Higher Education and State Workforce Productivity

By Michael B. Paulsen

NEA joins the Carnegie Commission in urging state legislatures and the federal government to continue to invest in education at all levels—to maintain the economic and social growth of this nation. To a large extent education has produced and sustained this growth, a fact becoming more apparent each day as science and technology grow more essential to the ability of this nation to compete in the world market. Public funds expended for education, research, and services must be considered an investment in the economic future of this nation.¹

oday's tight budgets and intimidating mid-year budget recisions intensify the perennial challenge to justify society's investment in higher education. Elaborate taxonomies of the many tangible and intangible benefits of higher education investments have been presented.² But the justification for public expenditures on higher education requires the demonstration of substantial public or social benefits—in addition to the purely private benefits—that result from such expenditures.

This article presents an overview of four types of evidence that demonstrate substantial and profitable payoffs—that is, social benefits—from public expenditures on higher education. It also provides results from a recent study of the effect of investment in higher education on workforce productivity and concludes with a brief discussion of the policy implications of the study results.

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The Social Benefits of Higher Education

Policy decision makers often distinguish between private and social benefits of higher education. Private benefits accrue only to the person receiving the education—for example, a higher personal income. Social benefits provide "something more."³ For example, an unambiguous social benefit occurs when increases in the productivity of the labor force result in higher average incomes for everyone, a benefit that is distributed across the population and is not restricted to educational consumers alone.

The economic value of the social benefits associated with expenditures on higher education has been assessed in a number of ways. These include:

Social rates of return on investments in higher education.

• Imputed values for intangible, nonmonetary benefits of higher education.

 Estimates of the impact of direct college and college-related spending on local and regional economic activity.

• Measurements of the contribution of higher education to the growth of productivity, output, and income in the American economy.⁴

We shall examine the value of the social benefits of higher education from each of these perspectives.

Social Rates Of Return

Analyses of the social rates of return on higher education compare the values of the benefits and costs associated with an investment. Calculations typically rely on available monetary measures. For example, to assess the payoff for a public investment in college education, social benefits are often measured as the increment in before-tax earnings of college graduates compared to high school graduates. Before-tax earnings are used instead of after-tax earnings because they include earnings that will be collected by the government in taxes and used to finance other expenditures that will lead to benefits for society as a whole. Social costs include

Social rates of return on college education compare favorably to financial market investments.

costs paid directly (such as tuition) or indirectly (such as earnings forgone while attending college) by the educational consumer; plus all public subsidies (such as state scholarships) used to cover the remainder of the full cost of college education.⁵

In a recent review of the literature based on a meta-analysis of 30 estimates drawn from 15 studies, Leslie and Brinkman⁶ found a median social rate of return to college education of 12.5 percent, with a range from 7.5 to 16.7 percent.

Other studies assess short-term rates of return, comparing starting salaries of college graduates with earnings of high school graduates who did not attend college. For example, for the early 1970s, Freeman⁷ found rates of return as low as 7.5 percent. However, these differences are sensitive to transitory economic and demographic changes.⁸

Acknowledging this, other studies use the earnings of college graduates seven to eight years after graduation to better assess the long-run social rate of return. Using this approach, McMahon and Wagner find rates of return over 13 percent.⁹ They also demonstrate that historically, long-run social rates of return on investment in college education compare favorably with average rates of return on financial market investments, in both magnitude and stability.

In a recent comprehensive analysis, McMahon computes social rates of return to college education for each year from 1967 to 1987.¹⁰ The analysis shows that social rates of return to college were in the 13 to 15 percent range in 1970 and 1971. During the 1970s, they declined temporarily to the 8 to 10 percent range as larger cohorts of graduates entered the job market. In the 1980s, rates increased, leveling off by the mid-1980s at the 12 to 13 percent range.

Nonmonetary Benefits

The costs of education for both individuals and society are mostly financial and so can be measured and included in calculations of social rates of return. But most studies include as a mea-

Estimates probably understate the social rate of return to investment in higher education.

sure of social benefits only the incremental tax payments collected from college graduates relative to high school graduates. The many nonmonetary, social benefits of higher education are excluded in the calculation of social rates of return, usually because they are difficult to measure. As a result, estimates probably understate the true social rate of return to investment in higher education.¹¹

Educators and social scientists identify a variety of nonmonetary benefits of higher education that have a social component. For some of these, they have analyzed correlations with educational attainment. The most comprehensive review of the literature on the nonmonetary benefits of higher education, conducted by Bowen,¹² identifies a variety of nonmonetary benefits—with a substantial social component—that are empirically related to investment in higher education:

• Acquiring a future orientation, a higher tendency to plan ahead.

• Adaptability, receptivity and inclination toward change.

• Political attitudes supporting social well-being, such as support for public programs.

• Greater interest and involvement in political affairs, including a greater sense of political awareness and efficacy.

• Involvement in volunteer work and other community services.

• A higher quality of family life, including better family planning.

• More effective and efficient consumer behavior, including a greater propensity to save and invest wisely.

• A reduction in criminal activity, including fewer violent crimes.

• A healthier life, including keeping better informed about matters of health.

Even the private components of these benefits can have a substantial social impact through an "intergenerational effect." "When higher education adds to the ability and motivation of parents, it enhances the life chances of their children and . . . succeeding generations."¹³

One way to measure the full impact of such expenditures is through a "multiplier" construct.

Higher Education And Local Economic Activity

Social benefits of higher education can also be demonstrated by estimating the impact of direct college and college-related spending on local and regional economic activity. These "economic impact studies" generate estimates of the effect of the presence of a college or university on the volume of business and the number of jobs in the economy of the local community. Studies of this kind help assess the social benefits of investment in higher education "because they measure benefits accruing to community members exclusive of the benefits to students themselves."¹⁴ One limitation: These studies include only monetary benefits, excluding the nonmonetary benefits of the presence of a college or university in a particular community.

Most economic impact studies rely on an economic base approach utilized in the earlier work of Caffrey and Isaacs.¹⁵ This approach assumes that a local economy experiences genuine economic gains—for example, in wealth and jobs—when the presence of a college or university attracts resources from outside the local market area. One important impact: expenditures by the institution, its employees, and their families, students, and visitors on local products and services, generating immediate gains in income and jobs for the community. One way to measure the full impact of such expenditures on the local economy is through a "multiplier" construct.

"Specifically, when a college and its personnel make expenditures in the local area, part of those expenditures become wages, salaries, and profits that are again spent locally, while other amounts leave the community. This process is repeated over and over until all of the original expenditures leave the locality. The figure that represents the continued respending and thus the increased value to the local community of each dollar originally spent is called the multiplier."¹⁶

In a recent meta-analysis of the results of 74 economic impact studies, Leslie and Slaughter used two measures to assess the economic impact of a college or university on its community: local

A community college budget of \$10 million generates local business volume of \$16 million.

business volume generated per million dollars of college budget and jobs created per million dollars of college budget. For public two-year colleges (n = 14), the averages for the two ratios were 1.6 and 55, respectively. For four-year institutions (n = 50), the respective averages were 1.8 and 53. Using the two-year community college average ratios for example, they estimate that "on average, a community college budget of \$10 million would generate local business volume of \$16 million and would create 550 jobs in 1988-1989."¹⁷

Higher Education and National Economic Growth Accounting

American economic growth can be defined as the percentage change in the national product from one year to the next, measured in constant dollars.¹⁸ This measure is often adjusted by the national population or the size of the labor force to provide a better picture of real economic growth. Why? If the population (or labor force) increases between the two years, the growth in national product or income per capita (or per worker) will be less than the growth in national product itself.

The standard macroeconomic techniques used to estimate the contribution of education to national economic growth are "growth accounting studies."¹⁹ These studies typically use an underlying concept of an "aggregate production function." This function illustrates the relationship between total national product (the output of the economic system) and the national resources (labor, physical capital, both equipment and structures, and land) that constitute the primary inputs of the economic system.²⁰ In growth accounting analyses, researchers seek to "account" for the growth in the national product by dividing the growth in output into percentage changes in the inputs of labor, capital, and land; and percentage changes in output per unit of input.²¹ Increases in the output per unit of input indicate improved productivity of labor, capital, or land.

Once the growth in inputs has been accounted for, the portion of growth in output left unaccounted for is often called the "resid-

Higher education contributes to improvements in the application of knowledge.

ual." Much of this residual is attributed to growth in factors that are believed to contribute to increases in productivity—particularly education and advances in knowledge.

A recent review of growth accounting studies conducted in the 1960s, 1970s, and 1980s revealed estimates indicating that a substantial portion of economic growth can be accounted for by the contribution of investment in education. "Estimates generally are in the 15-20 percent range; of this, approximately one-fourth may be assigned to higher education. Also, education, especially higher education, contributes to improvements in the application of knowledge. Estimates of the knowledge contributions range from about 20 to 40 percent."²²

A number of growth accounting studies have produced estimates of the percentage of the overall contribution of education to American economic growth that can be attributed to higher education. One of the first growth accounting studies examined the contribution of education to economic growth for the years 1929-1957. Estimates indicated that increases in the educational attainment of the labor force accounted for 16.5 to 20 percent of economic growth,²³ with higher education accounting for an estimated 17.2 percent of education's overall contribution.²⁴ In other words, investment in higher education was estimated to be responsible for 2.8 to 3.4 percent of economic growth. Using similar procedures, Psacharopouos calculated the overall contribution of education to economic growth to be 17.9 percent for the years 1960-1965; higher education was found to be responsible for 26 percent of this amount.²⁵ Investment in higher education was accounting for 4.7 percent of economic growth.

Recently, Pencavel reexamined the results of a well-crafted growth accounting study conducted by Maddison in order to compute the shares of economic growth attributable to both investment in education in general and higher education in particular.²⁶ These percentage contributions to American economic growth were calculated for three different time periods: 1913-1950, 1950-1973, and 1973-1984. For the earliest period—1913-1950—the contribution of education at all levels to economic growth was estimated to be 14.8

More researchers are beginning to use the gross state product data as a valuable resource.

percent, with higher education contributing 1.3 percent toward economic growth. For the middle period—1950-1973—education at all levels contributed 10.9 percent, while 2.6 percent of economic growth was attributable to higher education. For the most recent period—1973-1984—23.4 percent of American economic growth was attributable to increased education at all levels, while 14.6 percent was attributable to investment in higher education. The three sets of estimates, in combination, show some consistency with the estimates for early—but different—periods resulting from the Schultz and Psacharopoulos studies. The sets also demonstrate the increasing magnitude and importance of the contribution of investment in higher education to economic growth.

Higher Education and Workforce Productivity in the State Economies: An Empirical Investigation

In his recent review of research methods and findings on higher education and economic growth, Pencavel concludes that "more persuasive evidence of the impact of education and of higher education on economic growth than that contained in the growth accounting literature"27 can be drawn from studies that "examine the growth records of a cross-section of countries and determine the association between these growth rates and the educational attainment of the populations or labor forces."28 The study described below takes an approach similar to that recommended by Pencavel, but focuses on the American economy. It examines the relationship between productivity growth, measured as growth in output per worker, and the level of higher education attainment-a measure of the cumulative investment in higher education-for a cross-section of states. The assessment of output per worker is based on a gross state product measure recently developed by the U.S. Department of Commerce.²⁹ Gross state product is the "value of the goods and services attributable to labor and property located in a state. It is the State counterpart of the Nation's gross domestic product."30 In the 1990s, more researchers are beginning to use the gross state product data as a valuable resource to study the deter-

Theory and past research led to the development of these hypotheses about relationships among variables.

minants of workforce productivity and economic growth.³¹

As pointed out in the first section of this article, an unambiguous social benefit occurs when increases in the productivity of the labor force result in higher average incomes for everyone—a benefit that is distributed across the population and is not restricted to educational consumers alone. This study assesses the extent to which investment in higher education contributes to increases in workforce productivity—that is, unambiguous social benefits—for states.

Table 1 presents the values of all variables in the model for all 48 states included in the study. For each state, the second column shows the rate of growth in workforce productivity—measured as the percent change in the inflation-adjusted gross state product per worker from 1980 to 1989 (**GROWTH**). The third column presents the actual inflation-adjusted dollar value of the initial level of workforce productivity in 1980—that is, prior to the period of subsequent growth being studied—for each state (**PROD**). The fourth column shows the fraction of high school graduates age 25 and over who had college degrees in 1980 (**HIGHED**)—a measure of the initial cumulative investment in higher education. The last column indicates whether a state is in a coastal or interior region (**COASTAL**). The bottom row of Table 1 shows averages for each of the variables across all 48 states studied.

Statistical analyses of the effect of each of the independent variables—**PROD**, **HIGHED**, **COASTAL**—on the dependent variable—**GROWTH**—make it possible to draw out and see the relationships between the factors shown in Table 1.

Theory and past research led to the development of these hypotheses about the relationships among the variables:

• **HIGHED** has a positive effect on **GROWTH**. Prior research demonstrates the substantial contribution of higher education to economic growth.³²

• **PROD** has a negative effect on **GROWTH**. Research indicates that among economies with similar educational attainments, those with lower productivity levels learn over time how to adopt and use the ideas and techniques of more productive economies,

resulting in a convergence of growth rates among such economies. In other words, those economies with initially lower productivity would tend to grow somewhat faster, while those with higher productivity would tend to grow somewhat slower.³³

• Finally, **COASTAL** has a positive effect on **GROWTH**. The industries that experienced major recessions during the 1980s—farming and energy-related mining—are concentrated in the interior regions, yielding a relative "growth" advantage for state economies in coastal regions.³⁴

TABLE 1

Higher Education and Productivity Growth in the 48 States									
State	Growth _{89/80}	Prod ₈₀	Highed ₈₀ (Coastal	State Gr	owth _{89/80}	Prod ₈₀	Highed ₈₀ (Coastal
Alabama	.143	24870	.216	no	Nebraska	.132	26820	.211	no
Arizona	011	30253	.240	no	Nevada	030	36287	.191	yes
Arkansas	.100	24182	.195	no	New Hampshir	e .350	23410	.252	yes
California	.136	33203	.267	yes	New Jersey	.318	28673	.272	yes
Colorado	.076	29157	.293	no	New Mexico	.181	37173	.255	no
Connecticut	.330	28772	.294	yes	New York	.213	31422	.270	yes
Delaware	.117	29214	.255	yes	North Carolina	.158	25019	.241	yes
Florida	.003	28206	.223	yes	North Dakota	.122	31599	.223	no
Georgia	.159	26861	.259	yes	Ohio	.143	27726	.204	no
Idaho	.049	25856	.214	no	Oklahoma	.141	34333	.229	no
Illinois	.121	30451	.244	no	Oregon	.013	27398	.237	yes
Indiana	.126	26284	.188	no	Pennsylvania	.128	27291	.210	yes
Iowa	.043	27396	.194	no	Rhode Island	.189	23089	.252	yes
Kansas	.116	27655	.232	no	South Carolina	.156	24087	.250	yes
Kentucky	.160	26484	.209	no	South Dakota	.031	23473	.206	no
Louisiana	.202	46114	.241	no	Tennessee	.193	25626	.224	no
Maine	.217	23870	.210	yes	Texas-	.102	38481	.270	no
Maryland	.201	24466	.303	yes	Utah	.007	28674	.249	no
Massachusett	ts .326	26315	.277	yes	Vermont	.235	23204	.268	yes
Michigan	.125	28492	.210	no	Washington-	.007	31057	.245	yes
Minnesota	.210	26313	.238	no	West Virginia	.083	29190	.186	no
Mississippi	.092	24688	.224	no	Wisconsin	.153	25357	.213	no
Missouri	.124	26820	.219	no	Wyoming	249	56356	.221	no
Montana	101	29294	.235	no	Average	.090	31160	.241	

Details of these hypotheses and the variables involved, as well as the regression analysis used to obtain the coefficient estimates, are presented in Appendix 1. The results of the analysis are discussed below.

States with higher investment in higher education have higher growth in productivity.

The results of the analysis can be stated in terms of the effect on **GROWTH**_{89/80} of a 10 percent change in the average values of **PROD**₈₀ and **HIGHED**₈₀. The effect of initial level of workforce productivity in 1980 (PROD80) on the rate of growth of gross state product per worker between 1980 and 1989 (**GROWTH**_{89/80}) is negative and statistically significant. The magnitude of the coefficient (-.000010) indicates that all else equal, a 10 percent increase in the average value of **PROD**₈₀ (.10 \times 31160 = \$3,116) is associated with a 3.1 percent decrease (-.000010 \times 3,116 = -.031 or -3.1%) in **GROWTH**_{89/80}. This clearly supports the hypothesis that states with higher levels of initial workforce productivity have lower subsequent rates of growth in workforce productivity than states with lower levels of initial workforce productivity.

A comparison of actual values for Arkansas and Iowa in Table 1 illustrates this relationship. In 1980, these two state economies shared almost identical cumulative investments in higher education, .195 and .194. But Iowa had a higher initial workforce productivity than Arkansas—27,396 versus 24,182—and so also had a lower rate of growth in subsequent workforce productivity from 1980 to 1989, 4.3 percent versus 10 percent.

The effect of initial, cumulative investment in higher education in 1980 (**HIGHED**₈₀) on the rate of growth of gross state product per worker between 1980 and 1989 (**GROWTH**_{89/80}) is positive and statistically significant. The magnitude of the coefficient (1.64) indicates that all else equal, a 10 percent increase in the average value of **HIGHED**₈₀ (.10 \times .241 = .0241) is associated with a 4 percent increase (1.64 \times .0241 = .0395 or 4 percent) in **GROWTH**_{89/80}. This clearly supports the hypothesis that states with higher levels of initial, cumulative investments in higher education have higher subsequent rates of growth in workforce productivity than states with lower levels of initial investments in higher education.

A comparison of actual values for Connecticut and Florida in Table 1 illustrates this relationship. In 1980, these two state economies shared very similar initial levels of workforce productivity—28,772 and 28,206. Connecticut, however, had a substantially higher initial, cumulative investment in higher education than

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Florida—.294 versus .223. Therefore, Connecticut also had a much higher rate of growth in subsequent workforce productivity from 1980 to 1989—33 percent versus only 3 tenths of 1 percent. The importance of the magnitude of the estimated effect of initial investment in higher education on subsequent growth in workforce productivity is discussed below in the last section of this article.

Finally, the effect of a state being in a coastal rather than an interior region (**COASTAL**) on the rate of growth of gross state product per worker between 1980 and 1989 (**GROWTH_{89/80}**) is positive and marginally significant (p-value of .0578). The magnitude of the coefficient (.07) indicates that all else equal, states in coastal regions—compared to those in interior regions—experienced a 7 percent higher rate of growth in workforce productivity between 1980 and 1989. This clearly supports the hypothesis that state economies in coastal regions experienced higher average rates of growth in workforce productivity than states in interior regions between 1980 and 1989.

Data for Delaware and Utah in Table 1 illustrate this relationship. In 1980, these two state economies shared similar initial levels of workforce productivity—29,214 and 28,674—as well as similar levels of initial, cumulative investments in higher education—.255 and .249—however, Delaware is in a coastal region, while Utah is in an interior region. Therefore, Delaware had a higher rate of growth in subsequent workforce productivity from 1980 to 1989—11.7 percent versus 7-tenths of 1 percent. A plausible explanation for this difference is that while 6.3 percent of Utah's gross state product in 1980 was attributable to mining industries—which experienced a recession during the 1980s—only 6-tenths of 1 percent of Delaware's gross state product in 1980 was attributable to mining industries.³⁵

Conclusion and Policy Implications

In many ways we have become a "nation at risk," comparing unfavorably with other nations in both educational achievement and workforce productivity. Of course, a nation at risk is made up

A dramatic result is the magnitude of the impact of a state's investment in higher education.

of states at risk. One important feature of the study presented above is its state-level perspective on the relationship between investment in higher education and workforce productivity. The examination of gross state product data opens another window for learning more about how to enhance workforce productivity. The results of this study demonstrate that investments in higher education have a substantial and positive impact on the rate of growth in workforce productivity in our state economies. The magnitude of the coefficient measuring that impact is large enough to provide evidence of substantial social—as opposed to only private—benefits attributable to investments in higher education. As stated earlier, an unambiguous social benefit occurs because increases in the productivity of the labor force result in higher average incomes for everyone—a benefit that is distributed across the population and is not restricted to educational consumers alone.

The most dramatic result of the study is the impressive magnitude of the impact of a state's initial, cumulative investment in higher education on its subsequent rate of growth in workforce productivity. Results indicated that, all else equal, each 1 percentage point (.01) increase in a state's cumulative investment in higher education in 1980—the ratio of college graduates to high school graduates age 25 and over—was associated with an increase in the subsequent rate of growth in workforce productivity—from 1980 to 1989-of .0164 or 1.64 percent. The average rate of growth in workforce productivity between 1980 and 1989-that is, the nineyear growth rate—for the 48 states was .090 or 9 percent. Therefore, all else equal, each 1 percentage point (.01) increase in a state's investment in higher education would raise the rate of growth in workforce productivity for an "average" state by 18.2 percent (1.64/9 = .1822). In other words, all else equal, for an otherwise "average" state, a 1 percentage point (.01) increase in the state's investment in higher education would lead to an increase in their subsequent rate of growth in workforce productivity by an amount equal to nearly one-fifth of the average nine-year growth rate for the 48 sample states.

Furthermore, results indicate that, all else equal, if an average

The burden of financing higher education has been shifting from states to students and families.

state were to increase its initial, cumulative investment in higher education in 1980 by 10 percentage points (.10), the subsequent rate of growth in workforce productivity—from 1980 to 1989 would be .164 or 16.4 percent. And each 10 percentage point (.10) increase in a state's investment in higher education would raise the rate of growth in workforce productivity for an "average" state by 182 percent (16.4/9 = 1.822).

For the past 15 years, students and their families have watched with deepening concern as revenue shortfalls and budget cutbacks have diminished state funding for public colleges and universities. State investment in higher education has wavered for some time and is now in decline.³⁶ The burden of financing higher education has been shifting from states to students and their families—in the form of higher tuition that is often unaccompanied by increases in state student grant programs that are sufficient to offset the effects of rising tuition.³⁷ States are moving to a hightuition/low-aid approach to the finance of higher education. Research has clearly demonstrated that lower state appropriations tend to push up tuition in the public sector,³⁸ and that both high tuition and low aid reduce the probability that students will attend college and restrict the range of colleges accessible to them.39 Based on their recent research on the impact of college affordability on student choice and persistence decisions, St. John, Paulsen, and Starkey conclude that "the long-held covenant between states and their citizens-i.e., that the state would subsidize the costs of attending to a sufficient level to enable middle-class students the opportunity to enroll continuously in higher education-was not adequately supported." ⁴⁰ As the burden of financing higher education shifts from states to students, any concomitant reductions in access to and investment in higher education will result in an unfortunate outcome: States and their citizens will experience fewer of the social benefits of higher education.

In combination, the four types of evidence on the social benefits of higher education presented in the first section of this article social rates of return, nonmonetary benefits, impacts on local economies, and contributions to national economic growth—plus the important findings of the study presented in the second section of this paper—that investment in higher education has a substantial impact on growth in workforce productivity in our states' economies—constitute a compelling argument for more public investment in higher education.

Higher education should no longer be considered the "swing" element in state budgets—that is, unprotected, discretionary funds that are readily shifted away from their intended use in order to fortify the budget in politically-troublesome areas.

The many social benefits of higher education call for a reconceptualization of state public finance policy-one that automatically protects allocations to higher education from encroachments due to the vagaries of budgetary decisions. State budgets should be invested wisely and with substantial forethought-in ways that will maximize social benefits per dollar spent. Some states are now developing coordinated strategies for financing and investing in higher education. In such states, decisions regarding investments in higher education are not based on knee-jerk reactions to revenue shortfalls. For example, in Minnesota, decisions regarding changes in the tuition, aid, and subsidies that structure and direct investment in higher education are made in a coordinated—as opposed to disconnected—fashion in a high-tuition/high-aid environment.⁴¹ However, in states where the social benefits of higher education are overlooked in the midst of a rush of activity to balance a state's budget, some of the chances for greater social wellbeing will be turned into no more than missed opportunities.

Appendix 1

Equation (1) below expresses the hypothesized relationships between growth in workforce productivity from 1980 to 1989 (**GROWTH**)—the dependent variable—and the following independent variables: the initial level of workforce productivity (**PROD**)—for 1980, that is, prior to the period of subsequent growth being studied; the initial cumulative investment in higher education (**HIGHED**)—also for 1980, prior to the period of subsequent growth; as well as a dummy variable to control for the effect of being a coastal—as opposed to an inland—state on productivity growth (**COASTAL**). In order to investigate these relationships, equation (1) was estimated by applying multiple regression analysis to cross-section data on the productivity growth records for the 48 contiguous states for the period 1980-1989.^{42, 43, 44}

Equation (1)45

$GROWTH_{89/80i} = B_0 + B_1 PROD_{80i} + B_2 HIGHED_{80i} + B_3 COASTAL_i$

where i = 1, 2, . . . 48 contiguous states

Equation (1) states that the rate of growth in workforce productivity for an average state between 1980 and 1989—that is, the nine-year growth rate—is equal to some constant amount (B_0), plus some fraction (B_1) of the state's initial workforce productivity in 1980 (**PROD**_{80i}) plus some fraction (B_2) of the state's initial, cumulative investment in higher education (**HIGHED**_{80i}), plus—for coastal states only—the average difference between coastal and interior state economies in the rate of growth in workforce productivity between 1980 and 1989 (B_3). Variable definitions, data sources—in footnotes—and hypotheses are presented more formally below.

GROWTH_{89/80i} = the rate of growth in real gross state product per worker in state i between 1980 and 1989—that is, the nineyear rate of growth in productivity for each state.⁴⁶

PROD_{80i} = the initial level of real gross state product per worker in state i at the beginning of the period in 1980.

HIGHED_{80i} = the initial, cumulative investment in higher education in state i at the beginning of the period in 1980, measured as the number of college graduates—age 25 and over— divided by the number of high school graduates—age 25 and over.⁴⁷

COASTAL = a dummy or binary variable that equals 1 for states in regions along the Atlantic or Pacific coasts—including the Bureau of Economic Analysis regions of New England, Mideast, Coastal Southeast, and Far West—and equals 0 for states in the nation's interior regions—including the Great Lakes, Plains, Southwest, Rocky Mountain, and Interior Southeast regions. This variable is included to control for the negative effects on productivity growth—gross state product per worker—due to the recessions during the early- to mid-1980s in specific industries such as agriculture and energy-related mining—oil, natural gas, and coal which are heavily concentrated in the economies of the states in the nation's interior regions. On average, these recessions tended to result in advantages in productivity growth during the 1980s for coastal state economies relative to interior state economies (Renshaw, Trott, and Friedenberg 1988).⁴⁸

 B_0 = the net effect on **GROWTH** of all influences not specified in the equation.

 B_1 = the effect on **GROWTH** of a one-unit increase in **PROD**_{80i}, all else equal. The estimation of this coefficient provides for the test of the convergence hypothesis. Given a set of economies

with similar educational attainments, those with lower productivity learn to adopt and use the techniques and ideas of their more productive counterparts. The result is a convergence in growth rates over time for economies in this group.⁴⁹ This hypothesis states that all else equal, the growth in workforce productivity for a state between 1980 and 1989 is inversely related to its initial level of workforce productivity at the beginning of the period—in 1980. Hypothesis 1: $B_1 < 0$.

 B_2 = the effect on **GROWTH** of a one-unit increase in **HIGH**-**ED**_{80i}, all else equal. The estimation of this coefficient provides for the test of the hypothesis about the positive contribution of investment in higher education—human capital—to growth in workforce productivity in the states. This hypothesis states that all else equal, the growth in workforce productivity for a state between 1980 and 1989 is directly related to its initial, cumulative investment in higher education at the beginning of the period—in 1980. Hypothesis 2: $B_2 > 0$.

 B_3 = the average difference between states in coastal and interior regions in terms of the growth in workforce productivity between 1980 and 1989, all else equal. As explained above, the recessions in mining and farming during the 1980s affected industries that were heavily concentrated in the interior regions. The estimation of this coefficient makes it possible to test the hypothesis that state economies in coastal regions experienced higher average rates of growth in workforce productivity than states in interior regions between 1980 and 1989. Hypothesis 3: $B_3 > 0$.

The results from the estimation of Equation (1) appear below with p-values in parentheses under the coefficients and the means of the variables in brackets above each variable.⁵⁰

During the period from 1980 to 1989, the rate of growth in workforce productivity among state economies (**GROWTH**) was negatively and significantly related to the initial level of a state's workforce productivity in 1980 (**PROD**); and it was positively and significantly related to the initial, cumulative level of a state's investment in higher education in 1980 (**HIGHED**).⁵¹ Furthermore, coastal states had higher average productivity growth rates than interior states (**COASTAL**).⁵² These findings support each of the hypotheses presented above.

Endnotes

- ¹ National Education Association, 1994.
- ² Bowen, 1977; Schultz, 1963.
- ³ Baumol, Blackman, and Wolff, 1989, 199.
- 4 W. E. Becker and Lewis 1992, 1993a; Cohn and Geske, 1990, 1992; Pencavel, 1993.
- ⁵ Becker, 1975; Cohn and Geske, 1990; McConnell and Brue, 1986; Psacharopoulos, 1981.
- ⁶ Leslie and Brinkman, 1988, 72.
- 7 Freeman, 1975.
- ⁸ Murphy and Welch, 1989, 1992.
- ⁹ McMahon and Wagner, 1982, 160-161.
- ¹⁰ McMahon, 1991, 287.
- ¹¹ Cohn and Geske, 1992; Douglass, 1977; Haveman and Wolfe, 1984b; Leslie and Brinkman, 1988.
- ¹² Bowen, 1977.
- ¹³ Ibid., 198.
- ¹⁴ Leslie and Brinkman, 1988, 86.
- ¹⁵ Caffrey and Isaacs, 1971.
- ¹⁶ Leslie and Brinkman, 1988, 90.
- ¹⁷ Leslie and Slaughter, 1992, 230.
- ¹⁸ Cohn and Geske, 1990, 134.
- ¹⁹ Denison 1984, 1985; Jorgensen, 1984; Maddison, 1987; Pencavel, 1993; Psacharopoulos, 1973, 1984; Schultz, 1961, 1963.
- ²⁰ Becker and Lewis, 1993b; Cohn and Geske, 1990; Pencavel, 1993.
- ²¹ Denison, 1985, 22.
- ²² Leslie and Brinkman, 1988, 80-82.
- 23 Schultz, 1963, 45-46.
- 24 Schultz, 1961, 81.
- ²⁵ Psacharopoulos, 1973, 116, 119.
- ²⁶ Pencavel, 1993; Maddison, 1987.
- ²⁷ Pencavel, 1993, 62. A number of potential limitations of traditional growth accounting studies have been identified. First, such studies seek to identify the independent contribution that each input-including education-makes to economic growth, and therefore employ the Cobb-Douglas production function for which inputs are technically separable; however, in a real production process inputs such as capital and labor are typically nonseparable-that is, they are complementary-and any attempt to assess their independent contributions is ultimately problematic. Second, traditional growth accounting studies typically ignore the fact that some inputs-for example, education-are intermediate inputs that are produced at some cost in terms of other inputs. Third, the underlying production function has embedded in it a nonrecursive cause-effect relationship between output and educationthat is, while more education may lead to higher output, higher output and income tend to generate more education. Fourth, estimates of the contribution of education to economic growth are likely to be understated in such studies because their assessments of increments in the education of the labor force neglect education's role in maintaining the previous level of educational attainment. For more detailed analyses of these and other potential limitations, see Dean, 1984; Haveman and Wolfe, 1984a; Pencavel, 1993; Plant and Welch, 1984; and Psacharopoulos, 1984.
- ²⁸ Pencavel, 1993, p. 61. A variety of studies of this type are reviewed—including a summary of their principal findings—in Fagerberg, 1994. Specific examples of recent

and well-crafted studies of this type can be found in the work of Barro, 1991; Barro and Sala-i-Martin, 1995; and Baumol, Blackman and Wolff, 1989. Each of these studies examined a cross section of countries and found significant relationships between growth in real gross domestic product per capita—a productivity measure—and the level of schooling or educational attainment across these countries. These particular studies employed established data bases on either the level of schooling (Summers and Heston 1984, 1988) or educational attainment (Barro and Lee, 1993).

- ²⁹ Renshaw, Trott, and Friedenberg, 1988
- ³⁰ U.S. Department of Commerce, 1992, 423.
- ³¹ Barro and Sala-i-Martin, 1992; Carlino and Voith, 1992; Evans and Karras, 1994.
- 32 Leslie and Brinkman, 1988; Pencavel, 1993.
- ³³ Barro, 1991; Baumol, Blackman, and Wolff, 1989.
- ³⁴ Renshaw, Trott, and Friedenberg, 1988.
- ³⁵ Furthermore, the share of 1980 gross state product attributable to mining industries for all of the seven states that experienced rates of growth in workforce productivity in the 1980s of -10 percent or lower, ranged from about two to seven times the share of mining in gross state product for the whole U.S. economy.
- ³⁶ Hines, 1988, 1993.
- ³⁷ St. John, 1994.
- 38 Paulsen, 1991.
- ³⁹ Hossler, Braxton, and Coopersmith, 1989; Kearney, Townsend, and Kearney, 1995; Manski and Wise, 1983; Paulsen, 1990.
- ⁴⁰ St. John, Paulsen, and Starkey, 1995, 56.
- ⁴¹ Hearn and Anderson, 1995.
- ⁴² The latter year was the most recent year for which the Bureau of Economic Analysis had revised its gross state product data so that it would be consistent with the National Income and Product Accounts data.
- ⁴³ Following the lead of other researchers using the gross state product data (Barro and Sala-i-Martin, 1992; Carlino and Voith, 1992; Evans and Karras, 1994), the 48 contiguous states have been included in this analysis.
- ⁴⁴ When estimates are based on cross section data, there is some possibility of heteroscedasticity. If present, heteroscedasticity would tend to reduce the standard errors, thereby increasing the precision of the estimates, but not biasing them. However, in the present study, Park-Glejser tests were conducted and results indicated that no heteroscedasticity was present (Pindyck and Rubinfeld 1981, 150-151).
- ⁴⁵ Pencavel (1993) suggests that sometimes there may be the possibility of a second equation in systems similar to this. This is based on the notion that investment in higher education is potentially both a cause and a consequence of growth in workforce productivity. However, the possible two-way relationship represented by such a two-equation system does not introduce a simultaneous-equation bias into Equation (1) of this study. The primary reason for this is that the cumulative investment in higher education by state i through the year 1980 (HIGHED₈₀₁) is not determined by the growth of workforce productivity between 1980 and 1989 (which is the dependent variable, GROWTH_{89/801}); rather it is determined by the growth in workforce productivity over many years prior to the first year of this study.
- ⁴⁶ Gross state product data was acquired on computer disk directly from the Bureau of Economic Analysis in Washington. Labor force data came from the Statistical Abstract of the United States (U.S. Department of Commerce, 1991).
- ⁴⁷ The number of persons—age 25 and over—with high school diplomas and those with college degrees—the 1980 census figures were used—by state, came from the Digest of Education Statistics (U.S. Department of Education, 1992).

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- ⁸ For example, the share of the "total" U. S. gross state product—including the 48 contiguous states as well as Alaska, Hawaii, and the District of Columbia—contributed by mining industries decreased by 33.2 percent between 1980 and 1989, while the share of the national total generated by farming decreased by 7.3 percent over the same period.
- ⁴⁹ See Barro, 1991; Baumol, Blackman, and Wolff, 1989. Among economies with similar educational levels, some have higher initial productivity levels—the technological leaders —and others have somewhat lower initial productivity levels—the technological followers (Maddison 1982, 212). In the presence of adequate educational capability—educational levels fairly similar to the technological leader—follower economies can and do learn, adopt, and effectively utilize the new ideas and techniques that have been developed elsewhere. In this way, the initial productivity gaps between leaders and followers narrow so that their productivity levels converge over time. This pattern is often refered to as the "convergence" hypothesis (Barro, Mankiw, and Sala-i-Martin, 1995), and the apparent advantages accruing to follower economies are sometimes called the advantages or "opportunities of backwardness" (Maddison, 1987). Of course, as productivity levels manning economies do converge, any advantages of backwardness become progressively smaller (Abramovitz, 1986; Barro and Sala-i-Martin, 1992; Baumol, 1986; Maddison, 1984, 1987).
- ⁵⁰ An R² of .50 is impressive for a parsimonious, three-variable, model intended to examine the relationship between the growth rate of workforce productivity and investment in higher education at the state level. It also compares favorably with the results of similar efforts by Baumol, Blackman, and Wolff, 1989, based on a three-variable model for a cross-section of countries—R2=.47; the results of Barro's 1991 seven-variable model for a cross-section of countries—R2=.56; and the results of Barro and Sala-i-Martin, 1992—who used a three-variable model plus several regional dummy variables for a cross-section of 48 states, obtaining an R2 of .61.
- ⁵¹ These findings are consistent with those of Barro and Sala-i-Martin, 1992, who studied the convergence of growth in gross state product (gsp) per capita—another type of productivity measure—among the 48 states for an earlier period—1963-1986 finding that initial gsp per capita in 1963 was negatively related to subsequent growth. Since the effect of education was not the focus of their study, they reported no coefficient that estimated its effect on growth in gsp per capita. However, they "explored in a preliminary way" the addition of other variables and reported that one "variable that has a significantly positive influence on the growth rate is the fraction of the work force in 1960 that had accumulated some amount of college education" (244). Although their measure of investment in higher education differs from that used in the present study, this evidence does offer some corroboration for the findings of the present study.
- ⁵² This finding is also consistent with those of Barro and Sala-i-Martin, 1992, who used a more refined measure of a state's industrial composition to control for the effects of expansions and recessions—for example, in farming and mining—on growth in gsp per capita.

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