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Output-inflation Trade-offs: The Latin American Experience

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This paper investigates the natural rate hypothesis, using the Lucas and Hanson approaches for ten Latin American countries. The purpose of using two methods to test this hypothesis is to ascertain the robustness of the results to the underlying differences in the assumptions of these methods. The evidence strongly supports the natural rate hypothesis and the predictions of the Lucas model. The results of the Hanson method are in general consistent with the natural rate hypothesis, but they are not as conclusive as the results of the Lucas method. The evidence from the Hanson model suggests that the monetary growth predicted by past inflation performs better than the one predicted by past monetary growth.

Recently there has been a considerable research interest in investigating the natural rate hypothesis. Froyen and Waud (1980) examined this hypothesis for 10 highly industrialized countries using the methodology (with some modifications) originally modelled and implemented by Lucas (1973) for a group of 18 countries. Hanson (1988) tested a similar hypothesis for five of the Latin American countries using a variant of the Lucas model which incorporates the contention that it is the unanticipated growth in the money supply, modelled by Barro (1977), that has a significant effect on output and employment in the short run. In both models the aggregate supply specification is essentially the same. However, on the aggregate demand side of the economy the models of Hanson and Lucas do differ. In the Lucas model the aggregate nominal output is determined by monetary and fiscal policies and other factors on the demand side of the economy. However, Lucas assumes that the price elasticity of nominal output is unity, whereas Hanson imposes this income constraint directly in the money market. He assumes that the demand for output exceeds supply until income, prices, and opportunity costs adjust in such a way as to make the demand for money equal to the supply in one period.[1] In other words, the Hanson model requires a complete adjustment of the demand for money stock in one period to yield equilibrium in the money market. Further,

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[1]For details see [Hanson (1980), p. 974].

this model neglects the role of fiscal policy unless monetary and fiscal policies are perfectly correlated. The basic hypothesis that is tested in all these studies is that the prediction errors in wages and prices made by workers and firms will induce changes in output and employment from their natural rates, whereas predictions of wages and prices in individual markets are based on rational expectations but with incomplete information.

The main objective of this study is to test the natural rate hypothesis for a group of 10 Latin American countries (other than the ones investigated by Hanson) using two different methods, namely, the amended Lucas and the Hanson methods. The purpose of using two different methods to test this hypothesis is to ascertain the robustness of the results of this study to the differences in the assumptions underlying these methods on the aggregate demand side of the economy.

The results of this study indicate that the estimated correlation between the sample variance of the inflation rate and the estimated coefficients of the change in the aggregate nominal demand (described in the next section) is negative and significant, which is in agreement with the prediction of the Lucas model. This result suggests that the output-inflation trade-off deteriorates as the variance of the inflation rate increases. Further, the evidence indicates that the sample correlation between the variance of the change in the aggregate nominal demand and the variance of the inflation rate is positive and significant, supporting again the Lucas model. Finally, the results also suggest that there is an inverse relationship between the terms of trade-off and the variance of the change in the aggregate nominal demand, and the coefficient of this relationship is significantly different from zero for the group of 10 Latin American countries included in this study. The results obtained by using Hanson's method are in general consistent with the natural rate hypothesis. However, the evidence obtained from this method is not as conclusive as the one obtained by using the Lucas method. In some cases, the results of the Hanson method seem to indicate that the rate of growth of the money supply has no affect on output. The growth versions of the Hanson model also indicate similar results. This evidence may suggest that the assumptions that the demand for money adjusts in one period or that the monetary and fiscal policies are perfectly correlated may not be reasonable for all of the Latin American countries included in this study.

A brief discussion of the models and the data used in this study is presented in the next section. The empirical results are presented in Section II, and the concluding remarks are presented in the final section of this study.

I. THE MODELS AND DATA

The natural rate hypothesis modelled by Lucas is based on the view that the supply decisions of the economic agents are based on relative prices only with the presumption that the expectations of these agents on wages and prices are formed rationally but with incomplete information. Because of the incomplete information, the suppliers in a particular market may be led to believe that a change in the price for their good or service is due to a permanent shift in the demand for their good or service – as opposed to that it is due to the change in the general price level – and therefore increase their supply. In other words, it is the inability of the suppliers to make a distinction between the change in market-specific prices and the changes in the general price level due to lack of complete information on the latter which brings about a trade-off between output and inflation. However, as the variance of the general price level σ^2 increases as compared to the variance of the market specific-price σ_w^2 to the mean of the general price level, the suppliers in various markets will realize this distinction and their supply response to the changes in market-specific prices will be reduced. In other words, the more the suppliers recognize that the market-specific price changes are due to the changes in the general price level, the less likely that they will be 'fooled'. Integrating the supply responses in various markets, Lucas derived the aggregate supply relationship for an economy. Combining this with the aggregate nominal demand posited by Lucas, and using the assumption that the economic agents form their expectations on wages and prices rationally but with incomplete information, Lucas obtained the following testable relationship:[2]

$$y_{ct} = \alpha + \pi \Delta x_t + \lambda y_{ct-1} \qquad \ldots \qquad \ldots \qquad \ldots \qquad (1)$$

where the cyclical component y_{ct} is the residual $(y_t - y_{nt})$ from the fitted trend line $y_{nt} = a + bt$, y_{nt} is the log of secular component, y_t is the log of real GNP, and Δx_t is the change in the log of nominal GNP. The parameters π and λ measure the response of real output to the change in nominal demand shock Δx_t and the speed of adjustment, respectively.

Incorporating an important modification proposed by Cukierman and Wachtel (1979) to the Lucas model, Froyen and Waud obtained the following relationships:[3]

$$\pi = \frac{\gamma}{\sigma_x^2/\sigma_w^2 + (1 + \gamma)} \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (2)$$

$$\sigma^2 = \frac{\sigma_x^2}{(1 + \theta\gamma)^2} \qquad \ldots \qquad \ldots \qquad \ldots \qquad \ldots \qquad (3)$$

[2] For a complete explanation, see [Lucas (1973), pp. 326–330].

[3] For detailed derivations and proofs of these relations, see [Cukierman and Wachtel (1979), pp. 597–601]; or for a good summary, see [Froyen and Waud (1980), pp. 410–411].

$$\sigma_p^2 = 2\sigma^2 \qquad \cdots \quad \cdots \quad \cdots \quad \cdots \qquad (4)$$

$$\theta = \frac{\sigma_w^2}{\sigma_x^2 + \sigma_w^2}$$

where γ is the coefficient of supply response [see Lucas (1973), p. 327], σ_x^2 is the variance of the change in the log of aggregate nominal demand, σ_w^2 is the variance of the market-specific demand shock, σ_p^2 is the variance of the inflation rate and σ^2 is the variance of the general price level.

Making use of Equations (2), (3) and (4), and assuming that σ_w^2 and γ are stable across the countries, the implications of the amended Lucas model may be described as follows:[4]

(i) The parameters π and σ_x^2 are inversely correlated;

(ii) σ_x^2 and σ_p^2 are directly correlated; and

(iii) σ_p^2 and π are inversely correlated.

Hanson's method of testing the natural rate hypothesis is based on the contention that it is the unanticipated part of the money movements that would have an effect on output and employment. This contention has been explicitly stated in the rational expectations monetary model of Sargent and Wallace (1975) and Barro (1976). Later, Barro (1977) used this approach to test the natural rate hypothesis for the U. S. economy. Hanson, instead of using Barro's method directly, combined Barro's and Lucas's models and derived the reduced form equations to test the natural rate hypothesis. This may be described as follows.

Hanson assumes that the aggregate supply function of an economy is the same as the one posited by Lucas. However, on the aggregate demand side of the economy, he does not impose the income constraint that the price elasticity of aggregate nominal demand is unity, as assumed by Lucas. Instead, he imposes this income constraint directly in the money market; that is, he assumes that the demand for output exceeds supply until income and prices adjust to yield equilibrium in the money market. He then obtains the following testable reduced forms:[5]

$$y_t = \alpha_1 + b_1 DM_t + b_2 T + b_3 y_{t-1} + u_{1t} \qquad \cdots \quad \cdots \qquad (5)$$

[4] For a good exposition of the implications of the Lucas model, see [Froyen and Waud (1980), p. 411].

[5] For details, see [Hanson (1980), pp. 974–978].

$$y_t = \alpha_2 + b_1 DMR_t + b_2 T + b_3 y_{t-1} + u_{2t} \quad \ldots \quad \ldots \quad (6)$$

$$\Delta y_t = b_1 \Delta MR_t + \alpha_2^* + u_{3t} \ldots \quad \ldots \quad \ldots \quad \ldots \quad (7)$$

$$\Delta y_t = b_1^* \Delta MRP_t + \alpha_1^* + u_{4t} \quad \ldots \quad \ldots \quad \ldots \quad (8)$$

where ΔM_t is the change in the log of money supply, T is the time trend, y_t is the log of real income, $u_{1t}, u_{2t}, u_{3t}, u_{4t}$ are the error terms at time t, ΔMR_t and ΔMRP_t are the unanticipated components of the growth in the money supply which are estimated using the following equations:

$$\Delta M_t = d_0 + d_1 \Delta M_{t-1} + d_2 \Delta M_{t-2} + d_3 \Delta M_{t-3} + u_{5t} \quad \ldots \quad (9)$$

$$\Delta M_t = a_0 + a_1 \Delta P_{t-1} + a_2 \Delta P_{t-2} + a_3 \Delta P_{t-3} + u_{6t} \quad \ldots \quad (10)$$

where ΔP_{t-1} is the change in the log of price level at time $(t-1)$, u_{5t}, u_{6t} are the error terms at time t, and all other variables are as defined earlier.

Hanson assumes that the economic agents form their expectations rationally in the sense of Muth (1960); that is, they use all the information available to predict the relevant economic variables. In the context of the Hanson study, it is assumed that the appropriate economic relationships to predict the money supply growth rationally are given by Equations (9) and (10). Then the residuals obtained from the estimated Equations (9) (ΔMR_t) and (10) (ΔMRP_t) would represent the unanticipated components of the monetary growth. Notice that Equations (7) and (8) are obtained from Equations (5) and (6) using the constraint that b_2 is equal to zero, b_3 is equal to one and replacing ΔM by ΔMRP in Equation (5).

To test the natural rate hypothesis, using the Lucas and Hanson models, Equations (1), (5), (6), (7), and (8) were estimated using the annual data of 10 Latin American countries (other than the ones selected by Hanson); and the results are presented in the next section. The annual data from 1950 to 1981 on nominal income, real income, and the money supply were obtained from the special issue of *International Financial Statistics* (1982), which is published by the International Monetary Fund. The data on money supply and real income not available for some years in the 1982 issue were obtained from various earlier issues of the same publication. The latest data on income, money, and prices were not included in this study for two different reasons. First, in some of the countries included in this study, such as Argentina, Bolivia, and Uruguay, there was a rapid growth of money supply and inflation during the 1980s. With recent base 1980 used in this publication, the values of indices on prices for these countries prior to 1960 were almost close to zero. The second reason is that some of the countries included in the study experienced substantial supply and demand shocks due to the Latin American debt crisis associated with a rapid increase in the interest rates in the industrial countries since 1982. To avoid the problems associated with structural change, data on various variables since 1982 were excluded from this study. The money supply data used in this study is M_1 (demand deposits plus currency in circulation). The log of the price level used in this study is the difference between the log of nominal income and the log of real income (GDP deflator). The real income data for Uruguay were not available prior to 1955. Because of this reason, the beginning and the end of the sample periods are not the same for all countries included in this study.

II. EMPIRICAL RESULTS

The ordinary least squares (OLS) estimates of the parameters of Equation (1) and the estimated variances of σ_p^2 and σ_x^2 are presented in Table 1. As expected, the estimates of λ and π lie in between zero and one with the exceptions of Argentina, Bolivia, and Uruguay. There is a considerable variation in $\hat{\sigma}_p^2$ and $\hat{\sigma}_x^2$ across the countries. The evidence suggests that in moderate inflation countries – Ecuador, El Salvador, Guatemala, the Honduras, and Paraguay – it would seem reasonable to conclude that there is a significant output-inflation trade-off. However, as expected, in rapid inflation countries – Argentina, Bolivia, and Uruguay – the trade-off appears to vanish. To make any firm conclusions about the Lucas model, it would seem appropriate first to test the implications of the Lucas model.

Before using the OLS estimates of π to test the implications of the Lucas model, one should make sure that the OLS estimates of π do not contain any serious biases. This is an important problem in the context of this study for two reasons. First, Equation (1) contains the lagged dependent variable as an explanatory variable. Because of this, the OLS estimates of π may be biased unless the sample size is fairly large, and there is no serial correlation in the error term. However, if the serial correlation is present, the problem becomes more complicated. In most of the cases in this study, the sample size used in estimating the parameters of Equation (1) was greater than 29, which appears reasonable. However, as shown in Table 1, the *h*-statistics indicate the presence of serial correlation in two countries: Bolivia and El Salvador, and the Durbin-Watson test indicates the same for Uruguay. Second, in the Lucas model the aggregate nominal income is demand-determined; further, Lucas assumes that the price elasticity of nominal income is unity. If this assumption is not satisfied,[6] then the shifts in the aggregate supply curve will induce changes in Δx and, therefore, will make Δx an endogenous variable. In this case, the OLS estimates of π will have a simultaneous equation bias.

[6]For an interesting discussion regarding this assumption, see [Arak (1977), pp. 728–730], and Lucas's reply (1977), p. 730.

Table 1

The Ordinary Least Squares Estimates of Equation (1), and the Estimates of σ_p^2 and σ_x^2

Country	α	π	λ	R^2	DW	h Statistic	$\hat{\sigma}_p^2$	$\hat{\sigma}_x^2$
Argentina	.001	−.019	.350	.123	2.10	N.A.[b]	.9214	.2721
(1951–81)	(1.95)[a]	(1.45)	(1.57)					
Bolivia	.001	−.044	1.01	.893	.61	3.88	.2241	.075508
(1951–81)	(.27)	(−.84)	(12.0)					
Costa Rica	−.007	.061	.784	.653	2.16	−.58	.004904	.00432
(1950–81)	(−.80)	(.85)	(6.28)					
Ecuador	−.028	.227	.821	.705	1.71	.98	.00449	.00653
(1950–81)	(−2.74)	(3.21)	(6.88)					
El Salvador	−.017	.195	.772	.755	1.34	2.15	.0044	.0047
(1950–81)	(−2.49)	(2.76)	(7.43)					
Guatemala	−.022	.241	.506	.809	1.49	1.90	.003235	.004217
(1951–81)	(−3.41)	(4.49)	(3.56)					
The Honduras	−.023	.322	.771	.791	1.47	1.66	.001465	.00206
(1951–81)	(−3.55)	(4.67)	(6.67)					

Continued–

Table 1 – (*Continued*)

Country	α	π	λ	R^2	DW	h Statistic	$\hat{\sigma}_p^2$	$\hat{\sigma}_x^2$
Paraguay (1951–81)	–.014 (–.97)	.139 (1.68)	.972 (5.69)	.731	1.8	1.70	.023397	.021625
Uruguay (1955–81)	.010 (.68)	–.025 (–.79)	.413 (1.59)	.23	1.41	N.A.	.09409	.048093
Venezuela (1951–81)	.001 (.07)	.013 (.23)	.834 (5.84)	.663	1.64	1.33	.00872	.0123

[a]The numbers in the parentheses are *t*-statistics.
[b]The *h*-statistic is not applicable (N.A.).

To explore the possibility of a feedback from y_{ct} to Δx_t, the Granger test for the direction of causality from y_{ct} to Δx_t is investigated. The results of the Granger test indicate[7] that there is a feedback in three countries: Ecuador, El Salvador, and Uruguay. In light of the above discussion, it would seem reasonable to explore the possibility of using alternative methods of estimation to estimate π for four of the countries mentioned above. One possible approach to obtain a reasonable estimate of π is to use the instrumental-variable method, treating the percentage change in the money supply as an instrument. Another approach would be to develop a simultaneous recursive model, treating ΔM as an exogenous variable and estimate π. The latter approach is used in this study because it would not only correct for simultaneous equation bias but may also reduce the effect of serial correlation. The recursive model used in estimating π may be described as follows:

$$y_{ct} = \alpha + \pi \Delta x_t + \lambda y_{ct-1} + \epsilon_{1t} \quad \ldots \quad \ldots \quad \ldots \quad (11)$$

$$\Delta x_t = \beta_0 + \beta_1 \Delta M_t + \epsilon_{2t} \quad \ldots \quad \ldots \quad \ldots \quad \ldots \quad (12)$$

where Δx_t, y_{ct} are the endogenous variables, ΔM_t, y_{ct-1} are the predetermined variables, ϵ_{1t} and ϵ_{2t} are the error terms at time t.

The parameter estimates of Equation (1), using the recursive model approach[8] for four of the countries mentioned above, are presented in Table 2. The results indicate that the OLS estimates of the parameters of Equation (1) (Table 1) are not significantly different from the estimates of the recursive model approach (Table 2). This may suggest that the OLS estimates of π (Table 1) are not plagued by serious biases.

The implications of the amended Lucas model could be tested using the

[7] The Granger test (see Sargent, pp. 217–218) for the direction of causality used in this study is based on the following equations:

$$\Delta x_t = g_0 + \sum_{i=1}^{m} g_i \Delta x_{t-i} + \sum_{J=1}^{n} h_J y_{ct-J} + \epsilon_t$$

$$y_{ct} = e_0 + \sum_{i=1}^{m} e_i y_{ct-i} + \sum_{J=1}^{n} f_J \Delta x_{t-J} + u_t$$

The feedback is tested using the F-statistic for the null hypothesis h_j is equal to zero for $J = 1, 2, \ldots n$. The results are based on the choice m and n equal to 4.

[8] The method of estimation used is as follows. Estimate the parameters of Equation (12) using the OLS and obtain the predicted Δx_t ($\hat{\Delta x}_t$). Replace Δx_t in Equation (11) by $\hat{\Delta x}_t$ and estimate the parameters of Equation (11) using OLS. Under the assumption that ϵ_{1t} and ΔM_t are contemporaneously uncorrelated, it can be shown that the estimates obtained from this method are consistent.

estimated correlations among $\hat{\sigma}_p^2$, $\hat{\sigma}_x^2$ and π. These correlations are presented in Table 3. According to the amended Lucas model, one should expect to find a significant correlation between $\hat{\sigma}_p^2$ and $\hat{\sigma}_x^2$. The results strongly support this prediction of the Lucas model. Also, one would expect to find significant negative correlations between $\hat{\sigma}_p^2$ and $\hat{\pi}$, $\hat{\sigma}_x^2$ and $\hat{\pi}$. The evidence also strongly supports (see Table 3) these predictions of the Lucas model. It is interesting to note that the estimated correlations and their *t*-statistics of π for four countries and the OLS estimates of π for the remaining six countries are larger in absolute value as compared to the estimated correlations obtained by using the OLS estimates of π for all the countries.[9] The evidence based on the group of 10 Latin American countries strongly supports the predictions of the Lucas model.[10]

The results obtained by using the Hanson approach are presented in Tables 4 and 5. The adjusted multiple correlation coefficient ($\bar{R}^2$) is quite high for the level of output formulation. This is not surprising because of the presence of the lagged dependent variable in Equations (5) and (6). The *h*-statistics indicate that serial correlation is not a problem for a majority of cases in the level of output formulation. The Durbin-Watson test indicates that in most cases of the growth of output formulation [Equations (7) and (8)], serial correlation seems to be less of a concern than the explanatory power of the model.

The results of the level of output formulation [Equation (5)] seem to indicate that in three of the moderate inflation countries, i.e., Ecuador, Guatemala and Paraguay, there is a significant trade-off between the monetary growth and real output. It is interesting to note for the same three countries the OLS estimates of the growth of output formulation, with unanticipated money growth [obtained by using the predicted monetary growth as a linear function of past inflation, i.e., using Equation (10)] as an explanatory variable, indicate similar results. In high

[9]It may be interesting to explore the possibility of splitting the data of the whole period into sub-periods and test the implications of the Lucas model, using the results of sub-periods. This is not undertaken in this study because Equation (1) contains a lagged dependent variable. This may make the estimates of π for sub-periods highly sensitive and possibly create serious biases due to the small samples of the split periods.

[10]To test the robustness of the sample correlations and their t-statistics to the number of countries selected (size of the sample), the sample of 10 countries was increased to 15 by including an additional 5 countries: Brazil, Chile, Columbia, Mexico, and Peru. The estimated correlations and their *t*-statistics obtained by using the results of 15 countries were not significantly different from the ones presented in Table 3. It may be worthwhile to note that the same 5 countries (described above) were selected by Hanson for his study on growth and inflation. However, one may have to be restrained to make general statements based on these results because problems associated with import restrictions, frequent devaluations, debt problems, crop failures, etc., which are frequently experienced by these countries, were not addressed in this study.

Table 2

Recursive Model Estimates of the Parameters of Equation (1)

Country	α	π	λ	$\bar{R}^2$	SEE
Bolivia	.042	−.217	1.05	.766	.0033
	(1.62)[a]	(−1.81)	(7.9)		
Ecuador	−.025	.2058	0.842	.717	.0005
	(−2.17)	(2.35)	(7.27)		
El Salvador	−.018	.197	0.730	.691	.0006
	(−1.61)	(1.53)	(5.94)		
Uruguay	.020	−.047	0.458	.26	.0007
	(.94)	(−.99)	(1.93)		

[a]The numbers in the parentheses are t-statistics.

Table 3

Correlations among the Estimates of π, σ_p^2 and σ_x^2

Correlation between	Using the OLS Estimates π (Table 1)	Using the Recursive Model Estimates of π for Four Countries in Table 2 and the OLS Estimates of π for the Remaining Six Countries (Table 1)
$\hat{\pi}\ \hat{\sigma}_p^2$	−.7511	−.8715
	(−3.217)[a]	(−5.026)
$\hat{\pi}\ \hat{\sigma}_x^2$	.7506	−.8681
	(−3.213)	(−4.94)
$\hat{\sigma}_x^2\ \hat{\sigma}_p^2$	.9959	.9959
	(31.1)	(31.1)

[a]The numbers in the parentheses are t-statistics.

inflation countries, i.e., Bolivia and Uruguay, the results of the level and the growth of output formulations indicate that, as expected, there is no trade-off between output and inflation. These results are also consistent with the results obtained by

Table 4

The Ordinary Least Squares Estimates of Equations (5) and (6)

Country	Intercept	ΔM_t	ΔMR_t	Y_{t-1}	T	$\bar{R}^2$	DW	h-Statistic
Argentina	1.66	−.07		−.16	.05	.98	2.08	N.A.[b]
(1951–81)	(4.75)[a]	(−1.05)		(−.70)	(5.06)			
	1.58		−.084	−.078	.04	.99	2.47	N.A.
	(5.05)		(−1.37)	(−.37)	(5.14)			
Bolivia	1.70	−.002		.696	.016	.99	1.91	.27
(1951–81)	(4.26)	(−.07)		(10.4)	(5.2)			
	1.10		.051	.803	.011	.99	1.93	.25
	(2.75)		(1.48)	(12.7)	(3.9)			
Gosta Rica	1.16	.042		.754	.014	.99	2.26	1.10
(1950–81)	(1.74)	(.49)		(5.23)	(1.73)			
	.95		−.125	.798	.012	.99	2.04	−.16
	(1.39)		(−.87)	(5.35)	(1.40)			
Ecuador	−.030	.161		.852	.008	.99	1.64	1.55
(1950–81)	(−.22)	(1.94)		(5.81)	(.91)			
	−.129		.041	.754	.015	.99	1.33	3.14
	(−1.03)		(.27)	(4.96)	(1.64)			
El Salvador	1.24	.062		.733	.012	.99	1.64	2.15
(1950–81)	(2.17)	(.84)		(5.99)	(2.25)			

Continued –

Table 4 – (*Continued*)

	.956		.122	.797	.009	.99	1.4	2.62
	(1.68)		(.70)	(6.45)	(1.67)			
Guatemala	1.40	.153		.656	.017	.99	2.05	1.97
(1951–81)	(2.52)	(3.97)		(4.49)	(2.23)			
	1.29		–.002	.658	.018	.99	1.90	2.59
	(1.77)		(–.15)	(3.42)	(1.84)			
The Honduras	.946	.089		.785	.009	.99	1.53	7.17
(1951–81)	(1.21)	(1.22)		(4.21)	(1.11)			
	1.26		.060	.707	.012	.99	1.3	6.5
	(1.64)		(.33)	(3.91)	(1.64)			
Paraguay	–.045	.085		.961	.003	.99	1.86	.52
(1951–81)	(–.26)	(1.95)		(7.01)	(.59)			
	–.153		–.069	1.06	–.001	.91	1.86	.55
	(–.82)		(–.59)	(7.2)	(–.13)			
Uruguay	4.61	–.066		.161	.011	.92	1.62	N.A.
(1951–81)	(3.31)	(–1.32)		(3.46)				
	4.00		–.085	.261	.010	.99	2.2	N.A.
	(3.33)		(–1.45)	(1.21)	(3.9)			
Venezuela	.131	.025		.601	.021	.99	1.83	.51
(1951–81)	(2.55)	(.50)		(3.8)	(2.31)			
	.095		–.028	.635	.019	.99	1.92	.44
	(2.13)		(–.58)	(5.18)	(2.8)			

[a] The numbers in the parentheses are *t*-statistics.
[b] The *h*-statistic is not applicable (N.A.)

Table 5

The Ordinary Least Squares Estimates of Equations (7) and (8)

Country	Intercept	ΔMR_t	$\bar{R}^2$	*DW*	Intercept	ΔMRP_t	$\bar{R}^2$	*DW*
Argentina	.04	−.10	.25	2.8	.04	−.08	.15	2.8
(1951–81)	(4.3)[a]	(−1.54)			(4.10)	(−1.85)		
Bolivia	.03	.029	.02	1.05	.038	.006	.001	1.05
(1951–81)	(5.6)	(.62)			(5.5)	(.13)		
Costa Rica	.061	−.159	.06	2.23	.063	.088	.16	2.55
(1950–81)	(12.4)	(−1.18)			(12.4)	(1.10)		
Ecuador	.063	.078	.01	1.59	.06	.197	.22	1.70
(1950–81)	(8.5)	(.55)			(9.6)	(2.56)		
El Salvador	.044	.132	.03	1.50	.044	.082	.26	1.71
(1950–81)	(8.21)	(.77)			(8.3)	(1.16)		
Guatemala	.054	.046	.01	2.15	.054	.141	.22	2.00
(1951–81)	(13.2)	(.37)			(14.8)	(2.36)		
The Honduras	.044	.126	.03	1.50	.044	.036	.08	1.53
(1951–81)	(9.59)	(.75)			(9.55)	(.60)		

Continued–

Table 5 – (*Continued*)

Paraguay	.049	−.023	.001	1.40	.049	.118	.21	1.7
(1951–81)	(8.67)	(−.18)			(9.79)	(2.41)		
Uruguay	0.11	−.055	.09	2.00	.011	−.073	.12	1.6
(1955–81)	(1.86)	(−1.32)			(1.88)	(−1.47)		
Venezuela	.059	−.025	.10	1.75	.059	.069	.14	1.83
(1951–81)	(11.59)	(−1.7)			(11.74)	(.97)		

[a]Numbers in the parentheses are t-statistics.

the Lucas method (see Table 1). The Hanson and Lucas methods also seem to indicate similar results for the Argentina, Costa Rica, and Venezuela. However, in two of the moderate inflation countries, i.e., El Sàlvador and the Honduras, the Lucas method indicates a significant trade-off between output and unexpected inflation, whereas the Hanson method indicates no trade-off.[11] This result suggests that the assumption that the monetary and fiscal policies are highly correlated is not appropriate for all of the Latin American countries included in this study.

The results of the level and the growth of output formulations using the unanticipated monetary growth [obtained by using Equation (9)] as an explanatory variable seem to be inconsistent with the natural rate hypothesis, and are also inconsistent with the results obtained by using the Lucas method. This may suggest that for most of the Latin American countries included in this study, monetary growth predicted by the previous values of the monetary growth is not a satisfactory approximation. This may be explained partly by the fact that some of the monetary growth determining variables, such as government spending, the balance of payments, and unemployment, are omitted from Equation (9).[12] It may be interesting to note in this context that in some of the Latin American countries, past inflation seems to be a much better predictor of the monetary growth than the previous values of monetary growth (see Table 5).

III. CONCLUSION

In this paper the natural rate hypothesis is investigated using the Hanson and Lucas methods for 10 of the Latin American countries. The basic hypothesis tested is that the prediction errors in wages and prices made by workers and firms will induce changes in output and employment from their natural rates, where predictions are based on rational expectations but with incomplete information. The results of the Lucas method strongly support the natural rate hypothesis. The evidence from this method seems to suggest that in moderate inflation countries, i.e., Ecuador, El Salvador, Guatemala, the Honduras, and Paraguay, there is a significant trade-off between output and unexpected inflation; and in high inflation countries, i.e., Argentina, Bolivia, and Uruguay, this trade-off deteriorates as the

[11]The results of the level of output formulation with unanticipated monetary growth, obtained by predicting monetary growth by past inflation, are similar to the results of the growth formulation with the same variables [Equation (8) Table 5]. Similarly, the results of the growth formulation with the percentage change in money supply (ΔM_t) are similar to the results of the level of output formulation with ΔM_t [Equation (5) Table 4].

[12]Lack of sufficient data on those variables was the major reason for the exclusion of these variables from Equation (9). Further, the results should be interpreted with caution because many of the problems associated with natural resource-based less developed countries were ignored in this study.

variance of the inflation rate increases. Further, the results strongly support the predictions of the amended Lucas model. The evidence indicates that the output-inflation trade-off deteriorates as the variance of the inflation rate increases and there is a significant positive correlation between the variances of the change in the aggregate nominal demand and the inflation rate. Finally, the results also indicate a significant inverse relationship between the terms of trade-off and the variance of change in the aggregate nominal demand.

The results obtained by Hanson's method are, in some cases, consistent with the natural rate hypothesis but they are not as conclusive as the results of the Lucas method. The evidence from the level and the growth of output formulations, using the percentage change in money supply and the unanticipated monetary growth (obtained by predicting the monetary growth by past inflation) as explanatory variables, seems to be consistent with the results of the Lucas method and the natural rate hypothesis. However, the results of the same formulations with unanticipated monetary growth, obtained by predicting monetary growth by the previous values of the monetary growth, as an explanatory variable seem to be inconsistent with the natural rate hypothesis. This result seems to suggest that the monetary growth predicted by past inflation is much better than the one predicted by past monetary growth. The poor performance of the latter method may be due to the fact that some of the important variables such as government spending, the balance of payments, and unemployment, which are determined by monetary growth, are omitted (due to lack of sufficient data) from this equation. As a final concluding note it should be pointed out that the results of this study should be interpreted with caution because many of the problems associated with natural resource-based developing countries such as import restrictions, frequent devaluations, debt problems, crop failures, etc., were not explicitly incorporated in the estimation of the models included in this study.

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