

present value of investment in education for people of the same ability will be equal. One would observe a positive rate of return over cost on investment in a field that requires a higher ability relative to investment in a field that requires a lower ability if he is looking at the average return to all members of each profession. The equilibrium in the investment alternatives excluding the rent to ability implies the attainment of equilibrium in the labor market, where both the supply curve and the demand curve intersect. If equilibrium in the labor market for each profession is reached but the equilibrium returns differ by field, the long-run supply of graduates will adjust, with students moving into the fields which have relatively higher net returns.

The investment period in education for a professional specialization is normally about four years for the bachelor's degree, two years for the masters degree and four years for the Ph.D. degree on a full-time enrollment basis. If to complete a degree is added the time it takes for individuals to be aware of and to react to differences in returns, or for educational institutions to provide facilities for fields that experienced an increase in enrollment or applicants, adjustment to a disequilibrium situation in the investment market will take a longer time than that required to complete a degree. Therefore, the adjustment towards the equilibrium in investment in education will have a time lag of at least the number of years

to complete a degree.

The Aggregate Supply Function of Degrees:

When investment in each field at each level of degree is aggregated for the whole economy, we have the total number of degrees in each field representing the total investment in the corresponding field of those who completed the degree.

From the viewpoint of the labor market, the number of graduates in each field adds to the total stock of labor with professional training in the field.

A supply function of degrees (graduates) for each group of fields G may be drawn by aggregating the individual decisions to major in each field. The greater the available stipends and the higher the present value of expected lifetime income from investment in field i , the larger the number of eligible students who will be attracted to specialize in this field. Assuming linearity, the relationship may be expressed in the following:

$$D_{nit} = a + d_1 Y_{nit-\lambda} + d_2 S_{nit-\lambda+s} \quad (4)$$

where $n = 1, 2, 3$ levels of degree.

The numerical subscripts stand for level of degree completed - 1 for bachelors, 2 for master's, and 3 for Ph.D. degree. Y is the present value of expected lifetime income, D is the number of degrees, S is for stipends. The subscripts indicate lengths of time lag for the corresponding variable, field and level of

degree.

This supply function has a positive slope and is defined by equation (4) when applied to fields belonging to group G. It is a supply function unique to group G and may be regarded as a long-run supply function of labor with education in any field in G.⁷

Labor Market Adjustment:

In the short-run, the supply curve for each professional skill can be regarded as vertical. At any point in time the stock of labor with professional training in one field, D_i is constant. A relatively small shifting of labor with academic training in field j to an occupation that requires academic training in field i may occur in the short-run. The firm or the individual may decide to invest in training on the job or in a short period of schooling in field i equivalent to the completion of a degree in this field. Investment in this type of training follows the same present value criterion as what governs investment in completing a degree. However, for simplicity of exposition, we will regard the short-run function as vertical and the long-run with a positive slope.

⁷In the empirical test differences in academic requirement is treated by taking the relative proportion of graduates to those eligible. This is explained in Part I. The number of degrees, D can be adjusted by the relative proportion of graduates to eligible which would give us D^* as the dependent variable.

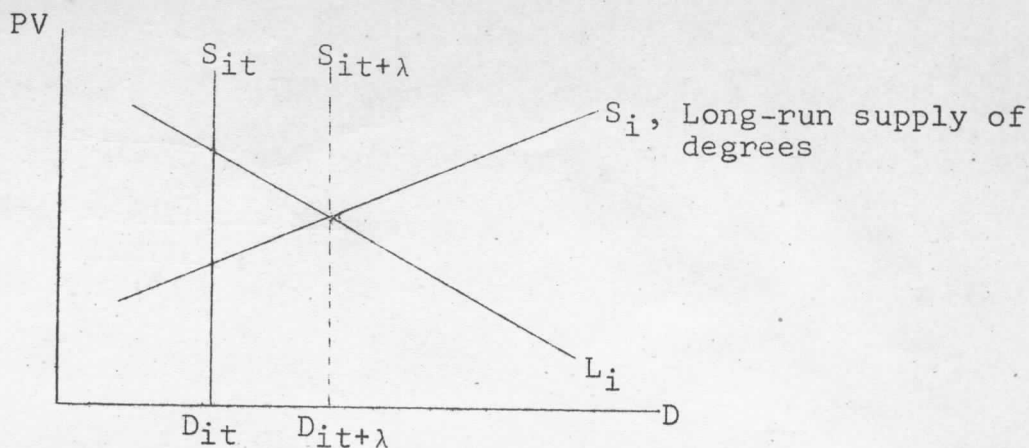


Chart 1

The short-run and the long-run functions are presented graphically in Chart 1.

For each type of labor with professional training in any field in group G, a long-run demand function of the following form probably exists:

$$L_{ni} = L(\hat{Y}_{ni}), \text{ where } \frac{\partial L_{ni}}{\partial \hat{Y}_{ni}} < 0 \quad (5)$$

The demand curve assumes the traditional negative slopes which is derived from a declining marginal revenue product of labor.

The solution to reach a long-run equilibrium in the labor market is shown graphically in Charts 2a and 2b.

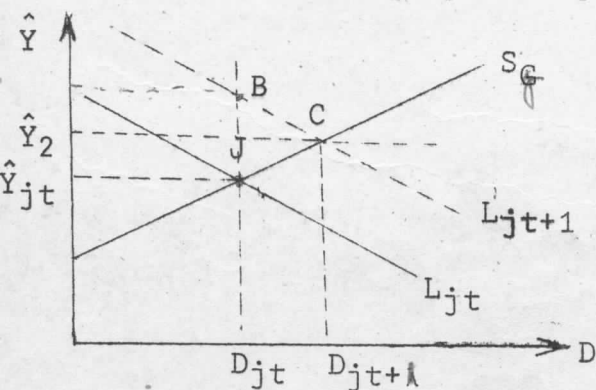


Chart 2a

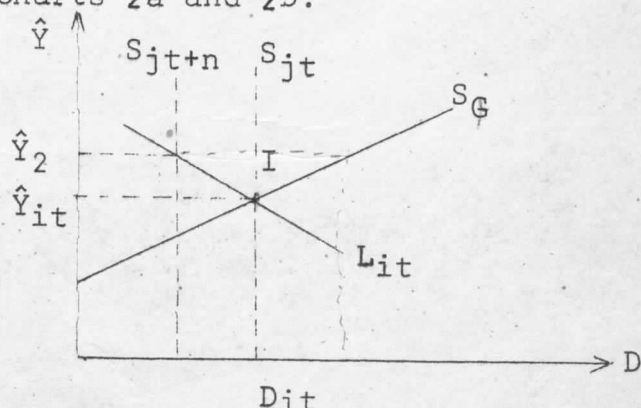


Chart 2b

Charts 2a and 2b show the supply and demand curves for fields i and j at time t and $t+1$. The long-run supply curves, S_i and S_j have the same slope as they are a miniature representation of the long-run supply curve for group G to which fields i and j belong. The demand curves L_i , L_j , L'_j , have different slopes.

Suppose a general equilibrium is attained in both the labor and the capital markets. This equilibrium is represented by points I and J in the labor market where the present value of income from fields i and j are equal at \hat{Y}_{it} and \hat{Y}_{jt} and where the number of graduates employed in each field are D_{it} and D_{jt} . If a permanent shift in demand occurs in only one field, say, j , with the supply curve remaining constant, the present value of investment in this field will be pushed upward and the rate of return over cost to field j will be positive. The capital market is in a disequilibrium situation though the labor market may have achieved short-run equilibrium point B . This field will attract eligible students who have decided to complete a degree in any field in group G . Investment in field j is the only one that has a positive rate of return over cost. It can absorb a net increase in the number of graduates at time t minus the loss to the profession due to retirement and other causes without a decline in present value of income up to the new equilibrium point C . The shift in demand from L_j to L'_j defines a new long-run general equilibrium at C .

If it becomes worthwhile for those who have graduated in field i before time t to shift fields by specializing in another field i , there will be a reduction in the stock of labor in the profession j . This will then push the \hat{Y} or income in field i as a consequence of the decrease in stock from D_{it} to D_{it+1} . To stop the exodus of members of profession i , society (or the industry that employs labor j) must bid up their wages to make it competitive with field i . The normal attrition in field i due to retirement, death and other reasons without replacement will reduce the supply of labor in field i .

Empirically, it is difficult to distinguish the short-run equilibrium from the long-run values of PV after an observed change in present value of income. If the shifts in demand occurs at the same time in all fields, the problem will be minimized for we can just look at the relative change in the present value of income between two time periods in each field. The field that experienced the biggest **change in PV** will have a positive rate of return for a series of time period till full equilibrium in all markets is observed. The larger the shift in demand, the larger the observed change, given that they have the same slope. It is also to be noted that the larger the shift in demand, the larger the total labor units that can be absorbed before the new equilibrium is reached. The probability of being employed in the profession at the PV at least equal to the past value is higher the larger the outward shift in demand.

If the slope of the demand curve is not the same for each field and the shifts in each demand occur at different time periods, the initial levels of PV and the past and absolute successive changes in them would indicate the relative level of PV's.

In Chart 3, supposing we start from an equilibrium position with two demand curves for fields i and j , where the demand curve for i is less steep than that for j . An equal shift in both demand curves⁸ at time t from L_i to L'_i for field i and from L_j to L'_j for field j , will define new long-run equilibrium in the labor market^{which} will be attained only after adjustment in the long-run supply has been made. An equal shift in demand will result in different short-run equilibrium levels of net returns and employment. The field with the more elastic demand curve will have a higher equilibrium present value of income and larger employment possibilities of new graduates. If the shift in demand in the two fields happened at the same time, labor market equilibrium returns can be regarded as a close approximation of the expected *relative* present values or the rate of return as long as no new shift in demand occurred before the latter equilibrium is reached.

⁸ Measured as a perpendicular distance between two parallel demand curves.

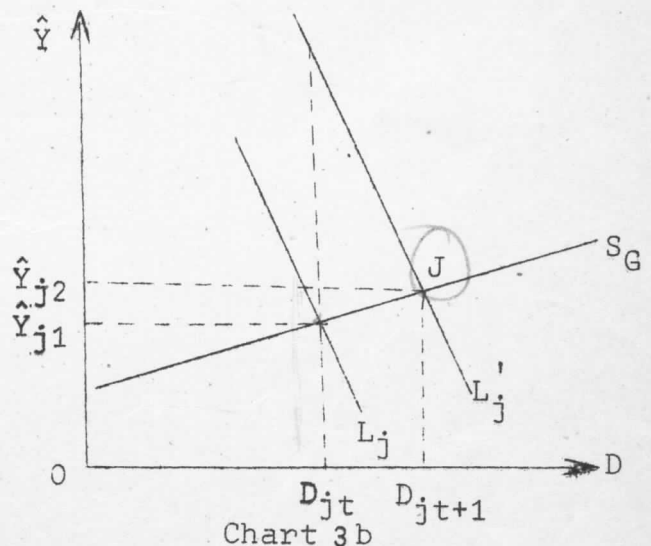
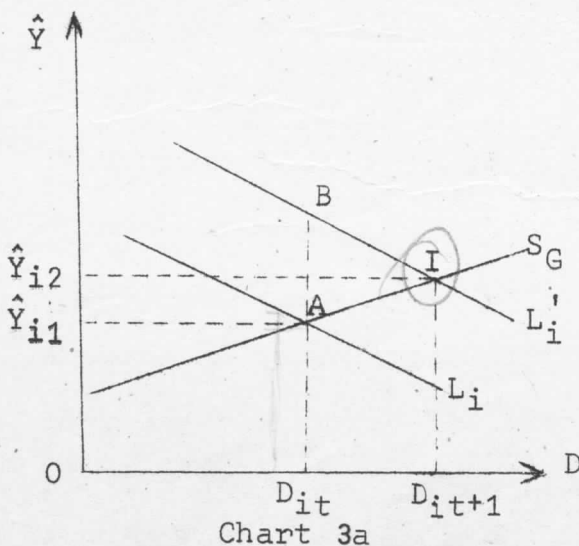
If a field i has experienced a bigger increase in discounted net returns than that experienced by other fields, it could be the result of:

(1) a larger shift in demand for field i relative to the shift in demand in other fields, given that the slopes of their demand curves are equal;

(2) shifts in demand in each field are equal in size, but the demand curve for field i is more elastic than the demand curves in other fields;

(3) if the demand curve in field i is more elastic than that in other fields and field i experienced a larger shift in demand, then the new long-run equilibrium returns in this field will even be higher than under either conditions (1) or (2).

Therefore, an observed higher change in discounted net returns to investment in one field relative to a change in the discounted returns to investment in other fields may result from a shift in demand under condition (1), (2), or (3). Compare points **J** and **I** on Chart 3.



where $D_{it+1} - D_{it} > D_{jt+1} - D_{jt}$

$$\hat{Y}_{i2} > \hat{Y}_{j2}$$

the larger the change in equilibrium discounted net returns to a given field, the larger the total number of labor units with training in this field that can be employed at least at this level of returns. A large change in discounted returns means either a very large shift in demand or a small shift of an elastic demand curve. Either condition would mean a large employment possibility at the new equilibrium point. To an individual decision-maker, the higher the change in discounted net returns, the lesser the risk of his not being employed in the field at the new equilibrium discounted net returns.

From the prevailing levels and movement of past income in various professions, one can estimate future average levels and relative positions of expected income in each field. The length of the time interval over which changes in net return is computed must be long enough so that the change can be regarded not merely as temporary. A change in net returns over a very short-time interval involves short-run adjustment which is very unstable. In Chart 3a on page 28, a change in net returns from point A to point B is a change from one long-run to a short-run equilibria when demand shifts from L_i to L_i' , given a stock of labor with professional training in field i , D_{it} . The long-run change in lifetime income is from point A to point I. The adjustment of supply and demand toward the new equi-

librium point I would take at least the time necessary to complete a degree in field i. ~~Point I takes at least the time necessary to complete a degree in field i.~~ Point I gives the long-run equilibrium net returns around which future levels will tend to fluctuate as long as the new demand curve L_i' remains the same. It is, therefore, likely that a change in net returns over a long time interval would approximate long-run changes better than the year to year changes. If shifts in demand are expected to occur in the future, changes in net returns over a number of time intervals will indicate the direction of change. The past trend of changes in net returns will indicate which fields are growing and which fields are experiencing a relative decline in demand. A high and continuous increase in net returns in field i would mean that the future returns to investment in this field are expected to increase with time unless the future shifts in demand reverse or slow down relative to the shifts in demand in other fields.

If shifts in demand for labor with academic training in different fields occur and are reflected in changes in expected net returns \hat{Y} , individual decision-makers are expected to respond positively to these changes. Assuming that available stipends, in each field also change, we would expect to observe the response of investors in education by an increase (decrease) in the number of graduates to the increase (decrease) in net returns \hat{Y} and available stipend S in the following equation.

Given that the relationship is linear:

$$D_{it+n} - D_{it} = a + d_1(\hat{Y}_{it} - \hat{Y}_{it-\lambda}) + d_2(S_{it} - S_{it-\lambda+s}) \quad (6)$$

In a way, equation (6) may be considered an adjustment process of the supply of degrees toward the new equilibrium levels changed with the shift in demand.⁹

The next question we need to resolve is the speed of adjustment of supply of graduates from one equilibrium to the next when a shift in demand occurs. If the following conditions are fulfilled: (a) perfect knowledge about the market for each professional training, (b) perfect capital market (or at least equality of the imperfection of the capital market in all fields, and, (c) complete homogeneity of taste among the students majoring in any field belonging to each group, I, (d) very elastic supply of academic facilities in each field, a disequilibrium situation will be followed immediately by a movement along the supply curve with a time lag equal to the number of years necessary to complete a required level of degree.

If conditions (a), (c) and (d) are not fulfilled, it will take longer time for students to react to a disequilibrium situation resulting from a shift in demand. In fact, the adjustment of supply of graduates to a disequilibrium situation may

⁹Equation (6) is equivalent to testing equation (4): $D_{it} = a + d_1(Y_{it-\lambda}) + d_2(S_{it-\lambda+s})$. If we subtract this from $D_{it+1} = a + d_1(Y_{it}) + d_2(S_{it})$ we get equation (6). However, in equation (4), the d's would give us the number of students who shift fields within a group in response to differences in income and stipends at a given time. Equation (6) give us the absolute change in the supply of graduates as a response to a change in income to each field.

occur gradually over a fairly long period of time, at least longer than the time necessary to complete the required degree. The gradual and slow change instead of a once-and-for-all change in supply of degrees may be expected if knowledge about the market spreads slowly. Relatively new but fast growing fields may suffer from the disadvantage of not being fully accepted types of employment. Factors other than differences in personal interest and specific attitude that we have controlled by grouping may actually exist so that the response to a relatively high present value of income in one field may require a change in taste. Change in taste does not usually happen in a short time. It is very unlikely that facilities for each field of specialization in institutions of higher education are flexible. The construction of plant and equipment and the training of teachers involves a number of years. Therefore, when conditions (a) to (d) are not fulfilled as discussed above, the adjustment will be gradual and slow, rather than equal to the number of years to complete the degree. The full adjustment will be observed after a time lag of $\lambda + n$, where n is the length of time for delays in adjustment because of market imperfections.

If the capital market is not perfect or not even equally imperfect for investment in different fields, this will further weaken the adjustment process. If students work part-time and study part-time, the adjustment to equilibrium will even be longer.

Part III - Estimation of Expected Future Returns:

The income of members of a profession have been used as the basis of estimating future income in the profession. The various methods used are as follows:

1. The most simple is to look at the hiring rate or at the income of members of each profession with a given level of degree during their first five years in the labor force.
2. Another basis is the income of people who are likely to be in close contact with the would-be-student. Schultz suggested that the income of members of the profession who are more or less of the same age as the parents of the students be used. The age bracket, 40-44 is used in his study. It is also at this age bracket that annual income for most occupations is at its peak.
3. A third method assumes that the expected lifetime income from investing in field i at time t is equal to the sum of income of the age cohort of the population in profession i at time t , given that they have completed the same level of degree as that being contemplated. Becker, Walsh, Friedman and others have used this method in estimating the rate of return to college education.

Methods 1-3 all assume that the absolute and relative income by occupation at time t will remain constant in the future. Methods 1 and 2 further ignores the differences in

annual income at ages other than the initial and middle part of the working life.

The labor market experiences shifts in demand for various skills all the time. Through one's working life and even during the investment period, successive shifts in demand are likely to occur. If successive shifts in demand are expected in the future, the prevailing level of net returns in each field cannot be considered to remain unchanged. Future returns will depend in part on shifts in demand and the present levels. In order to maximize the present value of expected lifetime income investors must take into account possible shifts in demand and how they affect the level and relative position of future returns. Two methods are suggested below:

4. A supply analysis of commodities uses the concept of permanent or normal price to which producers respond. An example of this approach is Nerlove's in his *Dynamics of Supply*, where the permanent or normal price is derived as a weighted average of past prices, the weights having a decreasing distributed lag the farther back in time the prices are taken. The estimation of the present value of lifetime income may be based on the same method, using income streams calculated at different time periods for prices.

However, if the time paths of income from three investment alternatives, A, B, and C during one's working life are as presented in graph (Chart 4) the use of a weighted moving average with a distributed lag will give a good estimate of future returns in each field up to time t below which time paths

A and C cross, assuming the same weight is used for each time period.

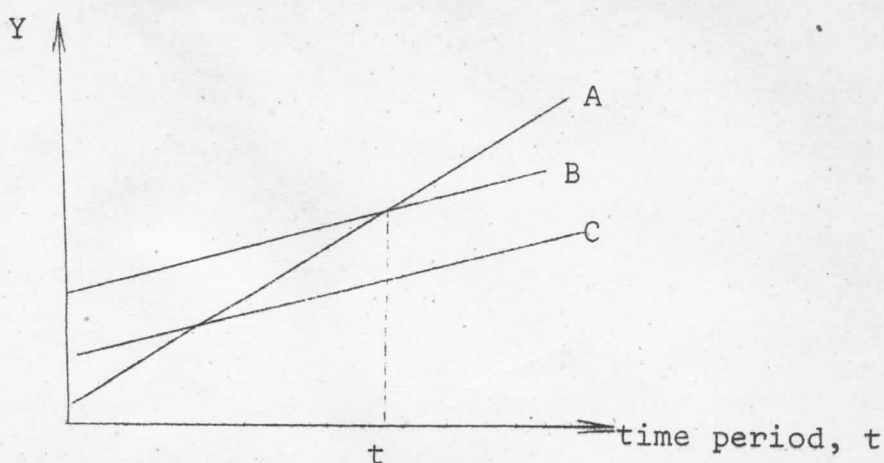


Chart 5

But the total future net returns of A, assuming further that the time paths are linear, will be higher relative to C and of course to B. The net returns estimated from a moving weighted average will be different at different time periods at which the estimate is made if the time path of net returns to investment alternatives cross. It is possible to correct the method of estimating future returns based on past levels by looking not only at the past levels but at the rate of change between two periods, or the rates of change over a series of time intervals in the past. Including the rates of change takes care of crossing time paths of future income.

The expected stream of lifetime income in each field will depend on the initial level and the expected shifts in demand. There are two initial conditions under which investors

may formulate their expectation about future income: that the prevailing levels of net returns in each profession are in equilibrium, or that the market is in disequilibrium, that is, the marginal present value of expected lifetime income in each profession with a given level of degree completed is not equal. Under the first condition the relevant variable in the estimation of relative future income is the expected shifts in demand. The relative level of future returns will depend only on the relative shifts in demand because the present values of expected lifetime incomes in various fields are supposed to be equal under equilibrium condition. Therefore, if Y is the prevailing income, g is the expected shift in demand, Y may be approximated as a function of g , such that

$$\hat{Y}_i = f(g_i) \quad (7)$$

If shifts in demand occur under a disequilibrium condition, relative shifts in demand are not adequate to show which field will have a higher present value of future income. The prevailing disequilibrium income, Y ,¹⁰ will enter into the estimation of expected future income, \hat{Y} , together with the expected future change in demand:

$$\hat{Y}_i = f(Y_i, g_i) \quad (8)$$

¹⁰ Y can be either annual income of the age cohort or the Present Value itself in the past.

The absolute or percentage rate of change of income \hat{Y} , will reflect shifts in demand and may be used as a proxy variable for shifts in demand. Using \hat{g}_i to represent the actual percentage change in income in field i , it is easily calculated given the income at two time periods in the following way:

$$Y_{it+\lambda} = Y_{it}(1+\hat{g})^\lambda \quad (9)$$

Part IV:

An empirical test of the model is performed for the following groups of fields:

1. Group I consists of six fields of science - agriculture, Biological Sciences, Mathematics, Physics, Chemistry, and Earth Science; and four fields of Engineering - Chemical, Civil, Electrical and Mechanical.
2. Group II consists of the health professions which require a degree leading to Doctor of Medicine, Dentistry, Optometry, and Veterinary Medicine. The rationale for this grouping is rather obvious. In these professions there is a common interest in the work of healing and care of patients.
3. Group III consists of fields dominated by women such as education, nursing, library science, social work, nutrition, and medical and dental technology. The fields in this group might be more heterogeneous in terms of specific aptitude and

personal interest than those in the first groups. However, all fields in this group show strong interest in working with people, especially in a nurturant capacity. On the other hand, women's role in society is regarded to be different from that of men; their career outside the home is secondary to their responsibility for the family. This being the case, women's response to economic variables may not be as significant as that by men. Secondly, society's attitude to the woman's role restricts their freedom to enter any occupation that is not, at any given time, conventionally acceptable.

Equations (4) and (6) are tested on a cross section of fields belonging to each group and for all groups listed above. Different estimates of expected lifetime income discussed in Part II are used:

1. H , the hiring rate or the average income of the first five years in the profession:
2. Y , income of members of the profession at the age bracket 40-44;
3. PV , the discounted income stream using the income of the age cohort of members of the profession as the expected future income when one reaches each corresponding age in the population;
4. \hat{PV} , the present value of expected lifetime income computed by a method suggested in this paper and given in equation (8), where

$$\widehat{PV} = PV(1+g)^t;$$

5. It is impractical to use Nerlove's method for lack of long enough time series data on income.

The method of least squares estimate of the coefficients is used in testing the equations.

Two variants of number of degrees are tested for Group I: a) the total number of degrees, D , conferred each year in each field; and b) the number of degrees, D^* conferred on students who were equally eligible. These data are available for the years 1952-64. The number of graduate students, GS , was also used as a dependent variable in the test for the masters and Ph.D. levels in the first group.

Data on eligibility (based on the AGCT scores) are not available for all fields. Therefore, only the groups where the data are available for all fields in each group use D^* in addition to D in the test.

Two variants of stipends are also tried: S_v for the total amount of stipend available by field, and S_n for the number of students who held stipends at each given year. But data on stipends are available only for the graduate level of Group I for 1954, 1958 and 1963.

Data on income by age, by degree and by field are given for 1957, 1960, 1962 and 1964. The present value, $\widehat{PV} = PV(1+\hat{g})^t$, can be calculated for 1960, 1962 and 1964 by using the growth

rate of income in the immediate past period such that \hat{g} applicable to 1960 is the growth rate of p_v between 1957 to 1960, that for 1962 is based on growth rate for either 1957-62 or 1960-62, that for 1964 is based on 1960-64, or 1962-64. Therefore, we only have \widehat{PV} for 1960, 1962 and 1964.

The first equation tested is as follows:

$$D_t = a + d_1 Y_{t-\lambda} + d_2 S_{t-\lambda+s} + d_3 D_{t-\lambda-x}$$

where λ , s , and x are greater than zero, and where λ is the investment period. For the bachelors and Ph.D. degrees, the length of the investment period in a given field based on full-time enrollment is assumed to be four years; for the masters degrees, 2 years, for the doctors in health fields, seven years.

Under the assumption of perfect market conditions, the response of students to a change in expected income at time t would be observed after the required investment period. When there are market imperfections such as rigidities in the supply of educational facilities or slow spread of information, the lag may be larger than the investment period, λ .

For the stipend variable, the lag is expected to be shorter than the income lag, thus $\lambda-s$. Stipends are expected to influence not only the investment choice but the investment period. The larger the available stipend, the larger the number of students who can complete a given degree without working for self-support. In fact the NORC-NSF survey of gradu-

ate students showed a very strong positive relation between the proportion of full-time students and the proportion with stipends by field.¹¹ The availability of stipend affects the number of students who enroll for a field and the number that graduate each year. Therefore, it may not be necessary to lag stipend as long as the lag in income; hence the time lag λ -s is used.

Variables where data do not exist are excluded from the equations tested. For instance, data on stipends are available for the graduate degrees for Group I only.

The lagged value of the independent variable is used to reflect labor market imperfections. But it is excluded in the test for the graduate degrees to minimize the loss of degrees of freedom when data on stipends are available. It would become the third independent variable in a test with only 10 observations.

A test of equation (4) was made using the different variants of both dependent and independent variables and length of lags. Only the lag and the variant of expected lifetime in-

¹¹ NORC-NSF is National Opinion Research Center-National Science Foundation: Graduate.

For the bachelors level, specialization in any one field may not begin till after the second or third year in college. In such a case the response to economic variables may be expected after a lag of 2 years such that the $\lambda=4$ for the Bachelors degree may already include some delay in response.

come and stipends which give the best fit, or the highest R^2 's are given below. Except when specified the results that are not presented here have the expected sign. Knowing this, the reader may assume that the theory is confirmed or disproved by empirical evidence from simply looking at selected results.

The figures in parenthesis under the coefficients are the corresponding significance levels. The years as subscripts indicate the time lags, and the E's are the elasticities of the dependent with respect to the independent variables in subscripts.

The elasticities are computed at the mean value of the variables. For example,

$$E_{PV} = d_1 \frac{\overline{PV}}{\overline{D}_{t-\lambda}}$$

where d_1 is the coefficient of PV in the equation.

The following "best" results were obtained:

Group I, Bachelors degrees:

$$D_{1963} = -569 + \underset{(.08)}{.010} \widehat{PV}_{1960} + \underset{(.06)}{1.226} D_{1957} \quad R^2 = .79$$

$$E_{PV} = .477$$

$$D_{1964} = -6,442 + \underset{(.08)}{.042} \widehat{PV}_{1960} + \underset{(.00)}{1.789} D_{1957} \quad R^2 = .78$$

$$E_{PV} = .509$$

Group I, Masters degree:

$$D_{1963} = -569 + .010 PV_{1960} + .111 S_{n1963} \quad R^2 = .54$$

(.37) (.12)

$$E_{PV} = .237 \quad E_{Sn} = .441$$

$$D_{1964} = -544 + .012 PV_{1960} + .124 S_{n1963} \quad R^2 = .65$$

(.27) (.06)

$$E_{PV} = .266 \quad E_{Sn} = .460$$

Group I, Ph.D. degrees:

$$D_{1963}^* = -1,117 + .154 PV_{1957} + .016 S_{V1958} \quad R^2 = .89$$

$$E_{LY} = 5.240 \quad E_{VS} = .619$$

$$D_{1964}^* = -963 + .178 PV_{1957} + .017 S_{V1963} \quad R^2 = .80$$

(.01) (.00)

$$E_{LY} = 5.431 \quad E_{VS} = .917$$

$$GS_{1963} = -2,947 + .357 Y_{1960} + 1.287 S_{n1963} \quad R^2 = .94$$

(.17) (.00)

$$E_Y = .380 \quad E_{Sn} = .908$$

$$GS_{1963} = -3,949 + .411 Y_{1957} + 1.717 S_{n1958} \quad -R^2 = .88$$

(.19) (.00)

$$E_Y = .473 \quad E_{Sn} = .912$$

$$GS_{1963} = -2,497 + .290 Y_{1957} + 1.260 S_{n1963} \quad R^2 = .94$$

(.19) (.00)

$$E_Y = .353 \quad E_{Sn} = .900$$

For both the Bachelors and Ph.D. levels, the coefficient of income are significant at less than 10%. The significance level for the masters degree is very high with a correspondingly lower R^2 . With a sufficient-

ly long time lag, \hat{PV} gives better fit than the other variants of income. It is possible that where \hat{PV} were available for 1957, it would give better results than PV for the Ph.D. degrees. The investment period might actually be longer than 4 years for this degree but a longer lagged relationship is not possible to test for lack of earlier data on income.

An elasticity of .477 in 1963 and .509 in 1964 for the Bachelors level would mean that for a percentage change in PV in one field relative to another, .477 or .509 of one per cent change in degrees may be expected after a lag of three and four years respectively.

No meaningful comparison can be made of the coefficients or elasticities of income between the bachelors and the two higher degrees because the tests performed do not use the same variables. There is no stipend for the former. However, there is a common trend in the elasticities. Their values increase with the length of time lags. This fact may be explained by the market being less perfect thru time. Information spreads gradually and educational facilities require time to build. So it is very likely that the response in a later period will be stronger than within a shorter period of time.

For the graduate degrees, stipends enter first in the stepwise regression explaining a larger percentage of the variable of degrees. The elasticity of degrees with stipends is also higher than that the elasticities with respect to in-