Shocks and Uncertainty: Central Banks at Attack

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Abstract

The objective of the paper is to find some explanations about the responses Central Banks adopt when economies are under the pressure of both, internal and external shocks, and their influence on output and price level. The monetary regime determines the availability of instruments to be applied in order to reach the policy objectives. For an empirical account of these features, a Structural Vector Error Correction Model (SVEC) is estimated and Impulse-Response and Variance-Decomposition analysis are performed. Three important Latin American economies (Argentina, Brazil, and Chile) are analysed, considering their evolution during the last decade: two of them (Brazil and Chile) with similar monetary regimes in force (inflation targeting) and the other (Argentina) with a different monetary regime (a mix of quantity of money control and managed exchange rate).

Keywords: Shocks, Central Banks, Latin American Countries, VEC Models.

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1 Introduction

During the last decades many external shocks have affected Latin American economies. These shocks do not generate isolated effects, but exert influence on both the real and the financial side of the economies. In this sense, economic authorities of a country are forced to make decisions as part of a large chain of effects, generating adjustments in monetary aggregates, international reserves, domestic absorption, domestic prices, interest rates, exchange rate or a combination of the aforementioned variables.

Central Bank (CB), as being the monetary authority, usually makes decisions about the degree of adjustment in financial variables for the purpose of mitigating the impacts both external and domestic shocks, particularly limiting the flexibility in the interest rate, the exchange rate, the international reserves and quantity of money. Depending on the monetary regime, monetary policy could give a greater importance to interventions in the money market or in the foreign exchange market. Also, the adjustment can be done through quantities (such as international reserves and domestic liquidity and credit), prices (such as the interest rate or the exchange rate) or a combination of both.

The monetary regime chosen by a country depends on a variety of factors, among which the objectives of the monetary authority, structural features and the context the economy faces in the short and medium term are noteworthy. Since every economy is exposed to shocks, policymakers have to respond to those taking into consideration the monetary regime implemented at that moment. These decisions and the idiosyncratic characteristics of the countries will define the results of those policies in terms of growth and inflation. The dynamic is another element to be included in the analysis. Therefore, in order to observe not only the effects of shocks on real and financial variables but also their durability, short run and long run effects are distinguished (Neder et al., 2011).

A Structural Vector Error Correction Model (SVECM) is implemented, allowing the use of non-stationary variables. In order to dimensioning those effects, econometric estimations are obtained, and through the use of IRFs (impulse response functions), it is possible to analyse how the shocks are channelled through the variables.

The countries considered in the analysis are Argentina, Brazil and Chile, three of the mayor players in Latin America and whose economic regimes implemented (mainly monetary ones) were key to determine their macroeconomic performances. They were also selected because they entail different monetary and exchange rate regimes which are interesting to be compared as their selection has non-neutral implications for macroeconomic results.

The remainder of the paper is organized as follows: in section 2 different monetary regimes are described, including exchange rate, monetary, and inflation targeting. Section 3 contains the econometric approach, explaining what variables were selected, how the series were generated, and giving some details on the Vector Error Correction Model(VECM) identification scheme that will be employed. The results for the countries selected are presented in section 4, and in section 5 concluding remarks are presented.

2 On monetary regimes

A monetary regime is a set of monetary institutions and agreements that are accompanied by a set of expectations made by economic agents about actions and decisions performed by policymakers. As stated by Bordo and Schwartz (1999) "by incorporating expectations, a monetary regime differs from the older concept of a monetary standard, which referred simply to the institutions and arrangements governing the money supply". The monetary regime carried out by a central bank is an important element for the success of economic policy, particularly when different macroeconomic aspects are considered.

Since every economy is exposed to shocks, policymakers have to respond to those taking into consideration the monetary regime implemented at that moment. These decisions and the idiosyncratic characteristics of the countries will define the results of those policies in terms of growth and inflation. The choice of the monetary regime depends on which is the variable where the accent of monitoring and control is put. Thus, there will be regimes that would generate a nominal anchor that restricts, in a credible way, the CB's policy discretion in the medium term. The before mentioned nominal anchor could be the nominal exchange rate (considering a commodity -for example, the gold standard-, or considering the currency of a strong

economy), a common currency in a currency area or a monetary aggregate. Consequently, the use of these anchors generates the existence of different monetary policy strategies, and will constitute the main schemes to be discussed. There is another regimen (inflation targeting) characterized by not having a specific anchor. Instead attention is concentrated on a price index.

All of them help to draw the line in the commitment-discretion dichotomy monetary authority faces. There are different ways to classify monetary regimes[1], but in this section it is followed those made by Mishkin (1999) and Mishkin and Savastano (2000): exchange-rate targeting (including hard and soft exchange-rate pegs), monetary targeting, inflation targeting and an implicit nominal anchor.

2.1 Exchange rate targeting

This monetary regime is linked to the existence of extreme cases with fixed exchange rate, such as a currency board and full dollarization. In a currency board, domestic currency is totally backed by a foreign currency, the exchange rate is fixed to this currency and monetary authority stands ready to respond to the will of exchanging domestically issued notes for the foreign currency on demand or buying all the foreign currency that people want to offer. It is usually said that a currency board implies that the CB loses its ability to conduct monetary policy but, although it restricts the possibility of monetary authority to act as a lender of last resort, there is always the possibility of handling mandatory bank reserves and open market operations. In the case of full dollarization the foreign currency become the legal currency and, since then, the monetary authority will not be able to issue notes. Therefore, monetary authority assumes a greater (or more expensive) commitment if it decides to change the parity of local currency.

The advantage of these monetary regimes is based on the fact that they provide a nominal anchor that is useful to maintain price stability in an easily understandable way to the public, since prices of tradable goods domestically produced are tied to the prices of the country whose currency is the anchor. They also would cut all inertial component of inflation based on expected devaluation (which may also be considered as a component of risk in domestic interest rates) if the commitment were credible. The most important disadvantage is the loss of capacity to respond to shocks which can impact negatively on the GDP and employment. Also, the lack of an adjustment mechanism through which resolve imbalances in the external sector, would exacerbate risks associated with a loss of competitiveness. Although literature often quotes as disadvantages of these schemes the inability of the CB to act as a lender of last resort (to both banks and the government), this may be more of a constraint for its proper operation. Hence, fiscal policy must be very strict due to the fact that the Central Bank cannot fund the government.

2.2 Monetary targeting

This monetary regime consists in controlling a monetary aggregate in order to give the CB the possibility of influencing on domestic economic activity through the liquidity of the economy. Thus, announcements of a rule on a monetary aggregate will guide inflation expectations of economic agents. This implies that lack of fiscal dominance will be required, such that monetary policy is not determined by fiscal considerations. Additionally, exchange rate should be flexible in order not to influence the level of the monetary aggregate.[2]

Advantages of regime depends on the relationship between the target variable (inflation or nominal income) and the controlled monetary aggregate. The closer the relationship, the greater the reliance on monetary policy. Moreover, this scheme does not imply that a monetary policy rule à la Friedman is followed, in which a monetary aggregate is kept on a steady growth path. Simply, it is maintained between objective values and this gives the CB greater reliability from the public which helps to mitigate the time-inconsistency problem of monetary policy. However, the realization of permanent changes in the bands of the levels required for the considered monetary aggregate can lead to problems of credibility with the consequent problems to keep price stability.

[1] One of them can be found in Zamorano Valiña (2010).

[2] If it were fixed, any speculative behaviour would influence the level of the monetary aggregate through sells and buys of international reserves.

2.3 Inflation targeting

This regime is not a rule but merely a framework for the implementation of monetary policy in which the main objective is to achieve and maintain a low inflation rate. In such a framework, some key elements should be distinguished involving, first of all, a particular announcement to a figure which will be the medium-term target for inflation. Secondly, it is necessary to establish an institutional commitment to the primary objective of price stability (to which other objectives will be subordinated) which involves not only the exchange rate and monetary aggregates but also other variables such as the degree of CB independence in conducting the monetary policy.

The advantage of this system is that while it focuses on domestic considerations, it can respond to internal and external shocks, since it (if it is successful) reduces inflation volatility lessening fluctuations in inflation expectations. This framework also has the advantage of being easily understood by the public. Even the CB is able to reduce the possibility of falling into the trap of time inconsistency since the monetary authority focuses its attention on the inflation target and not on other objectives. The incentives not to fulfil its commitment was coined by Bernanke and Mishkin (1997) as "constrained discretion".

In terms of disadvantages may be thought that controlling inflation is a disadvantage in itself because it is an extremely difficult task. Indeed, the implementation of inflation targeting regime requires a prior disinflation, the existence of a flexible exchange rate and monetary policy track with the least possible time inconsistency and the greater and achievable accountability and transparency. In the words of Kahn (2003), "inflation targeting strategy is not a panacea". Despite the fact that inflation targeting constitutes a useful framework for conducting monetary policy since it provides transparency, it requires a commitment by the monetary authority with policy consistency and it is necessary some flexibility to respond to any shocks. Additionally, fiscal discipline or prevention of fiscal dominance are prerequisites.[3]

3 Econometric approach

It is interesting to compare monetary and exchange-rate policy schemes and regimes because it results clear that choosing one over another has non-neutral implications for the effects that diverse disturbances (both internal and external) exert on the domestic economy. At this stage, it must be said that many features influence the adoption of a given regime by a country. Among them, the most prominent are: the character of the economy's international insertion, its history, the structure of its institutions and political economy factors. In the next section, as a prelude to the exposition of empirical results, comments on these features will be made for Argentina, Brazil and Chile. But, in order to build a quantitative base for comparison, a more general idea will be pursued abstracting from the latter.

The monetary authority decides over the instruments it controls taking into account (i) the state of macro-economy and broad policy objectives (ii) the conditions at the domestic financial system, and (iii) external conditions faced by the economy as a whole.

For the implementation of the empirical model, variables will be selected to represent (i), (ii), and (iii). Before that, it is necessary to warn that the econometric methodology to be applied limits the number of variables that can be included, so that the scale of the model is kept at a manageable level. However, a wise selection of variables may turn this limit into an advantage. First, the state of macro-economy at a given moment will be represented by two variables: output and the price level. Although other variables can be regarded to help describing the state of macro-economy (such as employment rates, budget and external accounts, etc.) output and inflation receive the greatest attention by Central Banks. Second, the conditions at the domestic financial system will be summarized by a monetary aggregate (M2), the stock of international reserves held by the Central Bank, a reference interest rate and an exchange-rate measure. Finally, the relationship with the international economy will be reflected through a commercial channel (which includes terms of trade and prices of goods that have a relevant share in trade) and through a financial channel (which includes an international interest rate).

For a given moment t macroeconomic variables (i) and financial variables (ii) will be included in a vector X_t while external variables (iii) will be included in a vector Z_t.[4] Because the economies under analysis are

[3] If some level of dollarization is present in the economy, a strict supervision of the financial sector would be required.

[4] To simplify, Z_t contains all external information relevant at time t, which means that Z_t can contain external variables dated t and lagged values of them.

"small"[5] it can be adduced that Z_t will not be affected by X_t (nor by its lagged values). This suggests that X_t is the vector of endogenous variables and Z_t is the vector of exogenous variables for our model. Let n be the number of variables contained by X_t (here, $n = 6$) and let n_z be the number of variables contained by Z_t.

It is assumed that the observed time series $\{\hat{X}_t\, \hat{Z}\}_{t=0}^{T}$ have been generated by a pair of stochastic processes $\{X_t\, Z_t\}_{t=0}^{\infty}$[6] and that $\{X_t\}_{t=p}^{\infty}$ (conditional on $\{Z_t\}_{t=0}^{\infty}$ and on $\{X_t\}_{t=0}^{p-1}$) admits a VAR(p) representation[7]

$$X_t = \Phi_1 X_{t-1} + \ldots + \Phi_p X_{t-p} + \Theta Z_t + D_t + \epsilon_t \quad t \geq p \tag{1}$$

where $\{D_t\}_{t=0}^{\infty}$ is a deterministic sequence (constants, trends and *dummies*) and $\{\epsilon_t\}_{t=0}^{\infty}$ is Gaussian vector white noise with $\epsilon_t \sim \text{iid}\, N(0, \Sigma)$, all t.

Also, it is assumed that $\{X_t\}_{t=0}^{\infty}$ is a non-stationary vector process with unit roots and stable first differences ΔX_t (i.e. it is a I(1) process) such that there are r cointegration relationships between the elements of X_t $(0 < r < n)$. These assumptions and Granger's representation theorem[8] allow finding matrices $\Pi, \Gamma_1 \ldots \Gamma_{p-1}$ such that

$$\Delta X_t = \Pi X_{t-1} + \Gamma_1 \Delta X_{t-1} + ... + \Gamma_{p-1} \Delta X_{t-p+1} + \Theta Z_t + D_t + \epsilon_t \quad t \geq p \tag{2}$$

Equation (2) will be a first base for inference in what follows.

In all the cases the procedure was this: the number of lags for the endogenous variables was restricted by using information criteria based on a VAR which excluded exogenous variables and *dummies*. Cointegration rank was established employing the trace and maximum-eigenvalue tests suggested by Johansen[9] trying with different deterministic structures and lag lengths.

Once the cointegration rank was selected, several alternative models (including exogenous variables and *dummies*) were fitted and compared on the basis of their performance in specification tests (mainly residual autocorrelation, normality and conditional heteroskedasticity). Estimation was implemented with a two-stage procedure in JMulti.[10] The Vector Error Correction Model (VECM) so far discussed, provides a description of the co-movement of all the variables considered. However, it does not afford specific information neither about the economic relationships which have generated the stochastic process nor about the effects of different disturbances to the system and the transmission mechanism they trigger. In order to go on that direction a structural model must be suggested which implies posing *ex ante* restrictions inspired in a theoretical model. Also, this involves an identification problem that must be tackled.[11]

Broadly speaking, two kinds of restrictions will be set: short-run and long-run restrictions. First, a relationship between prediction errors ϵ_t and a vector of orthogonal innovations u_t is proposed which will be given by

$$\epsilon_t = B u_t \tag{3}$$

It is assumed that $\{u_t\}_{t=0}^{\infty}$ is Gaussian vector white noise with $u_t \sim \text{iid}\, N(0, I)$, all t ($u_t = 0$ for $t < p$). The matrix B is nonsingular. Moreover, under the hypothesis of Granger's theorem it is possible to represent $\{X_t\}_{t=0}^{\infty}$ as

$$X_t = (\Xi B) \left[\sum_{j=1}^{t} u_t \right] + \left[\sum_{j=0}^{\infty} (\Xi_j B) u_{t-j} \right] + X_0^* + \Psi(D_t, Z_t) \quad t \geq p \tag{4}$$

Equation (4) decomposes X_t in a vector of a random walks governed by $n - r$ common-trends and a stable process, among other things. Clearly, the first term dominates in the long-run. Equations (3) and (4) exhibit the possibilities to restrict short-run and long-run consequences of innovations, respectively. A zero on the ij entry of B means that the jth innovation in u_t cannot affect the ith variable in X_t contemporaneously.

[5] In the sense of not influencing economic behaviour at an international level.

[6] Formally, a stochastic process is a probability space $(\Omega, \mathcal{F}, P)$, a measurable space $(Z, \mathcal{Z})$, a sequence of σ-fields $\{\mathcal{F}_t\}_{t=0}^{\infty}$ such that $\mathcal{F}_t \subseteq \mathcal{F}_{t+1} \subseteq \mathcal{F}$ for all t, and a sequence of $\{\phi_t\}_{t=0}^{\infty}$ such that $\phi_t : \Omega \to Z$ is $\mathcal{F}_t$-measurable for all t.

[7] In the lines of the last footnote, the stochastic process could be constructed as follows. The sample space Ω is chosen to be a set of sequences $\{\xi_t\}_{t=0}^{\infty}$ where $\xi_t \in \mathbb{R}^{np}$ for all t. The σ-fields can be generated from the semi-algebras of Borel rectangles and the probability measure can be defined by a transition density (conditional on Z_t and D_t). For example, by doing $\xi_t = F\xi_{t-1} + \breve{D}_t + \breve{\Theta}\breve{Z}_t + \breve{\epsilon}_t$ where the first n components of $\breve{\epsilon}_t$ behave as white noise for all t it turns out that $\{\xi_t\}_{t=0}^{\infty}$ is a Markov process. Finally, by defining $X_t = H\xi_t$ for all t where H is a null matrix except for the first n rows and columns which contains an identity matrix it is easy to show that $X_t : \mathbb{R}^{np} \to \mathbb{R}^n$ is a random n-vector ($\mathcal{F}_t$-measurable) and that a suitable choice of F gives it a VAR(p) representation. Also, note that there is no explicit model for $\{Z_t\}_{t=0}^{\infty}$.

[8] The version of the theorem that is cited here comes from Hamilton (1994).

[9] Also see Lutkepohl (2005).

[10] For more details, see Lutkepohl (2005).

[11] Again, the reference for this is Lutkepohl (2005).

On the other hand, a zero on the ij entry of ΞB means that the jth innovation in u_t cannot affect the ith variable in X_t in the long-run.

A priori restrictions to identify the model must be consistent with B being nonsingular and with the rank of Ξ (in particular, this imposes that at most r innovations could have transitory effects).

3.1 A theoretical model for identification

In this paper, three markets are explicitly described, namely: goods and services market, money market and exchange market. The former is conformed by producers (supply side) and consumers (demand side); the second of them is integrated by the public (demand side) and the monetary authority (supply side); while the latter is determined by financial and commercial relationships between local residents and the rest of the world, which are summarized in the value of the balance of payments. It is important to highlight that the CB intervene in that market both buying and selling foreign currency. All the markets are exposed to six structural shocks: supply shock (u^{AS}), aggregate demand shock (u^{AD}), money demand shocks (u^{MD}), external shocks (u^{EX}), exchange shocks (u^{ER}) and monetary policy shocks (u^{MP}).

As noted above, at most r (the quantity of cointegrated relationships presented in the system) of the structural innovations can have transitory effects and $n-r$ of them must have permanent effects. For local just identification, $r(r-1)/2$ contemporaneous restrictions are needed to disentangle the transitory shocks and $(n-r)((n-r)-1)/2$ contemporaneous restrictions to identify the permanent shocks.

Taking into consideration the preceding paragraph and the fact that countries under study have different operating procedures, three different identification schemes were evaluated. Restrictions for each country are described below:

- Aggregate supply shocks are permitted to have both contemporaneous and long run effects on the system. It is due to they are understood as a increase in production frontier.
- Aggregate demand shocks has no effect in the long run. They are interpreted as innovation in the autonomous component of domestic absorption.
- In any case, money demand shocks do not have long run effects, they do not have contemporaneous impact on output either. In the case of Chile, this shock do not affect prices and exchange rate contemporaneously. For Brazil, the variables not affected are interest rate and prices and for Argentina, only the exchange rate is not influenced. These restrictions are in line with the operating procedures followed by each CB in order to accommodate the money demand shock.
- Related to external shocks, permanent effects were permitted in all the countries. In the case of Chile and Brazil, they have no contemporaneous effects on GDP and, for Argentina, on the interest rate either.
- The exchange rate shock neither has permanent impact on the system nor on the output at the moment that the shock takes place. In the case of Chile, it does not affect the interest rate in impact either because it is assumed a more strict functioning of the Taylor Rule which implies that the reference interest rate adjusts only to deviations in output (related to its long run value) and inflation rate (related to the CB's target).
- Long run effects of the monetary policy shock are restricted in Brazil and Chile while, in Argentina, they are not. As usual, contemporaneously impact on output are supposed to be null in all countries. In the case of Brazil, the exchange rate is not affected either as well as the level of prices in Argentina.

Considering all above mentioned, matrix ΞB and B for each country are presented below. It should be noted that, for Chile and Brazil, shocks are presented by columns as follows: u^{AS}, u^{AD},u^{MD}, u^{EX}, u^{ER} and u^{MP}, while the order of the shocks for Argentina is u^{AS}, u^{AD},u^{MP}, u^{EX}, u^{ER} and u^{MD}. All the variables are presented by rows as follows: GDP, prices, quantity of money, international reserves, exchange rate and interest rate.

CHILE:

$$\mathbf{B} = \begin{pmatrix} * & * & 0 & 0 & 0 & 0 \\ * & * & 0 & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & 0 & * & * & * \\ * & * & * & * & 0 & * \end{pmatrix} \qquad \mathbf{\Xi B} = \begin{pmatrix} * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \end{pmatrix}$$

BRAZIL:

$$\mathbf{B} = \begin{pmatrix} * & * & 0 & 0 & 0 & 0 \\ * & * & 0 & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & 0 \\ * & * & 0 & * & * & * \end{pmatrix} \qquad \mathbf{\Xi B} = \begin{pmatrix} * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \\ * & 0 & 0 & * & 0 & 0 \end{pmatrix}$$

ARGENTINA:

$$\mathbf{B} = \begin{pmatrix} * & * & 0 & 0 & 0 & 0 \\ * & * & 0 & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & * \\ * & * & * & * & * & 0 \\ * & * & * & 0 & * & * \end{pmatrix} \qquad \mathbf{\Xi B} = \begin{pmatrix} * & 0 & * & * & 0 & 0 \\ * & 0 & * & * & 0 & 0 \\ * & 0 & * & * & 0 & 0 \\ * & 0 & * & * & 0 & 0 \\ * & 0 & * & * & 0 & 0 \\ * & 0 & * & * & 0 & 0 \end{pmatrix}$$

Estimation of the structural model was implemented by Maximum-Likelihood on JMulti.[12]

Once the structural model was estimated, impulse-response analysis and variance- decomposition could be performed. An Impulse-Response Function (IRF) is a graph that describes the evolution of a given variable contained in X_t (plotted as deviations from its non-stochastic steady state) after a unit innovation in an element of u_t, i.e. a shock. It offers a convenient and eloquent summary of the dynamics implied by the estimated model. Variance-Decomposition (VD) is a graph that shows what fraction of a variable's volatility can be attributed to each of the innovations contained in u_t and how this change as time goes by.

The next section will be advocated to develop the empirical analysis just outlined for Chile, Brazil and Argentina.

4 Results for Chile, Brazil and Argentina

During the last decades many external shocks have affected Latin American economies. These shocks, like domestic innovations, do not generate isolated effects, but exert influence on both the real and the financial side of the economies. In this sense, economic authorities of a country are forced to make decisions as part of a large chain of effects, generating adjustments in monetary aggregates, international reserves, domestic absorption, domestic prices, interest rates, exchange rate or a combination of the aforementioned variables. With this idea in mind, three Latin American countries were taken to be analysed, namely: Argentina, Brazil and Chile. They are three of the mayor players in the region and whose economic regimes implemented (mainly monetary ones) were key to determine their macroeconomic performances. They were also selected because they entail different monetary and exchange rate regimes which are interesting to be compared as their selection has non-neutral implications for macroeconomic results.

For each of those countries a SVECM is estimated and, from this, IRFs of each structural innovation and the variance decomposition of prediction errors of each variable are obtained. Based on exposure, some of the IRFs are presented in the body of the analysis and the remaining, together with variance decomposition's figures and the estimated values of the ΞB and B, are attached in the appendix.[13]

[12] See Lütkepohl (2005).

[13] To get further information about the estimation results as well as information related to the time series used and the treatment they received, please contact the authors.

Regarding the IRFs, innovations are supposed to be positive and of one unit and confidence bands used were constructed by bootstrap with the Hall method with a confidence level set at 0.90. It should be noted that the identification scheme restricts the impact on the system of each innovation but it does not mean that the direction of the co-movements between the variables implied by them are restricted.

In what follows, and unless noted, increases and decreases will refer to deviations relative to the non-stochastic steady state: the path that would be followed by the endogenous variables in absence of random innovations and changes in exogenous variables. Finally, it is important to specify what are understood by short, medium and long run. Medium term, as it is usually used by cyclical analysis, is a period which goes from 3 to 5 years and, therefore, short run is one which lasts less than 3 year and long run is a term which goes from 5 years onwards.

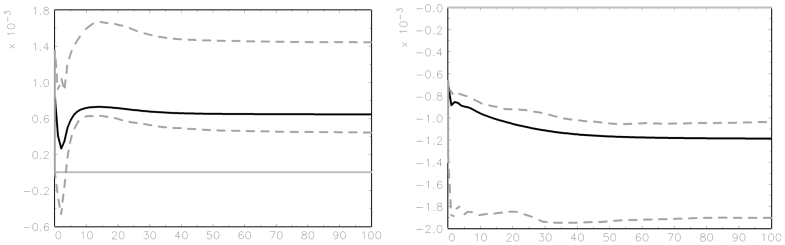
4.1 Chile

Chile adopted Inflation Targeting partially in 1990 as part of a gradual des-inflationary program and fully since 1999.[14] The first stage (called "convergence phase") was characterized by a progressive improvement in the ability of the Central Bank to influence liquidity and interest rates in the money market and, on the other hand, a marked will to intervene in the exchange-rate market through various mechanisms. The second stage (called "steady state phase") is different in that the Central Bank holds an almost flexible float for the exchange-rate (there being only occasional interventions in that market).[15] This second stage settled down slowly and also there was some instability caused by the successive episodes of crisis suffered by emerging economies. In line with this and for the sake of empirical analysis, the period to be considered starts at 2002. In what follows, the IRFs and VDs obtained from the model described in the previous section are interpreted.

It should be noted that the identification scheme used for Chile restricts aggregate supply shocks to be permanent and aggregate demand shocks to have only transitory effects on the whole set of endogenous variables. It does not, however, restrict the direction of the co-movements between output and prices implied by them. In that sense, by observing the corresponding IRFs, it can be concluded that the signs obtained conforms to the expected results: a positive supply shock induces an increase in output and a decrease in prices while a positive demand shock causes both output and prices to increase.

The effect of a supply innovation on output is not statistically significant in the short-run turning to be significant only after about a semester, since then output tends to stabilize on a higher long-run level (in the event of a positive shock). This is to say, a positive supply innovation accelerates growth temporarily within the year it hits the economy (after this, growth returns to its long-run trend). A similar analysis reveals that a positive supply shock causes the price level to go on a permanently lower long-run path implying a deceleration of inflation (or even a deflation) at the beginning. The related figure also shows that the deflationary pressure dies out very slowly which means that the inflation rate and not just the price level falls for a significantly long period.[16] Of course, a negative shock has opposite effects.

Figure 1: IRFs for u_t^{AS} on GDP (left) and the price level (right).



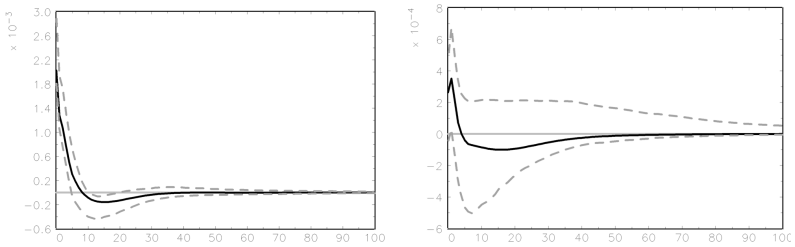
Positive demand shocks impinge a stronger (statistically significant) positive impact on output in the short-run (compared to supply shocks) but lasting just for less than a semester. On the other hand, effects on the price level have the expected sign but they result negligible and statistically insignificant.

[14] A complete survey on Chile's experience with Inflation Targeting can be found in Valdés (2007).

[15] It could be regarded that the second stage ended during the Subprime Crisis as interventions in the exchange-rate market have been stronger since then.

[16] This embodies the common-trend character of this shock under the identification scheme on use: long story short, a supply shock moves the economy to a new long-run trend.

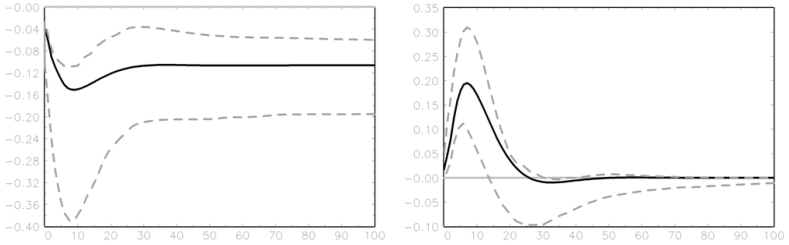
Figure 2: IRFs for u_t^{AD} on GDP (left) and the price level (right).



The dynamics of the domestic financial sector and the CB response to supply and demand shocks are described next. First, the CB sets the interest rate according to a Taylor Rule that takes into account the output gap and the deviations of the inflation rate relative to the target. Theoretically, a supply shock modifies both effective and potential output so its net impact on output gap can be regarded as ambiguous but, as already seen, it lowers inflation considerably and takes it below the target. This explains the fall on the interest rate following the shock. Permanently higher output and a lower interest rate stimulate real money demand which is satisfied at the beginning with an important increase in nominal supply of money (and also with a lower price level). A permanent higher long-run path for the monetary aggregate is suggested by the corresponding IRF but the hypothesis of it being different from the previous long-run path cannot be rejected (as the confidence bands contain the zero line).

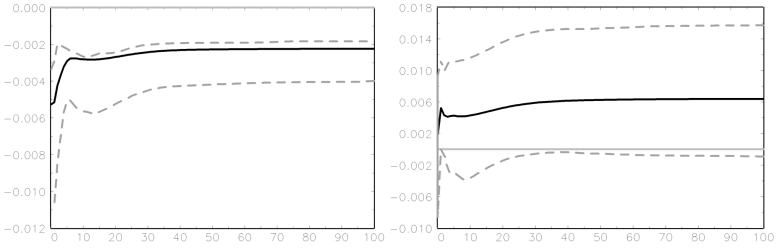
When faced with a demand shock the CB responds by increasing the interest rate. The response is faster and more aggressive than in the supply shock case and the impact on the monetary aggregate has the expected sign (it falls when the tightening monetary is taken) but does not result statistically significant. Given that the shock is transitory, the effects on financial variables last for a 12-to-18 month interval.

Figure 3: IRFs for u_t^{AS} (left) and u_t^{AD} (right) on interest rate.



With respect to the foreign exchange market, the supply shock induces an appreciation of domestic currency (or a deceleration of depreciation) plus an increase in international reserves, the latter not being statistically significant. The first result can be interpreted as evidence of a quick adjustment of the real exchange rate to a long-run level: given that the supply shock lowers the price level (relative to its long-run path) and the CB allows flexible floating, if the equilibrium real exchange rate were not modified significantly by the innovation, then nominal exchange rate should fall. The permanent increase in the stock of international reserves could be rationalized as part of a self-insurance strategy which consists of maintaining a given fraction of GDP in the form of self-assets at the CB but evidence is not conclusive about this (and it could be argued that within the sample employed for estimation this strategy was not always practised homogeneously).

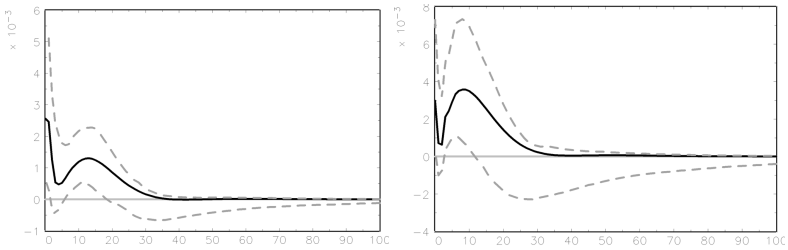
Figure 4: IRFs for u_t^{AS} on exchange rate (left) and reserves (right).



The demand shock, on its side, produces a depreciation of domestic currency and a temporary increase in international reserves. The first effect could be thought in the same line of the last paragraph: higher

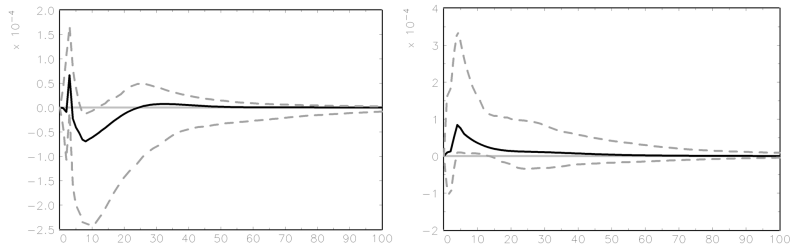
domestic income and prices shift demand from locally produced goods toward imported goods, and the disturbance to the foreign exchange demand is accommodated through price mechanisms. This partially offsets the positive effect on the supply of foreign exchange induced by the increase in domestic interest rate. Certainly there is some degree of intervention in the foreign exchange market but, as noted above, it is temporary and neutral in the long run.

Figure 5: IRFs for u_t^{AD} on exchange rate (left) and reserves (right).



Interpreting the money demand shock is a bit more complicated. Its impact on output and prices is small and difficult to determine: a positive innovation appears to affect output negatively in a 6-to-12 month interval while the effect on prices is very uncertain (the IRF suggest it is slightly positive).

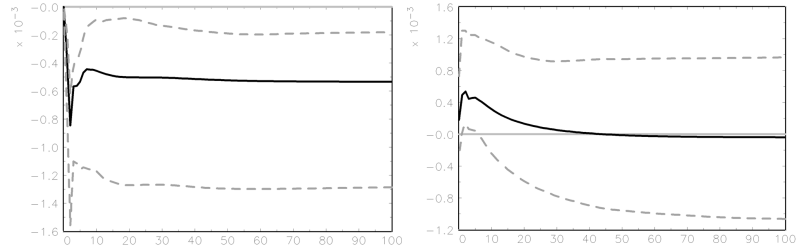
Figure 6: IRFs for u_t^{MD} on GDP (left) and the price level (right).



In response to the shock, the quantity of money increases and the interest rate jumps up in the very-short run (the effect on the monetary aggregate ceases to be statistically significant in few months). The whole process is managed by the CB who engineers part of the increase in money supply by accumulating international reserves which departs from its steady-state trend for some months. This underlines the incidental character of exchange rates interventions in Chile in response to certain shocks. Exchange rate exhibits the following dynamics: immediately after the shock it increases reverting in about 10 months to its long-run trend.

External shocks cause output to decrease permanently and the price level to increase temporarily, this last feature meaning an initial acceleration and posterior deceleration of inflation with respect to the steady-state trend. In many senses, the external shock resembles a negative supply shock (but with a less persistent impact on inflation).[17]

Figure 7: IRFs for u_t^{EX} on GDP (left) and the price level (right).

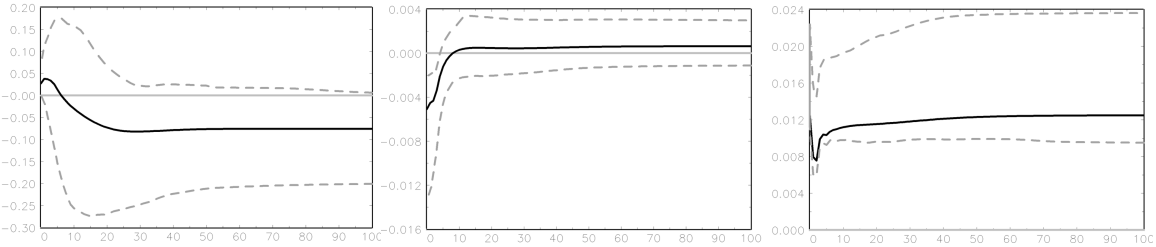


Initially, interest rate goes up and there is some downward-pressure on exchange rate, both effects being small and not very long-lasting. The CB responds by accumulating international reserves and, on a broad sense, injecting liquidity. CB interventions lead to offset the currency appreciation and also to lower interest

[17] It should be noted that external shocks, as supply shocks, are permitted to have permanent effect and admit a common-trend interpretation.

rates. As a matter of fact, interest rate goes on a permanently lower level and exchange rate goes on a slightly higher level when compared to the steady-state paths they would have developed in the absence of shocks but these results are not statistically significant. The monetary aggregate shows a reduction which takes place a year after the shock being statistically insignificant earlier probably because the CB efforts to provide liquidity in the initial stage of the shock. Since then, money supply adjusts to a lower level consistent with the (also) lower level of output.

Figure 8: IRFs for u_t^{EX} interest rate (left), exchange rate (center) and reserves (right).



Finally, it is instructive to analyse the consequences of monetary policy and exchange rate innovations.[18] Both shocks have a small negative effect on output and prices during a very short term (of a couple of months) after which they become negligible and statistically insignificant. This suggests that the macroeconomic impact of monetary policy innovations and exchange rate is immaterial.

Figure 9: IRFs for u_t^{MP} on GDP (left) and the price level (right).

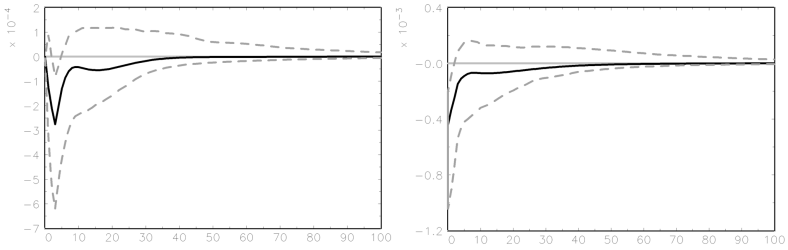
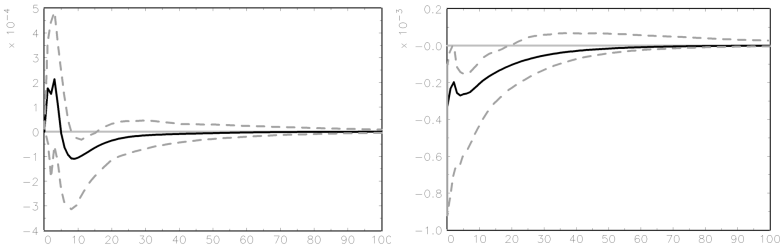


Figure 10: IRFs for u_t^{ER} on GDP (left) and the price level (right).



When turning attention to the financial sector the implications are as follows. A monetary policy shock raises the interest rate and lowers the exchange rate (this is the channel through which it affects negatively the real side of the economy but, as previously noted, the net impact is virtually irrelevant). The effect on liquidity is negative and lasts for a quarter or two. This is to say that a positive innovation reflects an unsystematic (or unexpected) policy with a contractive stance.[19]

An exchange rate shock has no apparent effect on interest rates (and if there was such an effect the IRF tells that it would be initially positive in line with uncovered interest rate parity) but implies an upward movement of exchange rate, that is, currency depreciation. Liquidity experiments a reduction after the shock, recovering to its long-run level as the time horizon recedes. On the other hand, international reserves increases which suggests that the shock could be engineered by an unanticipated intervention of the Central Bank on foreign exchange market.

[18] Exchange rate shocks are interpreted broadly: they are not necessarily the unsystematic component of an explicit exchange rate policy carried by the Central Bank (since a flexible float strategy -with occasional interventions- was followed mostly before the Subprime Crisis). These shocks can also be attributed to any other changes affecting the foreign exchange market.

[19] This seems natural since the shock was normalized with respect to the interest rate.

To gain further insight variance decomposition (VD) of prediction errors are performed.

It can be seen from the figure showing the VD of output that aggregate supply and demand shocks volatility explain virtually all the volatility of output in the very short-run: supply shocks account for around 15% of it while the remaining is explained by demand shocks. In the mid-term, external shocks gain importance and supply shocks increase their share progressively as demand shocks reduces its influence. After 100 months, supply shocks explain about 65%, demand shocks 15% and external shock 20%. It is a salient feature of the VD that monetary sources are completely irrelevant for explaining the volatility of output.[20]

Turning attention to the price level, the VD reveals that in the very short-run, unanticipated changes in monetary policy and innovation in exchange rate market account for about 40% of price level volatility. These sources of volatility tend to diminish their share as times goes by. A minor importance can be attributed to aggregate demand and external shocks both in the short and the long-run and a mayor importance to aggregate supply shocks (with its share ranging from 50% to 90% in a 100-month period).

For the monetary aggregate, it should be noted that the permanent shock that prevails in the long-run is the external shock (above 70% in a 100-month period) which suggests that there is a close link between variations on liquidity in the domestic economy and the international economy. The aggregate supply shock reaches a peak of 50% at the 12th month and then falls to a 25% share at the 100th. As it is expected, monetary policy and money demand shocks explain much of the volatility of monetary aggregate in a 12-to-18 month period (starting over 40%). Finally, very little influence of aggregate demand and exchange rate shocks can be found (practically null).

The VD for international reserves exhibits a mayor relevance of external shocks both in the short and the long-run (its share ranges from 60% to 80% in a 100-month basis). Exchange rate shocks account for an important fraction in the short-run (beginning at the 25% level). There is also a very stable share (of around 15%) of shocks which affect mainly the output level (supply and demand) that can be though, as noted earlier, in terms of a self-insurance strategy. Finally, monetary sources play very little role in explaining volatility in international reserves held by the CB. This could point out that monetary policy is implemented mainly through money market interventions relative to foreign exchange market interventions.

When concerned about interest rates, it must be said that both supply and external shocks tend to enlarge their share as the time horizon is extended and that exchange rate shocks volatility explain almost nothing of the interest rate volatility (this was already noted when the IRFs where analysed). On the other hand, money demand and aggregate demand shocks volatility have a large share in the interest rate volatility. The former's contribution is concentrated mainly in the first 6 months (reaching a maximum of 60%) while the latter's contribution is concentrated largely in the 6-to-18 month interval (with a maximum of 50%). Also, monetary policy shocks impinge some volatility (around 25%) to the interest rate in a very-short-run basis.

The last VD is the one of the exchange rate. It is interesting to note that supply shock volatility dominates in the long-run because it points out that such a shock should be interpreted in a broad sense as affecting productivity and competitiveness.[21] External shocks, exchange rate shocks and monetary policy innovations contribute to a 65% of the volatility of the nominal exchange-rate in the very short-run. That exchange rate shock has a significant share that follows from the definition of this shock.[22] It must be added, although, that it does not explain everything. The importance of external shocks suggests that the CB prefers to accommodate external disturbances primarily through exchange rate and secondly through international reserves on impact. Also, it should be said that when an unanticipated change in monetary policy occurs, which affects the relative attractiveness of domestic assets compared to foreign ones, the transmission mechanism to exchange rate operates through the capital account. Finally, neither aggregate demand nor money demand shocks posses a significant share in exchange rate volatility.

[20] The prominence of the two permanent (common-trend) shocks in the long-run is expected to prevail in all the variables as their volatility is much more persistent than that of transitory shocks.

[21] Productivity in the tradable sector is a core feature of an economy's insertion in the global economy. The relation between productiveness and exchange rate is the following: the more productive tradable sector, the lower exchange rate in the long run.

[22] It is a residual that captures innovations in exchange rates not explained by other sources.

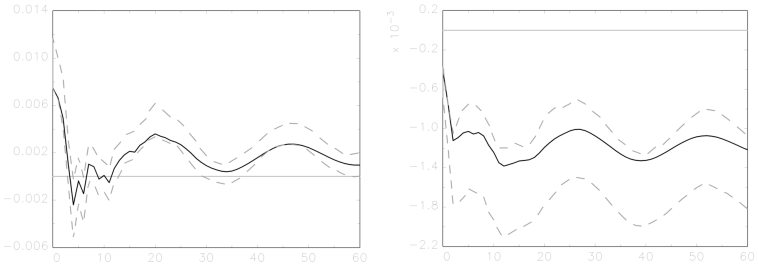
4.2 Brazil

In January 1999, after a currency crisis, Brazil implemented an inflation targeting regime with flexible exchange rate.[23] This regime generated an amazing performance in terms of inflation and economic growth rates, which put the country as the sixth biggest economy in terms of GDP in 2011. However, as a result of the liquidity injections of the world's major economies since 2008, economic policy conducted by the CB in Brazil had a huge challenge given the observed massive capital inflows: In order to contain inflation and prevent an excessive growth in the activity level, a Central Bank can increase interest rates. However, it will attract more foreign capital and further appreciate the domestic currency. Alternately and jointly, the CB could intervene directly on the foreign exchange rate market or on capital inflows[24], allowing "dirty float" of the currency in what is called an impure floating scheme. This implies an accumulation of reserves which is associated with two disadvantages: first of all, in the event of not being sterilized, it will generate upward pressure on the short and long term price level; and, secondly, holding reserves in excess has a high opportunity cost.

With the aim of analysing the way in which monetary policy and interventions in the exchange market are carried out by the CB of Brazil on a context of uncertainty, a VECM with four cointegration relationships is estimated. That is, when determining the specification of the model, it is considered that two shocks generate permanent effects (supply shocks and external shocks), while four of them generate non-permanent (transitory) effects (aggregate demand, money demand, exchange rate and monetary policy shocks). However, alternative specifications were considered in order to determine if policy shocks have permanent effects mainly on inflation and output.

For the period considered, empirical evidence suggests that supply shocks generate immediate impact on production levels (probably after a change in stocks) and in the long term. Note that although the shock does not seem to have significant effects on subsequent periods, this is not maintained in the long run. The reason for this lies on the fact that producers can readjust capital, production plant, workforce employed, etc., that enable a permanent increase in production levels. Related to prices, the result is a reduction in short, medium and long term. Even the latter is higher than the former, implying an initial reduction in the rate of inflation which tent to vanish as time goes by.[25] Thus, prices remain below the level that would have prevailed in the absence of the shock.

Figure 11: IRFs for u_t^{AS} on GDP (left) and the price level (right).



Aggregate demand shocks also generate contemporary effects on GDP although they are of smaller magnitude than the ones generated by a supply shock.[26] For every unexpected unit increase in the aggregate demand (aggregate supply), output in that period increases in 0,50% (0,75%). Moreover, the shock generates significant effects on prices of subsequent periods, unlike what is observed on the product.

How does the monetary authority respond to those shocks? If a supply shocks occurs, the CB will allow an increase in the exchange rate and a reduction in the reference interest rate. In an economy where about 80% of imports are production inputs[27], an increase in GDP leads foreign currency demand (and, therefore, its value) to rise. International reserves, on its side, do not vary significantly confirming that the adjustment in

[23] Monetary policy until early 2003 focused mainly on monitoring the exchange rate rather than adopting an inflation targeting regime given that the contextual conditions required so. However, from there to the present, the inflation targets are the main target taken into account by the monetary authority when deciding on policy measures.

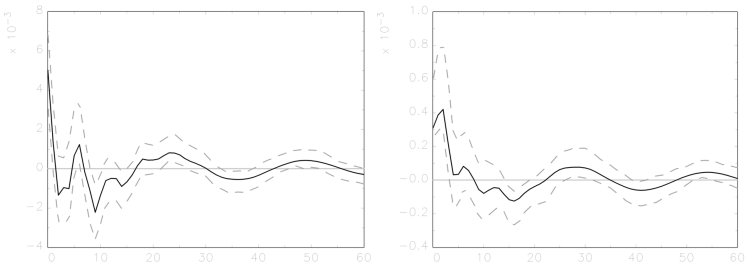
[24] China is an example of an emerging country which is able to prevent that these capital flows cause too many problems because it has strong capital controls and it does not allow its currency to appreciate.

[25] Estimated parameters are $\Xi B_{2,1} = -0,12\%$ y $B_{2,1} = -0,04\%$.

[26] Under alternative specifications, the remaining shocks do not show significant effects on GDP at the time they occur.

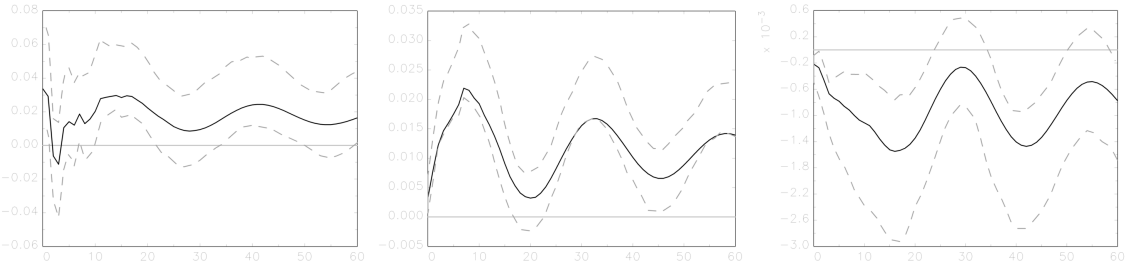
[27] Specifically imports of raw materials and intermediate goods, capital goods and fuels and lubricants are considered.

Figure 12: IRFs for u_t^{AD} on GDP (left) and the price level (right).



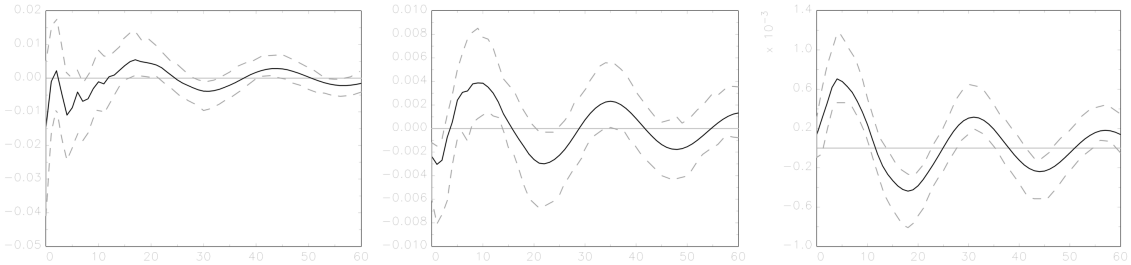
the exchange market is mainly through prices rather than quantities. Since the supply shock is understood as an increase in production possibilities, the CB reduces the reference interest rate to stimulate the investment necessary to validate the increase in output. That is, without departing from the countercyclical behaviour that the Taylor Rule suggests and realizing that the shock affect not only the effective but also the long run GDP, the CB validates the permanent increase in production though a reduction of the interest rate.

Figure 13: IRFs for u_t^{AS} on international reserves (left), exchange rate (center) and interest rate (right).



On the other hand, if the real shock comes from the aggregate demand, the monetary authority will respond in a different way. The interest rate will increase with several lags, so as to act counter-cyclically, reducing output volatility and avoiding a greater increase in prices. The adjustment mechanism in the exchange market, on its side, will be similar in the sense that the adjustment will be done via prices (exchange rate) instead quantities (international reserves). As a result, the aggregate demand shock brings an increase in the demand for money and, therefore, a appreciation of the local currency in terms of the foreign one.[28]

Figure 14: IRFs for u_t^{AD} on international reserves (left), exchange rate (center) and interest rate (right).

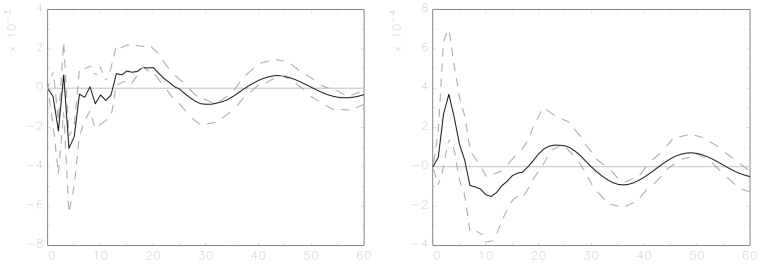


Like Chile, the interpretation of the money demand shock is not clear not only in what concerns about the response of the macroeconomic variables but also about what happens in the money market and the exchange market. The impact on GDP seems no to be important within a year since it takes place. However, between 13th month and 22th, it turns positive and statistically significant meanwhile, since 23th month to 46th it continue being significant but negative. Similar facts can be seen in the response of the level of price. On the other hand, in the money market the liquidity goes up and the interest rate fall in the very short

[28] Given the identification constraints of the model, aggregate demand shocks do not generate long-term effects in the system.

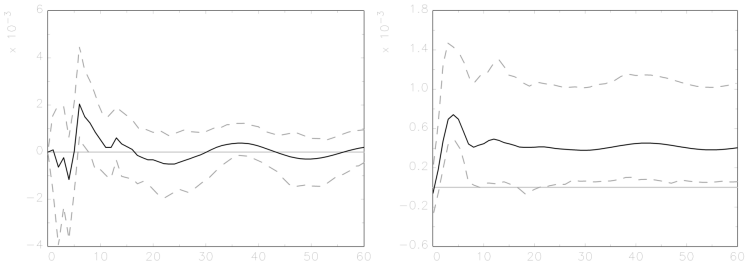
run. After several months, financial variables go in a zigzag path so that it is impossible to be conclusive related to the effects of that shock. The same occurs in the exchange market, where the exchange rate goes up but the quantity of reserves does not vary significantly.

Figure 15: IRFs for u_t^{MD} on GDP (left) and the price level (right).



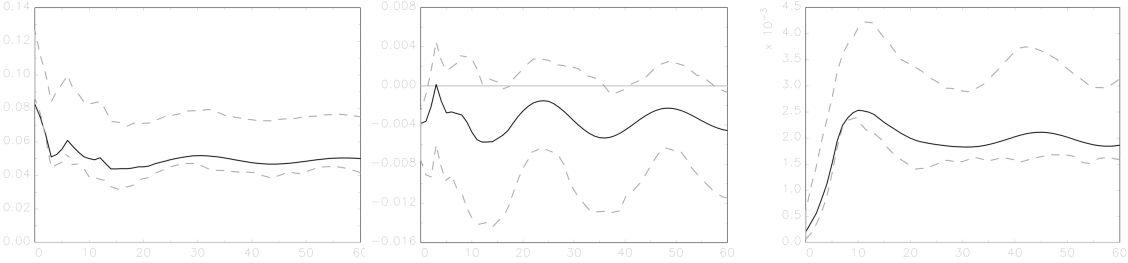
The effect of an external innovation on GDP is not statistically significant in the short, medium and long run term and the price level responds with an initial overshooting which gradually dissipate until it reaches a new long run value (greater related to the pre-shock value).[29]

Figure 16: IRFs for u_t^{EX} on GDP (left) and the price level (right).



The adjustment in this case is done primarily through a reserve accumulation and an increase in the interest rate in a permanent way. The reduction in the exchange rate takes place only in the very short run and it is not as deep as the adjustment through quantities. As can be inferred from the variance decomposition, the interest rate and international reserves are the variables that mainly absorb the volatility generated by the external sector. This policy intervention explains why GDP is not significantly affected by the occurrence of the shock. Also, the increase in the interest rate is one of the reasons for prices not to react in the long run.

Figure 17: IRFs for u_t^{EX} on international reserves (left), exchange rate (center) and interest rate (right).



The impact of an exchange rate innovation[30] neither produces significant effects on output[31] nor generates

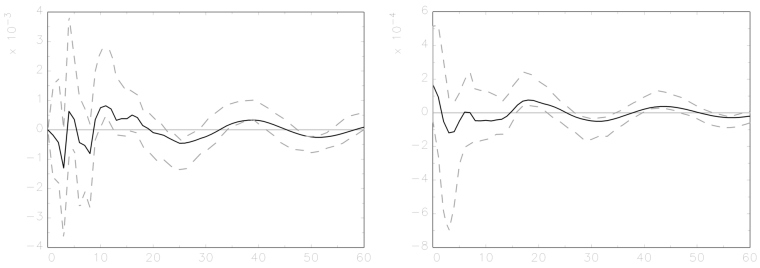
[29] In terms of inflation, the dynamics of the price level implies an initial increase in inflation that then has a slowdown and, when the price level is set at a higher level, the additional inflation that the economy must endure for the shock is zero.

[30] Remember that this shock has to be interpreted in a broad way.

[31] Restrictions chosen determines, partially, the outcome. In this case, other specifications were considered in order to allow the exchange shock to have contemporaneous and long run effects on GDP. Results were no different from the ones presented here.

a pass-through to prices in the short term. Anyway, estimated values of B show that the sign obtained conforms to the expected results: a positive exchange rate shock induces an increase in prices.

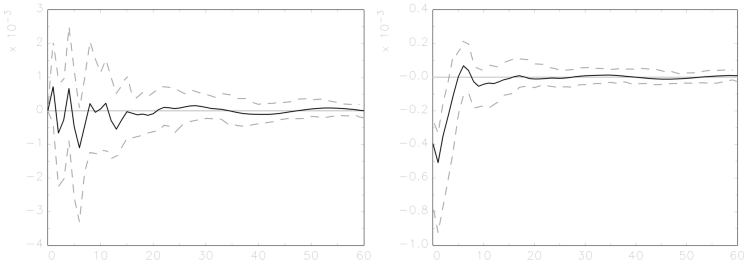
Figure 18: IRFs for u_t^{ER} on GDP (left)and the level of price (right).



From the estimated values of B, it is also possible to see that effects are significant only on the interest rate and the exchange rate. That is, the empirical evidence reinforces the idea that the monetary policy and the exchange rate are not independent and therefore, it is necessary to incorporate the interest rate as a function of the price of foreign currency in the Taylor Rule. When considering the variance decomposition of the interest rate, it is seen that in the very short run (2 months) the volatility of this variable is explained in more than 20% by the volatility of the exchange rate. Given the considered specification, these shocks do not generate long-term effects.

A positive monetary policy shock, as expected, reduces prices at the moment the shock takes place and also in the three subsequent periods but, since then, they tend to fade. GDP, on its side, is not affected in the short as well as in the medium term. It is necessary to emphasize that although long-term effects were restricted to identify the structural model, other specifications were considered in order to determine whether, under any of them, monetary policy could influence production and prices. As a result, none of them have shown statistically significant effects.
Monetary policy shocks have no effects, also, on the financial side of the economy, except for the interest rate. As was stated above, the monetary authority has the ability to control the short run interest rate but it does not imply that it can control the long run value. The corresponding IRF is in line with this asseveration because it evidences that the effects of the shock last about a quarter.

Figure 19: IRFs for u_t^{MP} on GDP (left) and the price level (right).



To summarize, it is possible to state that GDP responds in the short run to both aggregate supply and aggregate demand shocks, with greater intensity in the first of them than in the second one, while in the long run only supply shocks that shift the production possibility frontier of the economy, increase production levels permanently.

Short-term prices respond negatively to supply and monetary policy shocks and positively to aggregate demand shocks; meanwhile, in the long run, they are negatively affected by and aggregate shock. An external shock, on the other hand, induces an increase in the price level in both the short and medium run but it does not produce a significant change in the long run.[32]

The amount of money in the short run responds to changes due to transactional reasons (real output and

[32]This is probably the result of an increase in international prices that pass-through to domestic ones and/or an increase in the amount of money in the local economy (by accumulating reserves) whose liquidity is not absorbed by an increase in transactions but it is absorbed through a price increase (not statistically significant).

price level) as well as to external shocks because all capital income would increase the liquidity level of the economy in case the monetary authority did not sterilize that increase.

Related to the interest rate, it responds to shocks in aggregate supply and demand, in an opposite way, as explained above; to external shocks, in order to avoid that the uncertainty and volatility of the rest of the world were absorbed by the main macroeconomic variables, such as prices and product; and to shocks of exchange rate.

From the dynamic observed in the exchange market, a conclusion deserve to be stressed: in the short run, it seems to be that international reserves held by the Central Bank fully react to external shocks (unexpected changes in supply and exchange rate shocks seem to generate some variation but they are not relevant); whilst the exchange rate responds mainly to domestic shocks(of aggregate demand and supply, and of money demand).[33]

Finally, variance decomposition is performed in order to determine the sources of volatility of the main macroeconomic variables (output and prices) and policy instruments (exchange rate, international reserves, and reference interest rate).

In the case of the product, volatility is transmitted primarily through real factors, namely: aggregate supply and demand shocks which explain more than 80% in both the short and the medium and long run. Prices, unlike GDP, in the very short term absorb the interest rate and aggregate demand shocks volatility. However, in the long run, the share of the interest rate volatility vanishes while uncertainty from the rest of the world and aggregate supply shocks take the center of the stage.

When analysing the variance decomposition of the interest rate, it is necessary to make a temporal distinction. In the very short run, a monetary and exchange rate shock explain about 75% of the volatility of this variable, while focusing on medium and long term, over 70% of the volatility is explained by external shocks and more than 90% if it is also considered aggregate supply shocks.

Exchange rate shows differences according to the time horizon considered. Specifically, if the analysis is focused on the short run, the conclusion is that money demand and exchange rate shocks explain more than 50% of the volatility of the price of the foreign currency, while in the long run supply shocks seem to be responsible for more than 75% f that uncertainty. The volatility of the reserves held by the monetary authority, meanwhile, is mainly due to the uncertainty in the external environment (over 80%) and to a lesser extent (10%) by changes in aggregate supply.

From the sample considered, it is possible to conclude that Brazil was immersed in an international context that pushed a massive capital inflow. This would imply an appreciation of its currency provoking effects on price competitiveness of exports and threatening to become more relevant the primary sector; or an accumulation of international reserves, which would entail higher levels of inflation that would also harm their competitiveness and may lead to an excessive growth of its economy ending in a crisis. All above implies that the Central Bank of Brazil has adopted a pragmatic and flexible approach that combines several instruments (accumulation of international reserves, reductions in the reference interest rate, imposing taxes on capital inflows, etc.) in order to soften the appreciation of its currency without allowing inflation away above his upper band.

4.3 Argentina

Argentina abandoned the Convertibility regime (which lasted 10 years) in late 2001. This regime was characterized by a monetary authority that functioned as a kind of a currency board and with fixed exchange rate set in 1 peso per U.S. dollar. When abandoning the fixed exchange rate regime, not having been the result of a gradual process, some traumatic effects on the economy were generated: annual inflation reached 26%, GDP contracted by 10%, there was a disruption in the financial system, real wages decreased 20% in the industrial sector and unemployment rate increased to record levels (21,5% in the first quarter of 2002). In the second half of 2002, a phase of normalization in monetary and financial variables took place and the exchange rate began to experience a clear trend to nominal appreciation. The process of both nominal and real appreciation stopped in mid-2003, when national government started to base its economic policy on three pillars: fiscal surplus, external surplus, and competitive exchange rate.

A new monetary program that was published in June 2003, gave place to a new monetary regime. The

[33]The exchange rate reaction to changes in the external environment seems to be of very short duration.

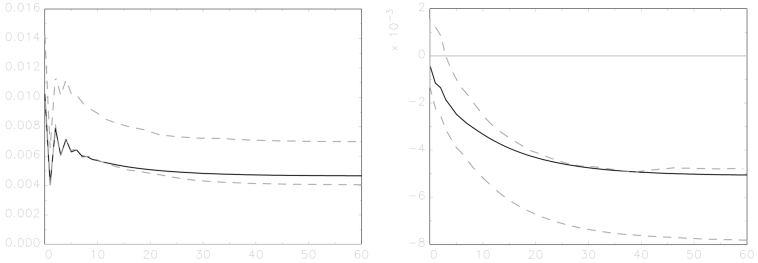
Central Bank of Argentina[34](BCRA) would announce its annual targets for creating money and would publish quarterly compliance (or not) of the plan. The credibility of the monetary authority started to vanish when that commitment was not fulfilled. In this regard, it must be mentioned that while in the beginning the goal was determined taking into account the monetary base, since 2006 the variable to control was M2; the objectives of the 2010 program (announced in late 2009) were modified in the course of that year; and finally, in the fourth quarter of 2012 the annual M2 growth exceeded the upper band program objective.[35]

During the first years of the program, the high exchange rate generated an incentive to increase exports, provoking significant foreign currency inflows that were absorbed by the BCRA. That is, buying foreign currency, the CB not only could maintain a competitive exchange rate but also accumulate international reserves without exposing the performance of the monetary program. However, since 2005, macroeconomic evolution began to show difficulties in managing both policies simultaneously, which was reflected in a gradual acceleration of the inflation rate.[36] The public perceived that the exchange rate was lower than its equilibrium value so capital flight reached levels higher than the US$ 20,000 million. This motivated the implementation of exchange controls by CB, which were introduced in November 2011, and gradually deepened as time went by. Thus Argentina entered into a managed floating exchange rate regime with exchange controls.

In order to draw conclusions regarding the dynamics of the GDP and the price level given the economic policy implemented by the monetary authority in Argentina in the time under analysis, a VECM is proposed. Given the considered sample and depending on the Johansen Trade Test, three cointegration relationships are found. It implies that three will be the variables whose shocks may generate long-term effects (according to the selected specification these are supply shocks, monetary policy shocks, and the external shocks), while the remaining (aggregate demand, money demand, and exchange rate policy shocks) are considered the transitory ones.

The model suggests that a positive supply shock increases the economic output and lowers prices permanently. Even in the long term, the adjustment is similar[37]: while the output elasticity is 0,46%, prices elasticity is -0,51%. As effects on the price level are not constant, the inflation rate is lower than the value that would have prevailed in the economy in the absence of it.

Figure 20: IRFs for u_t^{AS} on GDP (left) and the price level (right).



When faced whit this shock and since the CB has a commitment related to the liquidity of the economy, the money market reaches a new equilibrium with a higher interest rate and the same quantity of money.

In the exchange market, unlike the money market, the adjustment is through quantities instead prices. That is to say that international reserves go up (after several periods since the shock occurs) and the exchange rate assume little influence. This combination of results suggests that the aggregate supply shock encouraged an increased in exports[38] because of the rise in the production possibilities of the economy. If

[34]In 2012, the charter of the institution was changed by setting a multiple mandate that not only promotes monetary and financial system stability but also seeks for full employment of resources and economic development with social equity.

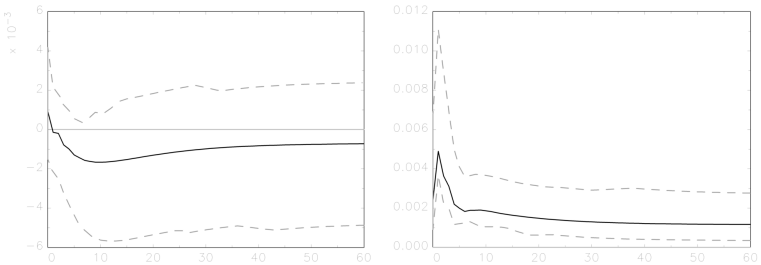
[35]Total M2 goals for 2012 were an increase of 6,2%, 12,9%, 18,1% and 26,4% for the first, second, third and fourth quarter of the year compared to the value that the stock assumed in December 2011. However, the increases observed were -5,9%, 8,2%, 10,6%, and 38,4%, respectively.

[36]Particularly, the difficulty of carrying out both policies when an increase in inflation is observed, is due to the CB (in order to stop inflation) should reduce the liquidity of the economy, which would push up the interest rate. This will imply a nominal appreciation of the local currency if the exchange rate floats freely (which is opposed to the will of reaching a competitive exchange rate).

[37]See ΞB and B in the appendix

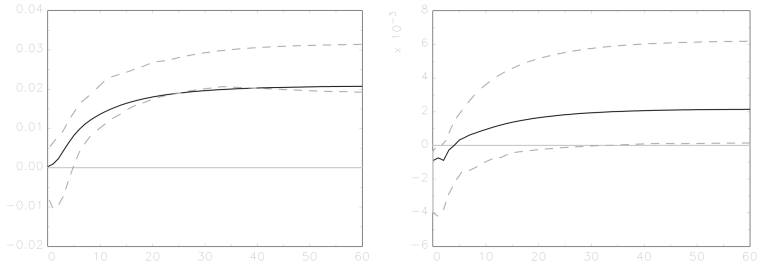
[38]Theoretically, the shock could be attract foreign direct investment but in practice the main source of foreign exchange settlement are agricultural exports and its derivatives.

Figure 21: IRFs for u_t^{AS} on M2 (left) and interest rate (right).



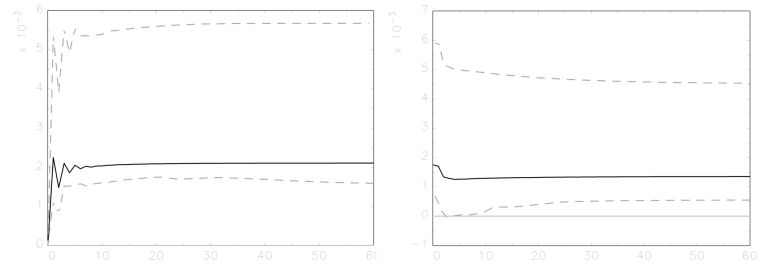
the supply innovation were the result of an increase in the factor productivity, it may involve a reduction in imports balances. The absorption of these foreign currencies by the monetary authority is what allows that the effects on the exchange rate were not significant.

Figure 22: IRFs for u_t^{AS} on reserves (left) and exchange rate (right).



In the presence of an external shock, both GDP and the price level increase significantly in the short and medium term. For prices, the initial increase is greater than that which is then perpetuated in the medium and long term, so that this implies an increase of inflation only at the initial time.

Figure 23: IRFs for u_t^{EX} on GDP (left) and the price level (right).



The behaviour of international reserves suggests that the CB absorbs foreign currencies when they are settled and it sells them in the market a few months after the shock. Thus, the change in the international reserves is not statistically significant. In an economy in which more than 80% of its imports are capital goods and inputs for production and where an external shock leads to a higher production level[39], it is to be expected that the international reserves which were sold by the monetary authority to the market are bought by those producers whose inputs are imported. Moreover, this also explains the permanent increase in the observed exchange rate after the occurrence of the shock.

The Central Bank, meanwhile, validates the increase in the needed amount of money to finance the higher level of nominal transactions that takes place in the economy after the shock. Otherwise, monetary policy would be countercyclical and, while it might attenuate the increase in the price level, it would inhibit the increase in the output as it is observed in the corresponding IRF.

[39]Imports have increased by 35% in the period under analysis, while the economy did it around 8%.

Figure 24: IRFs for u_t^{EX} reserves (left) and exchange rate (right).

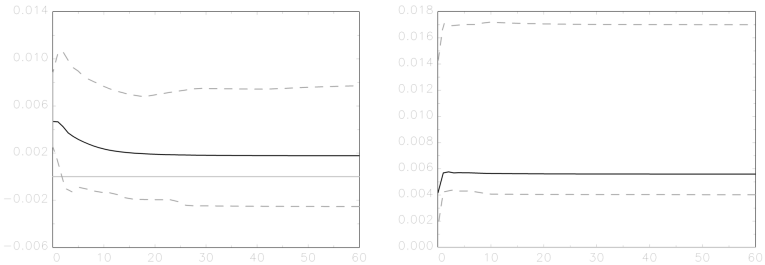
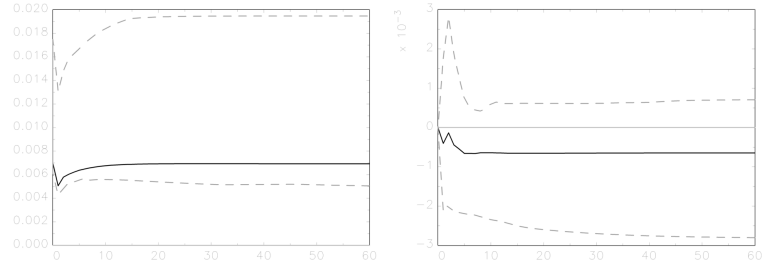


Figure 25: IRFs for u_t^{EX} on M2 (left) and interest rate (right).



As mentioned earlier, a period of stagflation was observed in Argentina's economy during 2012, with zero growth and the annual inflation exceeding 20%. In this context, the CB increases the monetary base to a rate higher than 35% yoy, what centers economists debate on whether the quantity theory is verified (or not) and how soon it provokes its effects. The judgement from the sample considered implies that a monetary policy shock does not seem to generate significant effects at the time this happens. However, after observing the IRF and the ΞB matrix, it is possible to asseverate that an unexpected increase in liquidity of the economy affects the price level in the medium and long term. Moreover, since the effect on prices increases as time goes by, the rate of inflation will be higher than the one that would prevail in the economy in the absence of the shock.

In terms of GDP, a monetary policy shock negatively affects output in the short and medium term with several lags. While this result is not expected from the point of view of standard theoretical models, it is possible to base on theories where the interaction between economics and psychology are considered.[40] In the '70s account imbalances from the public sector have conditioned the independence of the CB and the performance of key macroeconomic variables. So, in most Argentine crisis, fiscal deficit has been a necessary ingredient as were stated by Amado, Cerro & Meloni (2005).

Since 2005, public accounts had showed a surplus decline which turned into deficit 2009. This deficit have been financed by printing money. Since public funds are used inefficiently,[41] public expenditure is not translated into an increased production and influences economic agents's behaviour. That is, a representative agent begins to allocate their funds to investments that protect him from inflation and, furthermore, if it is expected that this kind of shocks turn recurrent, speculative investments are encouraged, harming the economy, at the expense of productive investments.

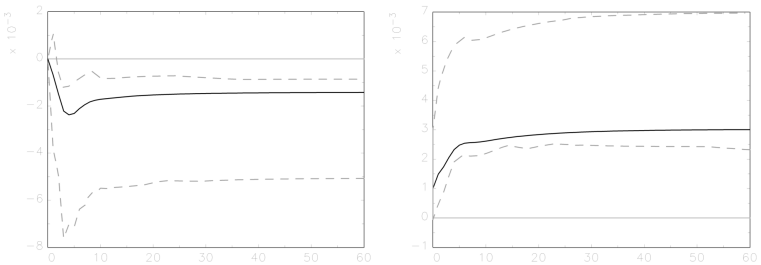
In the money market, as expected, the shock generates an increase in liquidity and a reduction in short, medium, and long term interest rate. This is the increase in liquidity which not being absorbed by an increase in the activity level, translates into a price increase. Finally, as it is observed in the corresponding IRFs, the monetary shock generates an increase in international reserves held by CB in the short run, because this was the main source of primary money creation until 2011. Then, public sector overtook that place. This, together with the scarcity of foreign currency relative to domestic one, would suggest that the exchange rate should increase after the shock. However, the dynamics of this variable showed by the IRF does not yield the expected result.[42]

[40] This field of study is known as behavioural economics.

[41] Economic subsidies to inefficient firms are on the rise, while real investment spending shrinks. This shows bottlenecks in some sectors and an outdated infrastructure that will limit economic growth.

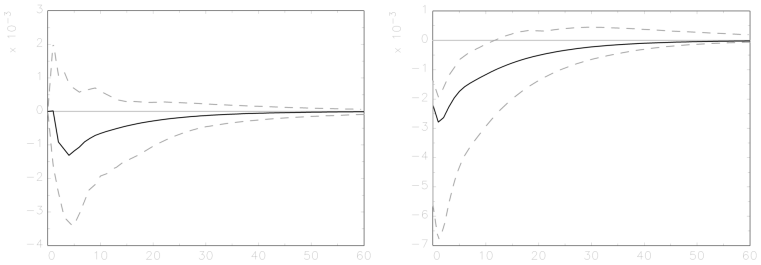
[42] This could be mainly attributed to problems associated with the sample or the identification scheme.

Figure 26: IRFs for u_t^{MP} on GDP (left) and the price level (right).



When faced to an unexpected increase in the net demand for foreign currency, GDP does not respond significantly. In this regard it should be mentioned that although the model identification determines this, under alternative specifications the shock effects are not significant either. On the other hand, the shock induces a fall in prices in the short run. As the last result were not expected from a theoretical and empirical point of view, it provides a starting point for future research to improve the performance of the model to explain the economic relations in Argentina.

Figure 27: IRFs for u_t^{ER} on GDP (left) and the price level (right).



In the exchange market, the shock pushes up the exchange rate, which is immediately offset by the monetary authority because, under the managed floating scheme, the CB intervenes in the exchange market seeking to reduce nominal short-term volatility. This is seen in the increase of international reserves held by the CB. However, as the IRF shows, liquidity in the economy does not vary significantly, suggesting that a sterilization process is being carried out. This, together with the stability of the exchange rate, explains that the interest rate does not respond to the shock. In other words, in a context where the liquidity of the economy does not vary and considering, at the same time, that uncovered interest rate parity is verified, it is expected that the interest rate in local currency looks unchanged.

Since Argentina, like many other emerging and developing countries, has a high volatility in their macroeconomic variables, it is necessary to analyse the sources that generate that volatility. For this, results of the variance decomposition of each variable are presented in the appendix.

Over 75% of output volatility is explained by supply shocks not only in the short but also in the medium and long run. The second source of volatility is the external shocks, whose share increases as time goes by: while in a period of six months they explain only 5% of the output volatility, in the long run they triple that percentage. On the other hand, exchange rate shocks and shocks which comes from the money market explain a have a small share as a source of volatility.

Prices volatility is explained by a combination of several shocks. In the short term, exchange rate shocks are the main source of uncertainty and, as time goes by, this fades up to explain only 1% in the long run. Something similar happens with external shocks: while in the very short term they explain 15%-30% of the price volatility, in the medium and long term they explain only 5%. So, the observed variability of prices in Argentina is mainly due to domestic factors and the monetary policy shocks play an important role.[43]

The variance decomposition of the amount of money and international reserves, could provide clues about the uncertainty that the monetary authority absorbs through its policy instruments to mitigate the volatility of macroeconomic variables such as output and prices. As noted, money market shocks (through supply and

[43] They account for about 25% approximately.

demand shocks) and external shocks are the main sources of volatility in the amount of money in the economy. In the case of money demand shocks, its share vanishes gradually from 40%-50% in the very short term (first quarter) to less than 5% after three years. Thus, variability of liquidity in the long term is not explained, for example, by transactional reasons (output and prices), but by monetary policy decisions and external shocks.

On the other hand, volatility of international reserves[44],responds to monetary policy shocks in the very short run. As mentioned above, rational behaviour of economic agents who have suffered from a large number of exchange and banking crises and who also saw the start of the gestation of these in a CB that financed the government unconditionally, explains the increase in the demand for foreign currency by the public (defined as store of value) that implies a change in international reserves given the CB´s will to keep the exchange rate stable. In the same line of analysis, exchange rate shocks -probably by an increase in uncertainty or by a loss of consumer confidence- generate high volatility on them in the short term. This is significantly reduced in the medium and long term. On the contrary, supply shocks explain a small part of the volatility of international reserves in the very short term, but they do it in more than 70% in the medium term and about 80% in the long run.

To summarize, it is possible to conclude that the CB operates under a scheme of monetary targeting and managed floating exchange rate -avoiding abrupt currency fluctuations without generating a commitment on the level or on the rate of change in the exchange rate- with exchange constraints. That is, the CB operates buying and selling foreign currency in order to moderate the volatility, respecting the trend determined by macroeconomic fundamentals. Evidence shown by the selected sample put into question the desirability of its results. This is so because if there is a monetary policy shock, the economy will register an increase in prices and a decrease in the level of GDP.

5 Concluding Remarks

The objective of the paper was to find some explanations about the responses Central Banks adopt when economies are under the pressure of both, internal and external shocks, and their influence on output and price level. In this respect, the monetary regime is crucial to describe those responses as they define the limit between a policy based on discretion or on commitment. More specifically, the monetary regime determines the availability of instruments to be applied in order to reach the policy objectives.

For an empirical account of these features, a Structural Vector Error Correction Model (SVEC) was estimated, being implemented on J-Multi. Impulse-Response and Variance-Decomposition analysis were performed.

Three important Latin American economies (Argentina, Brazil, and Chile) were analysed, considering their evolution during the last decade: two of them (Brazil and Chile) with similar monetary regimes in force (inflation targeting) and the other (Argentina) with a different monetary regime (a mix of quantity of money control and managed exchange rate).

At first, it is not possible to affirm that one regime is better than the other, but it is possible to draw conclusions on the success (or not) of a specific regime in a specific economy. For instance, considering the case of Argentina, it is not possible to say that the outcome of the monetary targeting regime is inferior −in the sense of not reaching the expected results− than that of the inflation targeting regime, because Argentina has not followed step by step the conditions required for a proper functioning of the regime (i.e., independence and accountability of the Central Bank).

In order to summarized main results, shocks are distinguished in internal (aggregate supply, aggregate demand, money demand and exchange rate shocks), external, and monetary policy shocks.

In the case of Chile, since the main instrument of the monetary authority is the short term interest rate, when facing an internal shock the adjustment is done trough money market and, in particular via price (that is to say, via the interest rate). When the shock is external, the CB intervenes the exchange market via quantities (that is to say, accumulating or disaccumulating international reserves). If the shock is provoked by itself (generating an increase in the reference interest rate), prices will fall in the very short run. This confirms that the monetary policy followed by the Central Bank of Chile is effective in reaching its objective.

In the case of Brazil, the way of facing internal shocks implies the use of all the instruments but international

[44]Since 2006.

reserves. However, in the presence of an external shock, the adjustment is done via a change of international reserves and, to a lesser extent, via interest rate. As can be seen, the Central Bank of Brazil seems to use a wide range of instruments both in the money market and in the exchange market. As was mentioned in the case of Chile, the monetary policy shock (represented by an increase in the interest rate) induces a fall in prices in the very short term.

Although Argentina theoretically follows a monetary regime, in practice it is not observed. The reason for that lies on the fact that the monetary authority is not independent of the central government and has no enough accountability to carry out a monetary regime. As a consequence, GDP decreases and prices has no change in the short run after a monetary policy shock occurs. Meanwhile, in the long run, an increase in prices is observed as the quantitative theory of money suggests. At the same time, there is an impact on GDP which is not statistically significant. Therefore, an unexpected increase in the quantity of money, done by the monetary authority, generates a welfare decrease revealing that the CB does not fulfil what should be its objectives.

Despite the obtained results, further research should be done on several directions such as the inclusion of other countries and other variables (for instance, fiscal and a greater detail on external accounts), the distinction between positive and negative disturbances (as it is expected, they could generate asymmetric responses which is not captured by a linear model) or the use of other econometric procedures (Bayesian method, different mix of restrictions). Additionally, a better treatment of the model could be intended to get more accurate determination of the residuals (for instance further research should be done on money demand to improve the estimation).

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