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CENTRAL BANK INDEPENDENCE AND FOREIGN EXCHANGE POLICIES IN LATIN AMERICA

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I. Introduction

The purpose of this paper is to analyze the links between central bank independence and foreign exchange policies, in the light of the recent experience of the major Latin American countries. To that end, the paper starts with a brief review of the literature on the subject. The second section of the paper deals with the different structures or models of central bank and foreign exchange management adopted in Latin America. The third and central part sets up an analytical model which describes the objective function of the authority and derives the expected inflation path for each type of Latin-American central bank model. The paper ends with a section of monetary games illustrating the conflicts that arise between the Government and an independent central bank, when the monetary and foreign exchange policies are not controlled by the same authority.

II. The conflicts between price stabilization and exchange rate policies

While the literature on credibility, central bank independence and inflation targets is a growing branch of macroeconomics, the references to central bank independence and foreign exchange policies are scarce and have been given a rather minor importance. From the point of view of this paper, it is important to underlie that the idea behind the central bank independence comes as a response to the well known dynamic inconsistency, as a means to give society a credible signal that it will not be subject to surprise inflation, **Kydland and Prescott (1977) and Barro and Gordon (1983).** The literature also finds that, to that end, it is better if central banks are given the sole mandate to control inflation. Finally, the empirical results indicate that, in effect, countries with more independent central banks tend to show lower inflation, **Cuckierman (1992) and Alesina and Summers (1993).**

In regard to the link between central bank independence and foreign exchange policy, the main reference on the subject, **Cottarelli (1994),** establishes that, although there are many arguments against giving the management of the exchange rate to the central bank (i.e. exchange rate policy is too important to be

left to central bankers; price stability does not pay attention to unemployment; sharing responsibilities for the exchange-rate role and monetary policy improves coordination, etc.), the fact is that "an independent central bank can not be fully independent in the pursuit of price stability as long as the government controls foreign exchange policy". To illustrate his view he shows that because the money supply and the exchange rate are not independent there may be conflicts when each policymaker acts. The degree of conflict depends on the amount of capital inflows and the effectiveness of capital controls and sterilization efforts.

In the same vein, **Fischer (1994)** argues that monetary and exchange rate policy can not be independent under floating rates, given that monetary policy, through the interest rate, affects the exchange rate. In the case of fixed rates, monetary policy becomes endogenous and the central bank loses its independent ability to determine the inflation rate and interest rates.

The conflicts that may arise between price stabilization and foreign exchange management is also evidenced in recent articles that analyze real exchange-rate targeting. **Montiel-Ostry, (1992) and Calvo-Reinhart-Végh, (1993),** find, from different perspectives, that the attempt to reach a real exchange rate inconsistent with its fundamentals would have an adverse impact on monetary policy and inflation. Montiel and Ostry's main result is that choosing an overdepreciated exchange rate, even with a view of achieving some external balance, leads to a rise in the economy's inflation rate. In the same sense, the model developed by Calvo, et.al. suggests that, in the absence of changes in fiscal policy, a more depreciated level of the real exchange rate can only be attained temporarily. The consequence would be a cost in terms of higher inflation or higher interest rates, depending on the degree of capital mobility.

III. The Latin-American Experience with independent central banks

Being the inflation prone continent, it is not surprising to find that the major Latin-American countries have, in the recent years, adopted strict stabilization policies and that, at the same time, in the major countries, there has been a trend

towards central bank independence, as an institutional means to reduce inflation. On the other hand, the Latin-American experience with the debt crisis and ensuing balance of payments problems have also led to a variety of policies to manage the exchange-rate in order to prevent its overvaluation. Such circumstances have implied the development of alternative models of central bank independence, **Junguito (1994); Dueñas-Lindgren (1995),** and foreign exchange policies that are worthwhile to evaluate.

To start with the models, Table 1, the case of Argentina, in effect, is more a currency board system, than that of an independent central bank, **Kiguel (1995)** and **Rodríguez (1995).** The exchange-rate is anchored to the US dollar through the convertibility law, which also establishes that the monetary base is covered 100% by reserves. As a result, there is an endogenous monetary policy and its inflation rate, even with inertial problems in the non-tradable sector, tends towards international inflation. In fact, the convertibility law allows little room for the authorities to accommodate shocks with expansionary fiscal and monetary policy. As a result of its institutional scheme, its independent central bank has, above all, the responsibility towards the protection of the banking system and it maintains the supervisory role, and it has severe limitations on its capacity to extend credit to the Government. The more recent Brazilian Plan Real system can be said to be an attempt to anchor the exchange-rate in order to reduce inflation which has been inspired by the Argentinean model.

A second and contrasting central bank model is that of Chile and Colombia. In these two countries central bank independence was created as a result of constitutional reforms. The central bank Boards in both countries have the unique macro economic mandate of controlling inflation. Besides, central banks have instrument independence in areas of monetary and foreign exchange policies. Both countries have adopted band systems to allow the exchange rate to fluctuate, thus gaining room in terms of monetary management. Capital controls in the form of reserve requirements on foreign capital inflows have been adopted in order to

TABLE 1

CENTRAL BANK INDEPENDENCE IN LATIN-AMERICA

COUNTRY	CENTRAL BANK INDEPENDENCE			MONETARY NDEPENDENCE		FOREIGN EXCHANGE POLICY		
	CBI	**Legal Background**	**Major CBI Goals**	**Monetary Policy**	**CB Limits To Finance Goverment**	**Exchange- Rate Policy**	**Capital Controls**	**Foreign Exchange Regime**
Argentina	Quasi Currency Board. 1992	Constitutional Law	Inflation and financial stability	Endogenous	Strict	Legal Nominal Anchor	None	Legal
Brazil	No	No	Inflation and Growth	Government	None	Legal Nominal Anchor	Yes Official	Official By Decree
Chile	Yes. 1989	Constitution	Inflation	Central Bank	Strict	Central Bank Exchange Rate Bands	Yes CB	Official and Legislation
Colombia	Yes. 1991	Constitution	Inflation	Central Bank	Strict	Central Bank Exchange Rate Bands	Yes CB	Official and Legislation
Mexico	Yes. 1993	Constitution	Inflation and Growth	Central Bank and Government	Loose	Flexible	None	Legal
Venezuela	Yes. 1992	Ordinary Law	Growth and Inflation	Central Bank and Government	Loose	Discretionary Management By Official Committee	Yes Official	Official By Decree

enhance the possibility to establish interest rate differentials with a minimum impact on exchange-rate appreciation due to inflows.

The Mexican and Venezuelan models represent, in a certain sense, a weaker version of the independent central bank scheme. Both countries have, in fact, adopted through legislation the independent central bank format, although in Venezuela it sprang ordinary legislation while in Mexico it has constitutional roots. In both countries it can be argued that the central banks have as a major but not unique mandate the control of inflation. In terms of instrument independence, in both nations the central bank is, in theory, autonomous in terms of monetary policy, but not so in exchange-rate policies. Foreign exchange policy in the two countries is decided upon through special committees where the central bank is present but the Government has the final decision. There has been, however, a significant difference in the two countries in terms of capital controls: while Mexico has maintained, even throughout the crisis, an open capital account, Venezuela introduced a severe exchange control scheme to restrict capital outflows. Another common characteristic consistent with the weaker autonomy of the central banks is the fact that the Government, in frequent cases, ends up being the final and major decision-maker, all of which means that there is little effective instrument independence in the hands of the central bank.

All such cases contrast with the more traditional and most prevailing model in which the government alone sets the development priorities (both inflation and growth targets) and keeps full instrument autonomy in terms of monetary and exchange-rate policies, in most cases without committing itself to any rules, and reserving itself full discretion in terms of targets, capital controls and instrument implementation. In these countries the central banks are an integral part of government and they intervene in the foreign exchange market and manage monetary policies according to Government directives. Due to the discretionary regime, society can be easily subject to inflation surprises and the outcomes in the terms of inflation and growth depend on government's discretion and society's credibility of official announcements.

IV. Implications of the Latin-American models

In order to analyze the implications in terms of the path of intertemporal inflation, stemming from the different central banking and foreign exchange policies models adopted by the Latin-American countries, which corresponds to the central banks' major objective, following **Gavazzi and Pagano (1988),** it is useful to consider a welfare function V, where authorities care for the profitability of the export sector and value positively the level of the real exchange rate (q). Besides, in the **Barro-Gordon (1983)** fashion, it is assumed that the authorities dislike price instability captured by a quadratic term in inflation (π_t^2) and they have an incentive to create inflation surprises ($\pi_t - \pi_t^e$), while (π_t^e) is the expected inflation. Given the authorities time preference discount rate (ρ), the welfare function can be written as:

$$V=\int_o^{\infty} e^{-\rho t}[hq_t + c(\pi_t - \pi_t^e) - \frac{a}{2}\pi^2]dt$$

where,

h > 0 is the relative weight given to the real exchange rate

c > 0 is the relative weight given to surprise inflation

a > 0 is the coefficient of inflation dislike

If, on the other hand, the time path of the real exchange rate depends on an initial level (i.e. ppp) less the accumulated inflation, which implies anchoring the nominal exchange rate for a period of (T) years, and defending the real exchange rate through lower inflation, Giavazzi and Pagano show that the maximization of the welfare function subject to the behavior of the real exchange rate yields a path for inflation given by:

$$\pi_t^* = (1/a)[c - \frac{h}{\rho}(1 - e^{\rho(T-t)})] \quad \text{for } t \in (0,T)$$

In this expression, the expected path of inflation is shown to decline not only with the higher the inflation aversion coefficient (a) and the importance given to the real exchange rate (h) but also by the longer the time period (T) that it takes before the nominal exchange-rate has to be devalued. The expected inflation path increases with the surprise inflation parameter. From the model, one may also derive that anchoring the nominal exchange rate, thus prolonging indefinitely the realignment period (T) lowers the expected inflation path. Besides, it ought to be noted that the higher the importance given by society to the defense of the real exchange rate, the lower is the expected inflation path given that, by assumption, the real exchange rate deteriorates if there is higher inflation.

In the event that the authorities adopt a flexible foreign exchange system and do not include the real exchange rate in the welfare function, the expected inflation becomes a constant rate, given by the quotient between the surprise inflation (c) and inflation aversion (a) coefficients. If compared with the more general model, it is found that the expected inflation rate path is always strictly smaller in the case that the real exchange rate is included in the welfare function.

This last result is used by Giavazzi and Pagano to illustrate the advantages for an individual European country to belong to the EMS system. Commitment to the European Monetary System would permit buying lower inflation, except at realignment dates. In the same way, it can be argued that the model may be used to compare the Argentinean-Brazilian A-B, model, with the Chilean-Colombian, C-C, one. In fact, Argentina and, in a lesser way, Brazil tied their hands in terms of nominal exchange-rate adjustments and to the extent that they share similar surprise and aversion coefficients to Chile and Colombia, their expected path of inflation would be lower. The case to expect a lower inflation is specially clear for Argentina, if due regard is given to the fact that the exchange-rate anchor was adopted by law; that its monetary system reduces the likelihood of inflation surprises, and that the expected period of an eventual realignment has been prolonged with the reelection of President Menem, and the continuation is office of Minister Cavallo. A different story is that of Brazil where the exchange rate

commitment is less solid, and where inflation surprises can not be disregarded. Table 2 and Graph 1 show the stylized facts which allow to compare the expected outcomes with the real observations.

As to the possible differences in the expected inflation paths of Chile and Colombia, the relevant model, which depends exclusively on the ratio of the surprise inflation and inflation aversion coefficients, suggests a lower path in Chile, given its more aggressive commitment to lower inflation. It is found that starting with similar inflation rates around 1990, targets have been more ambitious in Chile (i.e. reaching one digit inflation by 1994 vis a vis inflation targets around 20% for Colombia), which is indicative of a higher dislike coefficient. More importantly, in terms of credibility such targets have been consistently met in Chile, and not in Colombia, Table 3, which, on the other hand, suggests that the inflation surprise coefficient is larger in Colombia. After all, Colombia has shown a small, but almost consistent deviation in its commitments in terms of its monetary and fiscal intermediate targets. A potential future advantage of Colombia, which is not adequately taken into account in the model, regards the design of the exchange rate bands: while in Colombia the slope of the band is forward looking and estimated according to expected inflation differentials, in Chile it is adjusted according to registered inflation, given that it is directly linked to the indexation, UF, mechanism. This implies that an external shock could introduce in Chile an undesired inflation bias.

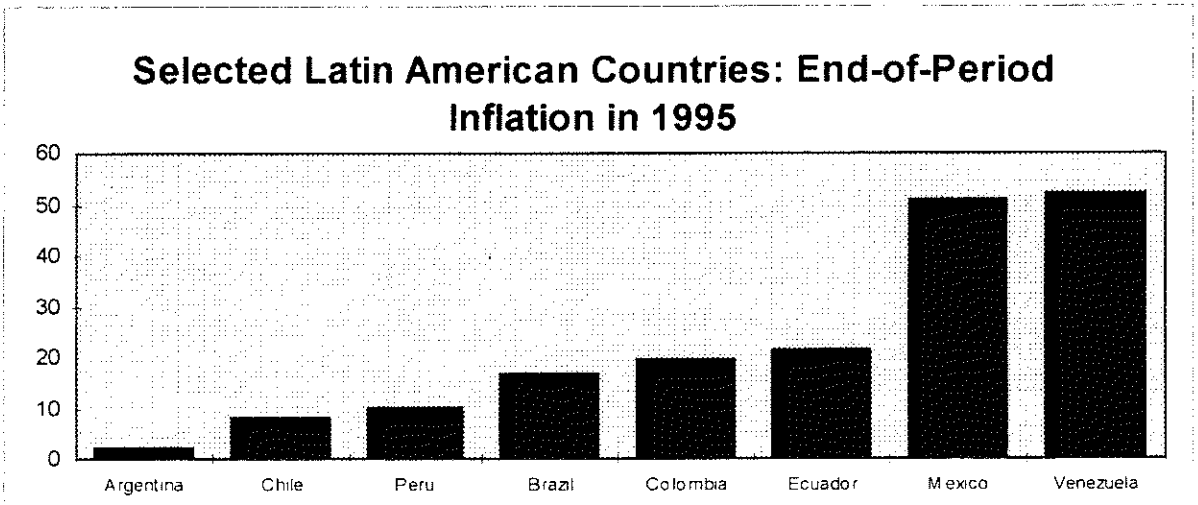
Giavazzi and Pagano extended their model to explore the implications in the case that the authorities need to tap the inflation tax beyond inflation surprises which have a growth and employment objective in mind. They consider additional motives for monetary expansion directed to reduce the real value of nominal liabilities and obtain revenues from seignorage as a further incentive to inflate. Such version of the model is useful in order to illustrate and compare the cases of Mexico an Venezuela, M-V, given that both countries used extensively their printing machines in recent years as a means to face the banking crisis and the macroeconomic disequilibria that the two countries faced.

Table 2

Country	Inflation 1/		M1 Growth 2/		Interest Rate 3/		Real Exchange Rate 4/		Fiscal Deficit 5	
	91	95	91	95	91	95	91	95	91	95
Argentina	171.7	3.3	148.6	5.9	61.7	12.2	N.D	N.D	(0.5)	(0.7)
Brazil	440.9	82.8	429.4	103.8	913.5	52.2	N.D	N.D	(1.0)	N.D
Chile	21.8	7.9	43.2	1.6	22.3	13.7	103.2	118.0	1.5	1.6
Colombia	30.4	20.9	31.7	14.8	37.2	33.4	103.4	115.3	(0.3)	(3.0)
Mexico	22.7	35.0	123.9	(8.9)	17.1	39.2	N.D	N.D	(0.2)	(0.9)
Venezuela	34.2	56.3	29.1	6.6	31.1	24.2	106.8	138.2	4.4	(4.3)

Source: IMF Statistics and Banco de la República.
1/ Information up to nov-94, nov-94, yearlyl of 1994, dec-95, sep-95 and jul-95, respectively.
2/ Includes information up to dec-94, nov-94, may-95, dec-95, oct-95 and sep-95, respectively.
3/ Considers information up to nov-95, dec-95, dec-95, dec-95, dec-95 y nov-95, respectively.
4/ In the three cases the date of 1995 includes information up to october.
5/ With information up to 1994 for Argentina, Chile, Mexico, and Venezuela, and up to 1995 in Colombia. Refers to Central Government Déficit.1

Graph 1



Source: Banco de la República and Fund staff estimates.

Table 3

Inflation Targets - Chile and Colombia

YEAR	CHILE		COLOMBIA	
	TARGET	OBSERVATION	TARGET	OBSERVATION
1990		27.3		32.4
1991	18-20	18.7	22.0	26.8
1992	13-15	12.7	22.0	25.1
1993	10-12	12.2	22.0	22.6
1994	9	8.9	19.0	22.6
1995	8	8.2	18.0	19.5
1996	6.5	?	17.0	?

Source: Banco Central de Chile and Banco de la República.

In the case of Venezuela, it should be recalled that since the beginning of 1994 its central bank was forced to issue money both as a lender of last resort to attend the banking crisis and even to attend insolvency cases, **Housmann-Gavin (1995),** as well as to facilitate the finance of its very large fiscal deficit. In the case of Mexico, the speculative attack on the currency and eventual devaluation of the peso at the end of 1994 and the consequent reimbursement of short-term capital inflows forced the authorities to use the seignorage, by expanding domestic credit, as a first step to facilitate the substitution of peso denominated government debt (Cetes) sold to the central bank, into dollar denominated paper (Tesobonos). Their argument was to prevent a banking crisis, that according to the authorities would have faced the country had the central bank opted to increase the domestic interest rates as a means to prevent the capital outflows, in what has otherwise been considered an inadequate policy response, since the government lost its liquidity and became financially very vulnerable **Sachs, Tornell and Velasco (1995).**

From the analytical point of view, the way to incorporate the seignorage into the model was to include within the brackets of the welfare function a term ($b\pi_t$) to "describe the authorities incentive to collect revenue the form seignorage", where the term (b) is the parameter that indicates the relative importance given to the incentive to collect revenue from monetary policy. The authors show that the optimal path for inflation, when seignorage is included, becomes:

$$\pi_t^{*|} = \pi_t^* + \frac{b}{a}$$

where,

$\pi_t^{*|}$ = Expected inflation path including seignorage

π_t^* = Expected inflation path in the original model

The result indicates that the introduction of seignorage into the welfare function leads to an expected inflation path which is strictly higher than in the basic model, and that the expected higher inflation depends directly on the seignorage parameter and inversely on the coefficient of adversity to inflation. Applied to the Latin-American models, the results shown above indicate that, given seignorage revenues, the expected inflation path in the M-V model would lead to higher inflation that in the A-B model. It should be recalled that in the case of Argentina the Convertibility Law limits very significantly the capacity of monetary expansion by the central bank.

The expanded version of the model, including seignorage, together with the stylized facts of Table 2, also allow a comparison between the expected inflation paths of Mexico and Venezuela. In the first place, the coefficient of inflation dislike is lower in Mexico if one considers its target inflation commitment and its inflation performance before its speculative attack on the currency. On the other hand, Mexico must also have a lower surprise inflation coefficient given that in the years previous to its crisis, it met almost consistently its inflation target, something that did not occur in Venezuela. Besides, the recurrent use of seniorage has been characteristic in Venezuela and not in Mexico, where the public finances have

been in equilibrium. Finally, even though in terms of the extended model Venezuela would seem to have on advantage edge by having anchored its nominal exchange-rate while Mexico has a floating regime, the real exchange rate in Venezuela, given the misalignment in fundamentals, has not been sustainable.

On the other hand, the comparison between the expected inflation paths of M-V and the C-C models is also easy to establish a priori. Chile and Colombia have the advantage of more restrictive rules to use seignorage, given their central banks' limited capacity to extend credit to the Government, and also, because their structure of more independent central banks, makes them less prone to use surprise inflation. At least vis a vis, Venezuela they hold a higher commitment to lower inflation, which implies a lower aversion coefficient. Besides, neither Venezuela or Mexico have a lasting commitment of pegging their exchange rates, while the C-C model, allows exchange -rate flexibility, but limited by the width of their band-system..

A final issue to discuss is the way in which capital controls affect the expected inflation paths. To start, it is useful to note that the basic analytical model developed so far assumed the existence of capital controls. This is so to the extent that a country that anchors its nominal exchange rate and which at some time in the future (T) realigns its currency does not appear to be subject to a speculative attack, despite the overvaluation of its currency.

Giavazzi and Pagano extend their model to include the case of complete absence of controls. Their argument is that the impact of controls, in terms of foreign exchange flows, can be offset through appropriate interest rate hikes. At the same time, they point out that the policymaker assigns a negative weight (f) to the volatility of nominal interest rates in its welfare function, by adding the term $-(f/2)(i_t^\tau - \bar{i}^\tau)^2$ in the welfare function V, where $(f)>0$ and (i_t^τ) is the interest rate on a deposit issued at a time (t) with maturity (τ), and $(\bar{i}^\tau)$ being its means.

With such assumptions and considering that the domestic interest rates are linked to the international market through interest rate parity, they work out the optimal inflation path as:

$\hat{\pi}_t^* = \pi_t^* + \frac{b}{a} - \frac{f}{\rho} x$ where x is a positive discount factor which depends on r, T

This result implies that the higher the adversity to interest rate instability (size of the (f) coefficient) the lower is the inflation path. The intuitive explanation of such result being that when the policy-maker is also concerned about the volatility of interest rates, he will be more cautious about generating inflation given that it will be translated into larger devaluation expectations, which will require a larger rise in interest rates to prevent a speculative attack.

This version of the model has interesting implications for the Latin-American case. In the first place, the absence of capital controls typical of the Argentinean model, with the resulting threat of interest rate instability acts as an additional or reinforcing element of care for rising inflation. The absence of capital controls was, however, one of the major problems faced by Argentina, as a result of the Mexican crisis and explains the exceptional importance given by its central bank to banking supervision and the need to recur to very high required reserves. The assumption of absence of capital controls gives an additional theoretical edge of advantage to the A-B model vis a vis a C-C model, which assumes capital controls. Despite the model the experience, as a result of the Mexican crisis, showed that Argentina became very vulnerable to capital outflows and that to curtail them the monetary authorities were forced to allow a significant rise in interest rates. As **Kiguel (1995)** shows, dollar denominated rates rose up to a peak level of 40% by March 1995.

When the cases of Chile and Colombia are compared, it is observed that Chile has been more cautious in terms of interest rate instability. In fact, Chile despite its capital controls has introduced the real interest rate as an intermediate target, as part of its financial indexation, **Mendoza and Fernández (1994)**, which is illustrative of the importance that it assigns to interest rate instability into its welfare function. This situation contrasts with that of Colombia, which has, so far, established monetary aggregates as an intermediate objective and where interest

rate instability was been larger. From the point of view of the model, Chile's relative advantage in terms of its expected inflation path is accentuated. Chile's position is understandable if it is recalled that its exchange-rate band system has an inflation bias and the country could more easily be subject to the nominal devaluation-interest rate spiral.

Before leaving the Chilean and Colombian cases, it is useful to point out that their capital control scheme has been mainly guided to reduce capital inflows rather than preventing outflows. However, to the extent that they have been successful to reduce their volume and, more importantly, to minimize the short-term inflows, they would be more protected in terms of an eventual speculative attack. The available literature regarding the effectiveness of capital controls in these two countries is rather mixed. Recent articles regarding the Colombia, **Cárdenas (1995)** and Chilean cases, **Valdes-Prieto and Soto (1995)** arrive to similar conclusions. In both countries it is found that capital controls have reduced temporarily the short-term inflows, but that their foreign-exchange deposit scheme has not been able to reduce the total volume of inflows.

As to the M-V case, contrary to what is suggested by the model, it should be noted that their adversity to interest-rate instability has been so significant that, to a large extent, their macro disequilibria is due to it. In the case of Venezuela, with the changeover of Government and the turnover of the Central Bank President, in 1994 the tight interest rate and monetary policy was abandoned, given the banking crisis and the need to finance the Government, and a strict and distorsionary capital control scheme was adopted. In the case of Mexico, as explained above, the speculative attack on the currency, in a country with an open capital account, was not suppressed through interest rate hikes. Neither country was able to adopt adequate policy responses to prevent a burst in inflation, despite their adversity to interest rate instability as implied in the model.

V. Central Bank Independence and Foreign Exchange Policy

A. Lessons from the Latin-American Experience

What can be said in terms of central bank independence and foreign exchange management, in the light of the Latin-American experience? The findings in this article based on the analytical model developed by Giavazzi and Pagano for the European nations shows that central bank independence with foreign exchange management in its hand does not seem to be a necessary condition for a lower expected inflation path, as the A-B currency model illustrates. In fact, as pointed out by **Rodríguez (1995),** in the case of Argentina the authority to devalue the nominal exchange rate was transferred to Congress through the convertibility law. Nevertheless, in order for and A-B type of model to work appropriately it is required that it becomes impossible to use monetary policy as a seignorage; and that complementary policies be adopted in order to commit to inflation aversion and minimize the risk of inflation surprises. Besides, the nominal exchange-rate must be set initially on its equilibrium level so that the period before the realignment is prolonged as soon as possible.

On the other hand, the results of the paper indicate that if the institutional model adopted is that of an independent central bank, rather than a quasi-currency board system, then it becomes advantageous that both monetary and exchange-rate policy, be managed by the central bank, as the literature indicates. Such conclusion was arrived upon by comparing the central bank models of Chile and Colombia, C-C, with those of Mexico and Venezuela, M-V.

In the case of central bank independence the C-C model performs better than the M-V model not only due to its stricter commitment to controlling inflation, and higher credibility, as well as to its lesser use of seignorage, but also due to its advantage in terms of management of foreign exchange policy. As discussed above, both Mexico and Venezuela were forced into massive nominal devaluations that were validated by monetary expansions to permit capital outflows, with a view of minimizing a financial crisis. The C-C type of model would, in the first place, have allowed more timely nominal exchange rate adjustment within wide bands so

as to reduce devaluation expectations and the size of the speculative attack, as well as a self-correcting domestic interest rate rise at the upper side of the band. Besides, the capital control scheme in the C-C model minimizes the inflow of short-term capital that could exacerbate the speculative attack as the M-V cases showed.

It should be added that an approach which allows for monetary games, **Goodhart (1994)** between the central bank and the government is a more formal and complementary way to take into account the conflicts and implications of delegating nominal exchange rate management to the government vis a vis maintaining it at the independent central bank level. The final section of this paper develops an exercise in such a direction.

B. Monetary Games

1. Description of the Problem

As noted by **Cottarelli (1994)**, as long as the sterilization policies are ineffective in the medium and long run, monetary and foreign exchange policies are not independent. Further, when a country sets an independent central bank (ICB henceforth), it does so intending to alleviate the time inconsistency problem that arises when the monetary authority values considerably the perceived expansionary effects of an inflation surprise. Under such circumstances, an ICB which does not control the foreign exchange policy is not completely independent and does not accomplish the task it was created to fulfill. The purpose of this section is to illustrate this point, using elementary game theory to model the conflicts that emerge when monetary and foreign exchange policies are managed by authorities with different objectives.

The starting point is the model by **Dornbusch and Giovannini (1990)**, where a small, open economy produces, consumes and trades in only one good. This economy is closed to capital inflows, and its price level is determined by the PPP condition. Besides, it is assumed that the external price of the good is constant and equal to one. Domestic absorption is the product of the quantity of

money times its velocity, while the current account surplus is the difference between output and real domestic absorption. This surplus (deficit) implies an accumulation (reduction) of foreign international reserves.

This simple model is modified in two ways: First, output is made a function of the inflation surprise, and second, the velocity of money is assumed to be constant. The formal representation of the model can be found in the appendix.

In this context, the government (G henceforth) and the ICB will play a static game in which each attempts to minimize the following loss function:

$$V^i = -\gamma_o^i (e_t - e_t^e) + \gamma_1^i/2 (e_t - e_{t-1})^2 + \gamma_2^i/2 (R_t - R^*)^2 , \quad i = G, ICB$$

where e_t is the natural logarithm of the exchange rate (and the price level in this model), and R_t is the level of international reserves at the end of period t. R_{t-1} and e_{t-1} are taken as given.

The first two terms of the loss function follow Barro and Gordon's (1983b) standard representation[1]. The third term reflects the cost implied by a deviation from an "optimal" level of reserves, R^*. This level can be interpreted as that which is consistent with society's optimal intertemporal consumption path, or it can be seen as the level that optimally weights the costs and benefits of holding a stock of reserves.

For simplicity, it is assumed that the initial stock of reserves coincides with the optimal one, and, therefore, that the authorities wish to accumulate zero reserves. In this model, this is equivalent to saying that the authorities want to achieve external balance. Thus, the loss function can be expressed as:

$$V^i = -\gamma_o^i (e_t - e_t^e) + \gamma_1^i/2 (e_t - e_{t-1})^2 + \gamma_2^i/2 (y^* + \alpha(e_t - e_t^e) + e_t - m_t - v_t)^2 , \quad i = G, ICB$$

[1] This specification assumes that the optimal level of inflation is zero. This assumption can be relaxed without loss of generality.

where y^* is the logarithm of the natural-rate output, α is the coefficient of the inflation surprise in the output function, and m_t and v_t are the logs of money and velocity, respectively[2]. In what follows, the results of the games are briefly described. The technical details are left for the appendix.

2. Results of the Games

a. One authority controls monetary and foreign exchange policies:

In this case, one authority, either the G or the ICB, sets m_t and e_t in order to minimize its loss function. Since the authority has control of the two instruments, it is able to set the inflation rate at the level it considers optimal, and then manage the money supply to achieve external equilibrium. Formally:

$$e_t - e_{t-1} = \gamma_o^i/\gamma_1^i$$

$$m_t = y_t + e_t - v_t = y^* + (1+\alpha)e_t - \alpha e_t^e - v_t$$

b. Nash Equilibrium:

When monetary policy is controlled by the ICB and the exchange rate is set by the G, there is room for conflict as long as the weights γ_j^i in their loss functions differ. If both players move simultaneously, then the outcome of the conflict will be described by the Nash equilibrium. In this case, the Nash solution is a trivial one: Since the ICB cannot affect the first two terms of its loss function, given an exchange rate set by the government, it will adjust the money supply to guarantee the external equilibrium. That is, it will accommodate the money supply to whatever exchange rate (and inflation rate) the government chooses. Hence, the result is the same as the one where the G sets both m_t and e_t., implying that the ICB is not independent in practice.

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[2] Notice that this specification implies that the authorities dislike external imbalances measured as a *proportion* of the domestic absortion.

c. Stackelberg Equilibria:

The Stackelberg equilibrium arises when one of the players is able to move first and be the "leader" in the game. The other player is the "follower" and takes the leader's move as given when it makes its optimal decision. Thus, the leader incorporates the follower's reaction function in its problem. The fact that one of the players is the leader indicates the extent to which it is able to influence the other player's decision. In this sense, an ICB playing as a leader can be considered to be "more independent" than an ICB that follows.

It should be clear that if G is the leader, the equilibrium outcome will be the same as that of the Nash equilibrium described above. When the ICB is independent enough to be the leader, it sets the money supply such that, given the expected response by the G, it minimizes its losses. Let us suppose that the ICB does not care about the inflationary surprise. Hence, it faces a trade-off between reaching its inflation goal and achieving the external equilibrium. Since it only has one control variable (m_t), the final outcome will probably have some inflation and some external imbalance, because the ICB balances the marginal benefit of reducing an external surplus and the marginal cost of increasing inflation.

d. Cooperation:

The G and the ICB can coordinate their policies to minimize a common loss function that averages each player's objectives. As the intuition suggests, the result of this arrangement will be an inflation rate which is an average of the optimal inflation for both authorities. In addition, since the coalition G-ICB has two instruments to minimize its losses, once it sets the exchange rate to reach its optimal inflation, it will use the money supply to ensure external balance.

Following **Barro and Gordon (1983b)**, if we assume that the private sector has rational expectations, any inflation surprise (and hence any inflation surprise benefit) will be zero in all the equilibria. Further, it must be noted that the

outcomes of the games described above depend on the perceptions that the G and the ICB have regarding the exchange rate expected by the public (the inflationary expectations). In particular, these perceptions will determine the choice of the money supply when it is set to achieve external balance.

In general, however, given the assumption of rational expectations and assuming that the ICB is less inflation-prone than G, the best outcome ex-post for both players occurs when the ICB controls the monetary policy and the foreign exchange policy. This follows because the inflation surprise is always zero in equilibrium, and because the ICB can use two instruments to attain a low level of inflation and to achieve the external balance.

Perhaps, the best way to illustrate the results of the different games is through an example. Consider the following values for the parameters of the model:

$\gamma_o^{ICB} = 0, \gamma_1^{ICB} = 2, \gamma_2^{ICB} = 2,$

$\gamma_o^{ICB} = 1, \gamma_1^{ICB} = 0.5, \gamma_2^{G} = 0.5,$

$y^* = 0, v_t = 0, e_{t-1} = 0, \alpha = 0.1$

With these values, the equilibrium outcomes of each game are presented in Table 4. The first part of the table shows the results that arise when the G and the ICB think that the expected exchange rate (inflation rate) is equal to zero. The second part of the table contains the results that follow when the G and the ICB perceive that the expected exchange rate coincides with the equilibrium rate[3]. Four points are worth mentioning about Table 4:

- The Nash solution coincides with the outcome of the case when G controls m_t and e_t. This is an illustration of the result mentioned above.

[3] This does not mean that the G and the ICB consider the inflation suprise to be zero ex-ante. Throughout the model it is assumed that the G and the ICB take e_t^e as given (Barro and Gordon, 1983).

- In equilibrium, the welfare of both players is the highest when the ICB controls m_t and e_t. Again, this is a consequence of the assumption of rational expectations (which drives the inflation surprise to zero), of the absence of an inflationary bias by the ICB ($\gamma_o^{ICB} = 0$), and of the ability of the ICB to manage m_t and e_t to reach the zero (optimal) level of inflation and the external equilibrium.
- As expected, inflation is lower in the cases where the ICB is more powerful, that is, when it controls m and e, when it cooperates and its objective receives a significant weight, and when it leads in a Stackelberg equilibrium.

TABLE 4
Examples of the Games
Assumptions:

$\gamma_o^{ICB} = 0, \gamma_1^{ICB} = 2, \gamma_2^{ICB} = 2,$

$\gamma_o^{ICB} = 1, \gamma_1^{ICB} = 0.5, \gamma_2^{G} = 0.5,$

$y^* = 0, v_t = 0, e_{t-1} = 0, \alpha = 0.1$

G and ICB's perception of $e_t^e = 0$	G sets m and e	ICB sets m and e	Nash Eq. = Stackelberg Eq. with G. leader	Stackelberg Eq. with ICB leader	Cooperation (weight of each objective = 0.5)
m_t	2,2	0	2,2	0	0,44
e_t	2	0	2	0,905	0,4
Inflation	2	0	2	0,905	0,4
External Imbalance	-0,2	0	-0,2	0,905	-0,04
Vg	1,01	0	1,01	0,409	0,0404
Vb	4,04	0	4,04	1,638	0,1616
G and ICB's perception of $e_t^e = e_t$					
m_t	2	0	2	-0,09	0,4
e_t	2	0	2	0,87	0,4
Inflation	2	0	2	0,87	0,4
External Imbalance	0	0	0	0,953	0
Vg	1	0	1	0,414	0,04
Vb	4	0	4	1,658	0,16

- However, even if the ICB is granted enough independence to influence the G's exchange rate decision (Stackelberg equilibrium with ICB as leader), the outcome will still be inferior to the one that is obtained when the ICB sets both, m_t and e_t. The rationale for this result is that, with only one instrument (m_t) to achieve at least two objectives, the ICB faces a trade-off and must tolerate deviations from the optimal levels of inflation and the current account balance. One can interpret this as indicating that even if the "appropriate guarantees" are in place to preserve central bank independence, the handing of foreign exchange policy over to the government will yield inefficient outcomes, unless the constraints imposed on the G are so strict that in practice the ICB will control both m_t and e_t (Cottarelli, 1994 p.345).

The conclusion of this analysis is that the gains from setting an ICB to alleviate the time inconsistency problem and the inflationary bias may be greatly reduced when a more inflation-prone G retains the control of the foreign exchange policy. The model used to show this point is extremely simple. Further work can be done to introduce dynamics, non-tradable goods and capital flows and capital controls.

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APPENDIX

Monetary Games

1. Basic Model (Dornbusch and Giovannini, 1990):

PPP and constant external price level $P^* = 1$
$p_t = e_t$

Ln(Domestic Absorption) $\equiv a_t = m_t + v_t$

Ln(Real GDP) $\equiv y_t = \bar{y} + \alpha (e_t - e^e_t)$

$\Delta R_t = Y_t - A_t / E_t$ (Capital letters denote levels).

2. Games

a. <u>One authority sets m_t and e_t</u>

$$\underset{m_t, e_t}{\text{Min}}\ V^i = -\gamma_o^i (e_t - e_t^e) + \gamma_1^i/2\,(e_t - e_{t-1})^2 + \gamma_2^i/2\,(y^* + \alpha(e_t - e_t^e) + e_t - m_t - v_t)^2, \quad i = G, ICB$$

Fist order conditions:

$$e_t: -\gamma_o^i + \gamma_1^i (e_t - e_{t-1}) + \gamma_2^i (y^* + \alpha(e_t - e_t^e) + e_t - m_t - v_t)(1+\alpha) = 0 \qquad (A.1)$$

$$m_t: -\gamma_2^i (y^* + \alpha(e_t - e_t^e) + e_t - m_t - v_t) = 0 \qquad (A.2)$$

Equilibrium Solution:

$e_t = e_{t-1} + \gamma_o^i / \gamma_1^i$

$m_t = y^* + \alpha(e_t - e_p^e) + e_t - v_t$

Rational Expectations: $e_t^e = e_t$

$V^i = (\gamma_o^i)^2 / (2\gamma_1^i) + \alpha^2 \gamma_2^i/2\,(e_{t-1} + \gamma_o^i / \gamma_1^i - e^e_p)$

where e^e_p is the perception that the authority has regarding the public's expectation about e_t.

b. <u>Nash Equilibrium</u>

As explained in the paper, the Nash Equilibrium coincides with the solution when the G sets both m_t and e_t. Formally, this can be easily seen by noting that the G and ICB's reaction functions are analogous to equations (A.1) and (A.2) respectively. Substituting the ICB's reaction m(e) from (A.2) into (A.1) yields the solution.

c. <u>Stackelberg Equilibria</u>

The case in which G leads clearly renders the Nash solution. When the ICB leads, its problem becomes:

$$\underset{m_t}{\text{Min}}\ V^{ICB} = -\gamma_o^{ICB} (e(m_t) - e_t^e) + \gamma_1^{ICB}/2\,(e(m_t) - e_{t-1})^2 + \gamma_2^{ICB}/2\,(y^* + \alpha(e(m_t) - e_t^e) + e(m_t) - m_t - v_t)^2$$

where $e(m_t)$ is G's reaction function derived from a condition analogous to (A.1). Thus, in this case the ICB can influence the G's choice of e_t and is able to affect all the terms in its loss function, unlike the Nash equilibrium solution.
The first order condition for this problem is:

$$- \gamma_o^{ICB} (de/dm) + \gamma_1^{ICB} (e(m_t) - e_{t-1}) (de/dm) + \gamma_2^{ICB} (y^* + \alpha(e(m_t) - e_t^e) + e(m_t) - m_t - v_t) ((1+ \alpha)(de/dm)-1) = 0$$

where it can be shown that de/dm > 0.
To better understand the intuition behind this condition, let us suppose that $\gamma_o^{ICB} = 0$, i.e., that the ICB does NOT care about the inflation surprise. Then, the first order condition can be expressed as:

$$\gamma_1^{ICB} (e(m_t) - e_{t-1}) (de/dm) = K \gamma_2^{ICB} (y^* + \alpha (e(m_t) - e_t^e) + e(m_t) - m_t - v_t)$$

where K = constant. This ecuation may be interpreted as:

Marginal cost of deviating from optimal inflation = Marginal cost of deviating from external equilibrium

Hence, it is clear that the ICB faces a trade-off, as long as it only has control of one instrument (m_t) to achieve two objectives. In general, then, it will have to tolerate some inflation and some external imbalance, and this makes the outcome inferior to that where the ICB controls both the money supply and the exchange rate. Finally, as in all the other cases, the assumption of rational expectations ($e_t^e = e_t$) implies that in equilibrium the inflation surprise is zero.

d. Cooperation

The G and the ICB can coordinate their policies to minimize a joint loss function that is an average of each player's function:

$$V^C = \beta V^{ICB} + (1-\beta) V^G$$

where β measures the importance of the ICB's preferences in the joint decision. The first order conditions of this problem imply the following equilibrium:

$$e_t = e_{t-1} + (\beta \gamma_o^{ICB} + (1-\beta) \gamma_o^G) / (\beta \gamma_1^{ICB} + (1-\beta) \gamma_1^G)$$

$$m_t = y^* + \alpha(e_t - e_p^e) + e_t - v_t$$

Rational Expectations: $e_t^e = e_t$

where e^e_p is the perception that the authority has regarding the public's expectation about e_t.

The solution has the agreed inflation and external balance. Since in equilibrium the inflation surprise is zero, the larger β (i.e. the larger the weight of the ICB's objective in the coordination process), the better the outcome.