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ABSTRACT

To study the relationship of education t. economic growth for the state of Iowa, the hypothesis that increasing the level of education for the labor force would lead to higher levels of income or economic growth was tested for the period from 1950-1967. The Cobb-Douglas production was used to evaluate the relationship. The function used labor nonfarm capital, agricultural capital, and the average level of education for the independent variables, and a linear equation was developed using logarithms. The results of the survey were not conclusive. The labor and agriculture variables were significant at the 95 percent level but the latter had a negative regression coefficient. The negative sign showed that agriculture was not in equilibrium, which in turn caused overinvestment in agriculture. The signs were positive for the nonfarm and education variables, but they were significant only at the 90 percent level. One explanation was that the education variable did not account for the variations in contribution to economic growth of the different educational expenditures. Another reason was that the nonfarm capital estimate was not a good approximation of the true capital value. (BC)

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Table of Contents

Tables

I. Summary

The purpose of this study is to examine the realtionship between education and economic growth. Interest in this question arises because quantitative measures of capital and labor can account for only 45.4% of U.S.'s economic growth from 1929 to 1950. The hypothesis to be tested is that increases in the average level of education of the labor force will significantly increase Iowa's state income for the period from 1950 to 1967. A Cobb-Douglas production function was used to estimate the relationship. The Cobb-Douglas production function includes the quantities of labor nonfarm capital, agricultural capital, and the average level of education as the independent variables. The estimated equation used in the study is linear in logarithms.

The results tended to be inconclusive. The labor and agricultural capital were significant at the 95% level, but the agricultural capital had a negative regression coefficient. Several hypothesis were suggested to explain this finding which said essentially that agriculture is in disequilibrium for a variety of reasons and causing overinvestment in agriculture. The signs of the regression coefficients of nonfarm capital and the education variable were as expected but they are only significant at the 90% level.

Several reasons were given for the low significance of the statistical tests: That the education variable as an average failed to account for the differences in the contribution to economic growth of various educational expenditures. The capital variables, particularly nonfarm capital, may not be a good approximation of the amount of capital in Iowa because of the method it was obtained. At the state level the effects of education may be sufficiently difused so that the relationship is weak. Lastly, some forms of education which are important to the labor force were not included in the education variable.

II. Introduction

Interest in economic relationships involving education occurs for both policy and theoretical reasons. One argument for state subsidization of education is that it contributes to the economic growth of an economy. The educated person is thought to be more productive than the uneducated, with other variables held constant. Therefore increasing the expenditures on education will cause the growth of income in the future. The policy maker is therefore concerned with the magnitude and direction of expenditures made in support of education.

Theoretical interest is aroused because the economist has not been able to explain economic growth solely in terms of quantitative measures of capital and lbbor. Edward Denison (2)* estimates that quantitative increases in capital and labor account for only 45.4% of U.S. economic growth from 1929 to 1950. Economists have tried to develop variables that measure qualitative changes in the factors of production. Solow(10) estimated the effect of technical change, to account for the quality of capital, on economic growth. Interest in education, as one measure of labor's quality comes from the studies of Schultz(9), Becker(1) and Denison(3). Denison's Why Growth Rates Differ is the most extensive study of the causes of economic growth, having included many variables measuring the quality of capital and labor.

Since educational expenditures are primarily the responsibility of state government, the question of how the levels of education will affect the economic growth of a particular state becomes interesting. The relationship between levels of education and economic growth may differ between the state and the nation. As education increases the productivity of labor, wages and output will increase, causing economic growth. In this case increases in the level of education within a state will cause economic growth in that state.

Increases in the level of education of labor also leads to the development of new products, the improvement of productive techniques, and the establishment of better management techniques. These results of education can cause economic growth, and possibly can be as important to economic growth as increasing the productivity of labor. But in the latter case the results of the increased education may not be applied in the state in which they originate. If this latter case is significant, it will follow that the relationship between the levels of education and economic growth will be weaker for the state than for the nation.

* Numbers in parenthesis refer to citations in the reference section.

The objective of this study is to examine the relationship of education to economic growth for the state of Iowa. The hypothesis to be tested is that increasing levels of education of Iowa's labor force has led to higher income or economic growth for the period of 1950 to 1967. Included in the study will be estimates of the growth of Iowa's labor force and capital supply. This is done to get a more general idea of the relative importance of education to economic growth.

While the focus of this study is on the relationship of education to economic growth, this does not mean that this is the only relationship of importance or the most important economic relationship involving education. This relationship is being studied because education is important to economic growth.

III. The model.

To test the hypothesis it is necessary to use an aggregate production function which will relate the factors of production to output or income. One such production function in the Cobb-Douglas production function, which has as its form:

1) $Y = AK^{a}L^{b}$

'Y' is the measure of output or income, 'A' is a measure of the unknown contributors to economic growth, 'K' and 'L' are respectively quantities of capital and labor with 'a' and 'b' their exponents. If 'a' and 'b' are each less than one, the assumption of diminishing marginal returns will hold for capital and labor. If the values are greater than one, then increasing returns will hold for that factor, or given percentage growth in that factor will result in a greater percentage growth in income. Returns to scale depend on the sum of 'a' and 'b'. If the sum is greater than one, there will be increasing returns to scale, meaning that an equal percentage growth in both factors will cause a greater percentage growth in income. Constant returns to scale will hold if the sum is equal to one, and diminishing returns to scale with the sum less than one.

To allow for education in the Cobb-Douglas production function, a variable, 'E', which measures the average level of education of Iowa's labor force will be added to the model. The equation is:

2) $Y = AK^{a}L^{b}E^{c}$.

To estimate the model, it is necessary to make the model linear. This can be done by taking logarithms of the variables resulting in:

3) $\log Y = \log A + a \log K + b \log L + c \log E + e.$

'logA' is the constant term to be estimated, which is an estimate of the median value of the unknown contributors. 'e' is the error term which is assumed to be lognormal and with a mean equal to zero. (5)

The economic theory used to examine the causes of growth was developed by the former Senator Paul Douglas. Douglas studied various industries, trying to estimate the economic relationship of the firm's capital and the labor to the firm's output. He was successful in developing a production function which is relatively efficient in estimating the economic relationships. The culmination of his work on production functions was his Presidential Address (4) to the American Economic Association in 1947.

IV. Data

This section will outline the derivation of the data in the study. It will attempt to justify the procedures used in the derivation with respect to the theoretical definitions of the variables used in the model.

The first variable to be estimated was income or 'Y'. Theoretically this variable should estimate the value of net product, gross product minus the depreciation of Iowa's capital supply. Iowa's net product will differ from the income of Iowa's factors of production because some of these factors work in other states and the factors of production from other states work in Iowa. In addition the indirect business taxes will cause net product to differ from state income.

The published series on total incomes in a state is the state's personal income in the Survey of Current Business. This differs from state income in that it does not include any corporation profits unless paid out in dividends. For instance, John Deere & Company has several plants in Iowa. The output of these plants should be included in Iowa's state product. State personal income will include the wages, interest, rents, and dividends paid to Iowans. But it will not include any of Deere's retained profits, nor the corporate taxes paid on those profits, which were generated because of the Iowa plants. Secondly, the ownership of a plant does not necessarily have a relationship to its location. Therefore profit income means the state personal income is a distorted proxy for state product.

In addition, state personal income includes transfer payments to individuals in the state and subtracts the taxes paid to finance the transfer payments. Because the transfer payments and taxes are included in the state personal income series it is relatively simple to adjust for this distortion.

One method of trying to get around the above difficulties was developed by W. L. L'Esperance and Gilbert Nestel of Ohio State University (8). They divided the economy into three general industries: private nonfarm industries, farming, and government. For farming they used income series from the U.S. Department of Agriculture to estimate farm income, net farm product, and gross farm product. Government income and product was assumed to be equal to the wage income paid out in that state. Income and product from the private nonfarm sector was estimated by the use of ratios developed from series on income originating by sectors compared to national income, net national product, and gross national product by industries. This procedure assumes that the state's industry is representative of the national average.

These ratios were used on the Iowa data to estimate Iowa's state income, net product, and gross product. Then it was used in the model alongside of the state personal income and the state personal income adjusted. There appeared to be no real difference between the results. Therefore it was decided to drop the ratio estimates of state income, net product, and gross product. State personal income and state personal income adjusted for transfer payments and taxes were used as proxies for state product. They were divided by the GNP deflator so that real income could be used as the dependent variable.

The second series of data to be developed were the estimates of capital. Capital was divided into two components which were estimated separately. Nonfarm capital was derived from a national series on structure and equipment values published by the Survey of Current Business. The equipment in manufacturing was multiplied by the ratio of manufacturing employees in Iowa to the manufacturing employees in the United States. This was adjusted for difference in the wage rates in the state from the nation. Using the results of a study by Stigler it was assumed that an increase in the wage rate of one percent would result in a substitution of capital for labor such that capital would increase by one percent. Therefore the manufacturing equipment was also multiplied by the ratio of average Iowa wage rates in manufacturing to average U.S. wage rates in manufacturing. (11)

Similar adjustments were made for nonfarm nonmanufacturing equipment. The national series was adjusted for the percent of nonfarm nonmanufacturing employees working in Iowa. Data on the average wage of the nonfarm nonmanufacturing employee was unavailable, so the average wage rate in manufacturing was used as a proxy. National values of structures adjusted for percentage of labor force and relative wage rates were also used to estimate the values of nonfarm structures in Iowa.

The estimates of nonfarm land used the structure values in Iowa with the method of deriving the land values developed by Goldsmith(2). The nonfarm sector was divided into three parts: industrial, commercial, and utilities. The industrial sector was defined to be equivalent to the ratio of production employees to manufacturing employees times the value of manufacturing structures. The value of industrial structures was divided by 85% so that the value of industrial land was equal to 15% of industrial real estate or industrial land plus structures.

The value of utility land was estimated by a more devious procedure. The percentage of utility land to total land values was determined from 1945 to 1958. This percentage was then extrapolated through 1967 and adjusted as above for differences in state and national wage rates. It was assumed that the resulting series would give the percentage of land and structures in utilities in Iowa to the total value of structures and land in Iowa.

The value of commercial land was estimated from the value of structures not used for utility or industrial purposes. The value of commercial structures was divided by 60% so that the commerical land values equaled 40% of commercial real estate or commerical land plus structures. Again the 40% figure was used by Goldsmith(3) in his study of United States wealth. The value of nonfarm capital was obtained by adding the equipment values, manufacturing and nonfarm nonmanufacturing, structure values, manufacturing and nonfarm nonmanufacturing, and land values, industrial, commercial and utility.

The value of agricultural capital was essentially obtained from agricultural census data on Iowa tied to yearly national survey data. The per acre price of farm land and structures was taken from the agricultural census of 1950, 1954, 1959, and 1964. This was tied to an index of national per acre price of farm land and structures to derive the yearly average price. The same census gave the number of acres in farms. A time trend of this was taken to estimate the number of acres in farms each year. The total number of acres in farms in Iowa was multiplied by the average price to determine the average value of farm land and structures in Iowa.

The number of tractors, farm trucks, balers, combines, cornpickers, and harvesters was also taken from the census. Again these were tied to a series on the total number of these pieces of equipment on U.S. farms. In a few cases the resulting series was adjusted by sight because of errors in the method of estimating the numbers of these machines on U.S. farms. The prices of agricultural equipment were determined by finding the average new price and the average rate of depreciation over time. Valuations of new and used equipment and and tractors, published by the National Farm and Power Equipment Dealers Association were used to determine the mean initial price and the mean yearly depreciation. The Survey of Current Business supplied a series on the average age of various types of equipment. This data was used to determine an average price for each type of equipment for each year. The average prices were multiplied by the numbers of equipment to find the value of agricultural equipment for Iowa. The above procedure was not followed for pickups where it was assumed the average value was equal to $2000. The value of agricultural equipment was added to the value of agricultural land to get the value of agricultural capital.

In the statistical testing the value of agricultural capital was not added to the value of nonfarm capital. The reason is statistical. In all probability there are errors in the estimation of both capital values. If these errors are constant throughout the entire period they will only affect the constant term and not the slope. If the two capital values are added together, and with the changing relative weights of agriculture and industry, errors made in the estimation of either would affect the slope of the regression line. Therefore it is hoped that the estimates can be improved by keeping the agricultural and nonfarm capital separate.

The quantity of labor was the third variable to be estimated. It was found simply by adding the number of farm workers to the number of nonfarm employees. Ideally the labor variable should be weighted by an average number of hours worked per week. Since this data could not be obtained for farm workers, it was decided not to make any adjustment for number of hours worked.

The last variable was the average number of years of education of the labor force. For the years 1950 to 1960, the census of those years with an interpolation procedure was used. The population was divided according to sex and years of age. The interpolation procedure resulted in an estimated number of people in Iowa by sex and years of age for the intervening years. It was assumed that the percentage of the population of one sex would change by a constant percent from 1950 to 1960. For each sex it was then assumed the percentage within a particular age group would also change by a constant percent. From 1961 to 1967 survey data from the Census Bureau for Iowa was used to get the sex-age distribution. The surveys were published for 1962 and 1964 to 1967. An interpolation procedure was used as above to get data for 1961 and 1963. Labor force participation rates by sex and age are multiplied by the age-sex distribution of the population.

To the age-sex distribution of the population, data on the educational attainment of the labor force was applied. This was obtained from the 1950 and 1960 census and surveys of the U.S. labor force. The percentage of the labor having different levels of education was determined and multiplied by the age-sex distribution of the labor force. For members of the labor force not in school, the last year of school attained by the person was used. For the members in school, the year of schooling in which they were was used. The years of schooling then was multiplied by the labor force distribution.

Years of schooling is associated with natural ability. In this study, as it deals with levels of education, natural ability should be discounted. As Denison has said, any given measure of natural ability in this situation is highly arbitrary, but any measure of natural ability may be better than nothing. Also higher levels of education are associated with higher incomes. Therefore higher levels of education should be given greater weights to account for that higher income. Weights were developed by Houthtakker and used by Denison to measure the relation between education and income. The difference in the weights was decreased by 60% to account for natural ability(2). This index was multiplied times the labor force distribution.

The distribution was summed over all variables for each year and then divided by the number in the labor force for that year. The result is an estimate of the average level of education of the labor force. The series that results may appear too high because a majority of the labor force have not had any college. Since the ability index is constructed so that eighth grade is equivalent to 100% and higher grade levels are multiplied by an index greater than 100% the height of the series data can be explained.

V. Results

The data was converted to logarithms to conform to the structure of the Cobb-Douglas production function. It was then run in a linear regression. The estimated equations are:

$$4)\quad \log SPY = -3.72850 + \underset{(5.23170)}{2.37981\log L} - \underset{(-2.50783)}{0.33863\log AgK}$$
$$+ \underset{(2.10637)}{0.30003\log NFK} + \underset{(1.78806)}{1.51264\log EDUC}$$

$R = 0.98196 \qquad DF = 13$

$$5)\quad \log(SPY-Tr) = -3.67389 + \underset{(5.12398)}{2.50596\log L} - \underset{(-2.13394)}{0.30980\log AgK}$$
$$+ \underset{(1.41108)}{0.21670\log NFK} + \underset{(1.77950)}{1.61852\log EDUC}$$

$R = 0.97777 \qquad DF = 13$

'SPY' denotes state personal income and '(SPY-Tr)' is state personal income with the transfer adjustment. 'L' is the labor variable, 'AgK' the agricultural capital, 'NFK' the nonfarm capital, and 'EDUC' is the average level of education of the labor force. The computed t values are in parenthesis below the equations. The 'R' is the multiple correlation and 'DF' is the degrees of freedom.

In Equation (4) labor and agricultural capital are significant at the 95% level as the absolute value of their computed t's are greater than 2.16. But agricultural capital's regression coefficient, rather unexpectedly, has a negative value. The nonfarm capital and education variable are not significant at the 95% level but are at the 90% with their computed t values greater than 1.77. This is below the usually accepted tests on significance, but the t values are high enough so that it is undesirable to throw the variables completely out. The multiple correlation is significant at the 99% level.

Equation (5) is probably theoretically stronger than Equation (4) because of the transfer adjustment. Yet the results of the regression are not as good as Equation (4)'s. Labor is the only variable significant at the 95% level, while agricultural capital and the education variable are significant only at the 90% level and nonfarm capital has yet a lower computed t value. Again the multiple correlation is significant at the 99% level.

Run singly against the dependent variables, the regression coefficients of all the independent variables are positive and significant at the 95% level.

$$6)\quad \log SPY = -11.95764 + \underset{(9.32307)}{3.99251\log L} \qquad R = 0.91899$$

7) $\log SPY = -1.11709 + 0.72323 \log AgK \quad R = 0.86661$
$$(6.94696)$$

8) $\log SPY = 2.04189 + 0.59423 \log NFK \quad R = 0.91520$
$$(9.08376)$$

9) $\log SPY = 6.74230 + 3.44450 \log EDUC \quad R = 0.94187$
$$(11.21383)$$

10) $\log(SPY-Tr) = -11.42339 + 3.90794 \log L \quad R = 0.92785$
$$(9.95167)$$

11) $\log(SPY-Tr) = -0.50614 + 0.69459 \log AgK \quad R = 0.85851$
$$(6.69663)$$

12) $\log(SPY-Tr) = 2.67729 + 0.56410 \log NFK \quad R = 0.89617$
$$(8.07871)$$

13) $\log(SPY-Tr) = 7.06019 + 3.30099 \log EDUC \quad R = 0.93106$
$$(10.20715)$$

The primary inconsistency between the single independent variable estimations and the four independent variable estimations is the behavior of agricultural capital. When by itself, its regression coefficient is positive, but becomes negative in the general model. One possible explanation of this change is that during the period examined agriculture has been in disequilibrium because of the increases in agricultural productivity and the continuation of the price support programs for agriculture. The effect of these conditions is that there is overinvestment in agriculture which tends to have a negative effect on income for the state.

VI. Conclusions and Recommendations

The statistical tests of the data do not allow for an immediate acceptance of the hypothesis. At the same time the statistical tests do tend to show support for the hypothesis as the computed t values for the education variable are relatively close to the 95% level of significance, the multiple correlation is significant at the 99% level, and the sign of the regression coefficient is positive which is consistent with the hypothesis.

There are several reasons for the education variable to have a low significance, while still the hypothesis should not be rejected. First the education variable was of an average level of education. There may be substantial differences in the contribution to economic growth of various groups of people with different levels of education. For instance, after attaining competency in certain elementary skills, additional education for skilled labor may be superfluous in terms of its contribution to economic growth. The technology used by the worker requires a certain minimum level of competency and the efficiency of the worker is not increased by increasing his education.

If this hypothesis is valid, it may be more important to increase the quality and quantity of the scientists and engineers rather than increasing the education of the skilled and unskilled workers to increase economic growth.

Secondly, the measure of the average level of education only includes formal education. Actually many other forms of education can affect the worker's productivity. If a worker attended a technical school after completion of his formal education, an effect on economic growth can be expected, but this was not included in the education variable. Additionally, on the job training may contribute to productivity of the workers and this is also excluded from the study. Better measures of educational attainment should improve the results of the statistical tests.

A third reason for the low computed t value of the education variable is that the relationship between the quality of factors of production and economic growth may be weaker for Iowa than for the United States as argued previously. As argued above, the externalities of education on economic growth may be sufficiently large for a state such as Iowa so the statistical relationship between education and economic growth is weak.

The capital data may have substantial errors which would affect the outcome of the statistical tests. Nonfarm capital is probably the worst of the two capital variables. This is because it essentially comes from a United States capital series. Land values were estimated using procedures developed by Goldsmith (7) in his study of U.S. saving. There is no particular reason that the relation of land to real estate values should be the same in Iowa as in the United States as a whole. There is also no particular reason to believe land values should have a different relationship to real estate values in Iowa than in the United States. The most promising aspect about the nonfarm capital data is that it had a fairly good relationship with income in Equation (4).

The agricultural capital data is better, having come from census data of Iowa. Therefore the negative regression coefficient may be indicative of the contribution of agriculture to economic growth in Iowa. The negative coefficient means that additions to agricultural capital have decreased income in Iowa, given the changes in the other variables. For Iowa, agricultural capital needs to be reallocated so that it can be used more efficiently. This may mean that the small farmer or the large farmer has too much capital. The elimination of the small farm may require less capital per unit of output, thus increasing the productivity of agriculture without increasing agricultural capital. These statements can only be suggestive of possible hypotheses as there are more direct methods of getting at the relation of agriculture's contribution to economic growth.

The regression coefficient of the labor variable produces an interesting result. Income increase by some exponential percentage, which is greater than two, of the percent increase of the labor force. For instance, if the labor force increases by 2%, state personal income will increase by about 5.2%.

In order to make policy recommendations for education expenditure, more research has to be done on the marginal increase in income from different types of educational expenditures. Comparative statements have to be made about the marginal returns to educational expenditures before an economic judgment can be made concerning the allocation of expenditures.

More and better data is needed on the economies of the states to improve the quality of economic research. Data on state product and capital supply should not be too difficult for the states in collaboration with the federal government to collect.

Doing this, improvements can be made in educational policy which will lead to the greater welfare of the people of the various states.

TABLE I

STATE PERSONAL INCOME, STATE PERSONAL INCOME (ADJUSTED), LABOR FORCE, LEVELS OF EDUCATION

(In real dollars)

Year	SPY	SPY (Adjusted)	Labor Force	Years of Education
	Mil.	Mil.	Thous.	
1950	$4859	$4648	945.6	12.1
1951	4821	4665	964.1	12.1
1952	4958	4802	962.5	12.2
1953	4757	4586	964.5	12.3
1954	5050	4858	959.1	12.4
1955	4738	4540	949.4	12.5
1956	4872	4672	944.2	12.5
1957	5207	4975	949.7	12.6
1958	5202	4938	943.9	12.7
1959	5235	4954	967.5	12.8
1960	5300	5014	970.0	12.9
1961	5490	5171	968.6	12.6
1962	5676	5353	974.4	13.0
1963	5925	5603	984.2	13.2
1964	6111	5791	986.4	13.3
1965	6823	6481	1002.6	13.4
1966	7335	6996	1042.5	13.6
1967	7296	6914	1063.8	13.8

TABLE II

QUANTITY OF NONFARM CAPITAL

(In millions of dollars, real)

Year	Equipment	Structure	Land	Total
1950	$2339.8	$1739.5	$1036.7	$5116.0
1951	2508.1	1808.7	1072.4	5389.2
1952	2522.3	1778.9	1054.2	5355.4
1953	2546.2	1781.1	1061.1	5388.4
1954	2721.5	1900.3	1135.7	5757.4
1955	2818.0	1944.7	1162.3	5925.0
1956	2927.3	2021.3	1211.2	6159.7
1957	3104.0	2147.3	1291.2	6542.5
1958	3359.8	2339.4	1407.0	7106.2
1959	3501.1	2424.0	1457.4	7382.5
1960	3561.1	2460.9	1486.5	7508.4
1961	3712.7	2572.6	1560.9	7846.2
1962	3730.2	2571.2	1563.9	7865.4
1963	3933.3	2679.5	1631.0	8243.8
1964	4156.2	2777.2	1690.9	8624.3
1965	4369.1	2880.3	1757.1	9006.5
1966	4792.4	3092.5	1885.0	9769.9
1967	5192.3	3258.6	1985.3	10436.2

TABLE III

AGRICULTURAL CAPITAL

(In real dollars)

	Mil.	$	Mil.	Mil.	Mil.
1950	34.3	$160.98	$5516.0	$1100.4	$6616.3
1951	34.2	202.70	6934.4	1254.6	8189.1
1952	34.2	221.67	7571.0	1376.0	8947.0
1953	34.1	210.29	7170.8	1468.0	8638.9
1954	34.0	198.91	6771.9	1516.9	8288.8
1955	34.0	215.75	7335.8	1575.6	8911.4
1956	34.0	220.56	7489.9	1637.9	9127.8
1957	33.9	230.18	7806.8	1638.4	9445.2
1958	33.9	237.39	8041.4	1641.0	9682.4
1959	33.8	254.23	8600.8	1656.4	10257.2
1960	33.8	260.08	8794.8	1631.8	10426.7
1961	33.8	242.54	8198.2	1610.6	9808.8
1962	33.8	254.23	8589.7	1602.1	10191.8
1963	33.8	260.08	8783.5	1581.7	10365.1
1964	33.8	271.77	9174.4	1575.7	10750.1
1965	33.7	286.39	9663.6	1587.5	11251.2
1966	33.7	327.31	11039.9	1610.1	12650.0
1967	33.7	374.08	12612.0	1608.2	14220.2

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