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Some International Evidence on Output-Inflation Tradeoffs

By Robert E. Lucas, Jr.*

This paper reports the results of an empirical study of real output-inflation tradeoffs, based on annual time-series from eighteen countries over the years 1951–67. These data are examined from the point of view of the hypothesis that average real output levels are invariant under changes in the time pattern of the rate of inflation, or that there exists a "natural rate" of real output. That is, we are concerned with the questions (i) does the natural rate theory lead to expressions of the output-inflation relationship which perform satisfactorily in an econometric sense for all, or most, of the countries in the sample, (ii) what testable restrictions does the theory impose on this relationship, and (iii) are these restrictions consistent with recent experience?

Since the term "natural rate theory" refers to varied aggregation of models and verbal developments,[1] it may be helpful to sketch the key elements of the particular version used in this paper. The first essential presumption is that *nominal* output is determined on the aggregate demand side of the economy, with the division into real output and the price level largely dependent on the behavior of *suppliers* of labor and goods. The second is that the partial "rigidities" which dominate short-run supply behavior result from suppliers' lack of information on some of the prices relevant to their decisions. The third presumption is that inferences on these relevant, unobserved prices are made optimally (or "rationally") in light of the stochastic character of the economy.

As I have argued elsewhere (1972), theories developed along these lines will *not* place testable restrictions on the coefficients of estimated Phillips curves or other single equation expressions of the tradeoff. They will not, for example, imply that money wage changes are linked to price level changes with a unit coefficient, or that "long-run" (in the usual distributed lag sense) Phillips curves must be vertical. They *will* (as we shall see below) link supply parameters to parameters governing the stochastic nature of demand shifts. The fact that the implications of the natural rate theory come in this form suggests an attempt to test it using a sample, such as the one employed in this study, in which a wide variety of aggregate demand behavior is exhibited.

In the following section, a simple aggregative model will be constructed using the elements sketched above. Results based on this model are reported in Section II, followed by a discussion and conclusions.

I. An Economic Model

The general structure of the model developed in this section may be described very simply. First, the aggregate price-quantity observations are viewed as intersection points of an aggregate demand and an aggregate supply schedule. The former is drawn up under the assumption of a cleared money market and represents the output-price level relationship implicit in

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[1] The most useful, general statements are those of Milton Friedman (1968) and Edmund Phelps. Specific illustrative examples are provided by Donald Gordon and Allan Hynes and Lucas (April 1972).

the standard IS-LM diagram. It is viewed as being shifted by the usual set of demand-shift variables: monetary and fiscal policies and variation in export demands. The supply schedule is drawn under the assumption of a cleared labor market; its slope therefore reflects labor and product market "rigidities."

The structure of this model, which is essentially that suggested in Lucas and Leonard Rapping (1969), will be greatly simplified by an additional special assumption: that the aggregate demand curve is unit elastic.[2] In this case, the level of nominal output can be treated as an "exogenous" variable with respect to the goods market, and the entire burden of accounting for the breakdown of nominal income into real output and price is placed on the aggregate supply side. In the next subsection, *A*, a supply model designed to serve this purpose is developed. In subsection *B*, solutions to the full (demand and supply) model are obtained.

A. Aggregate Supply

All formulations of the natural rate theory postulate rational agents, whose decisions depend on *relative* prices only, placed in an economic setting in which they cannot distinguish relative from general price movements. Obviously, there is no limit to the number of models one can construct where agents are placed in this situation of imperfect information; the trick is to find tractable schemes with this feature. One such model is developed below.

We imagine suppliers as located in a large number of scattered, competitive markets. Demand for goods in each period is distributed unevenly over markets, leading to relative as well as general price movements. As a consequence, the situation as perceived by individual suppliers will be quite different from the aggregate situation as seen by an outside observer. Accordingly, we shall attempt to keep these two points of view separate, turning first to the situation faced by individual suppliers.

Quantity supplied in each market will be viewed as the product of a normal (or secular) component common to all markets and a cyclical component which varies from market to market. Letting z index markets, and using y_{nt} and y_{ct} to denote the *logs* of these components, supply in market z is:

$$y_t(z) = y_{nt} + y_{ct}(z) \tag{1}$$

The secular component, reflecting capital accumulation and population change, follows the trend line:

$$y_{nt} = \alpha + \beta t \tag{2}$$

The cyclical component varies with perceived, *relative* prices and with its own lagged value:

$$y_{ct}(z) = \gamma[P_t(z) - E(P_t \mid I_t(z))] + \lambda y_{c,t-1}(z) \tag{3}$$

where $P_t(z)$ is the actual price in z at t and $E(P_t \mid I_t(z))$ is the mean current, general price level, conditioned on information available in z at t, $I_t(z)$.[3] Since y_{ct} is a deviation from trend, $|\lambda| < 1$.

[2] An explicit derivation of the price-output relationship from the IS-LM framework is given by Frederic Raines. Of course, this framework does not imply an elasticity of unity, though it is consistent with it. Since the unit elasticity hypothesis is primarily a matter of convenience in the present study, I shall comment below on the probable consequences of relaxing it.

[3] A supply function for labor which varies with the ratio of actual to expected prices is developed and verified empirically by Lucas and Rapping (1969). The effect of lagged on actual employment is also shown. In our 1972 paper, in response to Albert Rees's criticism, we found that this persistence in employment cannot be fully explained by price expectations behavior. Both these effects—an expectations and a persistence effect—will be transmitted by firms to the goods market. In addition, they are probably augmented by speculative behavior on the part of firms (as analyzed for example, by Paul Taubman and Maurice Wilkinson).

For a general equilibrium model in which suppliers behave essentially as given by (3), see my 1972 papers.

The information available to suppliers in z at t comes from two sources. First, traders enter period t with knowledge of the past course of demand shifts, of normal supply y_{nt}, and of past deviations $y_{c,t-1}$, $y_{c,t-2}, \ldots$. While this information does not permit exact inference of the *log* of the current general price level, P_t, it does determine a "prior" distribution on P_t, common to traders in all markets. We assume that this distribution is known to be normal, with mean $\bar{P}_t$ (depending in a known way on the above history) and a constant variance σ^2.

Second, we suppose that the actual price deviates from the (geometric) economy-wide average by an amount which is distributed independently of P_t. Specifically, let the percentage deviation of the price in z from the average P_t be denoted by z (so that markets are indexed by their price deviations from average) where z is normally distributed, independent of P_t, with mean zero and variance τ^2. Then the observed price in z, $P_t(z)$ (in *logs*) is the sum of independent, normal variates

$$P_t(z) = P_t + z \tag{4}$$

The information $I_t(z)$ relevant for estimation of the unobserved (by suppliers in z at t) P_t, consists then of the observed price $P_t(z)$ and the history summarized in $\bar{P}_t$.

To utilize this information, suppliers use (4) to calculate the distribution of P_t, conditional on $P_t(z)$ and $\bar{P}_t$. This distribution is (by straightforward calculation) normal with mean:

$$\begin{aligned} E(P_t \mid I_t(z)) &= E(P_t \mid P_t(z), \bar{P}_t) \\ &= (1-\theta)P_t(z) + \theta\bar{P}_t \end{aligned} \tag{5}$$

where $\theta=\tau^2/(\sigma^2+\tau^2)$, and variance $\theta\sigma^2$. Combining (1), (3), and (5) yields the supply function for market z:

$$\begin{aligned} y_t(z) &= y_{nt} + \theta\gamma[P_t(z) - \bar{P}_t] \\ &\quad + \lambda y_{c,t-1}(z) \end{aligned} \tag{6}$$

Averaging over markets (integrating with respect to the distribution of z) gives the aggregate supply function:

$$\begin{aligned} y_t &= y_{nt} + \theta\gamma(P_t - \bar{P}_t) \\ &\quad + \lambda[y_{t-1} - y_{n,t-1}] \end{aligned} \tag{7}$$

The *slope* of the aggregate supply function (7) thus varies with the fraction θ of *total* individual price variance, $\sigma^2+\tau^2$, which is due to *relative* price variation. In cases where τ^2 is relatively small, so that individual price changes are virtually certain to reflect general price changes, the supply curve is nearly vertical. At the other extreme when general prices are stable (σ^2 is relatively small) the slope of the supply curve approaches the limiting value of γ.[4]

B. Completion and Solution of the Model

A central assumption in the development above is that supply behavior is based on the *correct* distribution of the unobserved current price level, P_t. To proceed, then, it is necessary to determine what this correct distribution is, a step which requires the completion of the model by inclusion of an aggregate demand side.

As suggested earlier, this will be done by postulating a demand function for goods of the form:

$$y_t + P_t = x_t \tag{8}$$

where x_t is an exogenous shift variable—equal to the observable *log* of nominal *GNP*. Further, let $\{\Delta x_t\}$ be a sequence of independent, normal variates with mean δ and variance σ_x^2.[5]

[4] This predicted relationship between a supply elasticity and the variance of a component of the price series is analogous to the link between the income elasticity of consumption demand and the variances of permanent and transitory income components which Friedman (1957) observes. As will be seen in Section II, it works in empirical testing in much the same way as well.

[5] This particular characterization of the "shocks" to the economy is not central to the theory, but to discuss

The relevant history of the economy then consists (at most) of y_{nt} (which fixes calendar time), the demand shifts x_t, $x_{t-1}, \ldots$, and past actual real outputs $y_{t-1}, y_{t-2}, \ldots$. Since the model is linear in *logs*, it is reasonable to conjecture a price solution of the form:[6]

$$P_t = \pi_0 + \pi_1 x_t + \pi_2 x_{t-1} + \pi_3 x_{t-2} + \ldots + \eta_1 y_{t-1} + \eta_2 y_{t-2} + \ldots + \xi_0 y_{nt} \tag{9}$$

Then $\bar{P}_t$ will be the expectation of P_t, based on all information *except* x_t (the current demand level) or:

$$\bar{P}_t = \bar{P}_0 + \pi_1(x_{t-1} + \delta) + \pi_2 x_{t-1} + \pi_3 x_{t-2} + \ldots + \eta_1 y_{t-1} + \eta_2 y_{t-2} + \ldots + \xi_0 y_{nt} \tag{10}$$

To solve for the unknown parameters π_i, η_j and ξ_0 we first eliminate y_t between (7) and (8), or equate quantity demanded and supplied. Then inserting the right sides of (9) and (10) in place of P_t and $\bar{P}_t$, one obtains an identity in $\{x_t\}$, $\{y_t\}$, and y_{nt}, which is then used to obtain the parameter values. The resulting solutions for price and output are:[7]

$$P_t = \frac{\theta\gamma\delta}{1+\theta\gamma} - \lambda\beta + \frac{1}{1+\theta\gamma} x_t + \frac{\theta\gamma}{1+\theta\gamma} x_{t-1} - \lambda y_{t-1} - (1-\lambda) y_{nt}$$

$$y_t = -\frac{\theta\gamma\delta}{1+\theta\gamma} + \lambda\beta + \frac{\theta\gamma}{1+\theta\gamma}\Delta x_t + \lambda y_{t-1} + (1-\lambda) y_{nt}$$

In terms of ΔP_t and y_{ct}, and letting $\pi = \theta\gamma/(1+\theta\gamma)$, the solutions are:

$$y_{ct} = -\pi\delta + \pi\Delta x_t + \lambda y_{c,t-1} \tag{11}$$

$$\Delta P_t = -\beta + (1-\pi)\Delta x_t + \pi\Delta x_{t-1} - \lambda\Delta y_{c,t-1} \tag{12}$$

Let us review these solutions for internal consistency. Evidently, P_t is normally distributed about $\bar{P}_t$. The conditional variance of P_t will have the constant (as assumed) variance $1/(1+\theta\gamma)^2\sigma_x^2$. Thus those features of the behavior of prices which were assumed "known" by suppliers in subsection *A* are, in fact, true in this economy.

To review, equations (11) and (12) are the *equilibrium values* of the inflation rate and real output (as a percentage deviation from trend). They give the intersection points of an aggregate demand schedule, shifted by changes in x_t, and an aggregate supply schedule shifted by variables (lagged prices) which determine expectations. In order to avoid the introduction of an additional, spurious "expectations parameter," one cannot solve for this intersection on a period-by-period basis; accordingly, we have adopted a method which yields equilibrium "paths" of prices and output. Otherwise, the interpretation of (11) and (12) is entirely conventional.

Not surprisingly, the solution values of inflation and the cyclical component of real output are indicated by (11) and (12) to be distributed lags of current and past changes in nominal output. A change in the nominal expansion rate, Δx_t, has an immediate effect on real output, and lagged effects which decay geometrically. The

rational expectations formation at all, *some* explicit stochastic description is clearly required. Independence is used here partly for simplicity, partly because it is empirically roughly accurate for most countries in the sample. The effect of autocorrelation in the shocks would, as can be easily traced out, be to add higher order lag terms to the solutions found below.

[6] This solution method is adapted from Lucas (1972), which is in turn based on the ideas of John Muth.

[7] If a demand function of the form $y_t = \xi P_t + x_t$ had been used, these solutions would assume the same form, with different expressions for the coefficients. If $\xi \neq 1$, however, x_t is an unobserved shock, unequal in general to observed nominal income. In this case, the model still predicts the time-series structure (moments and lagged moments) of the series y_{ct} and ΔP_t and is thus, in principle, testable. I have found empirical experimenting along these lines suggestive, but the series used are simply too short to yield results of any reliability.

immediate effect on prices is one minus the real output effect, with the remainder of the impact coming in the succeeding period. We note in particular that this lag pattern may well produce periods of simultaneous inflation and below average real output. Though these periods arise because of supply shifts, the shifts result from lagged perception of demand changes, and *not* from autonomous changes in the cost structure of suppliers.

In addition to these features, the model does indeed assert the existence of a natural rate of output: the *average* rate of demand expansion, δ, appears in (11) with a coefficient equal in magnitude to the coefficient of the current rate, and with the opposite sign. Thus changes in the average rate of nominal income growth will have *no* effect on average real output. On the other hand, unanticipated demand shifts do have output effects, with magnitude given by the parameter π. Since this effect depends on "fooling" suppliers (in the sense of subsection A), one expects that π will be larger the smaller the variance of the demand shifts. We next develop this implication explicitly.

From the definition of π in terms of θ and γ, and the definition of θ in terms of σ^2 and τ^2 we have

$$\pi = \frac{\tau^2\gamma}{\sigma^2 + \tau^2(1+\gamma)}$$

Combining with the expression for σ^2 obtained above, this gives

$$\pi = \frac{\tau^2\gamma}{(1-\pi)^2\sigma_x^2 + \tau^2(1+\gamma)} \tag{13}$$

For fixed τ^2 and γ, then, π takes the value $\gamma/(1+\gamma)$ at $\sigma_x^2=0$ and tends monotonically to zero as σ_x^2 tends to infinity.

The prediction that the average deviation of output from trend, $E(y_{ct})$, is invariant under demand policies is not, of course, subject to test: the deviations from a *fitted* trend line must average to zero. Accordingly, we must base tests of the natural rate hypothesis (in this context) on (13): a relationship between an observable variance and a slope parameter.

II. Test Results

Testing the hypothesis advanced above involves two steps. First, within each country (11) and (12) should perform reasonably well. In particular, under the presumption that demand fluctuations are the major source of variation in ΔP_t and y_{ct}, the fits should be "good." The estimated values of π and λ should be between zero and one. Finally, since (11) and (12) involve five slope parameters but only two theoretical ones, the estimated π and λ values obtained from fitting (11) should work reasonably well in explaining variations in ΔP_t.

The main object of this study, however, is not to "explain" output and price level movements within a given country, but rather to see whether the terms of the output-inflation "tradeoff" vary across countries in the way predicted by the natural rate theory. For this purpose, we shall utilize the theoretical relationship (13) and the estimated values of π and σ_x^2. Under the assumption that τ^2 and γ are relatively stable across countries, the estimated π values should decline as the sample variance of Δx_t increases.

Descriptive statistics for the eighteen countries in the sample are given in Table 1.[8] As is evident, there is no association

[8] The raw data on real and nominal *GNP* are from *Yearbook of National Accounts Statistics*, where series from many countries are collected and put on a uniform basis. The choice of countries is by no means random: the eighteen used are all the countries from which continuous series are available. The sample could thus be broadened considerably by use of sources from individual countries. To obtain the variables used in the tests, the *logs* of real and nominal output, y_t and x_t, are *logs* of the series in the source. The *log* of the price level, P_t, is the difference $x_t - y_t$; y_{ct} is the residual from the trend line $y_t = a + bt$, fit by least squares from the sample

TABLE 1—DESCRIPTIVE STATISTICS, 1952–67

Country	Mean Δy_t	Mean ΔP_t	Variance y_{ct}	Variance ΔP_t	Variance Δx_t
Argentina	.026	.220	.00096	.01998	.01555
Austria	.048	.038	.00104	.00113	.00124
Belgium	.034	.021	.00075	.00033	.00072
Canada	.043	.024	.00109	.00018	.00139
Denmark	.039	.041	.00082	.00038	.00084
West Germany	.056	.026	.00147	.00026	.00073
Guatemala	.046	.004	.00111	.00079	.00096
Honduras	.044	.012	.00042	.00084	.00109
Ireland	.025	.038	.00139	.00060	.00111
Italy	.053	.032	.00022	.00044	.00040
Netherlands	.047	.036	.00055	.00043	.00101
Norway	.038	.034	.00092	.00033	.00098
Paraguay	.054	.157	.00488	.03192	.03450
Puerto Rico	.058	.024	.00205	.00021	.00077
Sweden	.039	.036	.00030	.00043	.00041
United Kingdom	.028	.034	.00022	.00037	.00014
United States	.036	.019	.00105	.00007	.00064
Venezuela	.060	.016	.00175	.00068	.00127

between average real growth rates and average rates of inflation: this fact seems to be consistent with both the conventional and natural rate views of the tradeoff. Since our interest is in comparing real output and price behavior under different time patterns of nominal income, these statistics are somewhat disappointing. Essentially two types of nominal income behavior are observed: the highly volatile and expansive policies of Argentina and Paraguay, and the relatively smooth and moderately expansive policies of the remaining sixteen countries. But if the sample provides only two "points," they are indeed widely separated: the estimated variance of demand in the high inflation countries is on the order of 10 times that in the stable price countries.

The first three columns of Table 2 summarize the performance of equation (11) in accounting for movements in y_{ct}. The estimated values for π all lie between zero and one; with the exceptions of Argentina and Puerto Rico, so do the estimated λ values. The R^2s indicate that for many, or perhaps most countries, important output-determining variables have been omitted from the model. The R^2s for the inflation rate equation, (12), are given in column (4) of Table 2. In general, these tend to be lower than for equation (11), and not surprisingly the estimated coefficients from (12) (which are not shown) tend to behave erratically. Column (5) of Table 2 gives the fraction of the variance of ΔP_t explained by (12) when the coefficient estimates from (11) are imposed. (A "$-$" indicates a negative value.)[9]

With respect to its performance as an intracountry model of income and price determination, then, the system (11)–(12) passes the formal tests of significance. On the other hand, the goodness-of-fit statis-

period. The moments given in Table 1 are maximum likelihood estimates based on these series. The estimates reported in Table 2 are by ordinary least squares.

[9] The loss of explanatory power when these coefficients are imposed on (12) can be assessed formally by an approximate Chi-square test. By this measure, the loss is significant at the .05 level for Paraguay only. As Table 2 shows, however, this test is somewhat deceptive: for several countries the least squares estimates of (12) are so poor that there is little explanatory power to lose, and the test is "passed" vacuously.

TABLE 2—SUMMARY STATISTICS BY COUNTRY, 1953–67

Country	π	λ	R_y^2	$R_{\Delta P}^2$	R_ω^2
Argentina	.011 (.070)	−.126 (.258)	.018	.929	.914
Austria	.319 (.179)	.703 (.209)	.507	.518	—
Belgium	.502 (.100)	.741 (.093)	.875	.772	.661
Canada	.759 (.064)	.736 (.075)	.936	.418	—
Denmark	.571 (.118)	.679 (.110)	.812	.498	.282
West Germany	.820 (.136)	.784 (.110)	.881	.130	—
Guatemala	.674 (.301)	.695 (.274)	.356	.016	—
Honduras	.287 (.152)	.414 (.250)	.274	.521	.358
Ireland	.430 (.121)	.858 (.111)	.847	.499	.192
Italy	.622 (.134)	.042 (.183)	.746	.934	.914
Netherlands	.531 (.111)	.571 (.149)	.711	.627	.580
Norway	.530 (.088)	.841 (.096)	.893	.633	.427
Paraguay	.022 (.079)	.742 (.201)	.568	.941	.751
Puerto Rico	.689 (.121)	1.029 (.072)	.939	.419	—
Sweden	.287 (.166)	.584 (.186)	.525	.648	.405
United Kingdom	.665 (.290)	.178 (.209)	.394	.266	.115
United States	.910 (.086)	.887 (.070)	.945	.571	.464
Venezuela	.514 (.183)	.937 (.148)	.755	.425	—

tics are generally considerably poorer than we have come to expect from annual time-series models.

In contrast to these somewhat mixed results, the behavior of the estimated π values across countries is in striking conformity with the natural rate hypothesis. For the sixteen stable price countries, $\hat{\pi}$ ranges from .287 to .910; for the two volatile price countries, this estimate is smaller by a factor of 10! To illustrate this order-of-magnitude effect more sharply, let us examine the complete results for two countries: the United States and Argentina. For the United States, the fitted versions of (11) and (12) are:

$$y_{ct} = -.049 + (.910)\Delta x_t + (.887)y_{c,t-1}$$

$$\Delta P_t = -.028 + (.119)\Delta x_t + (.758)\Delta x_{t-1} - (.637)\Delta y_{c,t-1}$$

The comparable results for Argentina are:

$$y_{ct} = -.006 + (.011)\Delta x_t - (.126)y_{c,t-1}$$

$$\Delta P_t = -.047 + (1.140)\Delta x_t - (.083)\Delta x_{t-1} + (.102)\Delta y_{c,t-1}$$

In a stable price country like the United States, then, policies which increase nominal income tend to have a large initial effect on real output, together with a small, positive initial effect on the rate of inflation. Thus the apparent short-term tradeoff is favorable, as long as it remains unused. In contrast, in a volatile price country like Argentina, nominal income changes are associated with equal, contemporaneous price movements with no discernible effect on real output. These results are, of course, inconsistent with the existence of even moderately stable Phillips curves. On the other hand, they follow directly from the view that inflation stimulates real output if, and only if, it succeeds in "fooling" suppliers of labor and goods into thinking *relative* prices are moving in their favor.

III. Concluding Remarks

The basic idea underlying the tests reported above is extremely simple, yet I am afraid it may have become obscured by the rather special model in which it is embodied. In this section, I shall try to restate this idea in a way which, though not quite accurate enough to form the basis for econometric work, conveys its essential feature more directly.

The propositions to be compared empirically refer to the effects of aggregate demand policies which tend to move inflation rates and output (relative to trend) in the same direction, or alternatively, unemployment and inflation in opposite directions. The conventional Phillips curve account of this observed co-movement says that the terms of the tradeoff arise from relatively stable structural features of the economy, and are thus independent of the nature of the aggregate demand policy pursued. The alternative explanation of the same observed tradeoff is that the positive association of price changes and output arises because suppliers misinterpret general price movements for relative price changes. It follows from this view, first, that changes in average inflation rates will not increase average output, and secondly, that the higher the *variance* in average prices, the less "favorable" will be the observed tradeoff.

The most natural cross-national comparison of these propositions would seem to be a direct examination of the association of average inflation rates and average output, relative to "normal" or "full employment." Unfortunately, there seems to be no satisfactory way to measure normal output. The deviation-from-fitted-trend method I have used *defines* normal output to be average output. The use of unemployment series suffers from the same difficulty, since one must somehow select the (obviously positive) rate to be denoted full employment.

Thus although the issue revolves around the relation between *means* of inflation and output rates, it cannot be resolved by examination of sample averages. Fortunately, the existence of a stable tradeoff also implies a relationship between *variances* of inflation and output rates, as illustrated in Figure 1. With a stable tradeoff, policies which lead to wide variation in prices must also induce comparable variation in real output. If these sample variances do not tend to move together (and, as Table 1 shows, they do not) one

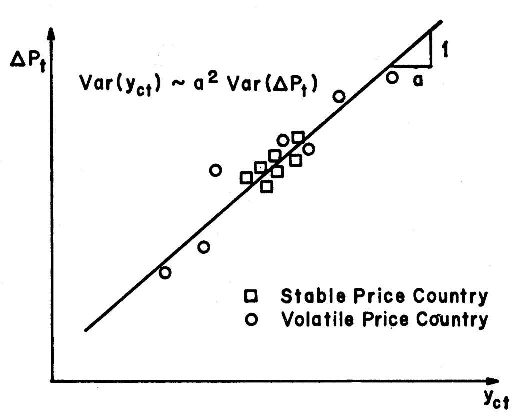

FIGURE 1

can only conclude that the tradeoff tends to fade away the more frequently it is used, or abused.

This simple argument leads to a formal test if the output-inflation association is entirely contemporaneous. In fact, however, it involves lagged effects which make a direct comparison of variances, as just suggested, difficult in short time-series. Accordingly, it has been necessary to impose a specific, simple structure on the data. As we have seen, this structure accounts for output and inflation rate movements only moderately well, but well enough to capture the main phenomenon predicted by the natural rate theory: the higher the variance of demand, the more unfavorable are the terms of the Phillips tradeoff.

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ERRATA

Some International Evidence on Output-Inflation Tradeoffs

By ROBERT E. LUCAS, JR.*

Neil Wallace has pointed out a serious conceptual error in the tests I described in my article published in this *Review*, June 1973. The point is obscured by my decision to discuss estimation in terms of the deviations of *log* output from trend (y_{ct}) instead of the *log* of the level (y_t), but it is clear from inspection of the two equations for y_t and P_t stated between (10) and (11) on page 329. Either of these equations can be obtained from the other using the *identity* $y_t + P_t = x_t$.

Much of the discussion of the within-country results given in Section II is marred by my erroneous impression that I was estimating a *two-equation* model; in fact, there is only one equation. Since it is too late to do anything about this, let me just indicate the main ways this error affects Table 2 and its interpretation. First, the columns headed R_y and $R_{\Delta P}$ have nothing to do with the ability of the model to explain real output *versus* inflation rate movement. The R_y measures the ability of the one equation in the model, estimated in level form, to explain output. The $R_{\Delta P}$ measures the ability of the *same* equation, estimated in first difference form, to explain inflation rates. Viewed in this (that is, the correct) way, a comparison of the two has no obvious interest. Second, the test discussed in footnote 9 and the column headed R_ω have *no* bearing on "cross-equation" theoretical restrictions; since there is only one equation in the system, there can be no such restrictions.

A correct understanding of the relationship between the "two" equations in my model is obviously essential to an interpretation of the within-country results, and as can be seen from the above paragraph, the necessary revisions are far from minor conceptually. Substantively, however, the main conclusion I reached is not altered. The within-country results, which seemed consistent with the evidence but not particularly impressive invalidly interpreted, appear about the same interpreted validly. The cross-country results, which were the *only* evidence bearing directly on the natural rate hypothesis in the paper, are not affected in any way.

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