Economic Performance of Ohio's 88 Counties[1]

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ABSTRACT. The value added by the work force varies greatly among Ohio's 88 counties. In the aggregate, the value added equals the gross domestic products (GDP) of the county. With an adjustment for depreciation, the value added by the county production system is equivalent to the aggregated real income (Y) of the county, the best measure of county economic performance. Measuring GDP or Y by aggregating all production of a region is a labor-intensive procedure. The purpose of this paper was to see if data on investment in real capital resources within the county and investment in human resources within the county (education) could be used to estimate domestic income without requiring a production census.

Aggregated county income in Ohio was predicted reliably using county-specific data on the current value of taxable real property (investment in non-human resources), and the estimated value of the investment in educational attainment by the non-degreed work force of the county (human resources). A data vector for investment in the degreed work force was also used in the analysis. All vectors include values for the exhaustive set of Ohio's 88 counties. A total of 9 regressions were computed using various combinations of the data. Using established statistical criteria the regression equation that uses investment in real capital and investment in the non-degreed work force was selected as the best method. These criteria included an R-square in excess of 0.99 and a mean square error that was smallest among the alternative regressions.

INTRODUCTION

The production function for each county can be envisaged as linear and homogeneous. Under this assumption, if all real input variables increase a given percentage, total real output will increase by the same percentage. This is true for both capital inputs and labor inputs, providing all units of input have consistent quality. The quality of the input is an obvious target to explain the variability in performance among the counties of Ohio (micro-regions). The effectiveness of capital is difficult to quantify, but the quality of the human input resource is measured by educational attainment, a variable easy to measure (Census Bureau 2000).

Economists have commonly made the presumption that differences in the levels of technology are the explanation for differences in performance in the long run (Janson 1993). But this study is not a long run analysis of the change in output of a focal geographical unit over time, where advances in marketable applied technology (innovation) result in more output per units of input. This is a comparative study of Ohio's 88 counties for the same specified time interval (one year) in a contemporary setting. No obvious assumption of differing levels of technology across Ohio can reasonably be made except for Amish agricultural production. The explanation for the differing levels of output among the 88 counties must be attributable to other causes. Differences in investment in education of the labor force and differences in the levels of invested real capital within each county are used as explanatory variables for the observed differences in performance of each county as a micro-region.

RELATIONSHIP OF PRODUCTION FUNCTION AND REGRESSION EQUATION

The production function is well established as the relationship between economic inputs and economic outputs. The production system of each micro-region consists of the processes used in the conversion of inputs to outputs. New technology means changing input ratios as new techniques require different combinations of the factors of production. This is an accepted definition for development, in contra-distinction to simple growth. But, in this study, the technologies of production in all micro-regions are assumed to be the same.

At a moment in time the association between real capital investment and human capital investment in all 88 Ohio counties is related to the income generated by the corresponding county during the same accounting period (Ohio County Indicators 2001). A cause-effect relationship between the independent variables and the dependent variable is accepted based on the concept of the production function. Given the values of the independent variables, the dependent variable can be estimated by means of a predictive equation using regression analysis.

PHYSICAL CAPITAL AND HUMAN CAPITAL

Physical capital is the embodiment of previous investment in real property, and includes land, factories, inventory, housing, equipment, and all other tangible property. Human capital is the embodiment of previous investment in education and skill development. The generation of real income requires the services of both

physical capital and human capital. Both physical capital and human capital represent roundabout investment, meaning that foregoing consumption in a specified accounting period for the purpose of increasing the quality of capital will result in a more productive factor of production. The expectation of an increase in the output justifies the investment from the perspective of economic development. The increase in the value of the output must be sufficient to pay the interest on the capital (both real capital and human capital) withdrawn from current consumption.

The raw value of variables associated with each of the counties was secured from sources that collected primary data (Ohio County Indicators 2001). These variables include aggregated values of personal income, transfer payments, taxable real property, size of the work force, and educational attainment among the population cohorts—socio-economic variables that are county specific. Single and multiple regressions using real physical capital, non-degreed human capital and degreed human capital as independent variables, and county income as the dependent variable were computed (Johnston 1978; Yeates 1968).

METHODOLOGY

The 88 counties of Ohio correspond to 4 associated attributes: (Y) is the aggregated income of all taxpaying individuals and corporations resident within the county minus transfer payments, such as welfare and social security. This transfer deduction is appropriate because transfer payments do not represent income earned within the county; (K) is the aggregated current value of all real property in the county estimated from tax evaluations, scaled up to current appraised value; (T) is the aggregated value of the investment in education for that part of the labor force resident within the county that is 25 years old or more and has less than a 2-year degree or continuing education certificate after high school (the average lifetime investment in education per worker is assumed to be $60,000.00 for category T); (H) is the aggregated value of the investment in education for that part of the labor force resident within the county that is 25 years old or more and has a 2-year degree or more after high school (the average investment in lifetime education per worker is assumed to be $120,000.00 for category H).

Every county of Ohio is unique in its history, settlement patterns, accessibility, industrial history, and access to universities. All of these factors characterize the economic environment. Some counties out perform significantly their predicted output, whereas others are laggards.

RESULTS AND QUANTITATIVE FINDINGS

Initially, three regression equations (Bradley 1975; Hoel 1947) were computed, two of which are simple regressions with only one independent variable. The third is a multiple regression equation with two independent variables. SEE denotes the standard error of estimate, and R^2 denotes the coefficient of determination.

$$Let\ Z = T + H$$

The simple regression equations are the following:

1. County income Y as a function of real capital investment, K is

$$Y = 293.53 + 0.59143\ K$$
$$SEE = 2536.5\ and\ R^2 = 0.81552$$

2. County income Y as a function of human capital investment Z is

$$Y = 258.36 + 0.47817\ Z$$
$$SEE = 713.04\ and\ R^2 = 0.98542$$

The multiple regression equation is stated below.

3. County income Y as a function of both real capital investment, K, and human capital investment, Z.

$$Y = 211.63 + 0.05749K + 0.44047Z$$
$$SEE = 677.23\ and\ R^2 = 0.98700$$

Following this analysis, the two categories of the work force were kept separated and 6 more regressions were computed.

The effectiveness of the single variable, investment in human capital, the sum of both work force categories to estimate county income is remarkable. The simple regression using human capital alone as the independent variable fares very well. The coefficient of determination, R^2, is the measure of the total variance explained by the regression equation, and the value of human capital in a micro-region explains 98.5% of the total variance. Investment in human capital alone can be used to predict aggregate county income with a high degree of confidence in the accuracy of the process. The standard error of estimate is reasonably close to the predictive equation, but there is a better model. The regression equation that uses the non-degreed vector T and the real capital vector K is clearly superior from a statistical perspective (Table 1).

POLICY IMPLICATION AND CONCLUSIONS

The profound implication of the multiple regression analysis is the overwhelming significance of human capital to a modern exchange economy. Going beyond the data, capital can and will be accumulated where comparative advantage permits successful competition in the market. There is no reason to assume fixed locations of real property capital in the long run. Even massive aggregations of fixed capital such as integrated steel plants become obsolescent through innovations that underlie the processes of development. In a rapidly changing industrial environment, even the depreciation of sunk costs (a non-cash cost) may not be sufficient to keep a plant viable. The same conclusion is valid for human capital. The human resource is mobile to such an extent that all developed nations have problems with illegal immigration. The highly educated and highly skilled work force will find employment wherever the opportunity is located. Individual personal income is so closely associated with educational attainment that a clear mandate to the legislature is to broaden and deepen educational opportunities by investment in human resources.

The investment in human resources (measured by

TABLE 1

Comparison of models describing aggregate county income (Y). A good model has: Small MSE; Large Rsquare (close to 1);
Small Cp (close to number of variables in equation + 1); Small AIC. Best model by these criteria is the one with K and T.

			Models Involving Total Human Capital (Z) (Note: Z = T + H)				
SSE	DFE	MSE	Rsquare	Rsquare Adj	Cp	AIC	Independent
43,724,741	86	508,427	0.9854	0.9853	11.33	1158.22	Z*
553,328,467	86	6,434,052	0.8155	0.8134	1122.44	1381.56	K
38,984,839	85	458,645	0.9870	0.9867	3.00	1150.12	K,Z

			Models Involving Degreed (H) and Non-Degreed (T) Human Capital				
SSE	DFE	MSE	Rsquare	Rsquare Adj	Cp	AIC	Vars. In Eq.
25,765,907	86	299,604	0.9913	0.9913	5.23	1111.68	T
127,297,196	86	1,480,200	0.9576	0.9571	356.84	1252.25	H
553,328,467	86	6,434,052	0.8155	0.8134	1832.24	1381.56	K
24,511,702	85	288,373	0.9918	0.9916	2.89	1109.28	K,T
98,565,608	85	1,159,595	0.9671	0.9664	259.34	1231.74	K,H
25,594,604	85	301,113	0.9915	0.9913	6.64	1113.09	H,T
24,255,651	84	288,758	0.9919	0.9916	4.00	1110.36	K,H,T

* County Specific Variables:

Y Aggregated income of all taxpaying individuals and corporations resident within the county minus transfer payments such as welfare and social security. (Transfer payments do not represent income earned within the county.)

T Aggregated value of investment in the non-degreed work force (25 years old or more with less than 2-year degree or certificate after high school).

K Aggregated value of all real property (capital in the county based on assessed value scaled up to current value.

H Aggregated value of investment in the degreed work force (25 years old or more with 2-year degree or more after high school).

Z Aggregated value of investment in both the non-degreed work force and the degreed work force. (Z = T + H)

educational attainment) was bifurcated to isolate the contribution of the work force with less than a 2-year degree (basic work force) from the work force that has completed a 2-year program of post high school education (highly trained work force). The result of this is shown by the regression equation.

$$Y = 32.3380 + 0.03154K + 0.7793T + 0.05214H, \text{ where}$$

Y is the domestic county income (value added within the ith county in the year 1999), K is the current value (1999) of all real property investment in the county, T is the educational investment (1999) in the human resource for the basic work force with less than a 2-year degree after high school, and H is the educational investment (1999) in the more highly educated work force.

The partial correlations are revealing and are reported as follows. The subscripts 1,2,3, and 4 correspond to Y, K, T, and H.

Correlation	Proportion of Variance Explained
$r_{12.34}$	0.2287
$r_{13.24}$	0.8683
$r_{14.23}$	0.1022
$r_{23.14}$	0.0080
$r_{24.13}$	-0.1016
$r_{34.12}$	0.3646

The subscript before the dot in the correlation column indicates the variables correlated and the subscript after the dot indicates the variables held constant.

The high correlation between the aggregated county domestic income (earned within the county) and the basic work force ($r_{13.24} = 0.8683$) with the other correlations held constant provides a clear message that the basic work force is the mainspring of county prosperity. Moreover, the correlation with the highly trained work force is almost trivial ($r_{14.23} = 0.1022$). An implication is that in the short run the emphasis on jobs—all jobs—is a reasonable policy imperative. The training of the basic work force is the first priority of the state. This is not inconsistent with the high tech initiatives of Ohio, including investments in university research and development. These priorities are for the long run and the benefits of innovation ripple throughout the world (Janson 1994). Investments in the highly trained work force have limited correlation ($r_{14.23} = -10$) with county domestic income. The partial correlation between the basic work force and the highly trained work force is significant ($r_{34.12} = 0.3646$). The partial correlation underscores the need in most industries for both categories of work force. Finally, the partial correlation between county earned domestic income and investment in real property within the county is also significant ($r_{12.43} = 0.23$). The same

implication is relevant. Viable industries require the services of investment in real property as well as the services of highly trained individuals to augment the services of the basic work force.

Note especially that the correlation between capital investment and investment in the basic work force is almost zero ($r_{23.14} = 0.0080$). This is desirable for two independent variables and eliminates suspicion of multi-collinearity. The coefficient of multiple determinations R^2 exceeds 0.99. The fit of the data from the 88 counties of Ohio to the regression line is quite good.

SELECTING THE BEST MODEL

The county specific independent variables selected to predict county aggregate domestic income are T, the investment in the basic work force with less than a 2-year post high school education, and K, the investment at current value of all real property in the county. The statistical criteria for selecting the best regression model are the following: (A) The smallest mean square error MSE; (B) The largest R-square, the proportion of variance explained by the regression equation; (C) The Cp closest to one more than the number of parameters to assure minimal bias; (D) The smallest AIC (Akaike's Information Criterion). To minimize autocorrelation, the independent variables in the regression equation should have minimal correlation. Using these criteria, the best model uses only K and T for independent variables. The variable H contributes nothing beyond that which is explained by K and T. Table 1 summarizes the statistical criteria. The regression equation computed is presented next.

$$Y = -63.6 + 0.030K + 0.821T$$

Y is aggregate county income, K is total investment in real property within the county, and T is total invest-

ment in the basic work force of the county.

FUTURE RESEARCH

The analysis can be converted to a dynamic model and a different trajectory for each county can be produced. Changing proportions of input factors is by definition development and the increase in county real income (or value added by production) is by definition economic growth. Ohio has a vital interest in both. Changing proportions of inputs almost always implies the expansion of high wage jobs, and economic growth usually implies expansion of jobs for our citizens. These concerns are the profound concerns of public policy in a highly articulated modern exchange economy. Good jobs for trained and willing workers is the best measure of opportunity and equity.

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