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ABSTRACT

This paper's overview of the relationship between vocational education and productivity includes the presentation of results from a multiple regression analysis of vocational education enrollments and various productivity indices. This tentative analysis contributes additional observations to the studies reviewed and offers pertinent suggestions about ways of increasing productivity in the United States. Discussions of topics related to policy also are included: the mix and length of programs, ways to share the costs of training, issues related to efficiency and equity, and vocational education's role in reducing unemployment and creating jobs. Needs related to data collection, the effects of emerging technologies, and developing trends also are discussed. The study suggests that improvement in American productivity will take an investment in time and money by management and labor; that vocational education needs to develop a more flexible delivery system--one better able to shift resources when demand shifts; and, to that effect, the vocational education system must play a part in the diagnosis of productivity problems as well as in creating their solutions. (KC)

Information Series No. 223

PRODUCTIVITY:
Vocational Education's Role

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FOREWORD

Productivity: Vocational Education's Role provides an overview of the relationship between vocational education and productivity. It includes a tentative analysis of vocational education enrollments and productivity indices with a discussion of policy implications and future needs.

This paper is one of six interpretative papers produced during the third year of the National Center's knowledge transformation program. The review and synthesis in each topic area is intended to communicate knowledge and suggest applications. Papers in the series should be of interest to all vocational educators including teachers, administrators, federal agency personnel, researchers, and the National Center staff.

The profession is indebted to Dr. August C. Bolino for his scholarship in preparing this paper. Dr. David Bushnell, The American University, and Dr. Lawrence Olson, Data Resources, Incorporated, contributed to the development of the paper through seminar participation and subsequent review of the manuscript. Recognition is also due Dr. John Kendrick, George Washington University; Dr. Paul Barton, Institute for Work and Learning; and Dr. Morgan Lewis, the National Center for Research in Vocational Education, for their critical review of the manuscript. Staff on the project included Alta Moser, Shelley Grieve, Raymond E. Harlan, and Dr. Carol Kowle. Editorial assistance was provided by Brenda Sessley.

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EXECUTIVE SUMMARY

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The author suggests that improvement in American productivity will take an investment in time and money by management and labor; that vocational education needs to develop a more flexible delivery system—one better able to shift resources when demand shifts; and, to that effect, the vocational education system must play a part in the diagnosis of productivity problems as well as in [illegible] their solutions.

INTRODUCTION

Productivity now commands a prominent place in all discussions of national economic policy, not only because it is a main component of the gross national product (GNP—the major determinant of the economic welfare of a nation), but especially because of its recent slowdown. As the Committee for Economic Development (1980) stated, "*This country cannot reasonably hope to control inflation, raise real income, and improve the quality of living unless the unfavorable trend in productivity is reversed.*"

Effective vocational education represents an economic investment in the future--trained workers produce more efficiently, and efficient workers increase productivity. The question is not whether vocational education has a role in contributing to the nation's economy, but how that role is to be defined and carried out.

Purpose

The purpose of this paper is to help vocational educators consider various present and future contributions of vocational education to increased productivity. To this end, this paper contains a review of productivity issues, a discussion of previous research on the effectiveness of vocational education, a tentative analysis of the relationship between productivity and vocational education, and a discussion of policy implications and future needs.

The U.S. Productivity Record

Historically, a leading factor in America's productivity growth was the development of new, highly technical, high-wage industries that encouraged workers to move out of low-wage and low-productivity industries. According to John Kendrick (Fellner 1979), increases in total factor productivity grew from 0.3 percent per year throughout most of the nineteenth century to 2.4 percent after World War II. After 1966, however, there was a disturbing deceleration in the growth of productivity: down to 1.6 percent per year before 1973 and 0.8 percent for the period between 1973 and 1978. Economists generally agree with Kendrick that productivity growth has slowed, but there is disagreement concerning which factors are most accountable for this deceleration. From historical perspective one factor is a slowdown in the growth of high-productivity industries.

Using econometric techniques, Robin Siegel (1979) has shown that the 0.5 percent growth of productivity in 1979 is one of the worst on record, and she confirmed the breaks in the productivity trends for the years 1967 and 1973. Stating that the manufacturing sector is typically associated with higher levels of output per hour than the nonmanufacturing sector, Siegel's analysis showed that for 1978 there was continued leadership of manufacturing in productivity performance. Despite the small 0.5 percent advance in total nonfarm productivity for 1978, manufacturing output per hour grew at a healthy 2.4 percent pace. For that year, nonmanufacturing productivity actually fell 0.3 percent. Thus Siegel attributed the productivity slowdown to the nonmanufacturing sector.

A number of factors have been cited by Siegel to explain the slowdown in productivity growth: changes in relative energy prices, high expenditures on pollution-abatement equipment, changes in output mix (a change in the percentage of the gross national product accounted for by manufacturing and other sectors), a decline in capital-labor ratios, changes in the composition of the work force (particularly in the addition of more inexperienced workers), and the "tax-effect" of the government taking a larger share of workers' incomes. (This tax-effect is said to act as a negative influence on worker motivation.) Consideration of Siegel's conclusions is important to vocational educators because many vocational graduates work in the manufacturing sector.

The Economic World of the 1980s

Although it is common now to describe the decade of the 1970s as one of "slow growth," economists predict that the economic performance of the 1980s will be an improvement over that of the 1970s (Lecht 1977, Saunders 1978). John Kendrick (U.S. Congress 1976) gave an optimistic prediction of productivity for the next decade when he stated, "The rate of increase in output per manhour in the decade ahead may well equal the longer run trend-rate of somewhat better than 3 percent a year on average. This more optimistic assessment of prospects for productivity relative to total factor productivity is based on the expected retardation of labor force growth in the years ahead."

Between 1945 and 1970, the U.S. population grew at an annual rate of 1.52 percent. By contrast, the growth from 1970 to 1980 was only half that rate. This slow growth of population should continue well into the 1990s. Thus the number of young persons aged fourteen to twenty-four may decline by nearly three million by the year 1990, while the number of persons from twenty-five to fifty-four years old may grow by 22 million, a rise of 30 percent. These demographic trends signal shrinking enrollments, some shortages in certain job skills, and fewer young workers entering the labor force. As the job market tightens, employers will look for new groups to tap for labor skills, including older persons, minorities, women who have been out of the labor force for a time, and persons with handicapping conditions.

In the economic environment of the 1980s, the number of students enrolled in federally aided vocational education programs should continue to grow, but at a slower pace. Between 1966 and 1972, enrollments in those programs grew at an annual rate of 11.5 percent, but between 1973 and 1978, the rate of growth declined to 6.3 percent. Because there will be fewer young persons to take vocational education programs, enrollments could decline to the extent that the growth rate may be only 3 or 4 percent during the 1980s. However, this slack could be taken up by increased enrollments in other areas. For example, adult, evening, community college, and similar programs could increase faster than the rate of decline in the secondary schools.

The results of a College Entrance Examination Board survey (1978) are relevant here. That data showed 36 percent of the population between the ages of sixteen and sixty-five (more than 40 million persons) to be at some stage of career transition. The majority work full-time at semiskilled or unskilled jobs. Sixty percent plan to seek additional education and are interested in professional or vocational (trade or technical) programs. Forty-seven percent of those surveyed, mostly adults, stated that they specifically had a "high interest" in job skills training. If their plans are carried out, millions of Americans will be looking to the vocational education system for assistance in career changes. With millions of Americans considering job improvements or changes, a more flexible vocational delivery system is now needed—one better able to shift resources when demand shifts. Improvement in American productivity will take an investment in time and money by management and labor. The vocational education system must play a part in the diagnosis of productivity problems and in the creation of solutions.

MEASURING PRODUCTIVITY

There are several concepts of productivity. Measures related to them are usually expressed in terms of output-input ratios. As such, productivity ratios are measures of efficiency. Labor productivity, usually measured as output per hour of employment, is a measure of the efficiency of labor when combined with other inputs. The most familiar measure of productivity is the index computed by the U.S. Department of Labor, Bureau of Labor Statistics (BLS). The BLS index is a useful but crude indicator of productivity. For this reason, economists have developed another measure called total factor productivity that compares output with capital and labor inputs (Kendrick 1961, Fellner 1979).

There are several definitional and conceptual problems that diminish the accuracy and usefulness of the current productivity indices. Most of these problems have to do with human and nonpecuniary factors. In measuring output, for example, we are unable to account for qualitative improvements in products or services. There are also several aspects of work that are generally not measurable, such as those having to do with the quality of life. Therefore, the productivity indices are generally understated. These problematic factors have special importance in the service industries because the output in these industries is often intangible. In education, for example, it is not only difficult to define good teaching, but it is also difficult to determine the final product of education. Economists usually circumvent these problems by counting the number of students who graduate as the output of education, assuming (perhaps erroneously) that the input *is* the output.

Productivity in the Service Industries

Since 1955, the United States has had a service economy; that is, over half its labor force has been employed in service industries. These industries are defined as "white collar" jobs employing professional, managerial, sales, clerical, private household, and other service workers. Economic affluence increases the demand for personal services including medical care, advertising, hair styling, legal counseling, management consulting, and computing. Today over 60 percent of American workers are employed in service jobs, and the number continues to grow. During the last thirty years, service employment overall has gained 120 percent while manufacturing employment has gained only 30 percent. The gap between service and manufacturing has been widening, and the U.S. Bureau of Labor Statistics consistently predicts that service employment will continue to rise, well into the future.

Study of this growth of service employment is also difficult. The government component of services has been the fastest area of growth, for example, but the BLS does not include government employment in its measurement of productivity. It does occasionally publish a separate statistic for government productivity--the number has averaged 1.3 percent for the past ten years. This statistic is controversial, however, because it is based on a very small sample of government agencies.

Barger (1955) was one of the first to study productivity in the service industries. Analyzing the distribution of finished goods, he found that the productivity of commodities rose five times between 1869 and 1959, while it grew only 80 percent in the service industries. Output per worker hour rose 2.6 percent for commodities but only 1 percent for distribution.

Fuchs (1965) amplified Barger's views. Fuchs, defining the service sector by the "residual method," eliminated all industries in agriculture, mining, or manufacturing. His service sector list included wholesale trade, retail trade, finance, insurance, real estate, government, personal services, and repair services. The increasing importance of the service sector is best seen in the growth of employment: from 40 percent of total employment in 1929 to nearly 65 percent in 1965. Fuchs offered the following rates of productivity increase for the years 1929 to 1965: agriculture 3.4 percent per year, industry 2.2 percent, and service 1.1 percent. In explaining the growth of employment in the service industries, Fuchs placed the greatest emphasis on lagging productivity.

Fuchs' earlier analysis is borne out by later statistics: the output of services in the 1970s equaled nearly one-half of the GNP, but almost two-thirds of total employment was required to accomplish that. Of this total employment, 58 percent was in government and trade. Productivity was low in the service occupations, especially in retail trade with its larger numbers of inexperienced or unskilled part-time workers. In recent years, fiscal restraints have increased pressure on the service industries to raise their productivity.

Regardless of how one measures productivity, it is fairly certain now that productivity enhancement is more difficult in the service industries. This is particularly true in education where so many factors are nonmeasurable. Baumol's research (1967) is relevant to this issue. He has argued that many of our nation's problems are the result of differential productivity and that continued shift into low productivity industries could lead to the end of economic growth in the United States. Although some service industries showed large increases in productivity, many others have been a drag on the economy (Employment and Training 1980). This applies especially to state and local government employment where, according to Renshaw (U.S. Congress 1976), there was very little effort made to measure or to increase productivity. The share of jobs in state and local government increased from 6.3 percent in 1947 to 13 percent in 1973. More than half these jobs were in the field of public education, and increases in the numbers of teachers and administrators appear to be unrelated to changes in enrollments or any measures of productivity

Returns from Vocational Education

At this point we can ask two questions. What are the returns from training in vocational education? Are they as large as (or larger than) those which have been attributed to formal, academic education? Our knowledge of this subject stems from research on the contribution of human capital to economic growth. When Schultz (1960) made estimates of investment in education for the period up to 1957, he showed the importance of human resource development in explaining the residual of economic growth or the productivity factor (the unexplained portion in the sum of the inputs). Schultz stated that educational capital was clearly an important element in production and that it had risen at a much faster rate than reproducible nonhuman wealth (physical capital). He found that the stock of education in the labor force rose eight and one-half times, while reproducible nonhuman wealth increased only four and one-half times (1962).

Denison (1962) broke the residual into parts. He made detailed estimates of the relative contribution of twenty-three factors affecting economic growth. In determining the sources of past economic growth, Denison derived distributions of males twenty-five years of age and over by years of school completed. He constructed rough distributions for 1910, 1920, and 1930, working backward from 1940. According to his study, improved education raised the quality of labor by 23 percent from 1929 to 1957, while growth for 1909 to 1929 was only 12 percent. This writer (Bolino 1973) is concerned with the types of education that Denison omitted. Denison's study covered all types of full-time education, except kindergarten, and many educational and training programs that add to the quality of labor were omitted. In taking this approach, Denison assumed that the process of upgrading the labor force operated only through the schools, that formal education could be equated with improvements in productivity.

Denison's growth accounting did not tell us if education is a good investment because his study was not intended to answer that question. The works of Becker (1964), Schultz (1960), and Mincer (1958) were pioneering efforts in this regard. Their studies of the rates of return for various levels of education showed a declining trend in rates as the level of education rose. For example, Schultz (1961) showed a 35 percent rate of return for grade school (mostly basic education) and a 14 percent return for high school. Hansen (1973) showed the returns declining from 15 percent for grade school to 10 percent for college. By comparison, Ashenfelter and Mooney (1969) estimated that the returns from graduate school education were less than 8 percent. This research raises an interesting question of priorities: if the returns from education are inverse to the level, should more resources be applied to basic education and to vocational education than to graduate studies?

The above research spawned a number of studies that deal specifically with the question of the efficiency, or payoff, from vocational education. The American Institutes for Research conducted a follow-up study of high school vocational course graduates for the years 1953, 1958, and 1962. The study

(Eninger 1965) attempted to compare vocational and academic graduates from the same schools by sampling the experiences of 1,800 academic graduates who attended the same high schools as the vocational graduates. According to Eninger, vocational school graduates had slightly higher starting wage rates than comprehensive school graduates, and they had more job stability. The vocational school graduates also found their first jobs more easily.

Somers, et al. (1971) used multivariate analysis and a national sample to compare the earnings of vocational graduates. This technique attempted to show how changes in the independent variables of age, race, education, marital status, or socioeconomic status can explain changes in the dependent variables of wages or earnings. The study indicated that more than one-half the vocational graduates took first jobs in fields unrelated to their training and that many were able to increase their wages only by moving out of their fields of training. In a more recent study, Grasso and Shea (1979) found clear evidence of an advantage in hourly rates of pay for vocational graduates only among women. For men, vocational education "makes essentially no difference," and it "is negatively associated with measures of longer-term career outcomes."

Several other studies compared vocational and general secondary school graduates. Using their cost-effectiveness study of 1969 as a base, Hu, Lee, and Stromsdorfer (1971) compared the economic performance of high schol graduates in the labor market by comparing vocational and comprehensive school graduates. Data were obtained from 2,767 questionnaires sent to males in 1966 and 1967. Using multiple regression analysis to measure the net effect of curriculum on labor market performance for the two types of graduates, they found that although vocational graduates earned $54 per month ($648 per year) more than did comprehensive graduates, the difference was not statistically significant. Other aspects of their research, however, did show the difference in wages to be significant.

This earnings differential contrasts with those found by Corazzini (1968) and Taussig (1968). Corazzini compared vocational and academic graduates. Taussig compared vocational and academic high schools in New York City. In both studies, the earnings differences between vocational and comprehensive high school graduates were smaller than those found by Hu, Lee, and Stormsdorfer, who claimed that Corazzini and Taussig did not control for a number of sociodemographic factors and that consequently their earnings were more gross than net. Also, Corazzini and Taussig used wage rates instead of earnings, and earnings will show higher figures because they will account for hours worked. Pautler (1967) compared vocational secondary school graduates, vocational school dropouts and nonvocational high school graduates who did not continue their educations. Pautler's cost-benefit analysis defined benefits as the time necessary to obtain the first job, the earnings on the job, and employment stability. Pautler did not find any major statistical differences among the three groups.

Hu (1980) analyzed the cost-effectiveness of vocational education by comparing average and marginal costs. After reviewing several studies done in New Jersey, Ohio, Kansas, Tennessee, and in several major cities, Hu concluded that although vocational education costs appear to be higher for some kinds of programs, the vocational programs overall may be cheaper, particularly when the size of the program is very large. Hu believes part of the difference is that the costs of vocational and general education (ranging from $200 to $700 per student) would disappear if analysts were to obtain accurate estimates of the marginal costs of training.

The above studies and other analyses of the benefits and costs of vocational education come to somewhat contradictory conclusions. The Mertens, et al. (1980) summary of vocational education studies since 1968 indicated there was no difference in unemployment rates between vocational and nonvocational graduates, but this was disputed by Li (1980). These researchers also claimed that a majority of vocational graduates obtained jobs in training-related areas, but this conclusion runs counter to the results obtained by Somers, et al. (1971). Only in the matter of earnings do Mertens, et al. agree with others that the results are mixed.

The Effects of Vocational Education Defined More Broadly

When vocational education is analyzed in broader terms, we can say more about its payoff. Fredland and Little (1980) reported on an investigation of the returns based on a sample drawn from national data of mid-career white male workers who received military vocational training during and immediately after World War II. The long-run, cross-sectional earnings regressions strongly suggested that those workers who used their vocational training received long term premiums; and that those who took training but did not use it earned no premiums, suggesting that military training is job-specific (Becker 1964). In this study, wages, salaries, and self-employment income were used as dependent variables. One important finding of the Fredland and Little study is that the users of civilian vocational training had higher coefficients, or earnings, than users of military vocational training, but that the coefficients for both were larger and more significant than those for nonusers of vocational training. These findings are important also because they focus on the long-run effects of vocational training rather than on short-run, cross-sectional analysis. The persons studied took their training fifteen to twenty years before the observation of their incomes.

Turner (1980) has done research on one aspect of a growing phenomenon: the retraining in the community colleges of four-year college graduates. He studied 1,371 four-year college graduates who enrolled at six Maryland public two-year colleges. More than two-thirds of those studied were employed full-time, and about three-quarters of them had earned degrees in liberal arts or in education. Well over half of the graduates chose business-related curricula. Turner found that the average rate of return on this kind of vocational training was an unusually high 133 percent. He attributed the high rate to two main factors: the shortness of the retraining period and the minimal indirect costs in the form of foregone earnings. Since the community college is assuming a greater role in the vocational training of all Americans, Turner's findings are particularly significant.

The Manpower Development and Training Act (MDTA) passed by Congress in 1962 mandated training in the regular vocational establishment. It limited the federal capital costs of retraining and stipulated that the states were to provide such training through existing agencies or institutions. If those agencies proved inadequate, then arrangements could be made with private educational and training organizations.

Page (1964) conducted one of the earliest benefit-cost analyses of MDTA. Analyzing a population of 907 trainees in Massachusetts between 1958 and 1961, Page found that the training was very "worthwhile." He estimated that the trainees had improved their earning powers by over $3 million, greatly exceeding the costs of training. Muir, et al. (1967) of the Planning Research Corporation analyzed benefits and costs for MDTA courses taken in fiscal years 1963, 1964, and 1965. Although a higher benefit-cost ratio for on-the-job training (3.28) than for institutional training was found, the institutional ratio was 1.78 to 1, which is still highly significant. Stromsdorfer found that while there was more relative variation in post-training employment, "the net monetary benefits to retraining are very high" (1968).

There are also several cost-effectiveness studies of non-MDTA programs. Cain (1967) estimated cost-benefit ratios for the Job Corps from a postcard survey of white, southern males. He concluded that the Job Corps did increase lifetime earnings by the teaching of reading and mathematics, as well as through its vocational training program. Cain felt the results would have been higher had there been fewer dropouts.

Kirby and Castagna (1969) studied the costs and benefits of an experimental vocational program called the Training and Technology Project (TAT). They found that the return on costs from this program was 20 percent, but they stated that the benefits are higher because the program eased a skills shortage in the area. TAT has also been used to train special groups, and the administrators of the program claim that 90 percent of the 2,000 TAT trainees were placed in jobs at $3.00 per hour. All persons worked in industrial settings, either rural or urban—Union Carbide in Appalachia, for example.

Vocational education, defined broadly, covers all the avenues by which persons in the labor force upgrade their skills. In this connection, postsecondary proprietary vocational schools are an important source of human capital formation. These schools make an important contribution to our supply of skills. Olson (1978), using national data for the years 1966 to 1973, found a negative marginal return from vocational school training which, he stated, provides an incentive for persons to be involved in short term vocational programs. His study noted a very high dropout rate in private vocational schools (37 percent). Olson's empirical results showed short term programs to be attractive, increasing wages by an estimated 20 percent for inner-city graduates and 11 percent for others, whether or not they completed their programs. Under these circumstances, dropping out may be practical.

Although rates of return for short term programs appear to be positive, Olson's results are troubling because they raise questions about the quality of programs. Sufficient evidence exists now to indicate that extremely short programs do not appear to provide skills sufficient for meeting the long-run problems of the labor market. This means that the positive short-run gains may be ephemeral. Although some maintain that short-run programs lead to dead-end jobs, Olson found no evidence of any decrease in the returns from vocational schooling over periods as long as ten years after schooling. So, the returns for short programs may persist over time, particularly the many short programs that are for very special purposes such as for inservice education.

Statistical Relationships Between Vocational Education and Productivity

The research summarized in the preceding sections has shown that academic education does play a role in increasing output. However, the research that analyzed vocational education specifically has given mixed results. In some of the cases wages after training rose and in some cases they did not; sometimes unemployment was reduced and sometimes it was not. Nearly all of the statistical analyses used costs of training programs to indicate the efficiency of the programs and a cross-section analysis approach. In this approach, a dependent variable (income, for example) is related to a number of independent variables (age, sex, race, and education, for example) for a single year or for a set of years.

In this paper, a time-series analysis is presented for the purpose of showing a statistical relationship between broadly defined vocational education and productivity. (See the appendix for the technical aspects of the study.) The analysis used existing data, most of which have been published by the U.S. Office of Education (Bolino 1973). Since these historical data lacked costs for most types of programs, enrollments were used in the analysis. We assumed that there is a relationship between a measure of input (vocational education, for example) and measures of output (productivity, for example). To confirm this idea, data for certain training and education variables and two productivity measures—real private gross domestic product per worker hour and output in total manufacturing per worker hour—were used in a multiple linear regression model. A close association of the variables would be shown if high values of the coefficient of determination, R^2, and the measure of significance, t, were obtained using the time-series data. The coefficient R^2 measures the percentage of the change in the dependent variable that has been explained by the changes in the independent variables. The higher the R^2 the better the equation used (a value of 1.0 or 100 percent would be a perfect explanation). The t statistic is a measure of how unlikely it is that there is *no* relationship between the dependent and the independent variables. The B values for the independent variables are the partial regression coefficients; they show the average change in the dependent variable when there is a unit change in one of the independent variables (holding the others constant).

When analyzing time-series data by multiple regression, several questions must remain unanswered. Nothing can be said about cause and effect, nor can any one factor in productivity be isolated. The statistics do not tell us what part of the manufacturing labor output pertains to vocational education; that is, what is the feedback and response between labor quality and vocational training? In addition, even if we obtain a low R , it does not mean that that particular variable is unimportant; other factors may be offsetting it. What is critical is the value of the F or the t ratio, the tests of multiple regression significance.

The findings of this study are highly tentative, but very suggestive. First, when the various vocational education variables were analyzed, total enrollments in federally aided programs explained the greatest share of R . For nearly all of the years, the bulk of the students was enrolled in adult and evening programs. Second, when the various types of evening and adult vocational programs were analyzed with a pair of academic variables, the evening and part-time enrollments showed a close correlation to changes in productivity. These results need to be qualified further, but they tend to substantiate the importance of the contributions made by vocational education to productivity and have predictive value for planning policy.

POLICY IMPLICATIONS

Alice Rivlin (1966) discussed "Critical Issues in the Development of Vocational Education" at the Princeton Manpower Symposium in May of 1965. She covered such issues as how much training should take place and who should bear the costs. These complex issues are still troubling vocational educators today. The question of how much vocational education should be offered, for example, incorporates questions of which skills are in short supply, what technologies are emerging, what kinds of subsidies are available, and which kinds of students need preparation for work.

Determining the Mix and Length of Programs

Schooling and training are the two chief approaches to investing in workers in order to increase their economic value. It is often difficult to separate the two. Estimates of returns from each approach are not easy to make because available statistics on actual costs per student in existing programs may not reflect the true costs of training. There are also hidden factors, such as those high school students who might have dropped out of comprehensive programs but who completed high school because they were in a vocational program.

Grasso (1973) stated that students who select vocational programs early in high school appear to do so with no better information than those who defer their choices until later. Schools must make special effort to provide career information to the general public as well as to those enrolled in secondary schools and postsecondary programs. And even if it is true, as some analysts have claimed, that vocational education generally does not create labor market advantages for its graduates, it is not true for the entire range of vocational programs. Vocational education administrators must nurture those specific programs where advantages do result.

Vocational education should be offered wherever there is a need for the program and at any location that is efficient. Training, for example, can sometimes be offered better in the private sector. Lauwerys and Scanlon (1968) believe that "vocational training in separate vocational schools is far more costly than inservice training provided by employers." They argue that federal monies should place maximum reliance on training by employers. Under some circumstances—such as when skills learning requires expensive equipment or when technology is changing rapidly—there is definite advantage to on-the-job training. In such cases, vocational education should be of a general type, and the specific training should be offered in a work environment or in a private school. Proprietary schools offer certain advantages to vocational students: courses are generally shorter, more intensive, and more job orientated, and the students usually suffer a minimum loss of work time. The chief disadvantages of proprietary schools are their high costs and sometimes lengthy programs, especially important factors during times of inflation.

Sharing the Costs of Training

The analysis of enrollments in vocational education programs and productivity indices presented earlier suggests that certain vocational programs correlate more highly with productivity than others. In dealing with the question of how to share costs, these correlations must be among the considerations. The question is more complicated than it seems. In current situations, everyone pays something, but many of the costs are hidden. When training takes place on the job or in a private school, the employer or the student pays. When training takes place in the public schools, it is believed that the taxpayer pays. Economists, however, include not only the direct costs of education but also the indirect costs of foregone earnings. It is also difficult to know the true costs of public vocational education because we would need to add to the direct costs such things as the pensions of teachers, the interest on the public debt, and other hidden costs.

In making cost comparisons, the results are inconclusive. While proprietary programs usually cost more they may, in fact, cost less in terms of lost work time and in terms of social costs. Jung (1980) made such a comparison of private and public vocational schools, and he concluded that "private school programs tend to be less costly than those offered in public vocational institutions." Jung's work was substantiated by that of Anderson and Barnes (1979) who found that community colleges in Illinois contracting with private schools for certain trade programs could offer the programs at lower cost.

Considering Efficiency and Equity

In recent times, the vocational education system has been called on to provide training for special needs groups including displaced homemakers, minorities, the disadvantaged, persons with handicapping conditions, and others. There is considerable controversy as to the effects of training for minorities. Research does not indicate that vocational training has had much of an impact in reducing marginality of employment of black youths, for example. Li (1980) makes the most positive statements concerning the role of vocational education in improving the conditions of employment for blacks. He believes that vocational training is narrowing the gap between these workers and others. The training experience, according to Li, appears to reduce the proportion of blacks in lower manual-type jobs and it tends to increase their proportions in clerical, sales, and craft jobs. Finally, Li believes that vocational education has increased the upper mobility of vocational trainees, thereby contributing to a democratization of American society.

Examinations of federal expenditures on vocational education continue to indicate problem areas. The federal share of total spending now exceeds $500 million while state and local governments spend over $5 billion for vocational education, and when analyzed in terms of major occupational specialties, we find that consumerism and homemaking account for 22 percent. Over 60 percent of all female students are still enrolled in programs for office skills or homemaking although the federal government has spent over $4 million to date attempting to erase sex bias in career training and career choice. Predicted demographic data indicate more employment opportunities in the 1980s for all special needs populations. In light of that, increased efforts are necessary if vocational education equity programs are to meet their goals.

Reducing Unemployment

The relationship of productivity to the subject of unemployment is suggested in the official definition of an unemployed person: one who is able to work, is seeking employment, and who cannot find it. Even in times of economic slack, those with the skills most in demand are better able to find and keep jobs. But the ease of finding employment is also related to the number of job vacancies and the problems of job creation.

The effect of vocational programs on unemployment depends upon the type of unemployment that exists. If unemployment is of the structural variety, then vocational education can increase the reemployment of persons. Public dollars could be spent to ease the search for work, to pay for the costs of moving, and to expand marketable skills. Most economists believe that these expenditures would be far less expensive than welfare or relief payments. But where aggregate demand is deficient, it may be wise for vocational educators to concentrate more on providing skills for job vacancies or by aiding in local efforts to create jobs. It has become a matter of policy for the United States to increase training funds during recessions—such as the Public Service Employment Act of 1971 which was replaced by the Comprehensive Employment and Training Act (CETA)—but so far this approach has not been used for funding vocational education programs.

Research studies have presented contradictory evidence on the impact of vocational training upon unemployment. Somers, et al. (1971) and Grasso (1975) cast some doubt on the employment benefits of vocational training. Their research stresses that only a small proportion of vocational graduates enter the fields for which they have been trained and that there appears to be no significant difference between vocational students and general students. Eninger (1965) concluded on the more positive side that vocational graduates require less time to find their first full-time jobs (about one month less); and Creech, et al. (1977) showed that the employment rates for vocational students were considerably higher than for general students (77 percent compared to 68 percent). Analyzing 13,719 American youth who received high school diplomas, Li (1980) found those with vocational training to have both greater employment and less unemployment than other graduates. The unemployment figures were 3.5 percent for vocational trainees and 4 percent for others. Moreover, Li dealt with the existence of the "discouraged worker hypothesis" by including those outside the labor force and those unemployed in the comparison of the two groups. The comparable statistics are 20.7 and 3.5 for vocational training and 32.0 and 4.0 for other graduates. These figures translate into 30 percent more idleness among nonvocational graduates.

Data Problems

Data related to vocational education outcomes, costs of alternative methods of training, incomes of vocational education graduates, and employment histories of graduates are seldom parallel and often incomplete. Without comparable bases, most analysts have had to use simplistic statistical techniques. To deal with the problem, Section 161 of the Educational Amendments of 1976 called for the development of a national vocational education data and accounting system (VEDS). The law established criteria to evaluate the effectiveness of vocational programs which involves assessing the number of program completers and the extent to which employers are satisfied with their new employees. Congress also requires that the VEDS system be compatible with the occupation information and the Comprehensive Employment and Training Act System.

After two years of planning, data collection began, and it was not long before old statistical problems arose. States could provide enrollments by program levels, but they could not deal adequately with "adult breakouts." They could not obtain accurate information on short term programs. Moreover, data were collected only for programs covered by the state plans for vocational education, in spite of the fact that each state had some public programs not covered by the plans.

There is still an urgent need for a vocational education database that includes the costs of various teaching methods; enrollment statistics; and information about job placement, income, human resource needs, and characteristics of clients in different programs. These data would make it possible to analyze career choices, aspirations, successes, failures, and client and employer satisfaction (Lewis and Russell 1980).

Effects of Emerging Technologies

Vocational educators need to keep up with emerging technologies so that more effective programs of education and training can be established. Discussions of changes, accompanied by projections of employment levels and rates of change, can be found in the Industrial Technology Outlook Reports of the U.S. Bureau of Labor Statistics. These reports are part of the Bureau's continuing research program on productivity and technological developments.

Information about the projections and the assumptions upon which they are based can be found in the December 1978 *Monthly Labor Review*.

There seems to be general agreement in the Bureau that microprocessing will be the leading technology of the 1980s. In fact, the whole electronics field appears to assume a commanding position. One technological advance uses ordinary wiring to develop links with satellites, computers, alarm systems, and heating and cooling equipment. The power-line communication system is feasible, for example, because of high frequency circuits and microprocessors.

In the automotive industry microprocessing is found in the use of robot technology. Japanese workers produce twice as many automobiles per year than do Americans. The reason is not the nature of the assemblyline, but the use of more sophisticated electronically controlled robots. In Japan, an automobile is assembled with 100 fewer hours of labor than in the United States, resulting in a saving of $600 per car. It is estimated that the Japanese now use 50,000 robot machines in their economy, while the Americans have only one-tenth as many. Robots are superior in those tasks that are repetitive and that require workers to hurry to complete them. In Japan, humans tend to devote more time to quality control. Nissan accomplishes 96 percent of its welding by automation, thus it can produce over 73.8 cars per worker year, which may be compared with only 11 for General Motors, Ford, and Chrysler (Kraar 1980).

New technology in the telephone communications industry is altering job content and skill levels. This industry is a high growth and a high employment one, and the technology of the 1980s will probably keep it that way. Investment and employment should remain high. By investing in electronic switching, transmission innovations, digital transmission and new computer applications, the telephone communications industry has shown one of the highest productivity growths in the United States. Productivity grew by 9.2 percent from 1955 to 1960, 5.8 percent from 1960 to 1977 and 7.1 percent from 1970 to 1977 (U.S. Bureau of Labor Statistics 1979a).

The growing field of microbiology has important implications for industrial development in the 1980s. In the area of DNA research, a bacterium was developed in the laboratory. Industrial microbiologists are also working to produce bacteria: antibiotics, beer, hormones and oil-eating substances (for use in petroleum spills).

Another area in which vocational educators need to develop curricula is the materials-handling field where emphasis is on conveyorization, such as in copper mining. This new technology has resulted in larger and larger trucks of all kinds and in the improvement in the size and capacity of conventional carrying equipment.

Developments in two other areas, oil and gas exploration and petroleum refining, will have great importance for the 1980s. In the first area, the new technology involves the ability to go deeper into the ground, and in the second, technological changes in petroleum refining—mainly in cracking, hydrotreating, and reforming—are combined with advanced instrumentation and computer controls. Capital investments have increased substantially, and productivity has risen as a consequence. It grew by 3.0 percent from 1967 to 1977 and by 4.3 percent from 1950 to 1977. This new type of production is changing the skill requirements for lab technicians and maintenance personnel (U.S. Bureau of Labor Statistics 1979b).

Vocational Education and Job Creation

To attack the problem of unemployment, vocational educators must have a two-prong plan: they must provide skills and must at the same time assist in job creation and development. Vocational education can play a role in attracting new business to a region, in assisting businesses to expand or to survive, in promoting the growth of locally owned businesses, and in creating public sector jobs. Job creation activities can be directed toward some of the problems of our time, especially pollution, safety, job discrimination, and technological problems.

There are a number of laws and regulations today allowing vocational educators to deal with the subject of job creation, although many of them have received little attention. A review of the legislation shows the wide array of opportunities. The first law to recognize the relationship between unemployment and job creation was the Area Redevelopment Act (ARA) of 1961. It was the first legislation in United States history to pay a training allowance, and it paved the way for the Manpower Development and Training Act (MDTA) of 1962, which followed and which subsumed the job training title of ARA. ARA takes credit for creating more than 100,000 jobs, most of them in the public works areas—highways, waterworks, and local construction like post offices.

The job creation aspects of ARA were taken up by the U.S. Department of Commerce under the Public Works and Economic Development Act (PWEDA) of 1965. The Economic Develoment Administration (EDA) created under this Act was designed to "help areas and regions of substantial and persistent unemployment and underemployment to take effective steps in planning and financing their public works and economic development." MDTA and EDA were designed to deal with the two aspects of unemployment: MDTA to deal with individuals by increasing skills and upgrading the labor force, and EDA to deal with the local job markets.

Congress laid the foundation for the other part of the job development program when it passed the Economic Opportunity Act (EOA) of 1964. This antipoverty legislation under Title VII encouraged the development of special programs by which both urban and rural low-income people might improve the quality of their economic lives through self-help and federal assistance. The primary vehicle for this assistance was the Community Development Corporation (CDC). According to the Appalachian Regional Commission, Appalachia, which includes all of West Virginia and parts of twelve other states, failed to develop its natural resources because it did not create a sufficient infrastructure. The Act alleviated this problem by providing for necessary highway construction, health projects, conservation and erosion control, water resources, housing assistance, and airport improvements. Through Title II, it also provided money for vocational education facilities and for vocational and technical education demonstration projects.

Rosenfeld (1980) discussed models of economic development. One is the "relocation model" under which states and local districts attempt to attract new industries and new plants to their areas. Nearly all states use federally funded vocational education facilities to entice corporations that are analyzing locations for new plants. The "expansion model" is better used when the buildup of a skilled labor force is important to attracting expanding industries. In this respect, the Community Services Administration (CSA), EDA, and CETA all have funds that can be used. These laws allow for subsidized training, loan guarantees, and some grants.

The "entrepreneurial model" operates on the assumption that it is easier to support locally owned business than to put monies in satellite plants that may be controlled elsewhere. Much of the work of the Small Business Administration (SBA) has been along these lines. Vocational education legislation has supported the concept of creating new business enterprises; these efforts are concentrated on student businesses and entrepreneurial training and workshops for women. Emphasis has been placed on the building trades where students build or renovate homes for sale, with the proceeds used to finance additional activities. Originally, labor unions did not support these efforts because they feared the competition that might arise, but in recent years this opposition appears to have waned.

As Rosenfeld (1980) has stated, the United States has created different sets of policies for local economic development and for education and training. This has tended to exacerbate the fragmentation of programs. A given local community can at one time be the recipient of funds from EDA, CETA, vocational education, HUD, and CSA. In a similar situation in 1965, the President's Committee on Manpower recommended the establishment of the Cooperative Area Manpower Planning System (CAMPS). It would appear now that we need an application of a CAMPS-like system for coordinating economic development in local areas.

Collaborative Efforts

The improvement of American productivity will require a closer collaboration among government, business, education, and labor. One idea that has won favor with the Congress, business, and many labor unions is the "reindustrialization" of the United States. What will be the impact in spending $12 to $15 billion dollars to retool our basic industries and to support the continuation of growth of high technology industries? Training workers for these industries requires ready access to expensive capital equipment and experienced instructors. Some of these requirements must be met on the job, but there will be a role for vocational education in meeting the shortages of such skilled workers as machinists and die makers.

The reindustrialization process would be another in a long line of cooperative ventures between government and industry. Much of the computer industry's early growth, for example, was financed from federal monies and grew out of defense projects. The highly productive aircraft industry is another such technological spinoff, and the nuclear and the communications industries have required cooperation between government and American business. Even the United States farm sector, which has been remarkable for its high productivity, has depended substantially on government assistance and support.

Which of the vocational approaches, public vocational education or proprietary schools, can meet the challenge of providing needed skills? Or do we need a mix of programs to guarantee flexibility? The methods of production give a clue to an answer. Although the top 500 companies listed by *Fortune* magazine each year receive most of the publicity, economic research shows that small companies hire most of the new employees. Vocational educators need to examine both the nature of the economy and the production processes used mainly in the United States. Galbraith (1967) believes that there is a dual American economy. For him it is both planned and competitive. Averitt (1968) believes that the American economy is, in fact, two economies and that we need to train people for each type. Averitt distinguishes between the center firm and the periphery firm. The center firm, large-scale and characterized by vertical integration, is more likely to be involved in process production. The periphery firm is relatively small and tends to produce in small batches. The training needs of these firms are markedly different. Process production tends to require highly educated professionals, while batch production depends on a majority of unskilled workers. Vocational offerings should be aimed at both types of firms: center, because it represents the newest and most technically advanced stage of production, and periphery, because small firms do much of the hiring.

Meeting Trends

The guideposts for vocational education in the 1980s will depend largely on the state of the economy. During the 1980s vocational education will need to provide greater program flexibility. It will be serving a clientele of more part-time students, students who may enter and exit from programs quickly, and a greater number of older students. We would expect those institutions that have been growing very rapidly, such as community colleges, to continue to do so.

The costs of vocational education will continue to grow during inflation, and fewer persons will be able to afford private vocational education. More people will depend on programs where public subsidies carry a large share of the financial burden. Should the federal and state governments be concerned with postsecondary, private noncollegiate schools that find themselves in financial trouble? If so, what are the implications for public schools? Financial difficulties based on schools replicating the work of other schools indicates a need for closer cooperation among public and private schools to reduce such replication.

When American business faces a tight cost-profit squeeze, we would expect lower rates of capital investment both in physical and in human terms. So there may be a reduction in corporation training programs and tuition aid programs calling, in turn, for new approaches of a joint business-vocational nature.

It is fitting that in this report on vocational education in the 1980s reference should be made to a report done earlier, "Vocational Education for the 1970s" (Crum, et al. 1971). That report emphasized the following goals for vocational career development:

- Vocational education must become part of the educational experience of all people
- Vocational education must be more responsive to the nation's present and future employment needs
- Private schools and private industry must be an integral part of career education
- Vocational education is the principal element of a career education program
- Leadership development to effect career education is essential

The report emphasized that career education would replace general education and would continue throughout life. The report stated that as students progressed through secondary and postsecondary programs, they would have alternative choices for skills training, for pretechnical education, and for advanced vocational and technical education. "The overriding principle is to provide a system that will keep options open for greater individual choice."

Can we offer any conclusions as to how well we have met the problems of the 1970s, and how we might address the changing environment of the 1980s? We can begin with the notion that those who are engaged in offering vocational education programs at all levels must deal with a rapidly changing demand for certain skills. Congress has mandated that these programs should be provided under equitable and efficient conditions. Can vocational educators resolve at one time the problems of training for all, full employment, job creation, and profit making? In the final analysis, evaluation should be linked to policy. Unproductive programs should be reduced or eliminated. But we have little solid ground upon which to eliminate programs because of data problems and because of disagreement over the true worth of programs. The goals for vocational career development emphasized for the 1970s are admirable; they must be priorities for the 1980s.

APPENDIX: PRODUCTIVITY MODEL

A multiple regression model was used to analyze time-series data (table I) to determine whether or not there is a mathematical relationship between productivity and certain training and education variables. Enrollment figures (table 2) were used and two productivity measurements: real private gross domestic product per worker hour (GDPWH) and output in total manufacturing per worker hour (MFGWH). The regressions were run for the entire time period, 1920 to 1970, and five periods ending in peak years: 1920 to 1929, 1930 to 1937, 1938 to 1949, 1950 to 1957, and 1958 to 1969. The coefficients for real private gross domestic product per worker hour (GDPWH), X , are given in table 3. For the first set of computations involving four independent variables (table 3, part a) it can be seen that nearly 91 percent of R^2 is explained by total vocational enrollments in federally aided schools (EVOC). In comparing the various time periods, we can note that there does not appear to be a decline in the B coefficient for the EVOC variable. In fact, the coefficient seems to be increasing over time. In the second set of computations (table 3, part b) where several types of education are analyzed (AVOC), once again a vocational variable explains the largest share of R , this time the total adult vocational enrollments, including evenings and part-time. In this case, however, periodization of the model yields mixed results—three negative coefficients and two positive ones. Here, too, the coefficients are rising over time.

When the dependent variable was changed to output per worker hour in manufacturing (MFGWH), the results are not too different. The EVOC and the AVOC variables again dominate their respective equations. In comparing the results in table 4, parts a and b, we are led to conclude that it does not matter particularly which measure of productivity we use. Only when several types of education were analyzed (parts b) are the results significantly different, and these only for two time periods. Since these time periods (1930 to 1937 and 1938 to 1949) involve the Great Depression and World War II, some of these deviations may be explained. The remaining variability in the main explanatory variables suggest a structural change that has not yet been identified.

The use of time-series analysis can lead a researcher into a number of pitfalls. Even if we accept this approach, we still have a number of statistical problems to overcome. One of the most serious is serial correlation of the independent variables. Another is the highly cyclical nature of productivity statistics, which usually are unadjusted. Also, we have growth in our data that would call for de-trending the data. If these problems can be overcome, we still face the need to deal with the lag problem. How many years must expire before a student's vocational education begins to affect productivity?

TABLE 1

TIME-SERIES VARIABLES

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}
1920	38.1	23.4	.265	.196	66	20.5	185	.587	1.700	9.7	2.6
1921	40.7	27.2	.324	.236	73	24.6	218	.709	1.700	12.1	2.8
1922	40.3	30.0	.476	.362	100	37.1	297	.831	1.600	14.4	3.0
1923	42.7	29.5	.537	.412	292	42.2	326	.796	1.600	14.2	3.1
1924	44.6	31.6	.653	.514	377	41.2	410	.761	1.500	16.0	3.2
1925	44.5	33.8	.677	.522	389	44.0	429	.779	1.334	16.6	3.3
1926	45.7	34.8	.770	.579	422	57.5	467	.826	1.251	17.3	3.4
1927	46.5	35.7	.785	.596	446	53.9	496	.910	2.000	17.7	3.4
1928	46.5	37.7	.858	.647	480	48.2	538	.994	1.952	18.1	3.5
1929	48.6	39.3	.887	.665	497	43.0	564	1.120	1.976	18.5	3.6
1930	46.8	40.3	.982	.730	547	55.5	619	1.245	1.016	18.8	3.7
1931	47.2	42.2	1.048	.761	511	56.6	592	1.283	.980	18.1	3.7
1932	45.4	39.2	1.078	.738	467	55.1	560	1.321	1.004	17.4	3.8
1933	44.5	41.3	1.032	.643	379	50.0	490	1.263	.992	15.5	3.8
1934	49.0	43.5	1.051	.610	343	51.2	467	1.206	1.016	13.6	3.9
1935	50.6	46.1	1.179	.676	372	87.4	504	1.307	1.054	14.5	4.0
1936	53.2	46.2	1.256	.699	392	141.6	537	1.408	1.055	15.4	3.9
1937	53.1	45.7	1.345	.754	421	167.3	581	1.606	1.068	16.3	4.0
1938	54.7	46.5	1.810	1.009	502	201.7	686	1.803	1.111	17.2	3.9
1939	56.9	51.1	2.084	1.142	519	240.5	715	1.926	1.126	17.5	3.9
1940	58.5	51.6	2.291	1.254	551	261.7	758	2.050	1.190	17.7	3.9
1941	61.8	52.1	2.429	1.310	573	322.7	805	2.251	1.190	17.3	3.8
1942	62.0	52.6	2.625	1.420	553	362.9	851	2.453	1.208	17.2	3.7
1943	63.0	53.1	2.282	1.238	422	260.0	618	2.056	1.244	17.5	3.6
1944	67.2	53.6	2.001	1.054	373	235.7	543	1.660	1.282	17.7	3.5
1945	70.7	54.0	2.013	1.074	348	184.6	523	1.675	1.282	19.2	3.5
1946	68.7	54.5	2.228	1.240	432	263.4	631	1.689	1.322	20.6	3.5
1947	68.7	54.9	2.509	1.463	503	319.4	720	1.341	1.366	25.0	3.6
1948	71.4	58.0	2.836	1.732	546	201.7	763	2.129	1.389	29.4	3.7
1949	74.0	60.1	3.095	1.933	588	247.7	802	2.350	1.462	34.0	3.8
1950	80.1	64.4	3.365	2.117	582	239.9	805	2.573	1.515	38.3	4.0
1951	82.0	65.9	3.363	2.037	577	230.3	792	2.707	1.543	42.6	4.2
1952	83.5	66.2	3.166	1.801	586	185.6	793	2.565	1.572	46.6	4.1
1953	87.4	68.4	3.100	1.662	585	213.2	809	2.936	1.634	51.3	4.4
1954	89.9	69.5	3.165	1.674	579	144.1	827	2.722	2.222	55.8	4.6
1955	94.2	73.7	3.314	1.785	617	153.5	871	2.947	2.315	60.4	4.8
1956	94.6	72.9	3.413	1.856	637	177.1	884	3.172	2.364	64.9	4.9
1957	97.2	74.4	3.522	1.908	690	175.0	952	2.562	2.415	71.3	5.1
1958	100.0	74.4	3.629	1.965	712	165.7	984	2.420	2.525	77.6	5.3
1959	103.5	78.6	3.701	1.985	687	153.6	968	2.896	2.584	82.1	5.5
1960	104.9	79.9	3.768	2.027	666	160.1	938	2.950	2.778	86.1	5.8
1961	108.5	81.9	3.856	2.072	692	152.7	964	3.060	2.778	92.5	6.0
1962	113.5	86.6	4.073	2.153	711	142.7	1005	3.150	3.003	98.4	6.2
1963	117.4	90.1	4.217	2.267	772	153.4	1002	3.240	2.701	104.8	6.5
1964	121.6	94.5	4.566	2.255	767	162.0	1069	3.320	3.179	111.0	6.7
1965	125.7	98.4	5.431	2.379	757	169.4	1008	3.420	3.253	122.3	6.9
1966	129.5	99.0	6.070	2.531	804	176.9	1269	3.500	3.482	133.3	7.0
1967	131.5	100.0	7.047	2.941	966	184.4	1491	3.697	3.111	148.7	7.2
1968	135.2	104.7	7.534	2.987	1031	181.5	1629	3.910	3.219	163.9	7.3
1969	135.6	107.4	7.979	3.050	1042	221.2	1721	4.277	3.445	181.3	7.4
1970	137.2	108.0	8.794	2.666	953	239.4	1906	4.979	3.228	198.1	7.5

KEY FOR TABLE 1

	Variable	Symbol	Source
X_1	Real private gross domestic product per worker hour, total economy, 1958 = 100	GDPWH	*Historical Statistics of the United States*
X_2	Output per worker hour, total manufacturing, 1967 = 100	MFGWH	Same as X_1
X_3	Total vocational enrollments, federally aided schools	EVOC	Same as X_3
X_4	Total adult vocational enrollments, evenings and part-time	AVOC	U.S. Office of Education, Annual Reports of Vocational and Technical Education
X_5	Evening trade and industry enrollments	ETAI	Same as X_4
X_6	Number of trade and industry (trade extension plus cooperative education)	TECE	U.S. Office of Education, Annual Reports of the Federal Board for Vocational Education
X_7	Total trade and industry enrollments, federally aided schools	TTAI	Same as X_4
X_8	Adult education enrollments	AE	U.S. Office of Education, Statistics of state school systems
X_9	Total enrollments in correspondence schools	CS	National Home Study Council; U.S. Office of Education, *Bulletins*
X_{10}	Public school expenditures, per capita, elementary and secondary education	SCHPC	Same as X_1
X_{11}	Total time in school, public elementary and secondary day schools (average daily attendance times length of school day)	TDES	Same as X_1

TABLE 2

FULL-TIME EQUIVALENT PERSONS IN OCCUPATIONAL EDUCATION PROGRAMS

	Adult Education	Adult Vocational Education	Apprentices	Correspond-ence Schools	Federal Training Program	On-the-Job Training	Private Business Schools	Special Schools	Total Full-time Equivalents	Ratio: Full-time Equivalent/ Total Enrollment (per decade)
1900-1909	535,031	–	159,225	388,074	–	–	3,387,533	561,795	5,031,658	.0272
1910-1919	1,026,656	50,777	356,589	720,322	–	–	6,032,849	1,154,978	9,342,171	.0423
1920-1929	1,434,056	816,021	344,254	2,945,340	–	450,359	7,670,162	2,066,670	15,726,862	.0583
1930-1939	1,935,035	1,176,197	274,045	2,210,112	853,444	1,833,175	7,496,843	1,705,511	17,484,362	.0594
1940-1949	2,600,296	2,041,799	967,173	3,102,028	973,760	4,386,418	5,813,953	2,267,546	22,152,973	.0744
1950-1959	3,288,500	2,439,510	2,030,590	4,175,199	–	3,681,201	6,332,598	5,882,495	27,830,093	.0764
1960-1969	3,573,094	2,934,167	1,878,938	5,979,273	5,301,779	4,518,629	4,089,539	9,918,867	38,194,286	.0837
Total Full-time Equivalent	14,392,668	9,458,471	6,010,814	19,520,348	7,128,983	14,869,782	40,823,477	23,557,862	135,762,405	
Total Enrollment	112,801,116	68,290,228	8,990,790	90,613,110	23,310,153	8,879,149	30,362,730	21,465,706	2,086,933,875	
Ratio: Full-time Equivalent/ Total Enrollments	.127	.138	.668	.215	.305	1.674	1.344	1.097		.0650

Source: August C. Bolino, *Career Education: Contributions to Economic Growth*, p. 185.

TABLE 3

REGRESSION RESULTS: TIME-SERIES ANALYSIS OF REAL PRIVATE GROSS DOMESTIC PRODUCT PER WORKER HOUR (GDPWH)

Part a

Independent Variable	1920-1929			1930-1937			1938-1949			1950-1957			1958-1969			1920-1970		
	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ
TTAI	.029	.952	12.6	.011	.026	3.3	-.047	.559	5.8	.143	.811	5.1	-.042	.050	7.0	-.106	.008	16.2
ETAI	.008	.008	9.1	–	–	–	-.017	.003	4.5	-.046	.003	3.7	.028	.003	5.3	.085	.029	16.4
EVOC	-8.079	.002	7.1	-3.152	.000	2.4	20.825	.323	2.2	11.720	.019	4.8	14.171	.867	8.1	25.096	.908	21.9
TECE	-.010	.000	5.6	.075	.789	4.7	–	–	–	-.036	.114	5.6	-.169	.021	6.3	.022	.003	14.4
Constant	35.519			52.278			57.474			41.453			100.941			46.328		

Part b

Independent Variable	1920-1929			1930-1937			1938-1949			1950-1957			1958-1969			1920-1970		
	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ
TDES	23.173	.949	12.2	-43.734	.109	3.0	-14.290	.046	8.9	5.879	.008	12.8	14.011	.986	26.0	5.608	.009	27.9
AE	-10.320	.009	7.3	3.226	.008	3.2	4.196	.004	7.2	1.164	.001	7.2	-4.689	.002	19.3	5.200	.002	25.2
SCHPC	-.476	.004	6.1	-3.724	.009	2.4	.485	.007	5.7	.262	.977	16.1	.080	.005	22.1	-.034	.000	22.3
CS	2.935	.005	8.5	134.190	.192	4.9	39.468	.900	9.5	2.042	.001	9.3	3.571	.001	16.7	9.766	.050	28.5
AVOC	-9.825	.002	5.1	72.253	.040	2.1	-8.155	.006	6.2	-2.319	.005	11.5	3.500	.000	14.1	16.818	.922	24.0
Constant	14.393			85.173			60.258			45.070			15.186			.498		

– indicates that F level insufficient for further computations.

TABLE 4

REGRESSION RESULTS: TIME-SERIES ANALYSIS OF OUTPUT PER WORKER HOUR IN MANUFACTURING (MFGWH)

Part a

Independent Variable	1920–1929			1930–1937			1938–1949			1950–1957			1958–1969			1920–1970		
	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ
TTAI	.035	.966	15.0	-.077	.006	1.5	-.034	.311	9.7	.083	.808	5.0	-.041	.058	6.6	-.066	.023	18.6
ETA	-.015	.018	14.4	.042	.093	2.6	-.012	.003	7.7	-.031	.004	2.9	2.592	.003	4.5	.066	.009	18.4
EVOC	13.528	.001	11.0	3.879	.637	3.2	12.156	.644	4.2	-4.409	.007	3.7	12.281	.850	7.5	16.076	.925	24.5
TECE	-.014	.000	8.8	.065	.021	2.0	-.001	.000	6.2	-.024	.097	4.9	-.090	.009	5.4	–	–	–
Constant	15.543			57.164			42.683			37.379			70.979			30.960		

Part b

TDES	12.128	.975	17.7	-27.549	.654	3.3	–	–	–	5.180	.959	12.0	12.000	.981	22.8	7.913	.045	37.7
AE	3.785	.011	15.7	–	–	–	2.322	.050	8.0	1.326	.003	8.1	-2.819	.001	15.2	5.547	.003	34.2
SCHPC	.535	.001	12.6	-.032	.037	1.9	-.060	.001	6.2	1.093	.001	6.1	.232	.006	18.3	-.065	.000	29.9
CS	1.260	.001	10.3	81.841	.049	2.4	32.217	.885	8.8	.103	.003	4.7	1.201	.000	12.8	1.623	.000	26.9
AVOC	-6.541	.000	8.4	58.459	.131	2.3	.457	.000	5.1	–	–	–	-10.935	.005	17.8	11.865	.938	27.3
Constant	-16.803			75.498			8.895			34.708			18.282			-3.729		

– indicates that F level insufficient for further computations.

Serial or autocorrelation refers to a situation in which the error terms associated with time-series observations are correlated. As a rule, the presence of serial correlation does not affect the unbiasedness of ordinary least squares (OLS) estimates, but it does tend to understate the standard error. The Durbin-Watson (D-W) test is the most popular for testing for serial correlation. In the regressions of the time-series, the D-W statistic was low, indicating the presence of serial correlation, but since the F and t values were very high in most cases, the bias in standard errors is not as large a problem. Both log and non-log functions were computed, and in general, the log form regressions did not perform as well as the non-log multiple regression models. The log form of several independent variables gave lower correlation coefficients and in many cases the wrong sign. For these reasons, the log functions were abandoned.

Analysts of the productivity division of the U.S. Bureau of Labor Statistics were skeptical of the possibility of correlating vocational education variables and productivity, particularly because the productivity statistics are not adjusted for cyclical variations. For this reason, they suggested that wage rates be used as a proxy for productivity.

In dealing with the practical problems of applying regression techniques to time-series data, three approaches were used. In handling serial correlation, we used the recommended rule of thumb that when pairs of independent variables in a multiple regression show a correlation above .95, discard one of the variables (Chou 1975). To diminish the cyclical factor in the analysis, a method was chosen that has been used in the past by Peter Clark (1978) and others, that of combining the time-series data in such a way as to have each period terminate in a peak year. Since the data ran from 1920 to 1970 they were grouped as follows: 1920 to 1929, 1930 to 1937, 1938 to 1947, 1948 to 1955, and 1956 to 1969. To deal with the question of lag between time of education and effect, we used rank correlations of cross-sections of ending years (1920 and 1970). These analyses suggested that a four-year lag was best.

As a check on the time-series analysis, cross-section regressions were run using end point years (1920 and 1970). We also did some rank correlations of state per capita incomes (lagged) and vocational and training enrollments. The data and sources for 1920 are presented in table 5. Because the standard deviation exceeded the mean of all variables (table 6), this suggests that we have a bimodal distribution and that we might obtain better results if we separated the states according to high and low values. For the results given, the school expenditures and commercial school variables explained 97 percent of the change in per capita incomes and the apprenticeship and capital variables showed a negative sign. These coefficients did not sustain our central hypothesis: that the number of vocational trainees is highly correlated with income, therefore the regressions were rerun using per capita variables. The new results were not improved.

The comparative Pearsonian rank correlations are shown in table 7 for 1920 and 1970. The data for 1970 are not strictly comparable since the number of apprentices are for registered completions, while the earlier data are for enrollments only. What is important, however, is that this analysis confirmed what we found earlier using other quantative approaches. The returns from vocational education apprenticeships were greater in 1920 than for apprenticeships in 1974. To test the hypothesis that the Pearsonian coefficient could be increased with a lagged variable, the correlations were redone using income per capita (INC) and wages in manufacturing (EA) for selected years (table 8). This analysis suggests that a four-year lag may give the best results. Table 9 shows the results of using first differences of the dependent variables and four-year lag of the independent variables. The results are generally not improved over earlier computations, but at least one conclusion tends to be confirmed: the evening and adult programs show consistently higher rates of returns.

TABLE 5

CROSS-SECTION VARIABLES: 1920

		X_1	X_2	X_3	X_4	X_5	X_6
AL	01	736	870	1500	1102	434	1886
AZ	02	234	367	470	75	97	359
AR	03	576	172	829	526	132	1448
CA	04	3420	699	20866	2652	1139	20223
CO	05	684	2731	3613	357	218	4941
CT	06	1090	22589	8092	3315	1198	6199
DE	07	158	447	583	292	137	1676
FL	08	423	1071	763	780	186	1328
GA	09	1007	1460	2826	1304	425	2700
ID	10	258	289	289	137	90	1201
IL	11	5377	6228	31812	7456	3091	26088
IN	12	1706	5041	9785	2999	1270	9578
IA	13	1356	749	6812	875	360	7589
KS	14	1040	760	2998	633	338	7179
KY	15	968	289	2237	695	258	2241
LA	16	767	000	2522	1063	449	4727
ME	17	469	110	1391	963	410	1918
MD	18	1053	483	4067	1529	569	2903
MA	19	3494	43037	28064	7969	2855	15356
MI	20	2637	8199	16367	5344	2260	8934
MN	21	1370	1321	9029	1264	620	9600
MS	22	504	18	428	597	148	951
MO	23	1987	1739	11140	2255	864	11256
MT	24	344	360	2036	141	124	2741
NE	25	722	4174	3142	400	217	4146
NV	26	73	57	148	15	12	230
NH	27	291	000	1257	889	324	1004
NJ	28	2564	4742	20576	5833	2690	14573
NM	29	172	143	179	31	8	599
NY	30	10657	000	72514	14643	5490	37508
NC	31	907	2081	1145	1688	652	1242
ND	32	295	223	348	39	19	2614
OH	33	4070	770	28197	8381	3687	16895
OK	34	1023	507	2723	345	271	4863
OR	35	583	379	3153	631	216	3198
PA	36	6490	8597	34650	12245	5954	48538
RI	37	513	1150	3660	1540	577	2928
SC	38	565	2230	538	831	365	802
SD	39	343	15	412	62	25	1448
TN	40	844	613	2147	1007	380	3538
TX	41	2513	582	5063	1038	539	9024
UT	42	250	296	1942	186	131	1576
VT	43	204	000	346	366	130	23
VA	44	970	655	3272	1247	436	2498
WA	45	1045	850	7452	1395	533	7834
WV	46	750	1710	1354	801	322	1722
WI	47	1599	10071	8257	2994	1298	4586
WY	48	175	604	113	40	71	305

KEY FOR TABLE 5

	Variable	Symbol	Source
X_1	Personal income by states (millions of current dollars)	PI	Lee, Miller, Brainerd, and Easterlin, *Methodological Considerations and Reference Tables* (Phil.: The American Philosophical Society, 1957).
X_2	Trade and industrial apprentices	APP	U.S. Federal Board for Vocational Education, *Bulletin* No. 87, June, 1923, pp. 1-170.
X_3	Total current educational expenses in cities of 10,000 population and over	SCH	U.S. Office of Education, "Statistics of City School Systems," *Bulletin* No. 17, 1922.
X_4	Number of persons in manufacturing establishments	LAB	Same as X_1
X_5	Total capital in manufacturing establishments	CAP	Same as X_1
X_6	Total enrollments in commercial schools	COM	*Statistical Abstract of the United States*, 1921, p. 130.

TABLE 6

REGRESSION RESULTS:
CROSS-SECTION ANALYSIS OF 1920 DATA

Independent Variables	β	R^2	T	Significance
APP	-.031	.003	24.6	.0005
SCH	.065	.959	33.0	.0005
LAB	.643	.000	2/3	.0005
CAP	-1.200	.003	20.4	.0005
COM	.077	.013	28.0	.0005

TABLE 7

RANK CORRELATIONS: 1920 AND 1970

1920				1970			
State	Income Rank	Number of Trade and Industrial Apprentices	Rank	State	Income Rank	Apprenticeships Completed	Rank
NY	1	24,508	2	CA	1	4046	2
PA	2	8,597	3	NY	2	3681	3
IL	3	6,228	6	IL	3	3212	5
OH	4	7,770	5	PA	4	1962	7
MA	5	43,037	1	OH	5	3476	4
CA	6	699	9	TX	6	1451	8
MI	7	8,199	4	MI	7	4674	1
NJ	8	4,742	7	NJ	8	1100	15
TX	9	582	10	FL	9	1205	9
MU	10	1,739	8	MA	10	1140	14

1920: $R_s = 68.5$
$df = 8$
$\tau = 3.7$
significance level = .01

1970: $R_s = 27.0$
$df = 8$
$\tau = 3.3$
significance level = .01

Sources: Statistical *Abstract of the United States*, 1921 and 1971. Federal Board for Vocational Education *Bulletin No. 87*, June 1923, pp. 1-170; U.S. Department of Labor, Manpower Administration, July 1971.

TABLE 8

PEARSONIAN RANK CORRELATIONS: 51 Cases for Selected Years

Independent Variable	INC 1970	INC 1972	INC 1975	EA 1970	EA 1974
APP 1970	0.3625	0.3574	0.2600	0.3880	0.4291
	S=.004	S=.005	S=.033	S=.002	S=.001

KEY: S Significance level
APP Vocational education apprenticeships
INC Income per capita
EA Manufacturing wages

TABLE 9

FIRST DIFFERENCE EQUATIONS: Four-year Lag

Independent Variable	FD 1			FD 2			FD 3			FD 4		
	β	R^2	τ	β	R^2	τ	β	R^2	τ	β	R^2	τ
EVOC	-20.424	.011	1.40	1.661	.003	3.08	.076	.000	2.26	.470	.149	2.81
ETAI	.178	.070	1.82	-.060	.092	4.30	-.001	.001	2.64	.000	.000	3.77
TECE	–	–	–	.050	.365	5.08	.011	.315	4.55	.002	.030	2.19
TTAI	.043	.001	1.13	.023	.015	3.57	.002	.011	3.26	–	–	–
Constant	33.451			11.066			-.495			.435		
AVOC	36.265	.009	1.00	3.782	.029	5.38	[illegible]	.448	6.04	.402	.010	1.51
AE	-.304	.079	1.97	.108	.442	[illegible]	[illegible]	.002	3.27	.001	.033	2.22
CS	-.207	.009	1.46	.012	.001	[illegible]	-.005	.014	3.81	-.003	.017	1.90
SCHPC	-.995	.005	1.10	.060	.002	4.10	-.013	.004	2.92	.015	.150	2.81
TDES	.473	.007	1.22	-1.100	.198	6.25	.056	.041	4.58	-.023	.007	1.66
Constant	107.336			3.384			.118			.894		

KEY: – indicates that the F value is insufficient for further computations
FD 1 is the first difference of the per capita income variable
FD 2 is the first difference of the wages in manufacturing variable
FD 3 is the first difference of the GDPWH variable
FD 4 is the first difference of the MFGWH variable
All other variables are the same as those in table 1 with four-year lags

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