Carnegie-Rochester Conference Series on Public Policy
(supplement to the *Journal of Monetary Economics*)
10 (Spring 1979) 179-186

POTENTIAL GNP: ITS MEASUREMENT AND SIGNIFICANCE
A Dissenting Opinion

Charles I. PLOSSER and G. William SCHWERT*
University of Rochester

The concept of potential output has played a central role in discussions and the implementation of economic policy for at least fifteen years. The paper by Perloff and Wachter (1979) is the most recent in a series of efforts to bring improved economic theory and statistical methods to bear on the measurement of potential output. Before we discuss some of the specific issues raised by Perloff and Wachter, we would like to address a recurring problem that has plagued the interpretation of econometric results found in the literature on potential output since the work of Okun (1962).

1. Inverting Regressions

Many of the recent attempts to estimate potential output, including Clark (1977) and Perry (1977), follow the procedure outlined by Okun (1962) of using estimated regressions of unemployment on output to "solve out" for "potential output" as a function of actual output and a measure of the deviations of the unemployment rate from some "full-employment" rate or "natural rate" of unemployment.[1] Unfortunately, what appears to be a rather simple algebraic manipulation of the relationship between unemployment and output represents poor econometrics in practice, and can have important implications for the interpretation of subsequent results.

What Okun and others wish to do is to take a deterministic function relating two variables, Y and X,

$$Y = \beta X ,$$

and invert it to get the relationship between X and Y,

$$X = \frac{1}{\beta} Y .$$

*The National Science Foundation provided support for this research. Comments from Karl Brunner, Ronald Hansen and Clifford Smith are gratefully acknowledged.

[1]Perloff and Wachter use a similar procedure in equation (15) and the equation following (15) to estimate a "nonaccelerating-inflation rate of unemployment."

Unfortunately, regression relationships cannot be manipulated this way. The linear regression of Y on X (where we assume both Y and X have means of zero for convenience),

$$Y = \beta X + \epsilon ,$$

has a slope coefficient $\beta = \rho(Y,X) \cdot \sigma(Y)/\sigma(X)$, where $\rho(Y,X)$ is the correlation coefficient between Y and X, and $\sigma(Y)$ and $\sigma(X)$ are the standard deviations of Y and X, respectively. Hence, the expected value of Y given X is βX. On the other hand, the regression of X on Y,

$$X = \gamma Y + \eta ,$$

has a slope coefficient $\gamma = \rho(Y,X) \cdot \sigma(X)/\sigma(Y)$, and the expected value of X given Y is γY. It would be incorrect to use $\frac{1}{\beta} Y$ as a measure of the expected value of X given Y. It is easy to see that

$$\gamma = \frac{1}{\beta} \cdot \rho^2 (Y,X) .$$

Consequently, only in the case where $\rho(Y,X) = \pm 1$ will the regression of X on Y have a slope coefficient equal to the reciprocal of the slope coefficient in the regression of Y on X. In other words, only if Y and X are perfectly correlated (so both regressions are, in fact, deterministic) will such a procedure be valid.

In order to see the importance of this point, consider the simple Okun procedure for estimating potential output. Okun regresses quarterly changes in the unemployment rate (ΔU) on quarterly percentage changes in real GNP, $[\frac{\Delta Y}{Y}]$. We have estimated this equation using data from the first quarter of 1953 through the last quarter of 1970,

$$\Delta U = \underset{(0.050)}{0.261} - \underset{(0.039)}{0.301} \left[\frac{\Delta Y}{Y}\right] , \qquad (1)$$

$$\bar{R}^2 = 0.469, \quad \hat{\sigma} = 0.309, \quad D\text{-}W = 2.25 ,$$

where standard errors are in parentheses, $\bar{R}^2$ is adjusted for degrees of freedom, $\hat{\sigma}$ is the standard deviation of the residuals, and *D-W* is the Durbin-Watson statistic. Equation (1) implies that given a 1.0 percent increase in real GNP, the unemployment rate can be expected to fall by 0.3 percent. It is not correct to infer that given a 1.0 percent increase in the unemployment rate, real GNP can be expected to fall by 3.3 percent, which is the famous (infamous) 3 to 1 relationship between output and the unemployment rate called Okun's law.

If one is interested in the expected value of $\frac{\Delta Y}{Y}$, given ΔU, that is, the expected movement in real GNP conditional on some observed movement in the unemployment rate, it is appropriate to estimate the regression of the percentage change in real output on the change in the unemployment rate,

$$\left[\frac{\Delta Y}{Y}\right] = \underset{(0.087)}{0.857} - \underset{(0.206)}{1.58}\, \Delta U \,, \tag{2}$$

$$\bar{R}^2 = 0.469, \quad \hat{\sigma} = 0.708, \quad D\text{-}W = 2.25 \,.$$

Hence, given a 1.0 percent increase in the unemployment rate, real GNP is expected to fall by 1.6 percent, *not* 3.3 percent!

Using Okun's assumption that a 4.0 percent unemployment rate is the "desired" or "full-employment" rate, Okun's estimate of the gap, G, between "potential output," P, and actual output, Y, is calculated from

$$P - Y = G = 0.033\ (U - 4) \cdot Y \,.$$

If the unemployment rate is 1.0 percent above the 4.0 percent "full-employment" rate, the "gap" is 3.3 percent of actual GNP. However, using the correct estimate of the effect of unemployment on output from equation (2), the "gap" is calculated from

$$G = 0.016\,(U - 4) \cdot Y \,.$$

That is, the output gap is cut approximately in half.[2] Thus, the lax econometric procedures followed by Okun and others can have substantial implications for policy.

The above discussion is not meant to suggest that we believe that obtaining correct estimates of potential output is simply a matter of turning around a regression equation. To the contrary, we feel there are many important conceptual and statistical problems that must be overcome before a meaningful interpretation can be given to estimates of inherently unobservable measures like potential output.

2. Econometric Problems in the Perloff and Wachter Paper

The Perloff and Wachter approach to calculating potential output involves the estimation of a translog production function for the economy, equations (4) and (8), and a wage equation (16) from which they construct their "nonaccelerating-inflation rate of unemployment." Potential output is obtained by substituting the potential labor force obtained from a labor (supply or demand?) equation (18) into the aggregate production function (4).

Unfortunately, we feel that there are important statistical problems with the empirical analysis conducted by Perloff and Wachter. For example, it is not clear that the "cyclically-sensitive translog production function" provides a better description of the time series behavior of aggregate output than simpler models. Comparison of the first six columns of Table 3 reveals that the estimated production function with the smallest residual variance is the Cobb-Douglas model in column (6). In fact, it has a residual variance at least 30 percent less than any of the other specifications. It is unfortunate that Perloff and Wachter do not estimate this Cobb-Douglas model, correcting for autocorrelation, so it can be compared to the corrected, cyclically-sensitive translog models that are presented in the last two columns of Table 3.

Another disturbing aspect of the results in Table 3 is that the cyclically-sensitive production functions typically place more weight on the time trend terms (particularly the linear term, t) than on the term representing the factor inputs. Moreover, the estimated cyclically-sensitive models imply severe diminishing returns to scale. That is, the coefficient of the index of factor inputs is substantially below 1.0 (the value which seems to be implied by the production function model). This suggests that the estimates of the cyclically-sensitive model are not consistent with the theory.

There is an additional point regarding Perloff and Wachter's empirical analysis which we feel is of interest. To obtain a potential output series, a

[2] Of course, if the "full-employment" rate of unemployment is larger than 4.0 percent, the "gap" will be reduced, whether the estimates from equation (1) or (2) are used.

potential labor series, L^*, is constructed using (18) and setting $UGAP_1 = 0.25$. Aside from the severe autocorrelation problems present in the estimated model (as evidenced by a very low Durbin-Watson statistic), it should be noted that substituting $UGAP_1 = 0.25$ into (18) implies that the potential labor series simply follows a deterministic cubic time trend. Given that potential labor is a time trend, that labor makes the largest contribution to the index of inputs (See Table 1), and that output itself is further influenced by time trends (See Table 3), our interpretation is that Perloff and Wachter have obtained a measure of potential output which is dominated by a deterministic time trend. We doubt that Perloff and Wachter believe that these polynomials in time represent true models of economic activity, because they imply an explosive and *deterministic* growth path for the economy (Cowden, 1963, describes the perils of using regressions which are polynomial functions of time). An alternative view might be to consider actual output being associated with a particular growth *rate*, but not a deterministic growth *path* to which output tends to return. Such an alternative view would lead to models of output that appear to be more nearly like random walks with drift (where the drift is the expected growth rate), rather than deterministic time trends.

Despite the use of the time trends to represent the nonstationary behavior of output over time, the Durbin-Watson statistics for the first six columns in Table 3, which estimate the production function (4), are between 0.2 and 0.4, implying first-order serial correlation in the residuals of about 0.9 or 0.8. As a result of discussion which occurred at the Carnegie-Rochester Conference, Perloff and Wachter also estimate the cyclically-sensitive production function using first- and second-order Cochrane-Orcutt models for the regression residuals in the last two columns of Table 3. In these models, the quadratic and cubic time trend coefficients are insignificant and the autoregressive coefficients for the residuals are close to unity, implying close to nonstationary behavior. Perloff and Wachter argue that their regression estimates are consistent, even though they are not efficient. We believe, however, that the severe residual autocorrelation exhibited in the Perloff and Wachter regressions should not be dismissed so lightly. As we have argued in detail elsewhere (Plosser and Schwert, 1978), the costs of ignoring highly autocorrelated residuals can be very large in terms of statistical inference. If the residuals from the regressions in Table 1 are as highly autocorrelated as those in Table 3 (as we suspect), all of the statistical tests reported by Perloff and Wachter, in particular, the F-tests which compare various production function specifications in Table 2, grossly overstate the level of significance of their results.

One positive suggestion, which would provide a crude test of the specification of these models, is to estimate all of the models in terms of the first differences of the data. This would probably yield valid statistical tests (because the residuals would probably not be highly autocorrelated), and the comparison of the levels regressions with the differences regressions may indicate other possible specification errors. For example, if output follows a random walk with drift, the residuals from the differences model would be serially uncorrelated.

3. Conceptual Problems with Defining Potential Output

Even if all of these estimation problems can be overcome, there are serious problems with the meaning and usefulness of a concept like "potential output." We believe that a supply-oriented concept such as "potential output" has little operational significance. It is not an equilibrium concept, since there is no relationship with aggregate demand. Consequently, "potential output" cannot be viewed as representing the level of output which would prevail in the absence of any unexpected random shocks to aggregate supply or demand.

While the Perloff and Wachter measure of potential output seems to behave like "normal output" (for example, the level of output that would prevail if there were no unexpected monetary or fiscal shocks), because it allows for both positive and negative "gaps," the similarity is only superficial. For example, given that there is no aggregate demand in their model, all deviations of actual output from potential output implicitly arise from aggregate demand fluctuations. Therefore, demand management stabilization policies are the logically consistent way to control economic fluctuations and restore the economy to its "equilibrium" growth path. In fact, this would be true of any measure of so-called "potential output." However, aggregate demand policies are not necessarily appropriate in a world where actual output is viewed as the outcome of the interaction between supply and demand in both factor and product markets.[3] In such an equilibrium model "potential output" ceases to have any significance, and even measures of "normal output" are difficult to operationalize because they require comparing the relative merits of various equilibria.

Suppose one could model "potential output" as Perloff and Wachter are attempting to do. Lucas (1976) has argued that traditional econometric models cannot be used to design control policies because rational economic agents will react to the change in control regimes, thus changing the parameters of the econometric model. Perloff and Wachter recognize this problem in the last sentence of the paper: "Projections of this series are, therefore, a useful

---

[3]In a recent paper, Lucas (1978) has expressed similar doubts about the operational definition of full-employment and its usefulness as a theoretical construct or policy guide. For example, one possible definition of "potential output" is the level of gross national product which would result if all persons over 16 years old worked 24 hours a day, every day of the year. This extreme definition illustrates the futility of defining potential output without reference to utility maximizing behavior.

target for stabilization policy only if these rules and policies are not substantially altered from those existing during the estimation period." If Lucas's argument about econometric policy evaluation is correct, then policy-oriented uses of "potential output" are not only futile, they can be seriously misleading.

Perhaps attempts to estimate "potential output" should best be viewed as exercises in economic history, describing what existed under past policy regimes. Perloff and Wachter explicitly recognize the possibility that different regimes of government policy can influence their econometric models.[4] Nevertheless, most analysts, including Perloff and Wachter, would like to use estimates of potential output to guide future policy decisions. Unfortunately, even if the dummy variables and the cyclically-sensitive parameters capture the effects of past policies on the models' estimates, these models cannot be used to predict the future path of output under different policy regimes.[5] It would seem, therefore, that modeling "potential output" is an exercise with little merit, serving only to perpetuate the idea that its use as a policy guide can be justified through economic theory.

4. Conclusions

In this paper we have tried to point out some of the econometric and conceptual difficulties with defining and measuring potential output. In brief, most efforts to estimate potential output, including the paper by Perloff and Wachter, are essentially equivalent to trend extrapolation of output. The details of different approaches really amount to questions about whether the trend line should pass through the peaks of past output (as Okun's approach implies when the "full-employment" unemployment rate is set equal to a low 4.0 percent) or through the middle of past output (as Perloff and Wachter's approach implies). The former approach produces an "output gap" which is always positive, implying a continual need for stimulative government policies, while the latter approach implies that the "output gap" can be both positive and negative.

In general, the Perloff and Wachter estimates of potential output are well below the estimates produced by the Council of Economic Advisers (CEA). For example, Perloff and Wachter estimate a "gap" between potential and actual

---

[4] For example, the translog production function (4) has coefficients which are allowed to vary linearly with the "unemployment gap," which they rationalize through a "labor hoarding" argument. The wage equation (16) has dummy variables to represent different average changes in growth rates of wages during different presidential administrations and a dummy variable representing Phase I to Phase IV of price controls.

[5] For example, suppose that instead of wage and price controls, the economy is subjected to TIP (Tax-Based Income Policies). One could not use the Perloff and Wachter results to obtain measures of the future path of actual or potential output because TIP would affect the "full-employment" rate of unemployment.

output of $22.6 billion as of the fourth quarter of 1977, which is substantially below the CEA estimate of $136.1 billion. While we concur that the economy is probably not in need of the kind of fiscal or monetary stimulus implied by the huge CEA estimate of the output gap, we feel that the Perloff and Wachter study is deficient in its empirical analysis and leaves a number of important conceptual questions unanswered.

References

Clark, P.K. (1977), "Potential Gap in the United States, 1948-1980," in *U.S. Productive Capacity: Estimating the Utilization Gap*, Center for the Study of American Business, Washington University Working Paper 23: December 1977, St. Louis: Washington University.

Cowden, D.J. (1963), "The Perils of Polynomials," *Management Science*, 9: 546-50.

Lucas, R.E. (1976), "Econometric Policy Evaluation: A Critique," *The Phillips Curve and Labor Markets*, Carnegie-Rochester Conference on Public Policy, vol. 1, eds. K. Brunner and A.H. Meltzer. Amsterdam: North-Holland.

__________ (1978), "Unemployment Policy," *American Economic Review*, 68: 353-57.

Okun, A.M. (1962), "Potential GNP: Its Measurement and Significance," *Proceedings of the Business and Economics Statistics Section of the American Statistical Association*: 98-104.

Perloff, J.M., and Wachter, M.L. (1979), "A Production Function-Nonaccelerating Inflation Approach to Potential Output: Is Measured Potential Output Too High?" *Carnegie-Rochester Conference Series*, 10, eds. K. Brunner and A.H. Meltzer. Amsterdam: North-Holland.

Perry, G.L. (1977), "Potential Output and Productivity," *Brookings Papers on Economic Activity*, 2. Washington, D.C.: The Brookings Institution.

Plosser, C.I., and Schwert, G.W. (1978), "Money, Income, and Sunspots: Measuring Economic Relationships and the Effects of Differencing," *Journal of Monetary Economics*, 5: 637-60.