# Monetary policy in a dollarised economy: The case of Peru

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## The case of Peru* §

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### 1 Introduction

Persistent high inflation in Peru during the 1970s led households to hold foreign currency as store of value. This process of dollarisation increased significantly during the hyperinflation of 1988–90. In the years that followed, a wide-ranging package of reforms in the financial system and in the conduct of monetary and fiscal policy were introduced to bring a halt to the hyperinflation. But despite nearly a decade of subsequent economic stabilisation, the decrease in dollarisation has been slow: by June 1999 two thirds of domestic banking deposits were still denominated in dollars, only ten percentage points below their level in 1991.

How has dollarisation affected the efficacy of monetary policy in Peru? In theory, under dollarisation, revisions in expectations of devaluation can lead to instability of the domestic money demand, making monetary control more difficult. But instability in the demand for base money would seem to arise more from a dollarisation characterised by currency substitution (using dollars for transactions) than one characterised by asset substitution (using dollars as a store of wealth).

The second section of this paper characterises the dollarisation process in Peru. We show that agents prefer domestic currency for their current domestic transactions but hold dollars as a store of value: dollarisation reflects asset substitution. Monetary policy may still be effective in influencing nominal domestic transactions through the control of the domestic currency money supply. However, domestic open-market operations may have to be accompanied by foreign-exchange intervention and foreign currency reserve requirements. The subject of this paper is to discuss how a monetary policy that has both domestic and foreign currency dimensions has been effective in dollarised Peru.

The third section describes the recent history of monetary policy in Peru. The fourth section builds on this by using identified Vector Autoregression Regression (VAR) procedures proposed by Christiano, Eichenbaum, and Evans (1996) and Leeper, Sims, and Zha (1996). It focuses on the role of domestic and foreign components of money aggregates in

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explaining the variance of inflation. The Conclusions forms the fifth section.

## 2 Inflation and dollarisation in Peru

### *2.1 Inflation, hyperinflation, and stabilisation*

From the 1950s until 1990, the Peruvian Central Bank financed the public sector and the State Development Banks at subsidised interest rates in order to enhance the output of designated key sectors. These loan policies constituted the main source of base money creation since the 1970s (Chart 1).

The high level of default on development bank credits and the subsidised interest rates meant that the central bank provided a permanent flow of financing to these banks. Since 1985, when external debt service was suspended, the government's access to external financing was greatly reduced and its requirements from the Central Bank increased. The central bank extended subsidised credit to the development banks and implemented a fixed multiple exchange rate regime to promote exports and to subsidise 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, thus incidentally expanding base money.

This policy increased the inflation rate from an average of 9% during the 1960s to an average of 30% in the 1970s. Monetary policy was eased further after 1985, accelerating money base creation so that a hyperinflation process began in 1988.

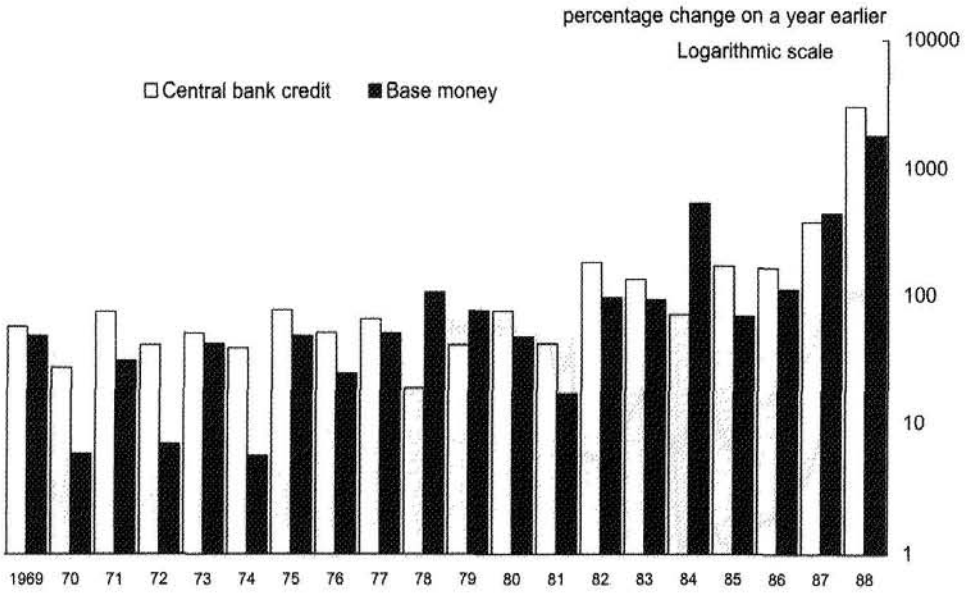



*Chart 1* Peru: Central Bank loans to state development banks and the money supply

In August 1990 the policy-induced inflationary process was arrested when a new government implemented a strict control of base-money creation through a drastic stabilisation programme. One component of the reform was the new Peruvian Constitution and Central Bank Charter, which established the autonomy of the central bank and made price stability its sole objective. The Central Bank is forbidden to:

(i) finance the public-sector (indirectly the Central Bank can buy in the secondary market up to 5% of the base money);
(ii) finance any state development bank;
(iii) grant guarantees;
(iv) lend to any particular sector of the economy; and
(v) establish a multiple exchange rates system.

The Central Bank's accountability has been oriented to guarantee its independence; the members of its board of directors may be impeached only by Congress. The transparency of monetary policy is promoted through next-day publication of central bank market operations, weekly publications of macroeconomic statistics, immediate publication of central bank policy statements and the annual publication of the Central Bank Report.

### *2.2 The dollarisation process*

Persistent high levels of inflation of the 1970s, together with underdeveloped capital markets and a repressed banking system that could not offer alternative assets, meant that US dollars became widely held.

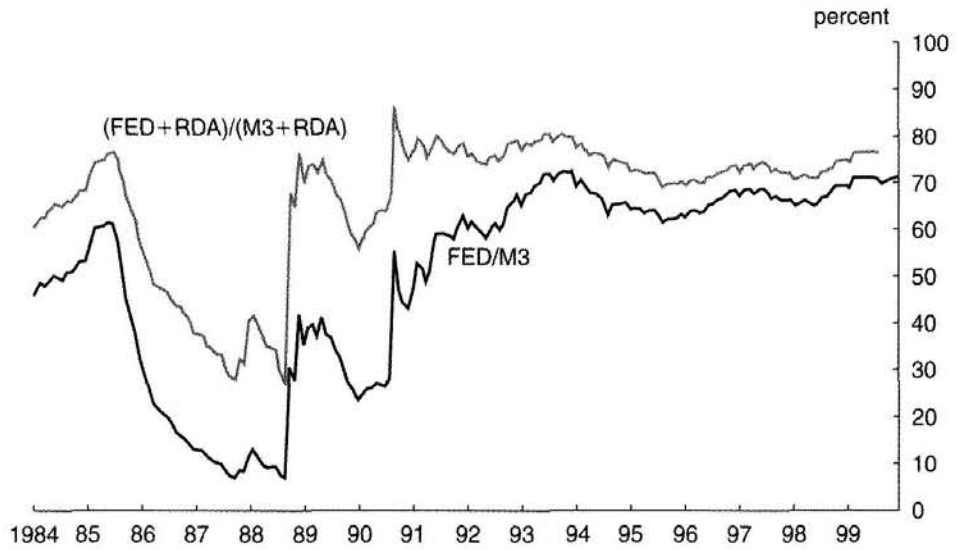



*Chart 2* Peru: dollarisation ratio, deposits

The dollarisation ratio can be defined as the ratio of foreign currency deposits in the domestic financial system (FED) plus resident deposits abroad (RDA) (using the data reported by the Bank of International Settlements) to a broad monetary aggregate[2] that includes both foreign and domestic currency deposits home and abroad, (M3 + RDA). This ratio has increased from 37% in 1981 to 65% in 1984. Chart 2 shows that since then, from 1985–8, foreign currency holdings of households in the financial system decreased substantially because the government confiscated foreign currency deposits. Evidently households that could not transfer their assets abroad to avoid confiscation substantially increased their foreign currency cash holdings, despite the opportunity costs involved (foregone interest).

The dollarisation ratio measured by foreign currency deposits in the domestic sector over M3, (FED/M3), has been growing since 1990, in spite of the stabilisation process. It now remains in the region of 65–70%. However, including non-banking sector deposits abroad as part of the private-sector foreign currency holdings and adding them also to the denominator, the new dollarisation ratio ([FED + RDA]/[M3 + RDA]) shows a slight but sustained pattern of decrease since 1991 (10% between 1991 and 1998).

Another important indicator of dollarisation 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% of total domestic lending at the end of 1990 to 80% at the end of 1997. When we include the offshore liabilities of the private sector (ACR), the share of the foreign exchange lending

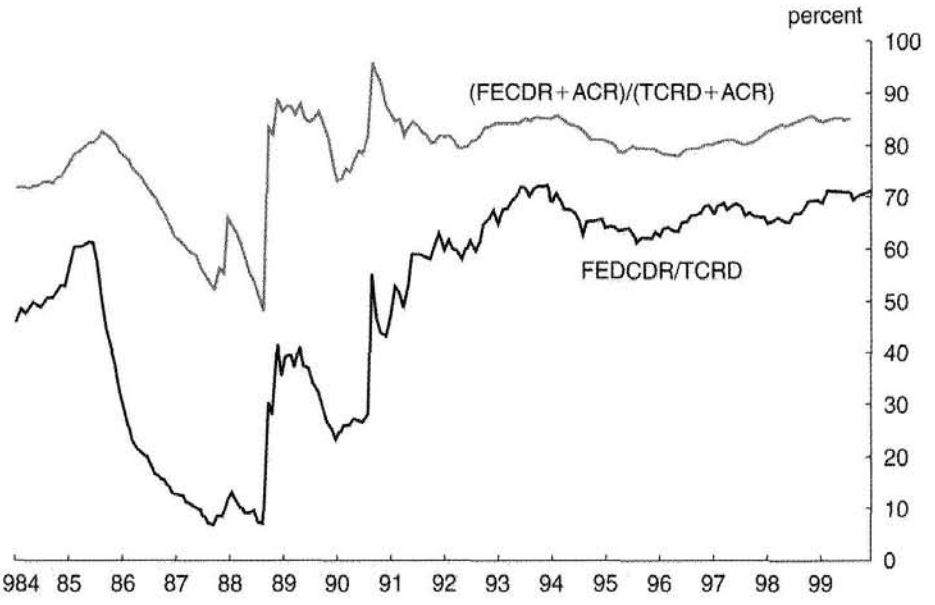



*Chart 3* Peru: dollarisation ratio, credits

([FEDCR + ACR]/[TDCR + ACR]) has slightly decreased from around 90% at the end of 1990 to 80% at the end of 1997. This confirms that process followed by the credit dollarisation is similar to deposit dollarisation.

Note also that, for both deposits and borrowing, the spread between the purely domestic rates and the ratio which includes external deposits and borrowing has narrowed substantially. For example many transfers of Peruvian private non-banking sector deposits from abroad back to the domestic financial system took place at the end of 1990 and early 1991, reflecting rising confidence in the Peruvian financial system subsequent to the stabilisation and structural reforms (including financial liberalisation). Despite this, the dollarisation ratio has fallen only modestly as inflation has fallen. There is therefore still a continuing lack of confidence in the domestic currency, due mainly to the recent history of hyperinflation.

### *2.3 Asset substitution*

It is arguable whether dollarisation need affect the conduct of monetary policy substantially. Possibly domestic-currency money demand could destabilise as a result of changes in expectations of devaluation or changes in the relative preferences of assets portfolios. However, the consensus among economists is that it is important to consider the difference between a dollarisation characterised by currency substitution and that characterised by asset substitution.

If current transactions can be paid with either domestic or foreign currency, and if the public chooses to use the latter, then the economy is said to be experiencing *currency substitution*, and the implementation of monetary policy will be more difficult. In the case of *asset substitution*, where the public choose to hold their savings balances, rather than their transactions balances, in foreign currency, monetary policy could still use intermediate targets that are closely related to current transactions and to inflation.

Peruvian economists agree that the dollarisation in Peru is of the asset substitution type rather than the currency substitution type. 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, taking into account the short-run transactions horizon of the average income and the important reduction in the annual inflation rate (to 3.7% in 1999). Domestic currency maintains its role of unit of account and means of payment, whereas foreign currency is used as store of value. In this sense the cash holdings of Peruvian households are a good indicator of current transactions and are a plausible intermediate target of monetary policy.

A useful indicator of asset substitution in the Peruvian economy is

*Table 1* Composition of bank deposits (percentages)[†]

| | *Domestic currency* | | | *Foreign currency* | | |
|---|---|---|---|---|---|---|
| | *current account* | *savings* | *time deposits* | *current account* | *savings* | *time deposits* |
| 1992 | 33.0 | 55.0 | 12.0 | 9.0 | 55.0 | 36.0 |
| 1993 | 41.0 | 44.0 | 15.0 | 13.0 | 43.0 | 45.0 |
| 1994 | 37.2 | 39.9 | 22.9 | 16.6 | 44.6 | 38.8 |
| 1995 | 33.4 | 42.3 | 24.2 | 15.2 | 40.8 | 43.9 |
| 1996 | 34.9 | 36.5 | 28.5 | 17.4 | 35.4 | 47.2 |
| 1997 | 33.4 | 34.6 | 32.0 | 17.5 | 33.8 | 48.7 |
| 1998 | 34.4 | 36.4 | 29.2 | 15.8 | 30.6 | 53.6 |
| 1999 | 33.0 | 34.1 | 33.0 | 17.1 | 29.4 | 53.6 |

[†] Source: De La Rocha. Javier (1998) and weekly statistics of the Central Bank of Peru

deposit composition (Table 1). In the banking system, domestic currency deposits are mostly checking accounts and savings deposits; foreign currency deposits are mainly savings 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. This shows that, again, while foreign currency is demanded for some transactions, its main role is as a store of value.

## 3 Monetary policy

### *3.1 Design of monetary policy*

The objective of the Central Bank of Peru is to reach international inflation levels in the medium and long term. To do so, it uses base-money growth as the intermediate target. That target is aligned with its inflation goals according to a monetary programme. The programme is reviewed monthly and monitored daily.

The monthly revision of base-money growth target is based on the analysis of indicators such as projected inflation, aggregate demand, interbank interest rates, the exchange rate, the fiscal stance, and credit to the private sector. These indicators tell the Central Bank of Peru how far the economy is from its sustainable rate of output growth, the targeted rate of inflation, and the forecast of the velocity of circulation (De la Rocha, 1998) and whether the target should be revised or defended. The base-money growth targets are not made public since technological shocks in the financial system make them subject to revision.

The daily monitoring of monetary policy is based on a careful study of the components of base money, in particular bank reserves, and some components of the banking system balance sheet, together with the evolution of the interbank interest rate, the exchange rate, and other relevant indicators. The demand side of the base money aggregate is mainly composed of the domestic cash holdings of households (75%–80%). The cash

Reserve requirements on foreign currency deposits, and the interest rate paid on these reserves, are also used as instruments to prevent the expansion of monetary aggregates denominated in foreign currency.[3] The foreign currency reserve ratio is important because Peru is subject to large capital inflows. Although 70% of these capital flows are estimated to be long term (De la Rocha, 1998, page 187), the scale of inflows is still sufficient to threaten monetary stability.

The foreign currency reserve ratio can also be a buffer against a sudden reversal of these inflows and can encourage the public to hold domestic currency. However, the ratio is not varied systematically for monetary policy purposes and remains a supplementary device. In 1993 the marginal reserve requirement for foreign currency deposits was 45%, but in October 1998 it was reduced to 35% and then to 20% in December 1998. Required reserves are remunerated at a rate of interest related to LIBOR and are computed on the basis of monthly averages. These reserves comprise cash and demand deposits at the Central Bank.

### *3.2 The role of fiscal policy*

The government's commitment to balance its budget is key to achieving inflation goals in an economy with dollarisation. That Peru's budget has been controlled can be observed from the fact that the central government raised, on average, a primary surplus of 1.4% of GDP between 1991 and 1998, with an average fiscal deficit of 1.9% of GDP during the same period (0.7% of GDP in 1998). This commitment lets the Central Bank concentrate on evaluating and avoiding other pressures over prices and revising the monetary targets, as the monetary policy indicators, including the foreign currency aggregates, reveal new information.

Another important factor in the Peruvian economy is the co-ordination of fiscal and monetary policies. The macroeconomic assumptions for the fiscal budget, especially the annual inflation targets, are set by the Ministry of Finance in co-ordination with the Central Bank. A fiscal committee meets monthly to set government expenditures, foreign-exchange purchases, and deposits. The Central Bank attends this committee.

Public-sector financial resources are kept at the Central bank as time deposits at the CD market interest rate. Also, the daily treasury cash surpluses, managed by Banco de la Nación, are deposited at the Central Bank (Choy, 1999, page 195). The revenues (in both foreign and domestic currency) from the privatisation of public enterprises must be deposited in the Central Bank at an interest rate related to LIBOR. The foreign currency needed by the public sector to service its external debts must be bought from the Central Bank to avoid unnecessary volatility in the exchange rate and the liquid assets of the banking system. These operations have to be reconciled with the price stability objective of the Central Bank. But co-ordination enabled the Central

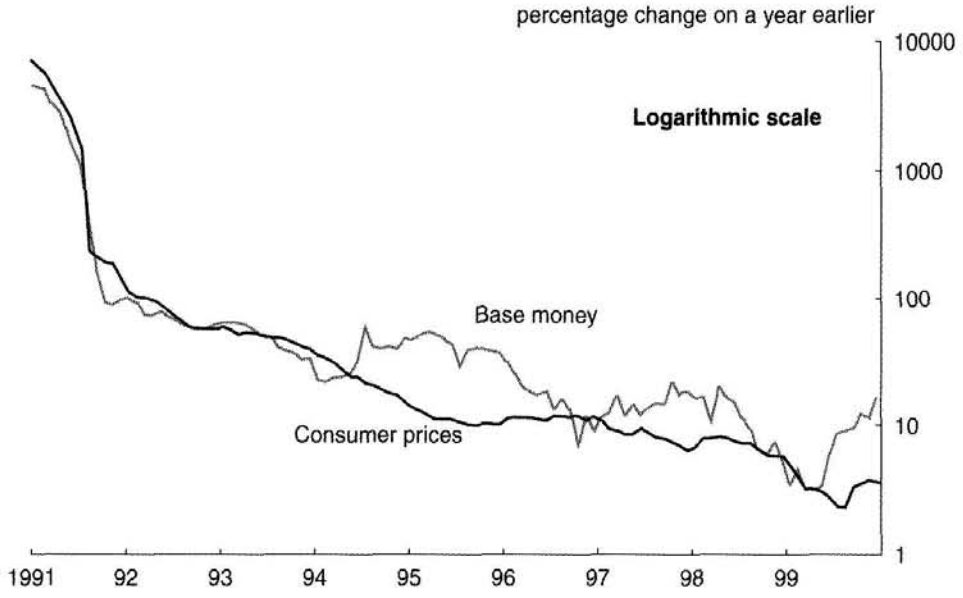



*Chart 5* Peru: prices and money supply (1991–99)

Bank to intervene and thereby inhibit excess volatility in the foreign-exchange market.

The outcome of this policy mix has been a reduction in the inflation rate: By September 1998, the annual inflation rate had come down to 6.5%.

### *3.3 The transmission of monetary policy changes*

In this paper we are interested in identifying the transmission mechanisms of the monetary policy active in reaching its main goal: the reduction of the inflation rate. The important features of the different channels of monetary policy transmission mechanisms in Peru are described by De la Rocha (1998) and summarised below.

The money channel seems to be effective in Peru because the dollarisation is not of the currency substitution type. Central Bank of Peru estimates have shown that an increase in Central Bank certificate of deposit interest rates tends to feed through to the interbank rate. This can then change longer-term market interest rates and so affect aggregate demand and inflation (De la Rocha, 1998, page 191).

It is less clear whether or not the credit channel is important in dollarised Peru. On one hand, corporations tend to rely on the banking sector for credit, and bank credit is replacing informal funds for investment finance. (It is also worth noting that many non-bank financial institutions have liabilities outside the domestic financial sector.) On the other hand, the access that firms have to foreign credit, and equity

finance (on domestic and foreign markets) is becoming ever more important.

The exchange rate would seem *a priori* to be an important means of monetary transmission in Peru. If domestic and foreign assets are highly substitutable, then interest-rate changes can lead to larger swings in exchange rates that can then feed through to domestic prices. The ability of the Central Bank to intervene systematically to control inflation through the exchange rate is, however, weakened by asset substitutability. Hence the Bank of Peru intervenes only to support its monetary targets and to smooth out fluctuations in the exchange rate

## 4 Analysis of the inflationary process using VARs

Deriving empirical facts about the transmission of monetary policy from raw data cannot be a value-free process. Any results are predicated on identifying assumptions about how the economy works and how monetary policy operates. In the rest of this paper, we will discuss what assumptions are appropriate in Peru and what inferences we can then draw.

As a suitable point of departure, we carry out pair-wise variance decomposition analysis between the inflation rate and the main monetary aggregates,[4] using quarterly data between 1982 and 1998.[5] Pair-wise variance decompositions tell us slightly more than a simple chart of the two series. They measure how much of the inflation variation is explained by each particular monetary aggregate (measured in real terms). But in order to obtain this information, we have to accept two assumptions: that a shock to the money aggregate takes at least one quarter to affect inflation and that money and inflation shocks are not correlated.

The results (reported in Table 2) clearly show that the amount of inflation explained depends on which measure of money is used. Real cash holdings and the broader aggregates M2, M3, and M3a (including residents' deposits abroad) have important explanatory power, whereas intermediate aggregates do not.

*Table 2* Pair-wise variance decompositions of 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 |
| 12 | 20.5 | 4.0 | 11.0 | 18.5 | 16.3 | 16.4 |

How much confidence can we have in these results? These bivariate results can be criticised in that:

(i) they exclude other important monetary policy variables in Peru such as foreign exchange interventions;
(ii) they ignore the relationships among the different monetary aggregates themselves;
(iii) they exclude other non-policy macroeconomic variables that are neither money aggregates nor inflation;
(iv) they do not tell us which components of these aggregates are the most important in explaining inflation;
(v) they depend on identifying assumptions that may not be valid; and
(vi) there are not enough degrees of freedom associated with the estimates.

There is a trade-off in coping with all of these criticisms. Criticisms (i) to (iv) will be dealt with in the following sections by introducing a wider set of variables in our VARs. Yet using more variables consumes more degrees of freedom and requires more identifying assumptions. In order to mitigate problems of type (v), we will try to find robust results by comparing across two different identifying schemes.

### *4.1 Approaches to identifying VARs in Peru*

In this section we will lay out what our different identifying assumptions could mean in the Peruvian context.

Following Bernanke and Mihov (1998), the underlying structure of the economy can be written as

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

$$Y_t = \sum_{i=0}^{k} B_i Y_{t-i} + \sum_{i=0}^{k} C_i P_{t-i} + A^Y v_t^Y \tag{2}$$

where the vector P represents monetary policy variables. The vector Y contains non-policy macroeconomic variables. Equation (1) are the policy-makers' reaction functions, whereas equation (2) represents the structural relationships that describe the rest of the transmission mechanism. The variables $v_t^P$ and $v_t^Y$ can be naturally interpreted as unobservable structural shocks to the policy variables and the rest of the economic structure, respectively. The system (1)–(2) needs to be identified before the parameters and structural shocks can be estimated.

1 We can assume that $v_t^P$ and $v_t^Y$ are mutually uncorrelated structural error terms. This need only mean that $v_t^P$ is defined as the vector of dis-

turbances to the policy variables that are unrelated to the rest of the economic environment. We can go further and assume that all interaction between these errors occurs through the dynamics of the system: that $A^Y$ and $A^P$ are both identity matrices. In what follows, we make this assumption.

However, additional, more controversial assumptions are necessary.

2 For example, equation (1) can be identified if in addition we assume that there is only one policy variable; and that the shocks to this variable do not affect the given macroeconomic variables within the current period (Christiano, Eichenbaum, and Evans, 1996).

The latter assumption ($C_0 = 0$) is more plausible with high-frequency data. We use monthly data on macroeconomic and financial variables (including the Central Bank of Peru's GDP estimates) that is reliably available since mid-1991. Despite that, with dollarisation, some of the banking-sector series that we could include in the VAR, such as domestic currency deposits, foreign currency deposits, and residents' deposits abroad, can respond within a month to changes in policy.

In the Peruvian case, we cannot make the alternative assumption that the policy-maker does not respond to contemporaneous information: we cannot assume that $D_0 = 0$. Information from macroeconomic variables can quickly lead to monetary policy changes. For example, foreign-exchange intervention is sometimes used to smooth out exchange-rate shocks on a regular basis.

Another problem with these assumptions is that interest rates, cash in circulation, foreign exchange intervention and total reserves can all be used as policy variables in Peru. If each of these variables affect the other macroeconomic variables through different channels, including only a single policy variable in the VAR may be difficult to justify.

### *4.1.1 Recursive assumptions to identify a role for policy*

One general schema for identifying both equations (1) and (2) is to impose a recursive structure on the contemporaneous reaction of all variables to each other (Christiano, Eichenbaum, and Evans, 1996).

Table 3A describes how such a recursive ordering might work, or not work, in the Peruvian case. In terms of equations (1) and (2), Table 3A describes the matrix

$$\begin{bmatrix} B_0 & C_0 \\ D_0 & G_0 \end{bmatrix}.$$

According to Table 3A, the variables in VAR are classified into the following categories:

*Table 3A* Recursive identifying assumptions for Peru

| | GDP | CPI | NER | CDR | M0 | CASH | QUASI | FCD | RDA |
|---|---|---|---|---|---|---|---|---|---|
| GDP | $C_{11}$ | | | | | | | | |
| CPI | $C_{21}$ | $C_{22}$ | | | | | | | |
| NER | $C_{31}$ | $C_{32}$ | $C_{33}$ | | | | | | |
| CDR | $C_{41}$ | $C_{42}$ | $C_{43}$ | $C_{44}$ | X | X | | | |
| M0 | $C_{51}$ | $C_{52}$ | $C_{53}$ | $C_{54}$ | $C_{55}$ | X | | | |
| CASH | $C_{61}$ | $C_{62}$ | $C_{63}$ | $C_{64}$ | $C_{65}$ | $C_{66}$ | | | |
| QUASI | $C_{71}$ | $C_{72}$ | $C_{73}$ | $C_{74}$ | $C_{75}$ | $C_{76}$ | $C_{77}$ | X | X |
| FCD | $C_{81}$ | $C_{82}$ | $C_{83}$ | $C_{84}$ | $C_{85}$ | $C_{86}$ | $C_{87}$ | $C_{88}$ | X |
| RDA | $C_{91}$ | $C_{92}$ | $C_{93}$ | $C_{94}$ | $C_{95}$ | $C_{96}$ | $C_{97}$ | $C_{98}$ | $C_{99}$ |

*Information variables* are used as indicators by monetary policy, and therefore current shocks to these variables feed through immediately to the policy variable. But because these indicators are assumed to be more costly to adjust than the policy variables, they react to policy shocks only after a lag of at least one month. In Peru we can assume that output (GDP), consumer prices (CPI) and, very contentiously, the exchange rate (NER) are examples of information variables. Table 3A explains that, in order to impose a recursive ordering between the variables, we can assume that the exchange rate responds immediately to shocks in all three; price responds immediately to its own shocks and shocks in GDP; and GDP only responds immediately to its own shocks.

*Policy variables* immediately reflect the monetary policy stance but only respond to the current shocks in information variables. Short-term money-market interest rates, such as the Central Bank Certificate of Deposits rate (CDR), cash (CASH), and money base (M0) are all likely contenders for this designation in Peru.

*Banking-sector or money-market variables* can respond immediately to all shocks, including policy shocks. Examples for Peru could be domestic currency quasi-money (QUASI), dollar deposits (FCD), and resident deposits abroad (RDA).

We need to make further assumptions about the contemporaneous relationships among the policy variables and among the money market variables. One possibility is to blank out the crosses in Table 3A so as to preserve the recursive structure of our identifying assumptions.

### *4.1.2 A non-recursive approach to identifying policy*

An alternative approach (Leeper, Sims, and Zha, 1996) would be to find enough restrictions on the contemporaneous reactions of variables to each other in Peru without necessarily invoking a recursive ordering.

Table 3B is the adaptation for Peru of this non-recursive VAR identification:

*Table 3B* Non-recursive identifying assumptions for Peru

| | GDP | CPI | NER | CDR | M0 | CASH | QUASI | FCD | RDA |
|---|---|---|---|---|---|---|---|---|---|
| GDP | $C_{11}$ | | | | | | | | |
| CPI | $C_{21}$ | $C_{22}$ | | | | | | | |
| NER | $C_{31}$ | $C_{32}$ | $C_{33}$ | $C_{34}$ | $C_{35}$ | $C_{36}$ | $C_{37}$ | $C_{38}$ | $C_{39}$ |
| CDR | | | | $C_{44}$ | $C_{45}$ | | | | |
| M0 | $C_{51}$ | $C_{52}$ | $C_{53}$ | $C_{54}$ | $C_{55}$ | $C_{56}$ | $C_{57}$ | $C_{58}$ | $C_{59}$ |
| CASH | $C_{61}$ | $C_{62}$ | ? | $C_{64}$ | $C_{65}$ | $C_{66}$ | $C_{67}$ | $C_{68}$ | $C_{69}$ |
| QUASI | | $C_{72}$ | $C_{73}$ | $C_{74}$ | $C_{75}$ | $C_{76}$ | $C_{77}$ | $C_{78}$ | $C_{79}$ |
| FCD | | $C_{82}$ | $C_{83}$ | $C_{84}$ | $C_{85}$ | $C_{86}$ | $C_{87}$ | $C_{88}$ | $C_{89}$ |
| RDA | | $C_{92}$ | $C_{93}$ | $C_{94}$ | $C_{95}$ | $C_{96}$ | $C_{97}$ | $C_{98}$ | $C_{99}$ |

1 GDP and prices are still assumed to be slow to adjust to the other variables, with output unresponsive to current price movements. However, the exchange rate is now allowed to react within a quarter to shocks to any of the other variables in the system. One reason why this happens is that the Bank of Peru intervenes to reduce 'abrupt and transitory changes in the exchange rate' (De la Rocha, 1998, page 186).

2 The assumptions about the response of base money reflect the fact that it is targeted by the Central Bank of Peru. The quarter-on-quarter changes to base money will therefore depend on either temporary deviations from target or revision to this target itself. Money targets can be set and revised during the year to incorporate information from GDP, prices and the exchange rate[6] about future inflationary pressure (De la Rocha, 1998, page 186; Choy Chong, 1999 page 196), and so these variables affect base money in the same period. Interest-rate changes that are understood to represent permanent changes in velocity can also be incorporated in the base-money target.

3 Short-term interest rates (represented by the CD rate) react within a quarter to their own shocks and to shocks to base money only.

4 Money components that are used for transaction purposes (cash holdings of households) may react immediately to current shocks in GDP and prices. But whether cash holdings will be affected by contemporaneous exchange-rate disturbances could depend on how important currency substitution is. A question mark in Table 3B indicates the coefficient over which this decision has to be made.

5 Some banking-sector variables, specifically domestic currency and foreign currency deposits in Peru and residents' deposits abroad, are held primarily as stores of value. Quasi-money, foreign currency deposits, and residents' deposits abroad are therefore assumed to be unaffected by current shocks to GDP. Exchange-rate shocks can, however, quickly feed through to these variables in Peru because of asset substitution. Contemporaneous price shocks are also important, because they could indicate future nominal exchange rate changes.

As above, other restrictions may be needed to identify this system fully; that depends on how many variables are included in the VAR. With these identifications in hand, we now turn to the interpretations of some estimates for Peru.

### *4.2 Results from VAR estimations and identifications*

#### *4.2.1 A VAR with data from the hyperinflation period (recursive assumptions)*

We begin by evaluating the role of interest rates, broad and narrow money components together, in determining variations of the inflation rate for the period 1980M1 to 1998M12. An unrestricted VAR is first estimated on two lags of monthly data working with an annual rate of change of all variables except the interest rate. The structural system is identified by ordering the variables as CPI, real output, real exchange rate, real interest rate, and real values of the specific components of the broad monetary aggregate: domestic cash holdings, domestic quasi-money, dollar deposits, and residents' deposits abroad.[7] Real values are used to make the series stationary during the hyperinflation years (see Table 5 in the appendix).

Table 4 reports the variance decomposition analysis of the inflation rate. The most interesting result is that growth in cash holdings explain about 30% of the long-run variance of the inflation rate, even when other money aggregates are included.[8]

Chart 6 reports the impulse response function from this VAR. It is clear that inflationary shocks are persistent. But, after one year, shocks to the cash holdings of the households can also significantly raise the inflation rate. Another influence is the short-lived positive impact of a depreciation

*Table 4* Variance decomposition of inflation in a VAR with broad money components

| *Per cent of inflation variance explained by structural shocks to:* | *Horizon (months)* | | | | |
|---|---|---|---|---|---|
| | *0* | *5* | *10* | *15* | *24* |
| CPI* | 100 | 80 | 66 | 55 | 52 |
| GDP | 0 | 4 | 3 | 3 | 2 |
| NER−CPI + USCPI | 0 | 2 | 2 | 3 | 3 |
| CDR−CPI + CPI(−12) | 0 | 4 | 3 | 3 | 3 |
| CASH−CPI | 0 | 5 | 16 | 25 | 30 |
| QUASI−CPI | 0 | 3 | 6 | 8 | 8 |
| FCD−CPI | 0 | 0 | 0 | 0 | 0 |
| RDA−CPI | 0 | 2 | 3 | 3 | 2 |

* All variables except the real interest rate are measured as annual rates of change in the VAR. Unit root tests of the 12-month variations of the variables except the interest rate (reported in the appendix) show that they are I(0). The lag length of the VAR is chosen to be two months by the Schwarz Bayesian criteria.

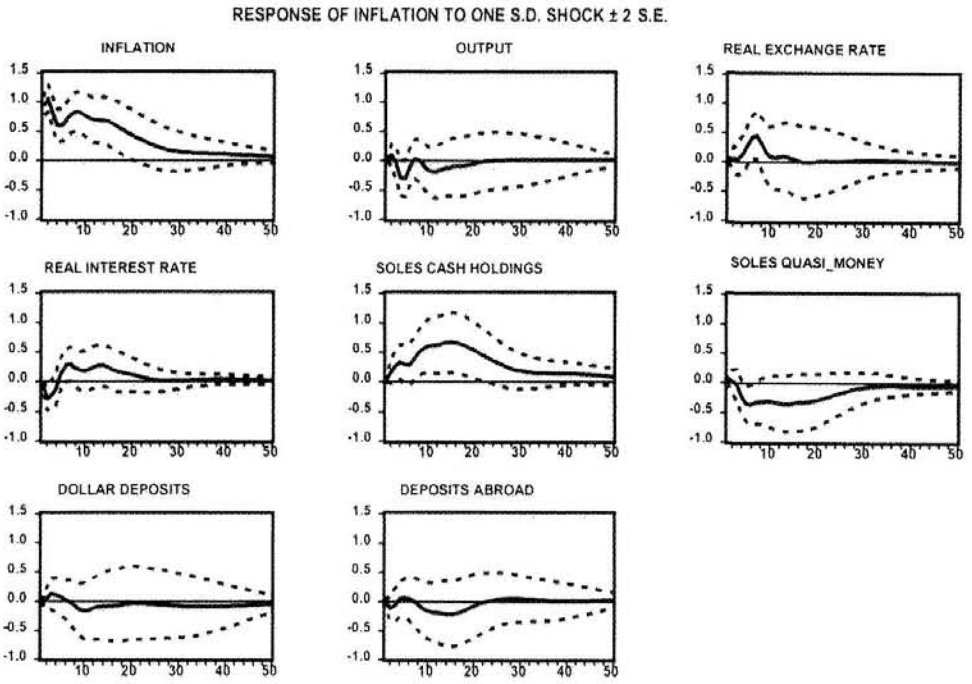



*Chart 6* Impulse response of inflation from a VAR with broad money components including the hyperinflation period

of the real exchange rate. Neither output nor real interest rate shocks have any discernible effect on the inflation rate at any horizon.

### *4.2.2 A VAR with data from the stabilisation period (recursive assumptions)*

To see if money shocks are still important for inflation, we derive estimates of impulse responses of a VAR that is estimated for post-hyperinflation data. A recursive identification of the variables according to the order CPI, GDP, NER, CDR, and M0 is used. That is as reported in the shaded block in Table 3A, with the additional restriction that the interest rate does not respond to current base-money shocks. The estimation sample is restricted to the sample mid-1991 to end-1998, and the VAR was estimated on monthly data using annual rates of change of all variables except the interest rate and by combining data in nominal and real terms.

Positive shocks to base money growth still have a significant effect on inflation. The peak of this effect is reached at its highest level in a year to year and a half. Apart from base-money growth surprises, inflation is driven by its own shocks and by shocks to the nominal exchange rate.

Other responses to a base-money shock seem plausible: a nominal exchange rate devaluation occurs almost within one month and real output falls initially, increases its rate of growth after one quarter, and returns to its original growth rate after three quarters. The interest rate initially

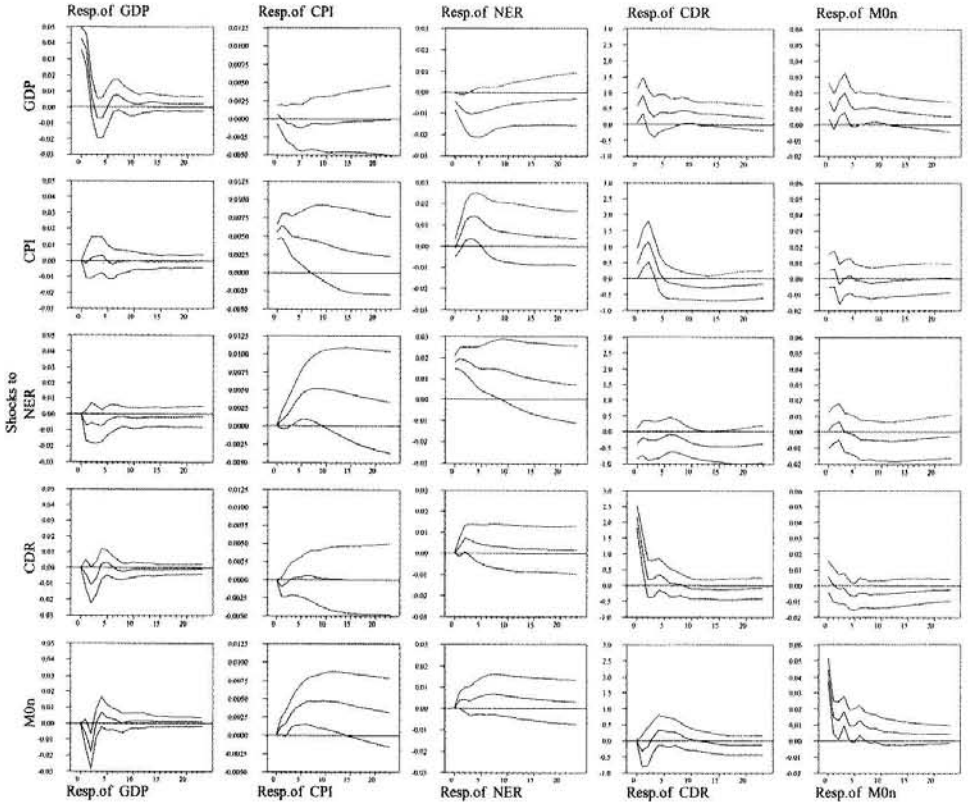



*Chart 7* Impulse responses from a VAR (recursive identification)

reduces its level and increases after two months, returning to its former level after one year.

Not all the impulse responses are as intuitive. An interest-rate rise leads to a slight exchange-rate depreciation, for example.

### *4.2.3 A VAR with data from the hyperinflation period (non-recursive assumptions)*

We can compare these impulse responses to what would be obtained from non-recursive assumptions. The same unrestricted VAR estimates are used; all that has changed is the identification scheme. The restrictions are as laid out in the shaded part of Table 3B.

The finding that a positive shock to base money significantly affects inflation after a year or a year and a half is shown to be robust. Many of the other impulse responses are similar, the main difference being that the money base now falls temporarily after a nominal exchange-rate depreciation.

As with the earlier identification, the effect of interest-rate shocks on inflation, the exchange rate, and money-base growth are among the least plausible findings. Another criticism that can be levelled at this VAR is

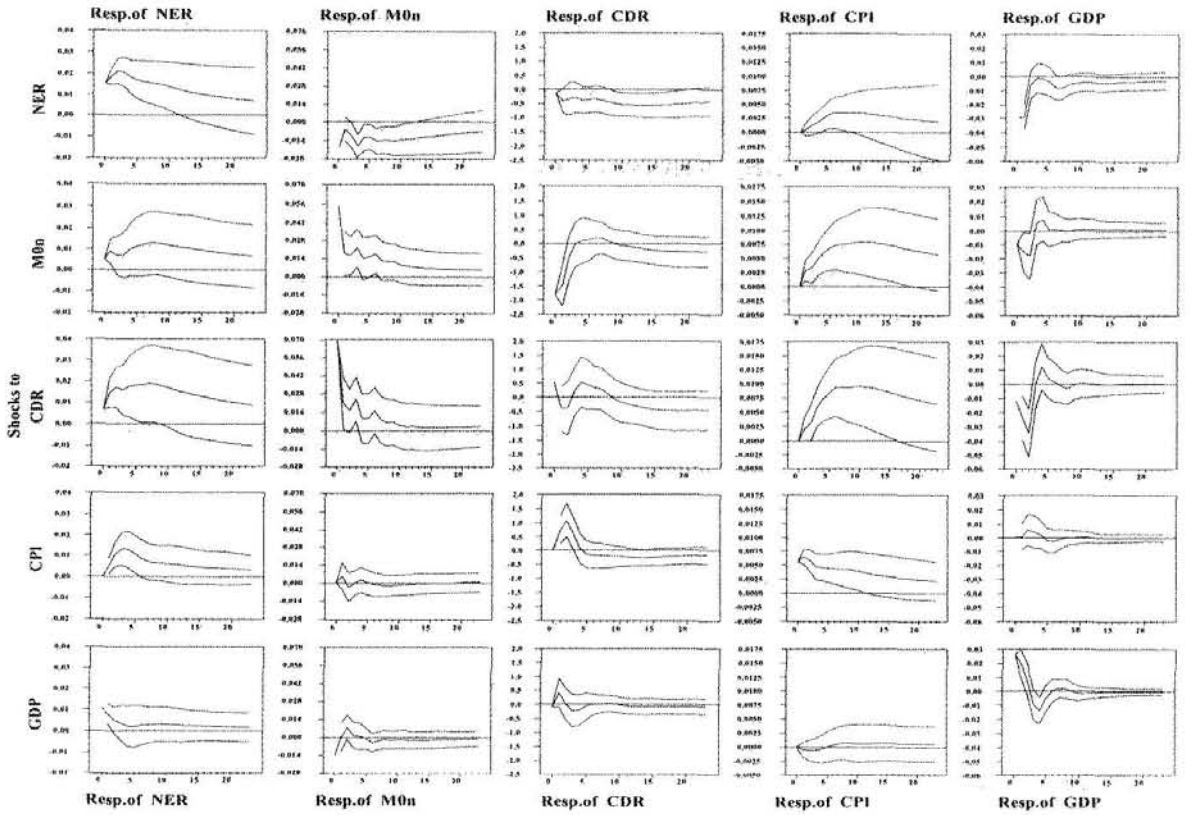
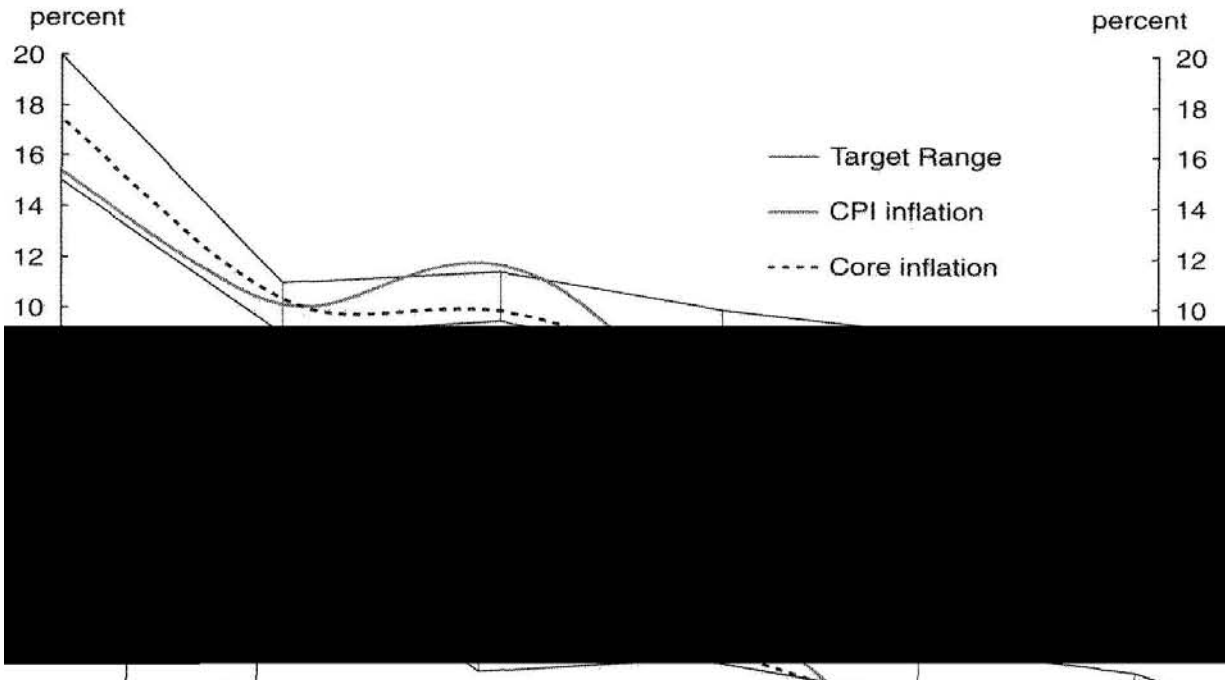



*Chart 8* Impulse responses from a VAR (non-recursive identification)



that, to correctly identify the role of policy, we should disaggregate M0 into its components – cash holdings of households, and total reserves – and also allow for a separate role for the Central Bank CD interest rate. The appendix discusses a scheme by which this could be done in Peru, following the work of Bernanke and Mihov (1998) on US Federal Reserve monetary policy.

But leaving aside these reservations, our results have at least established the robust result that M0 shocks (or possibly just shocks to its cash-holdings component) are responsible for about 30% of long-run inflationary movements.

It is important to recall that, to avoid misunderstandings about the variation of the base money, the Central Bank (in co-ordination with the central government) has been announcing a target range for the inflation rate since 1994. Chart 9 shows low levels of inflation, with only some small deviations from target. Underlying inflation exhibits better performance, although it is used only as an indicator.

In light of this, a possible interpretation of the VAR results is that money-base control has been successful in keeping the evolution of the inflation rate around its target range since 1994.

## 5 Conclusions

The dollarisation process in Peru is mainly of the asset-substitution type. Domestic currency is used for current transactions and is closely related to the inflation rate. Since cash holdings represent 75% to 80% of base money, there should not be any problem in considering base-money creation an intermediate target.

Fiscal discipline and monetary and fiscal policy co-ordination are the basic conditions enabling the Central Bank to succeed in its inflation objectives.

Shocks to the money base (predominantly domestically denominated cash holdings) explain most of the variance in inflation. Success in keeping to the inflation target could be related to this monetary strategy.

However, we should acknowledge that, to achieve its inflation target, the Central Bank of Peru has been using more than one policy variable. The results could be strengthened by accounting for these multiple instruments in identifying the causes of Peruvian inflation.

## APPENDIX

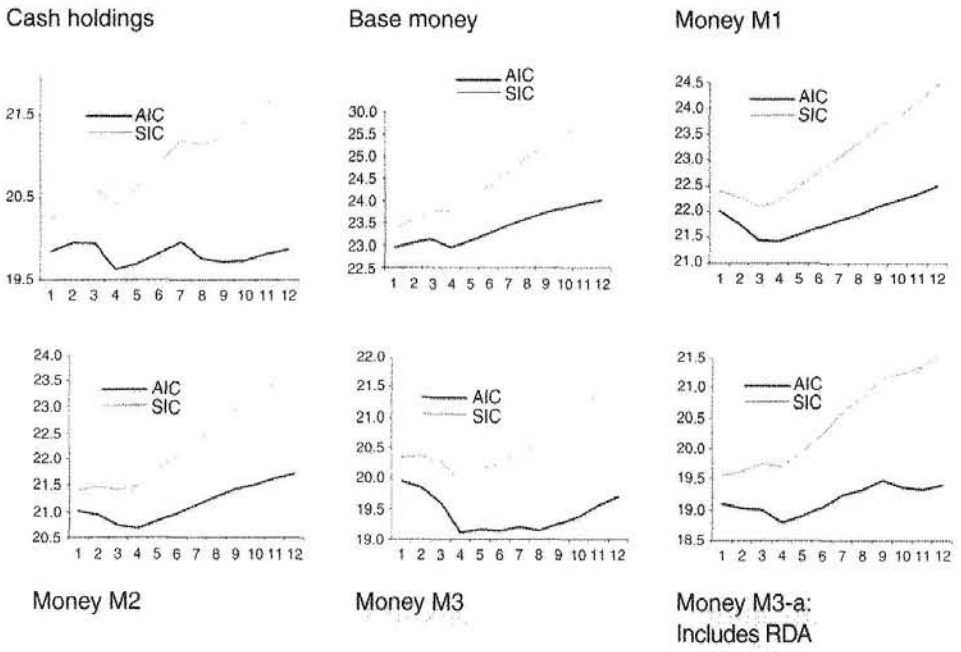



*Chart 10* Optimal Lag Identification of the Variation of Real Money Aggregates

*Table 5* Unit root tests

| *Monthly data 1991M1–98M6*<br>*Variables* | *Augmented Dickey–Fuller* | *Phillips–Perron* |
|---|---|---|
| Inflation | −7.36 | −17.53 |
| Output growth | −3.26 | −3.48 |
| Real exchange rate | −4.50 | −4.13 |
| Real interest rate | −8.78 | −2.28 |
| Growth of real cash holdings | −3.74 | −4.39 |
| Growth of real quasi-money | −3.40 | −3.46 |
| Growth of dollar deposits | −2.71 | −1.83 |
| Growth of deposits abroad | −2.62 | −1.97 |
| Growth of real base money | −2.56 | −3.08 |
| Critical values | | |
| 1% | −3.51 | −3.50 |
| 5% | −2.90 | −2.89 |
| 10% | −2.58 | −2.58 |

*Table 6* Pair-wise Granger causality tests

| *Sample: 1991M1–1998M6, Lags: 2*<br>*Null Hypothesis:* | *F-Statistic* | *Probability* |
|---|---|---|
| Growth GDP ⇒ INFL | 0.30 | 0.74 |
| INFL ⇒ Growth GDP | 6.05 | 0.00 |
| Real exchange rate ⇒ INFL | 3.06 | 0.05 |
| INFL ⇒ Real exchange Rate | 0.41 | 0.67 |
| Real Interest rate ⇒ INFL | 6.23 | 0.00 |
| INFL ⇒ Real interest rate | 12.81 | 0.00 |
| Growth cash holdings ⇒ INFL | 19.21 | 0.00 |
| INFL ⇒ Growth cash holdings | 1.32 | 0.27 |
| Growth quasi-money ⇒ INFL | 2.45 | 0.09 |
| INFL ⇒ Growth quasi-money | 0.07 | 0.93 |
| Growth dollar deposits ⇒ INFL | 10.07 | 0.00 |
| INFL ⇒ Growth dollar deposits | 14.07 | 0.00 |
| Growth deposits abroad ⇒ INFL | 0.03 | 0.97 |
| INFL ⇒ Growth deposits abroad | 0.00 | 1.00 |

## The identification of the Central Bank of Peru's operating procedure with many instruments

Bernanke and Mihov (1998) 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 uses foreign exchange market interventions as an important instrument to provide domestic currency liquidity and issues 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 base-money creation through control of the reserves market of the banking system.

In terms of equations (1) and (2) in the main text of this paper, the problem now becomes to identify the impulse responses and structural shocks when there are many policy variables in vector P and when the contemporaneous reaction matrices $A_0$, $B_0$, $C_0$, and $D_0$ cannot be restricted (as in Table 3A or Table 3B).

The observable residuals in the VAR equation with policy variables, equation (1), contain the component $u_t = (1 - G_0)^{-1}A^P v_t^P$. Bernanke and Mihov suggest that plausible restrictions can be imposed on the matrix $(1 - G_0)^{-1}A^P$, which tells us about how the unobservable policy shocks $v_t^P$ feed onto the policy variables.

In order to show how this can be implemented in Peru, an example can be provided with four policy variables: exchange-rate interventions (e), the money base (M0) and its two components separately: total reserves (TR) and cash holdings of households (CASH). We can write down the plausible set of restrictions between the observable residuals to these variables, VAR equations (the $u_t$) and the unobservable shocks (the $v_t$):

$$u_{TR} = -\alpha u_{CDR} + \beta u_e + v^D \quad \text{(A1)}$$
$$u_{CASH} = -\gamma u_{CDR} - \delta u_e + v^B \quad \text{(A2)}$$
$$u_{M0} = \varphi^D v^D + \varphi^B v^B + \varphi^e v^e + v^S \quad \text{(A3)}$$
$$u_e = \theta^D v^D + \beta^B v^B + v^e + \theta^s v^S \quad \text{(A4)}$$

Equation (A1) is the banking system total reserves demand, depends negatively on its price and the interest rate of Central Bank CDs,[9] and positively on deviations of exchange-rate devaluation. The positive relationship with the exchange rate comes from the interventions of the Central Bank in the foreign-exchange market.

Equation (A2) describes the household demand for cash holdings that are negatively related to the market interest rate (using as proxy the CD rate) and inversely related to the exchange rate. This relationship comes from the free holdings of currencies in the country.

Equation (A3) reflects the reaction function of the Central Bank to shocks in total reserves demand, to shocks in household cash-holdings demand, and to its own 'monetary policy' shocks.

Equation (A4) relates to the exchange-rate devaluations that are carried out or allowed by the Central Bank. As the exchange rate becomes a policy variable, the restrictions are analogous to equation (A3).

## Further identification assumptions

The system has 14 unknown parameters (including the four structural shocks) that have to be estimated from ten variances and co-variances. Just-identification of the system requires four more restrictions: First, we assume that $\alpha = \beta$, which means that the banking system interprets the difference between the nominal interest rate and the rate of devaluation as the cost of total reserves in domestic currency (this assumption is reliable for dollarised economies). The second assumption is that, for monetary policy to be effective in a dollarised economy, there is no currency substitution; a proxy to this assumption is to make $\delta = 0$. Consistent with this approach is to assume that the Central Bank does not react, through exchange-market interventions, to shocks to household demand for cash holdings, that is, $\theta^B = 0$. A fourth assumption comes from the separation of the reaction function of the central bank through exchange-market interventions from the reaction function through the base money creation, that is, $\varphi^e = 0$. This is a necessary assumption, since supply-side base-money creation should include (as a source) the exchange-market interventions of the Central Bank.

With these four assumptions, we can obtain a just-identified system whose estimation provides us with an indicator of monetary policy that is a weighted average of traditional indicators of monetary policy as the CD interest rate.

The solution for the just-identified model will then be:

$$\begin{bmatrix} u_{CD} \\ u_{TR} \\ u_{CASH} \\ u_E \end{bmatrix} = \begin{bmatrix} \dfrac{1-\theta^D+\alpha\theta^D}{\alpha+\gamma} & \dfrac{(1-\varphi^B)}{\alpha+\gamma} & \dfrac{\alpha}{\alpha+\gamma} & \dfrac{-(1-\theta^s)}{\alpha+\gamma} \\ -\dfrac{\alpha[1-\gamma\theta^D-\varphi^D]}{\alpha+\gamma} & -\dfrac{\alpha(1-\varphi^B)}{\alpha+\gamma} & \dfrac{\alpha\gamma}{\alpha+\gamma} & \alpha\theta^s + \dfrac{\alpha(1-\theta^s)}{\alpha+\gamma} \\ -\dfrac{\gamma[1+\alpha\theta^D-\varphi^D]}{\alpha+\gamma} & -\dfrac{\gamma[1-\varphi^B]}{\alpha+\gamma} & \dfrac{-\alpha\gamma}{\alpha+\gamma} & \dfrac{\gamma(1-\theta^s)}{\alpha+\gamma} \\ \theta^D & 0 & 1 & \theta^s \end{bmatrix} \begin{bmatrix} \nu^D \\ \nu^B \\ \nu^E \\ \nu^S \end{bmatrix}$$

Using these reactions, the impulse responses could be derived from a VAR that includes indicators of output, consumer prices, and commodity prices for example.

## Notes

*I am indebted to Lavan Mahadeva for his valuable support and excellent revision of this article.

1 The views represent those of the author and not those of the Central Bank of Peru.
2 Household holdings of domestic currency plus current account and time deposits in domestic and foreign currency in the banking system.
3 The importance of the reserve requirement on domestic currency deposits as an instrument of monetary control has diminished, and the ratio currently stands at 7%.
4 We do not have information of market interest rates and market exchange rates for the main part of this period, because of exchange controls and financial repression policies.
5 The optimal lag for these VAR estimations in real terms is 4, using both the Akaike and the Schwarz information criteria. See Chart 10 in the appendix for these results.
6 Net purchases of dollars by the Central Bank of Peru in foreign-exchange intervention are sterilised so as not to affect base money.
7 We consider the lending rate, since the other short-run interest rates, such as the overnight interest rate of the banking system, have been available only 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.
8 Table 6 in the appendix confirms that, in a pairwise Granger causality test, the growth in domestic cash holdings is found to Granger cause inflation.
9 The cost of total reserves for the banking system should be the federal funds rate. However the Peruvian banking system has reported this rate to the Central Bank only since the last quarter of 1995. Instead we use the interest rate of Central Bank CDs. The use of the CDs rate is valid because it is a market rate: the Central Bank auctions announced amounts of CDs and the bidders set the price. We have carried out estimations for a small sample that uses the federal funds rate to test the adequacy of this assumption.

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