POTENTIAL GNP: PRODUCTIVITY GROWTH

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Because a higher proportion of our population has been working in recent years, more individuals with lower skills and experience are on the job. This fact, together with the shift in the mix of what we produce and consume away from high productivity sectors, largely accounts for the disappointing sluggishness in output per worker.

The productivity of the labor force—the output per man-hour worked—is determined by technology, capital stock, the quality of the labor force, and the composition of the goods and services produced by the labor force. The rate at which productivity grows is strongly influenced by technology. Productivity growth slows when capital and labor are used to produce goods and services in industries where few technical improvements are possible, but it grows faster as capital and labor are used in industries where a large number of technical improvements are possible. Productivity growth will be faster in an industry with strong technical improvements as that industry increases its size.

John Kendrick[1] estimates that substituting capital for labor, by giving workers more equipment, caused an 0.7-percent annual increase in the rate of productivity growth in the period 1973-77. That increase accounted for half of all labor's productivity growth during the period. Other writers argue that there has been a decline in the rate of capital growth in relation to labor, but Kendrick also says a decline in technical progress has caused a slower growth in productivity. Expenditures for research and development dropped from the mid-'60s to 1977 from 3 percent of the actual GNP to 2.2 percent. The slower growth of capital stock—equipment and structures—means the average age of the stock went up, so it took longer for industry to be able to incorporate technical improvements. But Kendrick also says that productivity growth that did occur from 1973-77 was helped by better labor quality, in the form of more on-the-job experience, fewer young people starting to work, and higher levels of education.

Our evidence, which follows, suggests that the improvement in the quality of the labor force may be lower than Kendrick and others assume and that the idea of a homogeneous labor force, too, is invalid, especially in periods of sharp change.

First of all, there is reason to question the use of years of education as a measure of improvement in labor force quality, since achievement test scores for high school graduates have been declining for several years. College textbooks and military training manuals are written at lower reading levels because students cannot otherwise comprehend them. Although it is difficult to measure this decline objectively, we cannot accept the claim that more schooling automatically improves labor force quality.

Edward Denison[2] points out that employee dishonesty has increased substantially in recent years, indicating a real

[1] John Kendrick, "Reaching a Higher Standard of Living," Office of Economic Research, The New York Stock Exchange, 1979.

[2] E.F. Denison, "The Shift to Services and the Rate of Productivity," **Survey of Current Business,** October 1973.

decline in the motivation and diligence that characterized earlier generations of workers. Employee punctuality and attentiveness have suffered too, and absenteeism has increased.

Perhaps a more reliable sign of a change in the quality of the labor force is a change in the employment ratio, which is the number of workers holding jobs divided by the working age (or over 16) population. We believe that, other things being equal, productivity will drop as the employment ratio increases because an increase in the employment ratio will bring a disproportionate number of unskilled or more poorly motivated workers into the labor force. Other factors being equal, productivity will increase if the employment ratio drops and jobs are lost because the least desirable workers will be the first to go and the more productive ones will be retained. Periods of rapid growth in employment are times of slower growth or even declines in labor force quality and in productivity. A jump in the number of people working will add some marginally qualified workers to the labor force. This will reduce the overall capital-to-labor ratio and ultimately reduce productivity.

To test our hypothesis, we performed two sets of stepwise regressions, as shown in Appendix I. The results strongly support our contention that changes in the employment ratio affect productivity growth and suggest that labor force quality is not homogeneous among age, sex, and racial groups.

Since it isn't possible to predict changes in the employment ratio with much confidence, we can only project productivity or potential GNP with a wide range of possible outcomes. In most cases, the estimation procedures have yielded results that are apparently too high. Potential GNP cannot be determined by using only technology, capital stock, and working population; it also depends on society's attitudes toward work for its members and on labor supply responses to economic conditions. The same argument applies to capital. Savings and investment decisions and expenditures for research and development are determined, to a large extent, by actual inflation and expectations of what inflation will be.

As a final issue, we will look at the problem of the changing mix of goods and services produced by the labor force to see how the changes help determine productivity and productivity growth. The movement of man-hours worked from one sector of the economy to another, say from agriculture to government, affects this composition of output. But the shifting of man-hours from industries with a low productivity to those with a high productivity has not had as much of an effect on overall productivity in recent years as it did earlier.

A simple notion of measuring compositional effects on productivity involves a procedure used by the Council on Wage Price Stability[3] and Denison.[4] We can estimate the effects of changes in productivity in individual sectors of the economy, changes in the number of man-hours belonging to each sector, and the way these changes affect each other, called the interaction effect. The box below illustrates this.

$$\Delta qt = \left[\Sigma(li \cdot \Delta qi)\right] + \left[\Sigma(qi \cdot \Delta li)\right] + \left[\Sigma(\Delta qi \cdot \Delta li)\right] \cdot$$

qt = overall labor productivity = total real output divided by total man-hours;
li = ith sector share of total man-hours;
qi = ith sector productivity;
Δli, Δqi = changes in man-hour share and productivity in sector i; and
i = l, - - - n, where n = the number of sectors.

1st bracket — effect of productivity changes within sectors

2nd bracket — effect of change in man-hour shares of sectors

3rd bracket — interaction effect

The change in overall productivity is the sum of the changes in all of the sectors weighted by their share of man-hours. The change in the effect of the changing man-hour shares is the sum of the share changes weighted by the productivity of their particular sectors. Finally, the interaction effect is the sum of the products of the changes.

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[3]Council on Wage Price Stability—Special Release on Inflationary Developments—CWPS-289, October 4, 1978.

[4]E.F. Denison, "The Shift to Services and the Rate of Productivity Change," **Survey of Current Business,** October 1973, p. 20.

From 1950-67, some 0.15 of the average annual rate of productivity growth was due to man-hours shifting from one industry to another: The productivity growth factor was 2.36 and the interaction effect was -0.13. For the period 1967-77, the man-hour shift was 0.03, the growth factor was 1.60, and the interaction effect was -0.10. This demonstrates the decreasing effect that man-hours moving from one industry to another has on productivity.

There is a problem with the use of the composition shift measurement in this procedure because the industrial output must be converted to dollar values to have meaning. Over time, changes in the output of goods and services produced in each sector and in the whole economy must be determined by adjusting for price changes. Yet this adjustment artificially forces all years to reflect the relative prices during the year selected as the base year. In effect, productivity is limited to the notion of physical units of output. As long as relative prices do not change appreciably, the comparison of physical units of output between years is a satisfactory way to estimate changes in the value of what is produced. But if the relative prices change substantially, then this method of comparison could seriously distort the measurement of true productivity.

For example, if we calculate the productivity growth for nonfarm industries from 1947 to 1957 using 1957 prices, the increase is 30 percent. If we calculate the increase for the same period using 1967 prices, the increase is 28 percent. This problem presented itself during a period of slow overall price growth, although there were substantial changes in the composition of the output. Of course, the farther from the base year, the more likely a relative price shift would have occurred. Since 1967, the manufacturing sector has been losing ground, experiencing a decline in its share of output and man-hours. If a comparable shift in prices has occurred, then the estimates of real output and productivity could be understating true productivity.

Another point should be made regarding the use of labor productivity growth for estimating potential GNP. Most economists who have examined the problem usually look at how fast productivity has been growing and assume it will behave the same way in the future. But it is necessary to look at recent rates of productivity growth as well as the level of productivity. Appendix II illustrates this, and Appendix III shows how future productivity growth can be more accurately predicted by looking at factors that contribute to the changing growth rate of productivity.

Our calculations indicate that the changing mix of industrial output may be more important in determining the rate of growth of productivity than the estimates of earlier writers would lead us to believe. The total effect amounts to a reduction in the rate of productivity growth of 0.7 percent per year from 1960-64 to 1970-74. Of this reduction, 63 percent is due to slowing productivity growth within individual sectors and 35 percent is due to changes in growth of man-hour shares and output shares. The two industries that showed the most change in man-hour shares were services and manufacturing.

If we assume that productivity growth slowed at a steady rate over the ten-year period, that would mean it decelerated at a rate of 0.07 percent per year. If that same deceleration held for the next five years, then productivity growth would fall by 0.35 percent from the 1970-74 pace. To complete the analysis, we would need to calculate the differences in the rate of change in the productivity growth rate to see if the yearly percent reduction is itself changing. Because of unavailability of data, that calculation has not been performed. ■

APPENDIX I

The first regression equation sets the rate of productivity growth as a function of real output growth and employment ratio growth. Stepwise regressions are run to test for independence in the independent variables. Quarterly data for productivity, output, and the employment ratio were converted to percentage annual rates of growth. The regression results are shown in Table Ia. Results for the first step indicate that output growth is strongly correlated with productivity growth. The regression coefficient is significant at the one-percent confidence level, and the R^2 is 0.391. In the second step, the employment ratio term was added to the regression, and the results explain the growth of the employment ratio. The R^2 increased to 0.596, and both regression coefficients are strongly significant, indicating multicollinearity is not a problem. As expected, the output effect is positive and the employment ratio effect is negative.

Regression Results: Table 1a

Q2/1948-Q1/1979 Rates of Growth

Step 1

$$\text{PRODG} = 0.00566 + \underset{(8.8592)^{**}}{0.54825}\text{ROUTG}$$

$R^2 = 0.3915$ D. W. = 1.8702

Step 2

$$\text{PRODG} = -0.00150 + \underset{(13.346)^{**}}{0.80299}\text{ROUTG} - \underset{(-7.8319)^{**}}{0.89811}\text{EMRG}$$

$R^2 = 0.5962$ D. W. = 2.2330

Correlation Matrix

	1	2	3
1 ROUTG	1.0000		
2 EMRG	0.5406	1.0000	
3 PRODG	0.6257	-0.0424	1.0000

PRODG = rate of productivity growth;
ROUTG = rate of real output growth; and
EMRG = rate of employment ratio growth.

t-statistics in parentheses
**Significant at the one-percent confidence level.

In the second regression, the variables were entered in the form of deviations from trend rates of growth. Trend rates were determined by use of a smoothing procedure. Deviations were obtained by subtracting the trend value from the actual value. Results of the stepwise regressions are shown in Table 1b. In the second step, the employment variable is significant and the R^2 increased to 0.563. Both coefficients are significant and have the expected sign. Again, multicollinearity is not a significant problem.

Regression Results: Table 1b

Q4/1948-Q1/1979 Deviations from Trend

Step 1

$$\text{DTPRODG} = 0.00116 + \underset{(11.008)^{**}}{0.95823}\text{DTROUTG}$$

$R^2 = 0.5024$ D. W. = 1.9284

Step 2

$$\text{DTPRODG} = 0.00111 + \underset{(12.202)^{**}}{1.1378}\text{DTROUTG} - \underset{(-4.040)^{**}}{1.2574}\text{DTEMRG}$$

$R^2 = 0.5625$ D. W. = 1.9510

Correlation Matrix

	1	2	3
1 DTROUTG	1.0000		
2 DTEMRG	0.4766	1.0000	
3 DTPRODG	0.7088	0.1224	1.0000

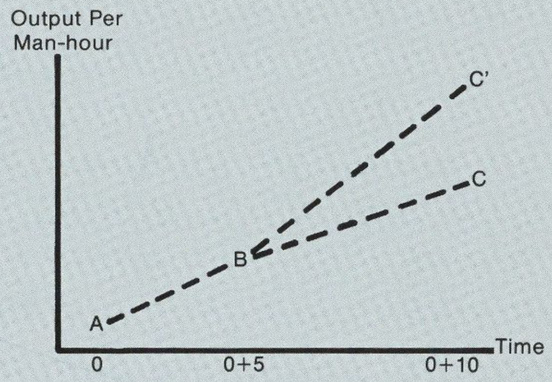
DTROUTG = deviation from trend rate of output growth;
DTEMRG = deviation from trend rate of employment rate growth; and
DTPRODG = deviation from trend rate of productivity growth.

t-statistics in parentheses
**Significant at the one-percent confidence level.

APPENDIX II

The figure to the right shows a hypothetical (output per man-hour) trend. Points A, B, and C represent measured levels of productivity in three different years taken at five-year intervals.

Suppose that in year 0 + 5 we know productivity for that year and for year 0, then we could estimate a constant trend rate of growth which would have increased productivity from point A to point B along the dashed line AB. By assuming that this particular rate of productivity growth will hold into the future, we could predict productivity at year 0 + 10 to be C′. But when year 0 + 10 arrives, we measure productivity to be at C, a substantially lower value than C′. What happened? Clearly, the projection of the recent trend rate was in error.



APPENDIX III

$$\frac{\Delta qt'}{qt} = \left[\Sigma\left(\frac{qi'}{qi} + \frac{li'}{li}\right)\Delta\frac{Qi}{Qt}\right] + \left[\Sigma\frac{Qi}{Qt}\Delta\frac{qi'}{qi}\right] + \left[\Sigma\frac{Qi}{Qt}\cdot\Delta\frac{li'}{li}\right] + \left[\Sigma\Delta\frac{qi}{qi}\cdot\Delta\left(\frac{qi'}{qi} + \frac{li'}{li}\right)\right].$$

$\frac{qt'}{qt}$ = growth rate of total productivity;

$\frac{qi'}{qi}, \frac{li'}{li}$ = growth rate of productivity and man-hour shares of sector i; and

$\frac{Qi}{Qt}$ = ith sector share of total real output.

1st bracket - change in output share effect
2nd bracket - change in productivity growth effect
3rd bracket - change in man-hour share growth effect
4th bracket - interaction effect

The change in the growth rate is in four parts: the effect of changing composition of output, determined by weighting the composition changes by the sum of the initial productivity and man-hour share growths; the effect of changing productivity, which uses initial sector output shares as weights; the man-hour share of growth change effect, which also uses sector shares of total output as weights; and, finally, the interaction effect, the sum of the products of the changes.

We have estimated the change in productivity growth from 1960-64 to 1970-74, dividing the economy into seven sectors: mining and construction; manufacturing; agriculture; transportation and utilities; services; wholesale and retail trade; and government. The results are shown below.

Sources of Change		Percent Share of Total Change
Effect of changing productivity growth within sectors	-.436	63.28
Effect of changing growth of man-hour shares within sectors	-.247	34.69
Effect of changing output shares	+.008	
Interaction effect	-.014	2.03
Total change in percentage rate of growth	-.689	