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THE LIQUIDITY EFFECT AND THE LONG-RUN NEUTRALITY OF MONEY IN GUATEMALA

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The liquidity effect and the long-run neutrality of money in Guatemala

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Abstract

The liquidity effect (a reduction of short-term nominal interest rates following a monetary expansion engineered by a central bank) and the long-run neutrality of money (the lack of any long-run real effects in the economy after a monetary policy action performed by a country's monetary authority) are two economic issues whose theoretical validity is widely accepted by economists around the world. However, the empirical research in both topics is still producing mixed evidence. In this paper both propositions are simultaneously considered for the Guatemalan case, and the results of applying a recursive VAR with the results obtained through a SVAR model that establishes a market for central bank's open market operations are compared. In both cases the results confirm the existence of a short-run liquidity effect and the long-run neutrality of money. The SVAR results also indicate that a tight monetary policy under a flexible exchange rate system with moderate Central Bank intervention, generates an exchange rate appreciation.

I. Introduction

The liquidity effect and the long-run neutrality of money are two economic issues whose theoretical validity is widely accepted by economists around the world. However, the empirical research in both topics is still producing mixed evidence. In this paper, both propositions are reconsidered simultaneously for the Guatemalan case, and the results of applying a recursive VAR with the results obtained through a SVAR model that establishes supply and demand equations for central bank's certificates of deposit are compared. In both cases the results confirm the existence of a short-run liquidity effect and a long-run neutrality of money. The SVAR results obtained also indicate that the central bank's monetary policy has indirect and significant effects over the exchange rate.

The remaining of the paper is organized as follows. Sections II and III contain a brief literature review where the liquidity effect and the money neutrality have been tested. In Section IV it is described the methodology used to identify monetary policy shocks and the results obtained. The first part of such section describes the setup and the results from a recursive VAR model, while the second part depicts the setup of the market for central bank's open market operations as well as the results of such estimations. Finally, Section V concludes.

II. The liquidity effect

The liquidity effect refers to the reduction in the short-term nominal interest rates that follows a monetary expansion engineered by a central bank. Although this effect is described in macroeconomic textbooks as a regular event, it has fail to hold consistently in practice. Cagan and Giandolfi (1969) found evidence of a liquidity effect in the US for the period 1910-1965. In their work, interest rates reach its minimum point six months after the monetary

expansion. Nevertheless, Melvin (1983) extended their work for a longer period of time and concludes that the liquidity effect was less persistent after 1973 because economic agents adjust their inflation expectations to the new money growth rate (this is called the Fisher Effect). Fung and Gupta (1994) found evidence for a liquidity effect in Canada but just in the short run, while in the long-run they found that the anticipated inflation effect will come into force and dominate the liquidity effect as people adjust their inflation expectations to the new money growth rate. As a result, interest rates will also increase in the long-run.

According to Pagan and Robertson (1995), one of the most important reasons why some studies about the liquidity effect fail to produce the expected result, is because they consider monetary policy actions as exogenous while in fact such actions are the sum of two components: the endogenous part, captured by the feedback received by policymakers about the state of the economy (GDP growth or expected inflation, among others), and the exogenous component given by the monetary shock itself. When the endogeneity of a monetary policy action is taken into account, empirical evidence provides a stronger support for the existence of the liquidity effect.

For instance, Christiano (1996) and Christiano, Evans and Eichenbaum (1994) found support in favor of the liquidity effect after considering that the exogenous component of monetary policy can be obtained after removing the effects of current and past realizations of GDP and the price level on nonborrowed reserves. Bernanke and Mihov (1998) employed a model for the market of bank reserves that considered the endogeneity of monetary policy under a structural VAR setting, and found evidence of the liquidity effect for the US for the period 1966-1996.

III. The neutrality of money

The neutrality of money refers to the lack of any long-run real effects in the economy after a monetary policy action performed by a central bank. As in the empirical tests of the liquidity effect, economists have tried to test the neutrality of money, getting mixed results." Currently, most economists accept that monetary policy affects the real variables in the short run, but it is neutral in the long-run.

With respect to the nonneutrality of money in the short run, the most famous empirical research is the work by Friedman and Schwartz (1963) who found systematic patterns in the behavior of GDP and M2 using almost 100 years of US data, which lead them to conclude that changes in the money growth rate anticipate and produce changes in the rate of growth of GDP. Nevertheless, the same study was used by Tobin (1970) to argue that the causality might go the other way around, so that monetary policy accommodates to changes in the economic activity. King and Plosser (1984) divided the money supply into two components: inside money, the money supply component that represents banking sector liabilities, and outside money, the money supply component that represents liabilities of the Federal Reserve. They found evidence that support that inside money is more highly correlated with output movements than outside money. They interpret such result as supporting a reverse causality hypothesis under which the money supply change as an endogenous response by the banking sector to changes in the economic activity, and not as a result of monetary policy actions. Through separating monetary policy actions between endogenous and exogenous components, and applying a VAR framework, Christiano (1996) found evidence that a monetary contraction is followed by a fall in output, employment, prices, retail sales, and profits, and an increase in inventories and unemployment using quarterly US data for the period 1959-1991.

The long-run neutrality of money was tested by McCandless and Weber (1995). By examining thirty years of data from 110 countries and applying several definitions of money, they found that the correlation between inflation and the growth rate of money is very close to one, varying slightly depending on the definition of money that is used. However, this finding does not imply a causal relation from money to inflation, since the Federal Reserve might accommodate the money growth to the price change. In addition, they found that there is no correlation between the growth rate of money (or alternatively, the inflation rate) and the growth rate of output. Geweke (1986) have also found evidence of a very strong positive correlation between money and inflation. However, he did not find evidence for a long-run relationship between money and output growth. Bernanke and Mihov (1998) employed a SVAR methodology that modeled the market for banking reserves, allowing for inequality constraints in the parameter setting and hence, a higher degree of flexibility,

to test for robustness of the long-run neutrality effect of money on real variables. They found supporting evidence of long-run neutrality of money for quarterly data from 1966 to 1996.

IV. Estimation of Monetary Policy Shocks

It is argued here that monetary policy variables, P, those under Central Bank management (used to loose or to contract the money supply), are a function of feedback variables, F, those that indicate the state of the economy, which in turn respond to monetary policy shocks. The identification of the shocks will be through a standard VAR model of the form:

$$\Omega_t = A_0 + A_1\Omega_{t-1} + ... + A_k\Omega_{t-k} + \varepsilon_t \quad (1)$$

Where Ω_t is a vector of endogenous variables composed of feedback and policy variables. The A matrices are nonsingular matrices of coefficients to be estimated through the VAR model, while ε_t is a vector of individually serially uncorrelated disturbances. The value of k represents the number of lags for each variable in the model.

The econometric testing of both the liquidity effect and the long-run neutrality of money for Guatemala is based in the expression (1) which will be estimated in two steps. First, an unrestricted VAR model is computed, and then, restrictions on the innovations are established in order to estimate a SVAR that models the market for central bank's certificates of deposit. These two steps are described in separate subsections below.

A. Unrestricted VAR model

As mentioned earlier, the setup of model (1) requires two different types of endogenous variables. The first group is the *policy block P*, which contains variables that the Central Bank can control to perform monetary policy actions. The variables included in this group are total banking reserves (ENCAJE), the monetary base (BASE), the ratio of total Central Bank certificates of deposit to the monetary base (OB), and the weighted average interest rate in deposit certificates issued by the Central Bank (TPPF). All these variables are in nominal form. The latter variable consists of a weighted average of all interest rates of central bank's certificates of deposit issued at different maturity dates, where the weights are given by the total amounts invested for each kind of certificate.[b] Note that the TPPF is used in the model instead of the interest rate for deposit certificates issued by the Bank of Guatemala at 28 days of maturity (CDP28), which is the official monetary policy rate.[c] The main reason for using the TPPF instead of the CDP28 rate is that even though the Bank of Guatemala provides a signal to the markets about its monetary policy stance through modifying the CDP28's rate, it keeps doing open market operations through the emission of its own certificates of deposit at different maturity rates without necessarily modifying the CDP28's rate.[d] Hence, a weighted average interest rate of the Central Bank deposit certificates is a better indicator of monetary policy actions in Guatemala. The decision to include just narrow aggregates in the VARs was based on Christiano and Eichenbaum (1992) who argue that innovations to narrow aggregates reflect shocks to money supply, which are the shocks that this research tries to identify.

The second group is the *feedback block F*, which contains variables that the Central Bank continuously analyzes and whose behavior can determine a monetary policy action. The variables included in this group are the consumer price index (IPC), the nominal exchange rate (TC), the nominal banking rate on repurchase agreements (TIR), and real output (PIB).

All variables included in this model are in levels and not in stationary form. The decision to include the variables in this form follows from Sims (1992). It is important to remark that among the policy variables employed in the model, the TPPF was included in every VAR model estimated. However, the variables ENCAJE, BASE, and OB were included just one at a time in order to test the liquidity effect and long-run neutrality of money using different measures of monetary shocks. In other words, the VAR models tested were of the following form:

$$
\begin{bmatrix} F_{1t} \\ F_{2t} \\ F_{3t} \\ F_{4t} \\ P_{1t} \\ P_{2t} \end{bmatrix} =
\begin{bmatrix} f_1^0 \\ f_2^0 \\ f_3^0 \\ f_4^0 \\ p_1^0 \\ p_2^0 \end{bmatrix} +
\begin{bmatrix} a_{11}^1 & a_{12}^1 & a_{13}^1 & \beta_{11}^1 & \beta_{12}^1 \\ a_{21}^1 & a_{22}^1 & a_{23}^1 & \beta_{21}^1 & \beta_{22}^1 \\ a_{31}^1 & a_{32}^1 & a_{33}^1 & \beta_{31}^1 & \beta_{32}^1 \\ a_{41}^1 & a_{42}^1 & a_{43}^1 & \beta_{41}^1 & \beta_{42}^1 \\ \psi_{11}^1 & \phi_{12}^1 & \phi_{13}^1 & \gamma_{11}^1 & \gamma_{12}^1 \\ \delta_{21}^1 & \phi_{22}^1 & \phi_{23}^1 & \gamma_{21}^1 & \gamma_{22}^1 \end{bmatrix}
\begin{bmatrix} F_{1t-1} \\ F_{2t-1} \\ F_{3t-1} \\ F_{4t-1} \\ P_{1t-1} \\ P_{2t-1} \end{bmatrix} + ... +
\begin{bmatrix} a_{11}^k & a_{12}^k & a_{13}^k & \beta_{11}^k & \beta_{12}^k \\ a_{21}^k & a_{22}^k & a_{23}^k & \beta_{21}^k & \beta_{22}^k \\ a_{31}^k & a_{32}^k & a_{33}^k & \beta_{31}^k & \beta_{32}^k \\ a_{41}^k & a_{42}^k & a_{43}^k & \beta_{41}^k & \beta_{42}^k \\ \phi_{11}^k & \phi_{12}^k & \phi_{13}^k & \gamma_{11}^k & \gamma_{12}^k \\ \phi_{21}^k & \phi_{22}^k & \phi_{23}^k & \gamma_{21}^k & \gamma_{22}^k \end{bmatrix}
\begin{bmatrix} F_{1t-k} \\ F_{2t-k} \\ F_{3t-k} \\ F_{4t-k} \\ P_{1t-k} \\ P_{2t-k} \end{bmatrix} +
\begin{bmatrix} \varepsilon_{1t}^F \\ \varepsilon_{2t}^F \\ \varepsilon_{3t}^F \\ \varepsilon_{4t}^F \\ \varepsilon_{1t}^P \\ \varepsilon_{2t}^P \end{bmatrix}
$$

(2)

Where F_1, F_2, F_3, and F_4 are the set of feedback variables, P_1 and P_2 are the set of policy variables (one of them is always the TPPF rate), the αs and the βs are the coefficients corresponding to the equations for the feedback variables, while the ϕs and the γs are the coefficients corresponding to the policy variables. The ε^F's and ε^P's are individually serially uncorrelated disturbances to feedback and policy variables respectively.

The empirical analysis is based in monthly data from 1998 to 2003.[e] The optimal number of lags, k, for the variables used in the VAR model is 2, which was chosen according to the likelihood ratio test. The whiteness of the residuals was checked according to the LM residual serial correlation test and the results confirmed the null hypothesis of no autocorrelation of the disturbances.

Results from the VAR estimations are shown in Figures 1 to 3. In each figure it is described the result of a VAR model that includes a different monetary aggregate, chosen among Encaje, Base and OB. Part (a) of each figure illustrates the shocks produced by the TPPF rate, while its part (b) illustrates the shocks produced by the monetary aggregate employed. From such figures it is concluded that a monetary policy shock generated through the TPPF rate produces a short-run (one month) although significant liquidity effect in all the aggregates used as a measure of money. Similarly shocks to the monetary aggregates also produce a short-run (no more than three months) and significant liquidity effect in the TPPF rate. Robustness of such results were tested using sixteen different orderings of the variables in forty eight VARs calculated. Such results are described in Table 1. It can be noticed that the liquidity effect is more robust when the monetary policy shock comes from the monetary aggregate to the TPPF rate. The long-run neutrality of money was also verified by both TPPF shocks to real output (PIB) and by monetary aggregates to real output. Nevertheless in the short-run total output decreases after a monetary contraction that comes mainly through TPPF shocks. Robustness of such results are also shown in Table 1.

In addition, there are some other important results shown in Figures 1 to 3 that are worth mentioning. First, a shock in the TPPF rate generates a significant reduction (appreciation) in the exchange rate (TC) in the period following the shock. This result is very important in a Central Bank that conducts monetary policy based on a flexible exchange rate system with moderate intervention, where the guatemalan Central Bank intervenes in the foreign exchange market just if it considers that there is volatility in the exchange rate generated through speculative factors.[f] Such result also implies that monetary policy might be affecting net exports, and hence, total output. Notice however in Table 1 that an exchange rate appreciation following a monetary contraction happened to occur just in 41.7% of the estimations using alternative variable orders. Furthermore, a monetary contraction, either through a TPPF shock or through a shock in any of the monetary aggregates used in the VAR models, generates a significant and robust increase in the banking rate on repurchase agreements (TIR), which agrees with the fact that a monetary contraction reduces the short-run liquidity of the banking sector, and increases the cost of interbank lending.

It is important to justify the reason of using shocks to OB as monetary policy shocks.[g] The argument is as follows: the Central Bank of Guatemala might affect the monetary base through its intervention in both the money market and the foreign exchange market. When intervening in the former market to tight monetary policy, the Central Bank performs open market operations (OMAS), through the issue of its own deposit certificates to contract liquidity. So, on one hand the Central Bank is increasing the amount of its total liabilities by issuing bonds, and on the other hand it is reducing the amount of monetary base (BASE) when the public purchase such certificates. Therefore, the ratio OB (= OMAS/BASE) has to increase after a monetary contraction engineered by the Central Bank. Similarly, such a ratio goes down after a loose monetary policy.

Furthermore, when the Central Bank intervenes in the foreign exchange market in order to smooth the exchange rate behavior, it also affects the monetary base. In fact, the monetary base increases when the Central Bank buys foreign exchange, and it decreases when the Monetary Authority sells foreign currency. However, since the Central Bank's intervention in the foreign exchange market through the purchase of foreign exchange might generate inflationary pressures, the Monetary Authority might also decide to neutralize such policy issuing more deposit certificates to reduce the monetary base by the same amount of its foreign exchange market intervention. If so, the monetary base won't change. As a result, the monetary policy would be more tight (since the amount of

OMAS will increase), but such contractive measure won't appear in the monetary base, since such variable will be unchanged. Therefore, using the monetary base alone as a measure of monetary policy shocks might be misleading since a Central Bank intervention in the money market, from where the monetary policy shocks are identified, can be offset if the Central Bank intervenes at the same time in the foreign exchange market. Thus, a shock to the OB ratio provides a better interpretation of a monetary policy shock.[h]

Therefore, since the VAR model illustrated in Figure 3, which includes two policy variables that can be interpreted as monetary policy shocks (TPPF and OB), provides more insightful estimates of monetary policy shocks for the guatemalan case, the error restrictions implied by a structural VAR will be applied to such a model in the next section.

B. Structural VAR model

The application of an SVAR becomes important to confirm the results obtained through the unrestricted VAR especially since the robustness of the latter results might vary depending on the ordering scheme imposed in each VAR model, as it was depicted in Table 1.

Following Bernanke and Mihov (1998), restrictions are imposed just to the policy block disturbances in order to establish a market for Central Bank's certificates of deposit. The restrictions imposed to the error terms that belong to such block are the following:

$$\varepsilon^{OB} = \alpha_{11}\mu^{IPC} + \alpha_{12}\mu^{TC} + \alpha_{13}\mu^{TIR} + \alpha_{14}\mu^{OB} \quad (3)$$

$$\varepsilon^{TPPF} = \alpha_{21}\mu^{PIB} + \alpha_{22}\mu^{OB} + \alpha_{23}\mu^{TPPF} \quad (4)$$

Equations (3) and (4) represent supply and demand functions for Central Bank deposit certificates, respectively.[i] With respect to the supply function, expression (3), the expected sign for α_{11} is positive, because it is expected that the Central Bank issues more certificates of deposit (OMAS), which will raise the ratio OB, in order to reduce the inflationary pressures generated by an increase in the consumer price index, IPC. The sign of α_{12} is expected to be cero or negative. The reason for it is that on one hand, the Central Bank does not intervene

directly in the money market to smooth the exchange rate behavior, in which case an increase in the exchange rate will not generate an increase in the ratio OB. However, the Central Bank might intervene indirectly in the money market after a drastic variation in the exchange rate. This follows because Central Bank interventions in the foreign exchange market to prevent the domestic currency to show major fluctuations, might generate inflationary pressures, that the Central Bank might decide to neutralize. Consider the case when the exchange rate shows a drastic appreciation. In this case the Central Bank intervenes to buy US dollars, increasing the monetary base. If the Monetary Authority considers that it is important to neutralize such intervention, then it might issue more certificates of deposit (OMAS), increasing the ratio OB since the monetary base would be left unchanged. The sign of α_{13} is expected to be negative, since an increase in the banking rate for repurchase agreements, TIR, results from low banking liquidity. Therefore, the Central Bank could reduce the amount of open market operations, OMAS, to provide more liquidity to the banks. The sign of α_{14} is expected to be positive, since both error terms (the estimated error, ε^{OB}, and the orthogonal disturbance, μ^{OB}) are expected to be positively correlated.

With respect to the demand function represented by equation (4), the expected sign for α_{21} is negative, since an increase in the public's income is expected to generate an increase in the amount purchased of Central Bank bonds, and hence, increasing their price, which is followed by a reduction in their interest rates. The expected sign of α_{22} is cero or positive, because when the Central Bank increases the amount of deposit certificates issued, it might decide either to increase the rates or to leave them unchanged. Finally, the expected sign of α_{23} is positive because of the same reason mentioned above for α_{14}.

Monetary policy shocks are those represented by μ^{OB} and μ^{TPPF} from the supply and demand equations, respectively. Both types of shock are important for the setup of the model, although exogenous monetary policy shocks, those engineered by the Central Bank of Guatemala are better represented by supply shocks, that is μ^{OB} shocks. The matrix notation that establishes the relationship between the estimated and the orthogonal shocks according to the restrictions imposed above, is the following:

$$A\varepsilon = B\mu \quad (5)$$

Where A and B are 6x6 nonsingular matrices that relate the estimated errors, ε, to the structural shocks, μ. Matrix A is the identity matrix, while matrix B is composed of the feedback variable block, which is left to be lower triangular (up to the forth row), and the policy variable block, which indicates the restrictions established by (3) and (4). Hence, expression (5) can be written as:

$$
\begin{bmatrix}
C(1) & 0 & 0 & 0 & 0 & 0 \\
C(2) & C(5) & 0 & 0 & 0 & 0 \\
C(3) & C(6) & C(8) & 0 & 0 & 0 \\
C(4) & C(7) & C(9) & C(10) & 0 & 0 \\
0 & 0 & 0 & 0 & 1 & 0 \\
0 & 0 & 0 & 0 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
\varepsilon^{PIB} \\
\varepsilon^{IPC} \\
\varepsilon^{TC} \\
\varepsilon^{TIR} \\
\varepsilon^{TPPF} \\
\varepsilon^{OB}
\end{bmatrix}
=
\begin{bmatrix}
1 & 0 & 0 & 0 & 0 & 0 \\
0 & 1 & 0 & 0 & 0 & 0 \\
0 & 0 & 1 & 0 & 0 & 0 \\
0 & 0 & 0 & 1 & 0 & 0 \\
0 & C(12) & C(13) & C(14) & C(15) & 0 \\
C(11) & 0 & 0 & 0 & C(16) & C(17)
\end{bmatrix}
\begin{bmatrix}
\mu^{PIB} \\
\mu^{IPC} \\
\mu^{TC} \\
\mu^{TIR} \\
\mu^{TPPF} \\
\mu^{OB}
\end{bmatrix}
\quad (6)
$$

The $C(i)$s are the coefficients to be estimated. Such estimations are depicted in Figure 5. According to such results, the estimated supply and demand equations are the following:

$$\varepsilon^{OB} = \underset{(0.04)}{0.042\mu^{IPC}} + \underset{(0.16)}{0.0.28\mu^{TC}} - \underset{(0.00)}{0.100\mu^{TIR}} + \underset{(0.00)}{0.139\mu^{OB}} \quad (7)$$

$$\varepsilon^{TPPF} = \underset{(0.02)}{-0.121\mu^{PIB}} + \underset{(0.00)}{0.386\mu^{OB}} + \underset{(0.00)}{0.209\mu^{TPPF}} \quad (8)$$

The numbers in parenthesis are the p-values computed for each coefficient. Notice that most of the coefficients are statistically significant (with the exception of the exchange rate error disturbance) and their signs are as expected. The impulse responses for the μ^{TPPF} and the μ^{OB} shocks are illustrated in Figures 6a and 6b respectively. According to Figure 6a, a TPPF shock (μ^{TPPF}), which consists of a 0.2 percentage points increase in the TPPF rate produces a Q/US$ 0.05 exchange rate appreciation during the month following the shock, but it does not have a significant impact on prices or output. On the other hand, a OB shock (μ^{OB}), which consists on a 0.086 percentage points increase in the OB ratio (equivalent to an increase of Q750 million in OMAS that contract the monetary base for the same amount), generates a significant and short-run liquidity effect on the TPPF that lasts two months after the shock. In effect, the TPPF rate rises 0.4 and 0.8 percentage points during the first and second month after the OB shock, respectively. A similar but shorter effect is produced in the banking rate for repurchase agreements, TIR. In this case, a OB shock generates a 1.14 percentage

points increase in the TIR in the month following the shock. Finally, a μ^{OB} shock also generates a Q/US$ 0.06 exchange rate appreciation during the next month after the shock. Robustness tests for twelve different orderings of the feedback variable block were tested, and the results obtained for the policy variable shocks remained unchanged.

When comparing the results obtained by the SVAR with those obtained by the recursive VAR model estimated in part A, it is noted that the former results confirm the more robust results obtained through the recursive methodology, which are indicated in Table 1. In such table, the most robust results imply that the shock from a monetary aggregate (an OB shock in this case) generates a short-run liquidity effect, and it also has a similar impact on the banking rate for repurchase agreements, TIR. Such results were confirmed through the SVAR methodology, and provide a higher degree of confidence to affirm the existence of a liquidity effect, and the neutrality of money in the long-run. The impact on the exchange rate coming from a TPPF shock was observed just in 41.7% of the tests described in Table 1. Nevertheless such results were 100% robust through the SVAR model through both a μ^{TPPF} and a μ^{OB} shock, which lead to the conclusion that a restrictive monetary policy through intervention in the money market has an indirect effect in the foreign exchange market, and generates an exchange rate appreciation.

V. Conclusions

Shocks to the ratio OB happened to be a better indicator of monetary policy shocks than just monetary base or TPPF shocks. This follows from the fact that the Central Bank of Guatemala not only intervenes in the money market but also it intervenes in the foreign exchange market, and the latter interventions might generate inflationary pressures, which might lead the Monetary Authority to perform more open market operations (without necessarily altering the interest rates in certificates of deposit issued by the Central Bank) in order to neutralize such interventions. In doing so, the monetary base would be unchanged, and just the ratio OB would show the Central Bank actions. Therefore, using OB and the TPPF rate as policy variables, the results obtained through both a recursive VAR, and a SVAR model that establishes supply and demand equations for

Central Bank deposit certificates, lead to conclude that there is a significant short-run liquidity effect mainly coming through OB shocks.

The SVAR results confirm the main findings obtained through the robustness analysis performed to the recursive VAR model. In other words, a TPPF shock generates an increase in the banking rate for repurchase agreements, TIR, and an exchange rate appreciation, while OB shocks produce a short-run liquidity effect in the TPPF rate, an exchange rate appreciation, and an increase in the TIR. In addition, although monetary policy has real effects in the short run, money is neutral in the long-run.

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VII. Endnotes

[a] As Lucas stated in its Nobel lecture in 1996, the effects of money in the real variables is a controversial topic since the time of David Hume.

[b] For a more detailed derivation of this rate see Castañeda, Juan Carlos; Catalán, Juan Carlos; and Herrera, Oscar: *Propuesta metodológica para medir la evolución de la tasa de interés de las operaciones de estabilización monetaria.* April 2003.

[c] This is the rate that the Monetary Authority changes either to loose or to restrict its monetary policy (this rate performs the same task for the Bank of Guatemala, as the Federal Funds Rate for the Federal Reserve in the US).

[d] It is important to mention that the open market operations performed by the Central Bank of Guatemala have a different connotation that the open market operations commonly made. In Guatemala the Central Bank issues its own deposit certificates, so it operates in the primary bonds market instead of participating in the secondary bond market negotiating treasury (government) notes. Therefore, each Friday the Monetary Authority decides the amount of deposit certificates to issue for the upcoming week, their maturity dates and the interest rates for each maturity according to the difference between the supply and demand of currency issue forecasted for such a week. The maturities at which the deposit certificates are issued will depend on the time when the Bank of Guatemala considers that it will be a scarcity of currency, so that the extra currency provided by the amount of deposit certificates that mature at that time, will not have inflationary effects.

[e] It is important to mention that there is evidence of a structural change from 2001 given that the way to do monetary policy in Guatemala changed from that year on. Therefore, the results described in the tables and graphs depicts just the latter three years.

[f] Volatility is defined as a variation in the exchange rate that exceeds 0.06 Q/US$ within a week. During the period 2001-2003, the amount of Central Bank intervention was very low, since it did not exceed 0.5% of the total amount of operations in the foreign exchange market.

[g] See also Castañeda (2003) for an alternative justification of including OB shocks as monetary policy shocks.

[h] An interesting point is that the ratio OB has its own dynamic, since it can be perfectly estimated through an ARIMA(1,0,0). The relatively easy way to model such a variable might indicate that monetary policy shocks can be computed as the forecasted errors resulting from the model just described (see Figure 4).

[i] Notice that different from the Bernanke and Mihov's approach, restrictions (3) and (4) involve shocks to some of the variables classified within the feedback variable block.

Table 1
Robustness of Unrestricted VAR Results

Conclusión	Encaje	Base	Ratio OB	Total
Testing the Liquidity Effect				
↑TPPF ⇒ ↓MA	8/16 = 50%	8/16 = 50%	4/16 = 25%	20/48 = 41.7%
↑MA ⇒ ↓TPPF	16/16 = 100%	16/16 = 100%	16/16 = 100%	48/48 = 100%
Testing for Money Neutrality in the Long Run				
↑TPPF ⇒ ↓PIB	0/16 = 0%	0/16 = 0%	0/16 = 0%	0/48 = 0%
↑MA ⇒ ↑PIB	0/16 = 0%	0/16 = 0%	0/16 = 0%	0/48 = 0%
Testing for Money Neutrality in the short-run				
↑TPPF ⇒ ↓PIB	8/16 = 50%	8/16 = 50%	8/16 = 50%	24/48 = 50%
↑MA ⇒ ↑PIB	4/16 = 25%	4/16 = 25%	8/16 = 50%	16/48 = 33.3%
Some Other Results				
↑TPPF ⇒ ↓TC	8/16 = 50%	4/16 = 25%	8/16 = 50%	20/48 = 41.7%
↑TPPF ⇒ ↑TIR	12/16 = 75%	12/16 = 75%	12/16 = 75%	36/48 = 75%
↑TPPF ⇒ ↓IPC	0/16 = 0%	4/16 = 25%	0/16 = 0%	4/48 = 8.3%
↑MA ⇒ ↑IPC	4/16 = 25%	4/16 = 25%	8/16 = 50%	16/48 = 33.3%
↑MA ⇒ ↓TIR	16/16 = 100%	16/16 = 100%	16/16 = 100%	48/48 = 100%

MA: Monetary aggregate used in the VAR (chosen among Encaje, Base, and ratio OB)
PIB : Total output in real terms
TPPF: Weighted average interest rate on deposit certificates issued by the central bank
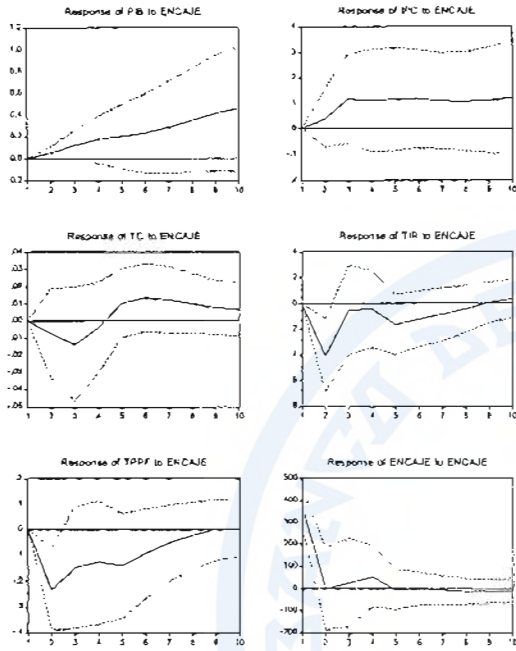TC: Exchange rate
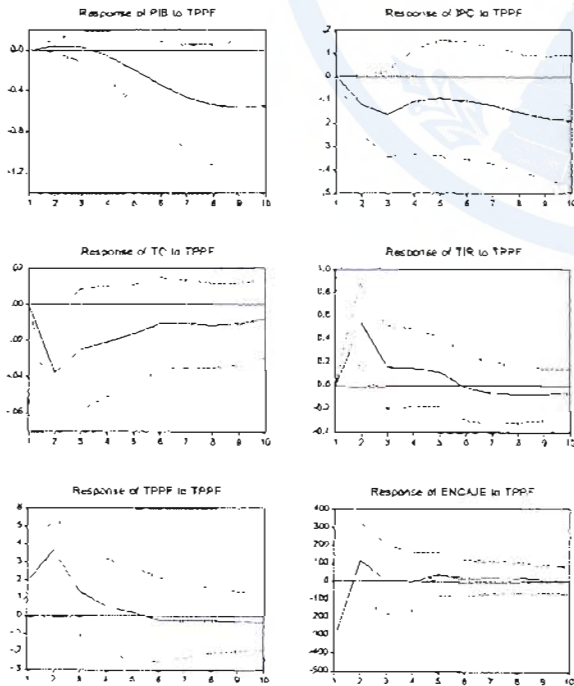TIR: Banking interest rate for repurchase agreements
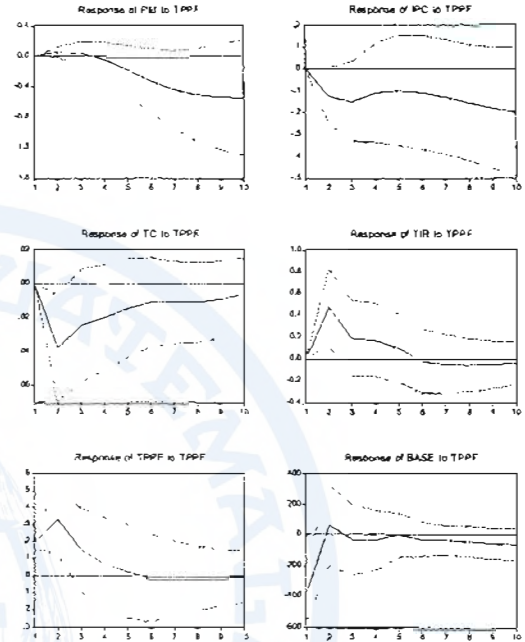IPC: Consumer price index

FIGURE 1b
Shocks to Encaje

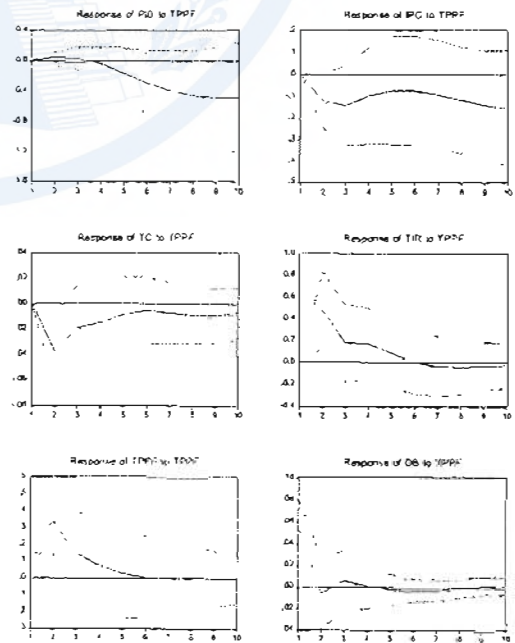**Response of PIB to ENCAJE**

Response of IPC to ENCAJE

Response of TC to ENCAJE

Response of TIR to ENCAJE

Response of TPPF to ENCAJE

Response of ENCAJE to ENCAJE

FIGURE 2a
TPPF Shocks
BASE is used as Monetary Aggregate

Response of PIB to TPPF

Response of IPC to TPPF

Response of TC to TPPF

Response of TIR to TPPF

Response of TPPF to TPPF

Response of BASE to TPPF

FIGURE 1a
TPPF Shocks
Encaje is used as Monetary Aggregate

Response of PIB to TPPF

Response of IPC to TPPF

Response of TC to TPPF

Response of TIR to TPPF

Response of TPPF to TPPF

Response of ENCAJE to TPPF

FIGURE 3a
Shocks to TPPF
OB was used as Monetary Aggregate

Response of PIB to TPPF

Response of IPC to TPPF

Response of TC to TPPF

Response of TIR to TPPF

Response of TPPF to TPPF

Response of OB to TPPF

FIGURE 3b
Shocks to OB

Response of PIB to OB

Response of IPC to OB

Response of TC to OB

Response of TIR to OB

Response of TPPF to OB

Response of OB to OB

FIGURE 2b
Shocks to BASE

Response of PIB to BASE

Response of IPC to BASE

Response of TC to BASE

Response of TIR to BASE

Response of TPPF to BASE
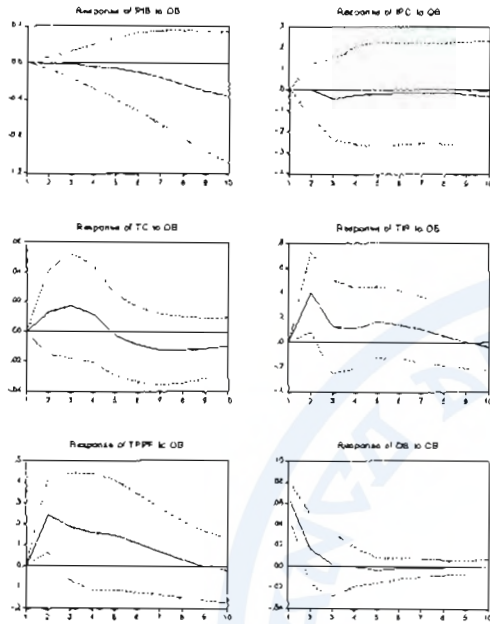
Response of BASE to BASE
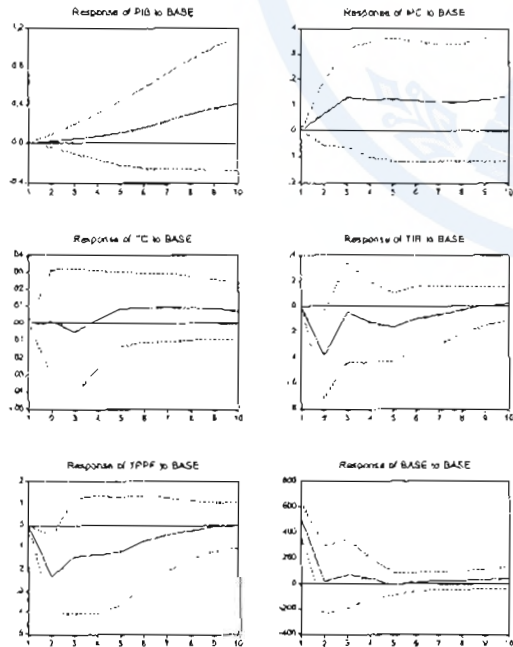
FIGURE 4
Ratio OB Observed and Estimated, and Forecasted Errors
2001 - 2003

—— Forecasted Errors
------ Observed
—— Estimated
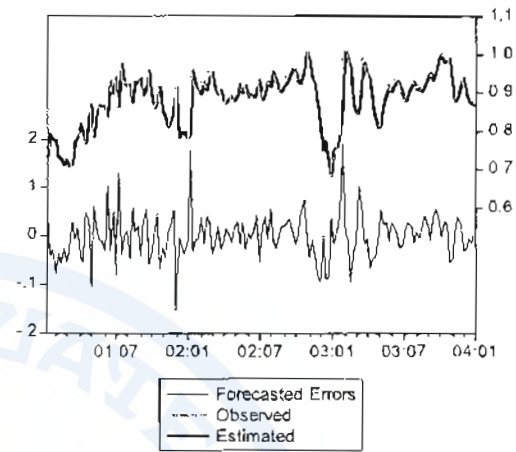
Figure 5
Structural VAR Estimates

Estimation method: method of scoring (analytic derivatives)
Structural VAR is over-identified (4 degrees of freedom)

Estimated A matrix:

5.484215	0.000000	0.000000	0.000000	0.000000	0.000000
0.304643	2.957810	0.000000	0.000000	0.000000	0.000000
0.343921	-0.009443	13.08218	0.000000	0.000000	0.000000
2.650387	0.284065	2.616493	1.323815	0.000000	0.000000
0.000000	0.000000	0.000000	0.000000	1.000000	0.000000
0.000000	0.000000	0.000000	0.000000	0.000000	1.000000

Estimated B matrix:

1.000000	0.000000	0.000000	0.000000	0.000000	0.000000
0.000000	1.000000	0.000000	0.000000	0.000000	0.000000
0.000000	0.000000	1.000000	0.000000	0.000000	0.000000
0.000000	0.000000	0.000000	1.000000	0.000000	0.000000
0.000000	0.042347	0.028653	-0.100317	0.139198	0.000000
-0.121701	0.000000	0.000000	0.000000	0.386007	0.209521

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	5.484215	0.646321	8.485281	0.0000
C(2)	0.304643	0.888825	0.342747	0.7318
C(3)	0.343921	0.904590	0.380195	0.7038
C(4)	2.650387	0.822552	3.222153	0.0013
C(5)	2.957810	0.348581	8.485281	0.0000
C(6)	-0.009443	0.492970	-0.019156	0.9847
C(7)	0.284065	0.494106	0.574907	0.5654
C(8)	13.08218	1.541749	8.485281	0.0000
C(9)	2.616493	2.202060	1.188203	0.2348
C(10)	1.323815	0.156013	8.485281	0.0000
C(11)	-0.121701	0.055337	-2.199285	0.0279
C(12)	0.042347	0.021207	1.996839	0.0458
C(13)	0.028653	0.020333	1.409183	0.1588
C(14)	-0.100317	0.016194	-6.194564	0.0000
C(15)	0.139198	0.016405	8.485281	0.0000
C(16)	0.386007	0.057349	6.730871	0.0000
C(17)	0.209521	0.024692	8.485281	0.0000

Log likelihood   23.73292
LR test for over-identification:

Chi-square(4)	57.52699	Probability	0.0000

Figure 6a
Structural VAR Model
TPPF Shocks
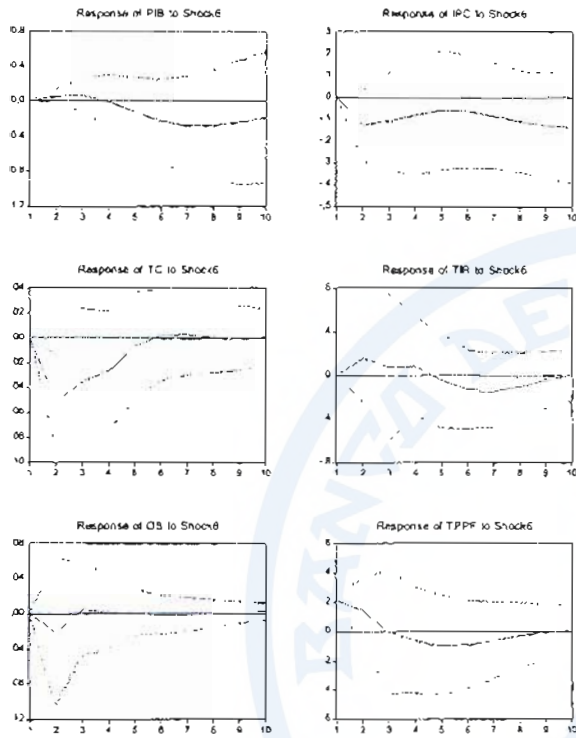
Figure 6b
Structural VAR Model
OB Shocks