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SECTORAL PRODUCTIVITY SLOWDOWN

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ABSTRACT

In this paper an attempt is made to answer two questions: 1) What set of factors explains the recent slowdown of the U.S. aggregate labor productivity, and 2) whether the same set of forces account for the slowdown of sectoral productivity growth as well. We specify a model which relates measured labor productivity growth to capital/labor ratio, level and rate of change of utilization, stock of R & D, and the rate of disembodied technical change. The model is estimated using sectoral and aggregate data for the period 1949-1978.

The results of the estimation suggest that the pattern of aggregate productivity growth can be explained by the growth of capital/labor ratio the gap between potential and actual output growth paths, the change in degree of utilization, the growth of stock of total R & D, and the time trend. In fact, both at the aggregate and sectoral levels, these factors account fairly well, first for the growth and then for the subsequent slowdown of labor productivity in the postwar period. To be sure, in some specific industries, the performance of the model could be improved. However, the overall conclusion reached is that the slowdown in growth of capital formation, the inability of the economy and various sectors to grow at their normal growth rates, and the slowdown in rate of technological change are some of the main reasons for the observed productivity slowdown of the recent years.

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SECTORAL PRODUCTIVITY SLOWDOWN

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The recent dramatic slowdown of the U.S. aggregate productivity growth has been the subject of intensive discussion in the literature. The causes of this slowdown are difficult to pinpoint, and many factors may be responsible. However, one source of the slowdown may be the substantial changes in the industrial composition of output, employment, capital accumulation, and resource utilization. It is fairly evident that the slowdown is widespread throughout all sectors of the economy, but what is not quite obvious are the factors which have been responsible for this pervasive phenomenon. Some available studies attribute the retardation of the aggregate productivity growth to sectoral shifts in the composition of output and employment.[1/] However, the intersectoral shift in employment can only explain a fraction of the aggregate productivity slowdown. Also, what is not readily known is the explanation for the changes in growth of the sectoral productivity.

In this paper, I shall concentrate on two questions: 1) What set of factors explains, at least partially, the growth of labor productivity in different sectors during the postwar period? and 2) is the weakening of the same set of factors accountable for the slowdown of the sectoral and aggregate productivity growth since 1973? What follows describes very briefly a model of labor productivity growth. The model is estimated using sectoral and aggregate data for the period 1949-1978. The data covers output, employment, capital stock, stock of R & D, level and rate of change

of utilization rate, and a proxy for disembodied technical change.

We conclude from our analysis that the growth rate of capital/labor ratio, the utilization rate and its rate of change, and the growth stock of total Research and Development, go a fair distance in explaining the pattern of sectoral and aggregate productivity growth. The weakening of the same set of forces is shown to have contributed to the recent slowdown in these growth rates.

I.

Before describing our model, it will be useful to note briefly that during the postwar period, substantial changes have taken place in patterns of sectoral growth output, employment, capital stock, and R & D accumulation, and degree of resource utilization. A brief look at the growth rates over the sub-periods, 1948-55, 1955-65, 1965-73, and 1973-78, indicate that the sectoral productivity growth rates have been dramatically changing. Some industries like Communications have been growing steadily, while sectors like Mining, Public Utilities, and Construction have lost their pre-1965 expansion rates. In fact, in the period 1973-78, labor productivity growth in Mining and Construction has been negative, while Transportation, Wholesale Trade, Services, and Public Utilities productivity growth rates have slowed considerably.

Substantial changes in sectoral mix of employment and capital growth have occurred, particularly since the early 1970's. For example, the exodus of labor from Farming has slowed, while Mining and Transportation have experienced substantial positive growth in employment. The employment

growth rates have been slowed considerably in all sectors of the economy during 1974-78, except in Mining and Transportation. Deceleration of output growth is also evident in most industries for this period, with the exception of Communications. This growth rate is even negative in Construction and Mining. Also, the growth of capital formation in various Sectors has been reduced substantially, and in some sectors, the slowdown is dramatic. Further, it is well documented that the growth of the stock of R & D has declined by about 2.5 to 3.0% in recent years.

These changes in sectoral growth rates of inputs and outputs over time have certainly affected productivity growth at the aggregate level. The results reported here indicate that the recent slowdown of productivity growth at both sectoral and aggregate levels can be explained to a considerable degree by the deceleration of output growth and inadequate utilization of existing capacity, plus the slowdown of growth of capital/labor ratio, and the pace of technical change in some sectors.

II.

The basic model of labor productivity growth is derived from an admittedly simple production function--a three-input, Cobb-Douglas production function with neutral technical changes. The inputs are capital, labor, and stock of R & D for the period 1948-78. Following W. Nordhaus, [2] we have estimated the demand for each sector as a function of its price relative to the general price level, the difference between actual and normal unemployment rates, and the level of normal aggregate output, a measure calculated by G.L. Perry [3]. The estimated normal demand for a given sector was then calculated by setting the level of actual employ-

ment equal to its normal level. The production function relates normal output to levels of manhours, stocks of fixed capital and R & D capital, and a linear time-trend. By setting normal output and normal demand to equality, assuming constant returns-to-scale in production, and that the adjustments of manhours to changes in short-term demand depends on the level of capacity utilization and to its rate of change, the following productivity equation is obtained:

$$\ln P = \alpha_0 + \alpha_1 \ln k + \alpha_2 \ln U_t + \alpha_2 \Delta \ln U_t + \alpha_4 \ln R + \alpha_5 t ,$$

where P is the level of output per manhour, k is the ratio of gross capital stock to manhours, U is the gap between the rates of growth of actual and normal output, $\Delta \ln U_t$ is the change in $\ln U$, R is the stock of R & D, and t is the time trend. The variable, R, is a measure of the aggregate stock of R & D developed by Kendrick, which was extended for the period 1969-78 using NSF published R & D data. 4/

The productivity equation was fitted using the aggregate and sectoral data for 1949-78. The fit of the equations were very good, based on conventional criteria. However, prior to the discussion of the results, a few remarks about the problems of estimation seem to be in order. For some industries, we have restricted the capital/labor ratio and the utilization rate to the same coefficients. This was done once we observed that the two sets of coefficients were exactly the same when the variables were introduced separately. However, the most troublesome estimation problem arose in the sectoral equations due to the multicollinearity between the stock of R & D and the time trend. When time trend was excluded from the regression, the coefficient of the R & D variable had the correct sign

and significant magnitude in almost all of the sectoral equations. This is not surprising. Our measure of R & D refers to the aggregate level, and to distinguish between the effects of disembodied technical change and the growth of R & D stock in specific sectoral productivity equations, what is needed is a measure of sector-specific stock of R & D. Unfortunately, except for the period since 1958 for the manufacturing industries, the necessary data are not available. Another reason may be that if the appropriate measure of capital, i.e., net capital stock, was used in estimating the model, the R & D variable could have been statistically significant. However, for the aggregate economy, the results indicate that we can distinguish between the effects of stock of R & D and disembodied technical change. The magnitudes of the coefficients of stock of R & D and the time trend were both statistically significant and positive. They were .06 and .01, respectively, in the aggregate economy productivity equations, and .10 and .01 in the regression equation for the total private economy. These estimates are reasonable and consistent with some previous evidence.

Our results also indicate that the level of productivity at both aggregate and industrial sectors are affected substantially by growth of capital/labor ratio. These results are in contrast to those found by W. Nordhaus (1972) and G. Perry (1977) and, most recently, L. Thurow (1979), who did not find any effect of capital stock on growth of productivity. They are, however, consistent with results recently reported by P. Clark.[5/] Evidently, the coefficients of the capital/labor ratio we have estimated are slightly greater than the share of capital in each sector or in the aggregate economy. This can be expected since our measure of capital is gross capital stock. The unavailability of net capital stock series for each sector for the entire 1948-78 period rendered the use of gross stock

series necessary.

The coefficients of the short-term variables were also statistically significant in each equation, which implies that measured productivity growth is affected significantly by the level of utilization and its rate of change. In some industries, $\Delta \ln U_t$ was not significant, while in Manufacturing Industries, Trade, Construction, and Public Utilities, this variable was significant. A more systematic variable that appeared in every regression was the level of the utilization rate, suggesting that an important factor in restraining growth of measured productivity has been the failure of output to grow fast enough to catch up with its normal growth rate. Finally, the results indicated that disembodied technical change affects productivity growth positively and significantly in each sector except for the three industries which have been experiencing negative productivity growth since 1973--Mining, Construction, and Public Utilities.

III.

Given the estimates, we can calculate the contribution of the capital/labor ratio, the short-term demand variables , and the R & D toward the slowdown of productivity growth since 1973 in the aggregate economy and its various sectors. These contributions toward the slowdown of productivity growth in period 1974-78 are shown in Table 1. Several aspects of these results are interesing. The slowdown of capital/labor ratio growth, and the decline in the utilization rate and its rate of change contribute to the decline of the aggregate and sectoral productivity growth rates.

TABLE 1: Contributions to the Slowdown of Aggregate and Sectoral Growth Rates of Labor Productivity in 1974-1978. (% per annum)

Variable / Industry	(1) Changes in Growth Rate	(2) Capital/ Labor Ratio	(3) Level of Utilization	Changes in Level of Utilization	(5) Stock R & D	(6) Time Trend	(7) Total Col. 2 to 6.
Total Economy	-0.93	-0.399	-0.439	-0.049	-0.18	0.01	-1.057
Total Private Economy	-0.78	-0.273	-0.222	-0.035	-0.30	0.01	-0.820
Farming	-1.17	-1.795	0.331			0.0004	-1.461
Mining	-6.79	-3.02	-0.576			-0.0008	-3.597
Construction	-1.06	-2.06	-0.004	0.440		-0.02	-1.644
Transportation	-2.45	-0.3996	-1.994			0.03	-2.364
Communication	2.52	0.248	0.211			0.074	0.533
Public Utilities	-2.66	0.041	-3.267	-0.117		-0.003	-3.346
Trade	-1.86	-1.215	-0.568	0.009		0.02	-1.750
Finance	1.59	-0.640	0.565			0.14	0.065
Services	-1.37	-1.37	-0.839			-0.004	-2.213
Government	-0.33	-0.164	-0.080			0.005	-0.239
Manufacturing	-1.02	-0.232	-0.662	-0.043		0.02	-0.917
Non-Durables	-0.94	0.034	-1.015	-0.076		0.02	-1.037
Durables	-1.07	0.252	-0.762	-0.153		0.02	-0.643

The slowdown in growth of aggregate stock of R & D contributes about one fourth and one third of the slowdown of productivity in total economy, respectively. These estimates are probably on the high side and could be improved by further refinement of the data. However, they clearly indicate that slowdown of aggregate labor productivity can be explained fairly well by the conventional factors.

The contributions of these factors in explaining sectoral productivity growth are also significant. In most sectors, the entire or large percentage of productivity growth is due to slowdown in growth of capital/labor ratio, degree of utilization, and the retardation of technical progress in some industries. In some sectors like Farming and Services, the slowdown of productivity growth rate is over-explained. In sectors where the growth or retardation of productivity growth has been substantial, for instance, Mining, Transportation, and Public Utilities, these set of factors account for a significant portion of the slowdown. In other sectors such as Finance and Communications, a substantial residual remains unexplained. It is possible that certain industry-specific factors like regulatory restriction on Public Utilities, or special factors in the Construction industry should be explicitly taken into account. Also, the strong growth of the Communication sector needs special attention. We have not made such an effort at this point, but will do so in the future.

Note that the magnitudes of the contribution of growth of capital/labor ratio, the short-term utilization rate, and technical progress vary considerably among the various sectors. The estimates of the contribution of capital/labor ratio are probably on the high side, as we noted

earlier, because we have used gross capital stock measures, while the appropriate data are the net stock series. Also, note that the contribution of the capital/labor ratio and the other variables are not always in the same direction. This is particularly true for the growth rate of technical progress, which in all sectors except for Mining, Public Utilities, and Services, contributes positively to growth of productivity and offsets the negative effects exerted by the slow growth of capital/labor ratio and the utilization rate.

The results shown in Table 1 are preliminary and can certainly be improved with better data and, perhaps, better specification of the model. For example, we have not controlled adequately for the specific effects of the sharp recession of 1974, which some investigators found to have significantly affected productivity growth. Also, the estimates could be improved if adjustments were made for quality imporvement in our capital and labor series. However, for the present, our results suggest that it is the slow growth of capital formation, the inability of the economy and various sectors to grow at their normal growth paths, and some slowdown in the rate of technical change which go a fair distance in explaining the slowdown of productivity growth since 1973.

High and steady growth of demand and rapid capital formation could lead to substantial improvement in aggregate and sectoral productivity growth. But the crucial policy decision is how to stimulate growth of demand and capital accumulation and at the same time lower the present high inflation.

FOOTNOTES

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[1]For examples see W. Nordhaus, "The Recent Productivity Slowdown", Brookings Papers, March 1972; J.R. Norsworthy and L. Fulco, "Productivity Costs in the Private Economy", Monthly Labor Review, June 1976; and L.C. Thurow, "The U.S. Productivity Problem", Mimeo, April 1979.

[2]See W.D. Nordhaus, "The Recent Productivity Slowdown"

[3]See G.L. Perry, "Potential Output and Productivity", Brookings Papers on Economic Activity, January 1977, 11-47.

[4]See J. Kendrick, The Formation and Stocks of Total Capital, NBER/Columbia University Press, New York 1976.

[5]See P.K. Clark, "Capital Formation and the Recent Productivity Slowdown", Mimeo, December 20, 1977.

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