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Mexico's monetary policy framework under a floating exchange rate regime

I. INTRODUCTION

The currency and financial crises experienced by the European Monetary System in 1992, by Mexico in 1994-95 and the recent emerging market crisis of 1997-99 have reignited the debate on the viable exchange rate regimes for small open economies and, in particular, for emerging markets. One common element in all of the aforementioned crises was the adherence to a predetermined exchange rate. These commitments were very costly to maintain, especially when promises not to devaluate lacked the institutional support provided by a monetary union or a currency board. In addition, as capital controls have been dismantled and financial innovation has progressed, the size and speed of capital movements has substantially increased the cost of sustaining a predetermined exchange rate.

Paper prepared by A. G. Carstens, Director General of Economic Research, and A. M. Werner, Director of Economic Studies, of the Banco de México. *This is a revised version of the paper presented, at the IV Meeting of the Network of America Central Bank Researchers, organized by the Banco Central de Chile, in Santiago, in October 20 and 21, 1999. The views expressed here are those of the authors and do not necessarily reflect those of Banco de México. We appreciate the comments and contributions of Everardo Elizondo, Moisés Schwartz and Daniel Garcés.*

In many cases a fixed or predetermined exchange rate regime was chosen as an instrumental element of an inflation stabilization effort. In countries where the central bank is faced with a credibility problem, a predetermined exchange rate provides a clear nominal anchor by which the central bank "borrows" the credibility of the currency to which it is pegging. Although in many of the crises countries this strategy proved successful in the fight against inflation, once inflation was brought down to manageable levels and policy priorities changed, the rigidity imposed by these regimes became a liability to the fixing countries, and when faced with significant shocks, they were forced to devalue.

Many countries under a predetermined exchange rate regime ran into the problem that at some point they assigned too many objectives to a single policy instrument. These inconsistencies eventually led to a collapse of the regime. In the case of Mexico, during 1994 monetary policy had to defend the predetermined exchange rate, without affecting a weak banking system. Recently, in the case of Brazil, interest rate policy needed to defend the currency, but without increasing the fiscal imbalance. Once the market caught the inconsistencies, the regimes were doomed.

In addition, the implicit exchange rate guarantees provided by a predetermined exchange rate, combined with a generous deposit insurance, proved to be a lethal combination that provoked excessive financial intermediation, unwise risk taking and moral hazard. These factors, in the context of a recently liberalized financial system, have generated important vulnerabilities in the financial sector, that in most cases, led to severe financial crises. A currency board arrangement, by clearly limiting the functions of lender of last resort of the monetary authorities and by minimizing (at least ex–ante) the deposit insurance coverage, provides a mechanism to discipline the financial sector, avoiding the generation of significant financial imbalances. On the other hand, a floating exchange rate eliminates the exchange rate insurance, limiting the extent of foreign exchange exposure by the financial institutions. Under this scheme, deposit insurance also can be limited, as Mexico gradually has been doing.

Thus, several economists and analysts have concluded that only under very specific and demanding conditions,[1] there might be a comfortable middle ground between a floating exchange rate and

[1] Cases that come to mind are the ones of Chile and Israel.

the adoption of a common currency. Although strict capital controls could provide the needed additional instrument to sustain a less extreme regime, in practice controls have been abused and the distortions generated by them have overwhelmed their potential benefits.

In Latin America this polarization in the election of exchange rate regimes is clearly represented by the different paths adopted by Argentina and Mexico. While Argentina, in April 1991, implemented a currency board in the midst of a severe financial and inflationary crisis, in Mexico, the 1994-95 currency crisis made the adoption of a floating exchange rate the only viable option. Although at that time there was a widespread view that this was not a suitable long term regime for our country, today, after more than four years, there is a much broader consensus about the benefits and appropriateness of it.

It has been claimed [Hausmann et al. (1999)] that since the 1970's Latin-American economies have been abandoning fixed exchange rates by adopting more flexible exchange rate arrangements. But, until very recently, this move implied the implementation of crawling exchange rates with or without bands. Thus, in these new regimes, the authorities still undertook important commitments regarding the behavior of the exchange rate. It is not until the late 1990's, when some Latin-American countries started abandoning exchange rate commitments and turning towards floating exchange rates.

Therefore, the recent Mexican experience with a floating exchange rate is one of the few cases of a Latin-American country that has sticked to such a regime for a relatively long period of time –not only as the only feasible alternative after a crises, but as desired exchange rate arrangement–.

After more than four years with the floating exchange rate regime, the Mexican experience provides an interesting case of study for other emerging economies considering the possibility of moving towards a more flexible exchange rate regime. In this paper we provide an overview of the functioning of the floating exchange rate in Mexico, the monetary policy framework and its main effects on the economy. In the next section, we briefly document the transition to the floating exchange rate regime during 1994-95; in section III we describe how monetary and exchange rate policy are conducted under this regime; in section IV we look at the behavior of financial and real variables during the float; and, in section V, we conclude with some lessons from the Mexican experience and challenges for the future.

II. 1994-95: A FORCED TRANSITION TO THE FLOATING REGIME

The fragilities accumulated during the early 1990's --the years of large capital inflows and financial liberalization--, plus the negative external and domestic shocks faced by the economy during 1994, gave way to the balance of payments and financial crisis of December 1994, when under severe pressure in the foreign exchange rate market, the central bank was no longer able to defend the predetermined parity and it was decided to let the peso float.[2]

As the weeks went by, it became clear that the crisis had three conceptually different aspects. The first one was due to the overspending in the economy that generated a current account deficit of significant proportions. This deficit was being financed by short run capital inflows. The second aspect was the equivalent of a run on Mexican external liabilities, both government and private. While debt and budget indicators highlighted the solvency of the Mexican government, the short maturity of the stock of government debt exposed the country to a financial panic. Even when investors recognized Mexico's solvency, they realized that if everybody else stopped the roll-over of Mexican debt the country would be unable to fulfill its financial obligations. Thus, the illiquidity of the Mexican government generated a run on its debt. The third aspect was the banking crisis that began to unfold, which required immediate attention, both to avoid a domestic run on the banks and to pursue consistency in the macro framework.

As the understanding of the nature of the crisis became clear, the policy reaction evolved from a package designed to adjust the overspending in the economy, to one that, in addition to taking these issues into consideration, generated enough confidence to stop the panic and restore confidence in Mexican assets, both external and internal. To achieve this, Mexico had to demonstrate its commitment to completely fulfill all its financial obligations without relying on inflationary finance or an outright default on debt, and at the same time applying a consistent set of policies.

Thus, in the aftermath of the 1994 devaluation of the peso, economic policy faced three immediate challenges:

i) To conduct an orderly macroeconomic adjustment in response to the steep reduction of capital inflows.

[2] An attempt to implement a controlled movement in the currency band was unsuccessful and lasted only one day.

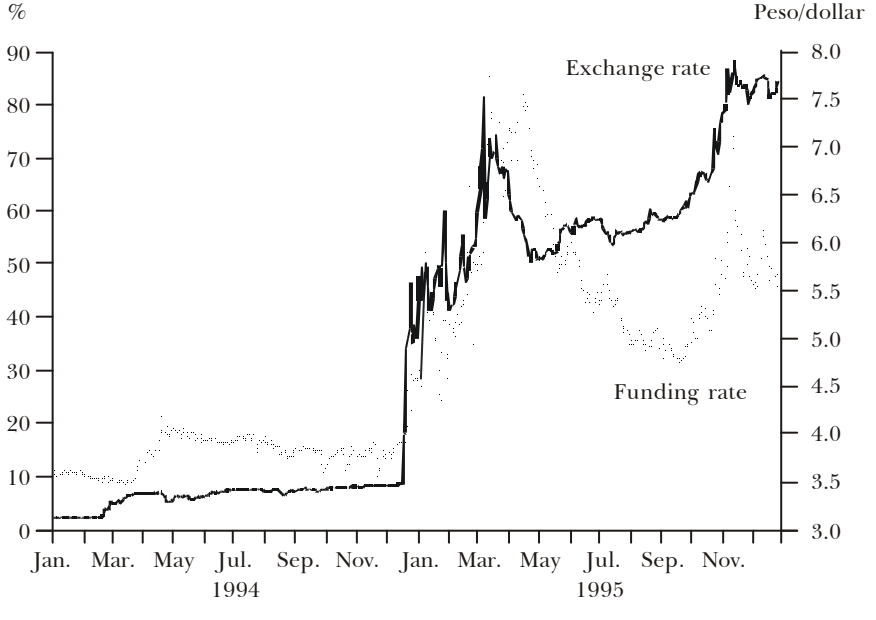
ii) To refinance short-term dollar denominated public debt by approximately US$30 billion.

iii) To maintain the solvency of the banking sector and protect depositors' savings.

In order to face these challenges, several measures were implemented during 1995:

a) To contain the inflationary effects of the devaluation, a tight monetary policy was followed. To make this policy credible, it became essential to spell out very clearly that monetary policy was going to be oriented exclusively to stabilize the nominal variables of the economy, consistent with Banco de México's autonomy. The banking sector problems were going to be dealt with specific programs (to be explained later), whose costs were going to be absorbed through fiscal adjustments spread over many years. So, monetary policy had only one objective –to reduce inflation–, a condition which was essential under a floating exchange rate regime, since under such an arrangement the said policy should be the nominal anchor of the economy. To build that anchor, monetary policy needed to be conducted without any interference from the banking sector problem. To

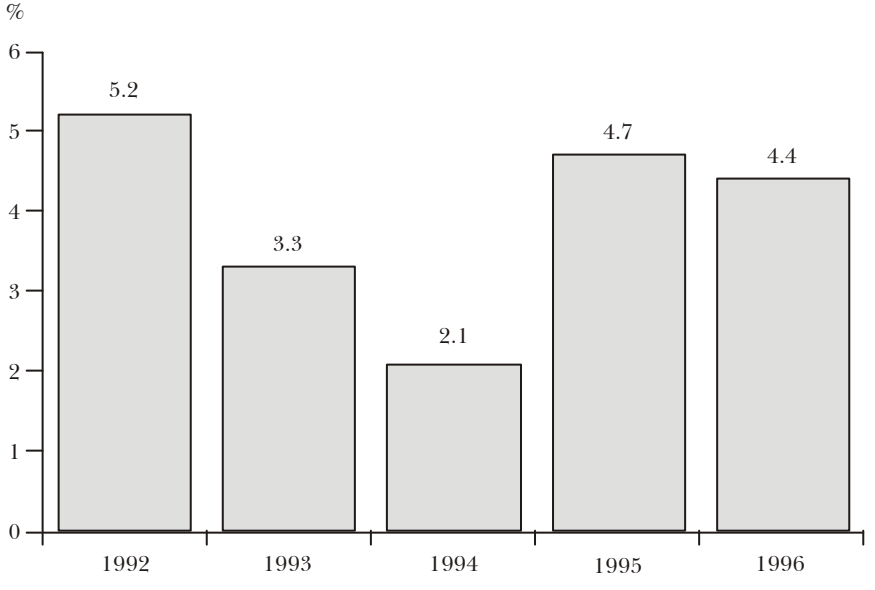
FIGURE 1. INTEREST RATE AND EXCHANGE RATE, 1994-95



demonstrate the resolve of the monetary authorities, it can be said that they contributed for the overnight interest rates to move from 16% in December 1994 to 86% in March 1995.

b) In order to accomplish an orderly adjustment of the current account, fiscal policy was tightened considerably as the primary balance went from a surplus of 2.1% of GDP in 1994 to a surplus of 4.7% of GDP in 1995, even when GDP contracted by more than 6%. In addition, a fiscal effort was necessary, to start absorbing some of the costs of the banking sector rescue package.

FIGURE 2. PRIMARY BALANCE (as GDP percentage)

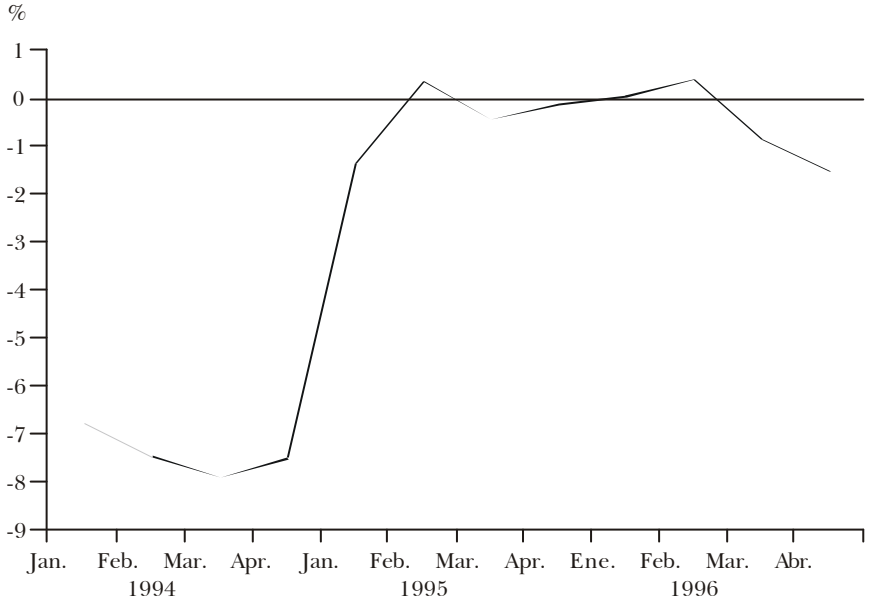


The tight monetary and fiscal policies, together with the expenditure switching effects of the devaluation, were absolutely essential to stabilize the currency and achieve the current account correction in a relatively orderly way.

c) To honor the financial commitments of the country, and more importantly, to induce creditors to roll-over their maturing loans to Mexico, the government negotiated and obtained a 52-billion dollars emergency support package from the international community, having the US government [i.e. the Ex-

change Stabilization Fund] and the IMF as the main suppliers of assistance.

FIGURE 3. CURRENT ACCOUNT, 1994-96 (millions of dollars)



d) To deal with the banking sector problem, a comprehensive strategy was put in place. The fragilities accumulated by the domestic financial system, the overindebtness of firms and households, and the damaging effects of the crisis seriously threatened the health of the Mexican financial system. To preserve the integrity of this sector, the authorities implemented a series of programs, with the following objectives:

- To prevent a systemic run on the banking system;
- To combat moral hazard and minimize distortions;
- To consider the cost of the banking sector restructuring as a fiscal issue;
- To reduce as much as possible the need for the central bank to act as the lender of last resort; and
- To strengthen financial sector regulation and supervision.

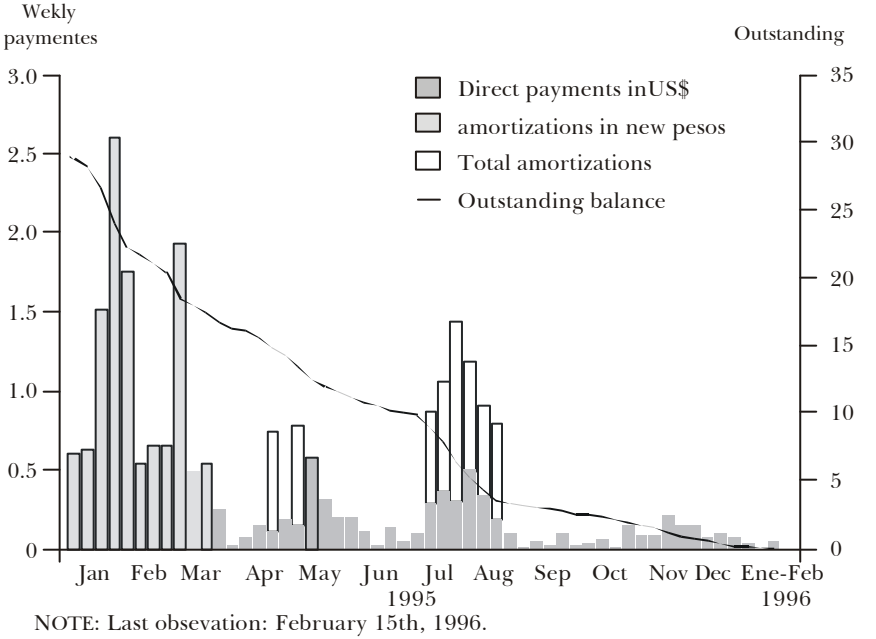
Based on these objectives, the central bank opened credit lines denominated in foreign currency at a penalty rate, so that com-

mercial banks could fulfill their external obligations; a program was established to promote the capitalization of the banking system; and legal reforms were undertaken to allow greater foreign participation in the banking system.

It should be highlighted that the fiscal authority, by recognizing the fiscal costs of the banking sector restructuring and by showing its commitment to deal with this problem with fiscal resources, liberated monetary policy to pursue its primary goal of price stability. Thus, at this point it was clear that monetary policy would not face the dilemma of trying to comply with conflicting objectives and that it would concentrate in lowering inflation, becoming the required nominal anchor under the floating exchange rate regime.

Low international reserves and the uncertainty prevailing in financial markets after the collapse of the currency made the discussion on alternative exchange rate regimes irrelevant. The only option was to stick with a floating exchange rate. Therefore, the important issue was to implement the necessary institutional and operational innovations to complement the floating exchange rate regime and start to reestablish the credibility of Banco de México (more on this on the next section).

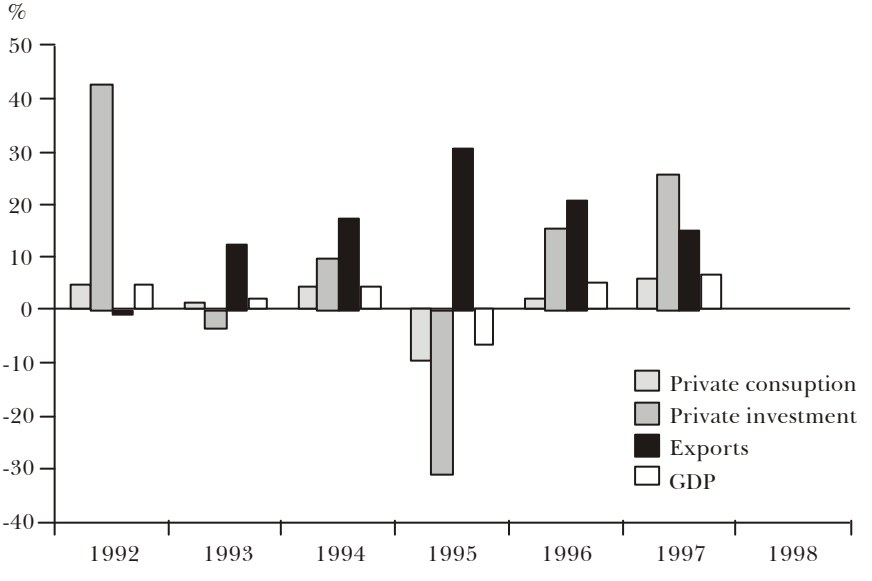
FIGURE 4. AMORTIZATION OF TESOBONOS, 1995-96 (as millions of dollars)



NOTE: Last obsevation: February 15th, 1996.

Following the implementation of the strategy, financial markets recognized the soundness of the measures taken, and the comitment of the Mexican government to pay all of its maturing debt. The peso became more stable, and after overshooting to 7.5 pesos per dollar in March, it went back in May to 6 pesos per dollar, regaining some of the ground lost during the weeks of uncertainty. Interest rates began to fall and the stock market returned to its pre-crisis level. The inflation rate quickly came down to manageable levels. The risk of a government default disappeared as TESOBONOS outstanding were being paid off in dollars and the government had sufficient resources to accomplish this task. Finally, it is important to notice that the Mexican government, as well as some private banks, regained access to international capital markets soon after the announcement of the program. Because of this, the Mexican authorities used only half of the emergency support provided by the US government, and these loans were paid in full by January 1997, three years before schedule.

FIGURE 5. GROWTH IN CONSUMPTION, INVESTMENT, EXPORTS, AND GDP, 1992-98 (growth rates)



The real economy showed an impressive turnaround in the external accounts. Exports increased by 30.6% from 1994 to 1995; and the trade deficit of $ 18,464 billion in December of 1994 turned into a surplus of $ 7,088 billion in December of 1995.

Economic activity and employment suffered considerably by the fall in domestic demand, due to the capital flows reversal, the reduction in government spending, increases in tax rates, high real interest rates and vanishing credit. Specifically, output, consumption and investment fell by 6.2, 8.4 and 29 percent, respectively, during 1995.

As the exchange rate stabilized, interest rates fell, international financial markets resumed lending to the Mexican economy, and the expenditure switching effects of the devaluation continued (for consumption as well as investment). Economic activity recovered rapidly, thanks to the broad restructuring that the economy had gone through in the previous decade. Thus, GDP grew 5.6 percent in average for the period 1996-98, while consumption and investment also recovered. At the same time, inflation dropped rapidly from 51.7% in 1995 to 18.6% in 1998.

The conclusion of this section is that the key for the success of the Mexican economy in stabilizing relatively quickly its nominal variables after the eruption of the crisis in 1994-95, was that a consistent macroeconomic program was adopted early in the last year mentioned. Therefore, even though Mexico did not have any experience under a floating exchange rate regime, this aspect was not an impediment for pursuing stability, as long as a consistent policy framework was in place.

III. MONETARY AND EXCHANGE RATE POLICY SINCE 1995

III.1.Monetary Policy

As a consequence of the devaluation of the peso and the return to a high inflation environment in 1995, the credibility of Banco de México was seriously damaged. The criticisms (some of them unfounded) concentrated mainly on two issues: (i) the lack of transparency in the conduct of monetary policy and in the dissemination of information, and (ii) the lack of ability to tighten monetary policy before, during and immediately after the crisis.

In addition, after dropping the exchange rate as the nominal anchor of the economy and turning to a floating exchange rate regime, monetary policy had to fill the vacuum and become the nominal anchor.

In theory, under a floating exchange rate regime the central bank acquires control over the monetary base, since it does not

have to add or subtract liquidity derived from compulsory interventions in the foreign exchange market. By acting directly on the monetary base, the central bank supposedly would be able to influence interest rates and the exchange rate, and through these, the general price level. Consequently, as the central bank reduces inflation, monetary policy becomes the anchor for the evolution of the general price level. These were the type of arguments that prompted the Mexican authorities to consider quantitative targets on monetary aggregates in early 1995 when designing its monetary program for the year.

Consistent with the above, Banco de México established as intermediate target a ceiling on the growth of the monetary base for the year. Since this program was just announced at the inception of the crisis, an assumption of no international reserves accumulation was made -- which is a natural assumption under a flexible exchange rate regime. Therefore, the ceiling on monetary base growth was in essence a ceiling on the expansion on the net domestic credit of the central bank, which in principle would keep inflation in line. For this quantitative target to become credible, Banco de México committed to inform monthly on the evolution of its net domestic credit.

Regretfully, very soon it became obvious that this very simple and intuitive monetary program was not enough to stabilize inflationary expectations, the exchange and the development of inflation itself. In early 1995, the rule-based monetary policy failed to perform as expected, due to the following:

a) In a crisis scenario, the velocity of money is very unstable, thus making also unstable the relationship between the monetary base and inflation;

b) It was not possible for the rule on monetary base growth to prevent the sudden exchange rate depreciations --resulting from external shocks or shifts in expectations--, to substantially affect inflationary expectations and eventually the price level; since the beginning, just after the collapse of the predetermined exchange rate regime, the pass-through from exchange rate depreciation to inflation was very high; and

c) The central bank had hardly any control on the monetary base in the short run. The evolution of this aggregate is driven by the demand for bills and coins in circulation, which has a very low interest rate elasticity in the short term. In addition, commercial banks did not hold any excess reserves in the central

bank --due to the zero reserve requirement policy in place and the operation of Mexico's payment system--, which prevented even more any short term control over the monetary base.

In February and March, 1995, the market participants expected a strong statement by the authorities, that would make credible their stated intentions about reducing inflation. In particular, they were expecting considerable hikes in interest rates, to counteract the inflationary shocks that were occurring. So, in late March, the central bank increased up to 100 percent the overnight funding rate (by establishing interest rate floors in its open market operations). This discretionary monetary policy action, together with the agreement with the IMF of a strong adjustment program and the availability of the Exchange Stabilization Fund, managed to brake the sharp tendency towards depreciation that the peso showed during the first quarter of the year, to stabilize inflationary expectations and, very soon afterwards, to reduce the monthly rates of inflation. By May, 1995 the peso started to appreciate and inflationary expectations to fall, which led to a reduction in nominal and real interest rates. This, in turn, mitigated the collapse of economic activity and prevented further deterioration in the banking system.

Therefore, the experience just described led the Mexican authorities to modify during the first half of 1995 its monetary policy: from one based solely on quantitative targets on monetary aggregates, to another were both rules (on the behavior of the monetary base) and discretion (by influencing the level of interest rates) were incorporated.

To be able to implement in a transparent fashion the discretionary policy measures, and also to tackle the criticisms that Banco de México was too slow and undecisive to adjust interest rates, the central bank decided to adopt a new reserve requirement scheme, the so called zero *average* reserve requirement.

By means of this scheme,[3] Banco de México established accounting periods of 28 days during which banks seek to post a zero daily average balance in the current accounts they hold in the central bank. Banks strive to obtain said balance because, should the daily average balance be negative, the bank in question would have to pay an interest rate equivalent to twice the prevailing 28-day CETES rate on the respective balance. On the other hand, should the daily average balance be positive, the

[3] For a detailed description of this mechanism, see Gil Díaz, Francisco (1998).

bank would lose the returns it could have obtained had it invested in the market the respective funds.

In order to meet the demand for bills and coins, the Banco de México offers credit to banks via daily auctions, so as to offset maturing credits previously granted to banks, movements in the Federal Treasury's account, and the monetary impact of transactions of foreign currency by the central bank.

The central bank determines the sum of credit to be auctioned each day so that the overall net daily average balance of all current accounts held by banks at the Banco de México – accumulated during the specific accounting period—may close the day at a predetermined amount. If said amount is negative, the central bank would put the banking system in "short" and, if the amount is positive, the system would be put in a long position. It follows that if the central bank puts the system in "short" (or applies a "short"), at least one credit institution will have to pay the penalty interest rate of twice the prevailing CETES rate.

It should be stressed that the Banco de México always supplies the credit necessary to completely satisfy the demand for bills and coins, even when the banking system is put in "short". Nevertheless, in this case, a portion of the credit is supplied at a higher interest rate, which is applied to the overdrafts in the current accounts of one or several banks.

When the system is put in "short", the central bank exerts upward pressure on interest rates, which can be quite significant. Nonetheless, more than for any other reason, said pressure is the result of the signal given by Banco de México. A point in case is that the maximum amount for which the system has been short in recent years is 160 million pesos, representing only 0.002% of the monetary base.

The main reason for the "short" to be effective in inducing hikes in interest rates, is because under a floating exchange rate regime the commercial banks do not have means to create balances in their accounts with the central bank (they cannot credit their balances by selling forex to the central bank, as they can do under a predetermined exchange rate regime). Therefore, the "short" imposes an unavoidable cost to the banking system. Under such circumstances, the rational response of the banking system is to allow interest rates to increase to the level they believe is the target of Banco de México, with the smallest possible "short" (or "corto" in Spanish). This is precisely what usually happens when a "corto" is applied or modified.

Since 1996, all the monetary programs that Banco de México

has implemented are fundamentally based on the elements just outlined. To be more precise, it can be said that Mexico's most recent monetary programs have included three main elements:

1) *A yearly annual inflation objective*. This objective is established jointly by the Federal Government and the Banco de México, and it is perceived as the result of a concerted effort to coordinate fiscal and monetary policies. Based on such objective the fiscal and monetary policies are designed, and it also helps for the determination of the minimum wage.

2) *Rules defined on the behavior of monetary base, together with quantitative commitments on the accumulation on net international reserves and the variation of net domestic credit*. The basic objective of these rules and quantitative commitments is to assure the market that Banco de México will not create the most basic source of inflation: excess supply of primary money. This, if it were to occur, would immediately raise the public's inflationary expectations, which would, in turn, result in exchange rate depreciation, interest rate increases, higher nominal wages and rises in the prices of goods and services. This is why the Board of Governors has established, as one of the elements of its monetary programs, a basic operational rule that assures that the central bank will not create a monetary base surplus. This rule goes as follows:

As a general rule, Banco de México will adjust, on a daily basis, the supply of primary money in a way that such supply matches the demand for base money.

This basic operational rule means, in more technical terms, that in the daily determination of its open market operations, the central bank will pursue, as a general rule, the objective of zero accumulated current account balances that commercial banks hold with this central bank. It also implies that Banco de México will sterilize the monetary impact that can derive from variations in the net international assets, and from operations that the Treasury carries out in the account it holds with Banco de México.

The strict application of this basic operational rule, under certain circumstances, could imply that Banco de México passively accommodates any demand of monetary base, which could be the source of some problems. In particular, the central bank could eventually be satisfying a demand for money consistent with a higher than expected inflation pattern.

To detect this situation and act in consequence, Banco de México compares daily the observed path of the base with one that is, in principle, consistent with the inflation objective for that year (which is published). This last path is difficult to determine in such a way that it has annual validity, due to the following factors: (a) the relationship between inflation and base money can change over time; (b) the basic assumptions made to forecast base demand for the year (related to the GDP growth and interest rate behavior) may not materialize, and (c) the relationship between base demand and the variables that explain its behavior might also change over time. For this reason, Banco de México must evaluate the divergences between the observed and estimated base path along with other indicators that could give more information about the evolution of future inflation, such as the exchange rate, the available measures of inflationary expectations, contractual wages and the relationship between potential and observed GDP. Given this caveats, the announced path of the monetary base does not constitute a formal policy objective.

The usefulness of the announced path lies mainly on the fact that it would be a signal of alert in case there were important deviations between the observed and the announced base paths. Banco de México evaluates such deviations and only in case they respond to circumstances implying additional inflationary pressures, Banco de México would be expected to adopt a restrictive position.

Banco de México is capable of adjusting primary money supply to its demand by means of variations either in its domestic credit or its net international assets. The central bank has relatively more control over its domestic credit. This is why using it wrongly is, potentially, the easiest way to generate an excess in the monetary base. In response to these considerations, and with the purpose of giving additional assurance that no inflationary pressures will surge, Banco de México has decided to incorporate in its monetary programs quarterly limits to the domestic credit variations. The rest of the expected increase in the demand for base money should then be generated by increases in net international assets.

The monetary authorities have estimated that the availability of a greater amount of international assets, will contribute to further strengthen Mexico's external financial position, what is particularly important in the present highly volatile environment registered in the international financial markets. More

solidity in that front will allow the country to continue having access to foreign resources, under favorable conditions with regard to the cost and maturity of foreign financing. This is why usually an important part of Banco de México's monetary programs consists of the commitment to generate a minimum net international asset accumulation.

3) *The last common element in Banco de México's monetary program is the possibility for the central bank to adjust its stance on monetary policy, in case unexpected circumstances make it advisable.* This element portrays the use of discretion in monetary policy management.

The element of the monetary programs described under item (2) above is aimed at preventing Banco de México from creating any excess supply in monetary base. Unfortunately, this is not a full guarantee for attaining the desired abatement of inflation. As it has been hinted before in this document, this is due to the fact that inflation may also surge from other sources. On one hand, external disruptions may cause an excessive depreciation of the domestic currency. On the other, contractual wage negotiations might result above the sum of the inflationary target plus productivity increases. By the same token, there could be unexpected adjustments to public prices with the purpose of keeping public finances under control.

Any of these events could cause interest rates to rise, tending to mitigate undesirable inflationary pressures. Nevertheless, the case may be that interest rates' automatic adjustment does not suffice to assure inflation's reasonable behavior. Under such circumstances, Banco de México would consider the possibility of restricting its monetary policy by means of the "short".

By increasing its "short", the central bank raises its negative target for accumulated balances of the current accounts commercial banks maintain in Banco de México. Through this action the central bank exerts an upward influence on interest rates which, in general, results from the signal sent to the market through this instrument, as it was explained before.

The above paragraphs may be summarized as follows: Banco de México, under the current circumstances of financial market volatility, requires the faculty of being able to discretionarily adjust monetary policy, particularly restricting it if necessary.

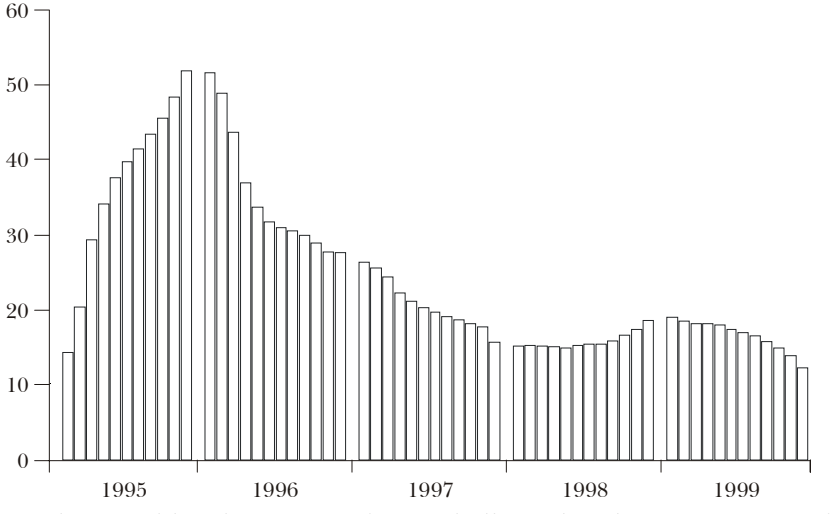
The central bank tends to use the "short", thereby adopting a more restrictive stance on monetary policy, under the following circumstances:

a) In case it detects future inflationary pressures inconsistent with the attainment of the inflationary target. Namely, monetary policy will strive to neutralize exogenous shocks's *side-effects* on prices and will occasionally act in a precautionary fashion by *partially compensating the direct inflationary effects* of the key prices in the economy. The ultimate objective resides in making the necessary adjustments in order for relative prices to impact the CPI only moderately –by raising its level- without deteriorating inflationary expectations in order to prevent inflation's dynamics from turning perverse;

b) When it is deemed necessary to restore order in exchange and money markets; and,

c) When inflationary expectations are deemed out of line with respect to the original target.

FIGURE 6. ANNUAL INFLATION, 1995-99

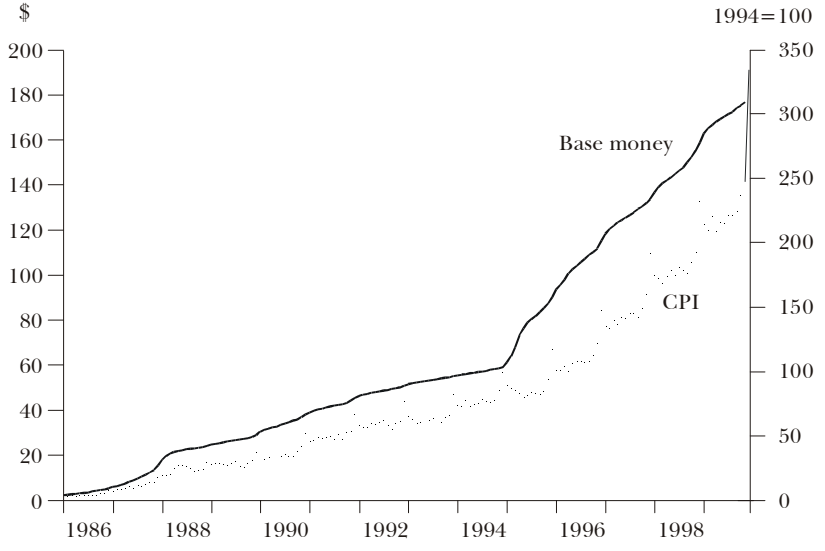


The combined use of rules and discretion in monetary policy has worked well for the case of Mexico. So far, inflation has been reduced from 52 percent in 1995 to 12.X percent in December, 1999. For 1999 as a whole inflation is expected to fall to 13 percent (see figure 6).

As a matter of fact, as the understanding of the inflation phenomena in Mexico is increased, the more evident it becomes that

the real nominal anchor of the economy is the discrete response of authorities to shocks. This sends a clear signal to the market about the authorities' commitment to attain the inflation objectives.

FIGURE 7. BASE MONEY AND CPI, 1986-99



As these are achieved, the more credible the policy and the objectives will be. Therefore, it could be said that Mexico is in the transition period towards a clear-cut inflation targeting scheme. As it will be apparent from the next subsection, the main factor that has prevented Mexico from adopting an explicit inflation targeting scheme is the frequency and incidence of exogenous shocks –both domestic and external– to the price level.

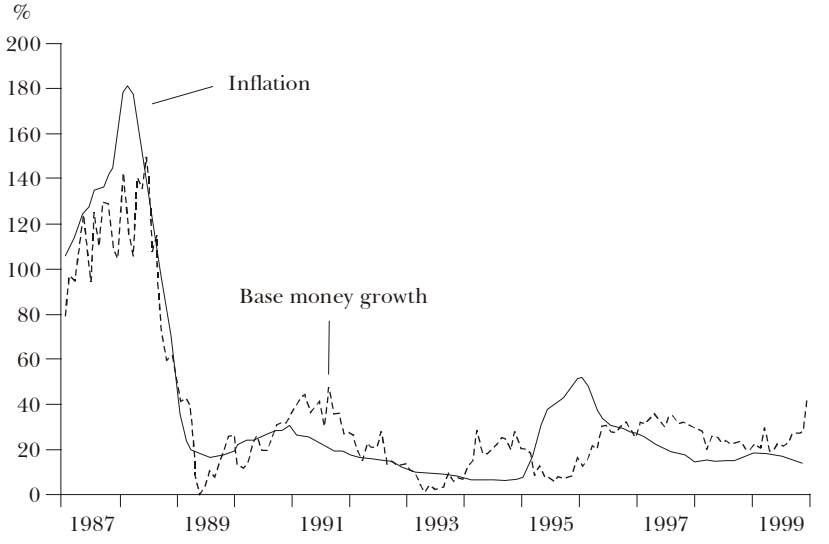
III.1.1.The Identification of the Inflationary Process in Mexico

To design a suitable monetary policy framework, it is essential to understand which are the main determinants of inflation, and how does monetary policy interact with them to affect the behavior of the rate of increase of the CPI.

As we all know, inflation is ultimately a monetary phenomenon. The evidence is clear that in the medium and long run, there is a very close correlation between the rate of growth of

monetary aggregates and inflation, once changes in output and velocity are taken into account. This correlation has been observed both in the international (see Lucas (1996)) and Mexican experiences (figures 7 and 8).

FIGURE 8. BASE MONEY GROWTH AND INFLATION, 1987-99



A quick reading of these findings might suggest that it should be relatively simple for the central bank to eradicate inflation, given its influence on the behavior of monetary aggregates and high power money in particular. But as we all know, the close correlation between money and prices says nothing about causality running in either direction.

Economic theory is useful to frame this discussion on causality. On the one hand traditional monetary models with flexible prices imply that causality goes from money to prices. In this setup, prices will adjust immediately to changes in the stance of monetary policy. For instance, if the monetary authority decides to reduce the rate of growth of the monetary base, agents will adjust their expectations accordingly and inflation will immediately converge to its long run equilibrium. On the other hand, models with price rigidities imply that in the short run inflationary shocks, such as wage increases that are inconsistent with the inflation target, cannot be offset immediately by the monetary author-

ity. The monetary authority could in principle maintain the money supply constant, however, given the low elasticity of the demand for real balances, the decrease in real balances would send interest rates through the roof. Under this circumstances, the central bank will be obliged to accommodate, totally or partially, the inflationary impact of such shock. In this case, the causality is turned on its head running from prices to money. Therefore, in this scenario, to judge the stance of monetary policy, we should focus on the degree of accommodation by the monetary authority. But even if the monetary authority accommodates the inflationary shock only partially, real interest rates will increase. This increase in real interest rates will slowly reverse the impact of the inflationary shock by affecting aggregate demand and appreciating the currency.

This discussion highlights two alternative sources of inflationary pressures. First, we have the traditional monetary explanation, where exogenous shocks to the supply of money cause inflation, therefore money is the driving force of the inflationary process. Secondly, in models with price rigidities, shocks to key prices in the economy (wages, exchange rates and public sector prices) directly affect inflation, and monetary policy partially accommodates these shocks. In this scenario, the degree of policy accommodation will be instrumental in determining the long-run inflationary impact of the shocks.

A first step in designing a suitable monetary policy framework is to determine wether the inflationary process in Mexico is driven mainly by exogenous monetary shocks or by shocks to key prices that are partially accommodated by the monetary authority.

Taking a close look at the evolution of the growth rate of the monetary base and inflation during the period 1986-1998 (see figure 8), it seems that changes in inflation have preceded changes in the growth rate of base money. Therefore, it seems that during this period, exogenous movements in money were not the fundamental cause of inflation. To analyze this result more formally, Granger causality tests were performed. The results of these tests show that there is causality running both ways between these two variables. However, these results do not quantify the influence that movements on each of these variables had on the other. To analyze this issue in more detail, we estimated a Vector Error Correction Model (VECM) that incorporates, as its endogenous variables: CPI, base money, exchange rate, wages and public sector prices. The impulse response functions are pre-

sented in figure 9 and the results from the variance decomposition[4] are shown in tables 1 to 5.

From the impulse response functions it seems that the shocks have been correctly identified. Public prices, exchange rate and wage shocks have positively affected the price level and money. It is also evident that each of these shocks has had indirect effects on the other two key prices of the economy. Finally, it is interesting to notice that money shocks have the expected effect, as they bring about increases in all prices in the economy. To establish the relevance of each shock as a determinant of the movements in the other variables in the system, the variance decomposition for each variable can be of assistance.

TABLE 1. PERCENTAGE OF THE VARIANCE OF BASE MONEY

Months	*Public prices*	*Exchange rate*	*Wages*	*Prices*	*Base money*
6	26.58	9.33	8.40	11.12	38.96
12	37.43	11.11	11.89	19.62	17.30
18	35.71	14.32	12.46	22.64	13.13
24	32.36	19.74	12.44	22.62	11.72
30	29.02	24.38	12.49	21.68	11.63

TABLE 2. PERCENTAGE OF THE VARIANCE OF PRICES

Months	*Public prices*	*Exchange rate*	*Wages*	*Prices*	*Base money*
6	39.68	24.43	7.16	27.38	1.24
12	26.49	35.53	12.27	22.71	2.95
18	17.67	44.83	12.89	18.40	6.02
24	12.85	50.92	12.58	15.07	8.05
30	9.97	54.75	12.12	12.80	9.49

TABLE 3. PERCENTAGE OF THE VARIANCE OF WAGES

Months	*Public prices*	*Exchange rate*	*Wages*	*Prices*	*Base money*
6	6.20	8.91	70.55	6.97	4.11
12	8.06	11.49	63.13	10.42	4.23
18	8.37	15.88	57.89	12.32	3.45
24	8.05	21.09	53.18	13.06	3.02
30	7.51	25.71	49.55	13.16	2.80

[4] The ordering of the variables for the identification of the shocks was: public sector prices, exchange rate, wages, prices and monetary base. However, the results are robust to changes in the ordering of the variables.

TABLE 4. PERCENTAGE OF THE VARIANCE OF EXCHANGE RATE

Months	*Public prices*	*Exchange rate*	*Wages*	*Prices*	*Base money*
6	5.35	81.79	1.77	2.51	6.57
12	2.97	78.56	4.55	1.93	9.66
18	1.61	77.71	4.62	1.43	11.74
24	1.00	77.25	4.48	1.08	12.81
30	0.69	76.89	4.33	0.85	13.50

TABLE 5. PERCENTAGE OF THE VARIANCE OF PUBLIC PRICES

Months	*Public prices*	*Exchange rate*	*Wages*	*Prices*	*Base money*
6	56.33	20.58	10.52	11.48	0.84
12	37.54	33.01	14.15	12.67	2.47
18	25.49	42.94	14.07	11.15	5.57
24	19.32	49.37	13.54	9.49	7.52
30	15.34	53.39	12.97	8.23	8.96

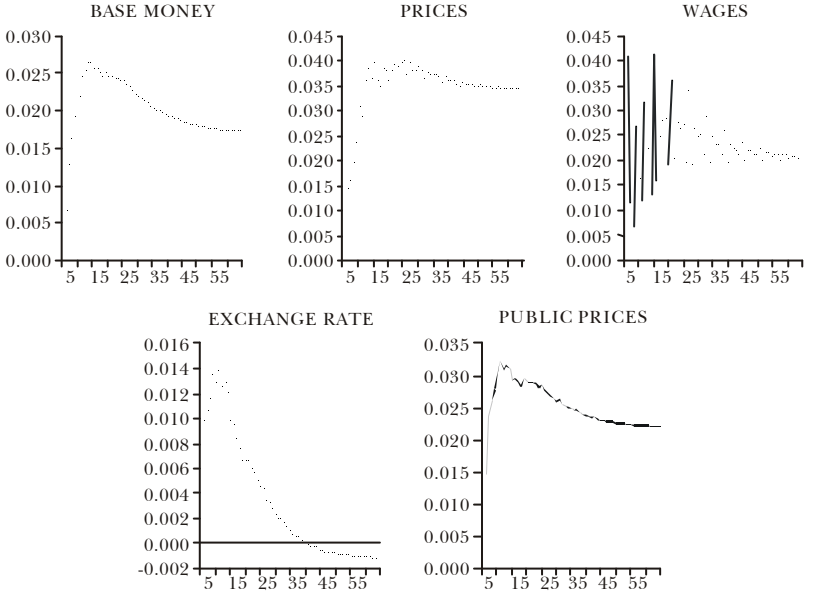
As it is clear from the variance decomposition, in the medium and long run movements in base money and prices have been determined mainly by exogenous changes in exchange rates, wages, public sector prices, and the general price level. But the impact of exogenous movements in base money on prices, exchange rates and wages have been negligible. In addition, almost 90% of the variance in the monetary base is explained by shocks to the other variables of the system. This result highlights that to a very important degree monetary policy has accommodated these inflationary shocks. Exogenous shocks to money have been negligible, and they are almost irrelevant to explain the behavior of prices, exchange rates and wages.

These results confirm that exogenous movements to the monetary base have not been a cause of inflationary pressures, but that the money base has accommodated inflationary shocks coming from the exchange rate, wages and public sector prices. *These results ratify the conclusion offered above, in the sense that discretionary policy measures (or reactions) to combat shocks or trends in these key prices in the economy that are inconsistent with the annual inflation objective should be the main component of Mexico's monetary program.*

In addition, the impulse response functions show that wages react significantly to shocks in the exchange rate and public sector prices, which suggests that these shocks significantly affected inflationary expectations (they were not interpreted as a once and

FIGURE 9. IMPULSE-RESPONSE FUNCTIONS

Response of the indicated variable after a shock in public prices



Response of the indicated variable after a shock in the exchange rate

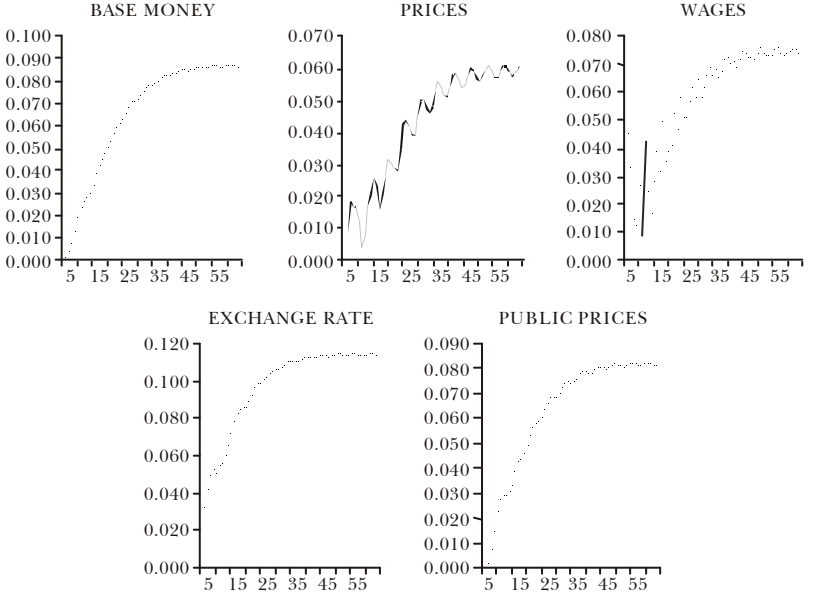
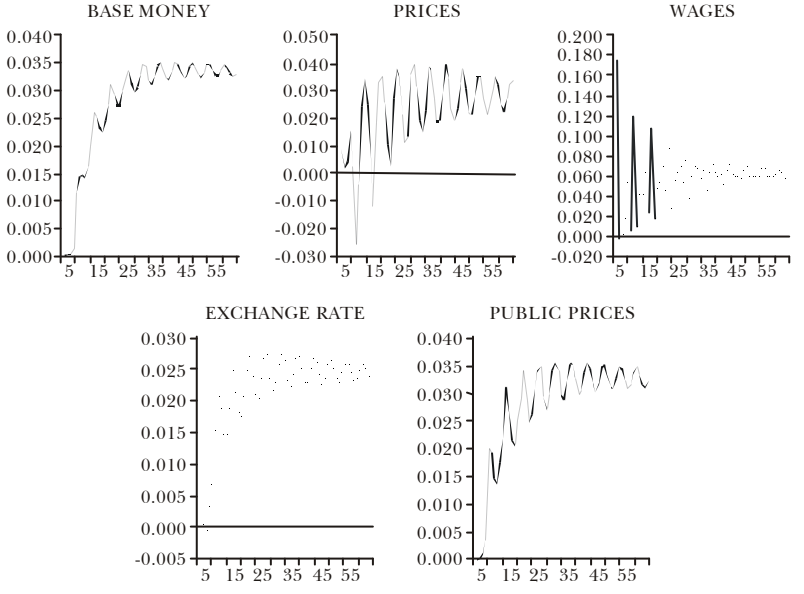


FIGURE 9 *(continue)*

Response of the indicated variable after a shock in wages



Response of the indicated variable after a shock in prices

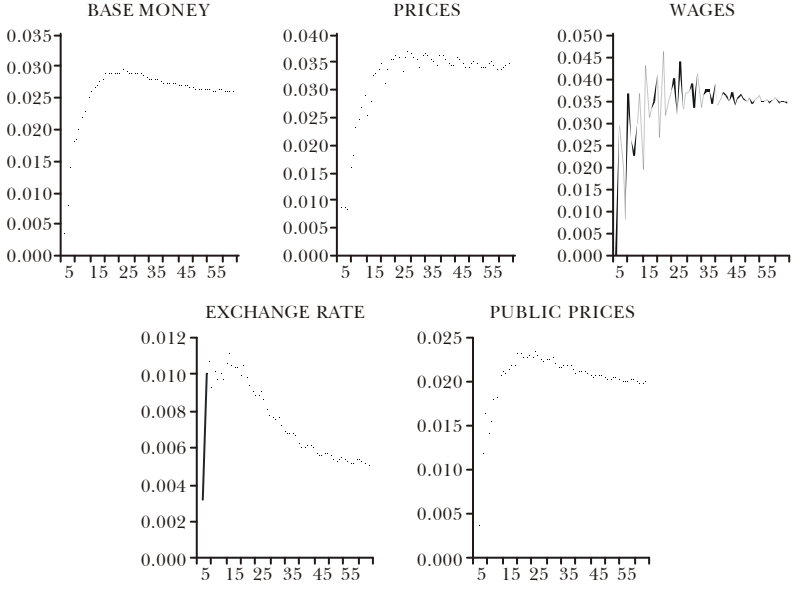
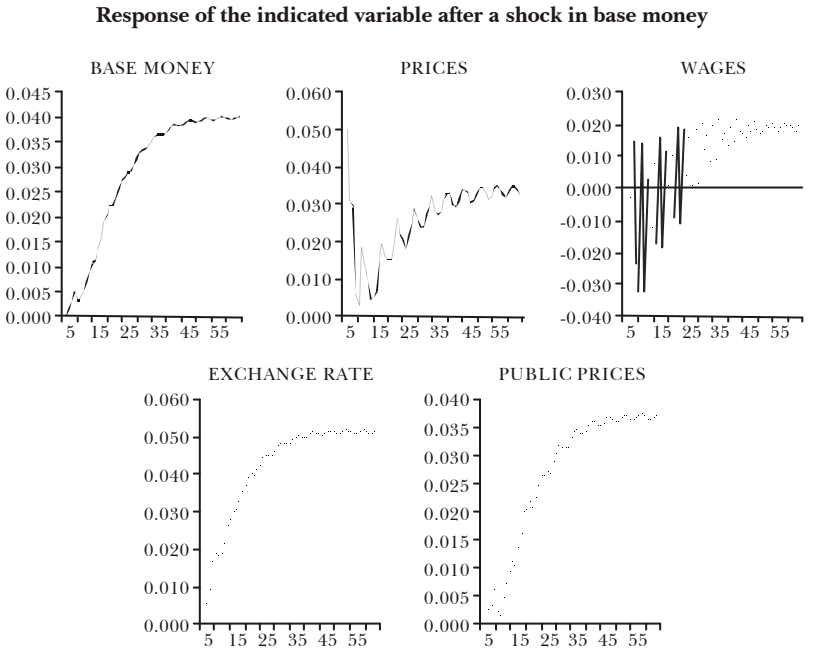


FIGURE 9 *(conclude)*



for all adjustment in the CPI) which in turn affected wage demands. This indirect transmission channel by which exchange rate and public prices shocks affect inflation expectations and wage adjustments, is explicitly tested below.

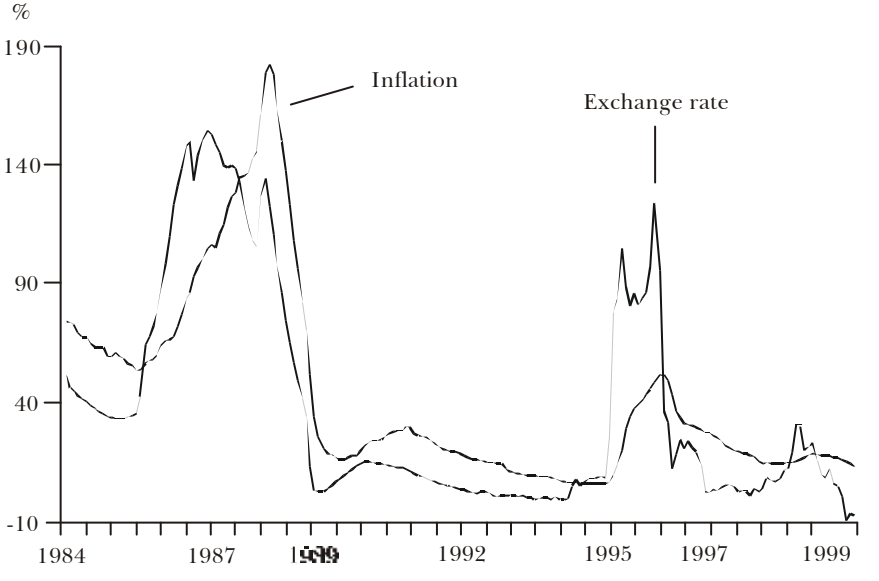
So it is safe to assume that inflationary pressures in Mexico have their origin in non-monetary factors (that have been validated ex-post by the monetary authority), among which we find: (a) the presence of external or domestic shocks which may generate sharp exchange rate depreciations; (b) changes in public sector prices; and (c) wage revisions that are inconsistent with the inflation target.

Confronted with these exogenous inflationary shocks, the central bank faces the decision to accommodate, totally or partially, the inflationary impact of such shocks, through its monetary policy actions, or not to accommodate at all. In order to understand the problems faced by the central bank, it is convenient to analyze first the case where there is some accommodation to these shocks.

Lets consider the case where an exogenous shock causes a sharp depreciation of the nominal exchange rate. If this depreciation is perceived as permanent, very rapidly it will translate into

increases in tradable goods prices, generating a higher CPI. This would, in turn, increase nominal demand for money. If Banco de México matches passively demand and supply of base money, this expansion would be validated and the central bank would have accommodated the increase in money demand brought about by the exogenous shock to prices caused by the exchange rate depreciation.

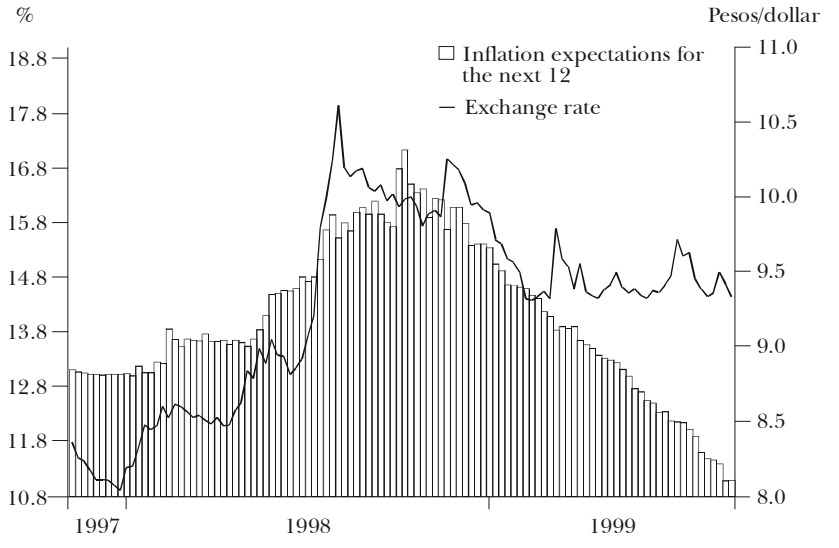
FIGURE 10. INFLATION AND EXCHANGE RATE, 1984-99



In an economic textbook this would be described as a once and for all adjustment in the price level, and according to the textbook explanation, it should be accommodated and it will not cause further problems to the monetary authority.

However, and given our history of high inflation and the high historical correlation between exchange rate depreciations and inflation (see figure 10), the dynamics triggered by the exchange rate depreciation are complicated if one considers that the public might revise their inflationary expectations upwards, as it has been the case lately (see figure 11), which would lead to rises in wages and non-tradable goods prices, and, therefore, subsequent rounds of exchange rate and wage adjustments, thus, perpetuating inflation and monetary base growth. In figure 12 it is clear that the inflation in tradable goods has led the inflation of non-tradable goods since 1995, lending support to the hypothesis that

FIGURE 11. RELATIONSHIP BETWEEN INFLATION EXPECTATIONS AND THE EXCHANGE RATE, 1997-99



SOURCE: Infosel and Banco de México.
NOTE: Last figure: December 17, 1999.

exchange rate depreciations have both a direct and indirect impact on prices.

Other phenomena that would trigger inflationary pressures, similar to those described above, are the adjustments to public sector goods prices and wage increases that are not compatible with the inflation target.

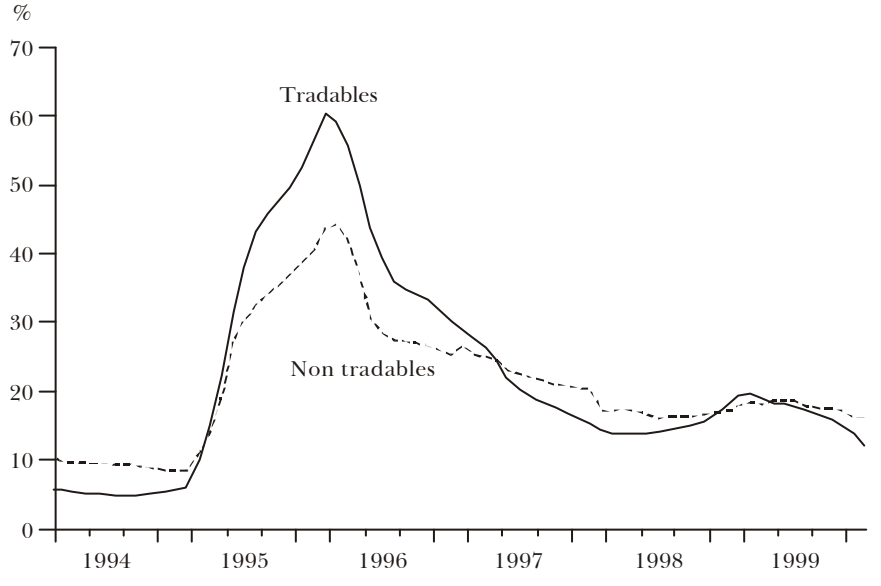
To estimate the significance of the indirect channel of influence of the exogenous shocks, by which these affect expectations, and expectations affect wages, we estimated two equations, one to ex-

TABLE 6. REGRESION RESULTS $\Delta(\Pi_T^E)$: DEPENDENT VARIABLE

Variable	*Coefficient*	*T-statistic*
ΔOBJ_T	0.015	3.916
ΔE_T	0.037	1.954
ΔE_{T-1}	0.052	3.072
(πSUR_{T-1})	0.839	2.619
ΔPSP_T	0.095	2.612
		R^2: 0.367; *D-W:* 2.057

plain the behavior of inflation expectations and the other wage settlements. The first equation explains the change in inflation expectations for the next 12 months, taken from the weekly survey conducted by a Mexican wire system (p_t^e). As explanatory variables we have the weekly depreciation of the exchange rate (Δe_t and Δe_{t-1}), inflationary surprises measured by the difference between observed and expected biweekly inflation ($P\,\mathrm{sur}_t$), the change in the "short" ($\Delta \mathrm{OBJ}_t$) and increases in public sector prices ($\Delta \mathrm{PSP}_t$).

FIGURE 12. TRADABLE AND NON TRADABLE GOODS INFLATION, 1994-1999



From the previous result, it can be derived that a 1 percentage point surprise in biweekly inflation affects inflation expectations for the next 12 months by 0.84 percentage point. This result shows that agents expect inflationary shocks to have an important permanent component. A 1% weekly depreciation affects inflation expectations by 0.09%, while in those weeks when public sector prices have adjusted by 1%, inflation expectations increased by 0.095%. These results might be reflecting the fact that in the past Banco de México has accommodated, at least partially, some of the inflationary shocks, contributing to make them permanent. This is probably the main reason why the pass-through of exchange rate variations to inflation is relatively high in Mexico.

Not surprisingly, during the last two years at least, the Banco de México has been trying to brake this link, by modifying the "short" in response to sharp fluctuations in the exchange rate, minimizing the effects of changes in the prices of tradable goods and on the corresponding to non-tradables.

The second equation explains the behavior of wage inflation, measured by wage settlements, as a function of the previous 3 months 12-month inflation (P_{t-3}), and the inflation expectations for the next 12 months (p_t^E).

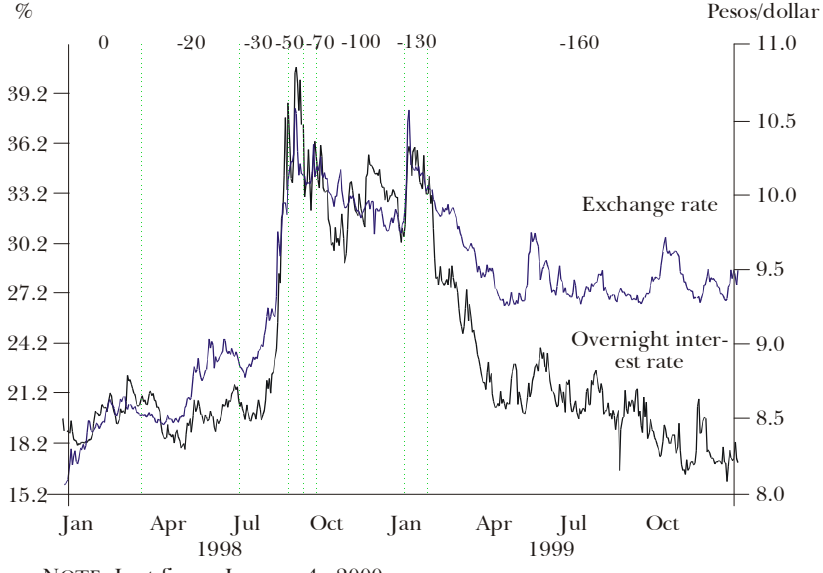
TABLE 7. REGRESION RESULTS WT_T: DEPENDENT VARIABLE

Variable	*Estimation 1*		*Estimation 2*	
	Coefficient	*T-statistic*	*Coefficient*	*T-statistic*
P_{T-1}			0.592	3.068
P_T^E	0.260	2.461	0.537	2.198
WT_{T-3}	0.788	9.965		
$R(1)$			0.740	5.531
R^2	0.354		0.257	
D-W	1.241		1.964	

The results from these regressions clearly show that both lagged and expected inflation have an influence on wage settlements. Taken together, the equations reported in tables 6 and 7 confirm that transitory inflationary shocks --exchange rate movements and adjustment in public sector prices-- affect inflationary expectations and the correction in expectations influence wage behavior, confirming the importance of the indirect effects mentioned before and that also appeared in the impulse response functions from the VECM. These elements have generated significant inertial effects from inflationary shocks in Mexico.

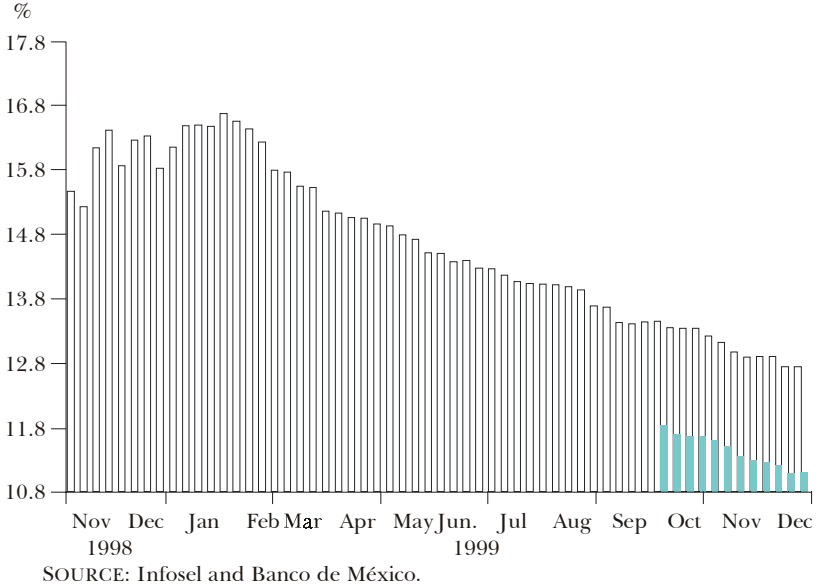
The central bank should be able to offset, at least partially, the inflationary impact of the exogenous disruptions on the exchange rate, public prices and contractual wages. This goal may be achieved if the central bank satisfies the daily monetary base demand, but at a rate above the one prevailing in the market. This is in fact what happens when Banco de México has applied or increased the "short". The resulting higher interest rates may, for example, partially reverse the impact of an exogenous exchange rate shock, limiting the exchange rate depreciation and moderating the adjustment of inflationary expectations. In fact, this was Banco de México's attitude during 1998, and it also has been in

FIGURE 13. OVERNIGHT INTEREST RATE, SPOT EXCHANGE RATE AND "SHORT", 1998-99



NOTE: Last figure January 4, 2000.

FIGURE 14. INFLATION EXPECTATIONS FOR 1999 AND 2000



SOURCE: Infosel and Banco de México.
NOTE: Last figure December 17, 1999.

the elapsed time of 1999, as it sequentially increased the "short" as additional inflationary shocks became apparent (see figures 13 and 14).

In the medium term, the rise in interest rates resulting from the authorities response to greater inflationary pressures will reduce monetary base growth. Such effect might be reinforced by the impact on demand for money of temporarily lower economic growth, associated to the rise in the cost of loanable funds. Additionally, of course, demand for monetary base would moderate in response to the achieved reduction in inflation.

Based on the above, it can be said that the dilemma that Banco de México faces, when conducting monetary policy, consists in determining the degree to which the institution is able to counteract the inflationary shocks that eventually show up.

To the extent that monetary policy is extremely restrictive, entrepreneurs will find it more difficult to pass on to final prices the higher costs resulting from shocks like exchange rate depreciation, rises in public prices, or wage increases above expected inflation plus productivity gains. Profit margins would decrease, to become even negative, along with the possibility of domestic producers losing international competitiveness. All these elements might lead to lower investment and employment. Workers losing their jobs and the unemployed not finding one, would suffer the most from this situation. Therefore a very restrictive monetary policy can have a recessionary impact on economic activity, employment and investment. At the same time, such a policy stance could have undesirable effects on the health of the banking system. These two set of problems could even make the gains in the reduction in inflation unsustainable. This type of considerations have induced the Board of Governors of Banco de México *to lean in favor of a gradual but sustainable path of desinflation*.

The costs of the disinflationary process will be less, to the extent that the central bank enjoys more credibility among the public with respect to its conviction of abating inflation. Then, no substantial increases in interest rates would be required to keep inflationary expectations under control. But the central bank may only gain credibility by acting in a timely and consistent fashion when confronted with mounting inflationary pressures (which would show its commitment to the desinflation process). Therefore, to the extent that Banco de México is able to foster a more accelerated abatement of inflation, it will minimize the short-term costs of implementing a restrictive monetary policy. In fact, empirical evidence suggests that the lasting benefits of a lower infla-

tion in the medium and long term will substantially compensate the temporary costs present in the process of converging towards price stability (see Ghosh and Phillips (1998)).

From the previous analysis, the basis on which Banco de México can support a medium-term strategy to achieve a sustained reduction in inflation, can be derived. Namely:

a) Reaching social consensus regarding the benefits of price stability is imperative, in order to make inflationary expectations, as well as price adjustments, consistent with inflation targets. Thus, disinflation would be achieved at the least possible cost.

b) Monetary policy, in addition to avoiding the primary cause of inflation –the generation of money supply surpluses–, should neutralize the secondary effects of the exogenous shocks on prices and should act in a precautionary fashion, in order to partially offset the direct inflationary effects of the key prices in the economy. The ultimate goal is reaching a situation where necessary adjustments in relative prices have a once and for all impact on the CPI –raising its level– but without deteriorating inflationary expectations, thus avoiding inflation dynamics from turning perverse. Eventually, the purpose is that by virtue of timely actions in monetary policy, Banco de México succeeds in making entrepreneurs, workers and investors, when making decisions, anticipate the possible reaction of the authority with regard to CPI disruptions and minimize the repercussions on expectations. If such behavior is followed, the impact of these disruptions on the economy will soften and credibility from the public with regard to Banco de México's inflation target will increase. This is how the disinflationary target should become eventually the nominal anchor of the Mexican economy.

c) Banco de México should expand the horizon of its disinflationary commitments. By enlarging the time span, given the lags with which monetary policy actions affect prices, the central bank would be able to adjust, in a timely fashion, its stance on monetary policy without confusing the public. The monetary policy scheme would then make the central bank's actions easier to understand which would, in turn, act as an aid in anchoring the medium-term inflationary expectations.

All these elements, in some way or another, are present in the monetary programs of Banco de México.

III.2.Exchange Rate Policy

The exchange rate in Mexico has been floating freely since late 1994. Nevertheless, at different stages since then, there has appeared for different reasons the need for the authorities to participate in the forex market. In all of these cases, the rule that always has been followed is that the intervention of the authorities in the forex market should be completely transparent, and without defending a particular level of the exchange rate – thus preserving the main characteristics of a flexible exchange rate regime.

As has been mentioned before, one of the most important elements of the crisis was the run on the country's external liabilities. On the public sector side, the run concentrated on the now famous TESOBONOS, that were dollar denominated government securities. Regarding the private sector, commercial banks faced difficulties in rolling-over their external liabilities. Even after the international assistance package was approved and the resources were available, and the adjustment program was already in place, relatively large amortizations of TESOBONOS and bank credits continued. Very soon it became obvious that if the excess demand for foreign exchange that generated this abrupt stock adjustment in the holdings of Mexican liabilities was not satisfied by official intervention, the depreciation of the floating exchange rate could have been enormous, with a risk of falling in a hyperinflation.

As a matter of fact, if the depreciation of the exchange rate had been the sole adjusting variable, such a price would have reached levels where less of a supply of forex would have resulted from additional depreciations (a back-bending supply curve would have ensued). Therefore, it was imperative to use the resources of the financial package to isolate the forex market from the token stock adjustment, and the indeterminacies that such an adjustment by itself would have created.

In line with the above, the authorities decided to open a special window at the central bank to cater the capital outflows related to the amortizations of TESOBONOS an commercial banks´ credit lines. Dollar financing under this program was extended to 17 commercial banks. At its peak in early April, 1995, the outstanding credit granted through this facility reached only 3.9 billion dollars. By September, 1995, all participating banks had paid their outstanding debt in full.

As a matter of fact, by May of 1995 the floating exchange rate system began to work "normally". But, in any case, in the face of

an abrupt stock adjustment, as the one Mexico confronted in early 1995, the stabilization effort could not have worked without the assistance of the IMF and U.S. government loans, that allowed the "isolation" of the forex market from such a stock adjustment.

Another important element that has contributed to isolate the forex market from significant shocks, is that Banco de México has been acting as the counterpart of the government, doing all of the resulting transactions at the daily "fix" exchange rate. In this way, the international reserves perform as an absorber to foreign exchange shocks (coming mostly from oil price fluctuations and external interest rate variations) affecting the government. In addition, given that the government typically runs a surplus in foreign currency, this practice has been helpful to increase our international reserves without intervening directly in the market.

In addition, in the aftermath of the crisis, Mexico faced the need to reestablish its international reserves to a suitable level, for the reasons that have already been explained. In July of 1996, given the stability that the exchange rate exhibited during the first part of the year and that capital was flowing back to Mexico, the Exchange Commission, integrated by officials from the Ministry of Finance and Banco de México and which is responsible for determining Mexico's exchange rate policy, considered that foreign reserves at the central bank could be increased without causing disruptions in the foreign exchange market. Although the Commission considered it appropriate to accumulate a larger amount of international reserves, it also emphasized that this accumulation had to be done without affecting the behavior of the floating exchange rate and without sending any type of signals to the market that could be interpreted as desired levels for the exchange rate. In addition, it was important that the way in which the accumulation of reserves took place would encourage purchases of dollar when there was an excess supply of foreign currency, and discourage those purchases when there was an excess demand.

The scheme that was adopted to reach these objectives, still in operation, works as follows:

1) On the last business day of each month, Banco de México auctions rights to sell dollars to the central bank (put options) among credit institutions. These rights can be partially or completely exercised within the month following the respective auction.

2) Holders of these rights can sell dollars to Banco de México at the interbank exchange rate published for the previous business day, if the exchange rate is not higher than the average exchange rate for the 20 business days previous to the date on which these rights are exercised.

3) The expansion of the monetary base caused by Banco de México is completely sterilized. Therefore, the evolution of the supply of primary money is in no way affected by the aforementioned operations.

The mechanism just described went into operation in August 1996. In that month, the total amount of put options that was auctioned was exercised. Therefore, the central bank purchased 130 million dollars from commercial banks. In light of the acceptance of this mechanism among banks, and the favorable results of the first placement of options, in late August the Exchange Commission decided to increase the amount of rights to be auctioned per month to 200 million dollars, and to 300 million in December. On February 1996, the Exchange Commission decided that, starting that month, in the case that before the 16 of each month, 80% or more of the month's options had been exercised, a new auction of options would immediately take place, therefore doubling the potential monthly accumulation of reserves. On July 1997, the auction was increased to 500 million and in October it was reduced to 400 million and to 250 in November. During 1998, this mechanism was suspended from October to December due to the extreme turbulence experienced in the forex market. This mechanism has accomplished its primary goal of accumulating international reserves without interfering with the functioning of the free float, and avoiding any misinterpretation of the intervention of the monetary authority in the foreign exchange market.

Both, theory[5] and practice have shown that the accumulation of reserves through this mechanism is sufficiently neutral to changes in the volatility and trend driving the exchange rate process. Therefore its establishment did not send any type of signals regarding the preferences of the central bank towards exchange rate changes or its volatility.

In several occasions under the floating exchange rate regime, when the domestic currency experienced sharp depreciations, liquidity in the forex market almost dryed up. Under such circum-

[5] See Werner, A. and A. Milo (1998).

TABLE 8. RESULTS OF THE AUCTION OF OPTIONS

Date of the auction	*Amount auctioned (millions of us$)*	*Aumount excercised (millions of us$)*	*Percentage excercised*
1996			
Aug. 7	130	130	100.0
Aug. 30	200	200	100.0
Sep. 30	200	179	89.5
Oct. 31	200	200	100.0
Nov. 29	200	200	100.0
Dec. 30	300	300	100.0
1997			
Jan. 31	300	300	100.0
Feb. 21	300	148	49.3
Feb. 28	300	120	40.0
Mar. 31	300	300	100.0
Apr. 15	300	263	87.7
Apr. 30	300	300	100.0
May 30	300	20	6.7
Jun. 30	300	300	100.0
Jul. 9	300	300	100.0
Jul. 31	500	460	92.0
Aug. 29	500	500	100.0
Sep. 30	400	375	93.8
Oct. 31	250	250	100.0
Nov. 28	250	250	100.0
Dec. 15	250	250	100.0
Dec. 30	250	49	19.6
1998			
Jan. 30	250	0	0.0
Feb. 27	250	250	100.0
Mar. 31	250	250	100.0
Apr. 6	250	210	84.0
Apr. 30	250	149	59.6
Jul. 14	250	250	100.0
Jul. 31	250	0	0.0
Aug. 31	250	20	8.0
Sep. 30			
Oct. 31		No auction	
Nov. 30			
Dec. 30	250	215	86.0
1999			
Jan. 29	250	250	100.0
Feb. 26	250	220	88.0
Mar. 31	250	250	100.0
Apr. 30	250	205	82.0
May 31	250	250	100.0
Jun. 30	250	180	72.0
Jul. 30	250	200	80.0
Aug. 31	250	200	80.0
Sep. 30	250	145	58.0
Oct. 29	250	0	0.0
Nov. 30	250	250	100.0
Dec. 29	250	30	12.0
Total	*10 580*	*8 493*	*80.3*

stances, small changes in the demand for foreign currency led to disproportionate depreciations of the peso. These conditions might lead to devaluatory spirals that can seriously affect inflation and interest rates. In order to moderate these extreme situations, a contingent dollar sales scheme was introduced in February of 1997. According to this scheme, Banco de México auctions everyday 200 million dollars with a minimum price that is two percent above the preceding day's exchange rate. This scheme is not intended to defend specific levels for the exchange rate, but only to moderate exchange rate volatility by reestablishing a minimum level of liquidity in stressful times.

Additionally, it should be pointed out that, by selling dollars through auctions and avoiding the defense of specific exchange rate levels, the exchange rate will rapidly reach the stage where foreign currency supply and demand reach equilibrium. Furthermore, it is possible that, by merely suggesting that the central bank might be willing to sell 200 million dollars, subject to the exchange rate depreciating two percent of further within the day, the likelihood of devaluatory spirals would be reduced.

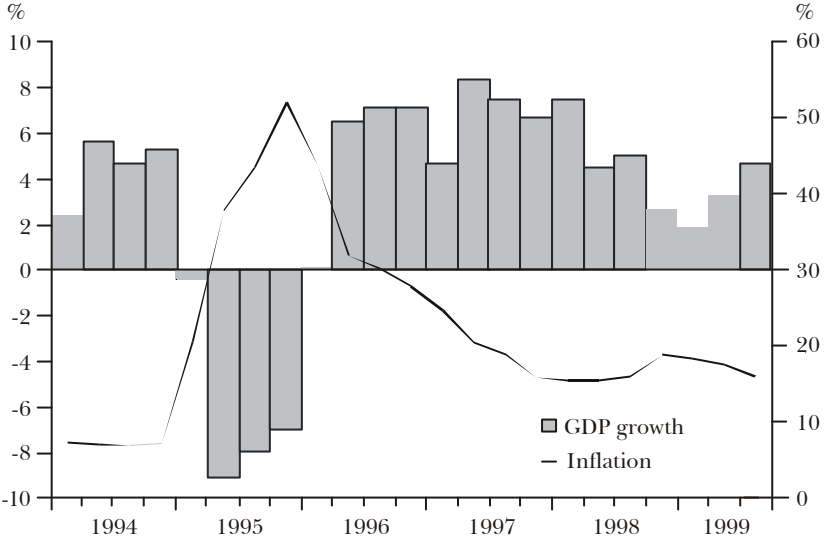
As a result of the international market volatility generated by the Asian, Russian and Brazilian crises, this mechanism was activated in several occasions. Banco de México's contingent dollar sale mechanism fostered greater stability and order in the currency exchange market without having compromised an excessive amount of international reserves during these periods, proving to be a suitable mechanism to reduce the volatility in the foreign exchange market.

IV. STYLIZED FACTS UNDER MEXICO'S FLOAT

First of all, we should mention that given the macroeconomic framework that has been maintained during the period of study, the floating exchange rate regime has not been an impediment to achieve a fast disinflation from a rate of 51.7% in 1995 to 18.6% in 1998 (with a temporary interruption during the second semester of 1998, due to the distress in the world economy). This disinflation coincided with a relatively high rate of growth of the Mexican economy.

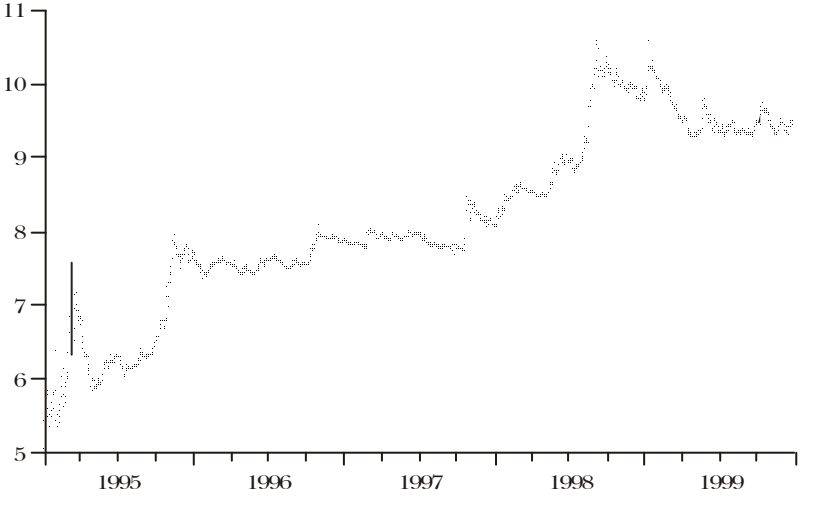
Immediately after the adoption of the floating exchange rate, the movements in the currency were erratic and significant depreciations took place. This behavior is entirely explained by the uncertainty regarding the policy measures that were going to be

FIGURE 15. GDP AND INFLATION, 1994-99 (annual growth rates)



implemented in response to the crisis and the acute international liquidity problem that the country was facing. Since April 1995, after the announcement of the IMF program and the international assistance package, the currency stabilized and the foreign exchange market was relatively stable until October, when another episode of high volatility and large depreciations started.

FIGURE 16. SPOT EXCHANGE RATE, 1995-99



Again, the main reason behind this episode was the uncertainty regarding the macroeconomic program for 1996 and the health of the financial system. Once these issues were cleared, the foreign exchange market has experienced long periods of stability that have been temporarily interrupted by bouts of volatility. In addition, and as a result of the Russian default, the currency suffered another episode of large depreciations and volatility from September to November of 1998. As a matter of fact, the peso experienced then an overshooting, that has been in the process of correction since December, 1998 with a small interruption due to the brazilian real devaluation (see figure 16).

The existence of an efficient foreign currency futures market has been of great use in order to diminish the volatility of the exchange rate. According to the sales or purchases carried out in this market, both importers and exporters and, in general, creditors and debtors of foreign currency, are able to eliminate or substantially reduce the exchange rate risks they face and thus alleviate pressures on the spot market. Therefore, Banco de México authorized banks complying with certain conditions, particularly those related to technical qualification and solvency, to carry out operations in foreign exchange futures. In 1995, Banco de México also issued the necessary provisions to facilitate the operation of a Mexican peso futures market at the Chicago Mercantile Exchange.

Overall, the volatility experienced by the Mexican peso during its float, once the macroeconomic and financial crises were contained, has been similar to that experienced by other currencies with a floating exchange rate regime. Since 1996, the implementation of consistent fiscal, monetary and exchange rate policies, the programs implemented to restructure the financial system and the accumulation of international reserves by Banco de México, reestablished confidence on our macro framework and as a result we have seen usually an orderly behavior of the peso.

Although it has been argued that by floating the exchange rate a country has an additional adjustment variable to confront external shocks and therefore the volatility of interest rates should come down, this is not necessarily true. When adopting a flexible exchange rate, a country also abandons the use of its international reserves as an adjustment variable to absorb transitory external shocks. Thus, we should think that when moving from a fixed to a floating regime a country changes its adjustment variables from international reserves and interest rates to the nominal exchange rate and interest rates. So, it is not obvious that interest

TABLE 9. EXCHANGE RATE VOLATILITY OF SOME COUNTRIES VIS-AVIS THE USD (percent)

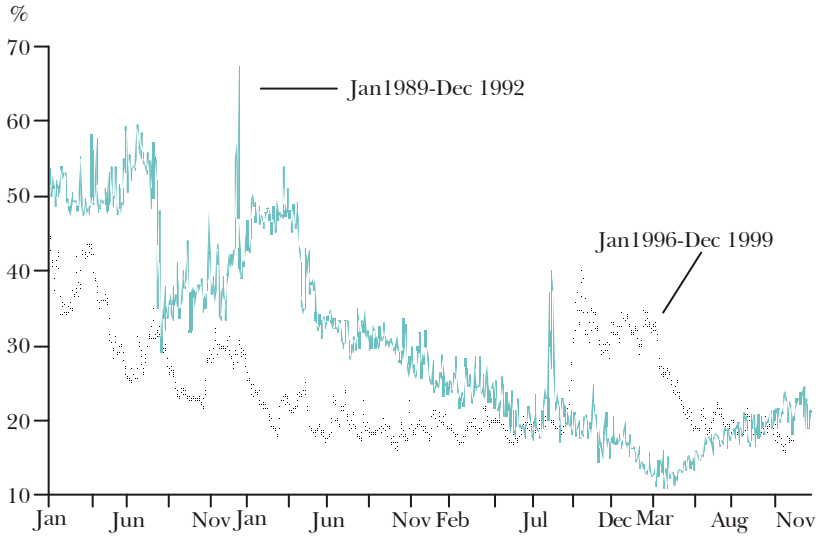
Country	*1995-I*	*1995-II*	*1996-I*	*1996-II*	*1997-I*	*1997-II*	*1998-I*	*1998-II*	*1999-I*	*1999-II*[a]
Australia	8.86	7.87	6.10	6.70	7.65	10.29	11.91	14.93	12.09	11.92
Canada	5.13	5.92	3.64	3.33	5.46	4.24	4.32	6.95	5.72	5.24
Finland	12.85	9.13	7.43	7.28	10.04	9.51	8.31	9.17	8.85	9.09
Germany	13.87	10.89	6.28	6.87	9.79	9.76	8.14	9.15	8.87	9.96
Italy	13.97	7.22	5.97	5.73	8.95	9.15	7.82	9.29	8.86	9.99
Japan	14.12	14.04	8.14	7.09	12.56	12.29	12.56	20.08	13.60	12.53
Mexico	48.56	17.60	5.99	5.31	4.92	10.69	6.68	10.95	9.92	7.05
New Zealand	6.67	5.35	5.56	6.01	5.88	8.61	12.45	14.95	9.54	10.08
South Africa	5.64	2.34	13.86	7.20	5.25	4.34	5.35	23.07	12.01	5.66
Suecia	12.70	9.91	8.02	7.28	10.26	10.58	9.57	12.59	8.73	9.22
Switzerland	16.67	12.13	7.77	8.84	11.70	9.81	8.70	10.91	9.63	10.88
United Kingdom	10.45	7.41	5.60	6.30	8.13	8.03	7.11	7.33	6.86	7.30

NOTE: The annualized volatility is defined as the annuañized standard deviation of the daily fluctuations of the exchange rate.
[a] Until December 31, 1999.

rate volatility should decline when a country adopts a floating exchange rate regime.

As a simple test of the effects of the different exchange rate regimes on interest rate levels and volatilities, we compare the behavior of interest rates in the 1996-1999 period with that observed during 1989-94. These periods share similar inflation performances: during 1996-98 inflation was 27.7, 15.7 and 18.6% respectively, while in the 1989-91 period the rate of inflation was 19.7, 29.9 and 18.8% respectively. On the other hand during the more recent period we had a floating exchange rate regime and in the 1988-94 period we had a predetermined exchange rate system.

FIGURE 17.FUNDING RATE, 1989-99

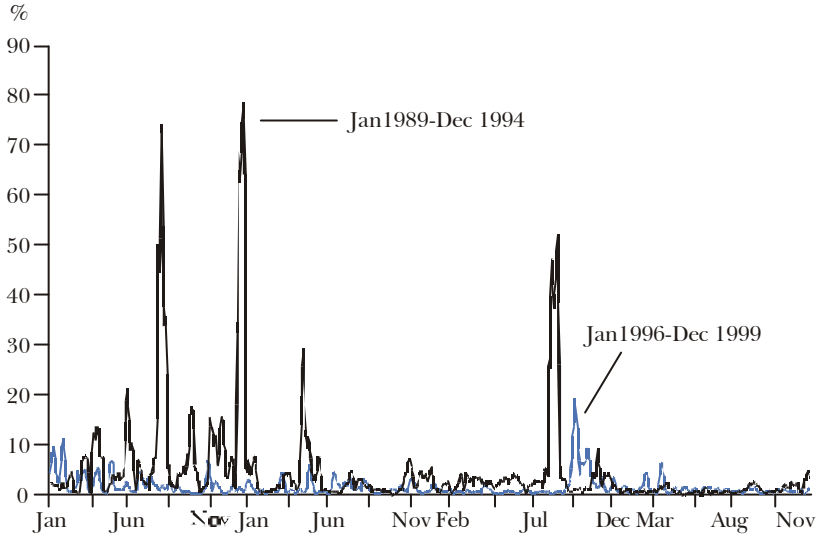


SOURCE: Banco de México.
NOTE: Until November 23, 1999.

It is clear that in the current stabilization effort, under a floating exchange rate, interest rates have been usually lower and less volatile than what was observed during the years of the Pacto (1997-94).

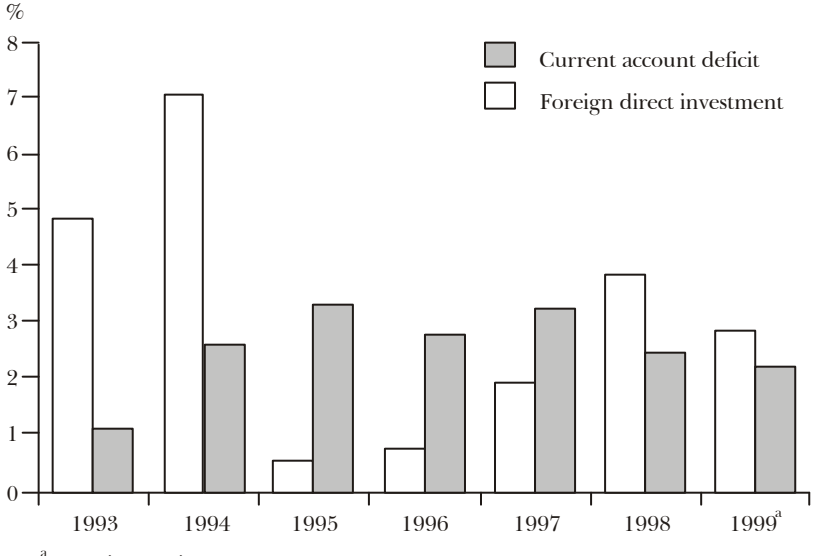
In Mexico's experience, the adoption of a floating exchange rate regime has substantially contributed in reducing speculative pressures in financial markets. A very important feature of this regime is that it discourages short-tem capital flows, due to the large losses that can be incurred by investors in the short-run. As

FIGURE 18.FUNDING RATE VOLATILITY, 1989-99



SOURCE: Banco de México.
NOTES: 10-day moving variancre. Until November 23, 1999.

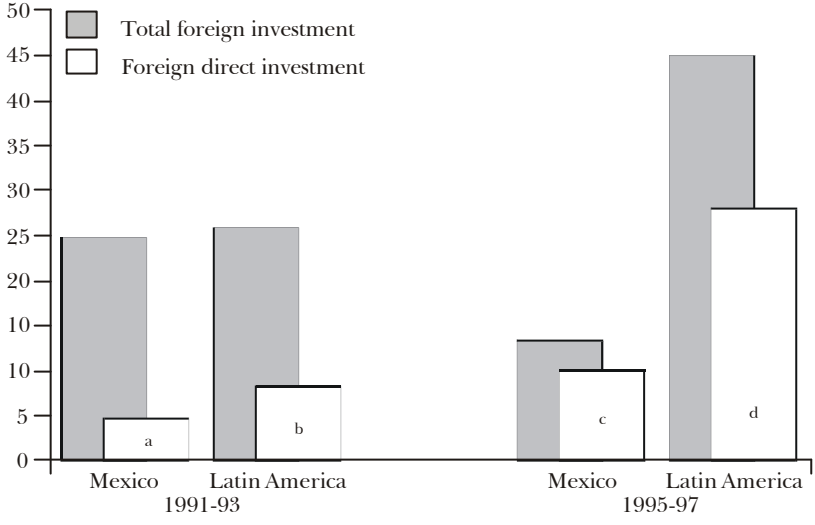
FIGURE 19. CURRENT ACCOUNT FOREIGN DIRECT INVESTMENT, 1993-99 (% GDP)



[a] Banxico's estimate.

it is clear from figures 19 and 20, the recent Mexican experience highlights this phenomenon, as the ratio of FDI to the current account deficit has increased significantly since the adoption of this regime. The reaction of the FDI to current account ratio deficit in Mexico has been larger than the one observed in other Latin-American countries that have not changed their exchange rate regime.

FIGURE 20. AVERAGE FOREIGN DIRECT INVESTMENT FOR MEXICO AND LATIN AMERICA, 1991-97 (as billions of US dollars)



SOURCES: *International Finance Statistics,* FMI, August, 1998; CD-ROM, June, 1998; and, Banco Central do Brasil.

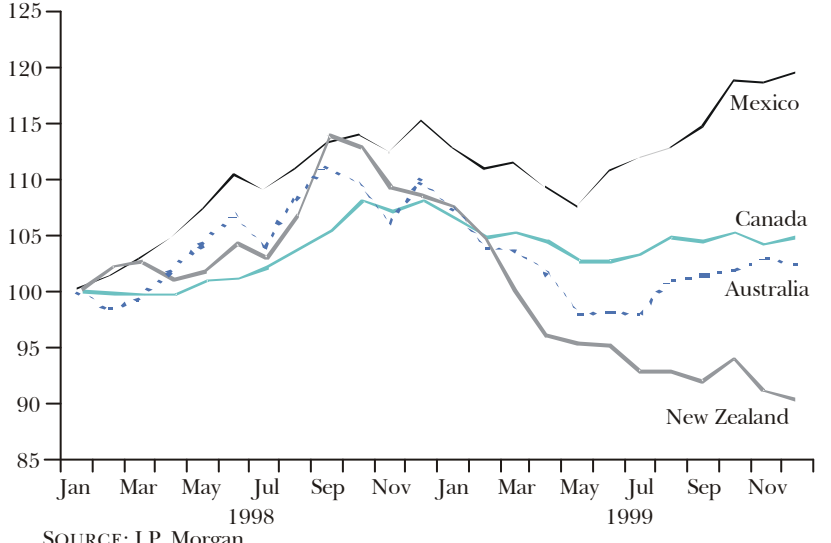
NOTES: The data for Latin America from 1995 to 1997 is complete only for the follow in countries: Argentina, Brazil, Chile, El Salvador, Peru, Uruguay and Venezuela. From 1991 to 1993 the data is complete for all Latin American countries except for the Dominican Republic, Paraguay, and Trinidad and Tobago.

[a] 18% of total foreign investment. [b] 25% of total foreign investment. [c] 76% of total foreign investment. [d] 65% of total foreign investment.

It is important to highlight the stabilizing properties of the floating exchange rate system and the free determination of interest rates when the economy faces a capital outflow (although not as large as the observed in Mexico in early 1995). Under these circumstances, the downloading of assets denominated in domestic currency will bring about a depreciation of the currency and an increase in interest rates. The simultaneous movements in these variables depresses asset prices, and discourages further

selling, stopping the capital outflow. The automatic movements in exchange rates and interest rates increases the price of speculating again the domestic currency. Given the fact that the levels that these variables reach during these episodes are inconsistent with the fundamentals of the economy, the currency will recover sooner or later, inflicting considerable losses to those who acquired the foreign currency at a high price and sold their domestic assets at rock bottom prices.

FIGURE 21. REAL EXCHANGE RATE, 1998-99 (Jan 1998 = 100)



SOURCE: J.P. Morgan.

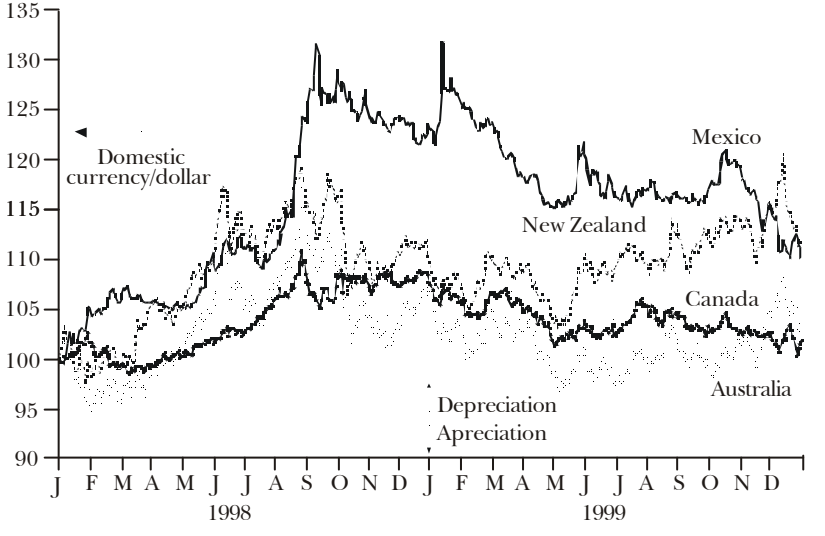
NOTE: Real exchange rate against countries (22 OECD countries and 23 emerging economies). Calculated with WPI, PPI and CPI indexes. Weighted with the trading patterns of manufactured goods of 1990.

The flexible exchange rate also facilitates the adjustment of the real exchange rate towards its equilibrium level whenever an external shock warrants a new equilibrium real exchange rate, without seriously affecting the credibility of the monetary authority. The best example of this role for the exchange rate is what we witnessed last year with the currencies of Australia, Canada and New Zealand.

These small open economies were affected severely by the fall in their terms of trade and the fall in demand from the Asian crises countries. As a reaction to these shocks, the currencies of these countries depreciated by large amounts. These currency movements were useful in diminishing the real effects of the aforemen-

tioned shocks. A similar phenomenon happened in Mexico, as our terms of trade fell by 5.5% and the international financial markets turned their backs on emerging markets. Both of these shocks should depreciate the equilibrium real exchange rate, justifying the observed depreciation of the currency.

FIGURE 22. NOMINAL EXCHANGE RATE, 1998-99 (Jan 1998 = 100)



These movements in the real exchange rate were useful to minimize the effects of the aforementioned shocks on the economy. During 1998, Mexico's GDP grew by 4.8%, only 0.2% below the growth rate expected at the beginning of the year, in part due to significant growth of non-oil exports (11.3%). However, given our history of high inflation and the high historical correlation exhibited between depreciations and inflation, as the exchange rate depreciated inflation expectations immediately reacted. Therefore, the inflation cost of achieving the necessary correction in the real exchange rate was around 2.2 percentage points and the nominal depreciation needed to achieve the same movement in the real exchange rate had to be significantly larger that the ones in the other countries considered (See 1999 Monetary Program, Banco de México).

A brief comparison between the speed of the passthrough effects in Mexico and Australia highlights the problem the former faces due to its previous inflationary history. Although the long term impact of an exchange rate depreciation on non controlled

prices is similar in Mexico and Australia (a 1% depreciation translates into a 0.55% inflation in Mexico and 0.44% inflation in Australia), in our country half of this effect takes place after 2 quarters, while 82% takes place within the year. On the other hand, in Australia,[6] only 7% takes place after 2 quarters and 14% after 4 quarters.

As we mentioned in the previous section, due to the high pass-through from exchange rate depreciation to inflation, during 1998 Banco de México had to tighten monetary policy sequentially to counteract the effects on inflation.

To reduce the high speed at which peso depreciations feed into inflation, is one of the key challenges that monetary policy faces in the future, so as for Mexico to be able to take full advantage of the floating exchange rate regime and let the exchange rate play its "relative price" role instead of being a signal for future inflation.

V. THINKING ABOUT ALTERNATIVES: ADVANTAGES AND DISADVANTAGES OF DOLLARIZATION

To evaluate the convenience of substituting the domestic currencies for the U.S. dollar in Latin America it is important to study two issues. First, we should analyze the issues identified by the traditional optimal currency area (OCA) theory, (outlined by Mundell) as important for assessing whether dollarization is convenient for some or all of the countries in Latin America. The second approach relies on the credibility gains that dollarization can provide for inflation prone economies.

The OCA theory suggest that the benefits from this arrangement come form the reduction of exchange rate volatility and lower transactions cost. On the other hand, the costs come from giving up the exchange rate as an instrument for macroeconomic adjustment. Therefore, the more integrated the economies of the region are with that of the U.S. the higher the benefits of dollarization. To counteract asymmetric shocks, once the exchange rate instrument is abandoned it is helpful to have flexible labor markets, labor mobility and fiscal transfers within member countries and capital mobility. Given that the latter elements are absent in the economies of the region (except free capital mobility), the only point worth studying is the degree of integration with the U.S.

[6] See Ericsson and de Brouwer (1998).

TABLE 10. GDP GROWTH CORRELATION: THE AMERICAS, 1990-98

	Argentina	*Brazil*	*Chile*	*Colombia*	*Ecuador*	*United States*	*Mexico*	*Peru*	*Venezuela*	*Average*
Argentina	1.000	-0.112	0.160	-0.285	0.492	0.063	0.611	0.157	0.074	*0.145*
Brazil	-0.112	1.000	-0.065	0.582	0.003	0.244	-0.268	0.813	-0.520	*0.085*
Chile	0.160	-0.065	1.000	0.337	0.323	-0.106	-0.493	0.050	0.326	*0.066*
Colombia	-0.285	0.582	0.337	1.000	0.266	-0.084	-0.521	0.468	-0.081	*0.085*
Ecuador	0.492	0.003	0.323	0.266	1.000	-0.451	0.211	0.220	0.470	*0.192*
United States	0.063	0.244	-0.106	-0.084	-0.451	1.000	0.192	0.299	-0.748	*-0.074*
Mexico	0.611	-0.268	-0.493	-0.521	0.211	0.192	1.000	-0.235	0.009	*-0.062*
Peru	0.157	0.813	0.050	0.468	0.220	0.299	-0.235	1.000	-0.488	*0.161*
Venezuela	0.074	-0.520	0.326	-0.081	0.470	-0.748	0.009	-0.488	1.000	*-0.120*
									Total average	*0.053*

TABLE 11. GDP GROWTH CORRELATION: EUROPE, 1978-97

	Germany	*Austria*	*Belgium*	*Denmark*	*Spain*	*Finland*	*France*	*Greece*	*Netherlands*	*Ireland*	*Italy*	*Luxembourg*[a]	*Portugal*	*U. K.*	*Suecia*	*Average*
Germany	1.000	0.485	0.293	-0.014	0.240	-0.482	0.144	0.391	0.451	-0.018	0.232	0.274	0.225	-0.264	-0.108	*0.132*
Austria	0.485	1.000	0.419	0.094	0.382	0.195	0.435	0.093	0.447	-0.008	0.439	0.183	0.609	0.046	0.263	*0.291*
Belgium	0.293	0.419	1.000	-0.030	0.620	0.406	0.756	0.525	0.544	0.408	0.682	0.539	0.618	0.158	0.534	*0.462*
Denmark	-0.014	0.094	-0.030	1.000	-0.032	0.219	0.030	0.216	0.291	0.158	0.107	0.310	-0.188	0.505	0.426	*0.149*
Spain	0.240	0.382	0.620	-0.032	1.000	0.289	0.608	0.166	0.541	0.321	0.354	0.602	0.521	0.456	0.434	*0.393*
Finland	-0.482	0.195	0.406	0.219	0.289	1.000	0.562	0.232	0.157	0.308	0.562	0.168	0.402	0.529	0.808	*0.311*
France	0.144	0.435	0.756	0.030	0.608	0.562	1.000	0.569	0.421	0.337	0.716	0.511	0.715	0.406	0.630	*0.488*
Greece	0.391	0.093	0.525	0.216	0.166	0.232	0.569	1.000	0.442	0.252	0.611	0.498	0.297	0.222	0.350	*0.348*
Netherlands	0.451	0.447	0.544	0.291	0.541	0.157	0.421	0.442	1.000	0.487	0.396	0.775	0.347	0.268	0.376	*0.424*
Ireland	-0.018	-0.008	0.408	0.158	0.321	0.308	0.337	0.252	0.487	1.000	0.143	0.373	0.298	0.203	0.335	*0.257*
Italy	0.232	0.439	0.682	0.107	0.354	0.562	0.716	0.611	0.396	0.143	1.000	0.379	0.659	0.333	0.752	*0.455*
Luxembourg	0.274	0.183	0.539	0.310	0.602	0.168	0.510	0.498	0.775	0.373	0.379	1.000	0.025	0.551	0.484	*0.405*
Portugal	0.225	0.609	0.618	-0.188	0.521	0.402	0.715	0.297	0.347	0.298	0.659	0.025	1.000	0.099	0.350	*0.355*
U. K.	-0.264	0.046	0.158	0.505	0.456	0.529	0.406	0.222	0.268	0.203	0.333	0.551	0.099	1.000	0.592	*0.293*
Suecia	-0.108	0.263	0.534	0.426	0.434	0.808	0.630	0.350	0.376	0.335	0.752	0.484	0.350	0.592	1.000	*0.445*
													Total average			*0.347*
													Average EURO 11			*0.361*

[a] Correlation with Luxembourg until 1992.

TABLE 12. GDP GROWTH CORRELATION: UNITED STATES REGIONS, 1978-96

	Far West	*Great Lakes*	*Mideast*	*New England*	*Plains*	*Rocky Mountains*	*Southeast*	*Southwest*	*Average*
Far West	1.000	0.553	0.816	0.743	0.588	0.225	0.701	0.329	*0.565*
Great Lakes	0.553	1.000	0.809	0.624	0.882	0.508	0.909	0.488	*0.682*
Mideast	0.816	0.809	1.000	0.908	0.690	0.204	0.876	0.305	*0.658*
New England	0.743	0.624	0.908	1.000	0.541	0.069	0.792	0.190	*0.552*
Plains	0.588	0.882	0.690	0.541	1.000	0.647	0.859	0.664	*0.696*
Rocky Mountains	0.225	0.508	0.204	0.069	0.647	1.000	0.561	0.848	*0.438*
Southeast	0.701	0.909	0.876	0.792	0.859	0.561	1.000	0.565	*0.752*
Southwest	0.329	0.488	0.305	0.190	0.664	0.848	0.565	1.000	*0.484*
								Total average	*0.603*

and the asymmetry between movements in GDP each country and the U.S. By looking at the historical correlations between each of the Latin America countries and U.S. and their exports to the U.S. as a % of GDP, it is clear that this criteria suggests that dollarization is not a great idea for the region.

The following tables compare the correlation of growth rates between some Latin American countries and the U.S. with that observed in Europe and between U.S. regions. The highest correlation between Latin American economies and the U.S. are those of Brazil, Mexico and Peru. However, these numbers are significantly smaller that the average correlation observed between the 11 economies that fond the EURO area (labeled average EURO 11 in the table) and almost one third of the average correlation between U.S. regions. This is a reflection of the low degree of integration of these economies with the U.S. and of the relative importance of domestic shocks.

Therefore, the perceived advantages from dollarization must come from the credibility bonus that abandoning the possibility of devaluing the currency brings whit it. This credibility bonus will be reflected in a rapid reduction of inflation and an interest rates.

The reduction of real interest rates will take place because:

i) The foreign exchange rate risk premia disappears (not 100% due to the possibility of a policy reversal).

ii) According to some observers, country risk could fall as a result of this measure. On the one hand, it could be argued that the elimination of speculative pressures may allow for a reduction in country risk as lower domestic interest rates improves the governments budget constraint. However, one could also argue that loosing the option of reducing the domestic debt burden by devaluing should increase sovereign risk. In addition, the sudden conversion of a sizeable stock of domestic currency debt would test the limits of the demand for the country's dollars debt, possibly increasing spreads.

V.1.Advantages and disadvantages of dollarization

Advantages

1) It strengthens the credibility of a fixed exchange rate regime by substantially eliminating or reducing the capability to pursue an active and independent monetary policy. It facilitates the adjustment of expectations to an inflation rate congruent

with a fixed exchange rate, thereby promoting wage and price discipline. This gives rise to a rapid fall in inflation.

2) By reducing the exchange rate risk, interest rates in the country in question rapidly converge to those in the country against which the currency is pegged, except for sovereign risk considerations. For these same reasons, it stimulates financial intermediation, productive investment and economic growth.

3) Fiscal discipline is promoted, inasmuch as capital markets will severely penalize the government should unsustainable fiscal policies be pursued. On the other hand, by reducing interest rates, the fiscal burden of debt service is reduced, improving the fiscal balance.

4) Financial discipline is promoted because the role of lender of last resort of the central bank is severely limited. This role will be transferred to institutions abroad or to mechanisms specifically established for that purpose. The support mechanism for savers would have to be a private insurance or depend on fiscal resources.

Disadvantages

1) The correction of a disequilibrium in the real exchange rate, due to external shocks (terms of trade, productivity, etc.) or internal shocks (salary or real estate price adjustments) will require a prolonged recession. In this sense, the greater the proportion of commercial goods that there are in the country and the greater the flexibility of wages, the less this problem will be.

2) Financial fragility: by eliminating the possibility of the central bank completely assuming the role of lender of last resort, the vulnerability of the financial system to bank runs increases. This risk is even greater if there is a weak financial system. Furthermore, given that the adjustment to balance of payments problems will take place only through adjustments in the interest rate, the financial system can find itself subject to excessive pressures.

3) Vulnerability to runs on public debt if there is a bunching of amortizations.

4) Capital inflows cannot be a perfect substitute for the management of liquidity carried out by the central bank. This is due to

the fact that arbitrage in external and internal interest rates can not be immediate.

5) Loss of seigniorage.

VI. FINAL REMARKS

Recent emerging market crises have reignited the debate on the optimal exchange rate regime for emerging markets. In addition, there is a widespread agreement that the costs of policy mismanagement have increased significantly and in several occasions were not proportional to the policy slippages undertaken on the crises countries. Therefore, independently of the choice of exchange rate arrangements, the recent financial market crises underscores the importance of maintaining a consistent macroeconomic framework to avoid financial and balance of payments crises and achieve long-lasting stability.

In relation to the conduct of monetary policy, it is clear that assigning multiple objectives to this single policy instrument, has led to the collapse of several predetermined exchange rate regimes. Because of this, one of the most important steps undertaken after the collapse of the Mexican peso was to spell out clearly that monetary policy was going to be focused exclusively in attaining its medium run goal of price stability and that the banking sector problem was going to be addressed by specific programs, whose cost was going to be assumed by the fiscal authority. In this regard, the recent Mexican experience highlights the importance of following consistent macroeconomic policies to accomplish a long lasting stabilization.

The evolution of monetary policy since the adoption of the floating exchange rate regime has converged on a framework that includes three main elements: an annual inflation target, the establishment of rules with respect to the evolution of base money and the use of discretionary measures to affect interest rates in the pursuit of our inflation target. This mixture of rules and discretion has worked well in recent years. On the one hand, the establishment of rules and quantitative commitments described in the paper has been helpful in guaranteeing the public that Banco de México will not create the most basic source of inflation: excess supply of base money. Due to the high pass-through of inflationary shocks, the instability in the demand for base money and the difficulty in affecting monetary aggregates in the short run, the strict

application of our rules, does not guarantee that the inflation target will be met. Therefore, to be in a position to quickly react to inflationary shocks, Banco de México has the possibility to discretionally adjust its monetary policy stance to influence the behavior of the interest rates in the pursuit of its inflation target. Therefore, as time has passed, the inflation objective, supported by our discretionary actions, has become the nominal anchor of the economy.

Going back to the discussion on exchange rate arrangements for emerging markets, our experience has shown that the Mexican peso has been as stable as other floating currencies, contrary to the original forecasts of several analysts. Therefore, this exchange rate regime has not represented an obstacle in our disinflationary efforts and it has contributed significantly to the adjustment of the economy to external shocks and to discourage short-term capital inflows. Thus, the floating exchange rate has become a very important element of Mexico's current macroeconomic policy framework.

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Zenón Quispe

Monetary policy in a dollarized economy: the case of Peru

I. INTRODUCTION

The persistence of high inflation in Peru during the 1970s has led households to hold foreign currency as store of value. This is due to the absence of domestic assets that could satisfy their liquidity and store of value requirements. This process of dollarization increased significantly during the hyperinflation of 1988-1990. Since 1991 the dollarization has shown a slight but sustained decreasing pattern as a result of the stabilization process and the structural reforms in the financial system. In March 1998, two thirds of domestic banking deposits were denominated in dollars, ten percentage points below their level in 1991.

In general, there is discussion regarding whether dollarization

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affects substantially the conduct of monetary policy. This is due to the possible instability of the domestic money demand due, principally, to changes in devaluation expectations. However, recently, there has been a consensus among economists that it is important to consider the difference between dollarization characterized by currency substitution and that characterized by asset substitution.

In an economy whose agents prefer domestic currency for their current domestic transactions, and hold dollars as a store of value, the dollarization type is of asset substitution and monetary policy is still effective in influencing nominal domestic transactions through the control of money supply. Otherwise, if households use dollars for current transactions, the economy faces currency substitution then the design of the monetary policy could be more difficult.

The second section of this paper examines the inflation and the dollarization process in Peru, showing that monetary policy could still be effective in influencing domestic transactions in part because these have remained predominantly in domestic currency and dollarization reflects primarily asset substitution. The third section characterizes monetary policy in Peru using identified VARs procedures proposed by Christiano, Eichenbaum and Evans (1996) and Sims and Zha (1995) with real and nominal variables. It focuses on the role of domestic and foreign components of M3 to explain the variance of inflation. We find that: shocks to domestically denominated cash holdings explain most of the variance of inflation, fiscal discipline is important because of its impact on aggregate demand, and The Central Bank seems to react inversely to positive deviations of forecasted inflation from its target range. This finding is stronger since 1994, when the Central Bank, in co-ordination with the Finance Ministry, began to announce the target range for the inflation rate.

The fourth section examines which indicator of monetary policy operations best explains The Central Bank reaction to shocks in the money and reserves markets. It does so by applying the structural VAR approach proposed by Bernanke and Mihov (1995). It extends this approach by introducing the exchange market interventions as an additional operating instrument of the Central Bank. The results show that non-borrowed reserves are the optimal indicator of the Central Reserve Bank of Peru monetary policy. However, we cannot reject the interest rate of the Central Bank Certificates of Deposits and the base money (mainly composed by household cash holdings: 75 percent). Taking these results together show that inflation targets have become the most

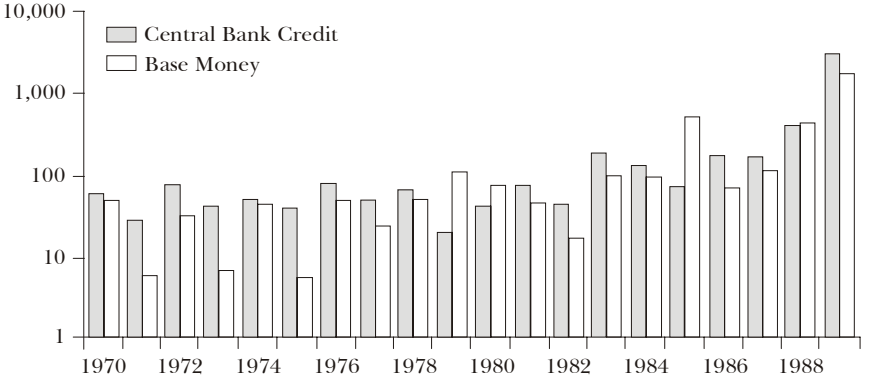
important factor in the setting of monetary policy instruments in Peru. To achieve its inflation target the Central Reserve Bank of Peru uses a variety of different indicators of monetary policy operations, which depend on monetary conditions.

II. INFLATION AND DOLLARIZATION IN PERU

Inflation and Hyperinflation

Since the fifties and until 1990 the Peruvian Central Bank financed the public sector and the State Development Banks at subsidized interest rates following a scheme of multiple objectives to enhance the output of determinate sectors. These loan policies constituted the main source of base money creation since the 1970s.

FIGURE. PERU: CENTRAL BANK CREDIT TO STATE DEVELOPMENT BANKS AND BASE MONEY, 1970-89 (logaritmic scale)

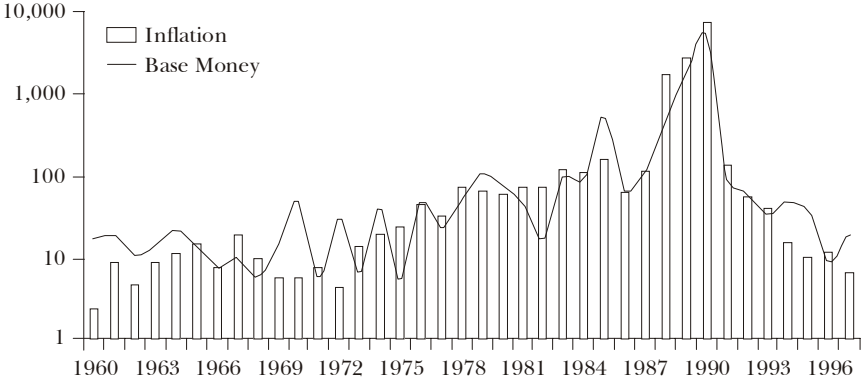


The high level of default on development bank credits and the subsidized interest rates meant that the Central Bank provided a permanent flow of financing to these banks. Since 1985, due to the suspension of external debt services, the government depleted available external financing and increased its requirements from the Central Bank. In addition the Central Bank extended the subsidized credit to the development banks and implemented a fixed multiple exchange rate regime to promote exports and subsidize basic imports via exchange rate differentials. The Central Bank paid more Soles per US Dollars to exporters and sold the dollars to importers at a lower exchange rate, expanding base money.

These factors increased the inflation rate average from 9 percent during the 1960s to 30 percent in the seventies. Since 1985 the monetary policy was further eased, accelerating the money base creation ending in 1988 in a hyperinflation process. In August 1990 the new government implemented a drastic stabilization program trough a strict control of base money creation. The new policy framework ensures Central Bank independence and mandates the sole objective of price stability.

Another important measure was the prohibition of financing the public sector and state development banks, flexible exchange rate regime, deregulation of the financial system, liberalization of capital markets and the commitment of fiscal discipline.

FIGURE. PERU: INFLATION AND BASE MONEY GROWTH, 1960-96 (logaritmic scale)



The Dollarization Process

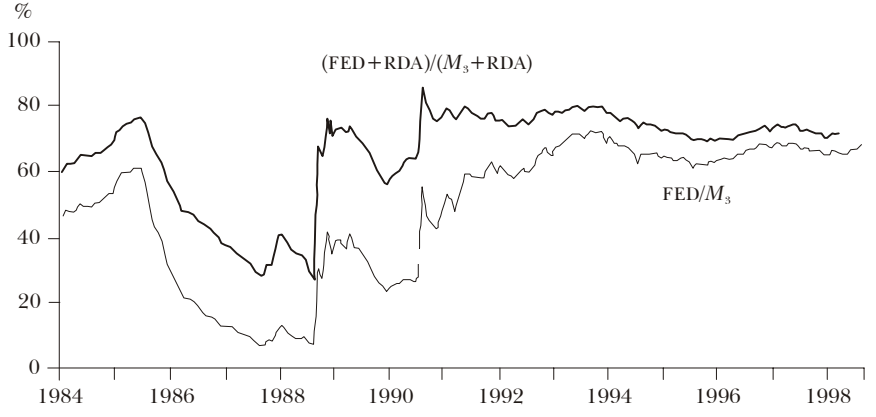
With the persistent high levels of inflation of the seventies, together with underdeveloped capital markets and a repressed banking system that could not offer alternative assets, the US dollars became the alternative asset to hold on. To preserve the value of their income, households decide to hold foreign currency as store of value, given the absence of domestic assets that could satisfy their liquidity and store of value requirements and due to high volatility of prices in domestic currency.

The dollarization ratio is defined as the relation between the foreign currency deposits in the domestic financial system plus residents deposits abroad with respect to the broad monetary aggregate that includes both deposits increased from 37 percent in 1981 to 65 percent in 1984.

During 1985-1988 the foreign currency holdings of the house-

holds in the financial system decreased substantially as a consequence of the confiscation policy of foreign currency deposits implemented by the government. There is some evidence that the households that could not transfer their assets abroad increased substantially their foreign currency cash holdings despite the opportunity costs lost in this decision.

FIGURE. PERU: DOLLARIZATION RATIO, DEPOSITS, 1984-98



Considering the ratio of foreign currency deposits in the domestic banking system with respect to the monetary aggregate M3[1] the dollarization ratio in Peru has been growing since 1990, in spite of the stabilization process. They remain at an average of 65 percent.

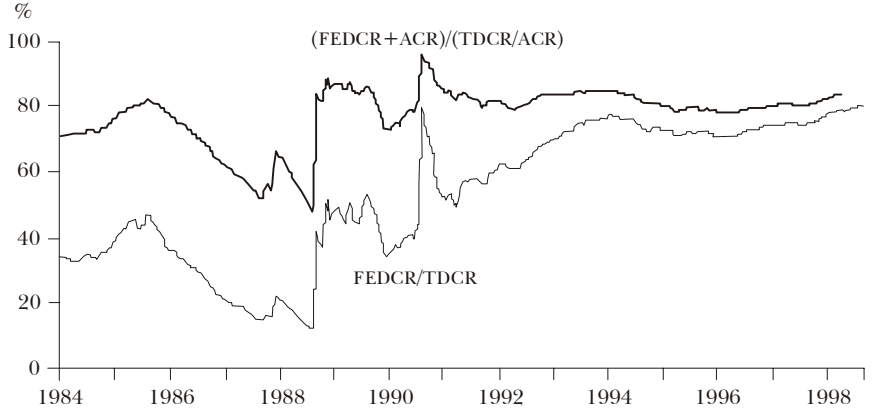
However, if we include the Peruvian residents (non banking sector) deposits abroad (using the data reported by the Bank of International Settlements) as part of the foreign currency holdings of the private sector and including it in the broad monetary aggregate, the new measure of the dollarization ratio shows a slight but sustained decreasing pattern since 1991. (10 percentage points between 1991 and 1998). An implication of this process is that the spread between these two indicators has been decreasing substantially in this period showing the increasing confidence in the Peruvian financial system. Furthermore, there is evidence of transfers of the Peruvian private non-banking sector deposits abroad to the domestic financial system after the stabilization process and structural reforms that in-

[1] Household holdings of domestic currency plus current account and time deposits in domestic and foreign currency in the banking system.

cluded a financial liberalization process at the end of 1990 and early 1991.

Another important indicator of the dollarization process in Peru is the foreign currency lending of the banking system to the private sector. Foreign currency lending in the domestic market (FEDCR/TDCR) increased from around 50 percent of total domestic lending at the end of 1990 up to 80 percent at the end of 1997. Considering the offshore liabilities of the private sector, the share of the foreign exchange lending [(FEDCR+ACR)/ /(TDCR+ACR)] seems to be slightly decreasing from around 90 percent at the end of 1990 to 80 percent at the end of 1997. The process followed by the credit dollarization is similar to the deposits dollarization.

FIGURE. PERU: DOLLARIZATION RATIO, CREDITS, 1984-98



The reduction of the spread in both indicators shows the improving services of the financial system. The slightly decreasing pattern of the dollarization ratio as inflation fell shows that there is still a lack of confidence in the domestic currency. This is due mainly to the recent memory of hyperinflation.

Asset substitution

In general, there is a discussion on whether dollarization affects the conduct of monetary policy substantially. These discussions rely on the possible instability of the domestic money demand explained by the changes in public expectations of devaluation or changes in the relative preferences of their assets portfolio. However, there is a recent consensus among economists that

it is important to consider the difference between a dollarization characterized by currency substitution from that characterized by asset substitution.

If the current transactions can be paid either with domestic currency or foreign currency and if the public choose foreign currency for those transactions, then this economy is said to follow a process of "currency substitution", and the design of monetary policy in this context will be more difficult. In the case of asset substitution, the design of the monetary policy could still consider the use of intermediate targets that are closely related to current transactions and to inflation.

COMPOSITION OF BANK DEPOSITS (percentages)

	Domestic currency			*Foreign currency*		
	Current account	*Savings*	*Time deposits*	*Current account*	*Savings*	*Time deposits*
1992	33	55	12	9	55	36
1993	41	44	15	13	43	45
1994	31	46	23	11	42	46
1995	30	44	26	12	40	48
1996	28	40	33	13	35	52
1997	33	35	32	17	34	49
1998 (Sep.)	26	35	38	17	33	50

SOURCE: Javier De La Rocha (1998) and weekly statistics of the Central Bank of Peru.

Peruvian economists agree that the type of dollarization in Peru is one of assets substitution rather than currency substitution. The current transactions are made in domestic currency while large transactions are made in foreign currency. Wages are paid in domestic currency. Given the low average income of Peruvian workers, the transaction costs of buying foreign currency are high compared to the benefits of holding them, If we consider the short run transactions horizon of their current income and the important reduction in the annual inflation rate (6 percent in 1998). The domestic currency maintains its role of unit of account and means of payment whilst the foreign currency is used as store of value. In this sense the cash holdings of the Peruvian households is a good indicator of the current transactions of the economy and could still be used as an intermediate target of the monetary policy.

Another useful indicator of the prevailing asset substitution in the Peruvian economy is the deposit composition. In the banking system, domestic currency deposits are mostly checking accounts

and saving deposits, whilst foreign currency deposits are mainly saving and time deposits. Furthermore, the withdrawal frequency (defined as a ratio of withdrawals to average balances outstanding) in domestic currency is almost three times as much as in foreign currency. Therefore, while foreign currency is demanded for some transactions, its main role is as a store of value.

III. MONETARY POLICY

Institutional Framework

Since august 1990, the government has started a stabilization and a structural reform program that included the elimination of exchange controls, restoration of full convertibility, liberalization of the capital markets, trade liberalization, adoption of a flexible exchange rate regime, deregulation of the financial system, privatization of state owned commercial banks, privatization of stock markets, implementation of private pension funds system letting workers to choose between private individual accounts and contributions to the old pay-as-you-go public pension system.

The new legal framework for the financial system stated the principles of universal banking, allowing equal treatment to the foreign investment in the financial sector, prudential regulations consistent with Basel standards were introduced, a deposit insurance scheme with partial coverage was implemented, and bank supervision improved significantly.

The New Peruvian Constitution and the New Central Bank Charter established the autonomy of the Central and that the sole objective of the Central Bank is the price stability.

The accountability of the Central Bank has been oriented to guarantee an independent Central Bank, the members of its Board of Directors may be impeached by Congress. The Central Bank is prohibited to: *a)* finance the public sector (indirectly the Central Bank can buy in the secondary market up to 5 percent of the base money), *b)* Finance any state development bank, *c)* grant guaranties, *d)* lend any particular sector of the economy, *e)* establish multiple exchange rates system.

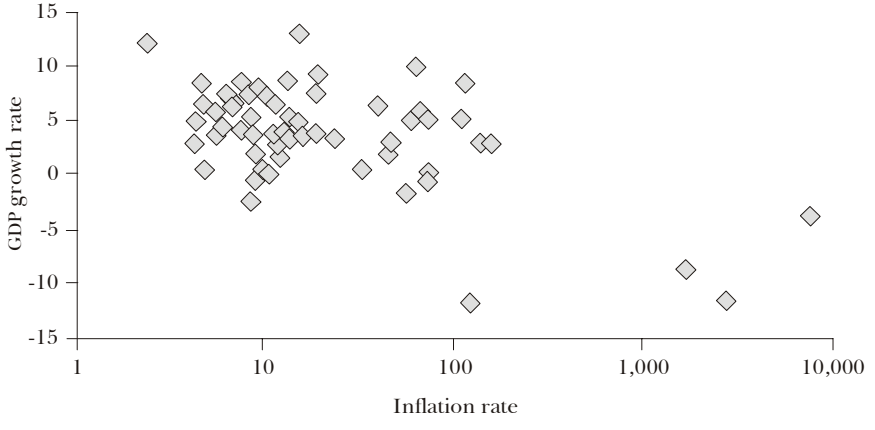
The transparency of the monetary policy is promoted through publication of the Central Bank market operations at the immediate following day, weekly publications of macroeconomic statistics, immediate publication of the Central Bank dispositions and the annual Central Bank Memory.

Design of the Monetary Policy

Each year, the Central Bank designs a Monetary Program, which includes liquidity and credit growth rates, compatible with a consistent macro-economic scenario and with its inflation objective. The program is monthly reviewed and daily monitored.

The objective of the Central Bank is to reach international inflation levels in the medium and long-term. To do so uses the base money growth as intermediate target, consistent with its inflation goals. The demand side of this aggregate is conformed basically by domestic cash holdings of households (75-80 percent). The cash holdings are good approximation to the current transactions of the economy that is fulfilled using mainly domestic currency. The base money growth targets are not made public since technological shocks in the financial system might arise forcing their revision.

FIGURE. PERU: INFLATION AND GDP GROWTH, 1940-97



International evidence show that the reduction in the inflation rate is one important element of macroeconomic stability which in turn is a condition for a sustained economic growth. The inflation-output growth long run relationship of the Peruvian economy shows a clear negative pattern.

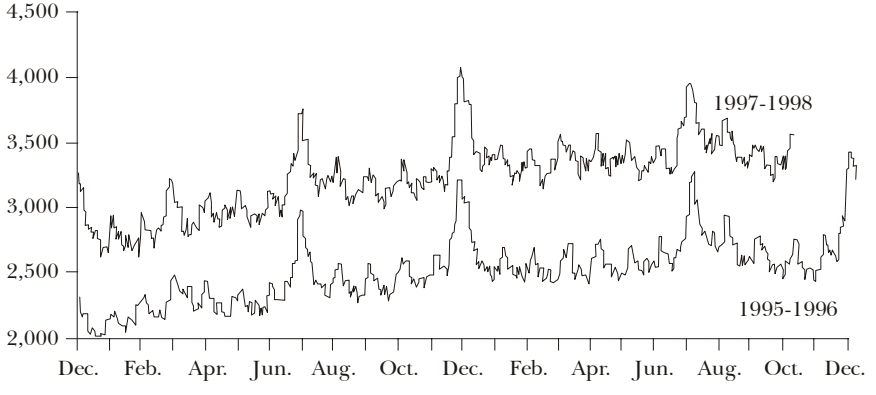
The monthly revision of the money base growth is based on the analysis of indicators as interbank interest rate, exchange rate, projected inflation, fiscal stance, aggregate demand and credit to the private sector.

The implementation of the monetary policy is based on market instruments as intervention in the foreign exchange market, basi-

cally purchasing foreign exchange as a mechanism of attending domestic currency liquidity needs of the financial institutions, and open market operations with the Central Bank CD auctioned announcing the amount of the issue and letting the auction determine the interest rate. To increase the liquidity of the Central Bank CD we use REPOs. Another instruments are the SWAPs with foreign currency and the lending trough the discount window.

Reserve requirements on foreign currency deposits and the interest rate paid on these reserves are used as supplementary instrument in order to control the expansion of monetary aggregates denominated in foreign currency. Since 1991 the marginal reserve requirement for foreign currency deposits was 45 percent, and since October of 1998 the marginal rate has been reduced to 35 percent. Required reserves are remunerated at a rate related to the LIBOR. Reserves are computed on the basis of monthly averages. Vault cash and demand deposits at the Central Bank are part of these reserves. The actual reserve requirement on domestic currency deposits is 7 percent.

FIGURE: PERU: NOMINAL CASH HOLDINGS (in millions of Nuevos Soles)



The daily basis conduction of the monetary policy is in charge of the Money and Foreign Exchange Commission of the Central Bank that meets every morning to decide intervention on the basis of the most recent information in the markets, deciding on the amount of dollars to be purchased in the foreign exchange market, whether to auction Certificate of Deposits and the amount to be auctioned and the discount rate.

The daily monitoring of the monetary policy are based in a

careful study of the components of the base money and the components of the banking system balance sheet, together with the evolution of the exchange rate, the interbank interest rate and other relevant indicators. One important variable is the daily cash holdings in domestic currency that follows a predictable pattern.

The dollarization process makes necessary study the evolution of the broad aggregates that includes the foreign currency assets as indicators. Another important issue is the capital inflows that creates appreciation pressures on exchange rate and facilitates rapid credit expansion as external financing is readily available to domestic banks. However over 70 percent of these inflows are long-term capitals that implies changes in the fundamentals of the equilibrium real exchange rate forcing its appreciation. However, to reduce the impact that capital inflows have on the exchange rate and on aggregate demand the Central Bank maintains the 45 percent marginal reserve requirement on foreign currency deposits. It also acts as a buffer stock against potential outflows and it induces holdings of domestic currency. Furthermore, the Central Bank sterilizes its net purchases of US dollars in order to keep base money growth under control. Sterilization is carried out through sales of Central Bank Certificates of Deposit (CDBCRP) or through public sector deposits at the Central Bank.

Fiscal Discipline

The commitment of the government to equilibrate its budget is a key condition to fulfill the inflation goals in an economy with dollarization. This commitment lets the Central Bank concentrate in evaluating and avoiding another pressures over prices and revising the monetary targets as the monetary policy indicators, including the foreign currency aggregates, raise new information. The Fiscal discipline could be observed in the average primary surplus of 1,4 percent of GDP that the central government raised between 1991 and the second quarter of 1998.

Another important aspect is the coordination between fiscal and monetary policies that helped for the success of Peruvian stabilization. At the early stages of stabilization, a strict fiscal discipline allowed to regain control of monetary policy. Additionally, since 1994, public sector deposits and purchases of foreign exchange from the Central Bank have given the monetary authority room to intervene in the foreign exchange market and prevent larger appreciation of the domestic currency. The most impor-

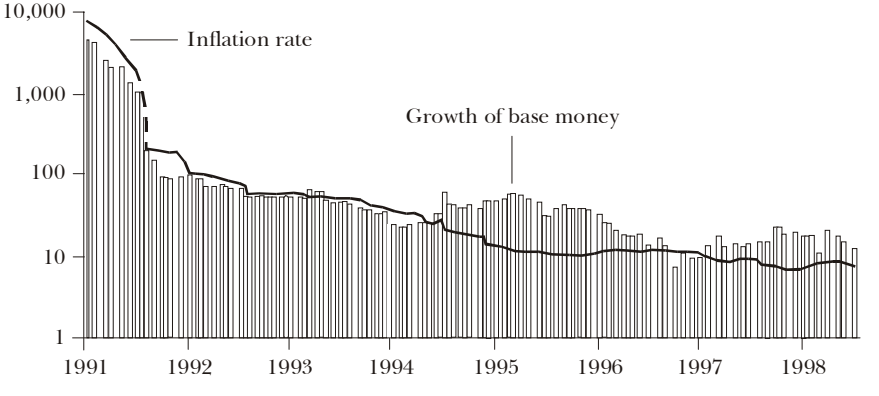
tant line of coordination is at the programming level: the macroeconomic assumptions for the fiscal budget, including the annual inflation targets, are set by the Ministry of Finance in coordination with the Central Bank and at the operations level: a Fiscal Committee meets monthly to set government expenditures, foreign exchange purchases and deposits. The Central Bank attends this Committee.

Our experience tells us that a strong condition for a successful monetary policy, in an economy with dollarization, is the commitment of the public sector to avoid fiscal deficits and a close coordination with the Central Bank to manage the domestic and foreign currency cash flows of the public sector to minimize unnecessary volatility in the available liquid assets of the banking system and in the exchange rate.

The public sector should keep in the commercial banking system deposits only in domestic currency, as needed for their cash flow operations (payments of their programmed expenses). The tax collections of the treasury should be deposited in the Central Bank being paid the market interest rate. The revenues of the privatization of public enterprises must be deposited in the Central Bank being paid an interest rate related to the LIBOR. The foreign currency needed by the public sector to pay the external debt must be bought from the central bank to avoid unnecessary volatility in the exchange rate. These conditions must be met besides the monetary policy regime to pursue the price stability objective of the Central Bank.

The actual macroeconomic stability of the Peruvian economy fulfills the basis for a sustained growth. This stability resulted from a successful monetary policy in reducing the inflation rate.

FIGURE: PERU: INFLATION AND ANNUAL % CHANGE OF BASE MONEY, 1991-98



To September of 1998 the annual inflation rate reached 6,5 percent.

However, international evidence shows that at low levels of inflation, the relationship of the base money growth and the inflation rate could be hidden by another factors.

Transmission Mechanisms of the Monetary Policy

In this document we are interested in identifying the transmission mechanisms of the monetary policy to reach its main goal: the reduction of the inflation rate. In this sense is important raise structural characteristics of the financial system in Peru.

In Peru, the corporations are bank-credit dependants because of the previous weak development of the capital markets with low demand for their equity or bond issues. So it seems possible that the credit channel of the transmission mechanism of monetary policy should be powerful. But while the central bank policies manages the domestic money supply affecting the supply of domestic currency credits, the banking system substitutes them getting foreign currency credits from the international banking system, with the possible weakening the effectiveness of the monetary policy trough the credit channel. Another aspect is that the non-banking sectors have liabilities with the financial system outside Peru.

There is a general agreement that dollarization would limit monetary policy if the economy were most involved in a currency substitution process, otherwise, if there is more assets substitution then there still will be space for a successful monetary policy. With currency substitution, the changes in expected depreciation will change the share of foreign currency related to domestic currency for current transactions which implies instability of money demand and difficulties for implementing the money targeting rule.

As we developed before, in Peru there is evidence that the dollarization is mainly of asset substitution. Additionally, as the Bank of International Settlements states, in the absence of capital controls, the efficacy of monetary policy is in theory determined by the exchange rate regime and the degree of substitutability between domestic and foreign financial assets. Under a floating exchange rate regime, monetary policy works trough two channels. First, since the money supply is controlled by the central bank, monetary policy could work trough conventional interest rate and liquidity effects. Secondly, monetary policy influences aggre-

gate demand and prices trough its impact on the exchange rate. The greater the substitutability between domestic and foreign assets, the greater the response of exchange rate to policy-induced changes in interest rates, and hence the larger the impact of monetary policy trough that channel.

However, If there is more domestic asset substitution and imperfect substitution between domestic and foreign assets (case of Peru), then assuming limited exchange rate changes, due to persistent long term capital inflows, the tightening of the monetary policy induces increases in the domestic interest rates which will induce borrowers to switch to foreign currency domestic loans and the savers to shift their assets into domestic currency deposits, leading to increase in domestic deposits in foreign currency and in the loan rates as well. In this case, monetary policy is effective.

Previous works on the transmission mechanism of the monetary policy has shown that the money channel seems to be the most effective in conducting the increases in the domestic interest rates, as the monetary policy tights the monetary base trough its open market operations, to the aggregate demand reaching its main goal of reduction of inflation.

For instance, during 1995, the Central Bank tightened monetary policy in order to prevent inflationary pressures and to keep external viability under a context of less fiscal discipline as previous years. Thus, the CDBCRP rate rose from 15 to 19 percent and the discount rate from 16 to 21 percent. As a consequence, liquidity in local currency decreased its growth from a rate of 61 percent in April to 35 percent in September. In the same period, foreign currency liquidity decreased its rate of growth from 36 percent to 19 percent.[2]

Impulse Response and Variance Decomposition Analysis of the Inflation

To evaluate the effectiveness of targeting the base money growth in the Peruvian economy, we first look to the pair-wise variance decomposition analysis between the inflation rate and the main monetary aggregates using quarterly data between 1982 and 1998. We do not have information of market interest rates and market exchange rates for the main part of this period due to exchange controls and financial repression policies. The uncon-

[2] Javier De La Rocha (1998).

strained pair-wise VAR analysis of the inflation rate with the monetary aggregates shows that the real cash holding explains most of the variance of the inflation rate in Peru.[3]

Additionally, the main aggregates M2 and M3a (including residents deposits abroad) have important explanatory power of the inflation rate. However, at this stage we can not deduce which components of this aggregates are the most important in explaining inflation.

VARIANCE DECOMPOSITION OF THE INFLATION RATE

Quarters	*Cash*	*M0*	*M1*	*M2*	*M3*	*M3a*
1	21.0	2.8	6.4	14.3	11.8	6.4
2	20.4	2.8	11.0	18.5	12.9	8.1
3	20.6	3.2	11.8	19.6	14.0	10.7
4	20.1	3.4	11.8	19.3	14.3	11.3
5	20.9	4.3	11.5	19.0	16.1	18.0
6	20.5	4.2	11.4	18.5	15.8	18.0
7	20.4	4.3	11.4	18.8	17.3	18.5
8	20.3	4.3	11.4	18.8	17.3	18.6
Prom.(1 2q)	*20.5*	*4.0*	*11.0*	*18.5*	*16.3*	*16.4*

Recursive and Non Recursive VAR Approaches

VARs identification procedures are useful instruments to evaluate the transmission mechanisms of the monetary policy. Recursive VAR approaches considers that the information variables set of the Central bank do not respond to contemporaneous realizations of the monetary policy shocks. This assumption is important if we work with high frequency small sample. In the Peruvian case reliable data of macroeconomic and financial variables are available only since mid 1991, in a monthly basis.

In general, the disturbances observed in the simultaneous relationship between macroeconomic variables, with a pre-identified lag structure, should be related to macroeconomic policy shocks through an identifiable parameter structure. However, to identify the fundamental monetary policy shocks it is important to assume that they are no correlated among themselves.

In general, "under the recursiveness assumption, … the variables related to the goods market are determined first; second,

[3] The optimal lag for these VAR estimations in real terms is 4 using both the Akaike and the Schwarz criteria. See the annex for these results.

the Central Bank sets its policy instruments; and third, the remaining variables in the money market are determined".[4]

The non-recursive approach considers that the Central Bank not only observes to variables that are predetermined relative to the monetary policy shock but to variables that are contemporaneous to the monetary policy.

Table A shows the non-recursive VAR identification for the Peruvian economy following the Christiano, Eichenbaum, Evans (1995) procedure. *P* refers to private variables like GDP and CPI; *I* is informative variable represented by the nominal exchange rate, and the residents deposits abroad RDA; B represents banking system variables like domestic currency quasi-money QUASI and dollar deposits FCD; *F* is Central Bank control variable CDR (Central Bank Certificate of Deposits rate).

The shaded area corresponds to the identification of policy variables whose ordering depends on which variable is considered the Central bank main indicator. However, if a bank has more than one indicator then the ordering could imply non-recursive assumptions.

TABLE A. PERÚ: RECURSIVE IDENTIFICATION OF VAR

		GDP	*CPI*	*NER*	*QUASI*	*FCD*	*RDA*	*CDR*	*CASH*	*M0*	*TR*	*NBR*
P	*GDP*	A_{11}										
P	*CPI*	A_{21}	A_{22}									
I	*NER*	A_{31}	A_{32}	A_{33}								
B	*QUASI*	A_{41}	A_{42}	A_{43}	A_{44}							
B	*FCD*	A_{51}	A_{52}	A_{53}	A_{54}	A_{55}						
P/I	*RDA*	A_{61}	A_{62}	A_{63}	A_{64}	A_{65}	A_{66}					
F	*CDR*	A_{71}	A_{72}	A_{73}	A_{74}	A_{75}	A_{76}	X	X	X	X	X
F/H	*CASH*	A_{81}	A_{82}	A_{83}	A_{84}	A_{85}	A_{86}	X	X	X	X	X
F/H	*M0*	A_{91}	A_{92}	A_{93}	A_{94}	A_{95}	A_{96}	X	X	X	X	X
F/B	*TR*	A_{101}	A_{102}	A_{103}	A_{104}	A_{105}	A_{106}	X	X	X	X	X
F	*NBR*	A_{111}	A_{112}	A_{113}	A_{114}	A_{115}	A_{116}	X	X	X	X	X

Table B is the adaptation for Peru of the Non-recursive VAR identification procedure followed by Leeper, Sims and Zha (1996), in this case the identification procedure considers specific relationships between the variables. For example, as the domestic currency cash holdings are mainly used for current transactions

[4] Christiano, Eichenbaum & Evans (1998).

there is a relationship with GDP, with the exchange rate (latter we shift this relationship considering that the dollarization process in Peru is mainly of asset substitution rather than currency substitution).

TABLE B. PERÚ: NON-RECURSIVE IDENTIFICATION OF VAR

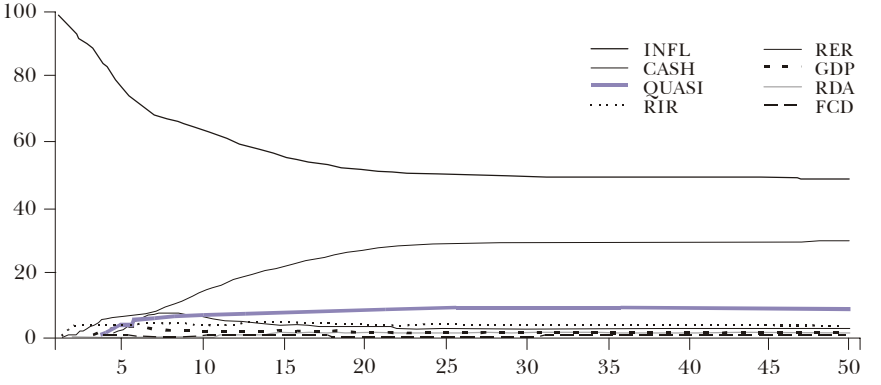
		GDP	*CPI*	*NER*	*QUASI*	*FCD*	*RDA*	*CDR*	*CASH*	*M0*	*TR*	*NBR*
P	*GDP*	C_{11}										
P	*CPI*	C_{21}	C_{22}									
I	*NER*	C_{31}	C_{32}	C_{33}	C_{34}	C_{35}	C_{36}	C_{37}	C_{38}	C_{39}	C_{310}	C_{311}
B	*QUASI*		C_{42}	C_{43}	C_{44}	C_{45}			C_{48}	C_{49}	C_{410}	
B	*FCD*		C_{52}	C_{53}	C_{54}	C_{55}	C_{56}				C_{510}	
I	*RDA*		C_{62}	C_{63}		C_{65}	C_{66}					
F	*CDR*							C_{77}		C_{79}		C_{711}
F/H	*CASH*	C_{81}		C_{83}				C_{87}	C_{88}	C_{89}		C_{811}
F/H	*M0*			C_{93}				C_{97}	C_{98}	C_{99}		
F/B	*TR*	C_{101}	C_{102}		C_{104}			C_{107}	C_{108}	C_{109}	C_{1010}	C_{1011}
F	*NBR*							C_{117}				C_{1111}

To evaluate the role of interest rates and exchange rates in explaining the variations of the inflation rate we consider a shorter period (1991-1998). And, To study the possible implications of dollarization for monetary policy we use a recursive VAR that relates inflation, real output, real exchange rate, real interest rate and the specific components of the broad monetary aggregate: domestic cash holdings, domestic quasi money, dollar deposits and residents deposits abroad.[5]

The period analysis is (1991-1998) and we use twelve-month variations in real terms of the domestic currency components of the broad monetary aggregate and twelve-month variations in US dollars of the foreign exchange components. The optimal lag for the monthly real variables is of two months for the aggregate VAR estimate (Schwartz criteria). The unit root tests of the included variables (included in the annex) shows that they are $I(0)$. Granger Causality tests shows that the cash holdings of the households, the real interest rates and the foreign currency depos-

[5] We consider the lending rate, since the other short run interest rates such as the overnight interest rate of the banking system are only available since 1994. The interest rate of the Central Bank certificates of deposit is available since end 1992, however we need to evaluate a market interest rate.

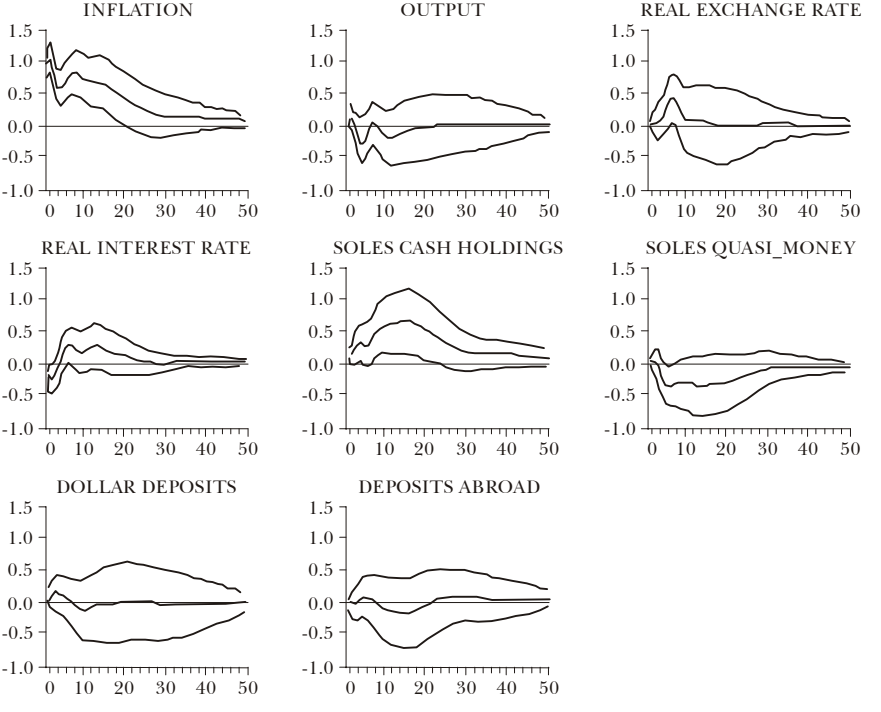
FIGURE: PERU: VARIANCE DECOMPOSITION OF INFLATION



its seems to explain the inflation process in Peru. The variance decomposition analysis shows that the cash holdings explains the variance of the inflation rate bay an average of 30 percent.

Looking to the impulse response function it seems that there is some inflation inertia. It is clear that shocks to the cash holdings

FIGURE: RESPONSE OF INFLATION TO ONE S.D. ± 2 S.E.



of the households has a clear impact (the main reaction of the inflation rate is after 12 to18 months of the shock) on inflation rate. There is no clear impact of output shocks on inflation nor of real interest rates. There is some positive impact of the real exchange rate. The negative performance of the domestic quasi-money could be explained by the important dollarization as asset substitution in Peru. Since here, relaxing the quasi money could lead to switch to foreign currency and with inverse effect on inflation rates.

However, domestic currency cash holding are endogenous since it corresponds to the household optimization problem. To identify the Central Bank optimal indicator variable we should try to evaluate the role of base money, non-borrowed reserves and Central Bank Certificates of Deposits rate in explaining CPI variance.

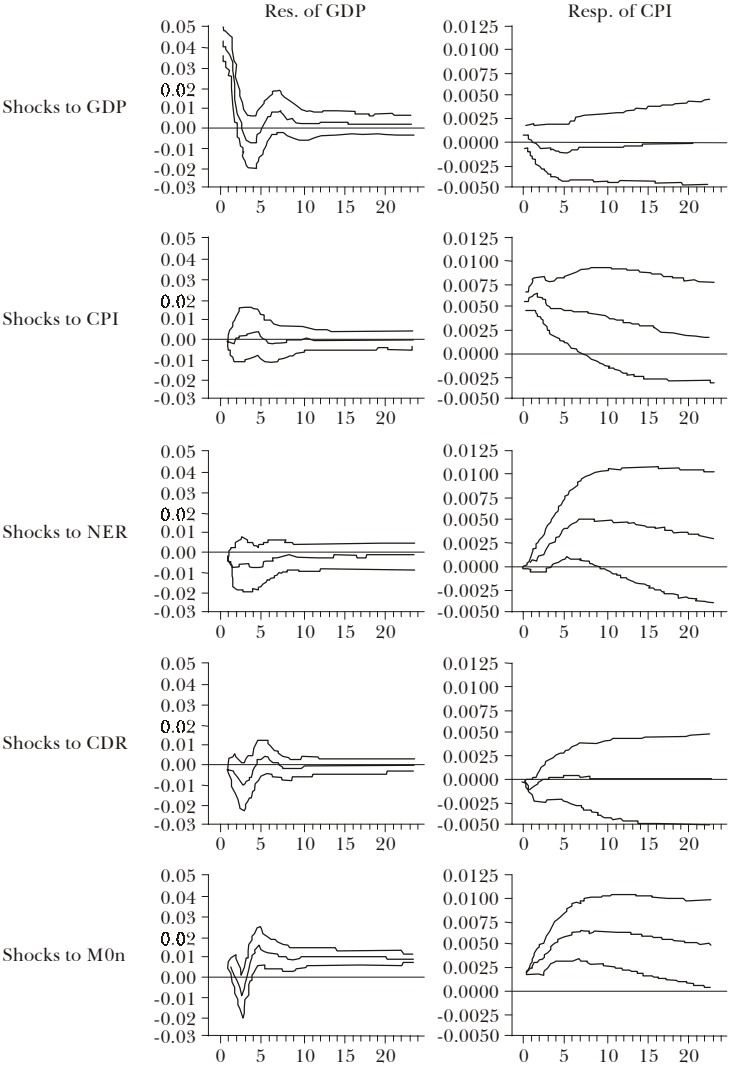
Using the recursive approximation discussed earlier we find that positive shocks to the base money generates clear positive reaction of the consumer prices, which reaches its highest level in between one year and one year and a half. The nominal exchange rate devaluates almost within one month, real output falls initially and increases its level after one quarter and reaches any variation after 3 quarters. The interest rate reduces initially its level and increases after 2 months reaching null change after one year.

The monetary policy optimal indicator identification procedure using non-recursive VAR analysis proposed by Lepper, Sims, and Zha (1996) shows similar results than the non-recursive estimation results. Positive shocks to the base money positive reaction in consumer prices with highest levels in between one year and one year and a half. In this case we show that there is an immediate negative reaction of the short-term interest rate which suggests that there is no liquidity puzzle in the Peruvian economy, and increase in the exchange rate reaching its main reaction after 9 months.

IV. IDENTIFICATION OF THE CENTRAL BANK OPERATING PROCEDURE

Bernanke and Mihov (1995 and 1996) propose that to identify the optimal monetary policy indicator it is worthwhile to study the operating procedure of the Central Bank. In Peru, with a banking system that intermediates dollar assets the Central Bank

FIGURE: CHRISTIANO/EICHENBAUM/EVANS



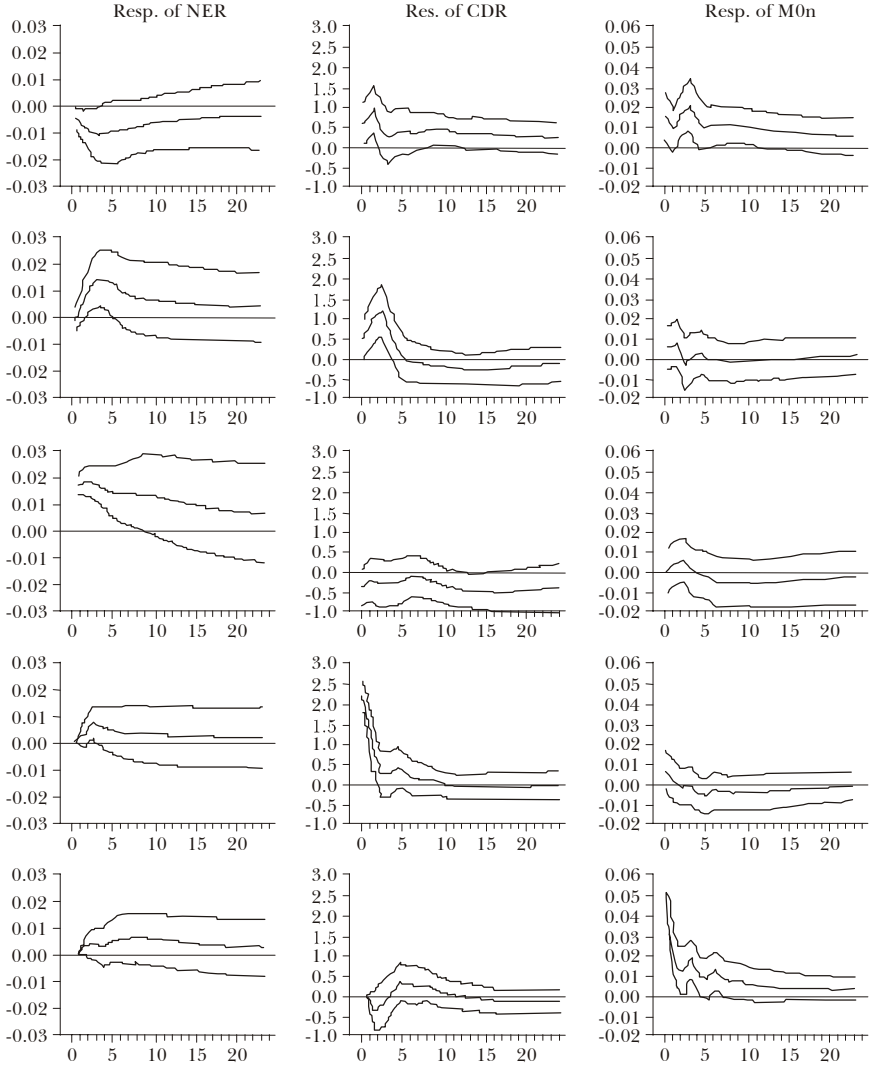
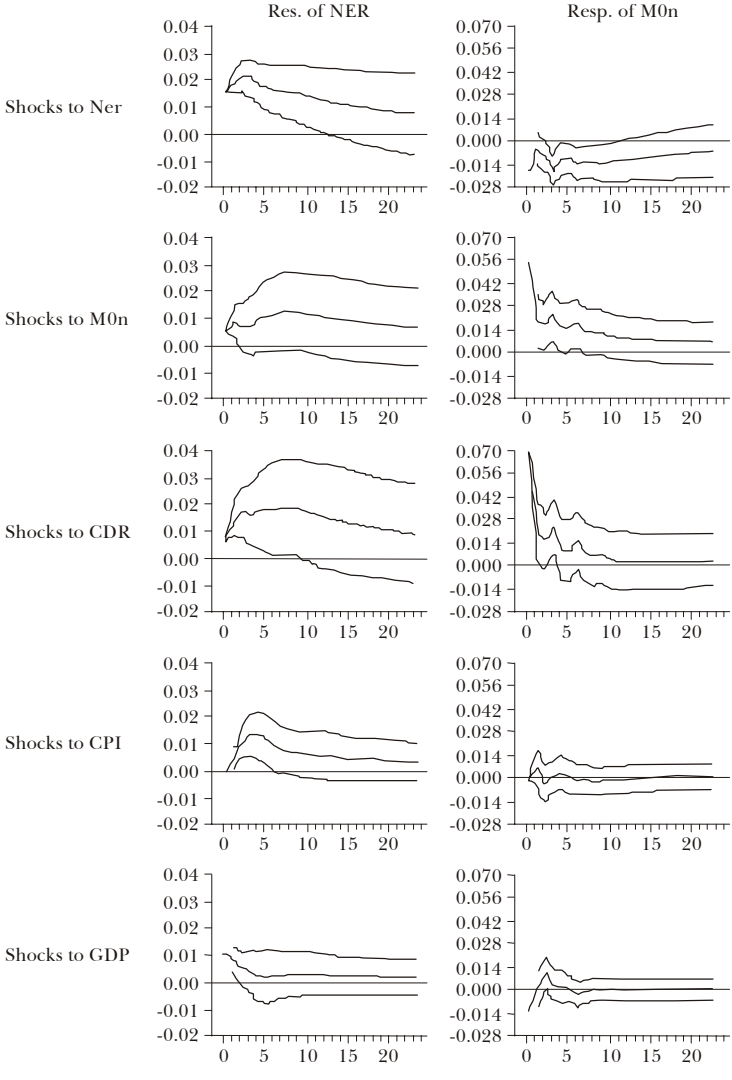
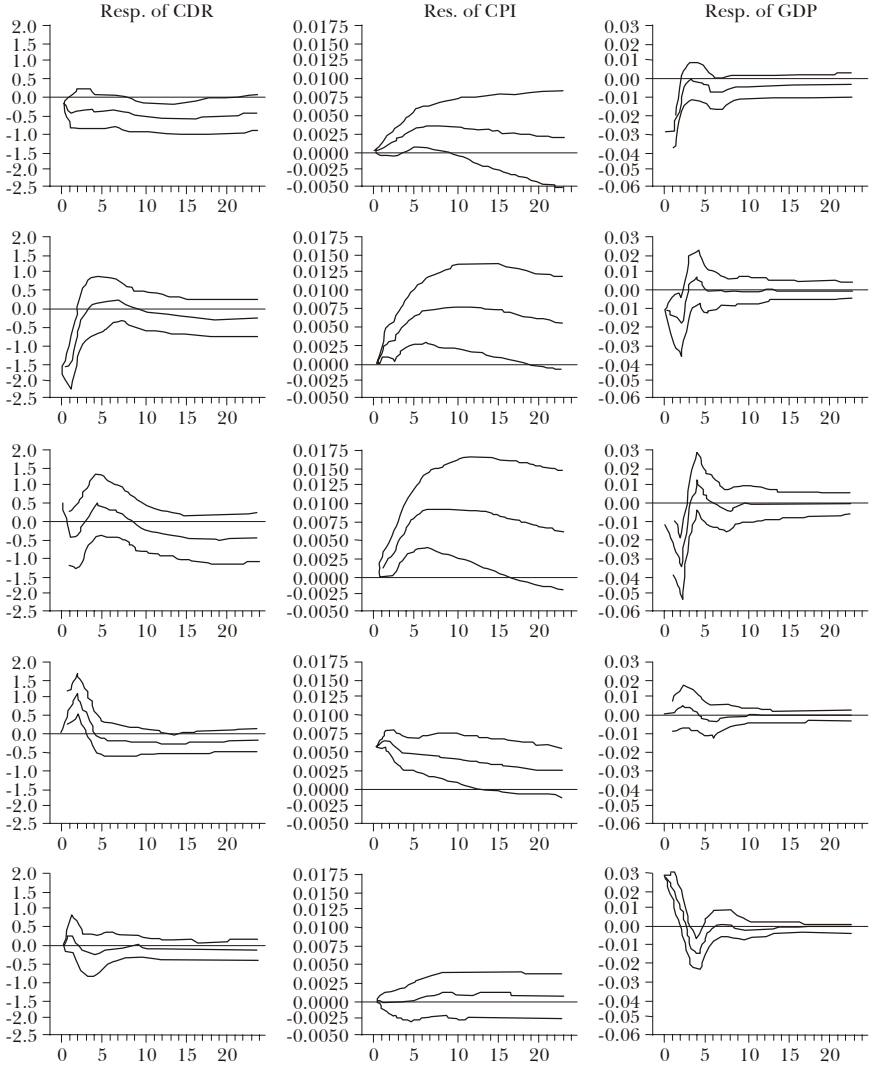

Resp. of NER
Res. of CDR
Resp. of M0n

FIGURE: LEEPER/SIMS/SHA




Resp. of CDR
Res. of CPI
Resp. of GDP
2.0
1.5
1.0
0.5
0.0
-0.5
-1.0
-1.5
-2.0
-2.5
0.0175
0.0150
0.0125
0.0100
0.0075
0.0050
0.0025
0.0000
-0.0025
-0.0050
0.03
0.02
0.01
0.00
-0.01
-0.02
-0.03
-0.04
-0.05
-0.06
0
5
10
15
20

uses foreign exchange market interventions as an important instrument to provide domestic currency liquidity and issue certificates of deposit to be auctioned in open market operations, announcing the amount of the auction and letting the market determine the interest rate. These instruments are used to regulate the base money creation through the control of the reserves market of the banking system.

A first approach to the operating procedure of the monetary authority (system 1) is introducing the amounts announced by the Central Bank for its operations (in innovations form) as variables accounted by the banking system for its reserves demand:

System 1: Reserves market with operational amounts of the Central Bank.

$$u_{TR} = \alpha_1 u_{mcd} + \alpha_2 u_{iem} + v_1 \tag{1}$$

$$u_{BR} = \alpha_3 u_{mcd} + \alpha_4 u_{iem} + v_2 \tag{2}$$

$$u_{CBS} = v_3 \tag{3}$$

$$u_{NBR} = \partial_5 v_1 + \alpha_6 v_2 + \alpha_7 v_3 + v_4 \tag{4}$$

$$u_{TR} = u_{BR} + u_{CBS} + u_{NBR} \tag{5}$$

Equation (1) is the demand for total reserves that should be explained inversely by the amount of CDBCR auctioned and directly by the amount of US$ purchased in the system and a shock to this demand. Equation (2) states the demand for borrowed reserves should depend directly on the amount of CD auctions and inversely on the exchange market interventions and a stochastic shock. Equation (3) says that the innovations in the operating cash holdings of the commercial banks are stochastic. The forth equation shows the behavior of the central Bank. v_4 should be identified with the monetary policy shock.

The second system tries to resemble the reserves market proposed by Bernanke-Mihov (1996). In this case the demand for total reserves depends inversely on the CD interest rates (our assumption is that because the interest rate of the CDBCR is endogenously determined it could be treated as an indicator of the inter-bank interest rate) and directly on the rate of devaluation of the domestic currency. The demand for borrowed reserves should have inverse relationship with the discount window interest rate.

System 2: Reserves market with interest rates and exchange rates

$$u_{TR} = -\beta_1 u_{CDR} + \beta_2 u_{E-IEM} + \upsilon_1$$

$$u_{BR} = \beta_3 (u_{CDR} - u_{RDW}) + \beta_4 u_{E-IEM} + \upsilon$$

$$u_{CBS} = \upsilon_3$$

$$u_{NBR} = \beta_5 \upsilon_1 + \beta_6 \upsilon_2 + \beta_7 \upsilon_3 + \upsilon_4$$

$$u_{CDR} = \beta_8 \upsilon_1 + \beta_9 \upsilon_2 + \beta_{10} \upsilon_2 + \beta_{11} \upsilon_4 + \upsilon_5$$

$$u_{BM} = u_{BR} + u_{CBS} + u_{NBR}$$

System 3: Base money market (Uses side): In this case the model considers the demand for the components of the base money: It is the banking system demand for total reserves and the household demand for cash holdings.

$$u_{TR} = -\gamma_1 u_{CDR} + \gamma_2 u_{E-IEM} + \tau_2$$

$$u_{CHH} = -\gamma_3 u_{CDR} + \gamma_4 u_{GDP} - \gamma_5 u_{E-IEM} + \tau_2$$

$$u_{BM} = \gamma_6 \tau_1 + \gamma_7 \tau_2 + \tau_3$$

$$u_{CDR} = \gamma_8 \tau_1 + \gamma_9 \tau_2 + \gamma_{10} \tau_3 + \tau_4$$

$$u_{BM} = u_{TR} + u_{CHH}$$

System 3a: Base money market (sources side): In this case the model considers the banking system demand for the sources of the primary emission: It is the banking system demand for the central Bank certificates of deposits, the banking system demand for the domestic currency in the exchange market interventions of the central bank, public sector demand for deposits at the central bank and other sources of base money creation that includes commercial bank demand for short term credits.

$$u_{M-IEM} = \varphi_1 u_{CDR} + \varphi_2 u_{E-IEM} + \omega_1$$

$$u_{M-CD} = \varphi_3 u_{CDR} + \varphi_4 u_{E-IEM} + \omega_2$$

$$u_{P-D} = \varphi_5 u_{CDR} + \omega_3$$

$$u_{OBMS} = \varphi_6(u_{CDR} - u_{RDW}) + \omega_4$$

$$u_{BM} = \varphi_7\varphi_1 + \varphi_8\omega_2 + \varphi_9\omega_3 + \varphi_{10}\omega_4 + \omega_5$$

$$u_{BM} = u_{M-IEM} + u_{M-CD} + u_{P-D} + u_{OBMS}$$

Operating strategy for measuring the dynamic effects of policy shocks

A first approach for identifying the operating procedure of the central bank is following the Bernanke-Mihov (1998) procedure which we resume in this section of the work:

If the true structure of the economy is, in VAR format:

$$Y_t = \sum_{i=0}^{k} B_i Y_{t-1} + \sum_{i=0}^{k} C_i P_{t-i} + A^y v_t^y \quad (6)$$

$$P_t = \sum_{i=0}^{k} D_i Y_{t-1} + \sum_{i=1}^{k} G_i P_{t-1} + v_t^p \quad (7)$$

This model is linear, unrestricted and dynamic model; Y: Non-policy macroeconomic variables; P: variable that indicates the stance of policy

Equation (7) could be interpreted as the policy makers reaction function; Equation (6) is the set of structural relationships in the rest of the economy v^y, v^p mutually uncorrelated structural error terms; Equation (6) allows the structural error term v^y be multiplied by A^y so that shocks may enter into more than one equation; Equations (6) - (7) is a system not econometrically identified in general.

To identify the dynamic effects of exogenous policy shocks on the various macrovariables Y, without necessarily having to identify the entire model structure it is sufficient to assume that policy shocks do not affect the given macroeconomic variables within the current period (Christiano, Eichenbaum and Evans 1994), i.e., $C_0 = 0$. This assumption is more plausible if the time period is short, and if the list of macroeconomic variables excludes such as interest rates that are likely to respond quickly to policy changes.

An alternative ideintifying assumption is that the policy maker does not respond to contemporaneous information, i.e., $D_0 = 0$

So assuming $C_0 = 0$, the system (6) - (7) can be written as:

(6') $$Y_t = b_0 Y_t + \sum_{i=1}^{k} B_i Y_{t-1} + C_0 P_t + \sum_{i=1}^{k} C_i P_{t-1} + A^y \nu_t^y$$

(6'') $$(I - B_0) Y_t = \sum_{i=1}^{k} B_i Y_{t-1} + \sum_{i=1}^{k} C_i P_{t-1} + A^y \nu_t^y$$

(6''') $$Y_t = (I - B_0)^{-1} \sum_{i=1}^{k} B_i Y_{t-1} + (I - B_0)^{-1} \sum_{i=1}^{k} C_i P_{t-1} + (I - B_0)^{-1} A^y \nu_t^y$$

(7) $$P_t = \sum_{i=0}^{k} D_i Y_{t-1} + \sum_{i=1}^{k} G_i P_{t-1} + \nu_t^p$$

(7') $$P_t = D_0 Y_t + \sum_{i=0}^{k} D_i Y_{t-1} + \sum_{i=1}^{k} G_i P_{t-1} + \nu_t^p$$

(7'') $$P_t = D_0 (I - B_0)^{-1} \sum_{i=0}^{k} B_i Y_{t-1} + D_0 (I - B_0)^{-1} \sum_{i=1}^{k} C_i P_{t-1} + + D_0 (I - B_0)^{-1} A^y \nu_t^p + \sum_{i=1}^{k} D_i Y_{t-1} + \sum_{i=1}^{k} G_i P_{t-1} + \nu_t^p$$

(7''') $$P_t = \sum_{i-1}^{k} [D_i + D_0 (I - B_0)^{-1} B_1] Y_{t-1} + \sum_{i=0}^{k} [G_i + D_0 (I - B_0)^{-1} C_i] P_{t-1} + + [D_0 (I - B_0)^{-1} A^y \nu_t^p]$$

Finally the new system should be:

(6''') $$Y_t = (I - B_0)^{-1} \sum_{i=1}^{k} B_i Y_{t-1} + (I - B_0)^{-1} \sum_{i=1}^{k} C_i P_{t-1} + (I - B_0)^{-1} A^y \nu_t^y$$

(7''') $$P_t = \sum_{i-1}^{k} [D_i + D_0 (I - B_0)^{-1} B_1] Y_{t-1} + \sum_{i=0}^{k} [G_i + D_0 (I - B_0)^{-1} C_i] P_{t-1} + + [D_0 (I - B_0)^{-1} A^y \nu_t^p]$$

Equations (6''') - (7''') show explicitly how reduced form VAR coefficients are related to the underlying structural coefficients, which are not separately identifiable.

Estimation of the system (6''') - (7''') by standard VAR methods followed by a Choleski decomposition of the covariance matrix

(with the policy variable ordered last) yields an estimated series for the exogenous policy shocks v^P.

Impulse response functions of the system with respect to the policy shocks can then be calculated, and can be interpreted as the true structural responses to policy changes (assuming that the linear structure is invariant). Further, the policy variable P_t itself, which is the sum of the forecasted portion of policy [portion predicted by both the lagged and contemporaneous macroeconomic variables and by lagged policy variables]

The Bernanke-Blinder method assumes that a good scalar measure of policy (e.g. the federal funds rate) is available. However, it may be the case that we have only a vector of policy indicators, *P*, which contain information about the stance of policy but are affect by other forces as well. For example: if the Central Bank operating procedure is neither pure interest-rate targeting nor pure reserves targeting, then both interest rate and reserves will contain information about monetary policy; but, additionally both variables may also be affected by shocks to the demand for reserves and other factors. In this more general case the structural macroeconomic model may be written:

$$Y_t = \sum_{i=1}^{k} B_i Y_{t-1} + \sum_{i=1}^{k} C_i P_{t-1} + A^y v_t^y \tag{8}$$

$$P_t = \sum_{i=0}^{k} D_i Y_{t-1} + \sum_{i=1}^{k} G_i P_{t-1} + A^P v_t^p \tag{9}$$

Equation (9) states that the policy indicator *P* depends on current and lagged values of *Y* and *P*, and on a set of disturbances v^P. We assume that one element of v^P is a money supply shock or a policy disturbance v^S. The other elements of v^P may include shocks to money demand or whatever disturbance affects the policy indicators.

Equation (8) allows the non-policy variables *Y* to depend on current and lagged values of *Y* and on lagged values only of *P*; allowing the non-policy variable to depend only on lagged values of policy variables ($C_0 = 0$) is analogous to the identifying assumption made above in the scalar case. [Actually, the assumption is a bit stronger than in the scalar case, as we are also assuming that non-policy innovations to the policy indicators do not feed back into the rest of the economy during the current period.

In analogy to the case of a scalar policy indicator we would like to find a way to measure the dynamic responses of variables in the system to a policy shock v^S:

$$Y_t = \sum_{i=1}^{k} B_i Y_{t-1} + \sum_{i=1}^{k} C_i P_{t-1} + A^y v_t^y \tag{8}$$

$$P_t = \sum_{i=0}^{k} D_i Y_{t-1} + \sum_{i=1}^{k} G_i P_{t-1} + A^P v_t^p \tag{9}$$

From (8):

$$Y_t = B_0 Y_t + \sum_{i=1}^{k} B_i Y_{t-1} + \sum_{i=1}^{k} C_i P_{t-1} + A^y v_t^y \tag{8'}$$

$$(I - B_0) Y_t = \sum_{i=1}^{k} B_i Y_{t-1} + \sum_{i=1}^{k} C_i P_{t-1} + A^y v_t^y \tag{8''}$$

$$Y_t = (I - B_0)^{-1} \sum_{i=1}^{k} B_i Y_{t-1} + (I - B_0)^{-1} \sum_{i=1}^{k} C_i P_{t-1} + (I - B_0)^{-1} A^y v_t^y \tag{8'''}$$

From (9):

$$P_t = D_0 Y_t + \sum_{i=1}^{k} D_1 Y_{t-1} + G_0 P_t + \sum_{i=1}^{k} G_i P_{t-1} + A^P v_t^p \tag{9'}$$

$$\begin{aligned} P_t = {} & D_0 (I - B_0)^{-1} \sum_{i=1}^{k} B_i Y_{t-1} D_0 (I - B_0)^{-1} \sum_{i=1}^{k} C_i P_{t-1} + D_0 (I - B_0)^{-1} A^P v_t^p + \\ & + G_0 P_t + \sum_{i=1}^{k} D_i Y_{t-1} + \sum_{i=1}^{k} G_i P_{t-1} + A^P v_t^p \end{aligned} \tag{9'}$$

$$\begin{aligned} P_t = {} & \sum_{i=1}^{k} [D_i + D_0 (I - B_0)^{-1} B_i] Y_{t-1} + \sum_{i=1}^{k} [G_i + D_0 (I - B_0)^{-1} C_i] P_{t-1} + \\ & + [D_0 (I - B_0)^{-1} A^y v_t^y + A^P v_t^p] + G_0 P_t \end{aligned} \tag{9''}$$

$$\begin{aligned} (I - G_0) P_t = {} & \sum_{i=1}^{k} [D_i + D_0 (I - B_0)^{-1} B_i] Y_{t-1} + \sum_{i=1}^{k} [G_i + D_0 (I - \\ & - B_0)^{-1} C_i] P_{t-1} + [D_0 (I - B_0)^{-1} A^y v_t^y + A^P v_t^p] + G_0 P_t \end{aligned} \tag{9''}$$

$$P_t = (I - G_0)^{-1}\sum_{i=1}^{k}[D_i + D_0(I - B_0)^{-1}B_i]Y_{t-1} + (I - G_0)^{-1}\sum_{i=1}^{k}[G_i +$$

$$(9''') \qquad + D_0(I - B_0)^{-1}C_i]P_{t-1} + [(I - G_0)^{-1}D_0(I - B_0)^{-1}A^y v_t^y +$$

$$+ (I - G_0)^{-1}A^P v_t^p]$$

So more compactly: from (8''') and (9''') we have:

$$(10) \qquad Y_t = \sum_{i=1}^{k} H_i^y Y_{t-1} + \sum_{i=1}^{k} H_i^P P_{t-i} + u_t^y$$

$$(11) \qquad P_t = \sum_{i=1}^{k} J_i^y Y_{t-i} + \sum_{i=1}^{k} J_i^P P_{t-i} + [(I - G_0)^{-1}D_0 u_t^y + u_t^P]$$

Imagine now that we estimate system (10) - (11) by standard VAR methods, then extract the component of the residual of (11) that is orthogonal to the residual of (10).

Comparing (11) with (9''') we see that this orthogonal component, u^P, is given by:

$$(12) \qquad u_t^P = (I - G_0)^{-1}A^P v_t^P$$

We can rewrite (12) as:

$$(12') \qquad (I - G_0)u_i^P = A^P v_t^P$$

$$(12'') \qquad u_t^P - G_o u_t^P + A^P v_t^P$$

$$(12''') \qquad u_t^P = G_o u_t^P + A^P v_t^P$$

$$(13) \qquad u = Gu + Av$$

Equation (13) is a standard structural VAR system which relates observable VAR based residuals u to unobservable structural shocks ν, one of which is the policy shock v^S. this system can be identified and estimated by standard methods by allowing recovery of the structural shocks, including v^S.

The policy shock v^S is analogous to the innovation to the federal funds rate in the scalar case analyzed by Bernanke and Blinder (1992). As in the scalar case, the structural responses of all variables in the system to a policy shock can be measured by the associated impulse response functions.

Further, given the estimated coefficients of the structural VAR, the following vector of variables is observable:

$$(I - G_0)A^{-1}P \tag{14}$$

The variables described by (9), which are linear combinations of the policy indicator P, have the property that their orthogonalized VAR innovations correspond to the structural disturbances v. In particular, one of these variables, call it p, has the property that its VAR innovations correspond to the innovations in the monetary policy shock. In analogy to the scalar case, in which there is a single observable variable (e.g. the FED funds rate) whose innovations correspond to policy shocks, the authors propose using the estimated linear combination of policy indicators p as a measure of overall monetary policy stance. Although not in itself a normative measure, a total measure of policy stance is potentially useful for evaluating the overall direction of policy, and for making comparisons of current policy stance with policies chosen under similar circumstances in the past. Thus the total policy measure may be useful input to the policy-making process.

Continuing to use u to indicate an (observable) VAR residual and v to indicate an (unobservable) structural disturbance, Bernanke-Mihov assume that the market for bank reserves is described by the following set of equations:

$$u_{TR} = -\alpha u_{FF} + v^D \tag{15}$$

This is the banks' total demand for reserves, expressed in *innovation* form; it states that the innovation in the demand for total reserves u_{TR} depends (negatively) on the innovation in the federal funds rate u_{FF} (the price of reserves) and on demand disturbances v^D.

$$u_{BR} = \beta(u_{FF} - u_{DISC}) + v^B \tag{16}$$

This equation determines the portion of reserves that banks choose to borrow at the discount window: as is conventional, the demand for borrowed reserves (in innovation form), u_{BR}, is taken to depend positively on the innovations in the federal funds rate u_{FF} (the rate at which borrowed reserves can be relent) and negatively on the discount rate u_{DISC} (the cost of borrowed reserves); v^B is a disturbance to the borrowing function [various sanctions and restrictions imposed by the fed on bank's use of the discount window make the true cost of borrowing greater than the discount

rate; hence banks do no attempt to borrow infinite quantities when the funds rate exceeds the discount rate].

The innovations in the demand for non-borrowed reserves, the difference between total and borrowed reserves, is u_{TR} - u_{BR}.

$$u_{NBR} = \varphi^D v^D + \varphi^B v^B + v^S \tag{17}$$

This equation describes the behavior of the central bank. We assume that the fed observes and responds to shocks to the total demand for reserves and to the demand for borrowed reserves within the period, with the strength of the response given by the coefficients φ^D and φ^B. That the fed observes reserve demand shocks within the period is reasonable since it monitors total reserves (except vault cash) and borrowings continuously; however, the case in which the fed does not observe (or does not respond to) one or the other of these disturbances can be accommodated by setting the relevant coefficients to zero. The disturbance term v^S is the shock to policy that we are interested in identifying. Note that the system (15) - (17) is in the form of equation (13). Reduced form relationship between the VAR residuals u and the structural disturbances v as in equation (12). To do so, we first make the simplifying assumption that the innovations to the discount rate is zero $u_{DISC} = 0$ [The principal reason for this assumption is to conform with the tree previous studies being examined all of which also ignore the discount rate. The discount rate which is an infrequently-changed administered rate, may also not be well-modeled by the linear VAR framework. An alternative to assuming that the innovation to the discount rate is zero, but which has essentially the same effect, is to treat the discount rate innovation as part of the innovation to the borrowing function.]. To solve the model we impose the condition that the supply of non-borrowed reserves plus borrowing reserves must equal the total demand for reserves. Solving in terms of innovations to total reserves, non-borrowed reserves, and the federal funds rate we have:

$$u = (I - G)^{-1} A v \tag{18}$$

$$u = \begin{bmatrix} u_{TR} \\ u_{NBR} \\ u_{FF} \end{bmatrix} \qquad v = \begin{bmatrix} v^D \\ v^S \\ v^B \end{bmatrix}$$

So the model to be solved is, with the assumption that $u_{DISC} = 0$:

(16') $$u_{TR} = -\alpha u_{FF} + v^D$$

(17') $$u_{BR} = -\beta u_{FF} + v^B$$

(18') $$u_{NBR} = \varphi^D v^D + \varphi^B v^B v^S$$

combining (16'), (17') and (18'), considering $u_{BR} = u_{TR} - u_{NBR}$ and solving for u_{FF} we get:

$$u_{FF} = \frac{1-\varphi^D}{\alpha+\beta} v^D - \frac{1+\varphi^B}{\alpha+\beta} v^B - \frac{1}{\alpha+\beta} v^S$$

Similarly, for u_{TR} we get:

$$u_{TR} = \frac{1-\alpha\varphi^D}{\alpha+\beta} v^D - \frac{\alpha(1+\varphi^B)}{\alpha+\beta} v^B - \frac{\alpha}{\alpha+\beta} v^S$$

$$v^S = -(\varphi^D + \varphi^B) u_{TR} + (1+\varphi^B) u_{NBR} - (\alpha\varphi^D - \beta\varphi^B) u_{FF}$$

First approach to the Peruvian case

Inclusion of the exchange market interventions:

(19) $$u_{TR} = -\alpha u_{FF} + \beta u_e v^D$$

(20) $$u_{BR} = \gamma u_{FF} - \delta u_e + v^B$$

(21) $$u_{NBR} = \varphi^D v^D + \varphi^B v^B + \varphi^e v^e + v^S$$

(22) $$u_e = \theta^D v^D + \theta^B v^B + v^e + \theta v^S$$

The monetary policy shock will be:

$$v^S = \{-[\varphi^D + \varphi^B - \varphi^e(\theta^D + \theta^B)] u_{TR} + (1+\varphi^B - \varphi^e\theta^B) u_{NBR} - [\alpha\varphi^D - \\ - \gamma\varphi^B - \varphi^e(\alpha\theta^D - \gamma\theta^B)] u_{FF} + [\beta\varphi^D - \delta\varphi^B - \varphi^e(\beta\theta^D - \delta\theta^B + \\ + 1)] u_e\} \frac{1}{1-\varphi^e\theta^S}$$

This way of written the monetary policy shock give us the possibility of estimation.

However, the model, written in this way does not allow the possibility of targeting the base money. One way to do so is just considering the total reserves demand of the banking system and the cash holdings demand of the households.

Money and Reserve Markets

An initial procedure to introduce the base money targeting scheme, without considering independently the foreign exchange market in this first approximation, could be resumed trough the demand for total reserves and the demand for cash holdings of households in the following just identified model:

(23) $$u_{TR} = +\nu^{D}$$

(24) $$u_{CHH} = -\beta u_{FF} + \nu^{B}$$

(25) $$u_{BM} = \varphi^{D}\nu^{D} + \varphi^{B}\nu^{B} + \nu^{S}$$

Equation (23) estates that the innovations in the total reserves demand of the banking system are identified with demand shocks in this market. Equation (24) represents the demand for cash holdings of households which is negatively related to interest rates, equation (25) reflects the reaction function of the Central Bank to shocks in total reserves demand, to shocks in household cash holdings demand and includes monetary policy shocks.

Inclusion of the base money targeting:

(26) $$u_{TR} = -\alpha u_{FF} + \beta u_{e} + \nu^{D}$$

(27) $$u_{CHH} = -\gamma u_{FF} - \delta u_{e} + \nu^{B}$$

(28) $$u_{BM} = \varphi^{D}\nu^{D} + \varphi^{B}\nu^{B} + \varphi^{e}\nu^{e} + \nu^{S}$$

(29) $$u_{e} = \varphi^{D}\nu^{D} + \varphi^{B}\nu^{B} + \nu^{e} + \theta^{S}\nu^{S}$$

Equation (26) is the banking system total reserves demand that depends negatively on its price, the interest rate of Central Bank CDs,[6] and positively on deviations of exchange rate devaluation.

[6] The cost of total reserves for the banking system should be the federal funds rate, however only since the last quarter of 1995 the Peruvian banking system reports this rate to the Central Bank. For the analysis we use the interest rate of Central Bank CDs as an indicator of this cost. The use of the CDs rate is

The positive relationship with the exchange rate comes from the interventions of the Central Bank in the foreign exchange market. The procedure of the exchange rate intervention is trough the announcement of the amount of intervention leaving to the banking system the bid of the exchange rate they would like to receive for its US dollars. The banks would like to receive more domestic currency for each US dollar.

Equation (27) describes the household demand for cash holdings that are negatively related to the market interest rate (using as proxy the CDs rate) and inversely to the exchange rate. This relationship comes from the free holdings of currencies in the country.

It will be useful to write the reduced form relationship of the observable innovations with the structural shocks:

$$\begin{bmatrix} u_{CD} \\ u_{TR} \\ u_{CHH} \\ u_e \end{bmatrix} = \begin{bmatrix} \frac{\theta^D(\beta-\delta)+(1-\varphi^D)}{\alpha+\gamma} & \frac{\theta^B(\beta-\delta)+(1-\varphi^B)}{\alpha+\gamma} & \frac{\beta-\delta-\varphi^e}{\alpha+\gamma} & \frac{-(1-\theta^S)}{\alpha+\gamma} \\ \beta\theta^D - \frac{\alpha[\theta^D(\beta-\delta)+(1-\varphi^D)]}{\alpha+\gamma} & \beta\theta^B - \frac{\alpha[\theta^B(\beta-\delta)+(1-\varphi^B)]}{\alpha+\gamma} & \beta - \frac{\alpha(\beta-\delta-\varphi^e)}{\alpha+\gamma} & \beta\theta^S + \frac{\alpha(1-\theta^S)}{\alpha+\gamma} \\ -\delta\theta^D \frac{\gamma[\theta^D(\beta-\delta)+(1-\varphi^D)]}{\alpha+\gamma} & -\delta\theta^B \frac{\gamma[\theta^B(\beta-\delta)+(1-\varphi^B)]}{\alpha+\gamma} & -\delta - \frac{\gamma(\beta-\delta-\varphi^e)}{\alpha+\gamma} & -\delta\theta^S - \frac{\gamma(1-\theta^S)}{\alpha+\gamma} \\ \theta^D & \theta^B & 1 & \theta^S \end{bmatrix} \begin{bmatrix} v^D \\ v^B \\ v^e \\ v^S \end{bmatrix}$$

Identification assumptions:

The system has 14 unknown parameters (including the four structural shocks) that have to be estimated from 10 variances and co-variances. Just-identification of the system requires four restrictions: First, we assume that $\alpha = \beta$, which means that the banking system cares about the differential of the nominal interest rate with respect to the devaluation rate as the cost of total reserves in domestic currency (this assumption is reliable for dollarized economies). The second assumption is that for the monetary policy to be effective on a dollarized economy there is no currency substitution, a proxy to this assumption is to make $\delta = 0$. And consistent with this approach is to assume that the central bank does not react trough the exchange market interventions to shocks to the household demand for cash holdings, that is $\theta^B = 0$. The fourth assumption comes from the isolation of the reaction function of the central bank trough exchange market interventions from the reaction function trough the base money creation,

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possible because it is a market rate since the Central Bank auctions announced amounts of CDs and the bidders put the price. Testing the adequacy of this assumption we do estimations for a small sample that uses the federal funds rate.

that is $\varphi^e = 0$, this is a necessary assumption since by the supply side the base money creation should include (as a source) the exchange market interventions of the central bank. With these four assumptions we can get a just-identified system whose estimation provide us with an indicator of the monetary policy that is a weighted average of traditional indicators of the monetary policy as the CDs interest rate.

The solution for the just identified model will be:

$$\begin{bmatrix} u_{CD} \\ u_{TR} \\ u_{CHH} \\ u_e \end{bmatrix} = \begin{bmatrix} \frac{1-\theta^D-\alpha\varphi^D}{\alpha+\gamma} & \frac{(1-\varphi^B)}{\alpha+\gamma} & \frac{\alpha}{\alpha+\gamma} & \frac{-(1-\theta^S)}{\alpha+\gamma} \\ -\frac{\alpha(1-\gamma\theta^D-\varphi^D)}{\alpha+\gamma} & -\frac{\alpha(1-\varphi^B)}{\alpha+\gamma} & \frac{\alpha\gamma}{\alpha+\gamma} & \alpha\theta^S+\frac{\alpha(1-\theta^S)}{\alpha+\gamma} \\ -\frac{\gamma(1+\alpha\theta^D-\varphi^D)}{\alpha+\gamma} & -\frac{\gamma(1-\varphi^B)}{\alpha+\gamma} & \frac{-\alpha\gamma}{\alpha+\gamma} & \frac{\gamma(1-\theta^S)}{\alpha+\gamma} \\ \theta^D & \theta^B & 1 & \theta^S \end{bmatrix} \begin{bmatrix} v^D \\ v^B \\ v^e \\ v^S \end{bmatrix}$$

This just identified solution for a system that includes innovations in devaluation of domestic currency, related to interventions of the central bank in the exchange market, and the assumption of non existence of currency substitution, inelastic relationship of the innovations in the domestic cash holdings of households with innovations to domestic currency devaluation, could be estimated trough a VAR including indicators of output, customer prices and commodity prices.

A very first evaluation of these models, not reported[7] in this preliminary version of the project, shows that non-borrowed reserves could be good indicator of the monetary policy conducted by the Peruvian central bank. However we cannot reject the importance of the base money and of the CDs interest rate as indicators of the monetary policy. Moreover it seems that the Central Bank of Peru has been using a combination of these three indicators to conduct its monetary policy.

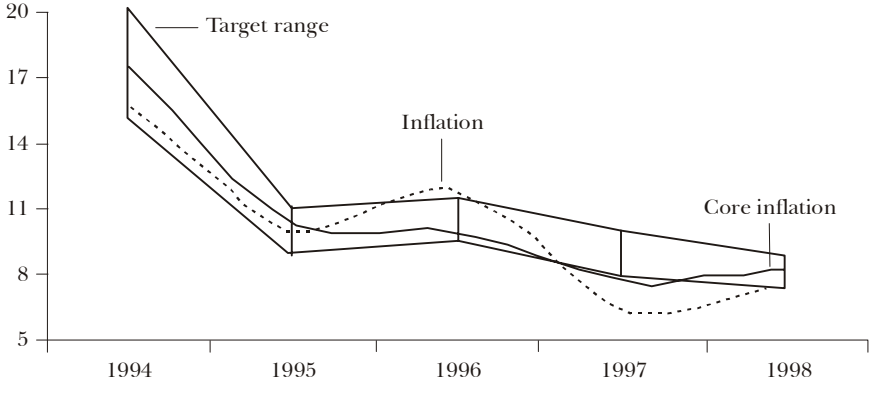
> If these preliminary estimated suggestions applies, then we could deduce that for the Central Bank of Peru inflation targets have become the most important factor in the setting of monetary policy instruments in Peru. To achieve its inflation target the Central Reserve Bank of Peru seems to be using a variety of different indicators of monetary policy operations depending upon monetary conditions

[7] The results are highly sensitive to changes in specification and to changes in the sample. We will try to apply specification tests and stability tests to evaluate the consistency of the preliminar results.

This possible interpretation of the results seems to be consistent with the evolution of the inflation rate in recent years that has been kept around its target range since 1994.

It is important to recall that since 1994 to avoid misunderstandings about the variation of the base money the Central Bank in coordination with the Central Government announces the target range for the inflation rate. It helped in reaching low levels of inflation within the target with some small deviations. The underlying inflation shows better performance, however it is used only as an indicator.

FIGURE: PERU: INFLATION RATE, 1994-98



V. CONCLUSIONS

1. The dollarization process in Peru is mainly of asset substitution. The domestic currency is used for current transactions and is closely related to the inflation rate. Since the cash holdings represents in between 75-80 percent then there should not be any problem in considering the base money creation as intermediate target.

2. The fiscal discipline is one of the most important conditions to succeed in our inflation objectives because of its impact on aggregate demand.

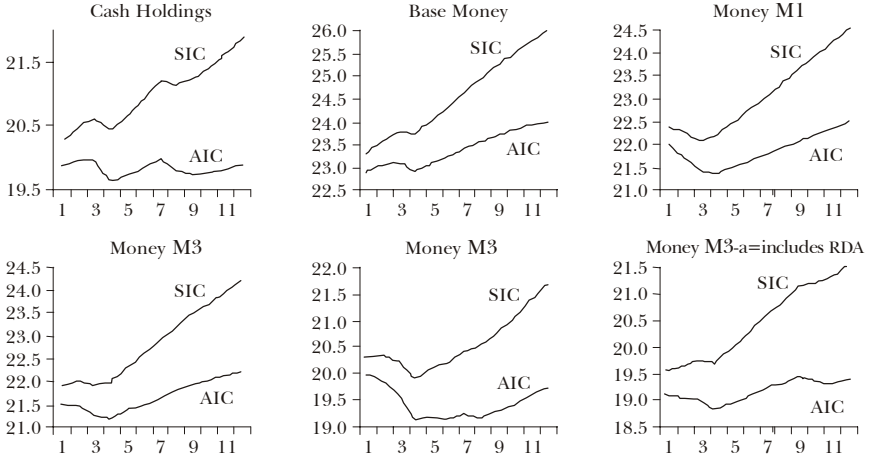
3. Shocks to domestically denominated cash holdings explain most of the variance of inflation.

4. However the preliminary econometric results, suggests that for

the Central Bank of Peru inflation targets have become the most important factor in the setting of monetary policy instruments in Peru. To achieve its inflation target the Central Reserve Bank of Peru seems to be using a variety of different indicators of monetary policy operations depending upon monetary condition. This finding is stronger since 1994, when the Central Bank, in coordination with the Finance Ministry, began to announce the target range for the inflation rate.

Annex 1

OPTIMAL LAG IDENTIFICATION OF THE VARIATION OF REAL MONETARY AGGREGATES



Annex 2

UNIT ROOT TEST: MONTHLY DATA, 1991-1998

Variables	*Augmented Dickey-Fuller*	*Phillips-Perron*
Inflation	-7.3586	-17.5278
Output growth	-3.2570	-3.4840
Real Exchange Rate	-4.5042	-4.1265
Real Interest Rate	-8.7811	-2.2768
Growth of Real Cash oldings	-3.7435	-4.3851
Growth of Real quasi-money	-3.3995	-3.4602

(prolongation)

UNIT ROOT TEST *(conclude)*

Variables	*Augmented Dickey-Fuller*	*Phillips-Perron*
Growth of Dollar deposits	-2.7144	-1.8309
Growth of Deposits abroad	-2.6208	-1.9725
Growth of Real Base Money	-2.5617	-3.0849
Critical Values (%)		
1	-3.5064	-3.5047
5	-2.8947	-2.8939
10	-2.5842	-2.5838

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Luis E. Arango
Andrés González

A nonlinear specification of demand for cash in Colombia

1. INTRODUCTION

A significant part of the empirical research agenda in economics on the last years has been devoted to the search for robust econometric specifications of empirical models of the demand for money with the desired property of theoretical coherence. This tendency was motivated and supported by the appearance of some complementary techniques during the last twenty years. These techniques are the error correction model, the equilibrium long-run relationships of the variables involved in a model, and the concept of Granger causality, which have been used to investigate the issues termed weak, strong and super exogeneity, each with different implications on inference, forecasting, and policy,

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and related to the Lucas critique, parameter constancy, invertibility of the money demand function and to measurement problems of the monetary aggregate used in the specification. On the theoretical side, precautionary demand, risk aversion, asset demands, adjustment costs, target-bounds, buffer stocks, expectations, learning and financial innovation, have played a central role.

The works of Hendry and Ericson (1991a, b) on the US and the UK demand for money have been of extreme importance to this area as well as the works done on the German case, before and after the unification (e.g. Wolters et al., 1998; Beyer, 1998; Lütkepohl et al., 1999). Some investigations on money demand dealing with the above points have been done in Colombia using quarterly data, monetary base, M1 or M3 as monetary aggregates (an exception is Steiner (1988), who also dealt with cash), the GDP as the scale variable and linear specifications (see Carrasquilla and Renteria, 1991; Misas and Oliveros, 1997; and Gómez, 1998, among others). However, the evidence of having an equation of money demand is rather mixed.

In this work we propose a different approach to arrive at the demand for money in Colombia. First, instead of using monetary base or some other broader aggregate, our definition of the monetary aggregate is cash. We assume that this variable reflects to a greater extent the preferences of agents to hold real balances while some other definitions could be affected by decisions of the Central Bank (e.g. changes in reserve requirements that would affect the measurement of monetary base), which could introduce an identification problem. Second, monthly data (1982:2-1998:11) are used to capture the short run dynamics of the demand for money on the belief that this is the most appropriate frequency to study the demand for real balances. Third, industrial GDP, measured by the Industrial Production Index, is used as a scale variable instead of the (quarterly) GDP. The latter variable is not entirely acceptable in Colombia because of measurement problems. Finally, we specify a nonlinear dynamic model of the demand for money using a smooth transition regression (STR) (see Granger and Teräsvirta, 1993; Teräsvirta, 1998) in which the scale variable, the short term interest rate and the rate of depreciation appear as the explanatory variables. In this paper, we show that the demand for cash in Colombia can be represented by a, noninvertible, nonlinear logistic specification of the STR-type. Moreover, our nonlinear error correction representation is consistent with the theory.

Findings of nonlinearities in money demand functions have

been reported recently. They have been addressed, for example, by Hendry and Ericsson (1991b), Muscatelli and Spinelli (1996), Teräsvirta and Eliasson (1998), Ericsson et al. (1998), and Sarno (1999). The nonlinear approach has been used to estimate models of constant parameters in samples of long span and low frequency (annual data for about one century or so). However, we also consider this approach more appropriate to approximate the DGP of a higher frequency series.

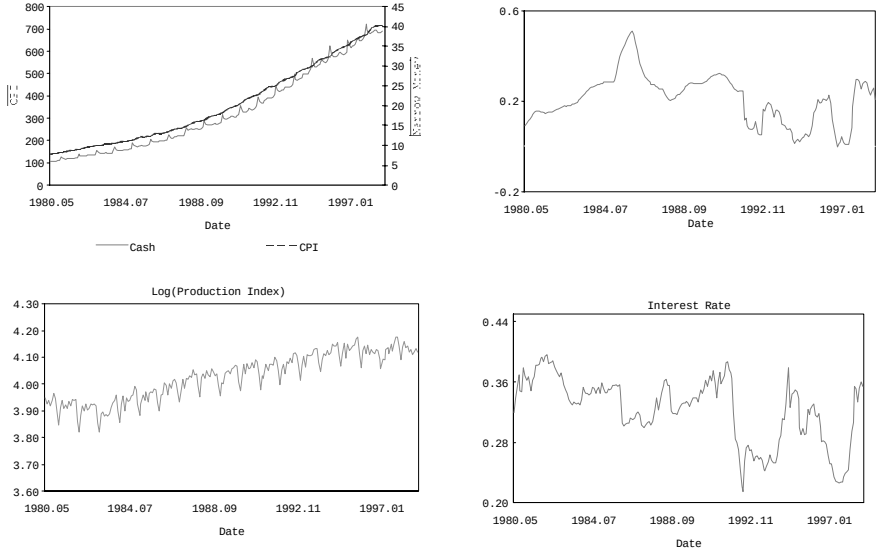
Nonlinear models of demand for money may be rationalized as either target-threshold or buffer stock models. The former type of models put forth by Miller and Orr (1966) and developed by Akerlof (1973, 1979) and Milbourne (1983), provide microfoundations for the presence of a close to unity coefficient of the lagged dependent variable in the equation of money demand. Under these target-bound models, the agents define a target zone (bounded above and below) for their real-money balances. The upper and lower long-run thresholds are defined on the basis of expenditure plans and precautionary anticipations. Consequently, nominal balances are forced by the agents to stay near to the mean of the target zone (translated into nominal terms) when facing short-run deviations from the band. One type of the second class of models (see Laidler, 1984) give a buffer stock role to money in the sense that it acts as an asset that absorbs temporary shocks for which agents cannot postpone adjustments which are assumed very costly. As we shall see below other different types of buffer stock models have been developed to account for the fact that, given the existence of adjustment costs, relatively small deviations from the long-run real-money holdings are allowed to persist in the short-run while relatively large are not.

The outline of the paper is as follows. The second section describes the data, shows some preliminary results and discusses the equilibrium long-run relationship and the exogeneity of the system. The third section deals with the linear error correction model of demand for money. The fourth section, extends the target-bound and buffer stock alternatives to rationalize nonlinearities of demand for money. The fifth section introduces the STR models, discusses some estimation and testing issues and shows the results. The sixth section makes some final remarks.

2. DATA, COINTEGRATION SYSTEM AND EXOGENEITY ANALYSIS

From the theoretical point of view, agents may hold money as an

FIGURE 1. SET OF VARIABLES (MONTHLY DATA, 1980:5 – 1998:11)



SOURCES: cash, interest rate and depreciation rate from the Banco de la República. CPI and Industrial Production Index from DANE.

inventory to reduce differences between the streams of income and expenditure. However, agents may also hold money as an asset in a multi-asset portfolio. Consequently, we could have a customary long-run specification for nominal money demand (M^d) such as:

$$M^d = f\,(P,Y,I) \tag{1}$$

where P is the price level, Y is the scale variable and I is a set of rates of returns on assets. The empirical model we consider imposes long-run price homogeneity, takes the industrial GDP as the scale variable, and regards the interest rate from period t to $t+1$ and the depreciation rate from $t-1$ to t as the opportunity cost of holding money. The behavior of these variables during the sample period is shown in Figure 1.

The long-run dynamic model is expressed as:

$$m - p = \lambda_0 + \lambda_1 y + \lambda_2 i + \lambda_3 e \tag{2}$$

where m is the log of cash, p is the log of CPI, y is the log of industrial GDP, i is the interest rate, e is the annual rate of depreciation and λ_j (j = 0, 1, 2, 3) are parameters.[1]

[1] The data corresponding to m, i and e are month average instead of end-of-month.

Following Wolters et al. (1998) we use seasonally unadjusted variables on the assumption that seasonal fluctuations are an important source of variation in economic time series and it seems sensible to model them instead of smoothing them out. The set of variables used in this work is monthly dated[2] (1982:2-1998:11). The objective of using this frequency is to trace the dynamics of demand for cash since it is more accurate for such an aim than annual or even quarterly data.[3]

Given that $(m-p)$, y, i, and e are $I(1)$ under conventional tests, we use Johansen techniques to investigate the cointegrating properties of the stochastic VAR system. The number of cointegrating vectors was tested by using a lag length of twelve,[4] an intercept in the cointegration space without allowing for linear trends in the data,[5] and including centered seasonal dummies out of the long-run relationship.[6] The results of the cointegration analysis (Table 1) show that according to the trace statistic there is only one cointegrating vector among the stochastic variables of the system. The equation of the demand for cash is correctly signed after normalizing by the coefficient of $(m-p)$. On the assumption that there is only a single long-run relationship between the variables of the VAR system, we found evidence of joint weak exogeneity of y, i, and e. This means that we are able to condition y, i, and e on $(m-p)$ without losing information relevant for the estimation of the parameters of interest and, consequently, the system of the demand for cash can be reduced to a single equation.[7] Furthermore, according to the results of Table 1

[2] To give a rough idea of the Colombian environment, during the sample period there have been at least three remarkable events. First, the financial crisis occurred in the first part of the eighties. Second, the opening up of the economy undertaken between the end of the eighties and the beginning of the nineties. Among the measures adopted within this framework, the change of the exchange rate determination regime from a crawling peg to a target zone is of particular interest for this study. Third, the new order brought to the monetary policy setting given the institutional changes, which allowed a more independent Central Bank.

[3] To our knowledge, no investigation on demand for money using high frequency data has been done yet to the Colombian case.

[4] The lag was chosen on the basis of the Likelihood ratio tests (see Lütkepohl, 1991).

[5] A trend in the cointegration space happened to be statistically insignificant.

[6] As the system contains an unrestricted constant, the asymptotic values do not need any correction because of the seasonal dummies.

[7] If we have a model such as $x_t = f(z_t)$, z_t will be weakly exogenous if the joint distribution of $w_t=(x_t, z_t)$ conditional on the past, can be factorised as the condi-

there is evidence of strong exogeneity, given the fact that the null hypothesis of block non Granger-causality cannot be rejected at conventional significance levels. This outcome implies no feedback from (*m-p*) to the stochastic subsystem composed by *y*, *i*, and *e*.

TABLE 1. COINTEGRATION SYSTEM ANALYSIS (TRACE TEST FOR THE COINTEGRATION RANK)

	Null hypothesis	*Alternative hypothesis*	*Trace*	*T. Critical value (90%)*
0.1089	$r = 0$	$r \geq 0$	52.23	49.92
0.0727	$r \leq 1$	$r \geq 2$	30.31	31.88
0.0669	$r \leq 2$	$r \geq 3$	15.98	17.79
0.0147	$r \leq 3$	$r \geq 3$	2.82	7.50

Standardized long-run coefficients

(*m-p*)	*Y*	*i*	*e*
1.0000	-0.370	2.619	0.291

P-values of testing

Joint weak exogeneity	*Block non causality*
0.3234	0.1149

In summary we have one equilibrium long-run relation among the variables of the demand for money, in which the variables appear rightly signed. The scale variable, the interest rate and the rate of depreciation are joint weak exogenous and there is no feedback from (*m-p*) to the block composed by *y*, *i*, and *e* so that strong exogeneity obtains.

3. THE ERROR CORRECTION REPRESENTATION OF THE DEMAND FOR MONEY

The results of section 2 permit us to conduct the analysis in a single equation framework. Consequently, the variations of (*m-p*) can be expressed in terms of an error correction mechanism, lags of

———

tional distribution of x_t given z_t times the marginal distribution of z_t. As a result, the parameters of the conditional and marginal distributions are not subject to cross-restrictions and the parameters of interest can be uniquely determined from the parameters of the conditional model.

the dependent variable, lags of the changes of y, i, and e and, possibly, deterministic components. OLS estimation can be used under the assumptions that the coefficients of money demand (m-p) are zero on the equations of y, i, and e and the structural shocks of (m-p) and y, i, and e are orthogonal.

Starting with twelve lags and seasonal centered dummies for each month, the error correction model we find, after excluding the variables found not statistically significant, is:

$$\begin{aligned}\Delta(m-p)_t = {} & 0.2133 - 0.0549 ecm_{t-1} - 0.1000 d_{1,t} - 0.0242 d_{8,t} + 0.0352 d_{11,t} + 0.2385 d_{12,t} \\ & (0.056) \quad (0.014) \quad (0.007) \quad (0.006) \quad (0.005) \quad (0.006) \\ & - 0.1475 \Delta(m-p)_{t-2} - 0.0907 \Delta(m-p)_{t-3} - 0.1147 \Delta(m-p)_{t-4} - 0.1444 \Delta(m-p)_{t-5} \\ & (0.033) \quad (0.035) \quad (0.026) \quad (0.020) \\ & - 0.0585 \Delta(m-p)_{t-7} + 0.1405 \Delta y_{t-1} + 0.0892 \Delta y_{t-2} + 0.1111 \Delta y_{t-3} + 0.3145 \Delta i_{t-7} + 0.2517 \Delta i_{t-11} \\ & (0.023) \quad (0.041) \quad (0.045) \quad (0.038) \quad (0.137) \quad (0.135)\end{aligned}$$

where,

$$ecm_t = (m-p)_t - 0.370 y_t + 2.619 i_t + 0.291 e_t \tag{3}$$

T = 1982:2-1998:11 = 202; R^2 = 0.948; *SEl* = 0.020; *DW* = 2.1685; *P*-value *LB*(36) = 0.628; *ARCH*(*1*) = 1.5910(0.208); *ARCH*(*4*) = 0.8235(0.5116); *JB* = 11.8679(0.0042); *RESET* = $0.5994(2.36\times10^{-10})$.

The linear error correction model in (3) exhibits correct signs for the error correction term and the seasonal dummies corresponding to January (d_1), August (d_8), November (d_{11}) and December (d_{12}). Also the coefficients have low standard errors (in parenthesis). The goodness of fit as measured by R^2 is very high and the standard error (*SEl*) seems of adequate magnitude. There is evidence of neither serial autocorrelation at one lag measured by the Durbin-Watson (*DW*) and 36 lags according to the *P*-value of the Ljung-Box coefficient nor *ARCH*-type nonlinearity at one and four lags. However, notice that, according to the Jarque-Bera statistic, the null of normality of the residuals is rejected. This result together with the rejection of the null of no misspecification of the RESET test suggests that an alternative dynamic model should be considered. This suggestion is in line with that of Hendry and Ericsson (1991), Ericsson, Hendry and Prestwich (1998), Teräsvirta and Eliasson (1998), Lütkepohl et al. (1999), and Sarno (1999). The alternative we consider here is an error correction STR model of the demand for money.

4. RATIONALIZING NONLINEARITIES WITHIN THE MONEY DEMAND FRAMEWORK

As mentioned in the introduction, nonlinear models of demand for money can be interpreted at least from two points of view: as the result of target-bounds and as a buffer stock, both micro-founded. With the target-bound models, first proposed by Miller-Orr (1966) and developed by Akerlof (1973, 1979), and Milbourne (1983), the agents, based on expenditure plans and precautionary anticipations define a band for their holdings of real money.

The fact that any target band introduces nonlinearities to the behavior of the targeted process, has been well documented in economics (e.g. Blatt, 1983, chapter 10, for the case of investment; or target zone models for exchange rates as in Krugman, 1991). It is also the case within the money demand framework (Akerlof and Milbourne, 1980) since nominal balances are forced by the agents to keep near to the mean of the target-bound when facing short-run deviations from it or even when the nominal balances are close to the upper and lower bounds.[8]

The buffer stock models (see Laidler, 1984) account for the fact that, given the existence of adjustment costs, relatively small deviations from the long-run real-money holdings are allowed to persist in the short-run while relatively large are not. Different approaches can be distinguished within the buffer stock models. First, there exist the disequilibrium models which can be of two different types: *single equation disequilibrium estimates* of money demand that have an autoregressive component which has been associated to slow adjustment of short-run to long-run desired money holdings; and, *complete disequilibrium models* in which a number of real and nominal variables are introduced.[9] These models require that, if the parameters of interest are the coefficients of the long-run money demand, then their estimates are conditional on the full specification of the entire model. Second, the shock absorber approach directly estimates the demand for money function although money supply is assumed to be held in

[8] Akerlof and Milbourne´s model captures the stylised fact that the short run income elasticity is small and could even be negative.

[9] These models consider an equation for a set of real and nominal variables (output, prices, interest rates, exchange rate, etc.) explained by predetermined variables and a lag polynomial of the differences between money supply and money demand; and other equations for the long-run money demand.

transactions balances. Rational expectations have been assumed and unexpected money supply shocks are voluntarily held in money balances. Fully anticipated money supply changes are reflected in price expectations and if prices are perfectly flexible, then real money balances remain unchanged (Carr et al., 1985). Carr and Darby (1981) found evidence in favor of the shock absorber approach whereas Cuthbertson (1986) rejected it by using a different estimation techniques. Third, the forward-looking approach of the buffer stock models, allow agents to hold temporarily cash due to unanticipated increases in income.

5. A SMOOTH TRANSITION REGRESSIVE MODEL FOR MONEY DEMAND

We consider the smooth transition regressive models (see Granger and Teräsvirta, 1993; Teräsvirta, 1998) to represent the error correction model of the demand for money as the alternative to the linear error correction mechanism estimated in (3); see also Teräsvirta and Eliasson (1998), Lütkepohl et al. (1998), Sarno (1999), for applications of this approach.

The model can be written as:

$$x_t = \beta' w_t + (\pi_1 + \pi_2 F(s_{i,t};\alpha))' z_t + u_t \qquad (4)$$

where x_t is the dependent variable, $w_t = (w_{1t},.....,w_{Mt})$ is a vector of K regressors which enter linearly with constant parameter vector β, $z_t = (z_{1t},.....,z_{Mt})$ is a vector of M regressors, $s_t = (s_{1t},.....,s_{Lt})$ is a $(L \times 1)$ vector of regressors whose elements may include those of w_t and z_t, and u_t is an *iid* error process, $E(u_t) = 0$, $Var(u_t) = \sigma^2$. F is a transition function bounded by 0 and 1 whose parameters are denoted by α. It is assumed that $E(w_t u_t) = 0$, $E(z_t u_t) = 0$, $E(s_t u_t) = 0$. The x_t, w_t , and z_t processes are assumed to be weakly stationary for the theory of linearity tests to work.[10] Some lagged elements of x_t may be included in w_t and z_t although weak exogeneity of the remaining elements of them, with respect to the parameters of interest in (4) is required.

Notice that when the transition function $F \equiv 0$ the *STR* model (4) will be linear but, in general, the vector of regressor coefficients, $\pi_1 + \pi_2 F(s_{i,t};\alpha)$, will depend on the values of the transi-

[10] However, the theory still applies when s_t is non stationary dominated by a polynomial in t (Lin and Teräsvirta, 1994).

tion variable s_t. The transition function can be parameterized either as a logistic function, in whose case we have a logistic STR (LSTR) model:

$$F(s_t;\alpha) = (1 + exp\{-\gamma(s_t - c)\})^{-1}\ ,\ \gamma > 0 \tag{5}$$

or as an exponential function, in whose case we have an exponential STR (ESTR) model:

$$F(s_t;\alpha) = 1 - exp\{-\gamma(s_t - c)^2\}\ ,\ \gamma > 0 \tag{6}$$

The null hypothesis is that of linearity ($H_0 : \gamma = 0$). However, (4) either with (5) or (6) is only identified under the alternative (H_1: $\gamma > 0$) which invalidates the asymptotic distribution theory. It has been shown that the problem can be solved by using the auxiliary regression obtained approximating $F(\bullet)$ by a third order Taylor series expansion (Granger and Teräsvirta, 1993; Teräsvirta, 1994; Teräsvirta, 1998):

$$x_t = \beta' w_t + \lambda_0' z_t + \lambda_1' z_t s_t + \lambda_2' z_t s_t^2 + \lambda_3' z_t s_t^3 + v_t \tag{7}$$

where the null of nonlinearity becomes $H_0 : \lambda_1 = \lambda_2 = \lambda_3 = 0$, with power against both the LSTR and ESTR. The choice between LSTR and ESTR can also be done using equation (7), following the sequence proposed by Teräsvirta (1998). When t takes the place of the transition variable ($s_t \equiv t$), the transition function is either:

$$F(t;\alpha) = (1 + exp\{-\gamma(t - c_1)(t - c_2)(t - c_3)\})^{-1};\quad \gamma > 0,\quad c_1 \le c_2 \le c_3 \tag{8}$$

or

$$F(t;\alpha) = (1 + exp\{-\gamma(t - c_1)(t - c_2)\})^{-1};\quad \gamma > 0,\quad c_1 \le c_2 \tag{9}$$

or

$$F(t;\alpha) = (1 + exp\{-\gamma(t - c_1)\})^{-1};\quad \gamma > 0 \tag{10}$$

Equation (7) can be used for testing parameter constancy in the linear case (Lin and Teräsvirta, 1994; Jansen and Teräsvirta, 1996). For testing parameter constancy in the nonlinear case we use equation (4.6) of Eitrheim and Teräsvirta (1996). If the test is carried out with either (8), (9), or (10), they will be termed LM3, LM2, or LM1, respectively. The LM1 is a test of H_0: $\lambda_1 = 0 \,|\, \lambda_2 = \lambda_3$

= 0, which has good power against a smooth change in the parameters and, depending on the value of gamma, also against a single structural brake. The LM2 is a test of H_0: $\lambda_1 = \lambda_2 = 0 | \lambda_3 = 0$, and the transition function is a LSTR2 (a logistic transition function with a rest path in the middle regime).

All variables of the linear error correction model were used as possible transition variables. The results do not indicate any nonlinearity at 5% of significance when the possible transition variable is one of the variables used in the linear model (3). The null hypothesis of linearity is rejected when the transition variable is $\Delta_{12}(y)_{t-10}$ given that the *P*-value is the lowest (0.0071).

With this result the selection procedure described in detail in Teräsvirta (1998) allowed us to choose a logistic STR model whose final specification is:[11]

$$\begin{aligned}
\Delta(m-p)_t &= 1.6552 - 0.4479\,ecm_{t-1} - 0.1168d_{1,t} - 0.2183d_{2,t} - 1.2146d_{4,t} - 0.2730d_{7,t} \\
&\quad (0.488) \quad (0.131) \quad (0.007) \quad (0.0502) \quad (0.3313) \quad (0.0847) \\
&- 0.1865d_{8,t} - 0.2222d_{9,t} - 0.3359d_{10,t} - 0.1701d_{11,t} + 0.0797d_{12,t} - 1.1743\Delta(m-p)_{t-3} \\
&\quad (0.048) \quad (0.062) \quad (0.095) \quad (0.061) \quad (0.046) \quad (0.302) \\
&+ 2.498\Delta(m-p)_{t-4} + 0.1223\Delta y_{t-1} + 0.182\Delta i_{t-7} + \{-1.464 + 0.3989\,ecm_{t-1} + 0.1672d_{2,t} \\
&\quad (0.691) \quad (0.038) \quad (0.117) \quad (0.490) \quad (0.132) \quad (0.050) \\
&+ 1.1847d_{4,t} + 0.2730d_{7,t} + 0.1352d_{8,t} + 0.1877d_{9,t} + 0.3359d_{10,t} + 0.1932d_{11,t} + 0.1427d_{12,t} \\
&\quad (0.331) \quad (0.084) \quad (0.049) \quad (0.063) \quad (0.095) \quad (0.061) \quad (0.046) \\
&+ 0.1031\Delta y_{t-2} + 1.0630\Delta(m-p)_{t-3} - 2.5971\Delta(m-p)_{t-4} - 0.1367\Delta(m-p)_{t-5} - 0.1481\Delta(m-p)_{t-7}\} \\
&\quad (0.037) \quad (0.302) \quad (0.693) \quad (0.018) \quad (0.023) \\
&* [1 + exp\{-36.9871[(\Delta_{12}y)_{t-10} + 0.0535]/\sigma_{\Delta_{12}(y)}\}]^{-1} \\
&\quad (38.289) \quad (0.002)
\end{aligned}$$

where,

$$ecm_t = (m-p)_t - 0.370\,y_t + 2.619\,i_t + 0.291\,e_t \tag{11}$$

T = 1982:2-1998:11= 202; R^2 = 0.959; *Senl* = 0.0187; *Varnl/Varl* = 0.852; *P*-value *LB*(4) = 0.418; *ARCH*(*1*) = 0.3178(0.573); *ARCH*(*4*) = 2.7362(0.067); *JB* = 21.3642(0.00).

From the statistics of the error correction *STR* regression in (11), it can be seen that this model outperforms the linear error correction model of equation (3). Thus, the standard error (*SEnl*) is smaller to the extent that the ratio of the residual variances is 0.852, the residuals are white noise but normality is not accompl-

[11] We thank Timo Terasvirta for providing us with some of the Gauss code used in this application and also Munir Jalil for further developments of it.

ished according to Jarque-Bera statistic, regardless of some points are correctly captured for our specification. The nonlinear model seems more accurate in capturing the behavior of the demand for cash in Colombia than the linear one, according to the Figures 2 and 3, a fact that can also be observed by looking at the residuals of the respective models (Figures 4 and 5), and the linear and nonlinear error correction mechanisms (Figures 6 and 7).

FIGURE 2. MONEY DEMAND: OBSERVED VS. LINEAR ESTIMATION

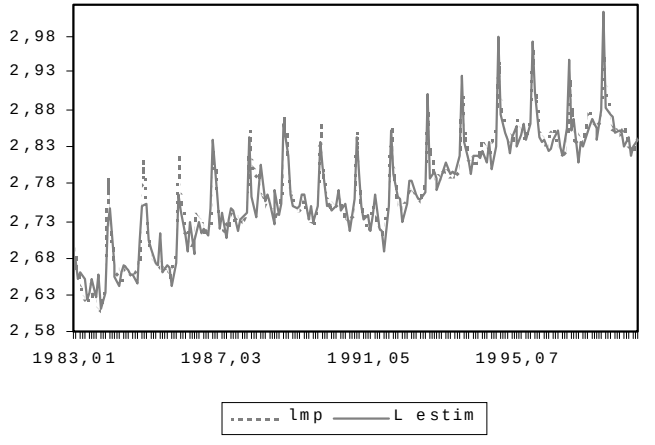
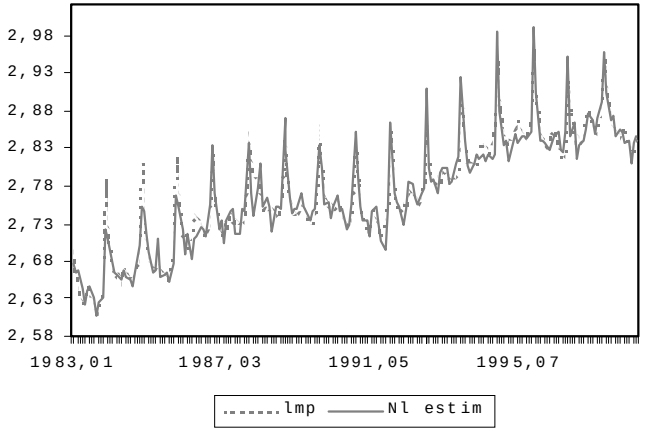


FIGURE 3. MONEY DEMAND: OBSERVED VS. NONLINEAR ESTIMATION



In addition to these specification tests we also implement the LM-type tests of no remaining autocorrelation, no remaining nonlinearity and parameter constancy developed by Eitrheim and Teräsvirta (1996) in order to check the adequacy of the estimated model in the nonlinear framework. The test of no remaining autocorrelation has under the alternative hypothesis a nonlinear model with autocorrelation of order q. Under the null the test is asymptotically distributed as a $\chi^2_{(q)}$, but with the purpose of having the size under control in small samples we use the F-version. The results (Table 2) indicate that the test fails to reject the null hypothesis of no error autocorrelation of order 1, 4, and 20 at any usual levels of significance.

FIGURE 4. RESIDUAL FROM THE LINEAR MODEL

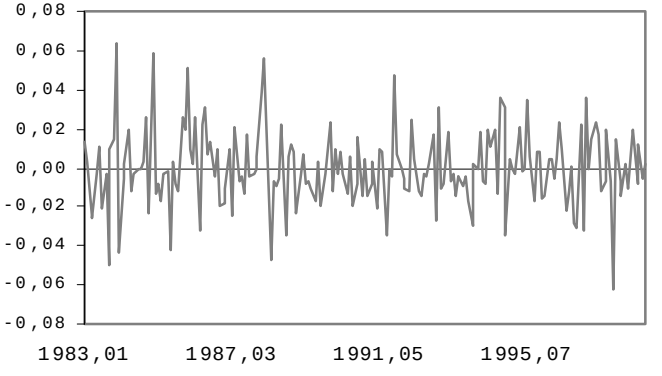


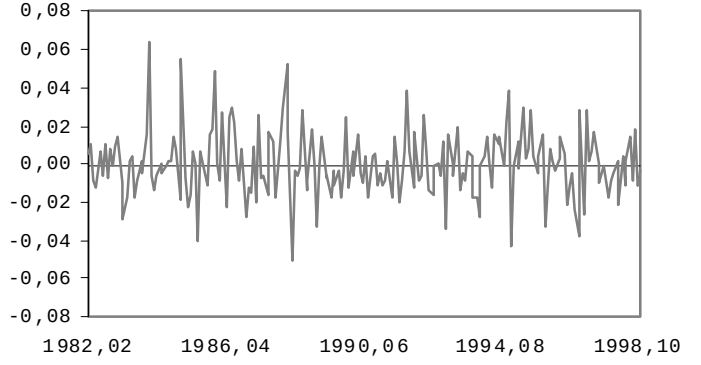
TABLE 2. P-VALUES OF THE LM TEST OF NO ERROR AUTOCORRELATION AGAINST (an AR [q] and MA [q] error processes)

	Maximum lag q						
Test	1	2	4	6	12	18	20
No error autocorrelation	0.898	0.483	0.419	0.426	0.539	0.683	0.796

Following Eitrheim and Teräsvirta (1996) we also check whether equation (11) is an adequate characterization of the nonlinear features rendered by the data by looking at remaining nonlinearity. Under the alternative the model is an additive STR model, and the test statistic has an asymptotic $\chi^2_{(q)}$ distribution under the null. However, the model is not identified under the null

but this problem is solved in the same way in which the linearity test is solved by Granger and Teräsvirta (1993) and Teräsvirta (1994). In this case, all variables in the linear error correction model of equation (3) were tried as potential transition variables in the additive nonlinear model. Nonetheless the results do not give any evidence in favor of remaining nonlinerity in the model of equation (11).

FIGURE 5. RESIDUAL FROM THE NONLINEAR MODEL



Finally, we have applied the test of parameter constancy under the alternative hypothesis of a smooth change in the parameters of the model which also includes the test of an abrupt change. The test under the alternative is parameterized using three different functions in which the transition variable is the time (equations 8, 9, and 10 above). These possible parameterizations allow a wide range of non constancy possibilities. Here, the constancy test is carried out over four different sets of parameters (seasonal, linear and nonlinear) of equation (11). The results in Ta-

FIGURE 6. LINEAR ERROR CORRECTION

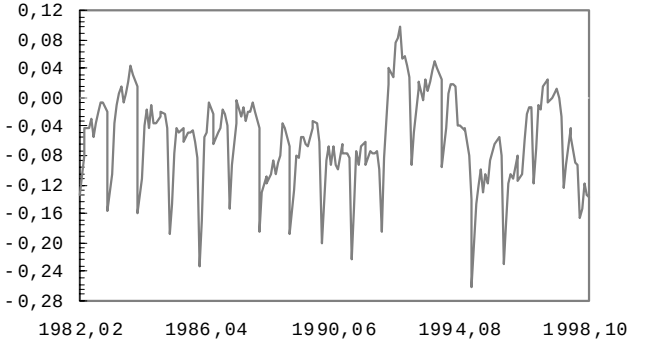


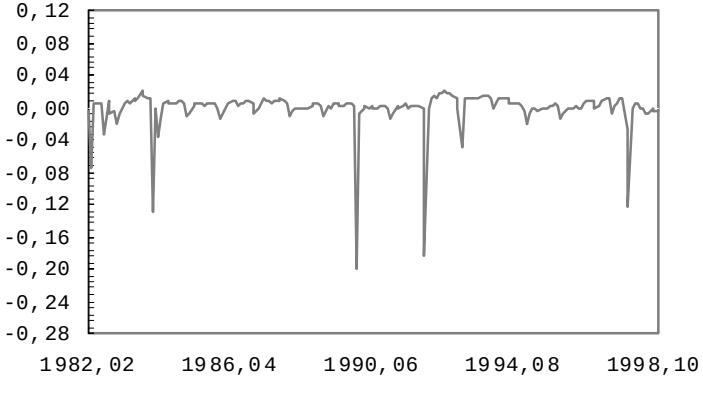
TABLE 3. *P*-VALUES OF THE LM TEST OF PARAMETERS CONSTANCY OF THE LSTR MODEL (11) (against STR-type non constancy)

	Null hypothesis					
	(1)	(2)	(3)	(4)	(5)	(6)
LM1	0.7042	0.5465	0.0000	0.0000	0.3038	0.4480
LM2	0.9570	0.4672	$3*10^{-6}$	$3*10^{-6}$	0.6397	0.7147
LM3	0.9861	0.6464	$17*10^{-4}$	$15*10^{-4}$	0.7958	0.8302

NOTE: The parameters not under test are assumed constant also under the alternative.
(1) H_0: "All parameters of the linear part of the model except the constant are constant".
(2) H_0: "All parameters of the nonlinear part of the model except the nonlinear intercept and the dummies are constant".
(3) H_0: "All parameters of the nonlinear seasonal part of the model are constant".
(4) H_0: "All parameters of the nonlinear seasonal part of the model are constant".
(5) H_0: "All parameters of the linear seasonal part of the model without the seasonal parameter d_{12} are constant".
(6) H_0: "All parameters of the nonlinear seasonal part of the model without the seasonal parameter d_{12} are constant".

ble 3 show that the constancy is not rejected at any level of significance for the parameters in the linear and the nonlinear part of the model. However, the null can be rejected for the parameters of the seasonal dummies. This result is generated by the non constancy of the dummy corresponding to December (H_0: (5) and H_0: (6) in Table 3). The other parameters are constant over time and hence maintain our final specification of equation (11).

FIGURE 7. NONLINEAR ERROR CORRECTION



6. FINAL REMARKS

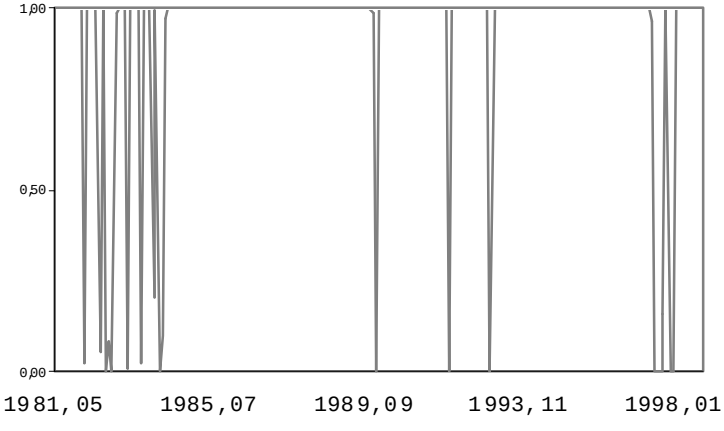
The final specification we have obtained could be analyzed as follows. There is an equilibrium long-run demand for cash in which price homogeneity has been imposed and the normalized coefficients are correctly signed. There is evidence of weak and strong exogeneity and, according to the statistics, our nonlinear model outperforms the linear error correction of equation (3).

The nonlinear dynamics works depending on the value of $(\Delta_{12} y)_{t-10}$, a result highly intuitive, not for the lag but for the variable, in the sense that agents can observe the evolution of the economic activity to decide, based on expenditure plans and precautionary anticipations a band for their holdings of real money. Nominal balances are forced by the agents to keep near to the mean of the target-bound when facing short-run deviations from it or even when the nominal balances are close to the upper and lower bounds.

The logistic STR model (11) contains a nonlinear error correction adjustment (*necm*) which we reproduce here as:

$$\Delta(m-p)_t = 1.6552 - 0.44793 ecm_{t-1} + \{-1.464 + 0.3989 ecm_{t-1}\} * [1 + exp\{-36.9871[(\Delta_{12} y)_{t-10} + 0.0535] / \sigma_{\Delta_{12}(y)}\}]^{-1}$$

FIGURE 8. TRANSITION FUNCTION OVER TIME



To analyze the local dynamics, notice that in the extreme regimes of the transition function, ($F = 0$ and $F = 1$ of Figures 8 and 9), the *necm* becomes:

$$necm_{F=0} = 1.6552 - 0.4479 ecm_{t-1}$$

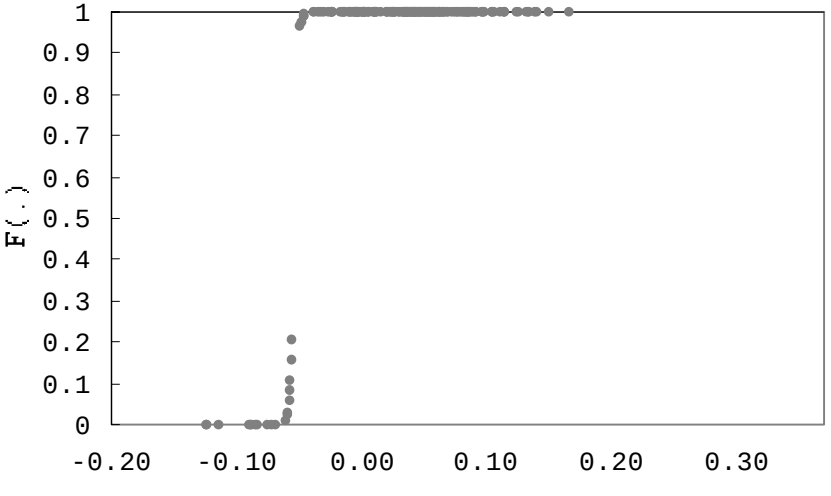
$$necm_{F=1} = (1.6552 - 1.4642) - (0.4479 - 0.3989) ecm_{t-1}$$

thus, when $(\Delta_{12} y)_{t-10}$ is close or less than the threshold value (c = -5.35%), where $F = 0$, the error correction is 9.14 [=0.4479/(0.4479-0.3989)] times the error correction when $(\Delta_{12} y)_{t-10}$ is greater than the threshold value, where $F = 1$.

These different adjustment processes towards the equilibrium are indicative of the asymmetric dynamics rendered by the logistic STR which could match the target-threshold models, in the sense that the agents adjust their holdings of real money to the desired level in different magnitudes and speeds depending on the value (and the sign) of $(\Delta_{12} y)_{t-10}$.

According to our nonlinear specification, the demand for cash in Colombia has remained, most of the time, in the upper regime given the values of the threshold and the historical value of the transition variable. Notice that, according to the value of gamma, the speed to move from regime the other is very high. Finally, the seasonal dummies of July and October tell us nothing about the demand for cash in Colombia since the corresponding linear and nonlinear parameters exactly compensates each other.

FIGURE 9. TRANSITION FUNCTION



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MONETARIA OCTUBRE-DICIEMBRE 2000

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