Transmission mechanisms of monetary policy in an economy with partial dollarisation: the case of Peru[1]

Zenón Quispe Misaico, Central Reserve Bank of Peru

1. Introduction

Implementing monetary policy requires a good understanding and modelling of the monetary transmission mechanism. In the particular case of developing economies like Peru, this transmission mechanism would need to consider the degree of financial market development, price rigidities, the partial dollarisation of the economy, some possible non-linearity and the operating procedures of the central bank. It is also vital to be able to identify if shocks are transitory or permanent, nominal or real. These characteristics, together with the central bank's aversion/tendency to frequent policy changes and the structure of its loss function, will exert some influence on the monetary policymaker's reaction function.

In Peru, studies on monetary policy have shown that monetary transmission channels are not very clear. Moreover, the macroeconomic predictors and lag structures are less stable than in the case of developed economies, while economic variable series present some structural differences and are quite short-sampled and unstable.

Another important issue for monetary policy is the ability to forecast inflation in order to activate the operational procedures required to reach its main monetary stability target. However, both forecasts of inflation and the magnitude and time horizon of the central bank's reaction function depend on adequate identification of the transmission mechanisms of monetary policy. In general, understanding monetary transmission mechanisms is essential to adequate design and implementation of monetary policy. This aspect is even more important when the monetary authority announces the medium-term path of the inflation target, as in the case of the Central Reserve Bank of Peru.

Four important elements should be noted with regard to these transmission mechanisms:

- the relative importance of supply and demand shocks in explaining inflation;
- the best indicator of monetary policy stance;
- the time horizon of monetary policy's impact on inflation; and
- the magnitude of monetary policy's impact on inflation.

We are interested in identifying the transmission mechanisms of the monetary policy action in reaching its main goal: the reduction of the inflation rate. First, we intend to identify the sources of variation of the inflation rate, modelling, in a structural VAR, supply, demand and monetary shocks. The empirical evaluation of this model will give us some insights as to the policy instrument that best fits the monetary policy goals, whether influencing the aggregate demand or the supply side through the cost structure of firms. The empirical results show that the inflation process in Peru is mostly driven by demand shocks, with monetary shocks accounting for 30-40% of inflation rate variance.

The second step, identifying the best indicator of the monetary policy stance, found that different studies for Peru on this topic have shown that money aggregates are the best indicators of the monetary policy stance.

A third step in identifying the monetary transmission mechanisms is to model the operating procedures of the central bank, principally its interactions with the banking system through the money market, considering the partial dollarisation of the economy. The empirical results of these structural VAR

[1] This paper represents the views and analysis of the author and not those of the Central Reserve Bank of Peru.

procedures give some indication of the time horizon and the magnitude of the impact of monetary policy on its final target: the inflation rate. In this case, the estimations conclude that the time horizon of monetary policy transmission is between eight and 16 months. This result is consistent with a small open economy with partial dollarisation such as Peru. Another finding is that every 10 additional percentage points of variation in base money generate an additional 3.8% of inflation. A 10% depreciation of the exchange rate generates 1.2% of additional inflation.

A fourth interesting topic on monetary transmission mechanisms is the identification of the different transmission channels. We concentrate our attention on the money and credit channels considering the coexistence of currency denominations of banking sector credit to the private sector. The empirical results show that the money channel seems to be effective in Peru. There is no clear evidence of the effectiveness of the credit channel.

2. What drives the inflation rate: supply or demand shocks?

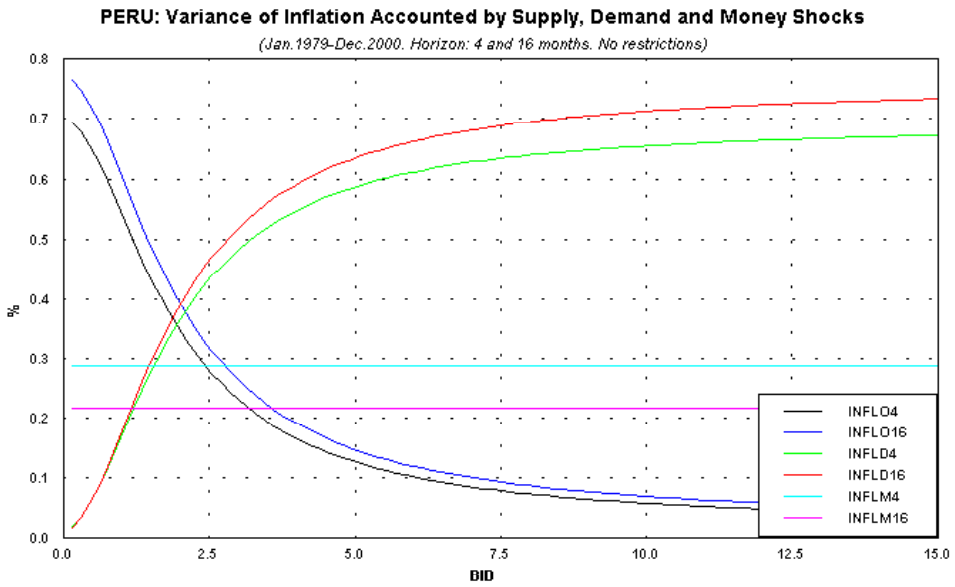
A first step in designing monetary policy is to diagnose the sources of inflation. In this section, we address the question of whether supply or demand shocks explain most of the inflation in Peru and the explanatory importance of money in demand shocks. We use the procedures developed by Machado et al back in 1994 to explain the postwar US inflation process, based on the VAR models used by Davis and Haltiwanger (1994) and the decomposition of shocks used in Blanchard and Quah (1989). The appendix describes the model identification and procedures of Machado et al (op cit).

With a classical GDP-prices-money structural VAR,[2] and considering that positive supply shocks increase output and reduce the price level while positive demand shocks increase both output and prices, we carried out some estimations using alternately base money and household cash holdings as monetary indicators. With monthly data from 1979-2000 we found that monetary shocks explain a significant part (between 22 and 30%) of the variance of inflation (see Graph 1). Demand shocks account for more than 60% over short (four-month) and long (16-month) horizons. Supply shocks seem to be of no relevance here. If we consider household cash holdings as the indicator of monetary policy, money shocks account for a more important portion of inflation (between 30 and 35%). This is consistent with the transactional role of household cash holdings which, consistent with many theoretical views, are the best indicator of aggregate demand in the economy (Graph 2). In sum, demand shocks explain more than 50% of the variance of inflation for short and long horizons, and money shocks explain inflation in a range of 30-40%. The evaluation of a smaller and more recent sample (considering important changes in monetary policy due to the stabilisation process and the structural reforms implemented since August 1990), from 1992-2000, produced no significant change in the results.

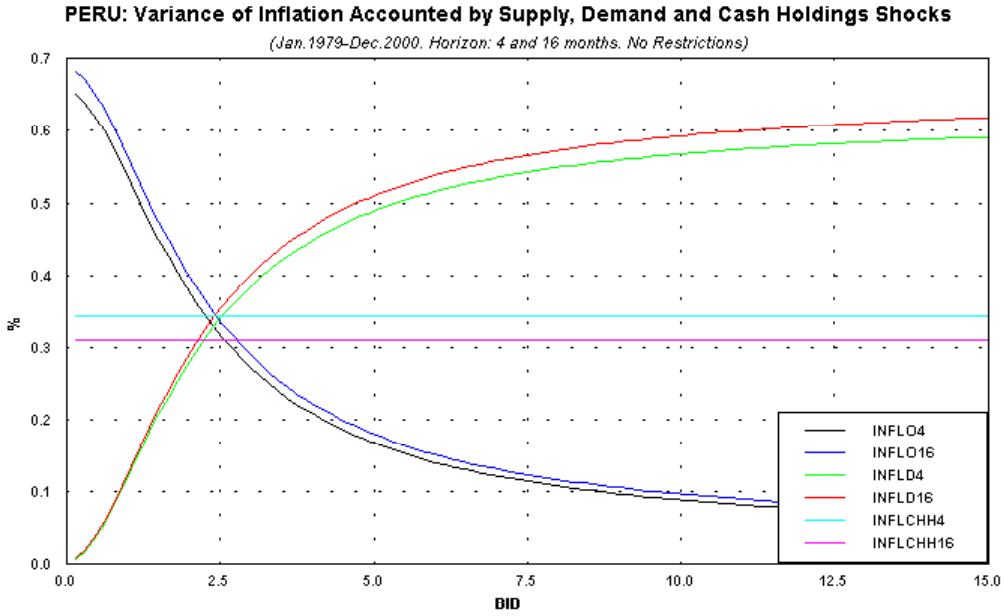
There was no clear conclusion about the relative importance of each shock in explaining GDP growth. We may argue that there are no important demand impacts on GDP growth, such that monetary policy is more effective when dealing with inflation.

[2] For the optimum lag structure of the variables and the Unit Root tests, we used the same procedures as Quispe (2000). The Akaike and Schwarz criteria result in a three-month optimal lag, and the augmented Dickey-Fuller and Phillips-Perron tests show stationarity of the economic variables in first differences.

Graph 1

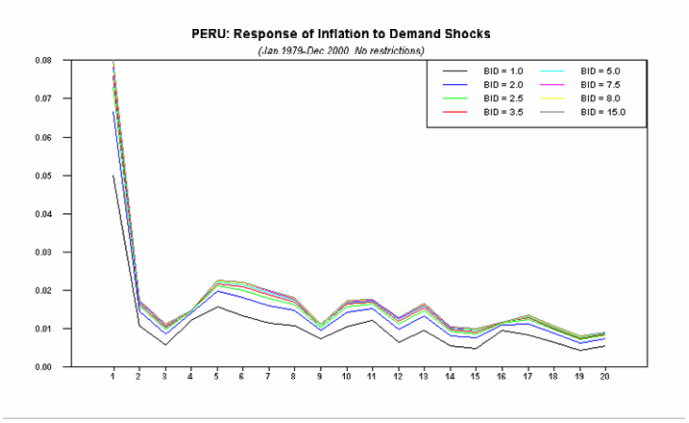


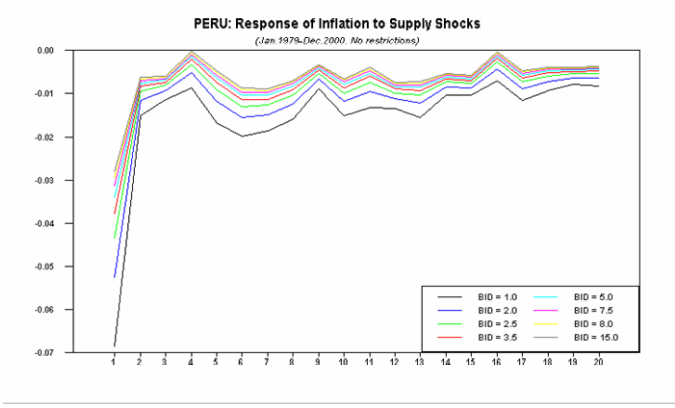
Graph 2



The impulse responses show a clear impact of demand shocks on inflation even with the identification uncertainty stated by the Machado et al model (Graph 3). The supply shocks explain inflation with the right negative sign but with less power than demand shocks.

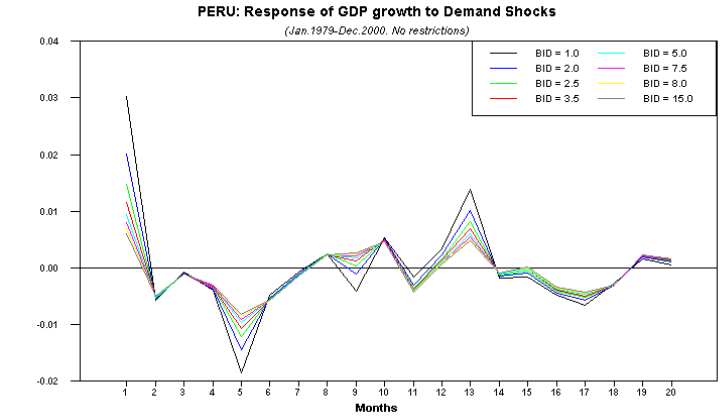
Graph 3



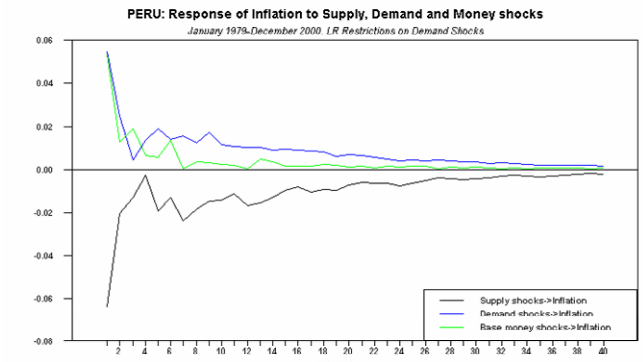


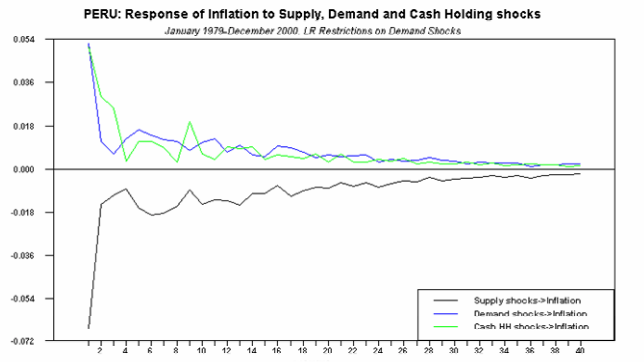
There is no clear conclusion about the relative importance of each shock in explaining GDP growth (Graph 4). This confirms our earlier finding that monetary policy is more effective in dealing with inflation. It also implies that there is no long-run effect of demand shocks on output growth.

Graph 4



Graph 5





The exactly identified model with the imposition of the long-run restriction gives no changes in the main results (Graph 5). Supply, demand and money shocks (base money or cash holdings) explain inflation with the expected sign as it is in the IS-LM framework.

3. Indicators of monetary policy stance

The previous section shows evidence that the inflation process in Peru has been driven by demand shocks, with monetary shocks accounting for a range of 30-40% inflation rate variance. Moreover, in identifying the best indicator of monetary policy stance, different studies have shown that money aggregates are the best such indicators in Peru.

Berg and Borenzstein (2000), using a sample of 82 quarters (from 1975 Q3 to 1995 Q4), found that narrow aggregates (base money and currency in circulation) best explain the inflation rate in Peru. However, given the structural breaks in price equations with all monetary aggregates in 1990, when Peru stabilised inflation and changed its exchange rate regime, they also made estimations with a smaller sample of 20 quarters (from 1991 Q1 to 1995 Q4) and found some evidence that broad money (including domestic and foreign currency deposits) could be the best predictor of inflation. In this last result, there is the possibility of a small sample bias due to low degrees of freedom.

Using a larger and monthly data sample (from 1991 M1 to 2000 M6), and considering end of period and monthly average data, Quispe (2000) found that narrow monetary aggregates are still the best predictors of inflation in Peru. These results are consistent with the asset substitution characteristic of the dollarisation process in Peru.

As seen in the previous section, money still has a significant impact on inflation. In addition, since 1995, different studies on monetary policy in Peru have shown that monetary aggregates seem to be the best indicators of monetary policy stance. The following table gives an overview of these studies.

Studies on monetary policy in Peru

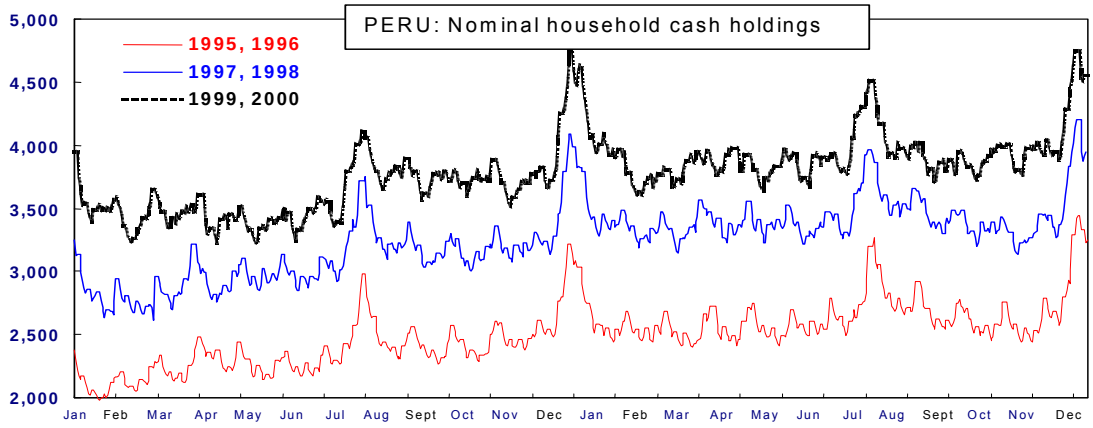
Researcher	Indicator of money	Time	Shocks impact - CD rates
Luque and Perea (1995)	Base money		
Ishisaka and Quispe (1995)	Reserves, current account balances in CB, CB CD interest rate	6-14 months	1.5%
Bringas and Tuesta (1997)	Excess reserves	3-12 months	
León (1999)	Cash holdings of households	4-14 months	
Barrera (2000)	CB CDs interest rate	8-12 months	2.0%
Grippa and Ferreyros (2000)	Cash holdings of households	9-12 months	
Quispe (2000)	Base money and cash holdings	8-16 months	

One explanation for the results of these studies is that the demand side of base money is mainly composed of household cash holdings (80%), which have a close relationship with current transactions in the economy. For current transactions, Peruvian households mainly use domestic currency.

Another aspect of these findings is connected to the time horizon of the transmission mechanism. This horizon has been expanding so that there is a more lagged impact of monetary policy on inflation, as the economy evolves over time and works in a more stable macroeconomic scenario. Is this a sign of higher credibility of monetary policy and of the commitment of the central bank to its inflation target? This evidence may suggest so.

As evidence of the transactional role of household cash holdings, the daily figures of this monetary variable follow a predictable pattern, reflecting the fact that the households are telling us: “I hold the money that I currently need for transactions” (Graph 6).

Graph 6



4. Monetary transmissions and the operating procedures of the central bank

With regard to the main channels in the monetary transmission mechanism in Peru, we summarise below important facts described by De la Rocha (1998).

The money channel seems to be effective in Peru because dollarisation is not of the currency substitution type. Central Reserve Bank of Peru estimates have shown that an increase in central bank CD interest rates tends to feed through to the banking overnight interest rate. This can then change longer-term market interest rates and so affect aggregate demand and inflation.

It is less clear whether the credit channel is important in a dollarised economy such as Peru. On the 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 of domestic firms to foreign credit and equity financing (on domestic and foreign markets) is becoming more important.

The exchange rate would seem a priori to be an important channel of monetary transmission in Peru. If domestic and foreign assets are highly substitutable, interest rate changes can lead to large foreign exchange swings and then feed into domestic prices. The ability of the central bank to intervene systematically to control inflation through the exchange rate is weak due to the asset substitution. These facts constrain the intervention of the central bank in the exchange market to only supporting its monetary targets and smoothing out large fluctuations in the exchange rate.

In Section 5, we try to identify the credit channel of monetary transmission considering that in the Peruvian case there is a banking credit dependence of small and medium-sized firms, and a very limited participation of large corporations in the incipient Peruvian capital markets. In theory, in this context the credit (lending) channel of monetary policy would be fully active. However, the central bank's ability to reduce the credit supply of the commercial banks through the reduction of domestic currency financial funds of the banking system is limited due to the existence of alternative external sources of funding, neutralising the possible impacts of monetary policy on domestic credit to the private sector.

Just by looking at the credit series it is not possible to identify which part of the credit variations represents changes in the supply of funds (associated with the credit or lending channel) and which part is accounted for by changes in the demand for credit (mainly associated with the money channel).

However, through a structural VAR procedure it is possible to model the fact that with demand shocks, we can expect positive variations in both domestic currency credit and foreign currency credit in the domestic market. If there is a negative supply shock in the credit market, we can expect a negative reaction of domestic currency credit and a positive reaction of foreign currency credit considering the

substitution of flow-of-funds capacity of the banking system. With these identifying assumptions, we decompose the variance of the change in domestic currency and foreign currency credit.

In this way, we can identify what percentage of variation in domestic credit is due to supply and demand shocks respectively. With monthly data from 1979-2000, the variance in domestic currency credit due to supply shocks is 20%, while the variance in foreign currency credit due to supply shocks is more than 90%. The variance in domestic credit explained by demand shocks represents around 80%, while the variance in foreign currency credit explained by demand shocks is almost zero. It is clear that 80% of the variation in domestic currency credit resulted from monetary transmission through the money channel.

In conclusion, it seems clear that the ability of the banking system to use substitute funding neutralises the credit channel of monetary transmission in Peru.

4.1 Transmission mechanisms of monetary policy

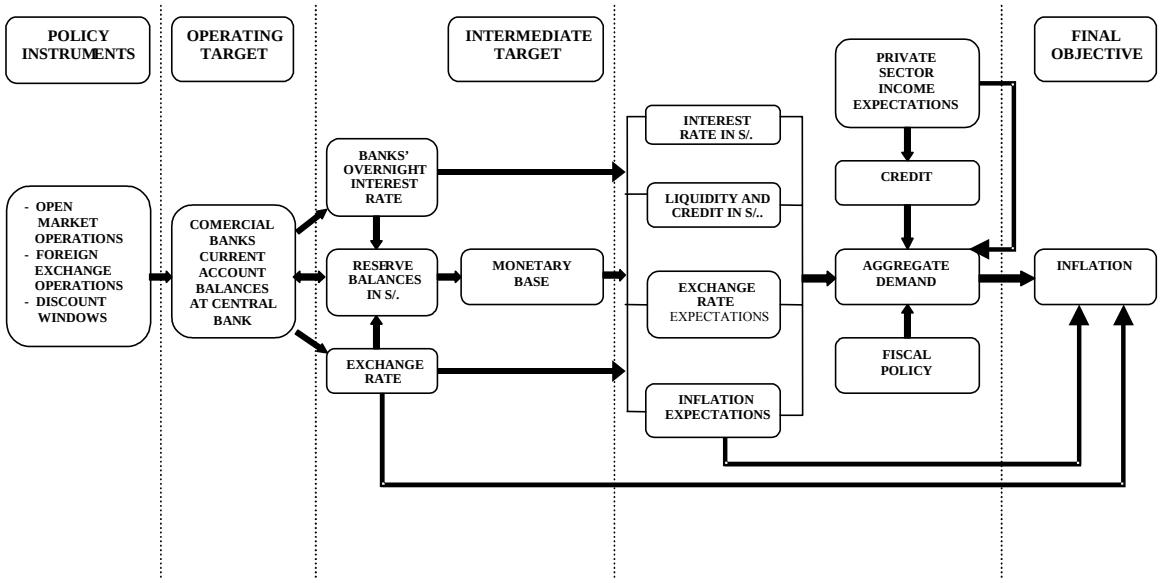
In attaining its main goal, the central bank announces the medium-term pattern of its inflation target and manages its policy instruments (open market operations, exchange market operations and discount window credits) in order to control the commercial bank current account balances maintained at the central bank (operational target).

The daily control of the commercial banks' average balances at the central bank, through management of the policy instruments and interaction with the financial system, induces the desired pattern of base money growth (intermediate target).

The strategy of the central bank rests on the close and stable relationship of base money growth with the inflation target. The evolution of base money growth gives an early warning about the stance of monetary policy and, through its impact on market interest rates, broad money aggregates, banking system credits to the private sector and expectations, influences aggregate demand and inflation.

The time horizon of these monetary transmission mechanisms is between eight and 16 months.

Transmission mechanisms of monetary policy



In the diagram it is clear that through the management of its policy instruments the central bank affects the liquidity position of banks and, subsequently, their current account balances maintained at the central bank. The change in the availability of funds in the money market causes changes in the overnight interest rate and the market exchange rate which, in turn, determine the banking system demand for reserves.

These central bank operating procedures lead to the desired target of base money growth. In turn, the base money, the overnight rate and the exchange rate affect longer-term lending interest rates and other variables such as inflation and depreciation expectations, the broad money aggregate in domestic currency, and private sector credit. This group of variables influences the spending decisions of the public, affecting aggregate demand. In particular, these variables influence the spending on consumer goods that comprise the CPI basket of goods and services. The variation of this index is the inflation definition used to specify the final targets. Finally, aggregate demand affects inflation.

4.2 Modelling the operating procedures of the central bank

As presented in Quispe (2000) and following Bernanke and Mihov (1998), the underlying structure of the economy can be written as:

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

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

where vector P represents monetary policy variables. The vector Y contains non-policy macroeconomic variables. Equation (1) shows the policymakers' 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 identifying assumptions before the estimation of the parameters and structural shocks.

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 disturbances 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 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 et al (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 Reserve Bank of Peru's GDP estimates) that have been 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 policymaker 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 market intervention is 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 affects the other macroeconomic variables through different channels, including only a single policy variable in the VAR may be difficult to justify.

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, auctioned in open market operations, announcing the amount of the auction and letting the market determine the interest rate. These instruments regulate base money creation through control of the reserves market.

In terms of equations (1) and (2), 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.

The observable residuals in the VAR equation with policy variables, equation (1), include 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 into 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^P):

$$u_{TR} = -\alpha u_{CDR} + \beta u_e + v^D \quad (1)$$

$$u_{CASH} = -\gamma u_{CDR} - \delta u_e + v^B \quad (2)$$

$$u_{M0} = \varphi^D v^D + \varphi^B v^B + \varphi^e v^e + v^S \quad (3)$$

$$u_e = \theta^D v^D + \theta^B v^B + v^e + \theta^S v^S \quad (4)$$

Equation (1), the banking system total reserves demand, depends negatively on its price and the interest rate of central bank CDs,[3] 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 (2), household demand for cash holdings, is 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 (3), shows 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 (4) 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 (3).

4.3 Further identification assumptions

The system has 14 unknown parameters (including the four structural shocks) that have to be estimated from 10 variances and covariances. Just-identification of the system requires four more restrictions. First, we assume that α = β, 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 δ = 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 θ^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 base money creation, that is φ^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.

[3] 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 CD 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.

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

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

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

4.4 Empirical results on operating procedures of the central bank

In order to evaluate the model, we need to write the equations in the form of variations and separate the total reserves demand of the banking system into its components.

One of the characteristics of monetary policy with the use of monetary aggregates as operative or intermediate targets is the close relationship between the operative procedures of the central bank and the money market of the banking system. The following is an extension of the model presented by Quispe (2000) regarding the operating procedure of the central bank.

The demand for base money includes the household demand for cash holdings and the banking system demand for reserves, which in turn includes the demand for vault cash holdings of the banking system and the demand for commercial bank current account balances at the central bank. The central bank uses this commercial bank current account balance as its operational target. Writing in differences we have:

$$\Delta m_t^D = -a_1\Delta i_t - a_2\Delta e_t + a_3\Delta real\_gdp_t + v_t^c \quad (5)$$

$$\Delta chh_t^D = -\beta_1\Delta i_t + \beta_3\Delta real\_gdp_t + v_t^c \quad (6)$$

$$\Delta vch\_bs_t^D = \delta_1\Delta m_t + v_t^J \quad (7)$$

$$\Delta m_t^D = \Delta cabs\_bcr_t + \Delta chh_t^D + \Delta vch\_bs_t^D \quad (8)$$

$$\Delta cabs\_bcr_t = \varphi^D v_t^D + \varphi^C v_t^C + \varphi^J v_t^J + v_t^S \quad (9)$$

Equation (5) is the change in demand for base money, which depends negatively on changes in the interest rate, negatively on changes in the depreciation rate and positively on changes in real GDP.

Equation (6) describes the change in the household demand for cash holdings, which is negatively related to changes in interest rates and positively related to changes in real GDP (indicator of current transactions). We skip the relationship with changes in the depreciation rate because, as stated in earlier sections of the paper, there is asset substitution rather than money substitution in the economy, and because of the current transactional role of the cash holdings.

Equation (7) represents the variation of demand for vault cash holdings of the banking system, which is related to changes in base money demand. Commercial banks hold operative cash to meet public cash requirements. These domestic currency operative cash holdings are proportional to the deposits of the private sector (5% on average during the last three years). It is known that this money aggregate results from the product of base money and the money multiplier, δ_1 = 0.05 times the money multiplier. This characteristic enters the model as a condition:

$$\delta_1 = 0.05 mult \quad (10)$$

Equation (8) is an identity referring to the demand side components of the variation in base money, which is the sum of: variation in household cash holdings, variation in vault cash holdings of the banks, and the current account balances held by commercial banks at the central bank.

Equation (9) reflects the reaction function of the central bank through changes on the current account balances of the banking system in response to base money shocks, shocks to household cash holdings demand, shocks to the vault cash holdings of banks and to its own "monetary policy" shocks.

Other conditions are related to the reserve requirement policy of the central bank (6% of the domestic currency liabilities of banks) and the requirement to maintain one percentage point of the reserve requirement as current account balances of commercial banks held at the central bank:

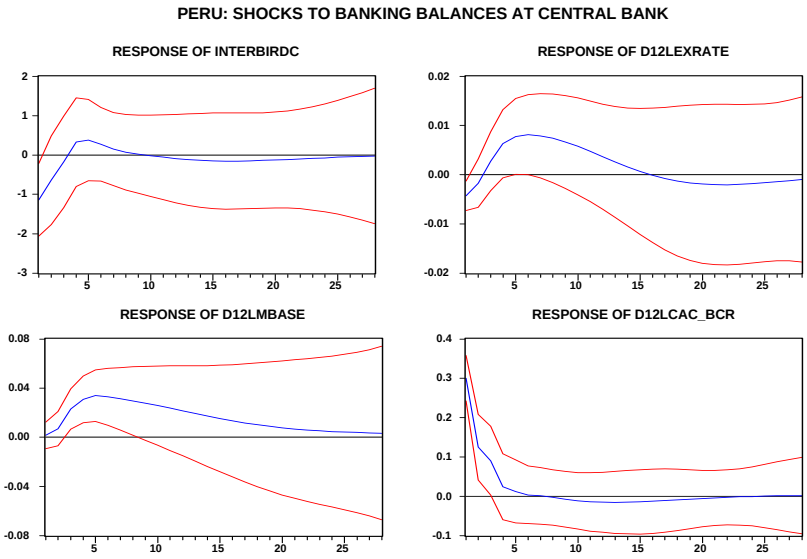
$$0.06(mult)(\Delta m_t) = \Delta vch\_bs_t + \Delta cabs\_bcr_t \quad (11)$$

$$0.01(mult)(\Delta m_t) = \Delta cabs\_bcr_t \quad (12)$$

Solving this system allows us to determine the reaction function of the central bank through its operational target, which, in turn, is translated into the intermediate target reflected in the changes in base money.

The preliminary results with a semi-structural VAR show that positive shocks to current account balances of the banking system cause an immediate negative reaction in the short-term banking rate (Graph 7). It returns to its former level after five months. Similarly, the domestic currency depreciates, reaching its highest reaction after six months and returning to its former pattern after 15 months. Finally, base money growth increases, reaching its highest reaction after three to four months, with asymptotic return to its former pattern after 24 months.

Graph 7



4.4.1 A non-recursive approach to identifying policy

To estimate the final effects on inflation we need to specify the whole system identification procedure. We use the approach presented by Leeper et al (1996), trying to find enough restrictions on the contemporaneous reactions of variables to each other in Peru without necessarily invoking a recursive ordering.

Commercial banks' current account as operational target for monetary policy

The following table is the adaptation for Peru of this non-recursive VAR identification merging the macroeconomic variables together with the operating procedures of the central bank, considering the case of using the commercial banks' current account at the central bank as operational target for monetary policy.

Non-recursive identification assumptions: commercial banks current account at the central bank as operational target for monetary policy

	CPI	GDP	BM0	CHH	VHB	VBN	NER	RBN	CAC
CPI	C_{11}								
GDP	C_{21}	C_{22}							
BM0	C_{31}	C_{32}	C_{33}				C_{37}	C_{38}	
CHH		C_{42}	C_{43}	C_{44}			?	C_{48}	
VHB			C_{53}	C_{54}	C_{55}				
VBN		C_{62}		C_{64}	C_{65}	C_{66}		C_{68}	C_{69}
NER		C_{72}	C_{73}	C_{74}		C_{76}	C_{77}		C_{79}
RBN		C_{82}			C_{85}	C_{86}	C_{87}	C_{88}	C_{89}
CAC	C_{91}	C_{92}	C_{93}	C_{94}	C_{95}	C_{96}	C_{97}	C_{98}	C_{99}

We classify the variables in the non-recursive VAR in the following categories:

Information variables are used as indicators by monetary policy; 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 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.

Policy variables immediately reflect the monetary policy stance but only respond to current shocks in information variables. Short-term money market interest rates (RBN), cash (CHH), base money (BM0) and commercial banks' current account at the central bank (CAC) are all likely contenders for this designation in Peru.

1. Output (GDP) and prices (CPI) adjust slowly to the other variables, with output unresponsive to current price movements (Graph 8). However, the exchange rate (NER) is now allowed to react within a quarter to shocks to any of the other variables in the system, with the exception of CPI, vault cash holdings of the banking system (VHB) and the overnight interest rate (RBN). One reason why this happens is that the Central Reserve Bank of Peru intervenes to reduce "abrupt and transitory changes in the exchange rate" (De la Rocha 1998, p 186).

2. The assumptions about the response of base money (BM0) reflect the fact that it is targeted by the Central Reserve Bank of Peru. The quarter-on-quarter changes to base money will therefore depend on either temporary deviations from the target or revision of the target itself. Money targets can be set and revised during the year to incorporate information about future inflationary pressure taken from GDP, prices and the exchange rate[4] (De la Rocha, (1998, p 186), Choy Chong (1999, p 196), and so these variables affect base money in the same period. Interest rate changes (RBN), understood to represent permanent changes in velocity, and exchange rates (NER) are incorporated in the base money target.

3. Short-term interest rates (represented by the overnight banking system rate, RBN) react within a quarter to CPI, GDP, vault cash holdings of the commercial banks (VHB), and vault cash holdings of Banco de la Nación (state-owned bank in charge of the management of treasury funds). Additionally, they react contemporaneously to nominal devaluations, their own shocks, and shocks to the current account of the commercial banks.

4. Money components used for transaction purposes (cash holdings of households, CHH) may react immediately to current shocks to GDP. However, whether cash holdings will be affected by contemporaneous exchange rate disturbances could depend on how important

[4] Net purchases of dollars by the Central Reserve Bank of Peru in foreign exchange intervention are sterilised so as not to affect base money.

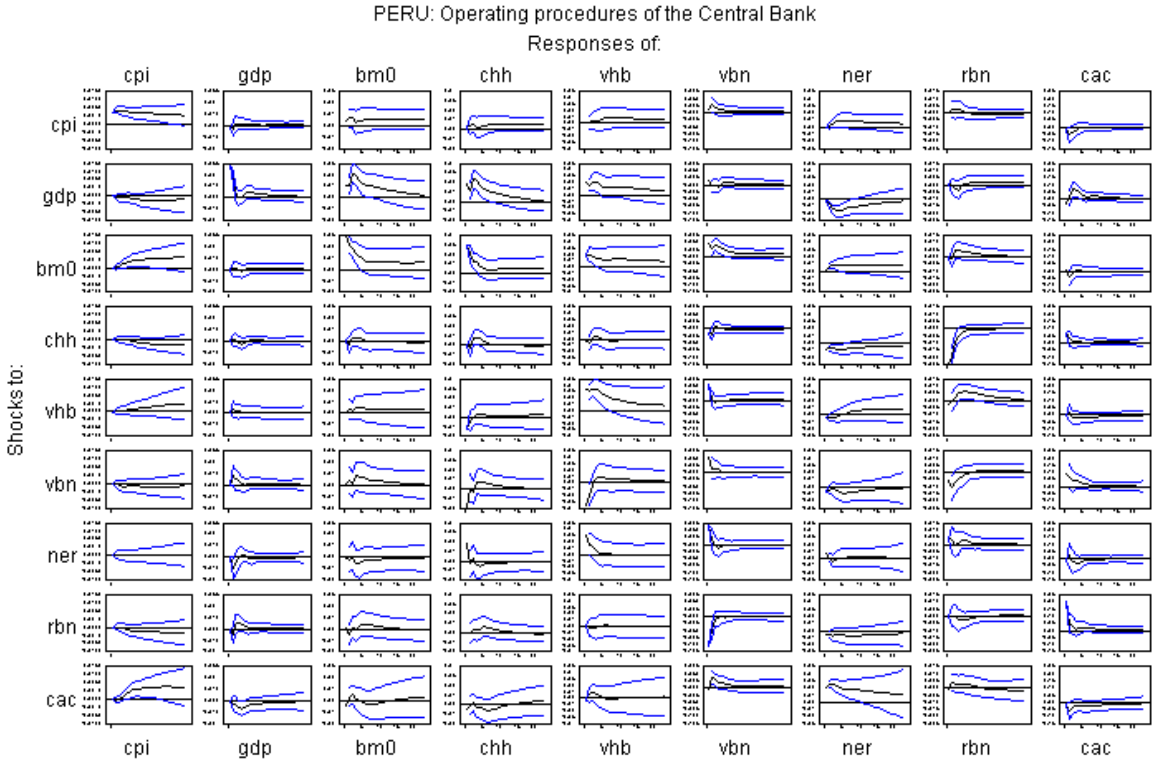
currency substitution is. A question mark in the table indicates the coefficient over which this decision has to be made. (We assume that in Peru there is no currency substitution given the empirical evidence previously stated by Quispe (2000). Of course, it depends on its own shocks and on interest rate shocks.

5. Some banking sector variables, specifically domestic currency vault cash holdings of commercial banks (VHB) and of Banco de la Nación (VBN), are held primarily for current financial transactions of the financial system. VHB is therefore assumed to be unaffected by current shocks to GDP. However, shocks to GDP have a contemporaneous impact on VBN considering that public sector current revenues are contemporaneous with GDP.

6. The operational target (CAC) reacts to all the variables. This corresponds to the approach that considers the contemporaneous relationship between the operational policy instrument and the other policy instruments, macroeconomic variables and the main target of monetary policy.

With this identification procedure, the non-recursive VAR estimates of impulse response functions for Peru (see the following graph) reflect clearly the fact that the current account performs adequately as a predictor of the inflation rate. A positive shock to the commercial banks' current account at the central bank leads to an increase in base money and in the inflation rate within a time horizon of eight to 16 months.

Graph 8



Testing the overnight interest rate as operational target for monetary policy in Peru

There is an important issue related to the relevance of monetary base targeting in a low-inflation environment. The lack of relationship between base money growth and the inflation rate, the instability of money demand, the increasing relevance of transparent monetary policy, and the increasing necessity of simple and clear communication with the population raise the importance of the interest rate as the operational target of monetary policy. Moreover, those facts are closely connected with the relevance of the interest rate as a clear signal of the stance of monetary policy related to its main objective of price stability with a stable long-run growth of output.

In that sense, we test through the non-recursive VAR estimation the performance of the overnight interest rate as if it were the operational target during the sample period. To do that we need to change some identification assumptions.

The overnight interest rate, acting in this case as the operational target for monetary policy, now reacts to all the variables, as can be seen in the following table.

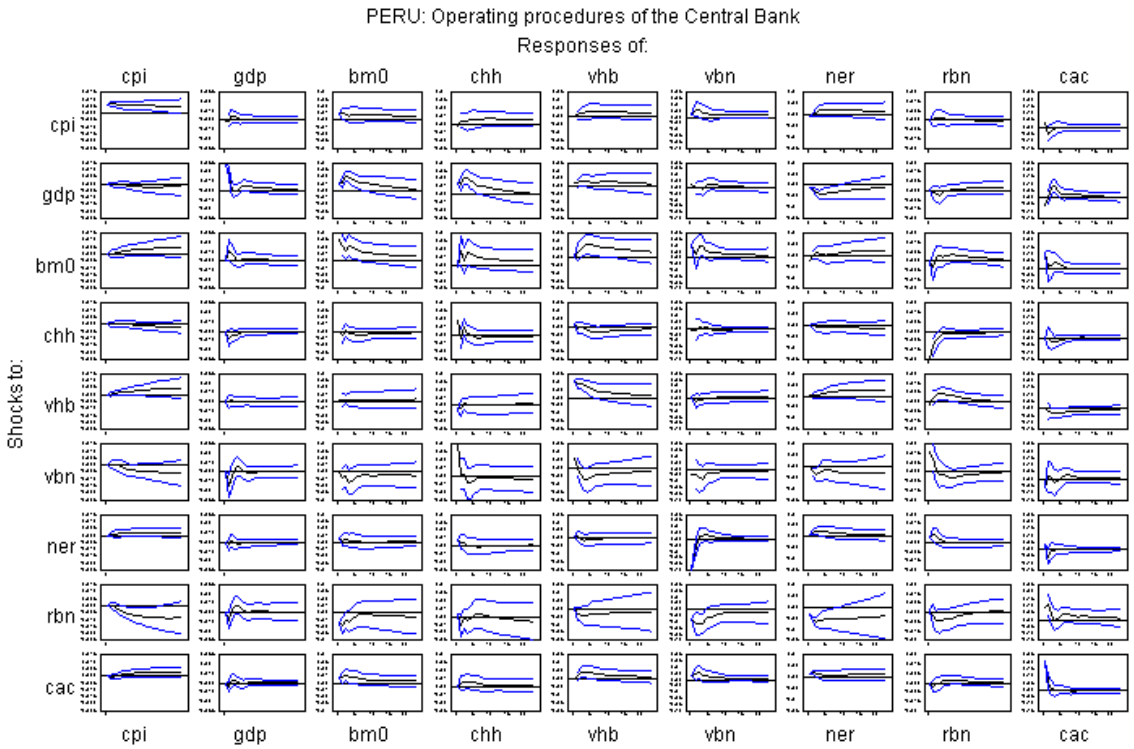
In contrast, the commercial banks' current account at the central bank, now acts mostly as an informative variable. It does not react to contemporaneous shocks on inflation, base money and cash holdings of households, maintaining its contemporaneous relationship with the other variables of the operative procedures of the central bank.

Non-recursive identification assumptions: overnight interest rates as operational target

	CPI	GDP	BM0	CHH	VHB	VBN	NER	RBN	CAC
CPI	C_{11}								
GDP	C_{21}	C_{22}							
BM0	C_{31}	C_{32}	C_{33}				C_{37}	C_{38}	
CHH		C_{42}	C_{43}	C_{44}			?	C_{48}	
VHB			C_{53}	C_{54}	C_{55}				
VBN		C_{62}		C_{64}	C_{65}	C_{66}		C_{68}	C_{69}
NER		C_{72}	C_{73}	C_{74}		C_{76}	C_{77}		C_{79}
RBN	C_{81}	C_{82}	C_{83}	C_{84}	C_{85}	C_{86}	C_{87}	C_{88}	C_{89}
CAC		C_{92}			C_{95}	C_{96}	C_{97}	C_{98}	C_{99}

We can see the estimation result of this new identification procedure in Graph 9. Here, a positive shock to the overnight interest rate of the banking system clearly generates a reduction in the inflation rate. There are theoretical arguments supporting these results: in the interbank money market the overnight interest rate is the price whose quantitative counterpart is the commercial banks' current account held at the central bank. Thus, in terms of monetary policy in Peru these findings give some support to the feasibility of using the overnight interest rate as operational target.

Graph 9

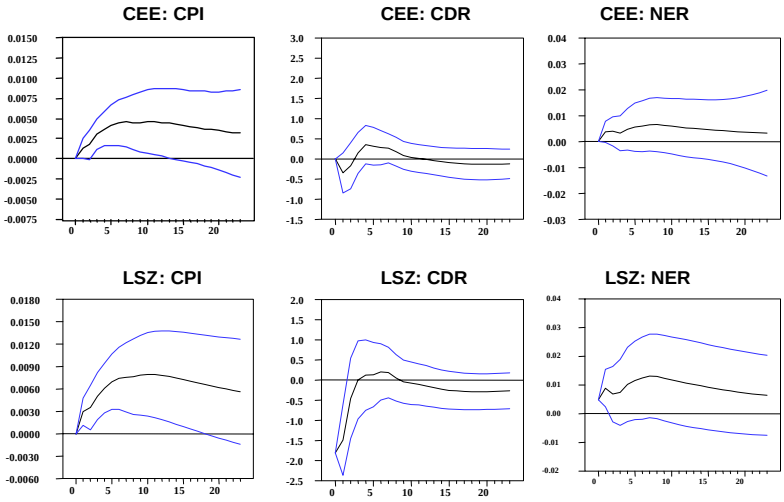


In summary, these identification procedures give a clear role to the monetary base as an instrument for reducing inflation in Peru. However, there is an important issue related to its relevance as an instrument for preserving long-run price stability in a context of low inflation.

As shown in Graph 10, using alternatively the recursive approach of Christiano, Eichenbaun and Evans (1996) - CEE, and the non-recursive approach of Leeper, Sims and Zha (1996) - LSZ; and considering the Central Bank Certificate of Deposits rate - CDR as the relevant interest rate for the operating procedures of the Central Bank, the finding that a positive shock to base money significantly affects inflation after eight months, a year or a year and a half is shown to be robust. Many of the other impulse responses are similar. Also, to confront the criticism that can be levelled at this VAR in terms of the correct identification of the role of policy, we have disaggregated M0 into its components - cash holdings of households, and total reserves (which in turn is composed of vault cash holdings of the commercial banks and the public sector bank, the current account maintained at the central bank) - and also allow for a separate role for the overnight interest rate.

Graph 10

PERU: Shocks to base money

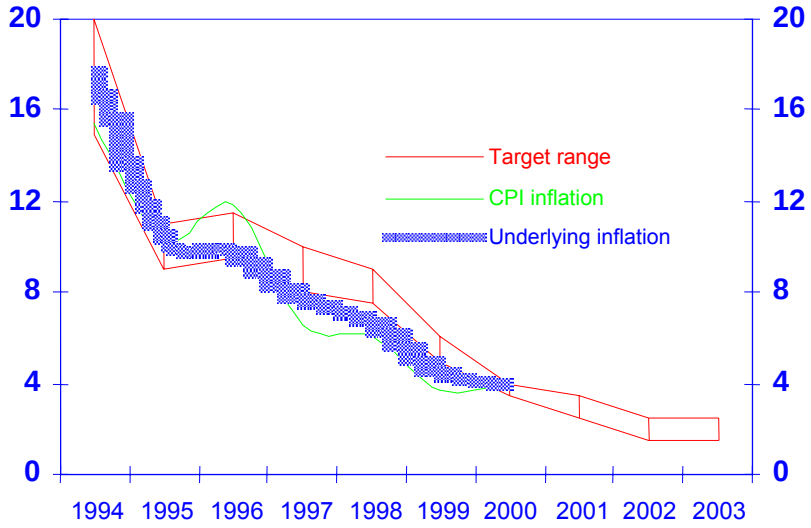


Our results have at least established the robust result that M0 shocks (or possibly just shocks to its cash holdings component) are responsible for about 30% of long-run inflationary movements.

The empirical results of these structural VAR procedures gave us some indication of the time horizon and magnitude of the impact of monetary policy on its final target: the inflation rate. In this case, the estimations conclude that the time horizon of monetary policy transmission is between eight and 16 months. This result is consistent with a small open economy with partial dollarisation such as Peru. Another finding is that every 10 additional percentage points of variation in base money generate an additional 3.8% of inflation. A 10% depreciation of the exchange rate generates 1.2% of additional inflation.

It is important to recall that, to avoid misunderstandings about the variation of base money, the central bank (in coordination with the central government) has been announcing a target range for the inflation rate since 1994. Graph 11 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.

Graph 11



In the 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. Identifying the money and credit channels of transmission

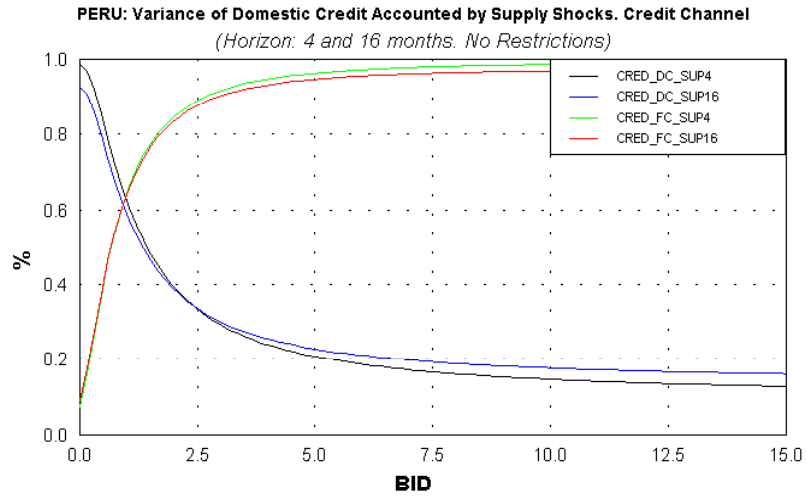
In the Peruvian case there is a banking credit dependence of the small and medium-sized firms, and even some of the big corporations still have only limited participation in the capital markets. This characteristic invites the conclusion that the credit (lending) channel of monetary policy is fully active. However, the central bank would have had only limited power to reduce the credit supply of the commercial banks, at least until 1996-97, through the reduction of the financial funds due to the existence of alternative external sources of funding for the banking system, neutralising the possible impacts of monetary policy on domestic credit to the private sector.

Just by looking at the credit series we cannot identify which part of the credit variations represents changes in the supply of funds (associated with the credit or lending channel) and which part is accounted for by changes in the demand for credit (mainly associated with the money channel).

We can indirectly identify these monetary policy channels using the supply and demand shocks structural VAR procedure. Thus if there are demand shocks, we can expect positive variations in both domestic currency credit and foreign currency credit in the domestic market. If there is a negative supply shock in the credit market, we can expect a negative reaction of domestic currency credit and a positive reaction of foreign currency credit considering the substitution of flow-of-funds capacity of the banking system. With these basic assumptions we decompose the variance of the change in domestic currency and foreign currency credit.

In this way, we can identify what percentage of variation in domestic credit is due to supply and demand shocks respectively. Graphs 12 and 13 show that during 1979-2000, the variance in domestic currency credit due to supply shocks is 20%, while the variance in foreign currency credit due to supply shocks is more than 90%.

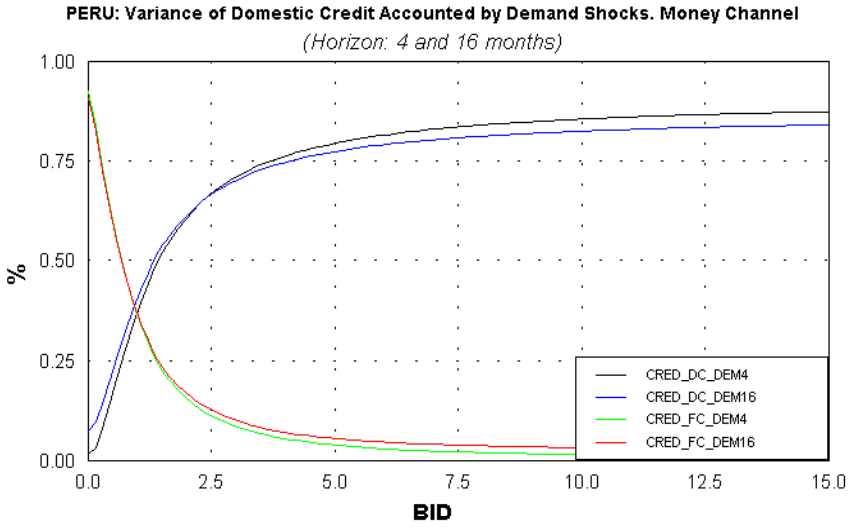
Graph 12



Furthermore, we can identify that the variance in domestic credit explained by demand shocks represents around 80%, while the variance in foreign currency credit explained by demand shocks is almost zero. It is clear that 80% of the variation in domestic currency credit resulted from monetary transmission through the money channel.

Thus it seems clear that the credit channel is neutralised by the funding substitution possibilities of the banking system.

Graph 13



6. Conclusions

The inflation process in Peru is driven by demand shocks, with monetary shocks accounting for a range of 30-40% of the variance in the inflation rate.

In identifying the best indicator of the monetary policy stance, we found that different studies for Peru on this topic have shown that money aggregates are the best indicators of the monetary policy stance.

The time horizon of monetary policy transmission is between eight and 16 months. This result is consistent with a small open economy with partial dollarisation such as Peru. Another finding is that every 10 additional percentage points of variation in base money generate an additional 3.8% of inflation. A 10% depreciation of the exchange rate generates 1.2% of additional inflation.

The empirical results show that the money channel seems to be effective in Peru. There is no clear evidence of the effectiveness of the credit channel.

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 75-80% of base money, there should not be any problem in considering base money creation an intermediate target.

The non-recursive identified model estimations reflect clearly the fact that the current account performs adequately as a predictor of the inflation rate, a sign of a good operational instrument of monetary policy. A positive shock to the commercial banks' current account at the central bank leads to an increase in base money and in the inflation rate within a time horizon of eight to 16 months.

The change in the identification procedure, preceding as if the overnight interest rate played the role of operational target for monetary policy, shows that this variable can be used as the indicator of the monetary policy stance in Peru. There is a clear negative reaction of the inflation rate against positive shocks to the commercial banks' overnight interest rate.

Appendix:
Model of supply, demand and money shocks used by Machado et al (1994)

This is a VAR model with inflation, GDP growth and money as dependent variables. In this model the innovations to the economy belong to two possible types, "supply" or "demand" shocks, and money shocks are accounted as monetary policy shocks. As in Blanchard and Quah (1989), names are given to the innovations according to the particular means of identification, since these shocks are unobserved - that is, not directly related to the left-hand side variables. These shocks completely describe the set of structural disturbances in the economy.

The model is described as follows:

$$Y_t = \begin{pmatrix} \Delta \ln P \\ \Delta \ln y \\ \Delta \ln M \end{pmatrix} = \sum_{i=1}^{8} C_i Y_{t-i} + \eta_t \qquad (1)$$

The Wold representation is $Y_t = \hat{D}(L)\eta_t$, where $\eta_t = \begin{pmatrix} \eta_p & \eta_y & \eta_m \end{pmatrix}'$.

The MA representation is $Y_t = A(L)\varepsilon_t$ where $\varepsilon_t = \begin{pmatrix} \varepsilon_{s,t} & \varepsilon_{d,t} & \varepsilon_{ms,t} \end{pmatrix}'$ is the vector of structural shocks in supply, demand and money supply respectively, and its variance-covariance matrix is given by:

$$\Sigma_\varepsilon = \begin{pmatrix} \sigma_s^2 & 0 & 0 \\ 0 & \sigma_d^2 & 0 \\ 0 & 0 & \sigma_{ms}^2 \end{pmatrix}, \quad B_0 = \begin{pmatrix} -1 & b_{id} & b_{im} \\ b_{ys} & 1 & b_{ym} \\ 0 & 0 & 1 \end{pmatrix}$$

The matrix B_0 needs to be fully identified. It is important to define a set of minimal assumptions and a long-run restriction to fully identify B_0.

Minimal assumptions

The minimal assumptions now specify the direction of the effect of an innovation in money growth on inflation and output growth. According to the standard IS-LM model, an innovation in money will increase both prices and output[5] (ie $b_{im} \geq 0$ and $b_{ym} \geq 0$). On the other hand, it is assumed that money growth is not affected contemporaneously (ie within a quarter) by either supply or demand shocks.

This set of assumptions, together with the relation $\hat{\Sigma}_\eta = B_0 \Sigma_\varepsilon B_0^T$ specifies a system of six equations and seven unknowns (four parameters in B_0 and three variances in Σ_ε). Thus, there is one degree of freedom to choose between b_{id} and b_{ys} while satisfying the relation

$$b_{ys} = \frac{-\hat{\sigma}_{im}\hat{\sigma}_{ym} + b_{id}(\hat{\sigma}_{ym})^2 + \hat{\sigma}_{iy}\hat{\sigma}_m^2 - b_{id}\hat{\sigma}_m^2\hat{\sigma}_y^2}{(\hat{\sigma}_{im})^2 - b_{id}\hat{\sigma}_{im}\hat{\sigma}_{ym} + b_{id}\hat{\sigma}_{iy}\hat{\sigma}_m^2 - \hat{\sigma}_i^2\hat{\sigma}_m^2} \qquad (2)$$

Notice that in this relation all variables but b_{id} and b_{ys} can be estimated from the VAR. Moreover, b_{im} and b_{ym} are uniquely determined and are not affected by the specification uncertainty on b_{id} and b_{ys}:

$$b_{im} = \frac{\hat{\sigma}_{im}}{\hat{\sigma}_m^2}, \quad b_{ym} = \frac{\hat{\sigma}_{ym}}{\hat{\sigma}_m^2} \qquad (3)$$

[5] See Sargent, T (1987), Chapter 2.

The minimal assumptions imply a positive relation between b_{id} and b_{ys} and therefore do not set an upper bound for these parameters. This does not pose a major problem for the results of the variance decomposition under specification uncertainty.

In this model there is a range of feasible values for b_{id}. However, this kind of uncertainty does not affect the fraction of the variance of inflation or GDP accounted for by monetary shocks, which is the same for any value of b_{id}. Again, values bigger than three do not lead to different behaviour in the decomposition of variances, so they are taken out of consideration.

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