Endogenous Foreign Exchange Intervention in Latin America

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Abstract
This paper shows the existence of an (inefficient) equilibrium foreign exchange intervention bias when the exchange rate regime is endogenous, in the sense that it is the outcome of an exchange rate policy game. The intervention bias holds regardless of the (first-mover) status of the players (central bank vs market participants) and is negatively related to the degree of central bank independence. We present evidence for Latin American countries for the latter result. We also show that the more independent a central bank is, the more likely is for intervention to be of the leaning-against-the-wind type.
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1 Introduction

A stylized fact of foreign exchange markets is that sterilized interventions by central banks are unlikely to have permanent influence over exchange rates. Why then do central banks continue to intervene if there is no benefit to compensate for the costs of intervention? One possible answer is that intervention is not exogenously carried out by central banks; rather, it may be an endogenous outcome of the strategic interaction between the central banks and private market participants.

This paper thus shows how a nonzero equilibrium amount of intervention obtains as foreign exchange intervention is endogenized. Loss functions of a central bank and a representative speculator are specified to yield a solution which is not free float, regardless of the status of the players in the exchange rate policy game; so an "intervention bias" is likely to occur.

The intervention bias is analogous to the well known "inflationary bias" of Barro-Gordon games of monetary policy. Arguably, a game of monetary policy can explain why a zero inflation does not obtain as central banks intervene to stabilize the domestic value of a currency. Since most central banks of industrialized countries give priority to manage the domestic (and not the external) value of their currency, it is expected that the literature on monetary policy games had received widespread attention. So do we need an exchange rate policy game still? Will two separate monetary policy games, one for the domestic country and one for the foreign country, suffice to explain the countries' relative price levels? We do not think so.

One reason is that two separate monetary policy games can yield optimal price levels that might conceivably be at odds with purchasing power parity (PPP). PPP cannot be ignored since it serves as the basis for the theories of international price determination and the conditions under which international markets adjust to attain long term equilibrium. To properly evaluate the external value of a currency, we thus need to replace two separate monetary policy games with an exchange rate policy game.

This paper thus presents an exchange rate policy game to model endogenous intervention. Section 2 shows the model, and Section 3 illustrates one of its results for Latin American countries. Section 4 concludes.

2 Model

2.1 Loss functions of the central bank and the representative speculator

A domestic central bank is assumed to intervene in the foreign exchange market at the end of time period s to react to shocks that materialized between the end of $s-1$ and the end of s. The central bank's loss function L_t^{CB} is postulated as

$$L_t^{CB} = \sum_{s=t}^{\infty} \rho^{s-t} \left[\frac{(\psi\phi_s)^2}{2} + \frac{\mu(\phi_s - \phi_s^e)^2}{2} + \frac{\gamma(E_s - E_s^T)^2}{2} \right] - U_t , \qquad (1)$$

where parameter $\rho \in (0,1)$ is a discount factor applied to future losses of the central bank regarding exchange rate management; $\psi \in (0,\infty)$ is a factor of proportionality for the costs of intervention through the portfolio balance channel; $\mu \in (0,\infty)$ is a parameter capturing the costs of the expectations channel of intervention; $\gamma \in (0,\infty)$ weights the central bank aversion to deviations from its exchange rate target; ϕ_s tracks the type of foreign exchange intervention at time period s (as discussed below in detail); $\phi_s^e \in (-\infty,\infty)$ is the central bank intervention expected by a representative speculator at the end of time period s; E_s is the nominal exchange rate (home currency price of foreign currency) at time period s; E_s^T is the domestic central bank target at time period s for the nominal exchange rate; and U_t is a generic utility function at time period t.

A domestic representative speculator's loss function L_t^S is assumed to be given by

$$L_t^S = \sum_{s=t}^{\infty} \sigma^{s-t} \left[\frac{\left(\phi_s^e - \phi_s\right)^2}{2} \right] - U_t, \qquad (2)$$

where $\sigma \in (0,1)$ is a discount factor relative to future losses of the speculator.

The first terms in brackets on the right hand side in both loss functions (1) and (2) are similar to those in Almekinders (1995), while the idea of taking the utility function in the second terms on the right hand side in (1) and (2) is borrowed from Obstfeld and Rogoff (1996). Time periods are assumed to be disconnected, and thus minimization of (1) and (2) is equivalent to minimizing such loss functions for each time period separately. Accordingly, analysis collapses to a study of a repeated play of one-shot games.

The first and second terms in brackets on the right-hand side in the central bank's loss function (1) proxy the costs of intervention through the portfolio balance and expectations channels respectively. Central bank losses are assumed to increase more than proportionately with the volume of these interventions. Since intervention volumes are very tiny compared to the daily turnover on the foreign exchange market, interventions through the portfolio channel may be negligible implying $\psi = 0$. Owing to this, equation (1) leaves room for the possibility of central bank intervention to work through the expectations channel. So the second term in brackets on the right-hand side in (1) allows the central bank to exploit the divergence between actual and expected interventions to influence the nominal exchange rate by catching the representative speculator off balance. There is no costs for this sort of intervention if the expectations channel is not operative, in which case $\mu = 0$.

The third term in brackets on the right-hand side in (1) tracks the fact that central bank losses increase more than proportionately with the nominal exchange rate changes that are not caused by the relative state of the macroeconomic "fundamentals" in the domestic country. The last term on the right-hand side in (1) shows that the central bank not only pays attention to exchange rate policy but also considers the utility of domestic residents.

The first term in brackets on the right-hand side in (2) captures the domestic representative speculator's aversion to being fooled by the central bank. When that really happens, the speculator's losses increase more than proportionately. The second term on the right-hand side in (2) shows that the speculator considers the losses coming from exchange rate policy after deducting the gains given by utility. In loss function (2), the strategic interaction between the central bank and the speculator is assumed to come into play only after a shock to the nominal exchange rate has materialized. Since such a shock is probably an outcome of the interaction between the various sorts of decision made by a number of market participants, the assumption above means that issues of intra-speculators' behavior can be prevented, and thereby it is possible to treat distinct foreign currency traders as a unique representative speculator.

The following policy rule is considered to model foreign exchange intervention:

$$\frac{M_t}{M_t^T} = \left(\frac{E_t}{E_t^T}\right)^{\phi}, \tag{3}$$

where M_t is domestic money supply at t, and M_t^T is the target of the money supply. The central bank parameter ϕ tracks the degree of intervention in the foreign exchange market. It is zero under free float and approaches plus or minus infinity under the regime of a fixed nominal exchange rate. Leaning-against-the-wind intervention is represented by $\phi \in (-\infty, 0)$, whereas leaning-into-the-wind intervention is given by $\phi \in (0, \infty)$. A log version of such a rule is suggested by, for example, Marston (1985); and Obstfeld and Rogoff (1996, p. 632) have made it standard.

Free float occurs when $\phi = 0$ because in that situation the central bank focuses exclusively on the target of the money supply M_t^T, refraining from any intervention in the foreign exchange market ($M_t = M_t^T$ if $\phi = 0$). The fixed exchange rate regime holds when $\phi \to \pm\infty$ because in that case the central bank focuses exclusively on its nominal exchange rate target E_t^T, expressing no concern about the money supply ($E_t = E_t^T$ if $\phi \to \pm\infty$). Leaning against the wind is the intervention operation that attempts to move the exchange rate in the opposite direction from its current trend, and leaning into the wind is motivated by the central bank's desire to support current exchange rate trends. Here both leaning against the wind and leaning into the wind are carried out by changes in M_t^T. It might be noted that whether such changes are sterilized is not discussed.

It might be argued that non-sterilized intervention is just a combination of a monetary change and a (sterilized) intervention, in which case we are here analyzing the influence of monetary policy on exchange rates, and not overall intervention.

Anyway if $E > E^T$ for any reason, the aim of leaning against the wind is to reduce the current nominal exchange rate E. That can be achieved by reducing M^T because $\phi < 0$. If $E < E^T$, the aim of the leaning-against-the-wind intervention is to increase M^T. Since leaning into the wind means supporting the current nominal exchange rate trend, if $E > E^T$ that sort of intervention means increasing M^T when $\phi > 0$. Finally, if $E < E^T$, leaning into the wind is meant to reduce M^T.

It might also be noted that in some countries (including the United States and Japan) it is not the monetary authority who decides intervention policy, it is the government.

2.2 Nash equilibrium of the exchange rate policy game

Since the strategic interaction between the central bank and the representative speculator in the domestic country takes place after a shock to the nominal exchange rate has occurred, the shock can be observed by both the central bank and the speculator. The central bank and the speculator then simultaneously set ϕ_t and ϕ_t^e respectively. As in Barro-Gordon type models, such an equal status of the players leads to a Nash equilibrium.

The function of the central bank's reaction to the expectation of the speculator can be obtained from the minimization of its loss at time period t, taking ϕ_t^e as given. So partially differentiating (1) relative to ϕ_t and setting the result to zero yields

$$\phi_t = \frac{1}{\mu + \psi^2}\left[\frac{\partial U_t}{\partial \phi_t} - \gamma\left(E_t - E_t^T\right)\frac{\partial E_t}{\partial \phi_t} + \mu\phi_t^e\right]. \tag{4}$$

In reaction function (4), it may be noted that ϕ affects both utility and the nominal exchange rate in particular ways that are left implicit in $\partial U_t/\partial\phi_t$ and $\partial E_t/\partial\phi_t$ respectively.

Speculator's reaction function is in turn obtained by partially differentiating (2) relative to ϕ_t^e (taking ϕ_t as given) and setting the result to zero. This produces

$$\phi_t^e = \phi_t. \tag{5}$$

The intervention that corresponds to the Nash equilibrium is found by plugging (5) into (4) to give

$$\phi_t = \frac{1}{\psi^2}\left[\frac{\partial U_t}{\partial \phi_t} - \gamma\left(E_t - E_t^T\right)\frac{\partial E_t}{\partial \phi_t}\right] \tag{6}$$

In equation (6), the greater the costs of intervention through the portfolio channel (the greater ψ), equilibrium intervention is more than proportionately lower. Besides that, except if by chance $\partial U_t/\partial\phi_t = \gamma\left(E_t - E_t^T\right)\partial E_t/\partial\phi_t$, there is a nonzero equilibrium "intervention bias" ($\phi_t \neq 0$).

Such an intervention bias of discretionary exchange rate policy is analogous to the well known inflationary bias of discretionary monetary policy in Barro-Gordon type models. By employing a distinct model, Almekinders (1995) has pioneered the intervention bias being discussed here. But the model presented here is simpler than the one in Almekinders. What is more, utility considerations have been taken into account in this model. Also, here leaning into the wind and leaning against the wind types of intervention have been considered explicitly.

Equation (6) also implies that equilibrium intervention will be leaning against the wind ($\phi_t < 0$) if exchange rate management factors — i.e. $\left|\gamma\left(E_t - E_t^T\right)\partial E_t/\partial\phi_t\right|$ — are given greater importance than utility considerations — $\left|\partial U_t/\partial\phi_t\right|$ — from the part of the central bank. Leaning-into-the-wind intervention ($\phi_t > 0$) will be optimal otherwise.

It can be argued that the intervention bias is inefficient because the costs involved are not offset by any benefits. There are no benefits because, as the nonzero amount of intervention is fully anticipated by the representative speculator (equation (5)), it is not successful at limiting the impact of the shock to the exchange rate. Also, as shown below, such an intervention bias holds regardless of the status of the players in the exchange rate policy game.

It might be noted that intervention will always be inefficient because (in a sense by definition) it cannot permanently change the exchange rate. Some might argue that this may not be the right way to think about intervention. But here we do not find it appropriate to discuss the issue of inefficiency in greater detail.

2.3 Stackelberg equilibrium

The central bank acts as a leader in a Stackelberg game when it takes action before the representative speculator and knows the exact shape of the reaction function of the latter, so that it is able to choose the point on the speculator's reaction function that minimizes its own loss function. The domestic central bank thus sets ϕ_t, and thereby ϕ_t^e is determined endogenously. The Stackelberg equilibrium is obtained by first substituting speculator's reaction function (5) into central bank's loss function (1), then by partially differentiating relative to ϕ_t, and finally by setting the result to zero. As one may wish to check it out, equation (6) again obtains.

The representative speculator acts as a Stackelberg leader before the central bank when he sets ϕ_t^e, and thereby ϕ_t is determined endogenously. Now the Stackelberg equilibrium is obtained as follows. First, by inserting central bank's reaction function (4) into speculator's loss function (2), then by partially differentiating relative to ϕ_t^e and setting the result to zero, and finally by plugging the resulting expression for the expected volume of intervention into (4). The output is again equation (6).

In Almekinders' model central bank leadership removes the intervention bias. But here the invervention bias holds regardless of the status of the players in the exchange rate policy game.

3 Equilibrium intervention and central bank independence

Central bank independence has been shown to be related to low inflation rates with no consequences to economic growth (Grilli, Masciandaro, and Tabellini 1991, Alesina and Summers 1993, Cukierman 1992, Eijffinger and Haan 1996, and Jacome 2001). The independence is for the cental bank to conduct monetary policy. But such an independence can also be evaluated in terms of exchange rate management. Here heightened independence is associated with lower central bank interventions in the foreign exchange market. This issue is our major concern in this section. We also consider whether intervention "leans against the wind" or "leans with the wind".

In terms of the model in Section 2, here we focus on parameter γ, which measures the importance a central bank places in preventing exchange rate fluctuations away from its target. In the monetary policy game literature, the parameter associated with the importance given to output stability is seen as the inverse of the degree of central bank independence

(Rogoff 1985). Similarly, a central bank which lacks independence is frequently forced to intervene in the exchange rate. Politicians do influence macro policy. In particular, the more independent a central bank is, the less it is influenced by political pressure to counteract speculative shocks to the exchange rate. Our model in Section 2 has tracked such a stylized fact. Indeed our parameter γ is negatively related to equilibrium intervention in equation (6). Likewise the greater the central bank independence, the lower the variability of the intervention volume (Almekinders 1995).

Analogous to the negative relationship between inflation rate and central bank independence, Almekinders (1995) has found evidence favoring a negative relationship between foreign exchange intervention and central bank independence for 20 industrialized countries. He employs the changes of currency reserves as proxies for intervention and uses the central bank independence index developed by Eijffinger and Schaling (1993). A negative relationship has also been found for the variability of intervention and independence.

Here we extend Almekinders' results to the emerging markets of Latin America. We take 13 countries, namely Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominican Republic, Guatemala, Mexico, Paraguay, Peru, Uruguay, and Venezuela, and consider the time period ranging from 1999 to 2001. The central bank (legal) independence index is taken from Jacome (2001). Intervention is proxied by both changes in the currency reserves of a central bank (as in Almekinders') and our policy rule given by equation (3).

For the first case, the percentual monthly average change in currency reserves (*ACFER*) is reckoned as

$$ACFER = \frac{1}{36}\sum_{1999/01}^{2001/12}\frac{\left(reserves_t - reserves_{t-1}\right)}{reserves_{t-1}} \tag{7}$$

Variability of the reserves (*VACFER*) is measured by the variance of equation (7), i.e.

$$VACFER = \frac{1}{36}\sum_{1999/01}^{2001/12}\left[\left(\frac{reserves_t - reserves_{t-1}}{reserves_{t-1}}\right) - ACFER\right]^2 \tag{8}$$

Table 1 shows the negative relationship between central bank independence and the percentual average change in currency reserves as well as the variance. As can be seen, countries with a lower index of independence usually carry out larger foreign exchange interventions. Also, the lower the independence index the greater the variance of reserve changes. Outliers are Argentina and Peru. The Argentine exception, for instance, can be explained by its regime of currency board. Its central bank's commitment to peg the exchange rate caused its reserve changes to vary a great deal. Table 2 shows the negative relationship as in Table 1 by employing an ordinary least square regression. (Argentina and Peru have been dropped from regression (2).) Our findings are thus in accordance with those of Almekinders for industrialized countries.

Using changes in foreign reserves to proxy for intervention might be criticized on the basis that reserves can change for reasons having nothing to do with intervention. For instance, if the currency of a country depreciates this will automatically increase the relative value of any foreign exchange holdings in the central banks portfolio. In such a situation the positive correlation between intervention (proxied by reserve changes) and lack of central bank independence could be explained by the fact that countries with a less independent central bank have more expansionary (and variable) monetary policy, which in turn leads to a more depreciated (and volatile) exchange rate, and therefore to larger (and more variable) foreign reserves.

Having in mind the discussion above we find it useful to check for the robustness of the positive correlation between intervention and lack of central bank independence. Thus we now take policy rule (3) to alternatively proxy for intervention. Actually we replace the nominal money supply deviation from its target with a target for the nominal interest rate i^T. We also stylize the departures of the nominal exchange rate from its target as the deviations of the real exchange rate R from its PPP value of one. This is justified because a central bank's main concern is to counteract speculative changes of the nominal exchange rate. Such a modified rule in natural logs is given by

$$\ln\left(i_t^T\right) = \phi \ln\left(R_t - 1\right) \tag{9}$$

The intervention coefficients employed in the cross-country evidence have been obtained by individually estimating equation (9) for every country (Table 3). Table 4 shows the results. Cases displaying NS are those for which an estimated coefficient is not statistically significant at the 10% level. Table 4 also shows that countries with greater central bank independence index have carried out intervention of the leaning-against-the-wind type. Likewise, countries with lower central bank independence usually lean with the wind. Exceptions are Costa Rica and Venezuela with non-significant coefficients. Table 5 shows the latter result with ordinary least square regressions.

That leaning against the wind is the usual type of intervention can be seen in the negative sign of the deviations of the real exchange rate from its PPP value of one in the regressions for Bolivia, Chile, Colombia, Mexico, and Peru in Table 3. In contrast, the positive sign of the regressions in Table 3 refers to the countries with leaning-with-the-wind intervention.

Regressions (1) and (2) in Table 5 present the negative relationship between the intervention coefficient and the central bank independence index by dropping from the sample those countries with non-significant intervention coefficients (Table 3) together with Bolivia (which is an outlier) (Table 4).

Regression (1) in Table 5 also shows that variables are related at a significance level of up 10%. Its R^2 suggests that nearly 37 percent of the changes in the intervention coefficient can be explained by the independence index. However, the Durbin-Watson test might be compatible with a first order autocorrelation. Yet the LM test with up to six lags has rejected the hypothesis of autocorrelation; also, the White test has rejected the hypothesis of heteroscedasticity. The shortened sample with Bolivia out has replicated the negative relationship (–0.612) and hightened the explanatory power of the regression (R^2 = 0.52).

Thus the proposition that increased central bank independence can be associated with lower intervention in foreign exchange markets has been extended from industrialized countries to emerging market economies. What is more, we have shown that the more independent a central bank is, the more likely is for intervention to be leaning against the wind. The latter result is novel and not shown by Almekinders to industrialized countries.

4 Concluding remarks

This paper shows that there exists an (inefficient) equilibrium foreign exchange intervention bias when the exchange rate regime is endogenous, i.e. when it is the outcome of an exchange rate policy game. Such an intervention bias is shown to hold regardless of the (first-mover) status of the players (central bank vs market participants).

Equilibrium intervention is found to be leaning against the wind if exchange rate management factors are given greater importance than utility considerations from the part of the central bank. And leaning-into-the-wind intervention will be optimal otherwise.

Such results depend critically on the shape of the postulated loss functions (1) and (2). Despite that, the finding that it is possible for a nonzero amount of foreign exchange intervention be an equilibrium remains of interest. That is because central banks continue to intervene unsuccessfully in real world markets with no benefit to compensate for the costs of intervention, and also because such loss functions are fairly standard in literature.

The intervention bias is negatively related to the degree of central bank independence. Such a result has been previously shown to hold true for industrialized economies. Here we further present evidence to Latin American countries. We also show that, to the Latin America data, the more independent a central bank is, the more likely is for intervention to be leaning against the wind, a result which is envisaged by our own theory.

Country	*ACFER*	*VACFER*	*CBI*
Argentina	1.0388	594.158	18.5
Bolivia	–0.1911	41.721	13.5
Brazil	–0.0127	94.056	12
Chile	–0.1895	6.818	16.5
Colombia	0.5568	5.231	15
Costa Rica	1.0550	98.147	12.5
Dominican Republic	–0.2374	6.936	7
Guatemala	3.1691	242.065	7
Mexico	1.7277	76.427	16
Paraguay	1.0053	9.262	10.5
Peru	1.2827	460.502	17
Uruguay	1.1974	18.224	12.5
Venezuela	–0.6422	23.211	10

Table 1. Intervention and central bank independence in Latin America, 1999-2001

Notes
Data for *VACFER* have been taken from IMF's *International Financial Statistics*.
ACFER stands for the intervention coefficient represented by the percentual monthly average change of currency reserves in the central bank in a given time period; *VACFER* is the variance of the percentual monthly average change of currency reserves in the central bank; and *CBI* is the central bank independence index.

$$ACFER = \underset{(2.63)}{2.594^{**}} - \underset{(-1.93)}{0.142^{*}}CBI \qquad (1)$$

Adjusted $R^2 = 0.186$ DW = 1.51 F-Stat = 3.75

$$VACFER = \underset{(3.64)}{233.644^{**}} - \underset{(-2.86)}{14.0147^{**}}CBI \qquad (2)$$

Adjusted $R^2 = 0.418$ DW = 1.85 F-Stat = 8.18

Table 2. Average changes in currency reserves and central bank independence

Notes
* and ** are meant significance at the 10% and 5% level respectively.
Figures in brackets show the *t*-statistic; DW is the Durbin-Watson statistic; R^2 is the deterministic coefficient; and F is the global statistic of a regression.

$\Delta i^T = 0.0042 - 0.00175\ \Delta D$ (Argentina)

(5.43) (–1.18)

Adjusted $R^2 = 0.04$ DW = 1.63 F-Stat = 1.40

$\Delta i^T = -0.065^{*} - 5.818^{*}\ \Delta D$ (Bolivia)

(–1.76) (–1.86)

Adjusted $R^2 = 0.09$ DW = 2.04 F-Stat = 3.098

$\ln i^T = 0.480^{**} + 0.685^{**}\ \Delta D$ (Brazil)

(43.09) (–3.39)

Adjusted $R^2 = 0.245$ DW = 2.15 F-Stat = 11.52

$\ln i^T = 1.015^{**} - 1.808^{*}\ \Delta D$ (Chile)

(27.6) (–1.79)

Adjusted $R^2 = 0.08$ DW = 1.83 F-Stat = 2.88

$\Delta i^T = -0.030^{*} - 1.769^{**}\ \Delta D$ (Colombia)

(–1.71) (–2.17)

Adjusted $R^2 = 0.129$ DW = 1.89 F-Stat = 4.73

$\Delta i^T = -0.006^{*} - 0.189\ \Delta D$ (Costa Rica)

(–1.94) (–0.37)

Adjusted $R^2 = 0.004$ DW = 1.98 F-Stat = 0.13

$\Delta i^T = 0.783^{**} + 4.816^{**}\ \Delta D$ (Dominican Republic)

(21.22) (2.27)

Adjusted $R^2 = 0.13$ DW = 2.06 F-Stat = 5.15

$\Delta i^T = -3.491^{**}\ \Delta D$ (Guatemala)

(–5.13)

Adjusted $R^2 = 0.30$ DW = 1.67

$\Delta i^T = 0.738^{**} - 0.658\ \Delta D$ (Mexico)

(12.45) (–0.20)

Adjusted $R^2 = 0.01$ DW = 1.89 F-Stat = 0.04

$\Delta i^T = -0.011^{*} - 1.081^{*}\ \Delta D$ (Paraguay)

(–1.76) (–1.91)

Adjusted $R^2 = 0.10$ DW = 1.83 F-Stat = 3.68

$\Delta i^T = 0.005\ \ln D$ (Peru)

(0.67)

Adjusted $R^2 = 0.00$ DW = 2.10

$\Delta i^T = 0.089 + 4.07^{*}\ \Delta D$ (Uruguay)

(1.28) (1.65)

Adjusted $R^2 = 0.07$ DW = 2.05 F-Stat = 2.40

$\Delta i^T = 1.361^{**} - 4.541\ \Delta D$ (Venezuela)

(16.77) (–0.60)

Adjusted $R^2 = 0.01$ DW = 1.82 F-Stat = 0.36

Table 3. Policy rule: individual country regressions

Notes

Δ stands for a series' first difference in natural logs, and D is the deviation of the real exchange rate from its PPP value of one.

All series are stationary, and all coefficients are stable over the sample period. ADF and Phillips-Peron tests have been employed to check for stationarity. Parameter stability has been evaluated by the CUSUM test. When autocorrelation and heteroscedasticity in residuals have been detected, they have been corrected properly.

Country	*IC*		*CBI*
Argentina	–0.001751	(NS)	18.5
Bolivia	–5.818		13.5
Brazil	0.685		12
Chile	–1.808		16.5
Colombia	–1.769		15
Costa Rica	–0.1895	(NS)	12.5
Dominican Republic	0.0050	(NS)	7
Guatemala	4.816		7
Mexico	–3.491		16
Paraguay	–0.6578	(NS)	10.5
Peru	–1.0812		17
Uruguay	4.07		12.5
Venezuela	–4.541	(NS)	10

Table 4. Intervention coefficient and central bank independence, 1999-2001

Notes
Data on nominal exchange rates, a country's price level, and the American price level have been collected in IMF's *International Financial Statistics*.
IC is the estimated intervention coefficient for every country (Table 3); NS stands for non-significant intervention coefficients (estimated in Table 3).

$$IC = 9.704^{*} - 0.749^{*}\, CBI \qquad (1)$$
$$\quad (2.09) \qquad (-2.29)$$

Adjusted $R^2 = 0.37$ DW = 0.95 F-Stat = 5.11

$$RIC = 8.941^{**} - 0.612^{**}\, RCBI \qquad (2)$$
$$\quad (2.95) \qquad (-2.98)$$

Adjusted $R^2 = 0.52$ DW = 1.54 F-Stat = 8.85

Table 5. Estimated intervention coefficient and central bank independence index

Notes
IC and *CBI* are now the intervention coefficient and central bank independence index respectively for the countries with significant coefficients.
RIC and *RCBI* are the former series with Bolivia dropped.

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