International Finance Discussion Papers

Number 118

May 1978

THE SHORT-RUN RELATION BETWEEN GROWTH AND INFLATION IN LATIN AMERICA: A QUASI RATIONAL OR CONSISTENT EXPECTATIONS APPROACH

by

James A. Hanson

The Short-Run Relation Between Growth and Inflation in Latin America: A Quasi Rational or Consistent Expectations Approach

by

James A. Hanson*

A. Introduction

The purpose of this paper is to explore the short-run relation between inflation and growth in Latin America. This topic was the subject of heated debate between "structuralists" and monetarists in the 1960's but has only begun to be explored empirically.[1] The evidence presented here also should provide a useful complement to the numerous studies of the relation between output and employment and inflation in developed countries,

---

*This paper was completed while the author was a member of the Visiting Scholar Program of the International Finance Division. The author is grateful for the use of computer facilities at CEPAL, Brown University and the Board of Governors and for comments from Roque Fernandez, Robert Gregory, Herschel Grossman, Dale Henderson, and Robert King, though the author of course bears full responsibility. The analysis and conclusions of this paper should not be interpreted as representing the views of the Board of Governors of the Federal Reserve System or members of its staff.

[1] For a review of existing work see Fernandez and Hanson. In the late fifties some of the structuralist interpretations of Latin American inflation posited a link between inflation and attempts at rapid growth which resemble Lipsey's explanation of the Phillips curve. According to these interpretations, rapid growth would encounter rigid agricultural supply, driving up food prices while industrial prices were inflexible downward. In addition, the structuralists posited a passive money supply, which, by following the rise in agricultural prices, would ratify the new price level and prevent a decline in urban employment. Only recently has this argument been subjected to econometric testing and Wachter presents some support in the Chilean case. In fact, the impetus for the rise in agricultural prices may have come from either of two sources: (1) from social programs, financed through monetary emission, which raised the demand for food, rather than for investment oriented toward rapid growth, or (2) in the case of Wachter's estimates, from seasonality, for the relation does not appear in regressions on annual data.

Other versions of the structuralist hypothesis place the blame on one or more of the following: the lack of government revenues which forced government to use monetary emission to finance its programs; the foreign sector; or sectoral clashes which cause the demand for output to exceed supply. Arguments similar to the last point were made by Aujac and Reder vis-a-vis the development countries and recently have surfaced again. Summaries of the structuralist view may be found in Campos, Sierra and Wachter, among others.

for Latin America provides a far broader set of well-documented "experiments" with which to test hypotheses regarding inflation than the Group of Ten.

To examine the relation between growth and inflation this paper uses a variant of the Phillips model formulated by Phelps, Lucas and Rapping, Lucas (1973) and Barro (1977, 1978). Observed deviations from "normal" output or growth rates are attributed to the difference between a (reduced form) of actual prices and expected prices; the latter being characterized by "rationality," as the term is defined below. The major conclusions obtained using this model are:

1. In Brazil, Chile before Allende, Colombia, Mexico and Peru a small, though significant, relation exists between output or growth and "unexpected" inflation. This result is substantially stronger than those obtained in earlier studies of Latin American inflations which suggested no statistically significant relation.[2]

2. Ten percentage points of unexpected inflation produce about one extra percentage point of growth vis-a-vis the trend. The size of this effect is statistically indistinguishable across the five countries, once the different processes of monetary supply and corresponding formulation of expectations are taken into account.[3] This result strongly supports Lucas' hypothesis, that the reaction to unexpected inflation depends on the predictability of inflation, for the predictability of inflation in the five cases is similar, once we allow for the differences in monetary supply processes.[4]

---

[2]For example, see Barro (1974) and Barro (1978).

[3]It is also interesting to note that the sample includes 1974, when oil prices rose. For Brazil and Colombia the regressions underpredict growth while for Peru and Mexico they overpredict.

[4]Lucas uses the variance of detrended nominal demand as a measure of its predictability because he assumes that variable can be characterized by random walk with trend. With a more complicated money supply process, preditability of, rather than the variance of, inflation becomes the key variable in determining the reaction to unexpected inflation.

This estimated effect of unexpected inflation is significantly smaller than those obtained by Lucas (1973) for the developed countries with more predictable inflations, confirming his hypothesis of a near vertical Phillips curve when nominal demands are unpredictable.

To put it another way, this paper may be considered as an attempt to add a "third data point"--moderately inflationary countries such as Colombia, Peru, and Mexico--to what Lucas (1973) refers to as "two data points"--the developed countries and the inflationary countries of Argentina and Paraguay.[5] In addition, there is an exploration of the cases of Brazil and Chile, which may be thought to add "weight" to Lucas' "second data point." The results of this paper suggest that countries with moderately and highly variable inflation may differ little in the predictability of inflation. Therefore their similar, low response to unexpected inflation strongly supports Lucas' hypothesis.

3. These results are in terms of growth rates. Lucas' original formulation hypothesized that the level of income is a function of unexpected inflation, lagged income and a time trend. However, in the five countries studied here there is no statistical distinction between the formulation of the growth rate as a (reduced form) function of unexpected inflation and Lucas' formulation.[6]

The growth formulation implies that increases in growth, achieved through unexpected changes in prices, last only as long as the price change is unexpected. Any

---

[5]It is worth noting that there is a slightly inverse relationship between the coefficient of unexpected inflation and the variability of inflation within Lucas' developed country data point, tending to confirm his hypothesis.

It is also worth noting that both within Lucas' (1973) sample and in Latin America, as discussed by Fernandez and Hanson, there is a nearly proportional relation between inflation and its standard deviation, which makes it difficult to distinguish Lucas' hypothesis from competing ones.

[6]Inspection indicates this is also true in about 60% of the cases studied by Lucas (1973).

temporary rise in the real growth rate and the corresponding level of income above the optimal trend, due to unexpected inflation, will be "paid for" as expected inflation overshoots actual. If, following unexpected inflation, expected inflation remained equal to actual, then output would remain above normal. However, as discussed below, the formation of expectations in the paper is assumed to and does predict inflation on average, over the sample, with serially uncorrelated errors. In this sense expectations are rational, though perhaps consistent would be a better term. Thus neither persistent, unexpected inflation nor a price level persistently above trend are possible. As a result, persistent deviations from normal growth or trend income do not occur. In particular, in the above example, expected inflation must at some later point exceed actual, providing the impetus to reduce the level of output to its long-run trend. Thus the sample can provide no information about the effect of a single, temporary unexpected rise in monetary growth or inflation.

4. It is difficult to establish the particular process of money growth and expectation formation, even in the rapid and variable inflations described here. In three cases there is little to distinguish between alternatives. In the two rapid inflations, however, lagged values of inflation seem to work better in determining income growth than the lagged values of monetary growth used by Lucas (1973) and Barro (1974, 1977, 1978). In part this seems to be because in these cases lagged inflation is at least as good a predictor of present monetary growth as lagged monetary growth, perhaps because government policy and (perhaps the balance of payments) is affected by lagged inflation, which is only imperfectly correlated with past monetary growth. Sargent and Wallace (1973) have provided an alternative justification for the use of lagged inflation as an optimal or rational predictor of inflation in hyperinflationary situations.

It also appears that for Latin American economies, with more rapid and empirically more variable inflation, more "up-to-date" data is useful in predicting inflation. However, this fact may simply reflect the peculiar seasonality of price changes and the money supply process in these countries.

Another interesting point is that the results for Brazil were substantially improved by dividing the sample into pre and post 1964 monetary regimes, which were statistically distinguishable in terms of the monetary growth process and the corresponding formation of expectations. This result may indicate that the process of forming expectations changes rapidly to correspond to a new monetary regime. However, the hypothesis could not be tested with data from the other countries owing to the shortness of similarly objectively identifiable, monetary regimes.

5. The lagged effects of unexpected money growth (and inflation) generally contributed insignificantly to current output, especially when the previous year's output was taken into account. Estimates which omit the previous year's output display autocorrelated residuals. These findings differ somewhat from Barro's work on the U.S. and on Mexico, and seem to indicate the persistence of relatively strong, nonmonetary disturbances. Perhaps such disturbances are related to supply shifts or to the simple treatment of the foreign sector in this paper, hypotheses which will be explored in later work.

B. The Basic Model

This paper may be thought of as using a basic model of the aggregate relation between output and inflation along the general lines of those presented by Phelps, Lucas and Rapping, and Lucas (1973). In their models suppliers increase (decrease) output above (below) its trend when prices turn out "better" ("worse") than expected. This argument is most commonly applied to labor supply, probably because of interest in the Phillips curve. When factor prices are higher than expected, above normal amounts of labor are supplied, and output increases faster than trend, because workers seek to take advantage of what they feel is a "good" wage.[7] This argument might be especially applicable to

[7] Lucas and Rapping generate such behavior with a Fisherian model of labor supply, together with assumptions regarding the formation of expectations--that inflation returns to normal--and persistence of the empirical relation between inflation and the real rate of interest. In Lucas (1973) suppliers are assumed to respond only to perceived relative price movements, but, because of imperfect information and the process of forming expectations about the aggregate price level, can be fooled into thinking unexpected aggregate price inflation is a favorable relative price. Phelps permits (differential) movement of prices and wages, with the implicit assumption that more labor is available at "higher" money wages.

Latin American countries, where the existence of secondary workers and rural-urban migration, as well as poor information networks, may create some short-run money illusion in the labor supply function.

Lucas (1973) writes the aggregate supply function as

$$(1) \quad Y_t = a_o + a_1 [P_t - P_t^E] + a_2 (\text{time}) + a_3 Y_{t-1} + u_{t1}$$

where

Y_t = aggregate supply time t

P = price level at time t

$P^E = E(P_t | \text{Information available at time } t)$

and all variables are expressed as logs.[8]

In estimating this equation we encounter two problems which we will treat in turn: 1) Specification of an aggregate demand equation which, together with (1) and P^E, will simultaneously determine output and prices and 2) specification of the process by which expectations are formed.

Rather than explaining the behavior of aggregate demand directly, subject to some income or wealth constraint, this paper simply applies the constraint directly. In particular, as a first approximation we assume these economies' monetary disturbances do not spill over into the world economy because of variations in the effective exchange rate and that within such "closed" economies households are satisfied with their nominal money holdings in every period, vis-à-vis the levels of

---

[8] Lucas derives the response to differences between the expected and actual price level from an explicit aggregation of micro behavior, not shown here. Some statistical difficulties may arise when national accounts, which are Paasche or Laspeyres weighted, are substituted for Lucas' geometrically weighted outputs and thus we simply posit the hypothesis on the aggregates. Lucas (1975) gives some motivation for inclusion of lagged output.

prices, income, wealth, and opportunity costs of money holdings. Thus we assume demand for output exceeds supply until prices, incomes and the opportunity cost of money adjust to yield:

(2) $M^S = M^D = P_t + c + b_1 y_t + b_2 r_t + u_{t2}$

where M_t = log of money stock and r_t = the log of the relevant opportunity cost of holding money at time t, which is omitted in the empirical work owing to its statistical insignificance.[10] Complete stock adjustment may seem to be a strong restriction, but the lack of autocorrelation in the empirical results suggests it is a reasonable approximation. While this approach seems to neglect fiscal policy, it may not be a bad approximation for the economies under consideration, where monetary and "fiscal" policy are closely associated.[11]

---

[9]In keeping with the spirit of Lucas' framework, we instead might write $M = c + b_1 Y_t + b_2 r_t + b_3 \theta P^E + b_4 (1-\theta) P_t$ with $b_3 = b_4$, $0 < \theta < 1$, without changing any of the results of the paper. In this paper reduced forms are used so we do not worry about the direction of causation in (2).

[10]Results will be provided on request.

[11]For a variety of reasons, such as low interest costs, desires to subsidize favored sectors, and perceptions of a narrow bond market, much of deficit financing is done through direct or indirect central bank purchases of securities, if not outright emission of currency. Harberger (1974), Baer and Beckerman and Barro (1973), present some estimates of the importance of these phenomena, relative to the size of the deficit, and of its contribution to monetary expansion. While in general such activities would tend to raise the opportunity costs of holding money, through effects on the nominal rate of interest and on bank profits, this may not always be the case. For example, if the government permitted non-interest bearing reserves to be used to purchase interest bearing government debt, then the tendency for bank profits to rise might result in higher interest rates being paid to holders of demand deposits.

Lucas hypothesizes that expectations are formed rationally in the sense of Muth (1961), i.e., using all relevant information, as if the relevant economic theory for its application were known. In the present context this would mean that expectations take into account the output-price adjustment process described by (1) and (2). This argument does not imply that all persons know all the relevant economic theory, but only that a sufficient number of persons are aware of the usual outcomes which occur when certain variables change to make the market reflect these predicted outcomes. For example, if people thought prices were random, rather than related to the money supply, then individuals who noticed any correlation could make money by speculating on any correlation, by buying or selling goods, or by selling predictions of inflation, to be used by others. Such predictions of inflation gradually would have a growing influence in the determination of goods' prices.

The keys to using this approach to predict inflation, particularly in the Latin American context, lie in the phrase "as if all relevant information and the economic theory for its application were known" and in the word "gradually." Presumably, large econometric models which are now in use in the U.S. incorporate all relevant economic theory and a great part of the relevant information. Yet their use is spreading only gradually, in part, because there is great debate over what is the relevant economic theory and over what is the relevant information, with the result that their predictions are often subject to fairly large errors, reducing incentive for their adoption.[12,13] Moreover, in an application of Heisenberg's views on experimentation to economics, one would imagine that if the models did convey new information, then they would change individuals' behavior and thus make future observations incompatible with themselves.

An additional, important piece of information is government behavior. As Lucas (1970), among others, has pointed out, if the government systematically made economic policy in response to indicators, then its behavior would also be part of the relevant information to be incorporated in the prediction. If government were to deviate from its systematic behavior pattern, then this would have an effect, but only until this new behavior were incorporated into the public's forecasts.[14]

In predicting the expected rate of inflation which affects economic decision making in the economies under consideration, where electronic computing facilities were and are limited, and where markets, knowledge of economic theory, and information are imperfect, the above arguments suggest that rather simplified approaches, incorporating the role of

---

[12]See Zarnowitz and Nelson.

[13]It is interesting to note that even in a case in which the system was completely defined by the laws of probability--the game of twenty-one--numerous years and electronic computers were necessary before a winning strategy could be defined, for example by Throop, and application was limited by the need for large amounts of capital and effort and because knowledge of the system spread gradually.

[14]Again the case of winning strategies in twenty-one is interesting because it illustrates possible government response; once the relevant information became incorporated, i.e., as a winning strategy was gradually employed, the rules of the game were changed. Also users of such strategies often were subject to nonmonetary costs by the casinos.

government, should be used. To that end two basic approaches were followed. These may be roughly identified with (1) Lucas' prediction of money supply and (2) Cagan's adaptive prediction of inflation.

The first general approach, in its simplest variant, follows Lucas (1973) by assuming (the log of) money is a random walk with trend (m). Lucas (1973) shows that using (1) and (2) the difference between actual and expected prices can be written as a function of

$$M_t - E(M_t) = M_t - M_{t-1} - m = \dot{M}_t - m.$$

Substituting into (1) we obtain a "reduced form":

$$(3) \quad Y_t = a_0 + a_1\dot{M}_t + a_2 \text{ time} + a_3 Y_{t-1} + u_{t3},$$

with m becoming part of the estimated constant and $\dot{M}_t$ the independent variable. That is (3) is a reduced form using the hypothesized money supply process and the stock money demand equation (2).[15] In a slightly more complicated model Barro (1977, 1978) hypothesizes money growth depends on, and therefore, is rationally predicted by, previous values of money growth and variables such as government spending, the unemployment rate, and the balance of payments. We use only the lagged values, plus a constant, which yields the difference between actual and expected prices as a function of

$$M_t - E(M_t) = M_t - M_{t-1} - \hat{\dot{M}}_t = DMR_t$$

equal to the residuals from an estimated equation of the form

---

[15]The actual method of solution is substantially more complex and involves questions of stability and convergence. For details, see Muth, Lucas (1970) and Barro and Fischer.

(4) $\dot{M}_t = d_o + d_1\dot{M}_{t-1} + d_2\dot{M}_{t-2} + d_3\dot{M}_{t-3} + u_{t4}.$

Thus we have

(5) $Y_t = a_o + a_1 \; DMR_t + a_2 \; time + a_3 Y_{t-1} + u_{t5}$

with r_t again neglected.

The second general approach follows Cagan's well-known adaptive expectations hypothesis. Cagan assumes that change in the expected rate of inflation is partially or adaptively adjusted to the error in the previous prediction. This adjustment implies expected inflation is a weighted sum of the previous expected rate of inflation and the actual or lagged value, assuming that information about present inflation is not immediately known, which in turn yields a geometrically weighted series of all previous rates of price inflation:

$$\dot{P}^E = \alpha\dot{P}_{t-1} + (1-\alpha)\;\alpha\;\dot{P}_{t-2} + (1-\alpha)^2\;\alpha\;\dot{P}_{t-3}\;\ldots$$

While this approach to expectations sometimes has been considered ad hoc, Sargent and Wallace (1973), among others, have shown that it can be "rational," in particular, when government "is financing a roughly fixed rate of real expenditures by money creation."[16]

This process of forming expectations seems an important one to explore in the case of rapid Latin American inflations. Harberger (1974), Baer and Beckerman, Barro (1973) and Ffrench-Davis have all indicated the importance of monetary

---

[16]P. 336. Dutton obtains some success in explaining Argentine quarterly data using a model with fixed real expenditure, real taxes which are inversely related to inflation, and a deficit financed by monetary creation.

emission as a source of Latin American government revenues and the "inflation tax" on money balances might reach 2.5 per cent of GDP in Chile and six to seven per cent in Brazil, as calculated from the data presented by Vogel.

In such a world, it seems reasonable to assume that households might take the (log of the) previous level of prices as given and forecast next period's by adding to it their prediction of inflation--$P_t^E = P_{t-1} + \dot{P}_t^E$. The actual price level, P_t, equals the previous level plus the solution for price changes taken from a difference version of (2)-- $P_t = P_{t-1} + \dot{P}_t = P_{t-1} + \dot{M}_t - b\,\dot{Y}_t + \dot{u}_t$. Substituting into (1) we obtain:

$$(6) \quad Y_t = \frac{a_1}{1+b_1a_1}(\dot{M}_t - \dot{P}_t^E) + \frac{a_2}{1+b_1a_1}(\text{time}) + \frac{a_3 + a_1b_1}{1+b_1a_1} Y_{t-1} + u_{t6},$$

a reduced form analogous to (3).

Two specific versions of this approach will be used. The first simply assumes $\alpha = 1$, $\dot{P}_t^E = \dot{P}_{t-1}$ yielding:

$$(7) \quad Y_t = a_1'(\dot{M}_t - \dot{P}_{t-1}) + a_2'(\text{time}) + a_3' Y_{t-1} + u_{t7}.$$

Though this might seem a strong restriction, it has the merit of simplicity and provides a useful standard of comparison for the more complex models. Finally it is a familiar approximation to students of Latin American inflation, appearing in Harberger's classic study of Chilean inflation (1963) and more recent cross-sectional studies such as Vogel, Sheehy, and Wachter.

The second version permits inflationary expectations to be determined by the history of past rates of inflation, plus a constant:

$$(8) \quad \dot{P}_t^E = d_1\dot{P}_{t-1} + d_2\dot{P}_{t-2} + d_3\dot{P}_{t-3} + d_o + u_{t8},$$

yielding

$$(9) \quad Y_t = a_1'(\dot{M}_t - \dot{P}^E) + a_2'(\text{time}) + a_3' Y_{t-1} + u_{t9}$$

where the d_i's are estimated without restriction. If $\sum_{i=1}^{i=n} d_i = 1$, $d_{i+1} = (1-d_1)d_i$, $i \geq 1$, for the estimated coefficients, then we have an adaptive expectations model. However, one can easily imagine some cyclical behavior of world prices or systematic government policy in response to inflation which yields negative coefficients.[17] If $d_i \neq 0$, $\sum_{i=1}^{i=n} d_i < 1$, then the economy tends to the rate of inflation $d_o / 1 - \sum_{i=1}^{i=n} d_i$. Of course, if $d_i = 0$, $i > 0$, inflation is a random walk with trend.

The two different approaches--equations (3) and (5) and equations (7) and (9)--may be thought of as two alternative hypotheses about the formulation of monetary growth policy and its optimal prediction.[18] Equations (3) and (5) are based on predictions of monetary growth using past monetary growth, while equations (7) and (9) can be thought of as representing a monetary growth policy based on past inflation. The two approaches would be equivalent if the money demand function--equation (3)--were nonstochastic and there were no errors in

---

[17]Diz rationalizes such coefficients in Argentina as over-reaction to monetary expansion, and Sheehy reports a significantly negative coefficient for twice lagged money in his regressions explaining Argentine inflation.

[18]The assumption of complete stock adjustment of money balances means history is useful only insofar as it conveys information about the future path of monetary policy; there being no "over-hang" of monetary balances, which must be absorbed or lagged effects in subsequent periods. However, this proposition cannot be tested directly. An alternative interpretation would be that (3) and (5) are simply constrained versions of using lagged values of money. As Barro (1977) points out it is difficult to separate such lagged influence of money from the influence of unexpected money unless we predict money with something other than lagged values. Nonetheless one might suspect that policy reactions dominate, rather than simply the effect of lagged money, if coefficients appear with negative signs, and lagged money growth is a relatively poorer predictor of inflation, especially if present monetary growth is well predicted by past inflation.

measurement. In that case P and M are exact functions of each other and (4) and (8) are equivalent. Given the stochastic nature of our simple money demand function and assuming the stochastic element is serially uncorrelated, a proposition examined empirically below, then the relative quality of the two predictions, in the sense of a smaller forecast error for the inflation rate, depends upon the actual policy rule which is used. That is, lagged inflation may provide a better predictor if past stochastic elements in the difference version of (2) affect present $\dot{M}$.[19,20] This may well be true--imagine the plight of a finance minister who justifies his inaction on inflation by reference to a random negative shift in money demand. We will explore this idea empirically by using such a predictor in (5).

Equation (8) seems to imply that past inflation causes present inflation, which in a sense it does over the sample, because of the (hypothesized) rule for monetary growth. However, this interpretation <u>does not imply</u> that money would have no effect on inflation--a new monetary rule would change the rate of inflation in a way which would be unpredictable using estimated versions of equations (7) and (8), but eventually predictable using the money demand function.

Sims has suggested tests of timing which might help distinguish the policy rule. Wachter's application of these tests to quarterly data indicates that for Brazil, Chile, and Mexico, among the countries studied here, one cannot reject the hypothesis that past inflation influences money creation. Fernandez' ARIMA results, also with quarterly data, indicate that, statistically speaking, lagged values of prices account for most of the current variation in prices.

---

[19]This point neglects measurement error in M, which Sargent and Wallace use as a justification for something like (7) and (9).

[20]Arak's critique of Lucas' (1973) test suffers from her neglect of the stochastic nature of the nominal demand function.

A statistical corollary of this point is that lagged rates of inflation or variables correlated with them could reduce the significance of present and lagged rates of monetary creation in estimated equations of inflation, since lagged inflation could be correlated with monetary creation. This provides an alternative to "passive" money in explaining the significance of structural variables such as lagged wages reported by Harberger, Diaz Alejandro (1970) and (1977) and Sheehey.[21]

Whichever of the four processes provide some "best" approximation to expectations of inflation, all except (7) imply that "future" information is used in predicting. This is because the estimated trend and coefficients of lagged values, which are hypothetically used for prediction at each point in time, are based on the whole sample, not just information previous to each observation, as is the case in the usual Cagan formulation.

This is perhaps less worrisome than might appear at first glance. Our estimated expectations of inflation are based on a quite simplistic formulation, which obviously omits many variables that might aid in prediction. Actual expectations probably have a much smaller forecasting error than we can obtain using only a very reduced set of variables available at each point in time. Through the use of an estimated constant (and coefficients) over the sample, we are in effect requiring our predictor be on average correct and perhaps may obtain a predictor which more closely approximates actual expectations.

Finally, since interest has focused on the relation between growth and inflation, and since it is natural to think in a growth framework when dealing with developing countries, we could convert equations (3), (5), (7) and (9) to (logarithmic) growth rates by assuming $a_2 = 0$, $a_3 = 1$ and subtracting Y_{t-1}.

---

[21]King also argues rational expectations might cause prices to "lead" money.

Thus we will also present the constrained estimates of

$$(3') \qquad \dot{Y}_t = a_1 \dot{M}_t + a_2'$$

$$(5') \qquad \dot{Y}_t = a_1 DMR_t + a_2'$$

$$(7') \qquad \dot{Y}_t = a_1' (\dot{M}_t - \dot{P}_{t-1}) + a_2'$$

$$(9') \qquad \dot{Y}_t = a_1' (\dot{M}_t - \dot{P}_t^E) + a_2'.$$

These equations have the straightforward interpretation that "normally" supply grows at some average or "natural" rate, a_2',[22] while actual supply grows by less or more than the "natural" rate because of differences between actual and expected inflation.

Strictly speaking the constraint $a_2 = 0$, $a_3 = 1$ implies a single, unexpected, positive disturbance in $\dot{M}$ would maintain income above "normal" forever afterward (equations (7) and (9) would imply a return to trend income after such a monetary disturbance; but a single, unexpected positive disturbance in $\dot{P}$ would keep income above trend.) However, as shown below, this particular monetary experiment is never performed in the data. The errors in prediction equations are basically uncorrelated, though there is usually some negative autocorrelation in the detrended $\dot{M}$ (and $\dot{P}$) series. Nor is this lack of such an occurrence or experiment surprising; its effects probably would tend to stimulate further experiments, with still further reactions by the public and then policymakers.

---

[22] Notice that in estimating (7') and (9'), the a_1' multiplied by the average difference between $\dot{M}_t - \dot{P}_{t-1}$ or $\dot{P}_t^E$ becomes part of the constant term, but that product is simply the (estimated) income elasticity of demand for money, multiplied by the average growth of income and a', so the interpretation of a_2' is similar to 3') and 5').

Thus, strictly speaking, the actual data cannot answer what would happen in the event of this occurrence, and it would not be surprising if the growth rate formulation cannot be rejected. All that is implied is that the growth rate formulation is consistent with the particular monetary processes followed in the sample(s). Evidence about the effect of different monetary rules can only be gleaned, if at all, from cross-sectional evidence, as Lucas (1977) points out.

Lucas (1973) hypothesizes that a_1 and a_1' depend upon the variability of inflation and finds that a_1 is always less than .8 and generally > .4. Most of the support for Lucas' hypothesis comes from his two outlying Latin American countries, his "second" data point.

C. Empirical Results Using Unexpected Changes in Money to Explain Output

Table I presents estimates and statistics of fit for equations (3) and (3')--the Lucas style formulation that assumes money supply is a random walk with trend. As shown by the SSR's presented in the upper and lower parties of Table I, the original Lucas formulation in terms of levels, (3), is statistically indistinguishable from the growth rate formulation (3'), in terms of the size of coefficients, fit and autocorrelation. This means that the low R^2 of growth formulations obtained in (3') could be raised to above .9 by using the statistically indistinguishable (3).

Unexpected monetary growth (vis-à-vis the trend) of ten percentage points raises output about one percentage point above the trend in the countries with moderate inflation--Colombia, Mexico and Peru. This coefficient is significantly different than zero only for Mexico, unless we adopt the growth formulation. In that case

Colombia also shows a significant response to unexpected inflation. The Durbin-Watson statistic indicates no autocorrelation for the growth rate form in the cases of Mexico and Peru, and marginal autocorrelation in the case of Colombia, providing some support for the view that complete stock adjustment in one period is a reasonable approximation.[23]

The high inflation cases, Brazil and Chile, exhibit a negative relation between money and real growth and possible autocorrelation. A combined regression of the high and low inflation cases, using separate constants (and different lag coefficients and time trends in the case of (3)) permits rejection of the hypothesis that the five countries reacted similarly to inflation. (See Table IV, equation (3), cols. I-IV.)

This difference between the two sets of countries is not surprising. An examination of the money supply process, preliminary to calculating DMR_t for use in (5) and (5'), indicates that the Brazilian and Chilean processes are significantly different than a random walk with trend. (See Table II where (5') is presented. Equation (5) is statistically indistinguishable.) Indeed the Brazilian money supply process is explosive $(d_o > 1, \sum_{i=1}^{i=3} d_i > 1)$, though more will be said about that below. The Chilean process is significantly different from a trend but stable, tending toward d_o = 26 per cent $(d_o = 0, \sum_{i=1}^{i=3} d_i = 0, d_i \gtrless 0)$. The Mexican process is clearly

---

[23]Notice, however, that money is defined as an annual average of end of month figures. This was done to smooth the data and avoid the erratic year end bulge in money which may have contributed to Barro's poor results. However, it also tends to bias the results toward acceptance of complete stock adjustment. On the other hand, the annual average figure for money tends to be quite close to the actual mid-year figure and the regression results would probably not be greatly worsened by substitution of the second for the first.

indistinguishable from a constant plus random deviations, while lack of comparable monetary data for the early years prevents a judgment on Colombia and Peru. Thus the use of equation (3) or (3') in the two high inflation cases imposes an incorrect, and therefore, "irrational," expectation regarding the money supply-inflation process.

Equations (5') (or (5)), also exhibits negative (insignificant) coefficients and low Durbin-Watson statistics for Brazil and Chile, despite its somewhat more sophisticated approach to prediction of monetary growth. The moderately inflationary countries exhibit similar results for (3) or (3') and (5) or (5') in terms of magnitude, significance levels of coefficient and autocorrelation of residuals.

Since Brazil and Chile have the highest inflationary finance component among the five countries, it seems reasonable to explore the alternative hypothesis, suggested by Sargent and Wallace, regarding the rational formation of expectations of inflation based on past inflation. This is particularly true since in Brazil and Chile past inflation is a better predictor of monetary growth than lagged monetary growth (compare lower half of Tables II and III). Moreover, we can reject the hypothesis that past money growth "causes" future inflation, while we are unable to reject the hypothesis that past inflation affects present money growth, using SSR's from Sims type tests on unfiltered data, as shown at the foot of Tables II and III. For the other three countries monetary growth is equally well predicted by lagged inflation and by lagged money growth.

As shown in Table III, the use of lagged inflation improves the predictability of Brazilian and Chilean monetary growth, as measured by the SEE, to a level comparable with that obtained in the three moderately inflationary countries.[24] Thus the "predictability" of inflation is roughly the same in the five countries. Lucas'hypothesis implies that the response to unexpected inflation should be similar, if the predictability of inflation is about the same. Therefore, the five country sample was pooled and run together.

The results shown in Table IV, equations V-VIII indicate that we cannot reject the hypothesis of similar coefficients, providing strong support for Lucas theory. Moreover, the individual and pooled country regressions

---

[24]It should be pointed out that for Chile and Brazil lagged inflation refers to the inflation rate over the period December to December. Thus the information provided by lagged inflation is one half year more up-to-date than that provided by lagged changes in the average money stock (centered at June 30). Lagged inflation is not contemporaneous with output, except for the fact that the December price level is announced in January or February.

If prices adjust rapidly to variations in the rate of monetary expansion, or if many prices in the index are government controlled and tend to be adjusted in December, then, speaking intuitively, December to December inflation should provide better predictions of year to year money growth than either lagged money growth or annual inflation rates. This hypothesis seems borne out by the data. In comparison to the results of Table III predictions of monetary growth made with inflation rates calculated from past annual averages of prices are only slightly better in terms of SEE's than those made with past monetary growth rates.

An alternative solution to obtaining up-to-date information might be to use December money supply figures. Unfortunately, these are distorted by the large and highly variable year end bulge in Latin American money supplies, which introduces spurious variance into the independent variable and reduces its usefulness as a predictor. Experiments using these data yielded results in equation (5) and in explaining June to June money growth which were similar to those obtained with annual averages of monetary growth.

For Colombia and Mexico the use of year end and annual averages of inflation made no difference in the results. The use of year end money reduced significance levels in the case of Colombia.

indicate a 95% confidence interval of about (0.01, 0.25) for the coefficient, which is below the 95% confidence interval for all of Lucas' non-inflationary countries except Austria, Honduras and Sweden, again supporting his hypothesis.

D. Empirical Results Using Past Inflation to Predict Monetary Growth and Explain Output

Table V presents estimates of equation (7') along with statistics on the average rate of inflation and its standard deviation. Table VI presents estimates of equation (9') along with the corresponding autoregressive predictor of inflation and tests of residual autocorrelation.

The major conclusion to be drawn from these two output equations is that simple lagged inflation provides a very good reduced form predictor of inflation. The proportionate effect on output growth of (the reduced form of) unexpected inflation remains about the same as shown in Tables I-IV--.1. However, that effect becomes statistically significant in four of five cases when unexpected inflation is proxied by monetary growth less a weighted average of past inflation, rather unexpected monetary growth.

The Durbin-Watson statistic of these output equations generally exceeds 1.4, suggesting that the growth effects of unexpected changes in inflation tend to be confined to the period in which they occur and that the hypothesized completion of stock adjustment in one period is not a bad approximation. Tests of prices as a function of money shown in Table III indicate rejection of the hypothesis that past monetary growth influences prices in the cases of Brazil and Chile and are ambiguous for the other cases. Again we cannot reject the growth rate formulation.[25]

Examining individual country results in more detail, we see that for the cases of Brazil and Chile monetary growth less the lagged inflation rate provides a much better explanation of deviations from trend growth than any of the other, more complicated explanations. The previous autocorrelation in the residuals is now eliminated. This improvement in the output equation is somewhat surprising since the autoregressive predictor of inflation yields somewhat smaller errors of prediction, as measured by the SEE. Mexican output growth is also best explained by (7'). For the case of Colombia (5') and for Peru (5') are the best output equations.

These are interesting results since the reduced forms for predicted inflation in Tables II, III, V and VI differ only in the weights they assigned to past money growth and the "errors" in a growth form of (2). Nonetheless in rapid inflation, the statistically insignificant difference in weights implied by the use of lagged inflation yields a "better" reduced form proxy for predicted inflation[26] than the more round-about process of predicting money growth with past inflation or past money

---

[25]Regressions of the level of output on unanticipated inflation and the lagged level of output, generally yield coefficients of the second variable which differed from one by the statistically insignificant amount of two per cent or less, statistically insignificant trend coefficients, coefficients of unanticipated inflation which were quite similar to those obtained in the growth equation and Durbin-Watson statistics which would allow rejection of the hypothesis of autocorrelation, although the test is somewhat biased.

[26]In the case of Tables V and VI predicted inflation refers to the December to December rate in the cases of Brazil and Chile. Use of weights which predict the annual average rate yields results similar to (5').

growth, and then generating predicted inflation from money less predicted money. In any case the improvement in the output equation seems to provide additional confirmation of the point that "rational" predictors of inflation involve past inflation if monetary growth policy is made on the basis of past inflation.
However, at least part of this result could be attributed to more up-to-date information.

In less rapid inflations, such as Colombia and Peru, in which monetary growth and inflation more closely approximate a random walk with trend, there seems to be little to choose between the different weighting schemes or even a random walk with trend.[27] The case of Mexico presents something of an anomaly. Lagged inflation works substantially better in the output equation than any other proxy of inflation, despite the random walk nature of the monetary process. Possibly this is due to Mexico's greater reliance on a fixed effective exchange rate, which under the monetary model of the balance of payments hypothesis, would make money more of an endogenous variable.

Regarding adaptive expectations, as shown in the lower portions of Table VI at least one coefficient is generally negative and one is significantly negative in the case of Chile. We generally cannot reject the hypothesis of a stable inflation process ($\sum d_i < 1$), though perhaps it is random with trend. The exception is the case of Brazil, where inflation appears to be explosive, but this case will be discussed in more detail below. However, the power of all these tests is low. In fact, the low significance of non-trend elements in the regressions for Mexico and Peru means

---

[27]December to December inflation rates yield the same results as June to June.

we also cannot reject slow adaptation to inflation, providing initial expectations were "right." Neither can we reject rapid adjustment (e.g., $\dot{P}_t^E = \dot{P}_{t-1}$) in either of those cases, or the other three, as seen from comparisons of SSR's in Tables V and VI.[28]

The similarity of the five regression coefficients for equation (7'), Table VII--those using lagged inflation as a predictor--suggests a test of their equality. Pooling the data, and weighting the observations on growth and unexpected inflation by the inverse of the estimated standard error of estimate to eliminate heteroskedasticity, we obtain the combined, output regression equations of Table VIII. As shown in Table VIII, no statistically significant difference in individual country coefficients is indicated by a comparison of the normalized sum of squared errors in these equations with the corresponding sum of squared errors shown in Table V. Thus a good approximation for Latin America continues to be that an unexpected ten percentage point increase in the rate of monetary expansion yields about a one percentage point increase in the growth rate over the sample. This extra growth was "paid for," within the sample, as money growth returned to its usual rate and lagged inflation overshot the corresponding inflation figure.

---

[28]For the case of Chile we can barely reject the constraint that d_o, d_{t-2}, $d_{t-3} = 0$, $d_{t-1} = 1$ but presumably some slightly smaller adaptive coefficient would not be significantly worse than the unconstrained result shown in Table II.

While these results are in accordance with those shown in Table IV, they do raise some doubts concerning the Lucas hypothesis, and suggest the need for further theoretical and empirical work. Under Lucas' hypothesis the similar reaction to unexpected inflation shown in Table IV made sense; all five countries experienced equally predictable money growth. However, the results of Table V indicates fairly substantial differences in the predictability of inflation. Nonetheless we obtain both statistically similar response coefficients to unexpected inflation, as measured by monetary growth less predicted inflation, and a better fit than Table IV. This result casts some doubt on Lucas' hypothesis that responsiveness to unexpected shocks in aggregate demand is inversely related to the standard error of shocks in aggregate demand. Of course, the Lucas model is not strictly comparable to the one used here and the main difference seems to be between Peru and the other four countries.

E. Experiments with Changes in Monetary Regimes--Brazil

Section D shows that in three of five cases, simple lagged inflation provides a good approximation of expected inflation; as judged by its performance in the output equation. In the other two cases lagged inflation works about as well as any other expectations proxy. In part these results may reflect the fact that inflation is erratic in the countries studied (Table V shows standard deviations at least half as large as average inflation). This suggests that because of foreign circumstances or local government policy there may have been substantial differences in the autoregressive structure of inflation within the period studied. If this is true, then spurious errors may result from imposing a single prediction equation over the whole period, while lagged inflation may work reasonably well. The erratic nature of policymaking also reduces sample size for estimating autoregressive predictors in subperiods, while the small total sample size prohibits use of ARIMA techniques.[29] One possible exception is the case of Brazil which experienced a military coup in 1964. Thereafter the military government followed essentially similar policies until 1974. An experiment in subdividing the sample into pre and post 1965 autoregressive inflation structures yielded the results of Table IX, which are substantially better than those shown in Table II.[30]

The SSR's for the predictions of money growth are roughly a third of those obtained in Table II, a statistically significant difference.[31] In the first period, monetary growth and inflation are unstable. The sum of the coefficients of lagged money growth exceed one and the difference is statistically significant, even if the constant is omitted.[32] In the second period inflation is stable and the money supply process approximates a random walk with trend.

Turning to the output equation, the results are substantially improved by assuming two money supply processes prevailed. In the first period we assume money growth is predicted by past money growth,[33] in the second we assume a random walk prevails. This yields a strongly significant

---

[29]See Fernandez for an application of ARIMA techniques to Argentine and Brazilian quarterly data.

[30]Results corresponding to Table V, i.e., subdividing the period into different inflationary regimes yielded similar results.

[31]The F statistic exceeds 5 for the constraint that one money supply process (Table II) or one inflationary process (Table V) prevails over the whole period. The number of restrictions is 4 and the unrestricted degrees of freedom total 17.

[32]Predictions of monetary growth made with lagged money are slightly better than those made with lagged inflation.

[33]Predictions using past inflation work about as well.

coefficient for unexpected money growth, but one which is not significantly different than those obtained for the other four countries. This confirms Lucas' hypothesis in two ways. First, the predictability of inflation is about the same in both periods so the response coefficient is about the same, and lower than in the developed countries. Second, the output equation fits much better when we take into account the different formation of expectations under the two different money supply processes. Unfortunately, this methodology could not be applied to other cases, e.g., Chile and Peru, owing to the relatively short life of objectively identifiable monetary regimes.

F. Lagged Effects of Unexpected Inflation

Recent theoretical work by Lucas (1975) and empirical work by Barro (1977), (1978) has suggested that unexpected increases in inflation, may persist for some periods. In particular, Barro finds significant coefficients of contemporaneous and two lagged values of unexpected changes in money in the U.S. and jointly significant coefficients in the case of Mexico. The coefficients tend to have a triangular pattern. Thus there is some interest in seeing whether these results can be replicated.

Persistent "supply" shocks such as crop failures, natural disasters, world price changes, and exchange systems may be another important source of disturbance in the resource based, externally oriented countries considered here. Casual empiricism, confirmed by the high estimated coefficients of lagged output, suggests income is above or below "normal" for fairly long periods. Moreover, such shocks may have complex interactions with monetary growth and inflation. Neglect of these shocks would bias the significance of lagged money growth in output regressions which omit lagged output. Thus it also seems important to test for the independent influence of lagged changes in unexpected inflation.[34]

Table IX presents the estimates of output based on time, lagged output and the current and lagged unexpected inflation series which yielded the best fit. More than one lagged value of output was insignificant. Generally the unexpected inflation series is derived from the predictors which worked best when only contemporaneous variation in output and unexpected inflation was considered. However, our conclusions are applicable to all methods of predicting inflation used in this paper.

Although the coefficients of contemporaneous and lagged unexpected inflation display a triangular pattern when lagged output is omitted, this disappears when lagged output is included, as shown in the table. To test for the independent influence of lagged unexpected inflation and lagged output we compare the sum of squared residuals obtained by omitting first one and then the other set of variables with that of the joint hypothesis shown in Table IX[35] (Lines 20 and 21). Finally, the restriction of the growth rate form, using only contemporaneous unexpected inflation (Line 22), is shown for purposes of comparison.[36]

---

[34] Lagged output might also influence current predictions of inflation and/or monetary growth. However, this effect could not be separated from a lagged direct effect on output, for the same reasons as we are unable to distinguish between lagged direct effects of money and indirect effects, using only autoregressive predictors of money.

[35] This is similar to a Sims' test and was suggested to me by Robert King.

[36] Differences in sample size mean this not always the same figure as shown in earlier tables.

In all cases omitting the lagged value of output significantly worsened the fit of the output equation. However, omitting the lagged values of unexpected inflation had an insignificant effect on the fit of the output equation. Thus, while lagged values of unexpected inflation may be jointly significant in explaining output, if lagged output is omitted, a large part of that significance is due to their correlation with lagged output. Once that variable is included lagged unexpected inflation drops to insignificance. Given the low correlation of money and output once lagged output and "time" are taken into account, this seems to indicate persistent supply shocks, rather than lagged effect of unexpected inflation, are the major determinant of output. Indeed, the (constrained) growth rate formulation typically fits the data between two and four times better than regressions including only contemporaneous and lagged values of unexpected inflation and a trend.

G. Conclusions

This paper has investigated the long-standing question of the relation between inflation and growth in Latin America by applying a rational or consistent expectations approach to five inflationary Latin American countries. As a rule of thumb ten percentage points of unexpected inflation raise output about one percentage point above trend, or yield one percentage point of extra growth, when the data are interpreted in a growth rate framework. The growth formulation cannot be rejected with the present set of data.

Different simple hypotheses regarding the money inflation process reduce the predictability of inflation in the five countries under consideration to similar levels. These levels are low by OECD standards. The corresponding estimated coefficient of unexpected inflation is statistically indistinguishable across the five countries and significantly lower than in OECD countries, supporting the hypothesis that reaction to unexpected inflation depends on its predictability.

Different processes for forming expectations of inflation work about as well in explaining output to all countries. Exceptions are Brazil and Chile--the most inflationary countries--where money growth is predicted much better by past inflation than past monetary growth. These predictions "work" much better in the output equations. Also, at least one lagged value of inflation seems to have a negative effect on current inflation, casting some doubt on adaptive expectations. Experiments with Brazilian data indicate fairly rapid adjustment to new monetary processes, as measured by predictability of inflation and fit of the output equations.

Finally, most of the output effects of unexpected monetary disturbances seems contemporaneous. However, there are persistent deviations in output from trend which seem to be related to supply shocks. Future work will explore how these shocks might be related to the foreign sector.

REFERENCES

Arak, M., "Some International Evidence on Output-Inflation Tradeoffs: Comment," American Economic Review, December, 1977, 67, pp. 728-30.

Aujac, Henri, "Inflation as the Monetary Consequence of the Behavior of Social Groups: A Working Hypothesis," International Economic Papers, No. 4.

Barro, R., "Unanticipated Money Growth and Employment in the U.S.," American Economic Review, March, 1977, 67, pp. 101-105.

Barro, R., "Money and Output in Mexico, Colombia, and Brazil," in J. Behrman and J. Hanson, eds., Short-Run Macroeconomic Policy in Latin America, Ballinger, 1978.

Barro, R., "The Short-Run Relation Between Output and Inflation: Is There a Phillips Curve in Colombia?" Depto. Nacional de Planeación, Bogotá, 1974.

Barro, R. and S. Fisher, "Recent Developments in Monetary Theory," Journal of Monetary Economics, April, 1976, 2, pp. 133-167.

Baer, W. and P. Beckerman, "Indexing in Brazil," World Development, October-December, 1974.

Cagan, P., "The Monetary Dynamics of Hyperinflation," in M. Friedman, ed., The Quantity Theory of Money, University of Chicago Press, 1956.

Campos, R., "Two Views on Inflation in Latin America," in A. Hirschman, ed., Latin American Issues, New York: 20th Century Fund, 1961.

Diaz Alejandro, C., Essays on the Economic History of the Argentine Republic, New Haven, Yale, 1970.

Diaz Alejandro, C., Foreign Trade Regimes and Economic Development: Colombia, New York, NBER, 1972.

Diz, A., "Money and Prices in Argentina," in D. Meiselman, ed., Varieties of Monetary Experience.

Dutton, D., "A Model of Self Generating Inflation," Journal of Money Credit and Banking, November, 1971, 3, pp. 245-262.

Fernandez, R., "An Empirical Inquiry on the Short-Run Dynamics of Output and Prices," American Economic Review, September, 1977, 67, pp. 595-609.

Fernandez, R. and J. Hanson, "Las Interrelaciones Del Corto Plazo entre Inflación, Produccíon y Empleo en America Latina," ILPES, Las Interrelaciones del Corto Plazo entre Inflación Produccíon y Empleo en America Latina, ILPES Cuaderno #27. Santiago, Chile.

Ffrench-Davis, R., Políticas Económicas en Chile, 1952-1970, Santiago, CEPLAN, 1973.

Harberger, A., "The Dynamics of Inflation in Chile," in Measurement in Economics: Studies in Mathematical Economics and Econometrics in Honor of Yehuda Grunfeld, Stanford, 1963, pp. 219-50.

Harberger, A., "Inflación Fiscal," Cuadernos de Economía de la Universidad Católica de Chile, Año 12, No. 37, pp. 33-46.

King, R., "A Note on Expectations and Tests of Temporal Causation," unpublished.

Lipsey, R., "The Relationship Between Unemployment and the Rate of Change of Money Wages in U.K., 1862-1957, Further Analysis," Economica, 27, p. 151.

Lucas, R., "Econometric Testing of the Natural Rate Hypothesis," in O. Eckstein, ed., Conference on the Econometrics of Price Determination, Washington, 1970, pp. 50-59.

Lucas, R., "Some International Evidence on the Output-Inflation Tradeoffs," American Economic Review, June, 1973, 63, pp. 326-34.

Lucas, R., "Some International Evidence on Output-Inflation Tradeoffs," American Economic Review, December, 1977, 67, p. 730.

Lucas, R., "An Equilibrium Model of the Business Cycle," Journal of Political Economy, December, 1975, 83, pp. 1113-44.

Lucas, R. and L.A. Rapping, "Price Expectations and the Phillips Curve," American Economic Review, June, 1969, 59, pp. 342-50.

Muth, J., "Optimal Properties of Exponentially Weighted Forecasts," Journal of American Statistical Association, June, 1960, 55, pp. 299-306.

Nelson, C., "The Prediction Performance of the FRB, MIT, PENN Model of the U.S. Economy," American Economic Review, December, 1973, 62, pp. 902-17.

Phelps, E., "Money Wage Dynamics and Labour Market Equilibrium," Journal of Political Economy, August, 1968, Pt. II, 76, pp. 678-711.

Reder, M., "The Theoretical Problems of a National Wage-Price Policy," The Canadian Journal of Economics, February, 1948, 14, pp. 46-61.

Sargent, T. and Neil Wallace, "'Rational' Expectations, the Optimal Monetary Instrument and the Optimal Money Supply Rule," Journal of Political Economy, April, 1975, 83, pp. 241-59.

Sargent, T. and Neil Wallace, "Rationing Expectations and the Dynamics of Hyperinflation," International Economic Review, June, 1973, 14, pp. 328-50.

Sheehy, E., "The Dynamics of Inflation in Latin America: Comment," American Economic Review, September, 1976, 66, pp. 692-94.

Sierra, E., Tres Ensayos de Estabilización en Chile, Santiago, Editorial Universitaria, 1970.

Sims, C., "Money, Income, and Causality," American Economic Review, September, 1972, 62, pp. 540-53.

Throop, E., Beat the Dealer, New York, 1962.

Vogel, R., "The Dynamics of Inflation in Latin America, 1950-1969," American Economic Review, March, 1974, 64, pp. 102-14.

Wachter, S., Latin American Inflation, Lexington, Massachusetts, Heath, 1976.

Zarnowitz, V., An Appraisal of Short-Term Economic Forecasts, New York, Columbia, 1967.

Table I

Output and Growth of Output
as a Function of Money Growth

	Brazil 1952-1974	Chile 1952-1970	Colombia 1951-1974	Mexico 1950-1974	Peru 1951-1974
(3) $Y_t = a_0 + a_1 \dot{M}_t + a_2 (\text{time}) + a_3 Y_{t-1}$					
a_0	-.074	-.246	-.286	-1.11	-.487
(t)	(.2)	(.7)	(.5)	(1.9)	(1.2)
a_1	-.130	-.026	.092	.133	.092
(t)	(2.8)	(.4)	(1.8)	(2.3)	(1.2)
a_2	.00086	.0048	.0028	.016	.014
(t)	(.1)	(.9)	(.5)	(2.0)	(1.5)
a_3	1.02	.88	.95	.74	.71
	(9.3)	(5.6)	(8.1)	(5.6)	(4.1)
SSR	.0119	.0054	.0036	.0051	.0116
SEE	.0250	.0189	.0134	.0156	.0242
R^2	.997	.993	.999	.999	.996
DW	2.1	1.24*	1.45*	1.82	1.42*
(3') $\dot{Y}_t = a_2 + a_1 \dot{M}_t$					
Constant	.095	.051	.032	.047	.036
(t)	(5.8)	(3.1)	(4.3)	(6.0)	(3.2)
Coefficient of ($\dot{M}_t$)	-.082	-.050	.11	.134	.100
(t)	(1.7)	(1.0)	(2.6)	(2.2)	(1.5)
SSR	.0167	.0057	.0038	.0061	.0139
SEE	.0282	.0184	.0132	.0163	.0252
R^2	.12	.06	.23	.18	.09
DW	1.36*	1.30*	1.38*	1.97	1.58

Notes: D.F. = Degrees of Freedom
SSR = Sum of Squared Residuals
SEE = Standard Error of Estimate
DW = Durbin-Watson Statistic, * indicates possible autocorrelation.
t = "t" Statistic

Data Sources: IFS, Rosas, Ffrench-Davis (Chile).
U.N. Yearbook National Accounts (Peru 71-74).
Data available on request.

Table II

Output Equations Using Autoregressive Predictor of Money and Sims Tests of Prices as Predictor of Money

Coefficient of:	Brazil 1952-1974	Chile 1952-1970	Colombia 1953-1974	Mexico 1950-1974	Peru 1954-1974
	$(5)'\ \dot{Y}_t = a_2 + a_1\ DMR_z,\ DMR_t = M_t - \hat{M}_t$				
Constant	.069	.035	.051	.062	.051
(t)	(11.1)	(8.3)	(17.9)	(18.9)	(9.5)
DMR_t	-.045	-.070	.16	.12	.02
(t)	(.7)	(1.1)	(2.7)	(2.0)	(.2)
D.F.	21	17	20	23	19
SSR	.0186	.00567	.00318	.00635	.0117
SEE	.0298	.0183	.0129	.0166	.0248
R^2	.02	.07	.24	.15	.00
DW	1.21*	1.38*	1.44	1.93	1.22*
	$\dot{M}_t = do + d_1\ \dot{M}_{t-1} + d_2\ \dot{M}_{t-2} + d_3\ \dot{M}_{t-3} + U_t$				
Constant	.10	.21	.27	.14	.046
(t)	(1.7)	(2.4)	(3.1)	(3.6)	(1.0)
$\dot{M}_{t-1}$	.55	.71	.02	.02	.42
(t)	(2.5)	(2.7)	(.1)	(.1)	(1.7)
$\dot{M}_{t-2}$	.03	-.36	-.32	-.17	.06
(t)	(.1)	(1.3)	(1.1)	(.8)	(0.2)
$\dot{M}_{t-3}$	.11	-.01	-.33	--	.25
(t)	(.5)	(.1)	(1.5)		(1.1)
D.F.	19	15	18	22	17
SSR	.1851	.0853	.0482	.0732	.0858
SEE	.0987	.0754	.0637	.0576	.0710
DW	1.96	1.87	1.77	2.10	1.95
$U_t - \rho U_{t-1}$, t of ρ	.1	.1	.1	.4	.2

SSR's--Sims Tests of Inflation as a Function of Money Growth

	Brazil	Chile	Colombia	Mexico	Peru
$\dot{P}_t = a_o + \sum_{t-3}^{t} M_i^a$	.2009**[b]	.1610**[b]	.0577	.02761	.01913
$\dot{P}_t = a_o + \sum_{t}^{t+3} a_i M_i^a$	.0838	.1015	.0552	.03432	.01613
$\dot{P}_t = a_o + \sum_{t-3}^{t+3} a_i M_i^a$	.0612	.0509	.0457	.02591	.01299

Table II

NOTES

ρ is the regression coefficient of the residual on the previous residual.

Sample size differs for Sims Tests and other regressions.

[a] Similar results are obtained using two leads and lags.

[b] Indicates a significant change in SSR due to imposition of a constraint.

Table III

Output Equations using Past Inflation as a Predictor of Money

(5)' $\dot{Y}_t = a_2 + a_1 DMR_t$, $DMR_t = \dot{M}_t - \hat{\dot{M}}_t$

	Brazil 1/ 1952-1974	Chile 2/ 1952-1970	Colombia 1952-1974	Mexico 3/ 1950-1974	Peru 1952-1974
Coeff. of constant	.069	.035	.051	.063	.053
(t)	(11.2)	(8.2)	(19.5)	(18.9)	(10.1)
Coeff. of DMR_t	.086	.073	.153	.123	.113
(t)	(.9)	(.9)	(3.0)	(2.0)	(1.5)
DF	21	17	22	23	22
SSR	.0184	.0058	.0035	.0064	.0145
SEE	.0296	.0185	.0127	.0166	.0257
R^2	.03	.04	.29	.15	.10
DW	1.19*	1.24*	1.46	1.85	1.55

$$\dot{M} = d_o + d_1 \dot{P}_{t-1} + d_2 \dot{P}_{t-2} + d_3 \dot{P}_{t-3}$$

	Brazil	Chile	Colombia	Mexico	Peru
Constant	.132	.243	.178	.127	.094
(t)	(4.2)	(6.3)	(7.1)	(5.4)	(1.7)
$\dot{P}_{t-1}$	.66	.50	.28	.03	-.21
(t)	(5.4)	(3.5)	(1.6)	(.1)	(.4)
$\dot{P}_{t-2}$	.11	-.06	-.21	-.23	.88
(t)	(.8)	(.4)	(1.1)	(.8)	(1.8)
$\dot{P}_{t-3}$	-.04	-.16	-.21	-.01	-
(t)	(.3)	(1.2)	(1.8)	(.6)	-
D.F.	19	15	20	21	21
SSR	.0858	.0474	.0610	.0720	.121
SEE	.0672	.0562	.0552	.0585	.0761
DW	1.68	1.63	2.06	2.08	1.02*

Table III (continued

SSR's--Sims Test of Money Growth as a Function of Inflation

	Brazil	Chile	Colombia	Mexico	Peru
$\dot{M}_t = a_o + \sum_{t-3}^{t} a_i \dot{P}_t$ [a]	.0545[b]	.0411[b]	.0277	.0567	.0610
$\dot{M}_t = a_o + \sum_{t}^{t+3} a_i P_i$ [a]	.1597[b]	.0379[b,c]	.0284	.0495	.0805
$\dot{M} = a_o + \sum_{t-3}^{t+3} P_i$ [a]	.0544[b]	.0283[b]	.0213	.0402	.0527

Notes to Table III

1. Using mid-year inflation we obtain:

$$\dot{M} = \underset{(3.9)}{.14} + \underset{(4.6)}{.82}\,\dot{P}_{t-1} - \underset{(.8)}{.19}\,\dot{P}_{t-2} + \underset{(.3)}{.06}\,\dot{P}_{t-3}$$

R^2 = .68 SSR = .1100 SEE = .0761 DW = 1.63

$$\dot{Y} = \underset{(11.0)}{.069} + \underset{(.3)}{.03}\,DMR_t$$

R^2 = .005 SSR = .0189 SEE = .0300 DW = 1.16*

2. Using mid-year inflation we obtain:

$$\dot{M} = \underset{(6.5)}{.29} + \underset{(2.1)}{.33}\,\dot{P}_{t-1} - \underset{(.1)}{.01}\,\dot{P}_{t-2} - \underset{(1.5)}{.23}\,\dot{P}_{t-2}$$

R^2 = .47 SSR = .0726 SEE = .0696 DW = 1.69

$$\dot{Y} = \underset{(8.1)}{.034} - \underset{(.6)}{.04}\,DMR_t$$

R^2 = .02 SSR = .0060 SEE = .0187 DW = 1.30*

3. Using the Wholesale Price Index we obtain:

$$\dot{M} = \underset{(5.6)}{.123} + \underset{(.5)}{.13}\,\dot{P}_{t-1} - \underset{(.4)}{.11}\,\dot{P}_{t-2} - \underset{(.4)}{.10}\,\dot{P}_{t-3}$$

R^2 = .03 SSR = .0727 SEE = .0588 DW = 2.05

$$\dot{Y} = \underset{(19.4)}{.063} + \underset{(2.4)}{.14}\,DMR_t$$

R^2 = .19 SSR = .0060 SEE = .0162 DW = 1.91

[a]Similar results are obtained using two leads and lags.

[b]Similar results are obtained using changes in annual averages of prices, as opposed to changes in year end prices.

[c]Can be rejected using two leads and lags, similar results if annual averages are used.

Table IV

Output and Output Growth as a Function of Unexpected Money Growth, Pooled Data

Coefficient of:	1/ I	II	1/ III	IV	1/ V	VI	1/ VII	VIII
Unexpected money growth	.019	-.018	.04	.004	.108	.101	.113	.111
(t)	(.7)	(.7)	(1.5)	(.1)	(3.6)	(2.9)	(4.1)	(3.5)
Constant Brazil	.0492	.02	.058	.068	.18	.17	.069	.069
(t)	(.1)	(.1)	(5.8)	(7.4)	(.4)	(.5)	11.4	(15.8)
Constant Chile	-.39	-.27	.023	.034	-.45	-.45	.035	.034
(t)	(1.2)	(.8)	(2.5)	(3.5)	(1.7)	(1.4)	(8.4)	(7.2)
Constant Colombia	-.04	-.04	.045	.050	-.03	-.03	.032	.033
(t)	(.6)	(.4)	(9.2)	(8.2)	(.4)	(.3)	(6.2)	(4.9)
Constant Peru	-.77	-.84	.047	.052	-.61	-.63	.036	.036
(t)	(1.9)	(2.4)	(7.2)	(8.8)	(1.6)	(1.8)	(5.4)	(5.6)
Constant Mexico	-1.1	-1.1	.058	.063	-1.11	-1.11	.049	.049
(t)	(1.8)	(1.4)	(12.9)	(11.7)	(2.0)	(1.5)	10.7	(8.7)
Y_{t-1} Brazil	.99	1.00	-	-	.96	.96	-	-
(t)	(8.4)	(10.6)	-	-	(7.5)	(10.5)	-	-
Y_{t-1} Chile	.82	.87	-	-	.78	.78	-	-
(t)	(5.5)	(5.5)	-	-	(6.1)	(5.3)	-	-
Y_{t-1} Colombia	.97	.99	-	-	.95	.95	-	-
(t)	(7.8)	(5.3)	-	-	(8.3)	(5.3)	-	-
Y_{t-1} Mexico	.74	.74	-	-	.74	.74	-	-
(t)	(5.3)	(4.1)	-	-	(5.7)	(4.3)	-	-
Y_{t-1} Peru	.64	.61	-	-	.67	.68	-	-
(t)	(3.6)	(4.1)	-	-	(4.2)	(4.7)	-	-
time trend Brazil	.0021	.0018	-	-	.0038	.0035	-	-
(t)	(.3)	(.3)	-	-	(.5)	(.6)	-	-
time trend Chile	.0069	.0051	-	-	.0082	(.0080	-	-
(t)	(1.3)	(.9)	-	-	(1.8)	(1.5)	-	-
time trend Colombia	.0020	.0015	-	-	.0029	.0039	-	-
(t)	(.3)	(.2)	-	-	(.5)	(.3)	-	-
time trend Mexico	.0165	.0165	-	-	.0164	.0164	-	-
(t)	(1.9)	(1.5)	-	-	(2.0)	(1.5)	-	-
time trend Peru	.0186	.0199	-	-	.0164	.0158	-	-
(t)	(2.0)	(2.6)	-	-	(1.8)	(2.1)	-	-
SSR	1.2017	.0458	1.1568	.0536	1.0121	.0424	1.0042	.0482
R^2 2/	.99	.99	.41	.21	.99	.99	.49	.29

1/ Observations weighted by inverse of SSE for individual country equations for weighted regressions time trends and constants were converted by multiplying by SEE of individual countries and SSR normalized by dividing by D.F. of individual equations, i.e., normalized unrestricted SSR = 1.00.

2/ The coefficients of determination (R^2) refer to slightly different dependent variables because of the different weights and thus are not strictly comparable.

Table V

Reduced Form Regressions
Growth of Output as a Function of Money Growth
less Last Year's Inflation

	Brazil[1] 1952-1974	Chile[1] 1952-1970	Colombia 1951-1974	Mexico[2] 1950-74	Peru 1951-74
	$\dot{y} = a_2' + a_1(\dot{M} - \dot{P}_{t-1})$				
Constant	.058	.030	.047	.052	.046
(t)	(7.9)	(7.6)	(13.1)	(4.7)	(6.8)
Coefficient of $(\dot{M}_t - \dot{P}_{t-1})$	.166	.109	.067	.156	.075
(t)	(2.2)	(2.9)	(1.9)	(3.8)	(1.2)
D.F.	21	17	22	23	22
SSR	.0154	.0041	.0042	.0046	.0144
SEE	.0271	.0155	.0140	.0142	.0256
R^2	.19	.32	.14	.38	.06
DW	1.59	1.71	1.51	2.33	1.66
Standard Deviation of Inflation	.143	.137	.079	.051	.033
Average Inflation	.26	.28	.109	.059	.085
$\sum (\dot{P}_t - \dot{P}_{t-1})^2$	.1776	.1368	.1416	.0800	.0369

[1]Brazil and Chile use year end wholesale price data in computing $\dot{P}_{t-1}$. The corresponding regressions using annual averages are:

$$\dot{Y}_t = \underset{(8.4)}{.062} + \underset{(1.7)}{.12}(\dot{M} - \dot{P}_{t-1}) \quad SSR = .0168, \ SEE = .0283,$$

$R^2 = .12$, $DW = 1.54$

SEE using $(\dot{M}_t - \dot{P}_t) = .0165$, $DW = 1.47$,

for Chile:

$$\dot{Y}_t = \underset{(7.4)}{.033} + \underset{(1.4)}{.048}(\dot{M}_t - \dot{P}_{t-1}) \quad SSR = .0054, \ SEE = .0179,$$

$R^2 = .10$, $DW = 1.48$

SSE using $(\dot{M}_t - \dot{P}_t) = .0037$, $DW = 1.60$.

[2]Mexico uses CPI. Results using WPI are similar: $\dot{Y}_t = \underset{(12.9)}{.053} + \underset{(3.3)}{.14}(\dot{M}_t - \dot{P}_{t-1})$, SSR = .0050, SEE = .0148,

Table VI

Growth of Output as a Function of Money Growth
Less an Autoregressive Predictor of Inflation

	Brazil[1] 1952-1974	Chile[1] 1952-1970	Colombia 1951-1974	Mexico 1950-1974	Peru 1951-1974
Constant	.069	.029	.044	.053	.044
(t)	(8.4)	(6.9)	(12.3)	(11.6)	(6.6)
Coefficient of $(\dot{M} - \hat{\dot{P}})$	.006	.135	.126	.160	.120
(t)	(.1)	(2.6)	(2.7)	(2.9)	(1.5)
D.F.	21	17	22	23	22
SSE	.0190	.0043	.0037	.0055	.0146
SEE	.0301	.0159	.0130	.0155	.0259
R^2	.0002	.29	.25	.26	.10
DW	1.13	1.41	1.52	2.01	1.60
	$\dot{P}_t = a_0 + a_1\dot{P}_{t-1} + a_2\dot{P}_{t-2} + a_3\dot{P}_{t-3}$				
a_0	.107	.145	.075	.050	.074
	(1.9)	(2.1)	(2.2)	(2.5)	(3.0)
a_1	.494	1.019	.595	.336	.269
	(2.2)	(4.0)	(2.5)	(1.3)	(1.1)
a_2	.253	-.698	-.175	-.200	-.136
	(1.0)	(2.2)	(.6)	(.8)	(.6)
a_3	-.14	.16	-.075	--	--
	(.6)	(.6)	(.5)	--	--
SSE	.2866	.1550	.1119	.0571	.0245
SEE	.1226	.1016	.0748	.0519	.0341
R^2	.39	.56	.26	.09	.06
DW	2.05	1.93	1.96	1.59	1.81
Standard Deviation of Inflation	.143	.137	.079	.0510	.033
Average Inflation	.26	.28	.109	.059	.085
SSR of constraint $\sum_{i=t-1}^{i=t-3} d_i = 0$	.4183*	.1961	.1194	.0575	.0268

[1]Price series refers to end of year.

Table VII

Output Growth as a Function of $(\dot{M}_t - \dot{P}_{t-1})$

Pooled Data

Constant Brazil	Constant Chile	Constant Colombia	Constant Peru	Constant Mexico	Coefficient: $(\dot{M}_t - \dot{P}_{t-1})$
Weighted Data					
0.62	.030	.044	.045	.055	.11
(10.7)	(8.2)	(14.3)	(8.4)	(17.7)	(5.5)
SSR = 1.0305 R^2 = .54					
Unweighted Data					
.062	.030	.044	.045	.055	.12
(13.9)	(6.3)	(10.1)	(10.1)	(12.8)	(5.0)
SSR = .04377 R^2 = .36					

Notes:

For weighted regressions constants were converted to growth rates by multiplying by SEE of individual countries and SSR normalized by dividing by D.F. of individual equations, i.e., normalized unrestricted SSR = 1.00. The two coefficients of determination (R^2) refer to slightly different dependent variables because of the different weights and thus are not strictly comparable.

Table VIII

Brazilian Output Growth - Two Monetary Regimes

Equation (5) (using past money growth for prediction

1951-1964 $\dot{Y}_t = \underset{(93)}{.060} + \underset{(2.7)}{.090}\ DMR_t$

SEE = .0250 SSR = .0142 R^2 = .26 DW = 1.69

1951-1965 $\dot{M}_t = \underset{(1.6)}{.05} + \underset{(1.8)}{.36}\ \dot{M}_{t-1} + \underset{3.8}{1.03}\ \dot{M}_{t-2}$, $DMR = \dot{M}_t - \hat{M}_t$

SEE = .0400 SSR = .0176 R^2 = .94 DW = 2.36

1967-1974 $\dot{M}_t = \underset{(1.2)}{.19} + \underset{(.5)}{.21}\ \dot{M}_{t-1} + \underset{(1.1)}{.19}\ \dot{M}_{t-2}$ $DMR = \dot{M}_t$

SEE = .0510 SSR = .0131 R^2 = .19 DW = 1.30*

1966 $\hat{M}_t = .3775$, $(\dot{M}_t = .2275)$, $DMR_t = .15$

Total SSR for expectation equations = .0612

Table IX

Tests for Lagged Effects of Unexpected Inflation

$$Y_t = a_0 + a_1 X_t + a_2 (\text{Time}) + a_3 Y_{t-1} + a_4 X_{t-1} + a_5 X_{t-2} + a_6 X_{t-3}$$

	Brazil[a] 1952-1974 $X = (\dot{M} - \dot{P}_{t-1})$	Chile 1954-1970 $X = DMR_t$[b]	Colombia 1956-1974 $X = DMR_t$[c]	Mexico[d] 1950-1974 $X_t = (\dot{M}_t - \dot{P}_{t-1})$	Peru[e] 1956-1974 $X = DMR_t$[c]
a_0	.54	-.86	-.19	-.88	-.37
	(1.2)	(2.5)	(2.2)	(1.6)	(0.7)
a_1	.135	.108	.098	.130	.068
	(1.6)	(1.2)	(1.4)	(2.9)	(0.6)
a_2	.010	.015	.009	.013	.010
	(1.3)	(2.5)	(1.4)	(1.7)	(0.9)
a_3	.851	.631	.854	.794	.796
	(.13)	(3.9)	(6.8)	(6.6)	(4.0)
a_4	.114	.021	-.069	.043	.046
	(1.3)	(0.2)	(0.9)	(1.0)	(0.4)
a_5	.161	.002	.004	-.001	.044
	(1.9)	(0.0)	(0.1)	(0.3)	(1.5)
a_6	.004	n.a.	n.a.	n.a.	n.a.
	(1.0)				
DF	16	11	13	19	13
SSR	.01096	.002324	.001657	.00355	.00825
SEE	.0262	.01454	.01129	.0137	.0252
DW	1.71	1.66	2.07	2.29	1.19*
F stat. of $a_4 - a_6 = 0$	1.62	.03	1.64	1.93	.13
F stat. of $a_3 = 0$	43.62[f]	14.84[f]	46.54[f]	43.0[f]	15.8[f]
F stat. $a_3 = 0$ $a_4 - a_6 = 0$	1.30	3.32[f]	2.60	1.15	.40

Notes to Table XI

[a]Fit using lagged money was slightly better (SSR = .00727), but all coefficients of lagged money were negative. The results of F tests on constants yielded similar results.

[b]$DMR_t = \dot{M}_t - \hat{\dot{M}}_t$, $\hat{\dot{M}}_t$ = constant t $\sum_{i=1}^{i=3} \dot{P}_{t-i}$

[c]$DMR_t - \dot{M}_t - \hat{\dot{M}}_t$, $\hat{\dot{M}}$ = constant + $\sum_{i=1}^{i=} \dot{M}_{t-1}$

[d]Fit using lagged money was slightly worse for unconstrained equation (including Y_{t-1} and time trend) but slightly better for equation omitting Y_{t-1}. Results of F tests on constraints were not changed.

[e]Fit using lagged money was slightly better (SEE = .0249) and was usable over a longer period (1954-1974). However, three coefficients money were (insignificantly) negative. The results of F tests on constraints yielded similar results.

[f]Constraint significantly affected SSR using F statistic at 95% level.