NBER WORKING PAPER SERIES

THE "END-OF-EXPANSION" PHENOMENON IN SHORT-RUN PRODUCTIVITY BEHAVIOR

Robert J. Gordon

Working Paper No. 427

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge MA 02138

January 1980

The research reported here is part of the NBER's research program in Economic Fluctuations. Any opinions expressed are those of the author and not those of the National Bureau of Economic Research.

NBER Working Paper #427
January, 1980

The "End-of-Expansion" Phenomenon In Short-Run Productivity Behavior

ABSTRACT

The slowdown in the long-term growth rate of U.S. productivity has generated widespread concern and numerous studies. The present paper makes no contribution to an understanding of the long-term slowdown; rather, its main objective is to examine the short-run behavior of aggregate labor productivity in isolation.

In addition to the phenomenon of short-run increasing returns to labor identified in previous studies, the paper isolates a little-noticed but consistent tendency for productivity to perform poorly in the last stages of the business expansion. In 1956, 1960, 1969, 1973, and again in 1979, a productivity shortfall has developed with absolute declines in the level of productivity occurring in every episode but the first, and in every episode before 1979 the shortfall has subsequently been made up.

This paper contains estimates of regression equations that explain the response of changes in hours to changes in current and lagged output. Versions of the equation containing a new "end-of-expansion" variable perform better than those lacking this element and provide a much more accurate ability to track the behavior of productivity, both within the sample period and in post-sample-period extrapolations for 1978-79. The end-of-expansion effect is attributed to inertia and overoptimism in business personnel policies. The paper concludes that the absolute decline in the level of labor productivity in 1979 is consistent with the predictions of the equations based on past history, but that the trend growth of productivity began a further slowdown in 1977-78 from the already poor performance recorded during 1973-76.

Professor Robert J. Gordon
Department of Economics
Northwestern University
Evanston, IL 60201

(312) 492-3616

Forthcoming in *Brookings Papers on Economic Activity*, 1979, No. 2

THE "END-OF-EXPANSION" PHENOMENON IN SHORT-RUN PRODUCTIVITY BEHAVIOR

Robert J. Gordon

Northwestern University and

National Bureau of Economic Research

"I believe the principal explanation lies in the momentum and overoptimism of personnel policies." -- Arthur M. Okun

The startling decline in U. S. aggregate labor productivity during the first three quarters of 1979 (a 2.3 percent decline in the nonfarm sector at an annual rate) adds new urgency to the continuing concern about U. S. productivity behavior. Several important recent studies have documented a slowdown in the secular growth rate of productivity that has taken place in two stages, the first beginning in 1965 or 1966 and the second in 1973, and most studies appear to leave the causes of a large portion of the deceleration as an unresolved puzzle.[1] Does the 1979 experience suggest that a third stage of the secular slowdown has begun, or is this recent behavior consistent with previous occurrences at the same stage of the business cycle?

Many studies of the short-run cyclical behavior of labor productivity have been by-products of larger studies of secular trends. In the work of Perry and Hordhaus, for instance, a cyclical correction was required to construct measures of aggregate "normal" or "potential" productivity for studies of long-term trends and the sources of shifts in these trends.[2] This paper makes no contribution to an understanding of the secular slowdown in productivity other than contributing a new cyclical correction of the long-run trend. Rather its main objective is to examine the short-run behavior of aggregate labor productivity in isolation. In addition to the phenomenon of short-run "increasing returns to labor" (SRIRL) identified in previous studies, it isolates a little-noticed but consistent tendency for productivity to perform poorly in the last stages of the business expansion. In 1956, 1960, 1969, 1973, and now again in 1979, a productivity shortfall has developed, with absolute declines in the level of productivity occurring in every episode but the first, and in every episode before 1979 the shortfall has subsequently been made up. The paper is more successful in identifying this "end-of-expansion" phenomenon than in explaining it; the results suggest that firms tend consistently to hire more workers in the last stages of the business expansion than is justified by the level of output.

An improved understanding of the short-run behavior of productivity, while of far less importance than an unraveling of the secular slowdown puzzle, nevertheless has relevance for several issues. Any forecast of the paths of employment and unemployment that will accompany a given path of real output over the next few quarters requires a decomposition of recent productivity changes into their permanent and transitory components, as does the early recognition of shifts in the secular growth rate of productivity, and hence of the likely medium-term trends in potential GNP and in the full-employment government budget. Further, the same decomposition is required for structural price equations that attempt to explain the extent to which firms respond to changes in actual labor productivity by altering prices rather than profits.[3]

Alternative Specifications of the Short-run Productivity Relation

A common feature of previous work by Nordhaus, Perry, and others, is the explanation of procyclical fluctuations in average labor productivity as resulting from the partial adjustment of the ratio of aggregate labor hours to potential hours (H_t/H_t^*) in response to fluctuations in the ratio of actual to potential real output (Q_t/Q_t^*):

$$(1) \qquad \frac{H_t}{H_t^*} = \left(\frac{Q_t}{Q_t^*}\right)^{\beta}, \qquad \beta < 1.$$

The assumption that the parameter of adjustment (β) is less than unity can be interpreted as reflecting the variability of capital utilization and the fixity of some portion of labor input.[4]

The statistical estimation of equation (1) cannot proceed until a procedure is devised to construct time series for potential hours and real output. One of the two missing variables can be eliminated if it is assumed that "potential productivity" (Q_t^*/H_t^*) grows at the exponential trend rate $\underline{g}$:

$$(2) \qquad Q_t^* = H_t^* B e^{gt},$$

where B is a constant term. Perry's estimation procedure has been to use (2) to eliminate Q_t^*, and then to construct a time series for potential hours. Nordhaus used (2) to eliminate H_t^* and then constructed a time series for potential output. No matter which procedure is chosen, there is no escape from the necessity to select one or the other "potential" series, and thus to impose a criterion for deciding what conditions represent the economy's "potential."

Since this paper is concerned only with short-run adjustment, it eschews any discussion of problems involved in constructing potential output measures and instead adopts the series recently constructed by Perlof and Wachter.[5] Substituting (2) into (1) to eliminate potential hours, we obtain:

$$(3) \qquad \frac{H_t}{Q_t^*} = \left(\frac{Q_t}{Q_t^*}\right)^{\beta} A e^{-gt},$$

where $A = B^{-1}$. Equation (3) can be estimated directly, and can be made more flexible by allowing lagged values of the output ratio as well as the current ratio to influence hours, and by allowing for several different time trends to capture the effect of the slowdown in secular productivity growth.

The time period examined in this paper begins in 1954:2, the trough of the first post-Korean recession, and extends until the most recent available quarter. All regression equations are estimated over the period ending in 1977:4, allowing the use of data for 1978 and 1979 for an evaluation of the aspects of productivity behavior in recent quarters that are not predicted by the regressions. The raw data exhibit the much-discussed slowdown in secular growth rates; in this paper the dividing lines initiating the two kinks in the secular trend occur at 1965:4 and 1972:4.[6] The respective quarterly growth rates for the three periods, expressed at annual rates, are 2.75 percent for 1954:2 through 1965:4, 1.96 percent for 1966:1 through 1972:4, and 0.88 percent for 1973:1 through 1979:2. Thus the overall slowdown between the first and third periods is 1.87 percent.

Regression Equations Relating Hours to Output

There is no attempt here to estimate the stark and simple version of the hours-adjustment equation represented by (3). Instead, all our estimates differ from (3) by including three lagged output terms and in allowing for a broken time trend. Rather than estimate three separate time trends, all equations (except those covering sub-periods) include (a) a time trend for the whole period, (b) a second trend to measure the extent and significance of a slowdown during 1966:1-1972:4 from the overall trend, and (c) a third trend to measure the extent and significance of a slowdown during 1973:1-1977:4 from the overall trend.

The first equation to be estimated followed Nordhaus and Perry and relation (3) by specifying both dependent and independent variables as levels of logs.[7] The results are not included in Table 1, because a very low Durbin-Watson statistic suggested the presence of positive serial correlation. When the level equation was re-estimated with a Cochrane-Orcutt correction, the estimated first-order serial correlation coefficient

TABLE 1

Estimates of Hours Equations

Dependent Variable: Nonfarm Hours/ Potential Nonfarm Real GNP
Quarterly Data, Sample 1954:3 - 1977:4

	Quarterly Growth Rates				
	Whole Period			First Half	Last Half
	(1)	(2)	(3)	(4)	(5)
A. Time Trend (annual rate)					
1. Whole Period	-2.48**	-2.47**	-2.48**	-2.48**	---
2. Slowdown I (66-72)	0.45**	0.45**	0.46**	---	---[a]
3. Slowdown II (73-77)	1.42**	1.40**	1.42**	---	---[a]
B. Q/Q* Current	.423**	.450**	.457**	.497**	.415**
C. Q/Q* Lagged					
1. One Period	.266**	.269**	.270**	.217**	.323**
2. Two Periods	.100**	.087**	.088**	.111**	.073
3. Three Periods	.024	-.034	-.040	-.047	-.033
D. Sum of Q/Q* Coeff.	.813**	.772**	.775**	.778**	.778**
E. End-of-expansion Effect					
1. Whole Period	----	2.22**	1.80**	1.57**	2.29**
[t ratio]		[5.65]	[4.23]	[3.21]	[2.66]
2. Post 73:1 Effect	---	---	2.01**	---	1.41
[t ratio]			[2.31]		[1.22]
F. Regression Statistics					
1. R-squared	.750	.817	.828	.849	.818
2. S.E.E. (Percent)	.488	.419	.409	.397	.438
3. Durbin-Watson	1.73	2.13	2.27	2.33	2.14
G. Post-Sample Error in Predicting Cumulative Change in Productivity					
1. 1977:4 - 1978:4	-.50	-.52	-.49	---	-.55
2. 1978:4 - 1979:3	-1.55	-.70	.54	---	.28
3. 1977:4 - 1979:3	-2.05	-1.22	.05	---	-.27

was 0.883, suggesting that the relation written in equation (3) should be respecified with the data expressed in first differences. When lower-case letters are used to represent quarterly percentage changes, equation (3) can be rewritten as:

$$(4) \qquad \dot{h}_t - q_t^* = \beta(q_t - q_t^*) - g.$$

The basic first-difference result is presented in column (1) of Table 1. An interesting feature at the top of column (1) is the statistical insignificance of the 1966-72 secular slowdown. Indeed, this weakness of evidence supporting "Slowdown I" is a consistent feature of all the first-difference equations in this paper. "Slowdown II," on the other hand, is consistently significant, although the size of its coefficient (roughly 1.4 percentage points) is somewhat smaller than a crude calculation of the size of the slowdown (1.9 percentage points). The difference represents the impact of the high level of resource utilization in 1965 as compared to 1977.

There is a serious problem with the basic first-difference version in column (1) that is not evident in the summary statistics presented in Table 1. Although the Durbin-Watson statistic for the equation is 1.73, and although the Cochrane-Orcutt estimate of the first-order serial correlation is not statistically significant at the 5 percent level, nevertheless the residuals of the equation display a distinctively non-random pattern. The residuals tend to be positive for a number of quarters, followed by a solid string of negative values:

Interval Beginning	Fraction of Residuals of One Sign in Interval: Positive	Negative
1955:3	5/6	
1957:1		4/6
1958:3	5/7	
1961:1		7/8
1965:2		9/13
1968:3	7/7	
1970:2		10/12
1973:2	6/6	
1974:4		7/8

Thus of the 94 observations in this regression equation, fully 73 are included in these uniformly signed "strings." It is the negatively correlated zig-zag pattern of the remaining residuals that keeps the Durbin-Watson statistic from accurately revealing the nature of the serial correlation problem in this equation.

This pattern of autocorrelation poses two interesting questions that are relevant to an improved understanding of recent short-run productivity fluctuations. First, can the pattern of residuals be explained by some set of economic time series variables? Second, if the pattern of residuals cannot be explained statistically, can it be described in any helpful or interesting way?

Initially I assumed that it would be possible to explain the pattern of the residuals by some mixed autoregressive-moving-average statistical process. For instance, if there were an inertial process in hiring that caused a firm to base this period's hiring plans on last period's outcome, then one would expect a significant role to be played by lagged dependent variables. To test this hypothesis four lagged values of the dependent variable were added to column (1) and every other first-difference equation estimated in Table 1. In no case was any lagged dependent variable significant, even at the 10 percent level. Another supposition was that firms might make systematic errors in predicting output by basing their expectations on too long a moving average of past changes in output. But the addition of further lagged values of output to the equations in Table 1 makes no important contribution other than picking up a seasonal pattern.[8] These negative findings apply not only to the equations estimated for the full 1954:2-1977:4 sample period, but also to equations estimated separately for the first and last half of that period.

Specification of the "End-of-expansion Effect"

While it does not appear possible to explain the mysterious residuals in any conventional sense, it nevertheless is possible to "characterize" them in an appealing and interesting way. We date the last phase of the business cycle expansion as beginning when the ratio of real GNP to potential real GNP (Q_t/Q_t^*) reaches its peak. Up until that time real output has been rising faster than its long-run trend, and thus business firms may have discovered that their real sales have outstripped their previous plans and expectations, requiring upward revisions of plans for both hiring and capital investment. Managers of individual firms, each buoyed by a series of quarters when things have worked out better than expected, may feel justified in extrapolating this performance into the future. Given the economy's limited capacity to produce, the realization of each of their plans in some episodes would have required that each firm simultaneously raise its market share.

A dummy variable can be created that captures this "end-of-expansion effect." Each cyclical episode is constrained to commence in the quarter after the peak quarter of Q_t/Q_t^*, which for the five NBER business cycles since 1954:2 has occurred in 1955:4, 1959:2, 1968:3, 1973:1, and 1978:4.[9] Because it is assumed that managers eventually recognize that they have too many people on the payroll and take corrective measures, the dummy variable is constructed to take positive values for M quarters following the quarters when Q_t/Q_t^* reaches its peak, and then to take negative values for N quarters thereafter. The variable is constrained to sum to zero over any given business cycle, and thus does not distort the meaning of the secular trend coefficients in the hours regressions. An additional constraint is imposed by setting the values of M and N equal to the same number for each cycle. The values of M and N that best describe the process are six and eight quarters, respectively. The larger value of N reflects the tendency for firms to take their corrective action over a longer period than the time taken for the overstaffing problem to occur.[10]

In Table 1, column (2) illustrates the effect of adding the "end-of-expansion" (EOE) dummy variable to the equation in column (3). Line E1 indicates that the dummy variable is extremely significant statistically, with a t ratio of 5.65.[11] The variable is defined so that its coefficient indicates the cumulative percentage amount of overhiring that occurred on average over all cycles; during the six quarters of overhiring (M=6) hours reached a level 2.22 percent higher than can be explained by the behavior of current and lagged output, and this 2.22 percentage point excess was gradually eliminated over the subsequent eight quarters (N=8).[12] The sum of the coefficients on current and lagged output is about the same in both columns (1) and (2) and indicates only a partial response of hours, the effect known as "short-run increasing returns to labor." Thus the fitted coefficients in equation (2) combine the traditional procyclical fluctuations in the *level* of labor productivity together with an indication of unusual weakness in the last stage of the business expansion.

Several additional equations are presented in Table 1 to determine whether the significance of the EOE effect is due to a particular business cycle, or rather reflects a phenomenon that operates during each cycle. Column (3) is identical to column (2) but allows a separate value of the EOE dummy variable to enter after 1973:1. The coefficient on this variable in line E2 would be zero if the behavior of productivity during the 1973-74 episode were the same as the average of the previous cycles, and would be positive if there were a greater tendency toward excess staffing and slack productivity in that episode. It is apparent from line E2 that the 1973-74 episode was special, with a cumulative excess hiring of 2.01 percent over and above the "normal" EOE effect of 1.80 percent, for a total of 3.81 percent. Despite the unusual nature of the 1973-74 period, the coefficient on the overall EOE effect drops only slightly in moving from column (2) to (3), and its t ratio is still a robust 4.23.

The final two columns of Table 1 report the results that are obtained when the sample period is split in half, with separate estimates for 1954:3-1966:1 and 1966:2-1977:4. The major impact of the split sample results is to make the 1974 episode look less "special." In Line E2 of column (5) the coefficient on the 1973-74 effect is reduced to 1.41 percent with a t ratio of only 1.22, below the 10 percent level of significance. Despite the isolation of the 1968-69 and 1973-74 episodes in column (5), there still seems to be a significant end-of-expansion effect evident in column (4) for the first half of the sample period. The productivity slump of 1956 has long stood as evidence that the simple procyclical story of equation (1) above is an incomplete representation of the short-run behavior of productivity, and a similar cessation in productivity growth occurred in the next business-cycle expansion after the Q_t/Q_t^* peak was reached in 1959:2. The excellent performance of productivity during the first two years of the Kennedy Administration can thus be partly explained through the normal working of the "rebound" phase of the EOE effect.

Attempting to Explain the End-of-Expansion Effect

So far we have succeeded only in describing the end-of-expansion effect without providing any kind of behavioral explanation of its origins. We are first led to ask whether the sluggish response of aggregate *hours* at the end of business expansions represents the behavior of *employment* or *hours per employee* (HPE). To answer this question separate regression equations were estimated corresponding to each column of Table 1 in which employment and HPE alternatively replaced aggregate hours as the independent variable. Since quarterly changes in employment and HPE add up to quarterly changes in aggregate hours by definition, it is not surprising to find that the sum of the coefficients on the EOE dummy in the separate employment and HPE equations add up to the coefficient in the aggregate hours equation displayed in column (3) of Table 1. Of the 1.80 percentage point total EOE effect, 1.26 points are contributed by employment and 0.54 points by HPE. Thus it would appear that the EOE phenomenon primarily involves the maintenance of an excessive number of employees relative to output, with hours per employee making a minor additional contribution.[13]

Several suggestions have been made to explain the EOE phenomenon as being consistent with rational profit-maximizing behavior. First, labor and capital may be interdependent factors of production. In periods when capital investment is relatively high, extra employees may be required to install new equipment, and experienced employees may have to work overtime to train new employees. These "installation costs" would decrease when investment is low. To test this proposition the detrended ratio of fixed nonresidential investment to potential GNP was entered into the basic equation (column 3) in the form of both its level and first difference. The t ratios were miniscule, and the size of the EOE coefficients was not affected.

A second suggestion is that firms maintain some slack in their labor force when the quit rate is high to guard against being caught shorthanded. This slack subsequently disappears during periods when the quit rate is low and firms no longer are concerned that key employees may depart. Both the level and first difference of the manufacturing quit rate were added to the basic equation in column (3) with the same negative outcome as in the case of investment; t ratios were below the margin of significance, while the EOE coefficients were unaffected.

An inspection of the data reveals little relation between investment and the periods when the EOE effect has its main impact. For instance, the ratio of investment to potential GNP was higher in 1965 and early 1966 than at any other time in the post-1954 period, and yet productivity was rising rapidly and the residuals in column (1) are negative. Similarly, the quit rate was high throughout the prosperous 1966-69 interval, whereas the EOE effect came into play only in late 1968.

There might seem to be a role for the real wage in explaining the EOE effect. In periods when the real wage is decreasing firms may find that labor is cheap, leading to more employment in relation to output. When the current and lagged real wage were added to the basic equation, indeed there appeared to be a significant negative set of real-wage coefficients that eliminated the post-1973:1 dummy variable, although the size and significance of the overall EOE dummy was left intact. Almost all of this negative correlation between employment and the real wage occurs in 1974, when the OPEC oil shock occurred. I would interpret this relationship between the EOE effect and the real wage as representing the common impact of the oil shock rather than a highly elastic short-run demand curve for labor; nominal wage inertia allowed OPEC price increases to reduce the U. S. real wage sharply and promptly, while inertia in employment decisions allowed the sharp decline in output caused by the OPEC shock to show up as an unusually severe decline in labor productivity.

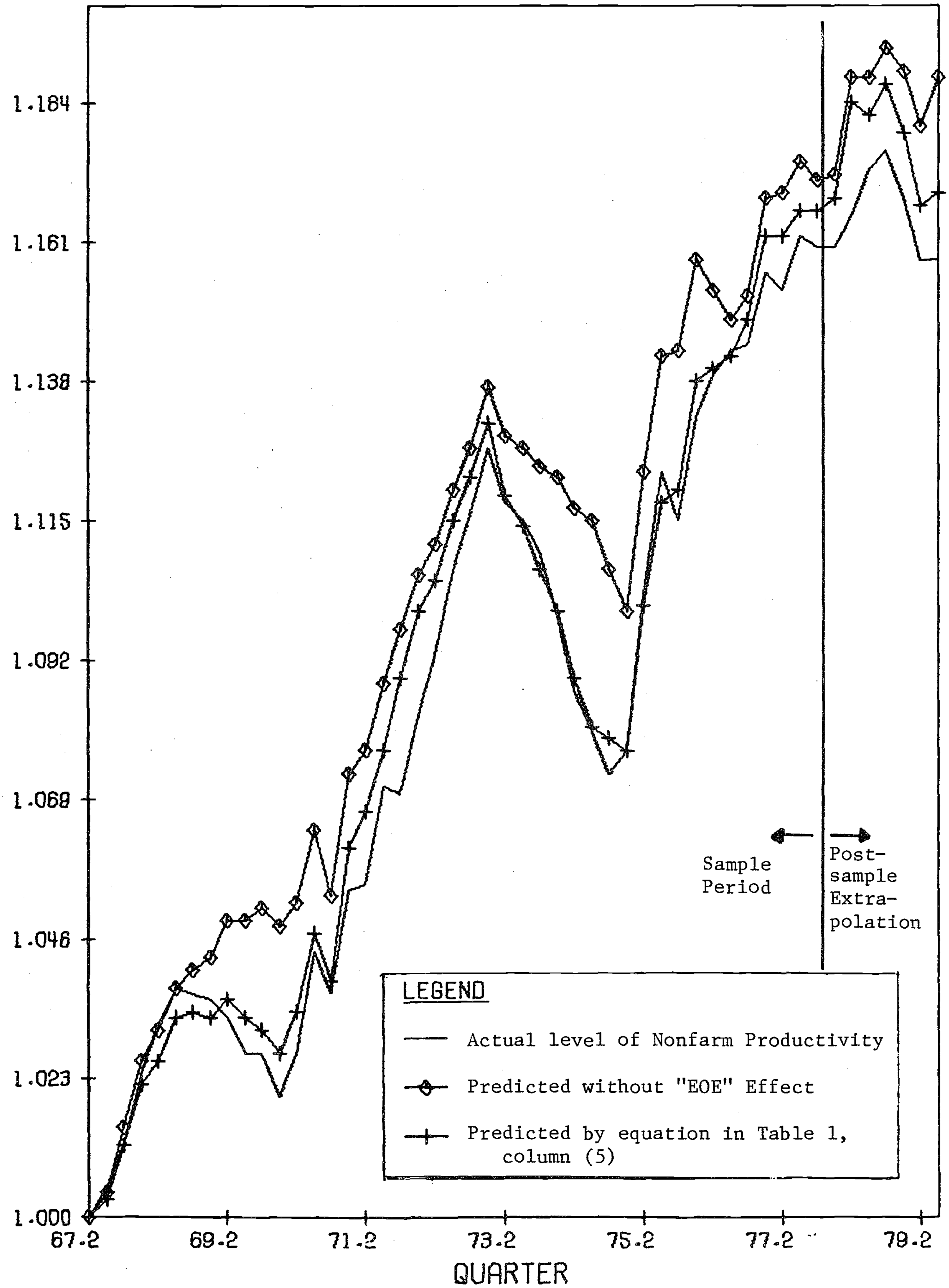
A final set of tests investigated the statistical legitimacy of the form of the equations displayed in Table 1. In principle the relation between output and hours could be tested with either hours or output on the left-hand side of the equation to be estimated. Following the procedure employed by Christopher Sims in his previous investigation of manufacturing productivity, an alternative equation was estimated with the rate of change of output on the left, and leading as well as current and lagged changes in hours on the right. A symmetric equation was estimated that adds leading values of output change to column (3) of Table 1. The results are completely consistent with the view that output is exogenous with respect to hours; leading values of hours had large and significant coefficients in the output equation, but leading values of output had insignificant coefficients in the hours equation.[14] A satisfying feature of this additional set of tests is that the EOE dummies are strongly significant (and of course with the opposite sign) when the relationship is estimated with output change as the dependent variable.[15]

Interpreting the 1978-79 Productivity Performance

The last section at the bottom of Table 1 lists the post-sample extrapolations of the equations. All equations but that in column (3) predict a growth rate of productivity during 1978-79 that is larger than the actual outcome, and thus a higher level of productivity than has actually occurred. The forecast errors become successively smaller as we move from column (1) to (3), with an underprediction of productivity of 0.05 percentage points in column (3) and overprediction of only 0.27 percentage points in column (5). Comparing the four equations, we note that the equations in columns (3) and (5) that include the significant post-1973:1 dummy predict a larger decline in productivity than actually occurred in 1978-79. The ability of these equations to "track" the precipitous decline in the level of productivity during the first half of 1979 results from the impact of the EOE effect (which first takes place in 1979:1), as well as from the assumption in those columns that the extra 1973-74 effect applies equally to 1979.[16]

In Figure 1 the actual values of the level of nonfarm productivity between 1967 and 1979 are compared with the predictions of levels implied by the fitted values of two growth rate equations, the simple version presented in column (1) of Table 1 (re-estimated for the 1966-77 period) shown as the dotted line and the version incorporating the EOE effect estimated for the same sample period in column (5) of Table 1 and shown as the dashed line. A comparison of the dashed and dotted lines illustrates the role of the EOE effect in improving the explanation of the absolute decline in productivity in 1969 and 1973-74, as well as the subsequent rebound in 1970-72 and 1975-76. The post-sample extrapolation of the dashed line also captures the decline in productivity during the first half of 1979, although its level is between one-half and one percentage point too high throughout 1977, 1978, and 1979, suggesting that a third slowdown in the secular trend may have begun in early 1977.

FIGURE 1


1.184
1.161
1.138
1.115
1.092
1.069
1.046
1.023
1.000
67-2
69-2
71-2
73-2
75-2
77-2
79-2
QUARTER
Sample Period
Post-sample Extra-polation
LEGEND
Actual level of Nonfarm Productivity
Predicted without "EOE" Effect
Predicted by equation in Table 1, column (5)

Conclusion

While the coefficients of dummy variables in regression equations cannot actually *explain* puzzling phenomena, at least they help to identify and *describe* interesting features of economic behavior. In my own previous work I have tested the significance of dummy variables for the 1971-74 price controls and subsequent post-controls rebound as an aid in describing U. S. price behavior, and "wage push" dummy variables in wage equations for various European countries. In each case there was an external event identified by contemporary accounts to help date and describe the phenomenon captured by the dummy variables. In this paper, the "end-of expansion" dummy variables are statistically significant and operate consistently across business cycles, but their interpretation is more conjectural. My conjecture is that the phenomenon stems from mistaken expectations and from inertia in changing personnel budgets. While no direct evidence is presented here that misperceptions actually occurred, at least the data are consistent with our imposed constraint that the dummy variable sums to zero, thus forcing any end-of-expansion overstaffing to be eliminated in subsequent periods.

In an early version of this paper I likened the EOE effect to other phenomena in economic time series involving overshooting, including booms in the stock market and overbuilding in the commercial construction industry. Yet at a deeper level these two examples of overshooting are very dfffere nt in nature. Stock market participants deal in an auction market in which there is no inertia beyond the expectations of other market participants that limit price movements, and in which there is no external guidepost to indicate a "correct" level of prices. Expectations in September, 1929, were incorrect only *ex post* and did not appear so at the time. In commercial construction, on the other hand, overbuilding may result from the long lags between decision making and project completion, imparting an inertia to the behavior of nonresidential construction expenditures that is familiar to students of business cycles. The end-of-expansion phenomenon of overstaffing may result from a similar lag between business decisions that set personnel budgets and the actual carrying out of hiring, training, and promotions. Business firms may not be irrational or even guilty of mistaken expectations at the time that the personnel budgets are set, but rather may gradually recognize an overstaffing condition and be unable to correct it rapidly due to the high costs of more frequent decision making and to the inevitable time taken to prune the workforce purely by attrition when layoffs are costly.

At the more immediate level of current policy discussions, the results in this paper suggest that standard equations may tend regularly to overpredict productivity growth during the interval following a cyclical peak in the ratio of actual to potential output. A corollary is the tendency for simple versions of "Okun's Law" to fail to explain why unemployment remains so low and employment so high at the end of expansions and the beginning of contractions.[17] Thus current forecasts based on conventional productivity equations may be unduly pessimistic about the increase in unemployment that will occur during late 1979 and early 1980, but overly optimistic for subsequent periods.

Finally, the structure of hours adjustment described in this paper should be noted by the NBER business cycle dating group and those who compile the cyclical indicators published monthly in *Business Conditions Digest*. The consistent lag of hours behind output, combined with the end-of-expansion overhiring effect, converts hours into a lagging indicator that should not be included in the coincident indicators and should play no role in discussions of business-cycle dating.[18]

FOOTNOTES

*The author is grateful to the National Science Foundation for research support, and to Jon Frye for his skilled assistance.

1. J. R. Norsworthy, Michael J. Harper, and Kent Kunze, "The Slowdown in Productivity Growth: Analysis of Some Contributing Factors," in this volume is forced to attribute 53 percent of the total slowdown in private business productivity to unidentified "other factors." Other recent studies are cited in the same paper.

2. George L. Perry, "Labor Force Structure, Potential Output, and Productivity," *BPEA*, 3:1971, pp. 533-65; William D. Nordhaus, "The Recent Productivity Slowdown," *BPEA*, 3:1972, pp. 493-536; George L. Perry, "Potential Output and Productivity," *BPEA*, 1:1977, pp. 11-47. Numerous other studies of the manufacturing sector could be cited, of which the most recent is Christopher A. Sims, "Output and Labor Input in Manufacturing," *BPEA*, 3:1974, pp. 695-728.

3. My own interest in the cyclical behavior of productivity stems originally from the need to distinguish between actual and trend productivity measures for price equations. Hours equations similar to those in Table 1 below were originally presented in my "Inflation in Recession and Recovery," *BPEA*, 1:1971, p. 150.

4. The traditional explanation of short-run increasing returns to labor is that a portion of labor input is fixed because of training and separation costs. The classic reference is Walter Y. Oi, "Labor as as a Quasi-Fixed Factor," *Journal of Political Economy*, vol. 70 (December 1962), pp. 538-55. More recently Robert M. Solow has argued that the variable utilization of capital is also necessary to explain

the observed facts, in his "Some Evidence on the Short-run Productivity Puzzle," in Jagdish Bhagwati and Richard S. Eckaus, *Development and Planning, Essays in honour of Paul Rosenstein Rodan* (Cambridge, M.I.T. Press, 1973), pp. 216-25.

5. Jeffrey M. Perloff and Michael L. Wachter, "A Production Function--Nonaccelerating Inflation Approach to Potential Output," in Karl Brunner and Allan H. Meltzer, editors, *Three Aspects of Policy and Policymaking: Knowledge, Data and Institutions*, Carnegie-Rochester Conference Series on Public Policy, volume 10 (North-Holland, 1979), pp. 113-64. See the discussion following the paper for a number of qualifications to the procedures used by Perloff and Wachter.

6. Experimentation revealed that the regressions cannot identify a statistically significant slowdown in the 1965-73 period, so the 1966:1 breakpoint was chosen to make the results roughly comparable to the Norsworthy-Harper-Kunze study in this volume.

7. The estimate of potential nonfarm output is equal to Perloff-Wachter's potential series for total real GNP, adjusted for the slower trend growth of nonfarm real GNP relative to total real GNP over the 1953-79 period (the downward adjustment is 0.32 percent per annum).

8. Versions or the equations were presented at the BPEA meeting with eight lagged output terms, and several participants commented that the significant zig-zag pattern of the weights on lags four and five might be a reflection of seasonality in the underlying data. Up to sixteen lags were also included with no improvement in fit.

9. As of the writing of the final version of this paper, the NBER had not

yet declared the existence of a recession in 1979. Nevertheless, it seemed likely that a recession would begin late in 1979 or early in 1980, and that in retrospect 1978:4 would represent the peak in Q/Q^*. The three quarters of 1979 all had Q/Q^* values significantly below the ratio registered in 1978:4.

10. The only exception to the statement made in the text is that, reflecting the shorter and sharper business cycle of the mid 1950s, M=4 and N=6 for the period beginning with the Q_t/Q_t^* peak in 1955:4.

11. In Table 1 space is saved by showing exact values of t ratios only for the EOE dummies, while the significance of other variables is indicated by asterisks.

12. As an example the dummy variable is defined as 1/6 for the first six quarters following 1968:3 and as -1/8 for the subsequent eight quarters.

13. A further indication that most of the EOE effect stems from employment rather than HPE is the high t ratio of 3.89 on the EOE dummy in the employment equation, as opposed to a t ratio of only 1.17 in the hours equation. For the post-1973:1 effect employment and HPE each make an equal contribution of about one percentage point with t ratios that are marginally significant at the ten percent level. Similar results were obtained when equations were run for the two sub-periods.

14. For more on the interpretation of these techniques, see Sims, "Output and Labor Input in Manufacturing." In my tests only two leading quarterly values were included, in contrast to the larger number of leading values included in Sims' study of monthly data. The only significant coefficient on a leading value of output in the hours

equation occurred with a two-quarter lead, but the coefficient had the wrong sign (negative).

15. George Perry has inquired whether the EOE effect might be explained in part by the cyclical mix of output. One would expect productivity to fall and employment to appear too large in years when the output of high productivity industries like automobiles is falling. While declining automobile sales may be part of the problem in 1973-74, the timing is wrong in earlier cycles. For instance, auto sales fell off from 1965 into 1966-67 as severely as in 1969-70, yet the EOE effect only shows up in 1969 and not in 1966.

16. Even the unadorned first-difference equation in column (1) predicts an absolute decline in productivity during the first three quarters of 1979, due to the impact of rapid 1978 output growth on 1979 hiring through the lagged output terms.

17. Arthur Okun is well aware of this problem and in fact has explained the low level of unemployment in 1974 in the quote at the beginning of this paper. See Artuhr M. Okun, "Unemployment and Output in 1974," *BPEA*, 2:1974, p. 503.

18. Presently nonfarm *employment* is included in the coincident indicators published monthly in *Business Conditions Digest*.