ASOCIACION ARGENTINA
DE ECONOMIA POLITICA

ANALES | ASOCIACION ARGENTINA DE ECONOMIA POLITICA

XLVIII Reunión Anual

Noviembre de 2013

ISSN 1852-0022
ISBN 978-987-28590-1-5

CREDIT AND INTEREST RATE SPREAD IN A SMALL MACROECONOMIC MODEL OF THE ARGENTINE ECONOMY

Aguirre Horacio
Blanco Emilio

Credit and Interest Rate Spread in a Small Macroeconomic Model of the Argentine Economy *

Horacio A. Aguirre† Emilio F. Blanco‡

August 2013

Abstract

We build and estimate a small macroeconomic model of the Argentine economy, augmented to depict the credit market and interest rate spreads ; and monetary policy with sterilized intervention in the foreign exchange market. We estimate it using Bayesian techniques; results indicate that shocks to lending rates and spread weigh on macroeconomic variables; likewise, the credit market is affected by macroeconomic shocks. We also find that the model augmented with credit market variables improves forecast performance over a conventional small model, and a model with foreign exchange policy but no "financial block".

Resumen

Construimos y estimamos un modelo macroeconómico pequeño para la Argentina, aumentado para describir el mercado de crédito, con tasas activas y spread de tasas de interés; y política monetaria con intervención esterilizada en el mercado cambiario. Estimando con técnicas Bayesianas, los resultados indican que shocks a las tasas de interés activas y el spread tienen efecto sobre variables macroeconómicas; y el mercado de crédito tambien es afectado por shocks macroeconómicos. Encontramos que el modelo con mercado de crédito mejora el desempeño predictivo de un modelo macroeconómico convencional y otro con política cambiaria pero sin "bloque financiero".

JEL classification codes: E17, E51, E52, E58

*All views expressed are the authors' own and do not necessarily represent those of the Central Bank of Argentina (BCRA).

†Economic Research, BCRA, Universidad de San Andrés and Universidad de Buenos Aires. Contact: haguirre@bcra.gob.ar

‡Economic Research, BCRA and Universidad de Buenos Aires. Contact: emilio.blanco@bcra.gob.ar

1 Introduction

As important as financial stability has become for monetary policy, standard models fail to reflect the integration of both dimensions: while so called "financial frictions" are gradually being incorporated in Dynamic Stochastic General Equilibrium (DSGE) models, the lack remains of a workable model of mid- to small scale that includes a representation of financial intermediation. We aim to incorporate financial stability aspects into a small open economy model of the Argentine economy, completely estimated and suitable for short-term forecasting and simulation exercises.

The financial side of the macroeconomy is built into central bank models in diverse ways, without a single unified and widespread framework comparable to the New Keynesian one. "Macro-modelling" options basically comprise financial accelerator effects, collateral constraints, and the explicit representation of banking intermediaries (see Roger and Vlcek, 2011, for a survey of central bank literature); the first two arise from some sort of informational asymmetry between lenders and borrowers. The financial accelerator is included, for instance, in Markovic (2006), Christiano et al (2010), and Dib (2010); collateral constraints are present in Andrés and Arce (2009), Lees (2009) and Gerali et al (2009); all of these models, generally built for North America and Europe, also include financial intermediation. In Latin America, modeling efforts have only recently been made for the depiction of financial issues in the macroeconomy. Perhaps the only fully fledged DSGE model with the explicit interaction of banks and monetary policy, designed and calibrated for a Latin American country before the international crisis brought these aspects to the foreground is that of Escudé (2008); he integrates both financial and real features of the Argentine economy, including intermediation through banks, that lend to families and whose deposits are subject to liquidity requirements. The central bank may influence macroeconomic performance through changes in interest rates, which impact on the banking system and its customers, and through foreign exchange intervention in order to moderate exchange rate volatility, thus weighing on decisions of firms which trade with the rest of the world.

The very same lack of an agreed framework to deal with financial stability in macroeconomic models also justifies the use of small structural ones, specially for applied work in central banks. For one, Sámano Peñaloza (2011) enlarges a small macroeconomic model for Mexico with a financial block in order to determine the interplay of macroprudential and monetary policy; the former is introduced through capital requirements. Szilagy et al (2013) also add financial variables to a standard small model in other to enrich the depiction of the Hungarian macroeconomy. Both of these models, while not explicitly derived from first order conditions of an optimization problem, show the basic New Keynesian structure. Other small macroeconometric models place some aspect of the financial market within an enlarged aggregate demand-aggregate supply plus monetary policy rule setting; the emphasis is more on econometric estimation and forecast; this group includes Ramanauskas (2006), Dushku and Kota (2011), Hammersland and Bolstad (2012), Grech et al (2013). Our model, in turn, builds on the insights of previous works done for Argentina (Elosegui et al, 2007; Aguirre and Grosman, 2010), while dealing with the financial dimension largely after Sámano Peñaloza (2011).

Our approach is basically empirical, in that a condition for model building is that parameters should all be estimated, therefore fully "letting the data speak". This stands in contrast with actual design and implementation of large scale DSGE models which, for all the richness of detail they provide, often rely to a substantial degree on calibration, being naturally less appropriate for estimation. Likewise, such models tend to be less workable in terms of forecasting: typically, smaller models forecast better than larger ones, with different models being used for different purposes (Canova, 2009). There is a place for representations of different sizes in a well-conceived modelling architecture, and enlarging semi-structural models already in use may be more useful than starting DSGE models from scratch (Roger and Vlcek, 2011). This is all the more relevant for central banks, where financial stability analysis has gained ground since the outbreak of the international financial crisis, with a pragmatic approach being favoured for the sake of incorporating this essential issue in formal models.

Within our general objective, we have both descriptive and forecasting goals. As for the former, we wish to improve the depiction of an economy where real aspects may not be dissociated from financial ones, i.e. where the financial sector may play a role in either originating or transmitting shocks (Borio, 2012). In this sense, our model involves an improvement from conventional comparable ones in two ways: a richer description of monetary policy, with the central bank using both interest rates and sterilized foreign exchange intervention as instruments, the monetary repercussions of which are explicitly acknowledged; and credit market dynamics, capturing the interplay of credit and interest rate spreads with the rest of the economy. We also want to find out whether short term forecasts may be improved using such an "augmented" model: if taking into account aspects of financial intermediation improves forecast performance over that of standard model. Our framework may also be appropriate to enquire whether macroprudential policy, implemented with some degree of concern for financial stability, may lead to better performance (for instance, less variability) of certain key variables -a point which may be introduced in further versions of the model.

The rest of the paper is organized as follows. Section 2 describes the model; section 3 presents the estimation and impulse-response functions that illustrate the basic workings of the estimated model. Section 4 evaluates how the model performs vis-à-vis another one without the financial block, exploring to what extent the inclusion of the latter implies an improvement in terms of out-of-sample forecasting. Section 5 concludes

2 The model

Following work by Elosegui et al. (2007) and Aguirre and Grosman (2010), our baseline model is a small structural open economy model with a Taylor-type rule and foreign exchange market intervention, with the monetary effects that these imply. As the it already incorporates a money market equation, it provides a natural starting point for the introduction of a simplified financial block, where we describe credit market conditions (in the manner of Sámano Peñaloza, 2011).

The standard macroeconomic block of the model comprises both an IS curve (1), a Phillips curve (3) and a Taylor-type rule (4). The first two can generally be obtained as log-linear approximations of first order conditions of consumer's and firms optimization problems in a monopolistic competition setting with non flexible prices. The IS (1) also contains the spread between the active rate of interest (charged for taking credit, as will be specified below) and the short term interest rate; as in Sámano Peñaloza (2011) and Szylagy et al (2013), this term aims at capturing the impact of credit market conditions on aggregate demand, as it represents the "extra cost" above the short term interest rate that the non financial private sector has to pay to banks in order to obtain resources; alternatively, the sum of the short term rate and the spread may interpreted as the active rate that the private sector pays to obtain funds. Another additional term in the IS corresponds to the effect of fiscal impulse on aggregate demand[1]. In turn, the Phillips curve (3) is augmented to reflect the effect of foreign prices in the domestic economy, through an "imported inflation" component via the real exchange rate (where we use

[1] This feature is of no particular relevance to our ends in this note, but included in previous models actually used for forecasting.

the trade weighted real exchange rate, considering Argentina's three main trading partners). The Taylor rule (4) also captures a concern for nominal exchange rate variability, as the short term nominal interest rate changes in response to the latter, in addition to inflation and the output gap; the short term rate also depends on its own lagged values, showing a desire to smooth interest rate movements.

Foreign exchange conditions and policy, as well as the money market, are described in equations (5)-(9). A modified uncovered interest rate parity (UIP) condition (5) considers the effects of central bank operations in the foreign exchange market: the nominal exchange rate depends on expected depreciation, the difference between the local and the international interest rate, and a country risk premium that is made up of an endogenous component and an exogenous shock. The former is determined by interventions in the currency market: the central bank intervenes by buying or selling international reserves, and issuing or withdrawing bonds from circulation in order to sterilize the effects of intervention on the money supply. Monetary effects naturally require an LM curve: equation (9) describes equilibrium in the money market, which may be estimated for narrower or broader definition of monetary aggregates. How exchange rate intervention is instrumented is described by equation (8), whereby the central bank buys or sells international reserves in reaction to nominal exchange rate variability; equation (6) shows to what extent such intervention is sterilized.

Having characterized the basic macroeconomic dynamics, together with central bank policy in the monetar and foreign exchange markets, the following step is to consider lending rates and credit. In the model, credit is basically a function of the output gap and the lending interest rate, as shown in a credit market equilibrium equation (10). In turn, equation (11) describes active (lending) rates as a function of the output gap, non performing loans and the short term rate; the spread emerges naturally as the difference between the lending and money market rate. We consider total credit to the private sector in terms of GDP, and rates on commercial loans[2]; and non performing loans are exogenous (modelled as an autorregressive process). The rest of exogenous variables also follow autorregressive processes: the international interest rate, the exogenous component of risk premium in (5), foreign inflation, two measures of the bilateral exchange rate, the fiscal balance and potential output. Unless otherwise indicated, all variables are expressed as deviations from steady state values, denoted by a circumflex.

Macroeconomic Block

$$g_t^y = \beta_1 \mathbb{E}_t g_{t+1}^y + \beta_2 g_{t-1}^y - \beta_3 \widehat{r}_t + \beta_4 \Delta \widehat{e}_t^{tri} - \beta_5 \Delta \widehat{sf}_t - \beta_6 (spread_{t-1}) + \varepsilon_t^y \quad (1)$$

g_t^y : output growth rate, r : real interest rate, e^{tri} : trilateral real exchange rate (RER), sf : fiscal surplus to GDP ratio, and interest rate spread is defined as

$$spread_t = \widehat{i}_t^{act} - \widehat{i}_t \quad (2)$$

i_t^{act} : nominal active rate, i_t: nominal (pasive) interest rate

$$\begin{aligned} \widehat{\pi}_t &= \alpha_1 \mathbb{E} \widehat{\pi}_{t+1} + \alpha_2 \widehat{\pi}_{t-1} + a_3 y_{t-1} + a_4 \Delta \widehat{e}_t^{tri} + \varepsilon_t^{\pi} \quad (3) \\ & \quad where \\ \alpha_2 &= 1 - \alpha_1 \end{aligned}$$

[2] Alternatively, lending rates and credit may be considered for two different segments, commercial and consumption credit. We plan to do so in further versions.

π_t : inflation, $\mathbb{E}\widehat{\pi}_{t+1}$: expected inflation, y_t: output gap

$$\widehat{i}_t = \gamma_1 \widehat{i}_{t-1} + \gamma_2 y_t + \gamma_3 \mathbb{E}_t \widehat{\pi}^a_{t+1} + \gamma_4 \widehat{\delta}_t + \varepsilon^i_t \tag{4}$$

π^a : annual inflation, δ : \$/USD depreciation rate

FX Policy Block

$$\widehat{i}_t = \widehat{i}^*_t + \omega_1 \mathbb{E}_t \widehat{\delta}_{t+1} + (1-\omega_1)\widehat{\delta}_t + \omega_2 \widehat{b}_t + \widehat{\lambda}_t \tag{5}$$

i^* : international interest rate, b : CB bonds to GDP ratio, λ : exogenous risk-premium

$$\widehat{b}_t = \frac{1}{1-\phi}\left(\widehat{res}_t + \widehat{e}^d_t\right) - \frac{\phi}{\phi - \phi}\widehat{m}_t \tag{6}$$

$$\phi = \frac{m}{m+b} \tag{7}$$

res : international reserves to GDP ratio, m: money to GDP ratio[3]

$$\widehat{res}_t = \kappa_1 \widehat{res}_{t-1} - \kappa_2 \widehat{\delta}_t + \varepsilon^{res}_t \tag{8}$$

$$\widehat{m}_t = -\eta_1 \widehat{i}_t + \eta_2 \widehat{\pi}_t + \eta_3 \widehat{b}_t + \eta_4 \widehat{\delta}_t + \varepsilon^m_t \tag{9}$$

Financial Block

$$\widehat{CR}_t = A_1 \widehat{g}^y_{t-1} - A_2 \widehat{i}^{act}_{t-1} + A_3 \widehat{CR}_{t-1} + \varepsilon^{CR}_t \tag{10}$$

CR : Non financial private sector credit to GDP ratio

$$\widehat{i}^{act}_t = B_1 \widehat{Delinq}_t - B_2 \widehat{g}^y_{t-1} + B3 \widehat{i}_t + \varepsilon^{act}_t \tag{11}$$

$Delinq$: ratio of non performing loans to non financial private sector credit[4]

$$\widehat{Delinq}_t = \rho^D_1 \widehat{Delinq}_{t-1} + \varepsilon^{Delinq}_t \tag{12}$$

Identities

$$\widehat{e^{tri}_t} \equiv \widehat{e^d}_t + c_1 \widehat{e^{US,R}}_t + c_2 \widehat{e^{US,E}}_t \tag{13}$$

$$\widehat{r}_t \equiv \widehat{i}_t - E_t \widehat{\pi}_{t+1} \tag{14}$$

$$\widehat{\Delta e^d}_t \equiv \widehat{\delta}_t + \widehat{\pi^*}_t - \widehat{\pi}_t \tag{15}$$

$$\widehat{g}^y_t \equiv \Delta y_t + g^{\overline{y}}_t \tag{16}$$

$$\widehat{\mu}_t \equiv \Delta \widehat{m}_t + \widehat{\pi}_t + \widehat{g}^y_t \tag{17}$$

[3] The parameter ϕ is calibrated equal to 0.5833

[4] Just as a first approximation we consider an autoregresive process. In upcoming research we plan to incorporate a different structure.

$e^{US,R}$: USD/REAL RER, $e^{US,E}$: UDS/EURO RER, π^*: international inflation, $g^{\overline{y}}$: potential output growth rate, g^y : GDP growth rate, μ : money growth rate

Exogenous variables[5]

$$\widehat{i^*}_t = \rho_1 \widehat{i^*}_{t-1} + \varepsilon_t^{i^*} \tag{18}$$
$$\widehat{\lambda}_t = \rho_2 \widehat{\lambda}_{t-1} + \varepsilon_t^{\lambda} \tag{19}$$
$$\widehat{\pi^*}_t = \rho_3 \widehat{\pi^*}_{t-1} + \varepsilon_t^{\pi^*} \tag{20}$$
$$\widehat{e^{US,R}}_t = \rho_4 \widehat{e^{US,R}}_{t-1} + \varepsilon_t^{e^{US,R}} \tag{21}$$
$$\widehat{e^{US,E}}_t = \rho_5 \widehat{e^{US,E}}_{t-1} + \varepsilon_t^{e^{US,E}} \tag{22}$$
$$\widehat{sf}_t = \rho_6 \widehat{sf}_{t-1} + \varepsilon_t^{sf} \tag{23}$$
$$\widehat{g^{\overline{y}}}_t = \rho_7 \widehat{g^{\overline{y}}}_{t-1} + \varepsilon_t^{g^{\overline{y}}} \tag{24}$$

3 Estimation

We estimate this baseline version of the model (equations 1-24) completely through Bayesian techniques[6], based on quarterly data and for the 2003Q3-2011Q2 period; this is the longest period spanning an homogeneous macroeconomic policy regime -the currency board regime adopted in 1991 was abandoned during the 2001-2002 crisis, after which a managed floating regime was adopted. Bayesian techniques prove particulary useful for this kind of situation: if one knows that structural change has taken place, this information can be included in a way not allowed by classical estimation methods.

Bayesian statistics allows researchers to incorporate *a priori* information on the problem under study, thus potentially improving the efficiency of estimates -and reflecting a frequent concern of both analysts and policy-makers regarding how to include what they know from experience about the economy in a formal framework. Under this approach, parameters are interpreted and random and the data as fixed. Both features are particularly relevant when the sample size is small due to structural breaks, as it is the case of Argentine economy in the period we focus on. Define $\boldsymbol{\theta} \in \boldsymbol{\Theta}$ as the vector of parameters. Given the prior information $g(\boldsymbol{\theta})$, the observed data $Y_T = [Y_1, Y_2, ..., Y_T]$ and the sample information $f(Y_T/\theta)$, the posterior density -transition from prior to posterior- of the parameters is given by the Bayes' rule:

$$g(\theta/Y_T) = \frac{f(Y_T/\theta)\, g(\theta)}{f(Y_T)}$$

$$g(\theta/Y_T) = \frac{f(Y_T/\theta)\, g(\theta)}{\int_{\Theta} f(Y_T/\theta)\, g(\theta)\, d\theta}$$

Notice that $f(Y_T)$ (the marginal likelihood) is constant, hence the posterior density is proportional to the product of the likelihood function $f(Y_T/\theta)$ and the prior density. The inclusion of prior information allows then to generate a more "concave" density, which is crucial for parameter identification when the information contained in the data is considered insufficient; in

[5] Parameter ρ_7 is calibrated

[6] Model solution, estimation and stochastic simulations were performed using the Dynare 4.3.3 software platform in Matlab.

other words, if we want to know which alternative model parameters are more likely to have been obtained from the sample used, providing *a priori* information improves the ability to identify them correctly.

The modes of the posterior distributions can be easily computed using standard optimization routines -in our case we choose a Monte-Carlo based approach. However, obtaining the whole posterior distributions is considerably more difficult, requiring the calculation of complex multivariate integrals. For this reason, many algorithms have been developed to compute samples of the posterior distributions by efficiently using available information. The most popular is the Random Walk Metropolis-Hastings algorithm, which we use in our estimation. The algorithm applies a random walk as a jumping process to explore the posterior distribution of the parameters. We used two chains of 50,000 replications each. The variance of the jumps is calibrated to achieve an acceptation rate between 0.2 and 0.4, which is considered an acceptable target to ensure that the search is global.

The priors chosen are based on the posterior distributions from an estimation performed for the pre-crisis, currency board period. The set of observed variables Y is

$$Y = [\widehat{\pi}, \widehat{i}, \widehat{i}^{*}, \widehat{\pi}^{*}, \widehat{g}^{y}, \widehat{\delta}, \widehat{m}, \widehat{res}, \widehat{sf}, \widehat{e}^{US,R}, \widehat{e}^{US,E}, \widehat{CR}, \widehat{i}^{act}, \widehat{Delinq}]$$

See annex I for a description of variables' definitions and data sources.

3.0.1 Results and impulse-response functions

Table 1 presents parameter estimates[7]; table 2 contains the standard deviation of shocks.

[7] It is worth mentioning that we estimated alternative specifications of equations (10) and (11) in terms of lagged variables and signs of parameters of interest, and selected the one with the best goodness-of-fit, as measured by the posterior odds ratio.

Table 1

parameter estimates

parameters	prior mean	post. mean	conf. interval		prior	pstdev
α_1	0.3	0.1823	0.0934	0.2729	beta	0.1
α_3	0.05	0.0141	0.001	0.0277	norm	0.035
α_4	0.1	0.0665	0.0241	0.1071	beta	0.05
β_1	0.3	0.4033	0.3043	0.4926	beta	0.1
β_2	0.5	0.3273	0.2259	0.4533	beta	0.2
β_3	0.17	0.1768	0.1412	0.2074	norm	0.05
β_4	0.2	0.1626	0.1236	0.2016	beta	0.1
β_5	0.3	0.3638	0.289	0.428	beta	0.1
β_6	0.3	0.3673	0.3015	0.4381	beta	0.1
ρ_1	0.5	0.961	0.9341	0.9909	beta	0.2
ρ_2	0.5	0.4454	0.2943	0.6019	beta	0.2
ρ_3	0.5	0.297	0.0833	0.4791	beta	0.2
ρ_4	0.7	0.9673	0.9341	0.998	beta	0.2
ρ_5	0.7	0.7712	0.6246	0.8995	beta	0.2
ρ_6	0.5	0.6465	0.4946	0.8252	beta	0.2
γ_1	0.7	0.5794	0.4055	0.7382	beta	0.2
γ_2	0	0.055	0.0264	0.0825	norm	0.2
γ_3	0	0.0059	-0.0124	0.0236	norm	0.2
γ_4	0.2	0.1025	0.0658	0.1398	beta	0.1
ω_1	4	4.1708	3.2053	5.2627	norm	1.5
ω_2	0.1	0.0089	0.0042	0.014	beta	0.05
η_1	1.5	1.1721	0.8424	1.5156	norm	0.3
η_2	0.5	0.7177	0.44	0.959	beta	0.2
η_3	0.5	0.0326	0.0135	0.0506	norm	0.3
η_4	0.5	0.644	0.5147	0.7855	norm	0.1
κ_1	0.7	0.97	0.9454	0.9974	beta	0.2
κ_2	0.1	0.1264	0.0713	0.1906	beta	0.05
A_1	0.3	0.269	0.1571	0.3977	beta	0.1
A_2	0.1	0.0698	0.0289	0.1004	beta	0.05
A_3	0.3	0.8724	0.8423	0.8974	beta	0.1
B_1	0.3	0.0308	0.0167	0.0443	beta	0.1
B_2	0.1	0.145	0.0856	0.227	beta	0.05
B_3	0.3	0.4896	0.4061	0.6241	beta	0.1
ρ_1^D	0.9	0.981	0.9655	0.9964	beta	0.2

Table 2
standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
ε^{i}	0.05	0.003	0.0023	0.0037	gamma	0.035
$\varepsilon^{g^{\overline{y}}}$	0.05	0.0043	0.0013	0.0074	gamma	0.035
ε^{y}	0.05	0.015	0.0118	0.0178	gamma	0.035
ε^{i^*}	0.05	0.0014	0.0011	0.0018	gamma	0.035
ε^{π^*}	0.05	0.0095	0.0074	0.0113	gamma	0.035
ε^{RP}	0.05	0.0334	0.0142	0.0543	gamma	0.035
$\varepsilon^{e^{US,R}}$	0.05	0.0687	0.0558	0.0838	gamma	0.035
$\varepsilon^{e^{US,E}}$	0.05	0.0436	0.0332	0.0528	gamma	0.035
ε^{π}	0.05	0.0106	0.0082	0.013	gamma	0.035
ε^{m}	0.05	0.0907	0.0719	0.1087	gamma	0.035
ε^{res}	0.05	0.1296	0.1087	0.15	gamma	0.035
ε^{sf}	0.05	0.0029	0.0023	0.0035	gamma	0.035
ε^{CR}	0.05	0.0491	0.0378	0.0592	gamma	0.035
ε^{act}	0.05	0.0055	0.0041	0.0071	gamma	0.035
ε^{Delinq}	0.05	0.0156	0.012	0.0187	gamma	0.035

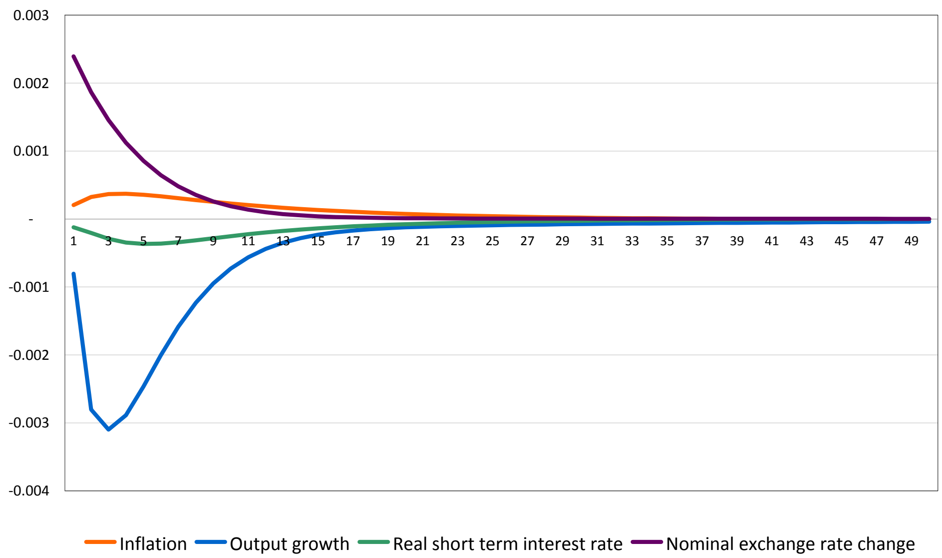
With this fully estimated model, we look at impulse-response functions in order to understand its basic dynamics, with emphasis on how the credit market block interacts with the rest of the economy. Following a positive shock to the lending rate (figure 1), credit decreases and the interest rate spread increases -the short term interest rate increases, but to a lesser degree than the active rate. This affects the real side of the economy, with a negative effect on output growth. As the short term interest rate increases, the nominal exchange rate depreciates -the impact on UIP means that a higher local rate, with no change in the international interest rate, translates into a depreciation of the local currency. Pass-through from the exchange rate to domestic prices entails a fall on the real interest rate. The central bank acts by gradually increasing the short term rate and intervening in the foreign exchange market to reduce foreign exchange volatility. When the passive rate is shocked (figure 2), output is affected, but to a substantially lower degree than in the previous exercise. The shock acts directly on the passive rate, translating immediately into a higher real (short term) interest rate; this goes together with nominal and real exchange rate appreciation. The central bank reacts by buying reserves and sterilizing the monetary effect of its operations. In the credit market, the lending rate goes up while credit diminishes -somewhat paradoxically, spread is reduced as the active rate is raised less than one-to-one with respect to the passive rate. We are aware that both exercises are just a crude approximation at describing the interplay between the credit market and the macroeconomy, and that certain aspects that are very relevant for financial stability analysis are omitted here -for one, the effect of passive rates on deposit growth[8].

[8] In this model, a higher passive rate means only a higher opportunity cost of holding transactional money, but, by construction, no effect on savings deposits (which are not included); however, this can be very significant.

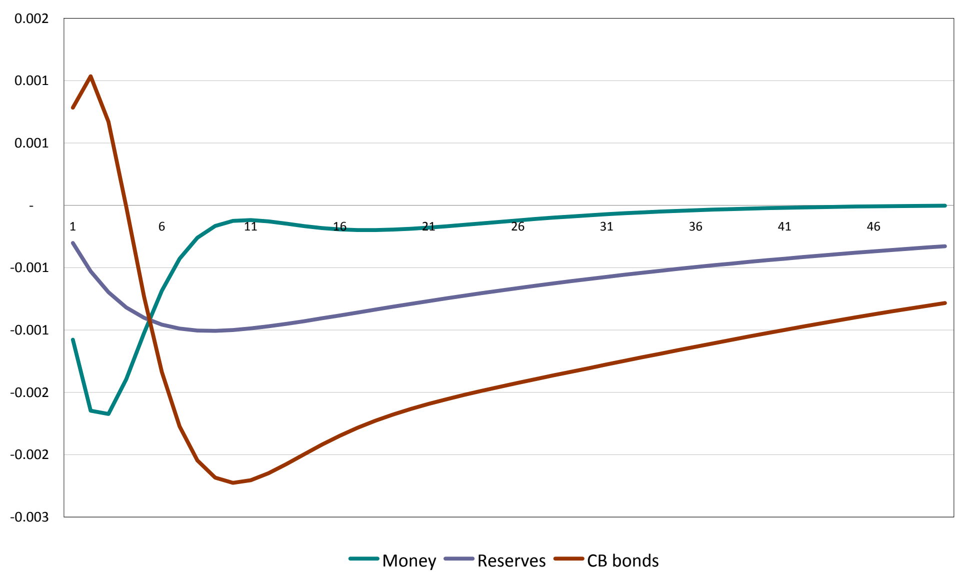
Figure 1

Accumulated responses to 1 s.d. shock to the lending rate

1 (a)



1 (b)



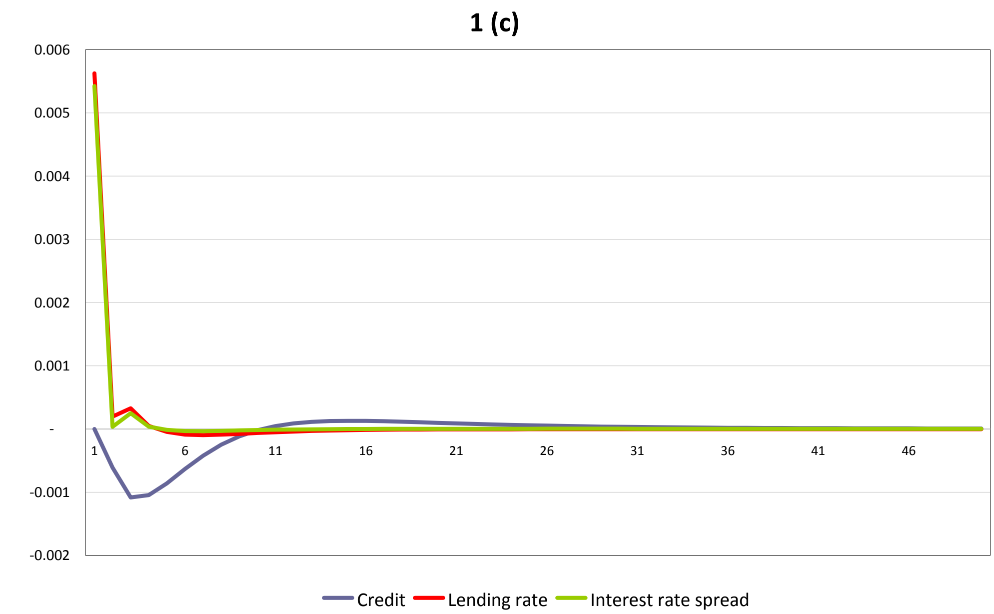
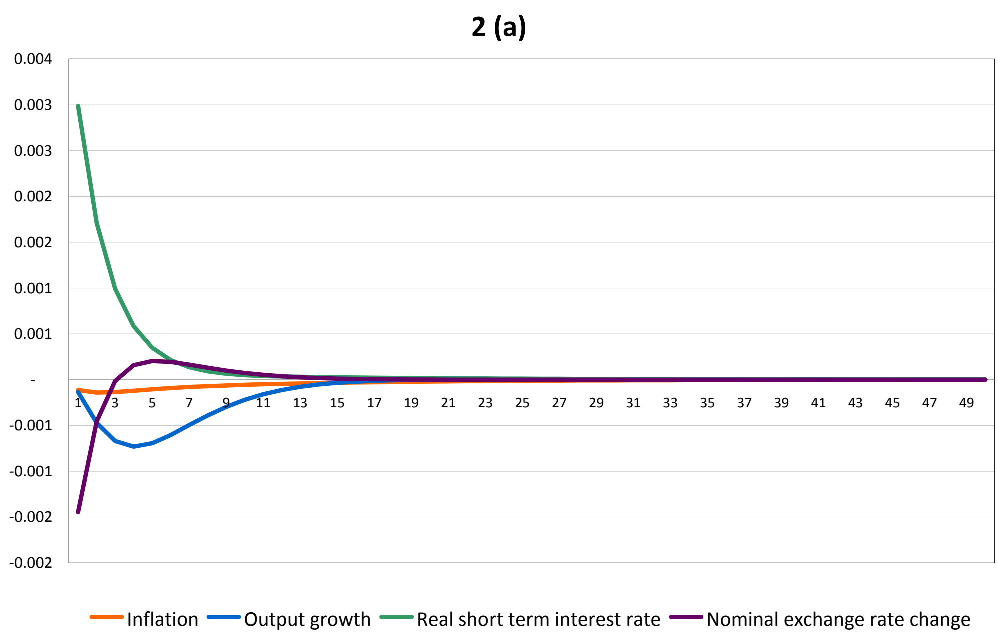
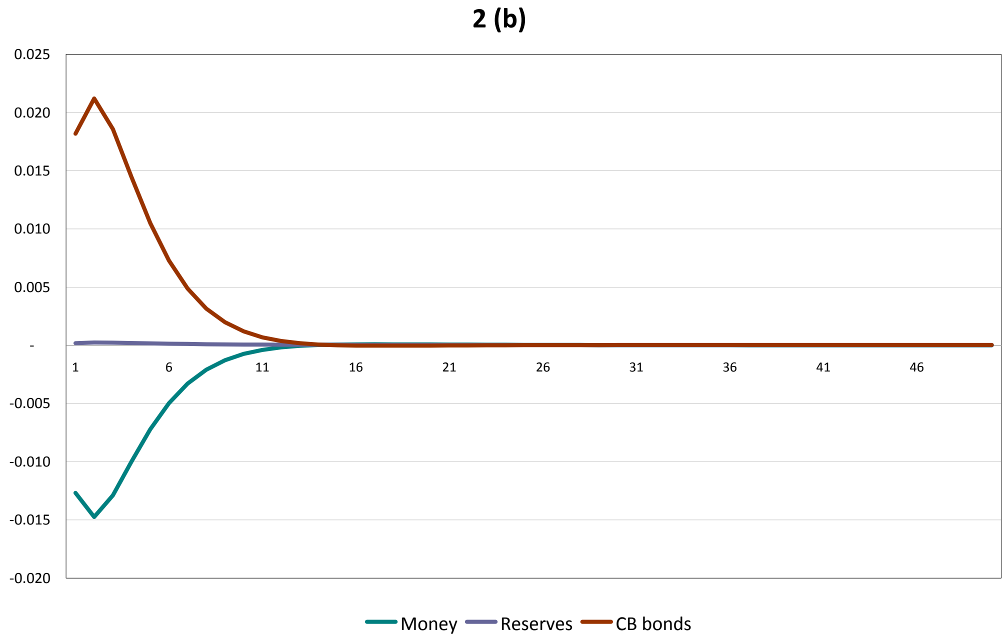
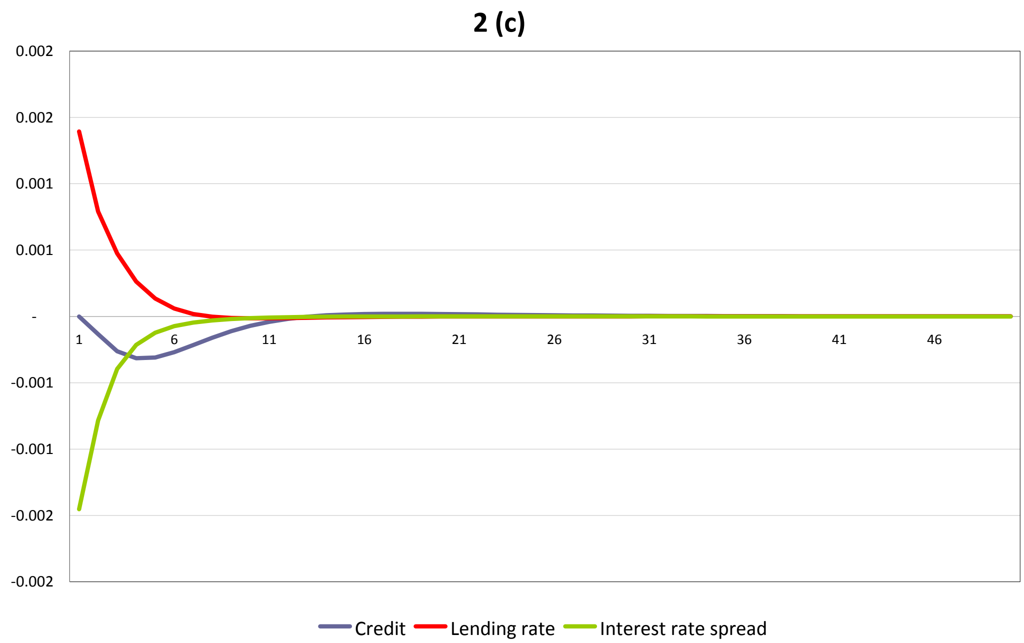


Figure 2

Accumulated responses to 1 s.d. shock to the short term interest rate







This exercise can also be done to analyze how a real shock is transmitted throughout the rest of the economy and the credit market (annex 2). A positive shock to the IS curve increases output and decreases inflation, as expected; the short term interest rate increases, in both nominal and real terms -basically due to the reaction required by the Taylor rule. This leads to real exchange rate appreciation so the central bank buys reserves to "resist" it and issues bonds to sterilize the monetary effects of its operations. Credit increases, the lending rate falls, and so does spread.

It is worth noting that, in the cases of shock to the lending rate and to output, the spread is countercyclical in the sense that higher (lower) spread entails lower (higher) credit and output[9]. In contrast, when the short term interest rate is shocked, the spread appears to be procyclical -while credit also goes down, since the active rate is going up, the spread is reduced. Our interpretation is that in the latter case the effect of decreased credit demand, together with lower output associated to a higher real rate, more than offsets the direct expansionary impact of a lower spread. In all of the three cases, credit is procyclical. At this point, the model does not yet allow us to analyze effects of shocks to credit on the rest of the economy. This is because the current specification implies that shocks to the credit market equation remain limited to credit, with no "spillover" to other markets. A possible solution to this would be to introduce a policy response to credit market conditions (Sámano Peñaloza, 2011); such an option will be investigated in further versions.

Thus, even a relatively simple specification as this appearst at least to be partly indicative of how the credit market interacts with the rest of the economy and with monetary policy. As shown by the exercises above, it is not only the traditional "transmission mechanism" of shocks that should be looked at, but the addition of both foreign exchange operations and the credit market reveal new channels that are relevant to the explanation of cyclical impulses. The following section aims at quantifying such relevance for forecasting purposes.

4 Forecasting performance

Typically, models such as this one are used for forecasting exercises: does it improve upon the results of a conventional model? To answer this question, we consider forecasts of key macroeconomic variables produced by the model as described by equations (1)-(24) with two alternatives: a standard New Keynesian "three equation model" plus a UIP equation (for example, the MEP model in Elosegui et al, 2007); a model augmented with sterilized intervention (Aguirre and Grosman, 2010). The former (in what follows, model 1) is comprised by equations (1)-(5), without the terms for: the interest rate spread in equation (1) (implying $\beta_6 = 0$); the exchange rate in the Taylor-type rule ($\gamma_4 = 0$); and central bank bonds in the UIP ($\omega_2 = 0$). The latter, model 2, is made up of equations (1)-(9); the full model is comprised of all equations (1)-(24); and all models, of course, contain the corresponding autoregressive processes for exogenous variables.

For the three competing models considered, we produced out-of-sample forecasts for horizons of one quarter, two quarters and one year (that is 1, 2 and 4 steps); for annual inflation, quarterly output growth, the short term interest rate (annual percentage rate) and quarterly nominal exchange rate depreciation. Different forecast horizons reflect the use of this kind of models for short term forecasting, and were chosen as it is not always the case that the best model for 1-step forecasts is also the best for 4-step forecasts. While 1- and 2-step forecasts would be applied to very short term uses, 4-step forecasts would be associated to yearly exercises, such as annual programming of monetary, financial and foreign exchange variables. We evaluated forecasts using two criteria: root mean squared error (RMSE) and mean average error (MAE); as several out-of-sample forecasts were produced for 1 and 2 steps, we averaged RMSEs and MAEs.

The results(table 3) show that for 1-, 2- and 4-quarter forecasts of output growth, short term interest rate and foreign exchange variability, model 3 outperforms the rest under both evaluation criteria. For inflation and at all time horizons, model 2 delivers the forecast with lowest average errors. Thus, results confirm that models "enriched" to reflect foreign exchange

[9]This agrees with the empirical finding of Aguirre et al (2013) for the Argentine economy in 1996-2012, that output growth has a negative effect on interest rate spread, also indicating countercyclicality.

operations, money market dynamics (model 2) as well as credit market conditions (model 3) imply not only a better description of the economy but also gains in terms of out-of-sample forecasting performance of key macroeconomic variables. Note that differences between RMSEs and MAEs from the different models are significant, as tested by the Giacomini-White procedure (annex 3).

Table 3

Forecasting performance

Root Mean Squared Error (average of forecasts)			
	Model 1	Model 2	Model 3
	Inflation		
1q ahead	0.0003863	**0.0003601**	0.0004164
2q ahead	0.0012309	**0.0011084**	0.0013154
1y ahead	0.0041688	**0.0035105**	0.0043853
	short term interest rate		
1q ahead	0.0126731	0.0137405	**0.0095607**
2q ahead	0.0135622	0.0160373	**0.0097047**
1y ahead	0.0139850	0.0194395	**0.0094282**
	gdp growth		
1q ahead	0.0002387	0.0000251	**0.0000000**
2q ahead	0.0002925	0.0000247	**0.0000194**
1y ahead	0.0003280	0.0000564	**0.0000649**
	nominal depreciation		
1q ahead	0.0022511	0.0004011	**0.0000087**
2q ahead	0.0018259	0.0003705	**0.0000086**
1y ahead	0.0010593	0.0002172	**0.0000607**

Mean Average Error (average of forecasts)			
	Model 1	Model 2	Model 3
	Inflation		
1q ahead	0.0196534	**0.0189759**	0.0204060
2q ahead	0.0326056	**0.0310329**	0.0337317
1y ahead	0.0582519	**0.0538322**	0.0598371
	short term interest rate		
1q ahead	0.1125746	0.1172198	**0.0977789**
2q ahead	0.1163943	0.1263115	**0.0985099**
1y ahead	0.1181953	0.1387171	**0.0970527**
	gdp growth		
1q ahead	0.0154513	0.0050123	**0.0000900**
2q ahead	0.0170306	0.0049674	**0.0031620**
1y ahead	0.0174216	0.0060057	**0.0059572**
	nominal depreciation		
1q ahead	0.0474463	0.0200285	**0.0029536**
2q ahead	0.0848728	0.0384642	**0.0058586**
1y ahead	0.1140001	0.0508887	**0.0235807**

Finally, a word is in order regarding how good model 3 is in describing credit market conditions. A preliminary evaluation suggests that it is more than acceptable: observed variability of credit-to-GDP, the active rate and the short term during the estimation period are similar to estimated variability of those variables (table 4).

Table 4
Observed and estimated standard deviations of selected variables

		Credit-to-GDP	Active rate	Short term rate
Standard deviation 2003-2011	Observed	0.1003	0.0074	0.0085
	Estimated	0.1026	0.0091	0.0110

5 Concluding remarks

We estimated a small macroeconomic model of the Argentine economy, augmented to include explicit depiction of the credit market, active rates and interest rate spread; and an enriched description of monetary policy, with sterilized intervention in the foreign exchange market. Bayesian estimation techniques allow us to assess our prior knowledge of the workings of this economy during the estimation period (2003-2011). Looking at impulse-response functions of the estimated model, we gain an intuitive understanding of the model's dynamics -whether they conform to hypotheses regarding the response of macroeconomic (activity, prices, exchange rates) and financial (money, credit) variables to different shocks. Higher lending rates are associated to higher spread, lower credit and output growth; in turn, higher output implies lower interest rate spread and higher credit. Impacts from the credit market to the rest of the economy should be further investigated to see whether a hypothesis of "financial cycles" (Borio,2012) may apply during the estimation period. Likewise, the financial system (in this highly aggregative representation) is affected by macroeconomic shocks: in particular, credit behaves in a procyclical way (in line, for instance, with evidenceby Bebczuk et al, 2011). Assessing the impact of changes in international financial conditions is also part of further work to be done.

We also did exercises that have to do with empirical goodness-of-fit and forecast performance. Is forecast performance improved by a structural macroeconomic model augmented with financial variables? The answer is clearly positive: our estimated model predicts quarterly output growth, annual interest rates and quarterly foreign exchange rate depreciation with significantly higher accuracy than: a conventional "three equation plus UIP" macroeconomic model; and a model with sterilized intervention (but no "financial block) -this is evaluated for 1-, 2- and 4-step out-of-sample forecasts, and using RMSE and MAE forecast evaluation criteria. The model with foreign exchange intervention, however, does provide better forecasts of annual inflation. Further work can be done in order to determine with the model with a "financial block" can help solve certain forecasting issues that typically arise from standard macro models (for instance, insufficient inertia in key variables such as output, prices and interest rates[10])?

Finally, and this is certainly a more ambitious goal, further research would involve finding out whether macroprudential policy can help macroeconomic performance in any meaningful way. Just as previous results show that macroeconomic variability is reduced when foreign exchange intervention is implemented in addition to interest rate rules (Escudé, 2009, shows this in a large scale DSGE model; Aguirre and Grosman, 2010, do so in a small structural model), we would like to determine if capital or liquidity requirements may affect not only solvency or liquidity conditions, but also macroeconomic conditions at large; whether, over and above their strictly

[10] "Insufficient" in the sense that forecast tend to move too quickly to their steady state variables, or at least more quickly than what expert judgment will admit as reasonable for the economy in the foreseeable future.

prudential role, they contribute to any desirable cyclical macroeconomic property –typically, smoothing output and price variability over the business cycle. If the latter is achieved, is it so through a noticeable smoothing of the "credit cycle" as well? What is the interaction between monetary policy tools (including foreign exchange intervention) and macroprudential tools? By answering such questions, the model should ultimately serve to enhance empirically based analyses of financial stability.

References

[1] Aguirre, H., T. Burdisso, F. Grillo and E. Giupponi (2013): "El *spread* de intermediación en la Argentina bajo distintos regímenes macroeconómicos: análisis de su evolución y determinantes, 1994-2012", mimeo.

[2] Aguirre, H. and N. Grosman (2010): "A Note on Managed Floating in a Small Economic Model", presented at the XLV annual meeting of the Argentine Economic Association, Buenos Aires.

[3] Andres, J., and O. Arce (2009), "Banking Competition, Housing Prices and Macroeconomic Stability," Banco de Espana Working Papers 0830

[4] Bebczuk R., Burdisso T., Carrera, J. and M. Sangiácomo (2011.): "A New Look into Credit Procyclicality: International Panel Evidence", BCRA Working Paper Series 2011 55, Central Bank of Argentina.

[5] Borio, C. (2012): "The financial cycle and macroeconomics: What have we learnt?", BIS Working Papers No 395, Bank of International Settlements.

[6] Canova, F. (2009): "How Much Structure in Empirical Models?", Palgrave Handbook of Applied Econometrics, T. Mills y K. Patterson (eds.), vol. 2, pp. 68-97.

[7] Christiano, L., R. Motto, and M. Rostagno (2010), "Financial Factors in Economic Fluctuations," European Central Bank Working Paper 1192

[8] Dib, A. (2010): "Banks, Credit Market Frictions, and Business Cycle," Bank of Canada Working Paper 2010–24

[9] Dushku, E. and V. Kota (2011): A Bayesian Estimation of a Small Structural Model for the Albanian Economy", Bank of Albania Working paper 04-27-11.

[10] Elosegui, P., G. Escudé, L. Garegnani, J. Sotes (2007): "Un Modelo Económico Pequeño para Argentina", Serie Estudios BCRA, No. 3

[11] Escudé, G. (2008): "ARGEM: un modelo de equilibrio general dinámico y estocástico para la Argentina", Serie Estudios BCRA No. 5.

[12] Escudé, G. (2009): "ARGEMmy: An Intermediate DSGE Model Calibrated/Estimated for Argentina: Two Policy Rules are Often Better than One", BCRA Working Paper Series 2009 42, Central Bank of Argentina.

[13] Gerali, A., S. Neri, L. Sessa, and F. Signoretti, 2010, "Credit and Banking in a DSGE Model of the Euro Area," Bank of Italy, Economic Research Department, Temi di Discussione 740

[14] Giacomini, R. and H. White, (2004): "Tests of conditional predictive ability", *Econometrica*, Vol 74 N^o 6, 1545-1578.

[15] Grech, O., B. Micallef, N. Rapa, A. Grech and W. Gatt (2013): "A Structural Macro-Econometric Model of the Maltese Economy", Central Bank of Malta working paper WP/02/13.

[16] Hammersland, R. and C. Bolstad Træe (2012): "The financial accelerator and the real economy: A small macroeconometric model for Norway with financial frictions", Norges Bank Staff Memo No. 2"

[17] Lees, K. (2009), "Introducing KITT: The Reserve Bank of New Zealand New DSGE Model for Forecasting and Policy Design," Reserve Bank of New Zealand Bulletin, 72: 5–20.

[18] Mandelman, F. (2009): "Business Cycles and Monetary Regimes in Emerging Economies: A Role for a Monopolistic Banking Sector", Working Paper 2006-17b, Federal Reserve Bank of Atlanta.

[19] Markovic, B.(2006), "Bank Capital Channels in the Monetary Transmission Mechanism," Bank of England Working Papers 313.

[20] Ramanauskas, T. (2006): "Interest Rates, Credit and Macroeconomy: a Small Structural Model for the Lithuanian Case", Central Bank of Lithuania, mimeo.

[21] Roger, S. and Vlcek, J. (2011): "Macrofinancial Modeling at Central Banks: Recent Developments and Future Directions", IMF Working Papers 12/21, International Monetary Fund.

[22] Sámano Peñaloza, D. (2011): "In the Quest of Macroprudential Policy Tools", mimeo, Banco de México.

[23] Szilágyi,K., Baksa, D., Benes, J., Horváth, A., Köber, C. and Soós G. (2013): "The Hungarian Monetary Policy Model", MNB Working Papers 2013/1, Magyar Nemzeti Bank.

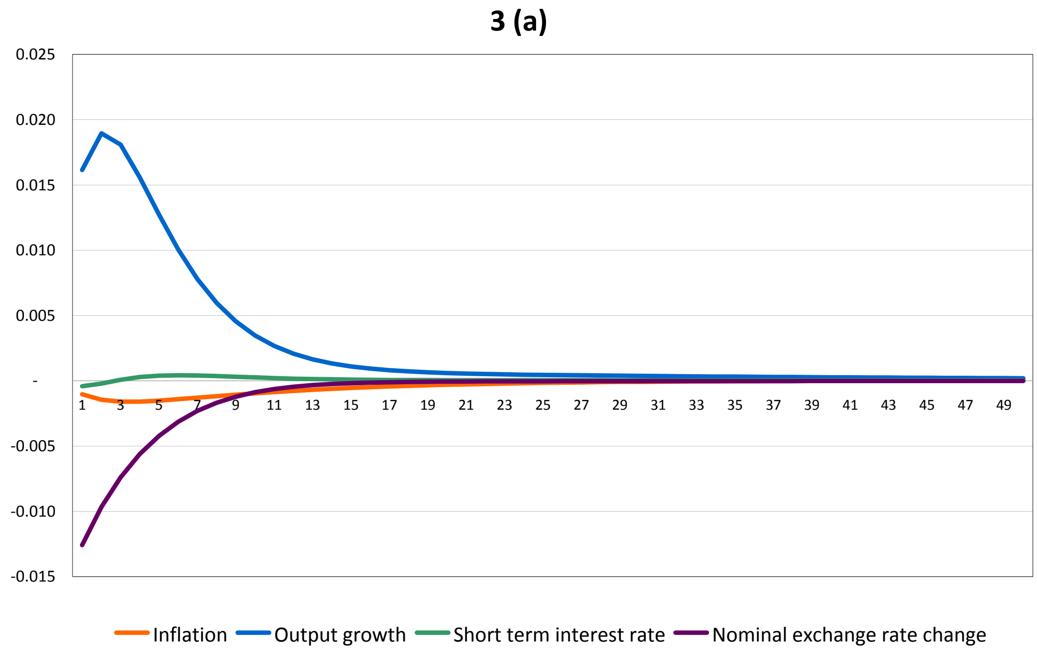
Annex 1. Description of variables and data sources

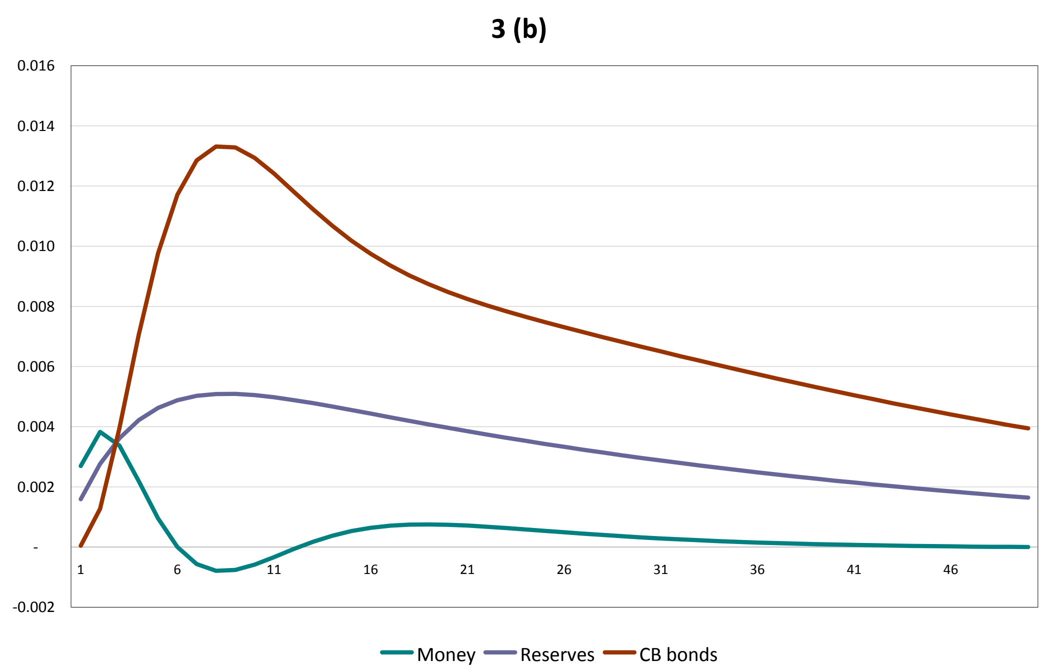
Table A.1

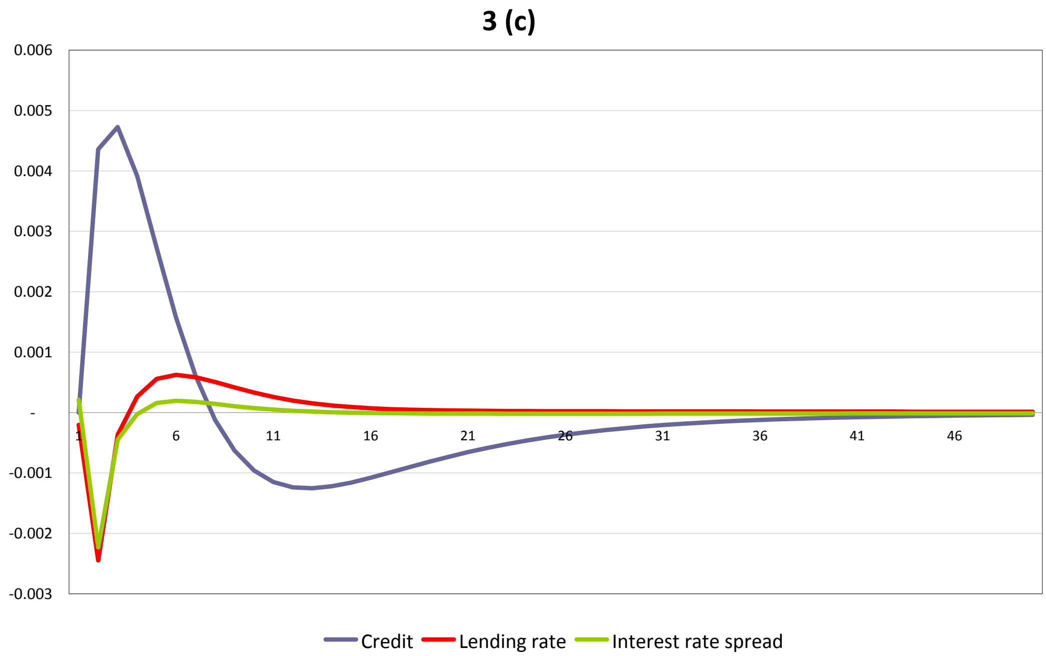
Variable	Description	Source
g^y	GDP growth seasonally adjusted	National accounts
π	Inflation, change in CPI	INDEC
i	Domestic pasive interest rate - fixed term deposits in AR pesos, 30-59 day maturity	Central Bank of Argentina
π^*	Foreign inflation,changes in: average main commercial partners US, Brazil and Euro-zone CPI	FRED and Bloomberg
i^*	Foreign interest rate - USD Libor, 3 months	Bloomberg
δ	Billateral exchange rate depreciation (US dollar, AR pesos)	Bloomberg
m	Money: currency in circulation in AR peso million as a percentage of GDP	Central Bank of Argentina
res	International reserves: in USD millions as a percentage of GDP	Central Bank of Argentina
sf	Fiscal surplus: revenues minus spending (primary)	Ministry of Economy
$e^{US,R}$	nominal exchange rate US dollar, BR real	Bloomberg
$e^{US,E}$	nominal exchange rate US dollar, euro	Bloomberg
CR	Credit: Ratio of non financial private sector credit to GDP	Central Bank of Argentina
i^{act}	Domestic interest rates on loans granted to the non-financial private sector - average overdrafts and bills	Central Bank of Argentina
$Delinq$	Non performing loans as a percentage of non-financial private sector credit	Central Bank of Argentina

Annex 2. Responses of selected variables to a 1 s.d. shock to output growth

Figure 3






3 (c)
0.006
0.005
0.004
0.003
0.002
0.001
-
-0.001
-0.002
-0.003
1
6
11
16
21
26
31
36
41
46
Credit
Lending rate
Interest rate spread

Annex 3. Testing out-of-sample forecast performance

We compare the predictive accuracy of out of sample forecasts for models (1), (2) and (3) using the methodology developed by Giacomini and White (2004). Giacomini and White approach focuses on finding the best forecast method for the following relevant future. Their methodology is relevant for forecasters who are interested in finding methodologies that improve predictive ability of forecast, rather that testing the validity of a theoretical model.

The test has the following advantages: **(i)** it captures the effect of estimation uncertainty on relative forecast performance, **(ii)** is useful for forecasts based on both nested and nonnested models, **(iii)** allows the forecasts to be produced by general estimation methods, and **(iv)** is quite easy to be computed. Following a two-step decision rule that uses current information it allows to select the best forecast for the future date of interest.

The testing methodology of Giacomini and White consists on evaluating forecast by conducting an out of sample exercise using rolling windows. That is, using the R sample observations available at time t, estimates of y_t are produced and used to generate forecast τ step ahead. The test assumes that there are two methods, f_{Rt} and g_{Rt} to generate forecasts of y_t using the available set of information $\mathcal{F}_t$. Models used are supposed to be parametric.

$$\begin{aligned} f_{Rt} &= f_{Rt}(\widehat{\gamma}_{R,t}) \\ g_{Rt} &= g_{Rt}(\widehat{\theta}_{R,t}) \end{aligned}$$

A total of P_n forecasts which satisfy $R + (P_n - 1) + \tau = T + 1$ are generated. The forecasts are evaluated using a loss function $L_{t+\tau}(y_{t+\tau}, f_{R,t})$, that depends on both, the realization of the data and the forecasts. The hypothesis to be tested is:

$$\begin{aligned} H_0 &: E\left[h_t\left(L_{t+\tau}(y_{t+\tau}, f_{R,t}) - L_{t+\tau}(y_{t+\tau}, g_{R,t})\right) \mid \mathcal{F}_t\right] = 0 \\ & \quad \text{or alternatively} \\ H_0 &: E\left[h_t \Delta L_{t+\tau} \mid \mathcal{F}_t\right] = 0 \ \ \forall\ t \geqslant 0 \end{aligned}$$

for all $\mathcal{F}_t$ -measurable function h_t.

In practice, the test consists on regressing the differences in the loss functions on a constant and evaluating its significance using the t statistic for the null of a 0 coefficient, in the case of $\tau = 1$. When τ is greater than one, standard errors are calculated using the Newey-West covariances estimator, that allows for heteroksedasticity and autocorrelation.

Following the afore mentioned methodology we compare the macro variables forecasts (GDP growth, inflation, nominal depreciation and interest rate) of the financial block model (3) (this would be our f_{Rt} forecasting method) with those of the standard New Keynesian small model (1) (our first g_{Rt}) and the foreign exchange-augmented model (2) (the second g_{Rt}). The loss function we choose was the root mean square error (RMSE), R equals 36 observations and we perform one quarter ahead ($\tau = 1$), two quarters ahead ($\tau = 2$) and one year ahead ($\tau = 4$) forecasts. Thus we have 6 forecasts for $\tau = 1$, 5 for $\tau = 2$ and 2 for $\tau = 2$. Results are significative supporting the idea that adding a financial block might also improve predictive ability.[11]

[11] However one has to recognize that it would be better to have a larger set of forecasts to perform this test.