

Credit and Macroprudential Policy in a Small Economic Model of the Argentine Economy*

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Abstract

We build and estimate a small macroeconomic model of the Argentine economy, augmented to depict the credit market, interest rate spreads and capital requirements; together with monetary policy with sterilized intervention in the foreign exchange market. We estimate it using Bayesian techniques with quarterly data for 2003-2011; 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”. Finally, capital adequacy ratios are assessed under alternative definitions: they appear to have contributed to lower volatility of key variables such as output, prices, credit and interest rates.

JEL classification codes: E17, E51, E52, E58

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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 order 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 macroeconomic 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 policy-oriented 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.

This framework is also 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. In particular, we include a macroprudential instrument (capital requirements) in addition to interest rates and foreign exchange intervention, so as to determine how it interacts with the other policy tools and whether, once again, it may help smooth short run macroeconomic and financial market fluctuations.

The rest of the paper is organized as follows. Section 2 describes the baseline model; section 3 presents estimation and impulse-response functions that illustrate the basic workings of the estimated model. Section 4 evaluates the model 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 extends the model to include macroprudential policy in the form of capital requirements, considering alternative formulations of the latter, with emphasis on macroeconomic and financial performance associated to them. Section 6 concludes.

2 The baseline 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. It already incorporates a money market equation, providing 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 demand¹. 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 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. Two terms account for the central bank's involvement with financial stability: the short term rate also depends on its own lagged values, showing a desire to smooth interest rate movements; and on the "credit gap", i.e. the difference between current credit to the private sector and its steady state value (more on this below).

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 loans²; and non performing loans are exogenous. Credit as previously defined also feeds back into the "macroeconomic block" of the model through its inclusion in the interest rate rule (4); this, of course, is not the only way in which credit may directly affect the macroeconomy (credit could, for instance, directly impact on output in (1)), but we prefer to consider only one channel that, albeit indirect, is related to financial stability considerations on the part of the central bank -a feature which, in our view, is relevant for the estimation period. Finally, exogenous variables 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

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

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

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

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

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

$$\alpha_2 = 1 - \alpha_1$$

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

$$\widehat{i}_t = \gamma_1 \widehat{i}_{t-1} + \gamma_2 y_t + \gamma_3 \mathbb{E}_t \widehat{\pi}_{t+1}^a + \gamma_4 \widehat{\delta}_t + \gamma_5 \widehat{CR}_t + \varepsilon_t^i \quad (4)$$

π^a : annual inflation, δ : \$/USD depreciation rate, CR : Non financial private sector credit to GDP ratio

FX Policy Block

$$\widehat{i}_t = \widehat{i}_t^* + \omega_1 \mathbb{E}_t \widehat{\delta}_{t+1} + (1 - \omega_1) \widehat{\delta}_t + \omega_2 \widehat{b}_t + \omega_3 \widehat{res}_t + \widehat{\lambda}_t \quad (5)$$

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

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

$$\phi = \frac{m}{m + b} \quad (7)$$

m : money to GDP ratio³

$$\widehat{res}_t = \kappa_1 \widehat{res}_{t-1} - \kappa_2 \widehat{\delta}_t + \varepsilon_t^{res} \quad (8)$$

$$\widehat{m}_t = -\eta_1 \widehat{i}_t + \eta_2 \widehat{\pi}_t + \eta_3 \widehat{b}_t + \eta_4 \widehat{\delta}_t + \varepsilon_t^m \quad (9)$$

Financial Block

$$\widehat{CR}_t = A_1 \widehat{g}_{t-1}^y - A_2 \widehat{i}_{t-1}^{act} + A_3 \widehat{CR}_{t-1} + \varepsilon_t^{CR} \quad (10)$$

CR : Non financial private sector credit to GDP ratio

³The parameter ϕ is calibrated equal to 0.5833

$$\widehat{i}_t^{act} = B_1 \widehat{Delinq}_t - B_2 \widehat{g}_{t-1}^y + B_3 \widehat{i}_t + \varepsilon_t^{act} \quad (11)$$

$Delinq$: ratio of non performing loans to non financial private sector credit⁴, CAR : capital adequacy ratio

$$\widehat{Delinq}_t = \rho_1^D \widehat{Delinq}_{t-1} + \varepsilon_t^{Delinq} \quad (12)$$

Identities

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

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

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

$$\widehat{g}_t^y \equiv \Delta y_t + \widehat{g}_t^{\bar{y}} \quad (16)$$

$$\widehat{\mu}_t \equiv \Delta \widehat{m}_t + \widehat{\pi}_t + \widehat{g}_t^y \quad (17)$$

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

Exogenous variables⁵

$$\widehat{i}_t^* = \rho_1 \widehat{i}_{t-1}^* + \varepsilon_t^i \quad (18)$$

$$\widehat{\lambda}_t = \rho_2 \widehat{\lambda}_{t-1} + \varepsilon_t^\lambda \quad (19)$$

$$\widehat{\pi}_t^* = \rho_3 \widehat{\pi}_{t-1}^* + \varepsilon_t^{\pi^*} \quad (20)$$

$$\widehat{e}^{US,R}_t = \rho_4 \widehat{e}^{US,R}_{t-1} + \varepsilon_t^{e^{US,R}} \quad (21)$$

$$\widehat{e}^{US,E}_t = \rho_5 \widehat{e}^{US,E}_{t-1} + \varepsilon_t^{e^{US,E}} \quad (22)$$

$$\widehat{s}^f_t = \rho_6 \widehat{s}^f_{t-1} + \varepsilon_t^{s^f} \quad (23)$$

$$\widehat{g}_t^{\bar{y}} = \rho_7 \widehat{g}_{t-1}^{\bar{y}} + \varepsilon_t^{g^{\bar{y}}} \quad (24)$$

3 Estimation

We estimate this baseline version of the model (equations 1-24) completely through Bayesian techniques⁶, 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 particularly useful for this kind of situation: if one knows

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

⁵Parameter ρ_7 is calibrated

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

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 $\theta \in \Theta$ as the vector of parameters. Given the prior information $g(\theta)$, the observed data $Y_T = [Y_1, Y_2, \dots, Y_T]$ 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 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 acceptance 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 estimates⁷; table 2 contains the standard deviation of shocks.

⁷It 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: Baseline model
parameter estimates

parameters	prior mean	post. mean	conf. interval		prior	pstdev
α_1	0.3000	0.2049	0.1426	0.2635	<i>beta</i>	0.1000
α_3	0.0500	0.0171	0.0057	0.0281	<i>norm</i>	0.0350
α_4	0.1000	0.0662	0.0387	0.0903	<i>beta</i>	0.0500
β_1	0.3000	0.3087	0.2159	0.3902	<i>beta</i>	0.1000
β_2	0.5000	0.2945	0.1842	0.3930	<i>beta</i>	0.2000
β_3	0.1700	0.1738	0.1169	0.2237	<i>norm</i>	0.0500
β_4	0.2000	0.1322	0.0966	0.1577	<i>beta</i>	0.1000
β_5	0.3000	0.1655	0.1147	0.2157	<i>beta</i>	0.1000
β_6	0.3000	0.2498	0.2087	0.2938	<i>beta</i>	0.1000
ρ_1	0.5000	0.9591	0.9294	0.9906	<i>beta</i>	0.2000
ρ_2	0.5000	0.6375	0.5061	0.7637	<i>beta</i>	0.2000
ρ_3	0.5000	0.2914	0.1621	0.4294	<i>beta</i>	0.2000
ρ_4	0.7000	0.9605	0.9263	0.9964	<i>beta</i>	0.2000
ρ_5	0.7000	0.8649	0.7781	0.9435	<i>beta</i>	0.2000
ρ_6	0.5000	0.3416	0.2481	0.4307	<i>beta</i>	0.2000
γ_1	0.7000	0.7380	0.6544	0.8064	<i>beta</i>	0.2000
γ_2	0.0000	0.0488	0.0114	0.0866	<i>norm</i>	0.2000
γ_3	0.0000	0.0065	-0.0153	0.0289	<i>norm</i>	0.2000
γ_4	0.2000	0.0925	0.0574	0.1314	<i>beta</i>	0.1000
γ_5	0.0000	0.0019	-0.0106	0.0150	<i>norm</i>	0.2000
ω_1	4.0000	5.0777	4.0724	5.9714	<i>norm</i>	1.5000
ω_2	0.1000	0.0108	0.0037	0.0185	<i>beta</i>	0.0500
ω_3	1.0000	0.1125	0.0000	0.2545	<i>norm</i>	1.0000
η_1	1.2000	0.7343	0.5863	0.9042	<i>norm</i>	0.3000
η_2	0.5000	0.7570	0.6196	0.8979	<i>beta</i>	0.2000
η_3	0.5000	0.0213	0.0144	0.0289	<i>norm</i>	0.3000
η_4	0.5000	0.7239	0.6638	0.7838	<i>norm</i>	0.1000
κ_1	0.7000	0.9635	0.9324	0.9956	<i>beta</i>	0.2000
κ_2	0.1000	0.0934	0.0608	0.1249	<i>beta</i>	0.0500
A_1	0.3000	0.3538	0.3298	0.3787	<i>beta</i>	0.0500
A_2	0.1000	0.0408	0.0181	0.0751	<i>beta</i>	0.0500
A_3	0.3000	0.4513	0.4099	0.4950	<i>beta</i>	0.0500
B_1	0.3000	0.0302	0.0144	0.0453	<i>beta</i>	0.1000
B_2	0.3000	0.1927	0.1014	0.2684	<i>beta</i>	0.1000
B_3	0.3000	0.3790	0.3240	0.4409	<i>beta</i>	0.1000
ρ_1^D	0.5000	0.9808	0.9644	0.9970	<i>beta</i>	0.2000

Table 2: Baseline model
standard deviation of shocks

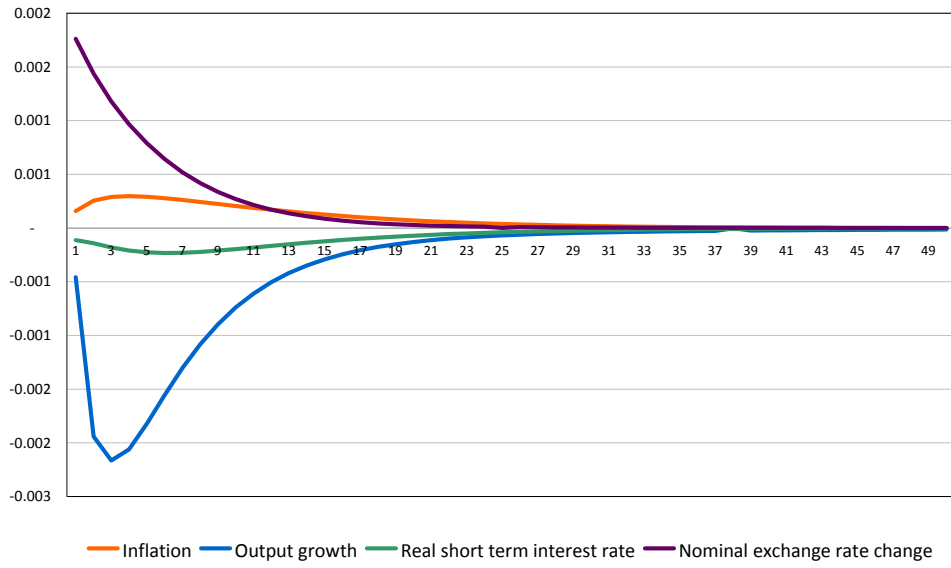
	prior mean	post. mean	conf. interval		prior	pstdev
ε^i	0.0500	0.0032	0.0023	0.0039	<i>gamma</i>	0.0350
ε^{g^y}	0.0500	0.0047	0.0017	0.0086	<i>gamma</i>	0.0350
ε^y	0.0500	0.0156	0.0124	0.0188	<i>gamma</i>	0.0350
ε^{i^*}	0.0500	0.0014	0.0011	0.0017	<i>gamma</i>	0.0350
ε^{π^*}	0.0500	0.0095	0.0076	0.0113	<i>gamma</i>	0.0350
ε^{RP}	0.0500	0.0262	0.0127	0.0368	<i>gamma</i>	0.0350
$\varepsilon^{e^{US,R}}$	0.0500	0.0667	0.0565	0.0796	<i>gamma</i>	0.0350
$\varepsilon^{e^{US,E}}$	0.0500	0.0397	0.0325	0.0468	<i>gamma</i>	0.0350
ε^π	0.0500	0.0105	0.0077	0.0130	<i>gamma</i>	0.0350
ε^m	0.0600	0.0284	0.0219	0.0350	<i>gamma</i>	0.0350
ε^{res}	0.0500	0.1271	0.1137	0.1406	<i>gamma</i>	0.0350
ε^{sf}	0.0500	0.0041	0.0033	0.0050	<i>gamma</i>	0.0350
ε^{CR}	0.1000	0.1659	0.1470	0.1821	<i>gamma</i>	0.0350
ε^{act}	0.0500	0.0061	0.0045	0.0074	<i>gamma</i>	0.0350
ε^{Delinq}	0.0500	0.0157	0.0120	0.0194	<i>gamma</i>	0.0350

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. A shock to the passive rate (figure 2), translates immediately into a higher real (short term) interest rate, which goes together with nominal and real exchange rate appreciation. Output is affected, but to a substantially lower degree than in the previous exercise. The central bank reacts by (initially) buying reserves and sterilizing the monetary effect of its operations by issuing bonds. 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 growth⁸.

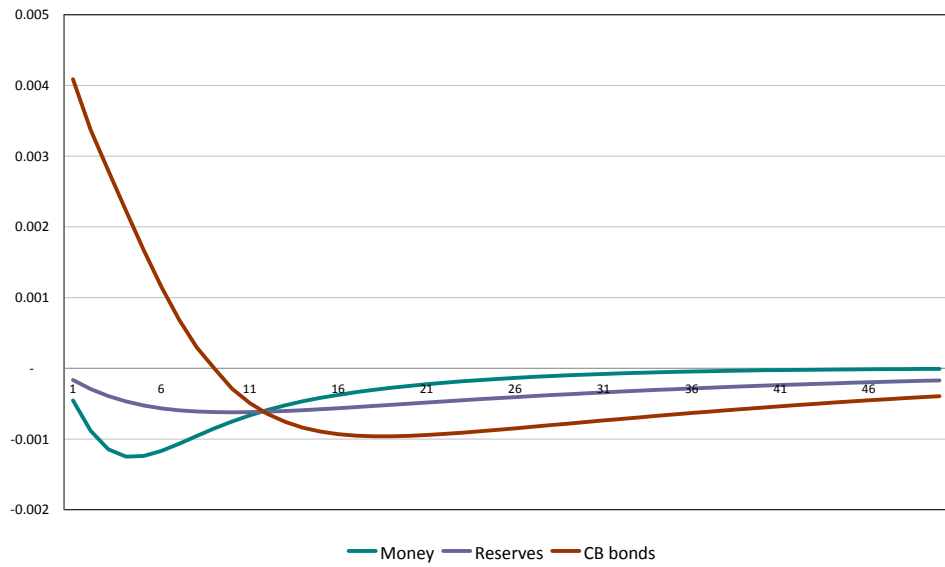
⁸In this model, a higher passive rate means only a higher opportunity cost of holding transactional money, but, by construction, no effect on savings deposits (which are not included); however, this can be very significant.

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

1 (a)



1 (b)



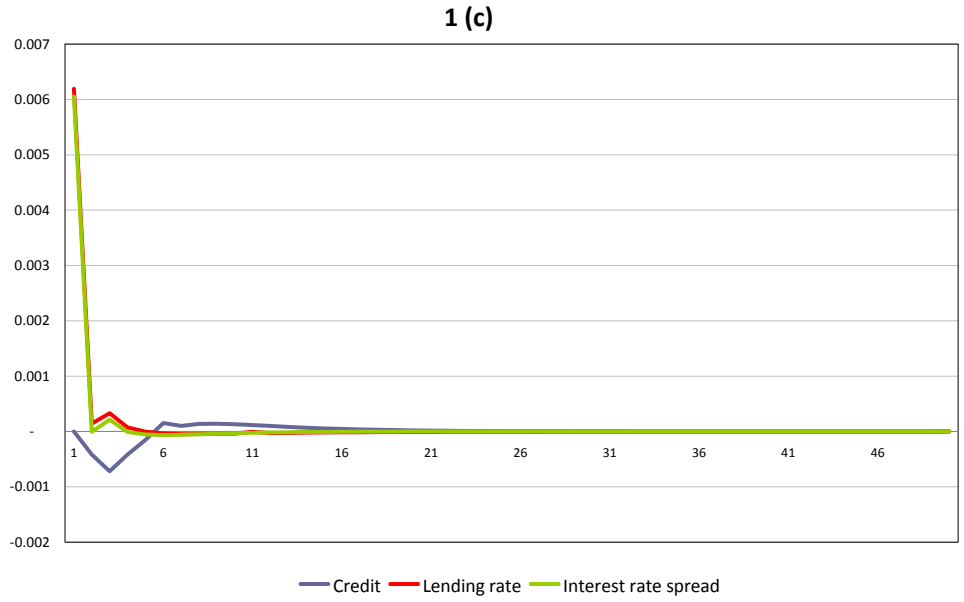
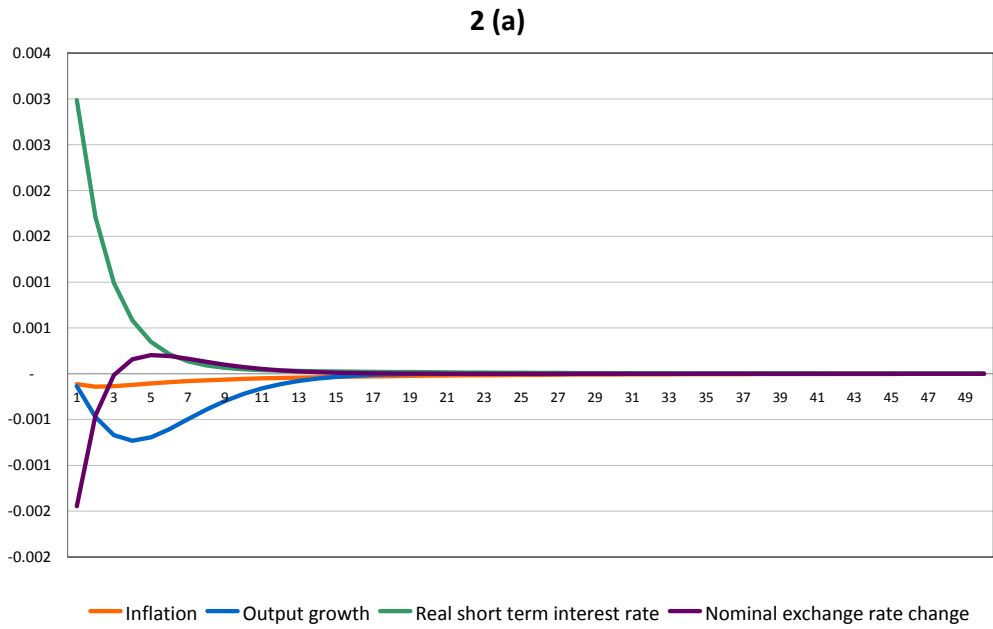
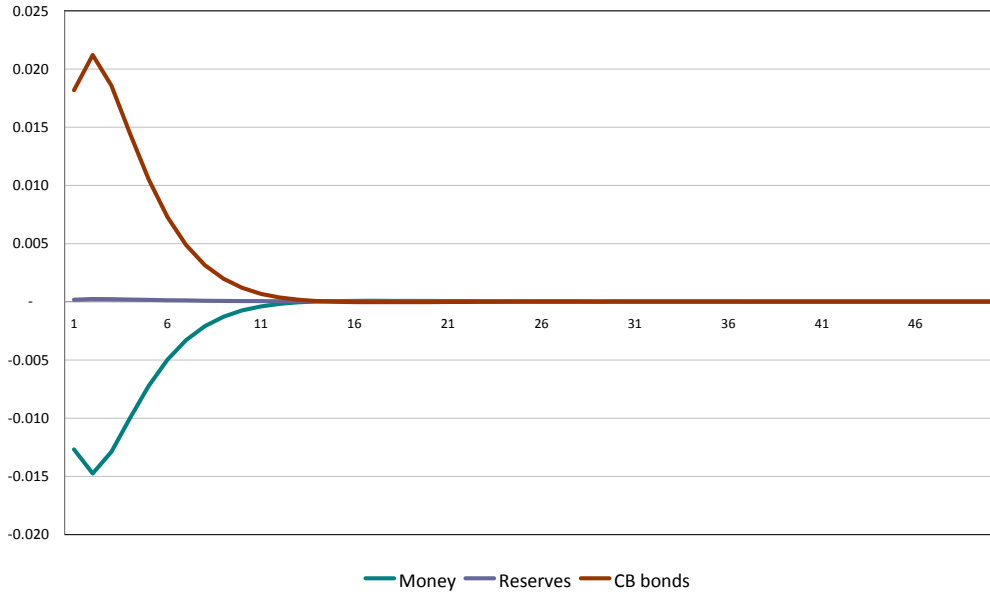


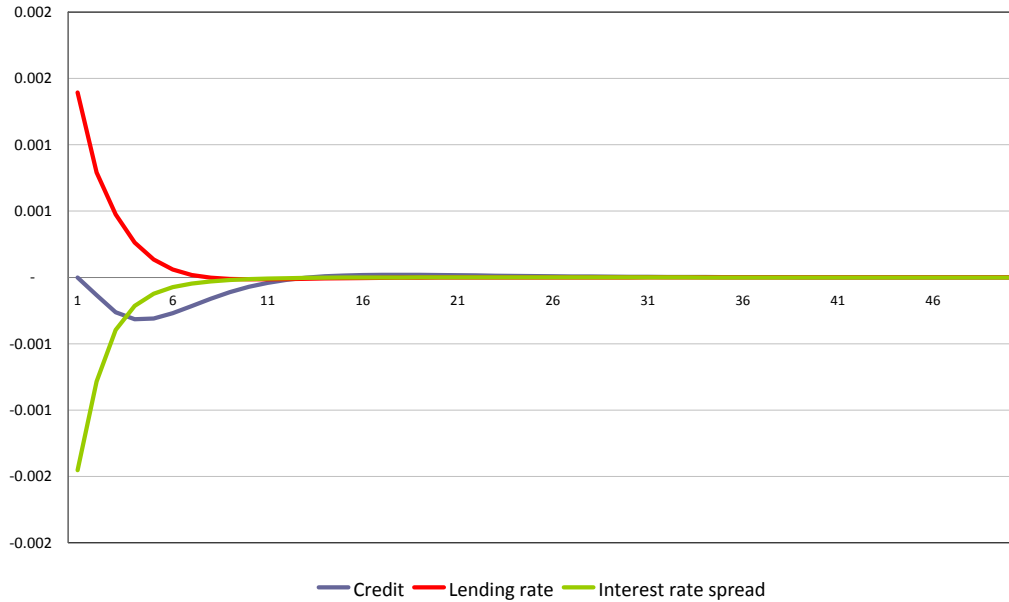
Figure 2
Accumulated responses to 1 s.d. shock to the short term interest rate



2 (b)



2 (c)



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; 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. An appreciated exchange rate (both in nominal and real terms) explains, via pass-through, why the direct effect of the shock is decreasing in inflation. In turn, 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 output⁹. 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 appears 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

⁹This 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 countercyclicity.

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
<i>Inflation</i>			
1q ahead	0.0003863	0.0003601	0.0004164
2q ahead	0.0012309	0.0011084	0.0013154
1y ahead	0.0041688	0.0035105	0.0043853
<i>short term interest rate</i>			
1q ahead	0.0126731	0.0137405	0.0095607
2q ahead	0.0135622	0.0160373	0.0097047
1y ahead	0.0139850	0.0194395	0.0094282
<i>gdp growth</i>			
1q ahead	0.0002387	0.0000251	0.0000000
2q ahead	0.0002925	0.0000247	0.0000194
1y ahead	0.0003280	0.0000564	0.0000649
<i>nominal depreciation</i>			
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
<i>Inflation</i>			
1q ahead	0.0196534	0.0189759	0.0204060
2q ahead	0.0326056	0.0310329	0.0337317
1y ahead	0.0582519	0.0538322	0.0598371
<i>short term interest rate</i>			
1q ahead	0.1125746	0.1172198	0.0977789
2q ahead	0.1163943	0.1263115	0.0985099
1y ahead	0.1181953	0.1387171	0.0970527
<i>gdp growth</i>			
1q ahead	0.0154513	0.0050123	0.0000900
2q ahead	0.0170306	0.0049674	0.0031620
1y ahead	0.0174216	0.0060057	0.0059572
<i>nominal depreciation</i>			
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 The extended model: macroprudential policy

Far from being a straightforward concept, "macroprudential policy" has come to be understood as an umbrella term for measures whose goal extends beyond safeguarding the solvency or liquidity of financial institutions (the aim of traditional "prudential" policy), to cover their link with macroeconomic performance -acknowledging possible spillovers from the financial system to the economy at large, and viceversa. Many different measures can be thus considered as "macroprudential" (see Lim et al., 2011, for a recent survey): we will focus on one of the most basic financial system regulations¹⁰ -a capital adequacy ratio- and will consider several variants, ranging from a purely exogenous ratio (thus akin to conventional prudential regulation) to rules according to which adequate capital depends on macroeconomic or financial system variables (Sámano Peñaloza, 2011). In order to do this, we enlarge the model's financial block by adding a capital adequacy ratio; it can either be exogenous (25), or be a function of the output gap (26) the credit gap (27), or the interest rate spread (28). These alternatives, which added to the baseline model are labeled respectively as models 4, 5, 6 and 7, correspond to different policy concerns: risk taken by banks is moderated by higher requirements, which may be more related to macroeconomic (model 5) or financial system performance (models 6 and 7). The capital adequacy ratio (CAR) is then included in the equation describing the active rate (29); we hypothesize that higher capital requirements will be associated to higher lending rates, since each additional loan has to be "backed" by more equity. The new equations are as follows.

Capital Adequacy Ratio

First Option: Exogenous

$$\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \varepsilon_t^{CAR} \quad (25)$$

Second Option: Endogenous .

$$\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 \hat{y}_t + \varepsilon_t^{CAR} \quad (26)$$

$$\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 \widehat{CR}_t + \varepsilon_t^{CAR} \quad (27)$$

$$\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 spread_t + \varepsilon_t^{CAR} \quad (28)$$

¹⁰That is, in addition to the managed floating foreign exchange regime. In so far as such policy limits variability of a certain class of assets that weigh on financial system dynamics, foreign exchange intervention can be considered part of the macroprudential "toolkit".

$$\widehat{i}_t^{act} = B_1 \widehat{Delinq}_t - B_2 \widehat{g}_{t-1}^y + B_3 \widehat{i}_t + B_4 \widehat{CAR}_t + \varepsilon_t^{act} \quad (29)$$

We then estimate four models with macroprudential policy using Bayesian techniques; as with the baseline model, we estimate using quarterly data of the Argentine economy for the 2003Q3-2011Q2 period. Estimates of parameters and standard deviations of model 4 are shown in tables 5 and 6; for a comparison with the rest of the models, we refer the reader to annex 4.

Table 5: Model 4, exogenous CAR
parameter estimates

parameters	prior mean	post. mean	conf. interval		prior	pstdev
α_1	0.3000	0.2404	0.2051	0.2967	beta	0.1000
α_3	0.0500	0.0590	0.0403	0.0807	norm	0.0350
α_4	0.1000	0.1533	0.1097	0.2021	beta	0.0500
β_1	0.3000	0.4147	0.3685	0.4653	beta	0.1000
β_2	0.5000	0.3068	0.2506	0.3604	beta	0.2000
β_3	0.1700	0.1706	0.1391	0.2044	norm	0.0500
β_4	0.2000	0.1249	0.0923	0.1563	beta	0.1000
β_5	0.3000	0.3797	0.3348	0.4260	beta	0.1000
β_6	0.3000	0.2593	0.2074	0.3072	beta	0.1000
ρ_1	0.5000	0.9565	0.9260	0.9896	beta	0.2000
ρ_2	0.5000	0.4216	0.3370	0.5231	beta	0.2000
ρ_3	0.5000	0.2199	0.1357	0.3044	beta	0.2000
ρ_4	0.7000	0.9604	0.9293	0.9954	beta	0.2000
ρ_5	0.7000	0.8796	0.7999	0.9699	beta	0.2000
ρ_6	0.5000	0.6536	0.5622	0.7879	beta	0.2000
γ_1	0.7000	0.5557	0.4857	0.6399	beta	0.2000
γ_2	0.0000	0.0522	-0.0029	0.1186	norm	0.2000
γ_3	0.0000	0.0081	-0.0267	0.0395	norm	0.2000
γ_4	0.2000	0.0929	0.0466	0.1322	beta	0.1000
γ_5	0.0000	0.0137	0.0032	0.0233	norm	0.2000
ω_1	4.0000	5.2828	4.4364	6.2797	norm	1.5000
ω_2	0.1000	0.0108	0.0045	0.0169	beta	0.0500
ω_3	1.0000	0.1043	0.0000	0.2294	norm	1.0000
η_1	1.2000	0.6806	0.5152	0.8385	norm	0.3000
η_2	0.5000	0.5772	0.4679	0.6966	beta	0.2000
η_3	0.5000	0.0178	0.0105	0.0248	norm	0.3000
η_4	0.5000	0.7044	0.6481	0.7583	norm	0.1000
κ_1	0.7000	0.9720	0.9476	0.9961	beta	0.2000
κ_2	0.1000	0.0860	0.0309	0.1430	beta	0.0500
A_1	0.3000	0.3687	0.3363	0.4051	beta	0.0500
A_2	0.1000	0.0521	0.0210	0.0841	beta	0.0500
A_3	0.3000	0.4543	0.4128	0.4871	beta	0.0500
B_1	0.3000	0.0440	0.0270	0.0585	beta	0.1000
B_2	0.3000	0.2577	0.1789	0.3298	beta	0.1000
B_3	0.3000	0.3032	0.2528	0.3602	beta	0.1000
B_4	0.3000	0.2093	0.1601	0.2590	beta	0.1000
ρ_1^D	0.5000	0.9764	0.9579	0.9954	beta	0.2000
ψ_0	0.5000	0.0105	0.0100	0.0110	beta	0.2000
ψ_1	0.7000	0.4417	0.2519	0.6413	beta	0.2000

Table 6: Model 4, exogenous CAR
standard deviation of shocks

	prior mean	post. mean	conf. interval		prior	pstdev
ε^i	0.0500	0.0029	0.0022	0.0035	gamma	0.0350
ε^{g^y}	0.0500	0.0037	0.0015	0.0060	gamma	0.0350
ε^y	0.0500	0.0150	0.0118	0.0178	gamma	0.0350
ε^{i^*}	0.0500	0.0015	0.0011	0.0018	gamma	0.0350
ε^{π^*}	0.0500	0.0093	0.0073	0.0112	gamma	0.0350
ε^{RP}	0.0500	0.0577	0.0437	0.0722	gamma	0.0350
$\varepsilon^{e^{US,R}}$	0.0500	0.0652	0.0528	0.0766	gamma	0.0350
$\varepsilon^{e^{US,E}}$	0.0500	0.0426	0.0339	0.0525	gamma	0.0350
ε^π	0.0500	0.0117	0.0085	0.0148	gamma	0.0350
ε^m	0.0600	0.0312	0.0246	0.0384	gamma	0.0350
ε^{res}	0.0500	0.1330	0.1150	0.1519	gamma	0.0350
ε^{sf}	0.0500	0.0045	0.0035	0.0053	gamma	0.0350
ε^{CR}	0.1000	0.1395	0.1202	0.1611	gamma	0.0350
ε^{act}	0.0500	0.0067	0.0052	0.0082	gamma	0.0350
ε^{Delinq}	0.0500	0.0167	0.0128	0.0206	gamma	0.0350
ε^{CAR}	0.0500	0.0128	0.0102	0.0153	gamma	0.0350

We use estimated models to try to gain some understanding of potential "stabilizing" properties of macroprudential policy. Are capital adequacy ratios associated to less volatility in the macroeconomy and the financial system? In order to answer this question, we will compute the estimated variability of selected variables under different CARs, and compare them with the baseline model. At this point, it is worth remembering that, by construction, estimated models reflect the type and magnitude of shocks that the economy underwent during the estimation period; so by showing variability under different (estimated) policies, we approximate the economy's performance under such policies in the face of the particular shocks occurred. We are fully aware that this may not be the only way of dealing with alternative policies; as is usual in larger scale DSGE models, we could compute variances of selected variables (or combine them in a "loss function") under different rules (chequear esto último)

A number of objections to the exercise may be raised. One could argue to what extent we can use a small structural model, not explicitly derived from optimizing behaviour of agents, to assess alternative policies. As policies change, so do responses of agents, something not necessarily captured by our behavioural equations. It should be noted, however, that the model is built with rational expectations so, at least at the level of aggregation we are working with, responses do incorporate expectations consistent with the model's structure. Also, models of the financial system derived from microeconomic principles do not generally show changes in the behaviour of firms and families as financial regulation changes, so at least part of the exercise proposed here remains valid.

In connection to the above, it could be pointed out that results in a structural model such as this one are subject to the "Lucas critique" -with the estimated parameters being biased as there is no guarantee of invariance to policy changes. This requires some methodological clarification: using a "micro founded" model would not, in and of itself, assure such invariance and, with it, unbiased results -even if this is usually taken for granted in the use of DSGE models. This is a purely empirical question¹¹ -and as practitioners know, parameters in macroeconomic models are

¹¹ As found by Ericsson and Irons (1995), macroeconomic models are typically subject to the Lucas critique in

usually re-estimated or re-calibrated periodically, implicitly violating the same condition they are assumed to satisfy. Macroeconomic models, whether large or small, are in practice subject to this bias -the question is how large it is, and how it compares to that of alternative models. Large-scale DSGE frameworks, for instance, are ridden with problems of identification and estimation -with certain key parameters or relationships being neither "micro founded" nor estimated. So that while we cannot rule out that the model presented here is indeed subject to the Lucas critique, in our view it represents an acceptable tradeoff between empirical tractability (with all parameters being estimated) and full analytical development that can (only theoretically) bring the model closer to invariance to selected policy interventions. Finally, we think that the empirical strategy employed here (estimating models for each policy rule) is a valid, albeit partial, remedy to the problem, as estimated coefficients reflect behaviour that incorporates the policy that is (assumed to be) implemented.

With the previous points in mind, we compute standard deviations of macroeconomic and financial variables under models 3-7, and compare them. We do the exercise for: inflation, output growth, the local and foreign short term interest rates, nominal USD/peso exchange rate, real USD/real and USD/euro exchange rates, money growth, international reserves, credit, lending interest rates and non performing loans. The comparison in table 8 suggests lower volatility during the estimation period under an exogenous capital requirement (model 4) for the following variables: inflation, output growth, short term local and foreign interest rates, nominal (bilateral) exchange rate depreciation and bilateral real exchange rate depreciation with Brazil, money and credit. Using no macroprudential instrument (model 3) but policy based on both interest rate¹² and foreign exchange intervention delivers lower volatility of international reserves and the lending interest rate. Finally, macroprudential policy implemented as capital requirements as function of interest rate spread would be linked to lower volatility in non performing loans and the bilateral real exchange rate with the euro. All in all, results suggest that for the 2003-2011 period, the interaction of monetary and foreign exchange policy (interest rate rules plus foreign exchange intervention) and macroprudential policy (capital requirements) generated lower volatility of key macroeconomic and financial variables than if no macroprudential policy would have been implemented, or if would have been implemented through an "endogenous" rule; in some cases, as noted, no macroprudential policy or an endogenous formulation (depending on spread) would have yielded lower variability of certain variables of the financial market.

What do we make of these results? First and foremost, measures that contain risk in the financial system also have an influence on macroeconomic performance -evidence for the relevance of macroprudential policy design. Just as the managed floating regime has been found to be optimal for the Argentine economy in a large scale DSGE model (Escudé, 2009) and to deliver lower observed variability of macroeconomic variables than alternative regimes in a fully estimated model (Aguirre and Grosman, 2010), an enhanced policy package that includes regulation of the financial system further contributes to lowering volatility of certain variables. For the estimation period and variables such as growth, inflation, interest rates, money and credit to the private sector, an exogenous capital adequacy ratio appears to have done a better work than if no such regulation had been in place, or if an endogenous rule (dependent on either growth, credit or spread) had been implemented. Lending rates are less volatile under no capital requirements, while the same applies to non performing loans when capital requirements depend on .interest rate spread.

practice; the econometric condition to be satisfied is that of superexogeneity, something that is independent of whether the model was derived from first order conditions of an optimization problem or not.

¹²It should be remembered that interest rate policy also includes consideration of financial stability, as a term for credit appears in the "Taylor type" rule.

Rationalising lower variability of the exogenous CAR rule is at least twofold. On the one hand, in an economy with a relatively small financial system, where credit barely reaches 15% of GDP by the end of the sample period, there does not appear to be a clear advantage of putting in place a rule that links capital requirements neither to some indicator of the state of the real economy or of the financial system at large; we hypothesize that this may have to do with a more significant influence from the real economy to the financial system than otherwise -something that calls for further work to be properly established. On the other hand, we cannot rule out that, since the CAR rule actually in place during the estimation period¹³ is more similar to that of model 4 (exogenous) than to a function of macroeconomic or aggregate financial system variables, this may imply a generally better fit to data (in this case, through lower variance) when compared to rules that were actually not in place. However, a measure of comparative fit like logarithmic data densities suggests that the model with CAR as a function of credit would be the one of choice (table 7). Of course, we may advance further by computing optimal policy and comparing it with what is reported; even within the limits of a small structural model, this could shed some more light on the interplay of monetary, foreign exchange and macroprudential policy -something we leave for the next step of this project.

Table 7: Log data densities of alternative models

Model	Log data density
4 Exogenous CAR	1146.31
5 Endogenous CAR (y)	1135.84
6 Endogenous CAR (cred)	1170.10
7 Endogenous CAR (spread)	1135.95

¹³Capital ratios in the Argentine financial system are a functions of the risk of the different type of assets held by financial institutions. See BCRA (2013) for details.

Table 8: Observed and estimated standard deviations of selected variables

	Model 3		Model 4		Model 5		Model 6		Model 7	
	Credit market, no CAR	CAR	Exogenous CAR	Endogenous CAR	Exogenous CAR (y)	Endogenous CAR	CAR (cred)	Endogenous CAR	CAR (spread)	Endogenous CAR (spread)
π	0.0311		0.0281		0.0422		0.0308		0.0633	
i	0.0118		0.0091		0.0113		0.0100		0.0209	
i^*	0.0099		0.0096		0.0099		0.0105		0.0096	
δ	0.0411		0.0363		0.0386		0.0380		0.0509	
g^y	0.0216		0.0215		0.0351		0.0226		0.0263	
$e^{US,R}$	0.2398		0.2342		0.2511		0.2495		0.2609	
$e^{US,E}$	0.0791		0.0896		0.0684		0.1225		0.0604	
m	0.1479		0.0957		0.1066		0.1258		0.2511	
res	0.4728		0.5582		0.5039		0.4896		0.4788	
CR	0.1862		0.1569		0.1694		0.2086		0.1603	
i^{act}	0.0088		0.0104		0.0142		0.0110		0.0417	
$Delinq$	0.0806		0.0775		0.0761		0.0777		0.0745	
CAR			0.0143		0.0271		0.0178		0.1742	

6 Concluding remarks

We estimated a small macroeconomic model of the Argentine economy, augmented -in its baseline version- 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 evidence by 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 rates¹⁴.

Finally, we enhanced the baseline model to find out whether macroprudential policy helped macroeconomic performance in any meaningful way during the estimation period. Just as previous results show that macroeconomic volatility is reduced when foreign exchange intervention is implemented in addition to interest rate rules (Escudé, 2009 Aguirre and Grosman, 2010), we find that capital requirements may affect not only solvency or liquidity conditions, but also macroeconomic variables at large; over and above their strictly prudential role, they contribute to desirable cyclical macroeconomic property -smoothing output, price, interest rate and credit volatility over the business cycle. This is found when comparing fully estimated models with alternative capital adequacy rules during the 2003-2011 period. These results suggest that the interaction of monetary policy, foreign exchange intervention and prudential tools is, in a way, synergic. Further work, of course, is required in order to properly establish such claim; this includes computing optimal policy and enriching the specification, specially as far as the depiction of the financial system is concerned. Even within the limitations of small structural models for simulation exercises, in our assessment results are strong enough to suggest a likely role for regulation of the financial system in dampening macroeconomic fluctuations in a developing economy like Argentina.

¹⁴ "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.

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Annex 1. Description of variables and data sources

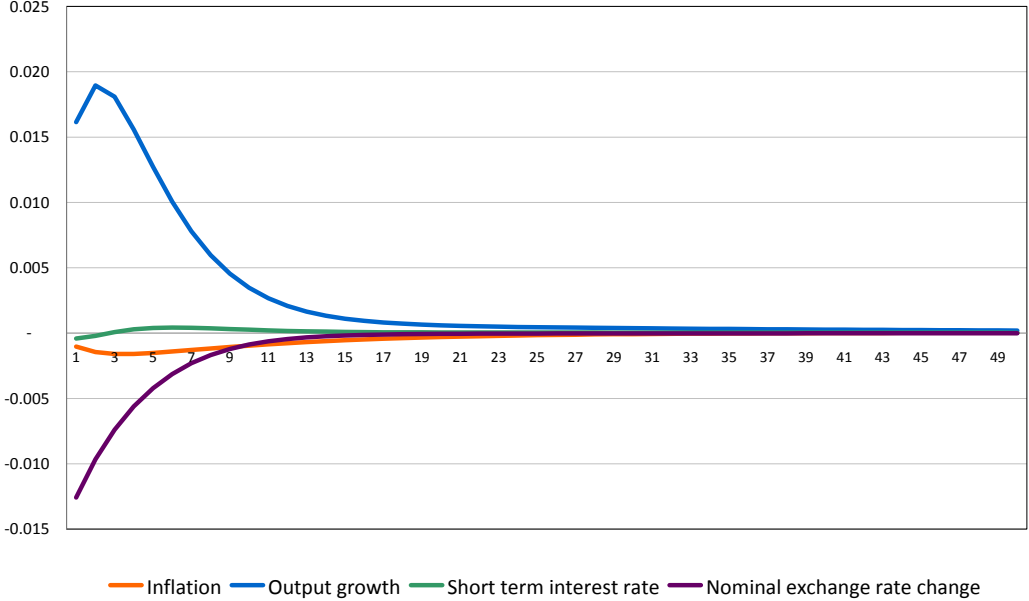
Table A.1

Variable	Description	Source
g^y	GDP growth seasonally adjusted	National accounts
π	Inflation, change in CPI	INDEC
i	Domestic passive 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	Bilateral 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
CAR	Tier 1 capital compliance / Risk weighted assets (financial system)	Central Bank of Argentina

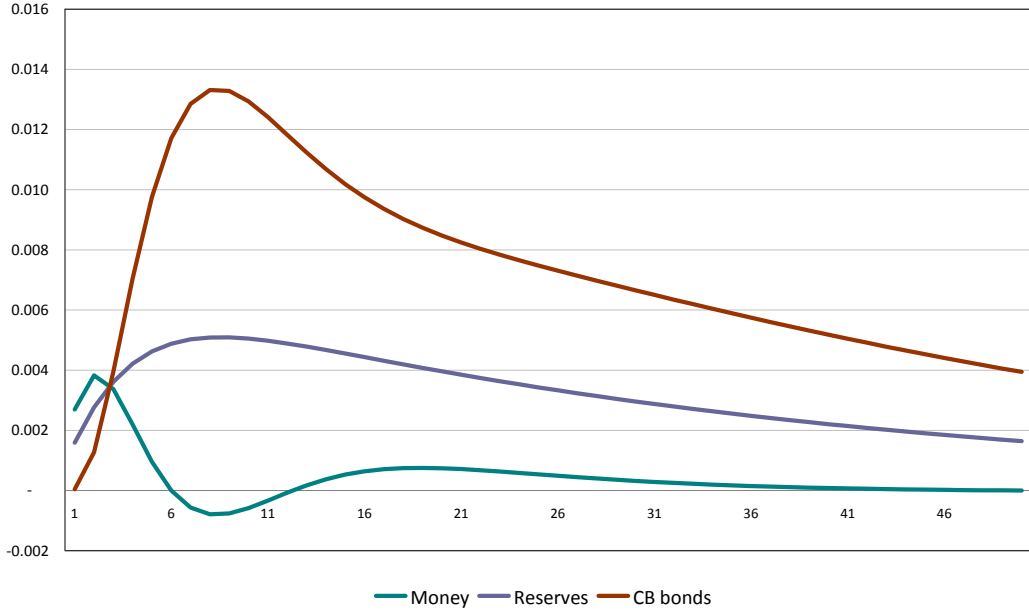
Annex 2. Responses of selected variables to a 1 s.d. shock to output growth

Figure 3

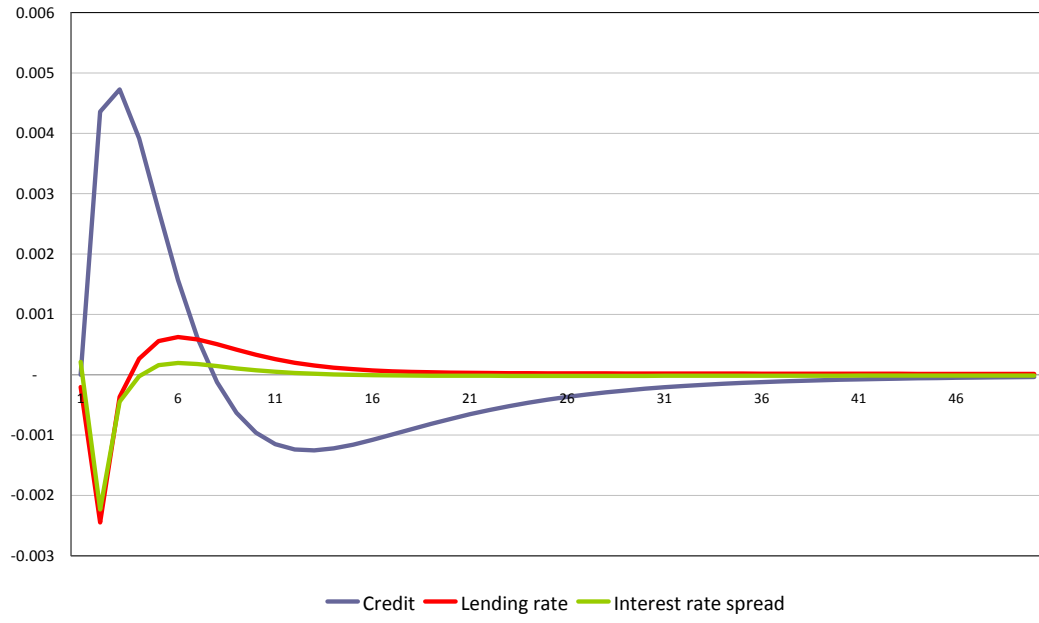
3 (a)



3 (b)



3 (c)



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 than 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:

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

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 heteroskedasticity 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 $\tau = 4$. Results are significant supporting the idea that adding a financial block might also improve predictive ability.¹⁵

¹⁵However one has to recognize that it would be better to have a larger set of forecasts to perform this test.

Annex 4. Parameter estimates of alternative models

Models 3-7: Posterior means

	No CAR	Exogenous CAR	Endogenous CAR <i>output gap</i>	Endogenous CAR <i>credit gap</i>	Endogenous CAR <i>credit spread</i>
ALFA1	0.2049	0.2404	0.1407	0.3567	0.2820
ALFA3	0.0171	0.0590	0.0320	0.0366	0.0704
ALFA4	0.0662	0.1533	0.0452	0.0650	0.0733
BETA1	0.3087	0.4147	0.4534	0.3825	0.2591
BETA2	0.2945	0.3068	0.4022	0.3859	0.3014
BETA3	0.1738	0.1706	0.1655	0.1710	0.2267
BETA4	0.1322	0.1249	0.1278	0.1235	0.1881
BETA5	0.1655	0.3797	0.2695	0.2574	0.1837
BETA7	0.2498	0.2593	0.1936	0.2342	0.1987
RHO1	0.9591	0.9565	0.9637	0.9623	0.9598
RHO2	0.6375	0.4216	0.6190	0.4023	0.6233
RHO3	0.2914	0.2199	0.3003	0.3149	0.2085
RHO6	0.9605	0.9604	0.9467	0.9502	0.9665
RHO7	0.8649	0.8796	0.8079	0.9392	0.6987
RHO8	0.3416	0.6536	0.4006	0.4182	0.2936
GAMMA1	0.7380	0.5557	0.4184	0.3904	0.4832
GAMMA2	0.0488	0.0522	0.0402	0.0191	0.0140
GAMMA3	0.0065	0.0081	0.0302	0.0287	0.0341
GAMMA4	0.0925	0.0929	0.0992	0.0986	0.1024
GAMMA5	0.0019	0.0137	0.0108	0.0220	0.0221
W	5.0777	5.2828	6.1041	4.8923	5.2458
W2	0.0108	0.0108	0.0133	0.0102	0.0120
W3	0.1125	0.1043	0.1296	0.0723	0.0975
MU1	0.7343	0.6806	0.8124	0.8289	0.8807
MU2	0.7570	0.5772	0.2806	0.5421	0.4095
MU3	0.0213	0.0178	0.0212	0.0211	0.0220
MU4	0.7239	0.7044	0.6305	0.7297	0.6253
K1	0.9635	0.9720	0.9672	0.9740	0.9732
K2	0.0934	0.0860	0.0619	0.0993	0.0284
A1	0.3538	0.3687	0.3633	0.3028	0.4164
A2	0.0408	0.0521	0.0999	0.0318	0.0875
A3	0.4513	0.4543	0.4673	0.3673	0.4753
B1	0.0302	0.0440	0.0419	0.0407	0.0364
B2	0.1927	0.2577	0.2923	0.2051	0.2345
B3	0.3790	0.3032	0.2736	0.4205	0.2349
B4		0.2093	0.1455	0.2005	0.1956
RHO_1	0.9808	0.9764	0.9794	0.9781	0.9743
PSI0		0.0105	0.0133	0.0127	0.0103
PSI1		0.4417	0.3145	0.6333	0.8841
PSI2			0.1864	0.0469	0.794