," Unpublished doctoral dissertation, University of Chicago, 1973.

Presidential Success: Thomas Kniesner and John McIntosh, "Political Experience and Presidential Success," Unpublished paper, University of North Carolina, September, 1976.

2) Jacob Mincer, Schooling, Experience, and Earnings, (New York, 1974), p. 19, 86.

3) Michael Grossman, "On the Concept of Health Capital and the Demand for Health," Journal of Political Economy, March/April, 1972, pp. 223 - 255.

4) For additional information on human capital production functions, see:

James Heckman, "Estimates of a Human Capital Production Function Embedded in a Life Cycle Model of Labor Supply," National Bureau of Economic Research, Conference on Income and Wealth, 1973.

Solomon Polachek and Thomas Kniesner, "Educational Production Functions: A Micro-Economic Analysis," Paper presented at the Econometric Society Conference, Dallas, Texas, 1975.

5) Jacob Mincer, Schooling, Experience, and Earnings, (New York, 1974), p. 19.

6) If $\delta_t = 1$, $\ln (1 - \delta_t)$ will approach $-\infty$, which will obviously exceed any value for $\ln E_0$ and any positive value for the term $\sum_{i=0}^{t-1} (1 - \delta_i) rS_i$ where $\delta_i \neq 1$. This negative value is, then, constrained to be zero, since it is not possible to have negative earnings.

7) Saad Nagi and Linda Hadley, "Disability Behavior: Income Change and the Motivation to Work," Industrial and Labor Relations Review, January, 1972, p. 225.

8) Jacob Mincer and Solomon Polachek, "Family Investments in Human Capital: Earnings of Women," Journal of Political Economy, March/April, 1974, pp. S76 - S108.

9) This assumption is necessary to limit the analysis to a model with two segments. Limitations in the data chosen for the empirical section do not allow for more than two segments.

10) Jacob Mincer, Schooling, Experience, and Earnings, (New York, 1974), p. 26.

11) For more information on these biases, see:

George Borjas and Jacob Mincer, "The Distribution of Earnings Profiles in Longitudinal Data," NBER working paper no. 143, August, 1976.

E. Lazear, "Age, Experience and Wage Growth," American Economic Review, Vol. 66, No. 4, September, 1976, p. 548 - 558.

P. Taubman, J. Behrman and T. Wales, "The Roles of Genetics and Environment in the Distribution of Earnings," Unpublished manuscript.

12) For more information, see:

Yoram Ben-Porath, "The Production of Human Capital and the Lifecycle of Earnings," Journal of Political Economy, Vol. 75, July/August, 1967, p. 355 - 356.