

Credit and Macroprudential Policy in an Emerging Economy: a Structural Model Assessment*

Horacio A. Aguirre[†] Emilio F. Blanco[‡]

This version: January 2015

Abstract

We build and estimate a small macroeconomic model of the Argentine economy, augmented to depict the credit market and interest rate spreads (distinguishing by credit to firms and families); monetary policy with sterilized intervention in the foreign exchange market; and macroprudential policy as capital requirements. 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. Capital requirements, beyond their strictly prudential role, appear to have contributed to lower volatility of key variables such as output, prices, credit and interest rates. The interaction of monetary policy, foreign exchange intervention and prudential tools appears to be synergic: counting on a larger set of tools helps dampen volatility of both macroeconomic and financial system variables, taking into account the type of shocks faced during the estimation period.

JEL classification codes: E17, E51, E52, E58

*Paper prepared for presentation at the closing conference of the BIS Consultative Council of the Americas' research network on "Incorporating Financial Stability Considerations in Central Bank Policy Models", Mexico, January 2015. For useful comments and suggestions, we wish to thank G. Escudé, E. Mendoza, F. Zanetti, participants in the research network and in the following meetings: XLVIII Annual Meeting of *Asociación Argentina de Economía Política*, XXIX Jornadas Anuales de *Economía del Banco Central del Uruguay*, I Jornadas Nacionales de *Econometría*, Universidad de Buenos Aires, and the economics seminar at Universidad de San Andrés. All views expressed are the authors' own and do not necessarily represent those of the Central Bank of Argentina (BCRA).

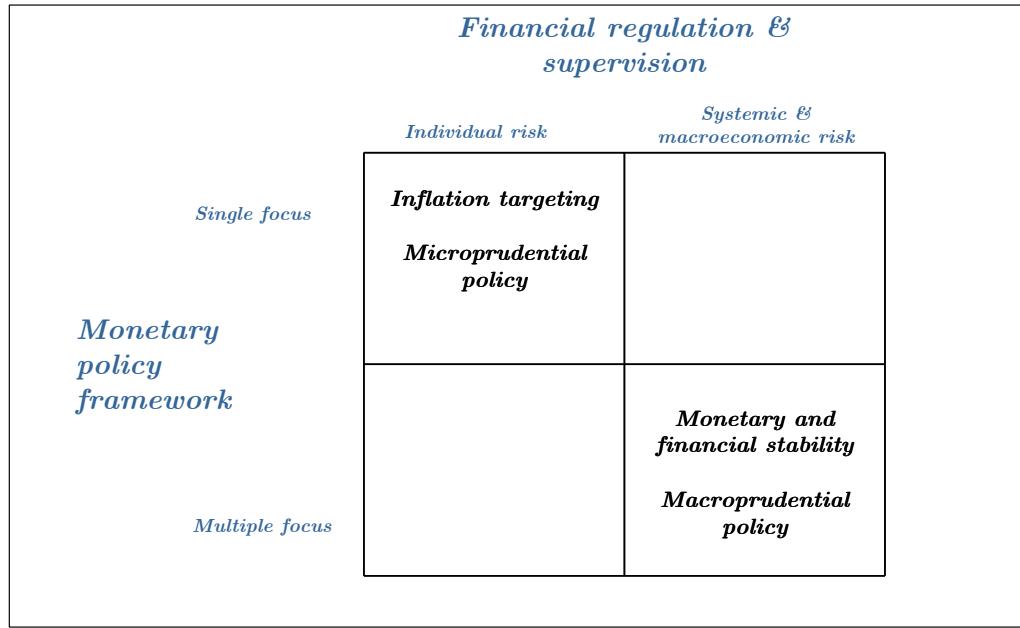
[†]Economic research, BCRA. E-mail: haguirre@bcra.gob.ar

[‡]Economic research, BCRA, and Universidad de Buenos Aires. E-mail: emilio.blanco@bcra.gob.ar

1 Introduction

Following the international financial crisis, there has been a change of perspective in monetary policy frameworks, with the conventional focus being gradually redefined: financial cycles are being accepted as part of the functioning of market economies (Borio, 2012), whose consequences on stability have to be dealt with by central banks; the latter have to be involved in the execution of financial stability policy, if such policy is to be effective. Charging the central bank with responsibility for financial stability is not sufficient –appropriate tools, authorities and safeguards are also needed (CGFS, 2011). Consequently, a double mandate is surging, with monetary and financial stability as acceptable central bank targets. Roughly speaking, the introduction of a financial stability mandate for central banks involves a move from a single focus for monetary policy and a concern for the individual performance of financial institutions, to multiple focused-central banks together with the oversight of financial institutions based on their potential impact on the financial system as a whole, and even on the economy at large. This shift is schematically represented in Figure 1, where two dimensions are sketched: the monetary policy framework, with either a single or a multiple focus; and financial supervision and regulation, aimed at the individual risks of institutions or at their systemic impact. Such shift has brought on the need to incorporate in formal models a wider set of tools used by central banks, such as macroprudential measures. The interaction between both spheres of central bank policy, monetary and macroprudential, has come to the foreground: following our previous work (Aguirre and Blanco, 2013), we aim to incorporate macroprudential instruments into a small structural open economy model of the Argentine economy, completely estimated and suitable for short-term forecasting and simulation exercises.

Figure 1



Macroprudential policy is far from being a well-defined concept, but a generic term for measures whose goal extends beyond safeguarding the solvency or liquidity of financial institutions, to cover their link with macroeconomic performance -recognizing possible spillovers from the financial system to the economy at large, and vice versa. Many different measures can be considered as macroprudential, ranging from capital and liquidity requirements as a function of

certain "cyclical" variables, to loan-to-value ratios, dynamic provisions and other tools that may incorporate to a certain extent the state of the financial system or the economy as an input to determine whether to soften or tighten regulations on banks. However broad in scope, measures taken under a macroprudential approach share a number of features: they are aimed at limiting systemic risk and spillovers from the financial system to the macroeconomy (and vice versa); they take into account externalities of individual financial firms, such as interconnection, procyclicality, and common exposures; as a consequence, the financial system is considered as a whole, and systemic risk is treated as endogenous.

A common theme running through macroprudential analysis is that prevention is key: central banks and supervisors should act before the "turn" of the cycle, as critical pressures build up but before a crisis breaks out. In particular, countercyclical macroprudential policy aims at: i) strengthening the financial system so that it is better prepared to face the downturn of the (financial and business) cycle; ii) smoothing the cycle, preventing imbalances from accumulating during the "boom" phase. In this paper, we look at capital requirements implemented in different ways, as a function of the credit-to-GDP gap, the output gap or interest rate spreads.

Models that integrate the most widely used monetary policy analysis framework -the New Keynesian one- with macroprudential tools have only recently been developed, and a unified approach is lacking. Angelini et al. (2010), Denis et al. (2010) are recent examples that inquire about the interaction between monetary policy and macroprudential tools, and find that introducing a new policy rule in coordination with monetary policy helps to reduce the variance of output and inflation. Indeed, a frequent concern is to what extent both types of policy may be considered complements or substitutes. Cecchetti and Kohler (2014) propose an enlarged aggregate demand-aggregate supply system with both interest rates and capital requirements; they use a game-theoretic approach to investigate the optimal degree of coordination between both policy tools, in a static, theoretical framework. They show that both type of instruments are full substitutes, in the sense that if the ability to use one is limited, the other can "finish" the job; when a financial stability objective is contemplated, that characteristic depends on the coordination between them -under full coordination, substitutability remains. In turn, and in the context of a comprehensive discussion of financial stability and monetary policy, Agenor and Pereira da Silva (2013) analyze whether monetary and macroprudential policy are complementary in an small macroeconomic model: they find them to be so, and have to be calibrated jointly, accounting for the type of credit market imperfections observed in middle income countries and for the fact that macroprudential regimes may affect in substantial ways the monetary transmission mechanism. Végh (2014) argues that both foreign exchange intervention and reserve requirements act in the sense of allowing interest rate policy to achieve other goals: thus, for emerging market countries facing a sudden stop, exchange rate intervention may be used to "defend" the local currency, so that interest rates do not necessarily have to be raised with that aim, while reserve requirements are changed in order to influence credit market conditions –this gives monetary policy higher degrees of freedom to act countercyclically. Once again, none of these models are based on the same structure; and in the case of Cecchetti and Kohler (2014) and Agenor and Pereira da Silva (2013) nor are they derived from the explicit solution of microeconomic problems of households and firms. In turn, and considering that capital controls may be part of the macroprudential policy package, one can also look at recent works such as Escudé (2014): he includes taxes on capital flows in a DSGE open economy model with foreign exchange intervention and interest rate policy; and finds that the use of the three policies is optimal in the sense of achieving a lower value for the loss function than using just one of them or the combination of any two of them. Recent contributions to the study of macroprudential policy in macroeconomic models in the Latin American case include most of the papers presented in the BIS CCA network, such as

Carvalho et al (2013), González et al. (2013).

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 and as a first approximation to the problem. 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. The model we present here is an extension of Aguirre and Blanco (2013), who in turn build 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 modeling choices are close related to our practical goals: if we had a theoretical interest, we would certainly pursue another modeling strategy. In the first place, we take an empirical approach, in that a condition for model building is that parameters should all be estimated, therefore fully "letting the data speak". This contrasts 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, and are 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); in Aguirre and Blanco (2013), we showed the superior forecasting performance of a structural model enlarged to represent financial system features, vis-a-vis a standard New Keynesian "3-equation model". There is a place for representations of different sizes in a well-conceived modeling architecture¹, 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, and a pragmatic approach may be favoured for the sake of incorporating this essential issue in formal models. As pointed out by Galati and Moessner (2011), models that link the financial sector to the macroeconomy are far from having reached a stage where they can be operationalized for analysis and simulation -but such tasks do call for workable solutions even before a new "consensus model" is reached.

In Aguirre and Blanco (2013), we augmented an open economy version of a semi structural New Keynesian model, 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. We estimated using Bayesian techniques, allowing us to assess our prior knowledge of the workings of this economy during the estimation period (2003-2011). We evaluated its forecasting performance: 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 but no financial block, however, does provide better forecasts of annual

¹In the case of Argentina, a fully fledged DSGE model with the explicit interaction of banks and monetary policy has already been developed, even before the international financial crisis brought these aspects to the foreground; Escudé (2008) integrates both financial and real features of the 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.

inflation). We also enhanced the baseline model to find out whether macroprudential policy, implemented as capital requirements, helped macroeconomic performance in any meaningful way during the estimation period.

In this work, we present several improvements in the representation of the credit market: commercial and consumption credit lines are distinguished, both in terms of quantities and interest rates (instead of considering credit to the private sector as whole); and non-performing loans, one of the determinants of lending interest rates, are endogenous (a function of economic activity), and also distinguished by credit and consumption lines. Instead of looking at forecasting performance, we perform some additional exercises, aiming to disentangle the relation between credit and the business cycle. Finally, we introduce capital requirements under different possible definitions, corresponding to alternative macroprudential "rules", cyclical and not, in order to assess whether the interaction between monetary, foreign exchange and macroprudential policy helps dampen macroeconomic fluctuations.

Thus, 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.

This framework can also be taken as a first approximation 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. There are, as is well known, limitations to what structural models can provide in terms of policy and simulation exercises: however, we consider our proposal to be a reasonable trade-off between tractability and ability to take the model to the data. This is all the more important when we build a model that allows us to consider not only monetary policy and macroprudential instruments, but also foreign exchange policy; actually at the level of emerging economies' monetary policy models, ours is one of the few to consider those three dimensions together. Indeed, we consider worth highlighting that, to the best of our knowledge, this and Aguirre and Blanco (2013) are the first empirical assessments of the macroeconomic impact of prudential regulations in Argentina, carried out in a completely estimated macroeconomic model.

Finally, a word is also in order regarding the isomorphism between financial stability issues, at which macroprudential measures aim, and DSGE models (or models like ours, which are based on them). Financial stability ultimately reflects the sustainability of financial intermediaries' operations and its interaction with the macroeconomy: for example, the so-called "subprime crisis" put in the foreground the relationship between asset prices, credit growth and macroeconomic performance, and whether it may lead to unstable behavior of the variables involved -actually, the comeback of an intellectual tradition embodied by economists like Minsky and Kindleberger but that had been out of the mainstream for decades. Such dynamics, however, are extremely difficult to represent in models based on linear approximations around steady states, and which are solved to yield stable solutions. Thus, "financial frictions" turn out to be a device that allows for explicit representation of credit market variables in DSGE models, but that does little by the way of modelling the potential transition from the normal functioning of the system

to a financial crisis; such transition calls for non linear techniques applied to "macrofinancial" models, something that recent works are developing (see Bianchi et al., 2013). Therefore, there certainly is a gap between financial stability analysis and what can be described by models that depict "well behaved" cyclical deviations around a steady state. With this caveat in mind, the following sections present a model inspired by the New Keynesian tradition that incorporates macroprudential policy.

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 others 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 an IS-type equation (1), a Phillips curve (5) and a Taylor-type rule (6)-the first two of which can be obtained as log-linear approximations of first order conditions of consumers' and firms' optimization problems in a monopolistic competition setting where price adjustments are sluggish. The IS equation contains output growth, and not the output gap, as endogenous variable, due exclusively to empirical considerations; and it is augmented to reflect the impact of open economy variables, namely the real exchange rate, on consumption decisions and hence on output; it also includes a lagged growth term, that can be related to the assumption that preferences over consumption exhibit habit formation (Fuhrer, 2000). 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 be interpreted as the active rate that the private sector pays to obtain funds. The average spread is made up of those corresponding to firms and households' credit. An additional term in the IS corresponds to the effect of fiscal impulse on aggregate demand, which is just a convenient way of depicting fiscal shocks, but which serves no direct purpose to the exercises in this paper.

In turn, the Phillips curve (5) evidences the effect of foreign prices in the domestic economy, through an "imported inflation" component via the real exchange rate ; the inclusion of the latter in both the IS and Phillips curves is derived analytically by Galí and Monacelli (2005). Lagged inflation in the Phillips curve, as well as empirically significant as found in many studies, can be thought of as a consequence of the ability of firms to adjust prices according to lagged inflation (Galí and Gertler, 1999). Lagged output gap in the Phillips curve is basically due to empirical fit, something that turns up in estimates of other economies (Galí et al., 2001), and may be justified in relation to GDP data being released with lags (Pincheira and Rubio, 2010,

treat this issue in the Chilean case). The Taylor rule (6) also includes a coefficient on nominal exchange rate depreciation, so that the central bank's behavior not only depends on the output gap and inflation. 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).

Macroeconomic Block

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

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 as²

$$spread_t = \xi^H * spread_t^H + \xi^F * spread_t^F \quad (2)$$

where

$$spread_t^H = \hat{i}_t^{H,act} - \hat{i}_t \quad (3)$$

$$spread_t^F = \hat{i}_t^{F,act} - \hat{i}_t \quad (4)$$

$spread_t^H$: spread - household credit, $spread_t^F$: spread - firms credit, $i_t^{H,act}$: nominal active rate - households, $i_t^{F,act}$: nominal active rate - firms, i_t : nominal (passive) interest rate

$$\hat{\pi}_t = \alpha_1 \mathbb{E} \hat{\pi}_{t+1} + \alpha_2 \hat{\pi}_{t-1} + a_3 y_{t-1} + a_4 \Delta \hat{e}_t^{tri} + \varepsilon_t^\pi \quad (5)$$

where

$$\alpha_2 = 1 - \alpha_1$$

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

$$\hat{i}_t = \gamma_1 \hat{i}_{t-1} + \gamma_2 y_t + \gamma_3 \mathbb{E}_t \hat{\pi}_{t+1}^a + \gamma_4 \hat{\delta}_t + \gamma_5 \widehat{CR}_t + \varepsilon_t^i \quad (6)$$

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

$$\widehat{CR}_t = \widehat{CR}_t^H + \widehat{CR}_t^F$$

CR^H : Household's credit to GDP ratio, CR^F : Firm's credit to GDP ratio

Foreign exchange conditions and policy, as well as the money market, are described in equations (7)-(11). A modified uncovered interest rate parity (UIP) condition (7) 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 (11) describes equilibrium in the money market, which

²Where ξ^H and ξ^F are calibrated $\frac{1}{2}$.

may be estimated for narrower or broader definition of monetary aggregates. How exchange rate intervention is instrumented is described by equation (10), whereby the central bank buys or sells international reserves in reaction to nominal exchange rate variability; equation (8) shows to what extent such intervention is sterilized.

This specification merits some further explanation. Introducing a policy of sterilized intervention can be thought of as "augmenting" or modifying the uncovered interest rate parity (5); actually, what we have is a new equation for the determination of the nominal exchange rate -after all, the purpose of sterilized intervention is precisely to "block" in a way the conditions imposed by UIP in its normal form. In our setting, 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. This modified UIP can be rationalized as follows: domestic agents may invest in both local and foreign currency-denominated bonds, which are not perfect substitutes; returns of bonds in pesos have to compensate for expected depreciation; in turn, bonds in foreign currency pay the international rate but reflect a liquidity risk. It may further be assumed that not all actors that participate in the foreign currency market optimize on the base of fundamentals; some of them decide on the past performance of the currency (and are called "chartists"); this is behind the expected depreciation term in (5), which corresponds to agents that act on fundamentals, and the current depreciation term, which corresponds to "chartists".

In turn, the endogenous component of risk premium in (5) is determined by interventions in the currency market: the central bank buys or sells international reserves, and issues or withdraws bonds from circulation in order to sterilize the effects of intervention on the money supply. The consequent change in the endogenous risk premium may be rationalised as reflecting both counterparty (\widehat{b}_t) and exchange rate risk ($\widehat{\Delta res}_t$): to hold a higher stock of bonds, local investors demand a higher rate (this would not be the same as holding bonds issued abroad, reflecting a different counterparty); changes in international reserves are associated to changes in exchange rate risk, as when it intervenes, the central bank modifies the foreign currency volatility. Other rationalizations could read as follows: regarding the presence of \widehat{b}_t , if central bank bond issuance is interpreted as postponed liquidity supply, higher bonds today may mean higher liquidity tomorrow and, therefore, a higher interest rate rate today; international portfolio adjustment could be considered costly, depending on the relative holdings of bonds in pesos and in foreign currency, and so central bank intervention using reserves actually changes the endogenous risk premium and, with it, the exchange rate (Sierra, 2008).

Central bank interventions are ruled by a "propensity" to avoid exchange rate movements to a certain extent as measured by the coefficient in (10), in keeping with the aim of a managed floating regime of smoothing short term "excessive" fluctuations of the nominal exchange rate. Thus, any external financial shocks are smoothed by the central bank in line with its aim of minimizing short run disruption in the foreign exchange market. A desire to act gradually is reflected by the autoregressive coefficient, which can be rationalized on the grounds of financial stability.

FX Policy Block

$$\widehat{i}_t = \widehat{i}_t^* + \omega_1 \mathbb{E}_t \widehat{\delta}_{t+1} + (1 - \omega_1) \widehat{\delta}_t + \omega_2 \widehat{b}_t + \omega_3 \widehat{res}_t + \widehat{\lambda}_t \quad (7)$$

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

$$\hat{b}_t = \frac{1}{1-\phi} (\widehat{rest}_t + \hat{e}_t^d) - \frac{\phi}{1-\phi} \hat{m}_t \quad (8)$$

$$\phi = \frac{m}{m+b} \quad (9)$$

m: money to GDP ratio³

$$\widehat{rest}_t = \kappa_1 \widehat{rest}_{t-1} - \kappa_2 \widehat{\delta}_t + \varepsilon_t^{res} \quad (10)$$

$$\widehat{m}_t = -\eta_1 \widehat{i}_t + \eta_2 \widehat{\pi}_t + \eta_3 \widehat{b}_t + \eta_4 \widehat{\delta}_t + \varepsilon_t^m \quad (11)$$

Having characterized the basic macroeconomic dynamics, together with central bank policy in the money and foreign exchange markets, the following step is to consider lending rates and credit. In the model, credit -strictly, the credit gap- is basically a function of the output gap and the lending interest rate, as shown in both credit market equilibrium equations, one referred to household (consumption) credit and the other to corporate (commercial) credit (12). In turn, equation (14) 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. This specification is consistent with empirical results for the Argentine economy that spread depends negatively on growth and positively on non-performing loans (Aguirre et al, 2014). As before, lending rates are considered for both commercial and consumption loans. Non performing loans are a function of economic activity, in line with their observed cyclical behavior. Credit as previously defined also feeds back into the "macroeconomic block" of the model through its inclusion in the interest rate rule (6); 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 autoregressive processes: the international interest rate, the exogenous component of risk premium in (7), 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.

Financial Block

$$\widehat{CR}_t^H = A_1^H \widehat{g}_{t-1}^y - A_2^H \widehat{i}_{t-1}^{H,act} + A_3^H \widehat{CR}_{t-1}^H + \varepsilon_t^{HCR} \quad (12)$$

$$\widehat{CR}_t^F = A_1^F \widehat{g}_{t-1}^y - A_2^F \widehat{i}_{t-1}^{F,act} + A_3^F \widehat{CR}_{t-1}^F + \varepsilon_t^{FCR} \quad (13)$$

$$\widehat{i}_t^{H,act} = B_1 \widehat{Delinq}_t^H - B_2 \widehat{g}_{t-1}^y + B_3 \widehat{i}_t + \varepsilon_t^{Hact} \quad (14)$$

$$\widehat{i}_t^{F,act} = B_1 \widehat{Delinq}_t^F - B_2 \widehat{g}_{t-1}^y + B_3 \widehat{i}_t + \varepsilon_t^{Fact} \quad (15)$$

³The parameter ϕ is calibrated equal to 0.5833

$Delinq^H$: ratio of non performing loans to household credit, $Delinq^F$: ratio of non performing loans to firms credit

$$\widehat{Delinq}_t^H = \rho_1^{DH} \widehat{Delinq}_{t-1}^H + \rho_2^{DH} \widehat{g}_{t-1}^y + \varepsilon_t^{HDelinq} \quad (16)$$

$$\widehat{Delinq}_t^F = \rho_1^{DF} \widehat{Delinq}_{t-1}^F + \rho_2^{DF} \widehat{g}_{t-1}^y + \varepsilon_t^{FDelinq} \quad (17)$$

Identities

$$\widehat{e_t^{tri}} \equiv \widehat{e^d}_t + c_1 \widehat{e^{US,R}}_t + c_2 \widehat{e^{US,E}}_t \quad (18)$$

$$\widehat{r}_t \equiv \widehat{i}_t - E_t \widehat{\pi}_{t+1} \quad (19)$$

$$\widehat{\Delta e^d}_t \equiv \widehat{\delta}_t + \widehat{\pi^*}_t - \widehat{\pi}_t \quad (20)$$

$$\widehat{g}_t^y \equiv \Delta y_t + \widehat{g^y}_t \quad (21)$$

$$\widehat{\mu}_t \equiv \Delta \widehat{m}_t + \widehat{\pi}_t + \widehat{g}_t^y \quad (22)$$

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

Exogenous variables⁴

$$\widehat{i^*}_t = \rho_1 \widehat{i^*}_{t-1} + \varepsilon_t^{i^*} \quad (23)$$

$$\widehat{\lambda}_t = \rho_2 \widehat{\lambda}_{t-1} + \varepsilon_t^\lambda \quad (24)$$

$$\widehat{\pi^*}_t = \rho_3 \widehat{\pi^*}_{t-1} + \varepsilon_t^{\pi^*} \quad (25)$$

$$\widehat{e^{US,R}}_t = \rho_4 \widehat{e^{US,R}}_{t-1} + \varepsilon_t^{e^{US,R}} \quad (26)$$

$$\widehat{e^{US,E}}_t = \rho_5 \widehat{e^{US,E}}_{t-1} + \varepsilon_t^{e^{US,E}} \quad (27)$$

$$\widehat{s^f}_t = \rho_6 \widehat{s^f}_{t-1} + \varepsilon_t^{s^f} \quad (28)$$

$$\widehat{g^y}_t = \rho_7 \widehat{g^y}_{t-1} + \varepsilon_t^{g^y} \quad (29)$$

3 Estimation

We estimate this baseline version of the model (equations 1-29) completely through Bayesian techniques⁵, based on quarterly data and for the 2003Q3-2011Q3 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 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

⁴Parameter ρ_7 is calibrated

⁵Model solution, estimation and stochastic simulations were performed using the Dynare 4.3.3 software platform in Matlab.

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 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 $\boldsymbol{\theta} \in \Theta$ as the vector of parameters. Given the prior information $g(\boldsymbol{\theta})$, the observed data $Y_T = [Y_1, Y_2, \dots, Y_T]$ and the sample information $f(Y_T/\boldsymbol{\theta})$, the posterior density -transition from prior to posterior- of the parameters is given by Bayes' rule:

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

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

Notice that $f(Y_T)$ (the marginal likelihood) is constant, hence the posterior density is proportional to the product of the likelihood function $f(Y_T/\boldsymbol{\theta})$ 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

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

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

3.1 Results and impulse-response functions

Table 1 presents parameter estimates⁶; table 2 contains the standard deviation of shocks.

⁶It 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 | psdev |
|---------------|------------|------------|----------------|-------|--------|
| α_1 | 0.3000 | 0.2640 | 0.2326 0.3046 | beta | 0.1000 |
| α_3 | 0.0500 | 0.0779 | 0.0621 0.0942 | norm | 0.0350 |
| α_4 | 0.1000 | 0.0648 | 0.0510 0.0776 | beta | 0.0500 |
| β_1 | 0.3000 | 0.5257 | 0.4547 0.5986 | beta | 0.1000 |
| β_2 | 0.5000 | 0.3971 | 0.3401 0.4555 | beta | 0.2000 |
| β_3 | 0.1700 | 0.1357 | 0.1249 0.1486 | norm | 0.0500 |
| β_4 | 0.2000 | 0.1093 | 0.0840 0.1329 | beta | 0.1000 |
| β_5 | 0.3000 | 0.1134 | 0.0714 0.1586 | beta | 0.1000 |
| β_6 | 0.3000 | 0.1229 | 0.0752 0.1691 | beta | 0.1000 |
| ρ_1 | 0.5000 | 0.9372 | 0.8823 0.9888 | beta | 0.2000 |
| ρ_2 | 0.5000 | 0.7412 | 0.6172 0.8729 | beta | 0.2000 |
| ρ_3 | 0.5000 | 0.3202 | 0.2832 0.3615 | beta | 0.2000 |
| ρ_4 | 0.7000 | 0.9719 | 0.9447 0.9990 | beta | 0.2000 |
| ρ_5 | 0.7000 | 0.7114 | 0.6511 0.7730 | beta | 0.2000 |
| ρ_6 | 0.5000 | 0.6576 | 0.5442 0.7642 | beta | 0.2000 |
| γ_1 | 0.7000 | 0.5730 | 0.5192 0.6228 | beta | 0.2000 |
| γ_2 | 0.0000 | 0.0207 | -0.0158 0.0567 | norm | 0.2000 |
| γ_3 | 0.0000 | 0.0246 | 0.0120 0.0376 | norm | 0.2000 |
| γ_4 | 0.2000 | 0.0827 | 0.0640 0.1006 | beta | 0.1000 |
| γ_5 | 0.0000 | 0.0073 | 0.0047 0.0098 | norm | 0.2000 |
| ω_1 | 4.0000 | 5.9114 | 5.5979 6.2623 | norm | 1.5000 |
| ω_2 | 0.1000 | 0.0078 | 0.0018 0.0136 | beta | 0.0500 |
| ω_3 | 1.0000 | 0.1776 | 0.0002 0.3797 | norm | 1.0000 |
| η_1 | 1.2000 | 1.2028 | 1.1366 1.2702 | norm | 0.3000 |
| η_2 | 0.5000 | 0.5528 | 0.4770 0.6227 | beta | 0.2000 |
| η_3 | 0.5000 | 0.0309 | 0.0233 0.0384 | norm | 0.3000 |
| η_4 | 0.5000 | 0.6645 | 0.6346 0.6948 | norm | 0.1000 |
| κ_1 | 0.7000 | 0.9815 | 0.9643 0.9981 | beta | 0.2000 |
| κ_2 | 0.1000 | 0.1377 | 0.1159 0.1592 | beta | 0.0500 |
| A_1^H | 0.3000 | 0.4007 | 0.3847 0.4174 | beta | 0.0500 |
| A_2^H | 0.1000 | 0.0664 | 0.0560 0.0780 | beta | 0.0500 |
| A_3^H | 0.3000 | 0.3785 | 0.3649 0.3973 | beta | 0.0500 |
| B_1^H | 0.3000 | 0.0685 | 0.0478 0.0922 | beta | 0.1000 |
| B_2^H | 0.3000 | 0.1688 | 0.1447 0.1944 | beta | 0.1000 |
| B_3^H | 0.3000 | 0.2279 | 0.1793 0.2788 | beta | 0.1000 |
| ρ_1^{DH} | 0.5000 | 0.8104 | 0.7605 0.8563 | beta | 0.2000 |
| ρ_2^{DH} | 0.3000 | 0.4720 | 0.4186 0.5177 | beta | 0.1000 |
| A_1^F | 0.3000 | 0.3333 | 0.3190 0.3429 | beta | 0.0500 |
| A_2^F | 0.1000 | 0.1100 | 0.0910 0.1285 | beta | 0.0500 |
| A_3^F | 0.3000 | 0.4096 | 0.3923 0.4266 | beta | 0.0500 |
| B_1^F | 0.3000 | 0.0180 | 0.0100 0.0245 | beta | 0.1000 |
| B_2^F | 0.3000 | 0.2301 | 0.2115 0.2485 | beta | 0.1000 |
| B_3^F | 0.3000 | 0.2146 | 0.1528 0.2749 | beta | 0.1000 |
| ρ_1^{DF} | 0.5000 | 0.9118 | 0.8942 0.9294 | beta | 0.2000 |
| ρ_2^{DF} | 0.3000 | 0.4546 | 0.4239 0.4846 | beta | 0.1000 |

Table 2: Baseline model
standard deviation of shocks

| | prior | mean | post. | mean | conf. | interval | prior | pstdev |
|--------------------------|--------------|-------------|--------------|-------------|--------------|-----------------|--------------|---------------|
| ε^i | 0.05 | 0.0028 | 0.0022 | 0.0035 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{g\bar{y}}$ | 0.05 | 0.0237 | 0.014 | 0.0395 | <i>gamma</i> | 0.035 | | |
| ε^y | 0.05 | 0.0146 | 0.0107 | 0.0185 | <i>gamma</i> | 0.035 | | |
| ε^{i^*} | 0.05 | 0.0015 | 0.0011 | 0.0019 | <i>gamma</i> | 0.035 | | |
| ε^{π^*} | 0.05 | 0.0092 | 0.0075 | 0.0111 | <i>gamma</i> | 0.035 | | |
| ε^{RP} | 0.05 | 0.022 | 0.0131 | 0.0315 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{e^{US,R}}$ | 0.05 | 0.0734 | 0.0606 | 0.0815 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{e^{US,E}}$ | 0.05 | 0.0455 | 0.0354 | 0.0567 | <i>gamma</i> | 0.035 | | |
| ε^π | 0.05 | 0.0105 | 0.008 | 0.0131 | <i>gamma</i> | 0.035 | | |
| ε^m | 0.06 | 0.0383 | 0.0326 | 0.0438 | <i>gamma</i> | 0.035 | | |
| ε^{res} | 0.05 | 0.1054 | 0.096 | 0.1151 | <i>gamma</i> | 0.035 | | |
| ε^{sf} | 0.05 | 0.0045 | 0.0034 | 0.0053 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{CR,H}$ | 0.10 | 0.1135 | 0.1008 | 0.1266 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{act,H}$ | 0.05 | 0.0061 | 0.0046 | 0.0077 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{Delinq,H}$ | 0.05 | 0.0086 | 0.0066 | 0.0105 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{CR,F}$ | 0.10 | 0.2017 | 0.1874 | 0.2152 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{act,F}$ | 0.05 | 0.007 | 0.0053 | 0.0087 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{Delinq,F}$ | 0.05 | 0.0107 | 0.0084 | 0.013 | <i>gamma</i> | 0.035 | | |

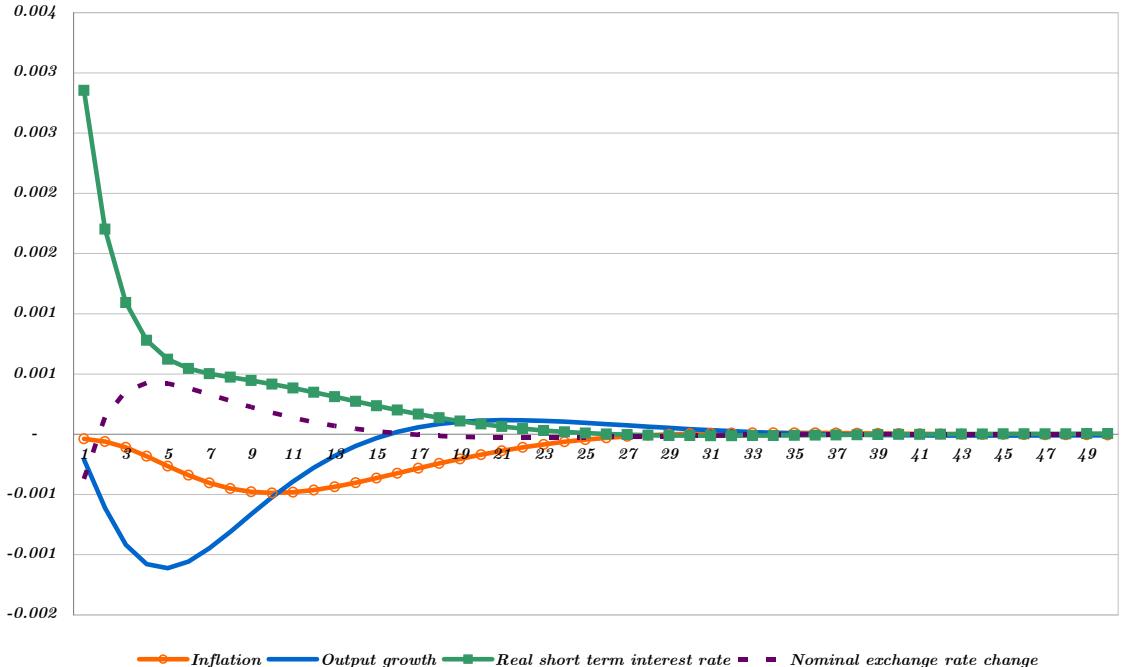
With this fully estimated model, we look at impulse-response functions in order to understand its basic dynamics, with emphasis on how the credit market block interacts with the rest of the economy. Following positive shocks to lending rates -both for commercial and consumption credit- (figure 1), credit decreases and the interest rate spread increases -the short term interest rate increases, but to a lesser degree than the active rate. As expected, each line of credit reacts more strongly to an increase of its own 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 higher expected 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 (initial) nominal and real exchange rate appreciation; output is also affected. 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 -, 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 example, the effect of passive rates on deposit growth⁷.

⁷In 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 2
Accumulated responses to 1 s.d. shock to the short term interest rate

Baseline Model
Short term IR Shock



Baseline Model
Short term IR Shock

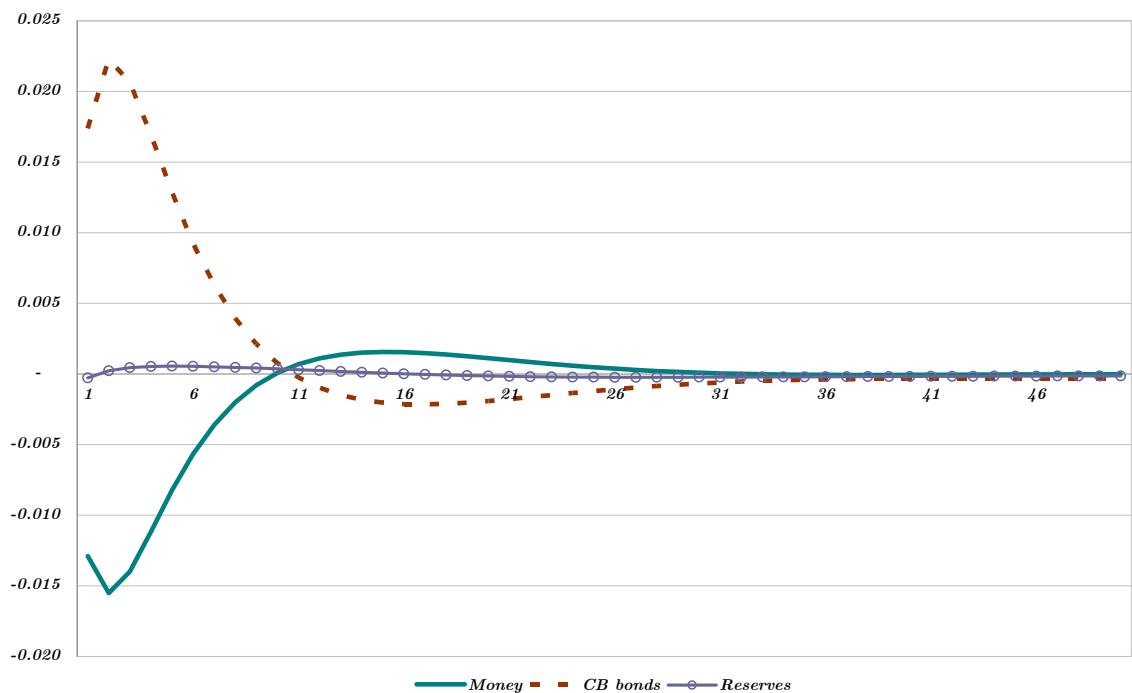


Figure 2 (cont.)
Accumulated responses to 1 s.d. shock to the short term interest rate

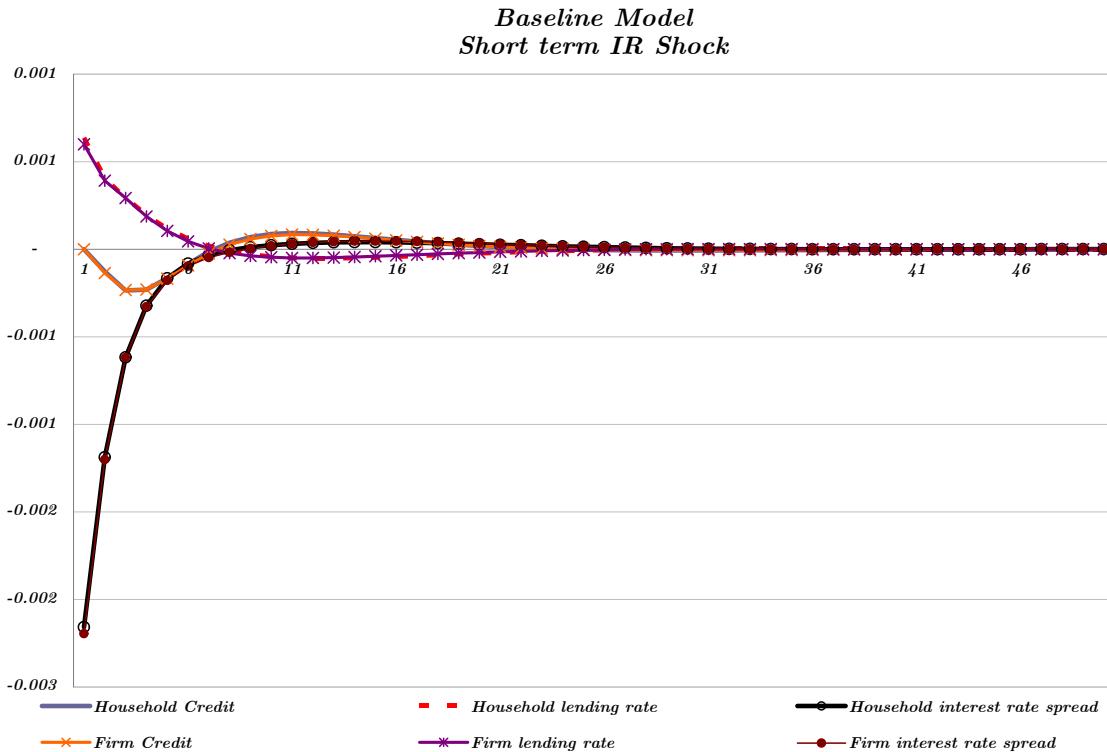


Figure 3
Accumulated responses to 1 s.d. shock to the Household lending rate

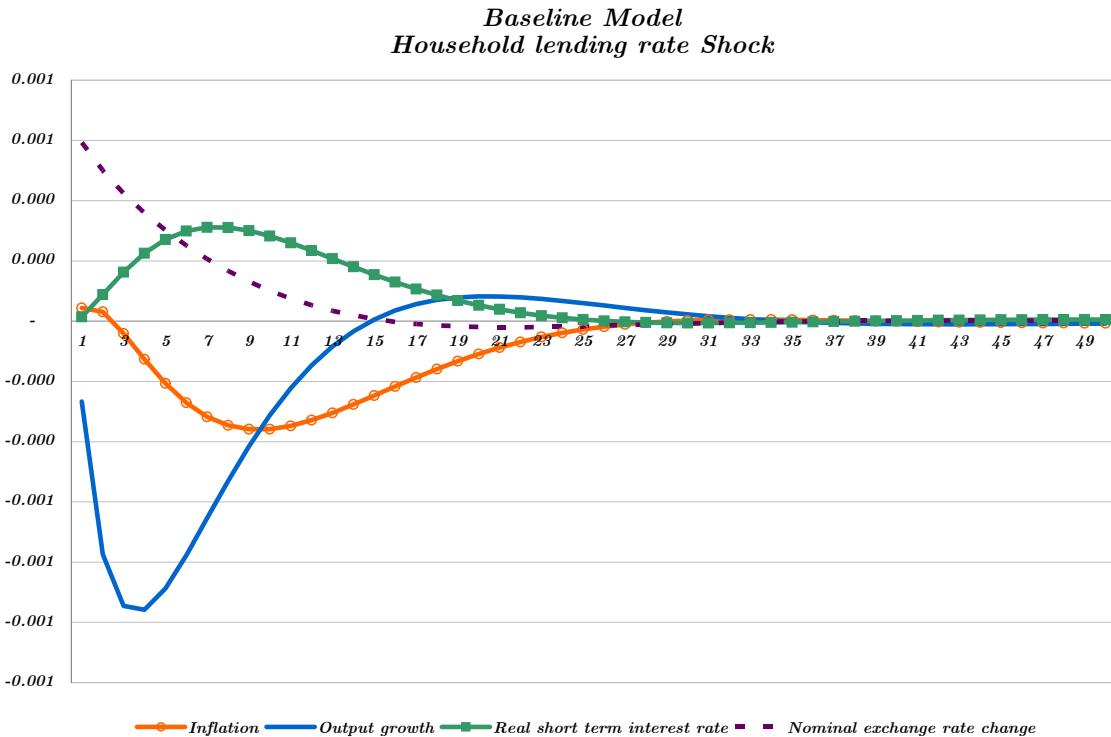


Figure 3 (cont.)
Accumulated responses to 1 s.d. shock to the Household lending rate

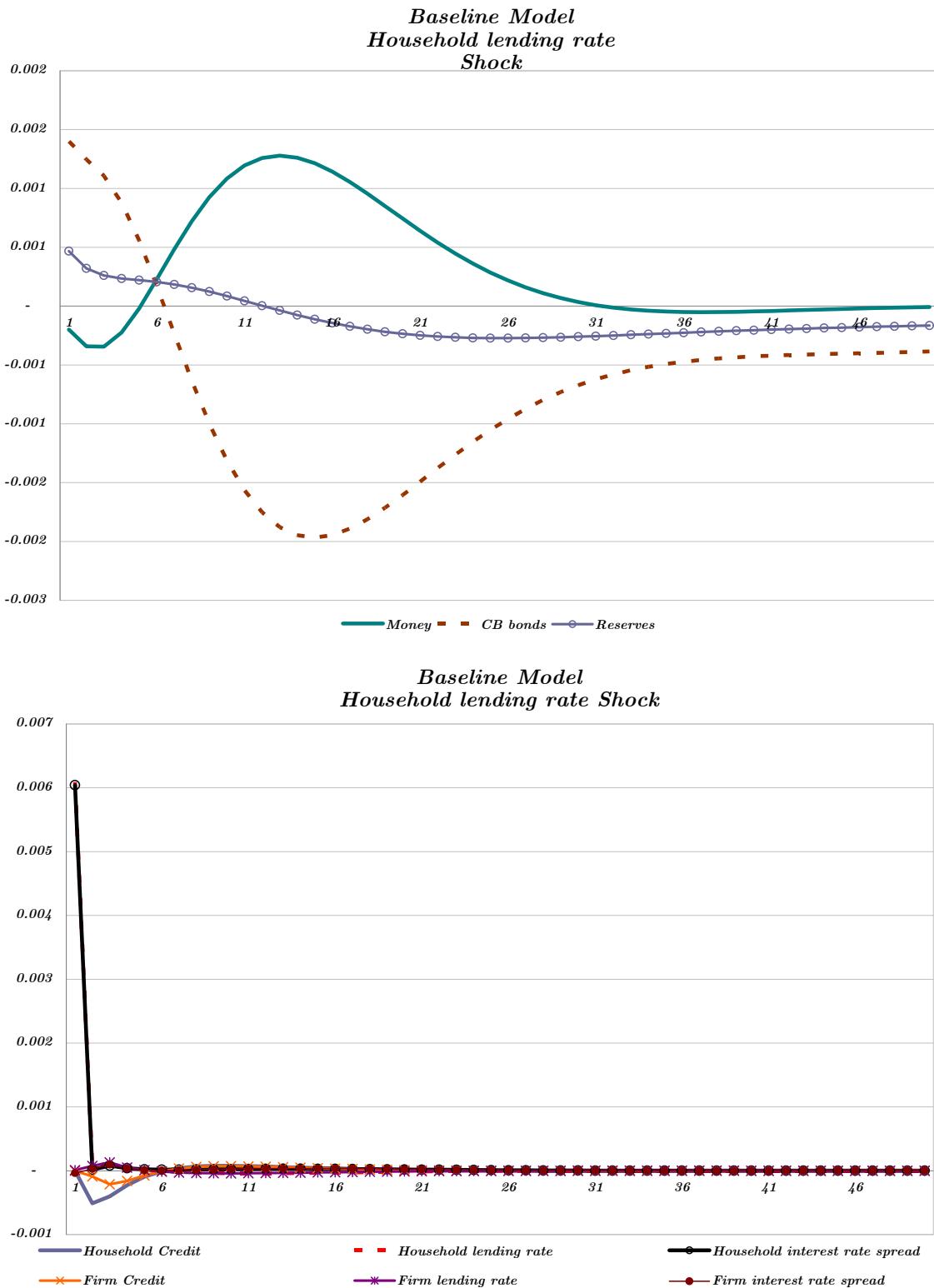
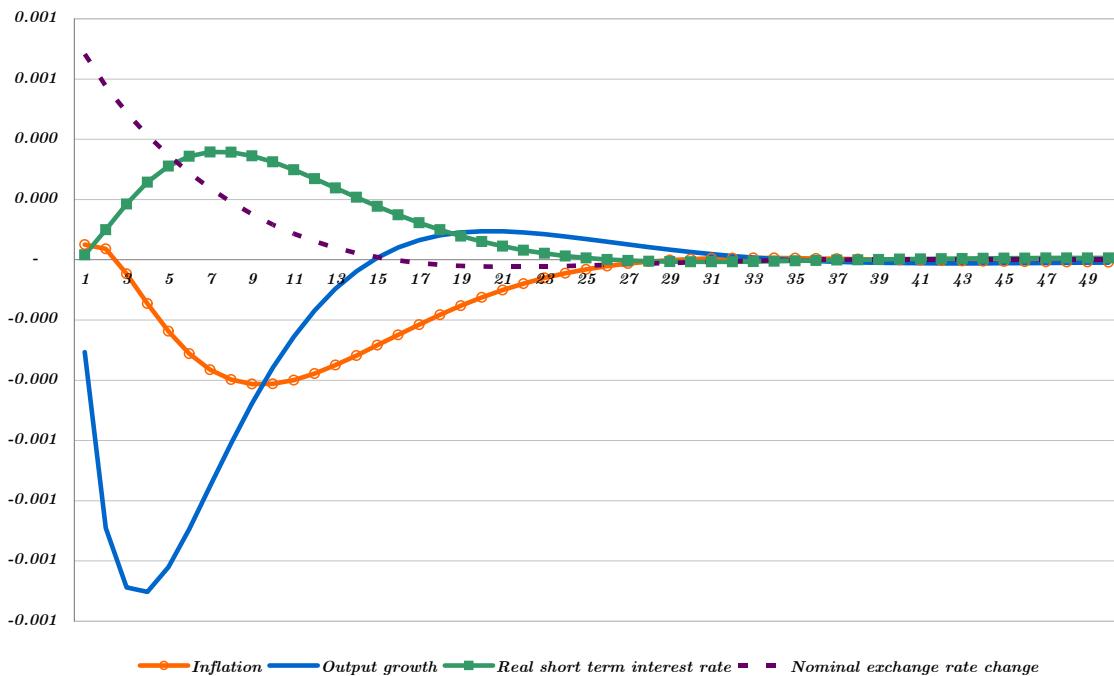


Figure 4
Accumulated responses to 1 s.d. shock to the Firm lending rate

Baseline Model
Firm lending rate Shock



Baseline Model
Firm lending rate Shock

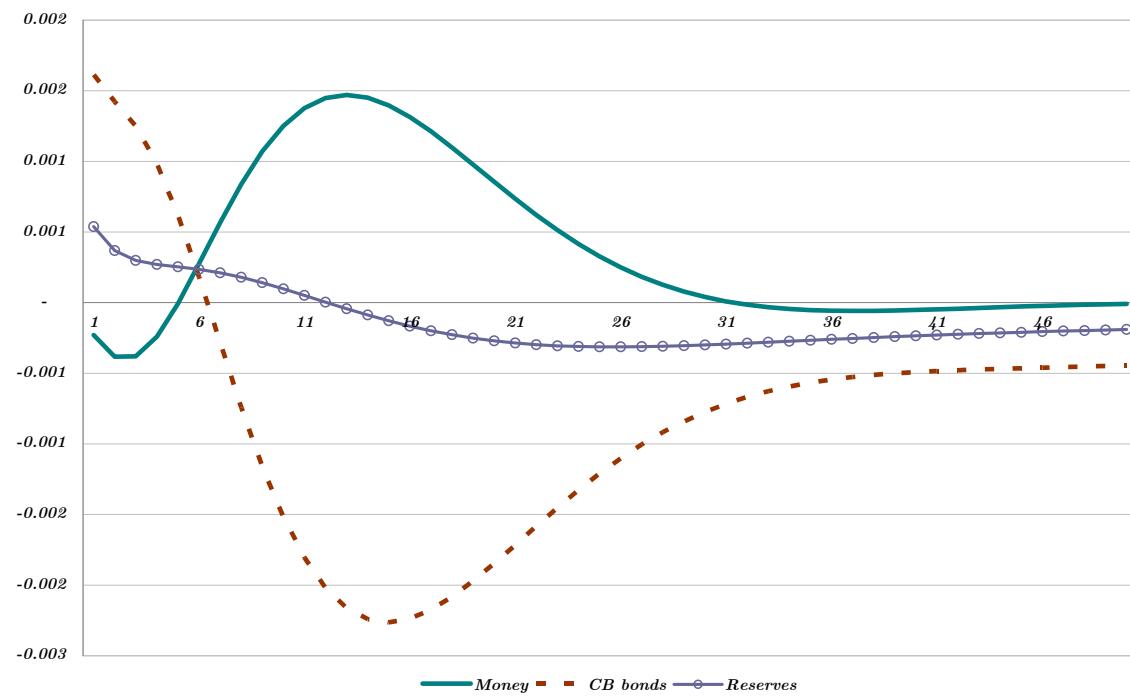
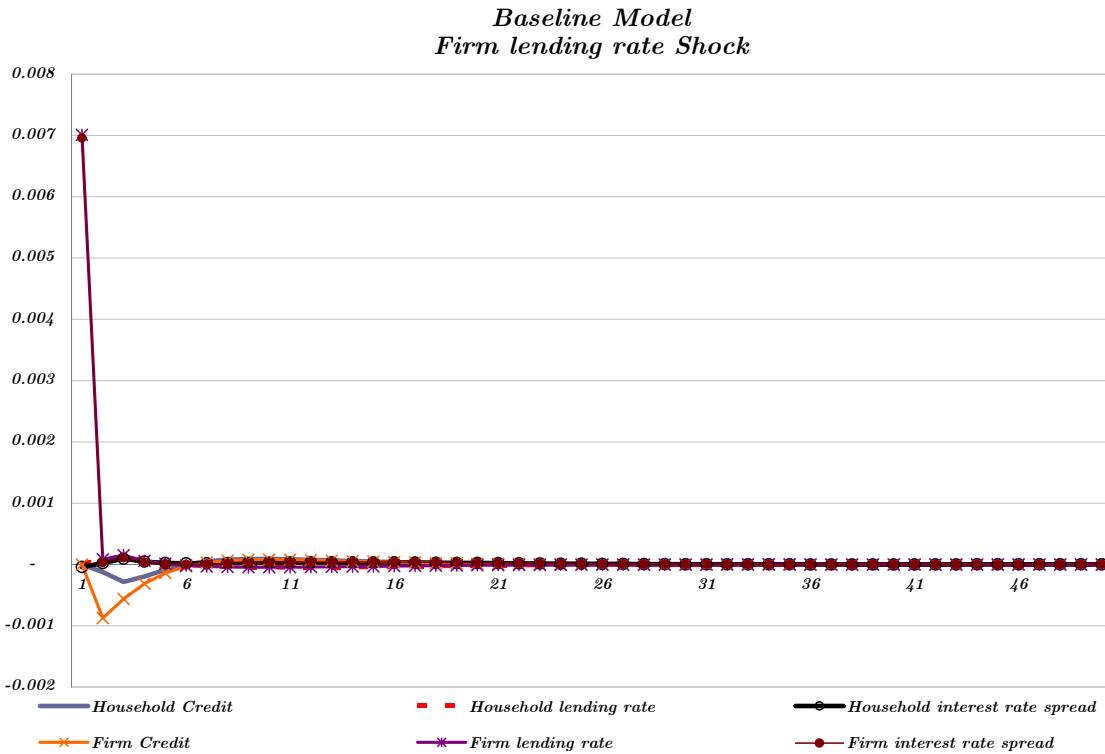


Figure 4 (cont.)
Accumulated responses to 1 s.d. shock to the Firm lending rate



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 inflation; the short term interest rate increases, in nominal terms -basically due to the reaction required by the Taylor rule- but decreases in real terms. 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. In turn, both types of credit increase, the lending rates fall, and so do both spreads.

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 output⁸. 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.

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. In this respect, we can also look at suggestive results from the relationship between the macroeconomic

⁸This 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.

and the financial blocks of the model: we compare the variability of credit following a shock to output growth, and the variability of the latter in the face of a credit shock. Table 3 shows that the standard deviation of credit following shocks to consumption and commercial credit: growth is more variable in the face of a shock to corporate credit than one to household credit. But both types of credit are several times more volatile following a shock to output growth. This suggests that impulses coming from the real side of the economy weigh more heavily on the financial system than the other way around.

Table 3
Standard deviations of responses to shocks of selected variables after

| | 10 quarters | 20 quarters | 30 quarters |
|---------------------------|-------------------------|-------------|-------------|
| <i>Consumption credit</i> | | | |
| <i>Output</i> | 0.000151409 | 0.000221678 | 0.000222296 |
| | <i>Corporate credit</i> | | |
| <i>Output</i> | 0.000286187 | 0.000416377 | 0.000419054 |
| | <i>Output growth</i> | | |
| <i>Consumption credit</i> | 0.003384811 | 0.002514053 | 0.002036951 |
| | 0.002970155 | 0.002228947 | 0.001806152 |

Finally, a word is in order regarding how good our baseline model 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 |

4 The extended model: macroprudential policy

Of the many different measures that can be considered as "macroprudential", we will focus on one of the most basic financial system regulations⁹ -a capital adequacy ratio- and will consider several variants, ranging from a purely exogenous ratio from the macroeconomic point of view (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, which can be defined in alternative ways: exogenous (30), in the sense that its level does not depend on variables explicitly modelled¹⁰; a function of the output gap (31); a function of the credit-to-GDP gap (32), which is the standard way in which countercyclical capital regulation is currently being designed under Basel III (Drehmann and Tsatsaronis, 2014); or the interest rate spread (33). These alternatives,

⁹ That 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".

¹⁰ Strictly speaking, of course, capital requirements are always endogenous from the point of view of financial institutions, as they depend on their risk-weighted assets.

which added to the baseline model are labeled respectively as models 2, 3, 4 and 5, correspond to different policy concerns: risk taken by banks is moderated by higher requirements, which may be more related to macroeconomic (model 3) or financial system performance (models 4 and 5). The main difference in motivation between models 4 and 5 is whether quantity-based or price-based indicators perform better in terms of early warning of crises (Shin, 2013). The capital adequacy ratio (CAR) is then included in the equation describing the actives rates (34) and (35); 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

$$\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \varepsilon_t^{CAR} \quad (30)$$

where CAR : capital adequacy ratio

Second Option: Endogenous

$$\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 \hat{y}_t + \varepsilon_t^{CAR} \quad (31)$$

$$\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 \widehat{CR}_t + \varepsilon_t^{CAR} \quad (32)$$

$$\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 spread_t + \varepsilon_t^{CAR} \quad (33)$$

$$\widehat{i}_t^{act,H} = B_1^H \widehat{Delinq}_t^H - B_2^H \widehat{g}_{t-1}^y + B_3^H \widehat{i}_t + B_4 \widehat{CAR}_t + \varepsilon_t^{Hact} \quad (34)$$

$$\widehat{i}_t^{act,F} = B_1^F \widehat{Delinq}_t^F - B_2^F \widehat{g}_{t-1}^y + B_3^F \widehat{i}_t + B_4 \widehat{CAR}_t + \varepsilon_t^{Fact} \quad (35)$$

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 2003Q3-2011Q3 period. Estimates of parameters and standard deviations of model 2 are shown in tables 5 and 6; for a comparison with the rest of the models, we refer the reader to annex 3.

Table 5: Model 2, exogenous CAR
 parameter estimates

| parameters | prior | mean | post. mean | conf. interval | prior | pstdev | |
|---------------|-------|------|------------|----------------|--------|--------|-------|
| α_1 | | 0.3 | 0.2146 | 0.1801 | 0.2458 | beta | 0.1 |
| α_3 | | 0.05 | 0.0324 | 0.0057 | 0.0619 | norm | 0.035 |
| α_4 | | 0.1 | 0.1413 | 0.1176 | 0.1704 | beta | 0.05 |
| β_1 | | 0.3 | 0.3234 | 0.2898 | 0.3601 | beta | 0.1 |
| β_2 | | 0.5 | 0.4587 | 0.4005 | 0.5182 | beta | 0.2 |
| β_3 | | 0.17 | 0.2174 | 0.1853 | 0.2491 | norm | 0.05 |
| β_4 | | 0.2 | 0.1584 | 0.1075 | 0.2111 | beta | 0.1 |
| β_5 | | 0.3 | 0.1657 | 0.1241 | 0.2062 | beta | 0.1 |
| β_6 | | 0.3 | 0.2595 | 0.1606 | 0.3539 | beta | 0.1 |
| ρ_1 | | 0.5 | 0.9619 | 0.931 | 0.9924 | beta | 0.2 |
| ρ_2 | | 0.5 | 0.7094 | 0.6085 | 0.8324 | beta | 0.2 |
| ρ_3 | | 0.5 | 0.3641 | 0.2951 | 0.4473 | beta | 0.2 |
| ρ_4 | | 0.7 | 0.9619 | 0.9278 | 0.9979 | beta | 0.2 |
| ρ_5 | | 0.7 | 0.9047 | 0.8274 | 0.961 | beta | 0.2 |
| ρ_6 | | 0.5 | 0.2195 | 0.1127 | 0.3167 | beta | 0.2 |
| γ_1 | | 0.7 | 0.6256 | 0.5332 | 0.7434 | beta | 0.2 |
| γ_2 | | 0 | 0.0127 | -0.0091 | 0.0363 | norm | 0.2 |
| γ_3 | | 0 | 0.0241 | 0.005 | 0.0425 | norm | 0.2 |
| γ_4 | | 0.2 | 0.0766 | 0.0452 | 0.1063 | beta | 0.1 |
| γ_5 | | 0 | 0.0053 | 0.0007 | 0.0098 | norm | 0.2 |
| ω_1 | | 4 | 5.5952 | 4.7328 | 6.4999 | norm | 1.5 |
| ω_2 | | 0.1 | 0.0095 | 0.0025 | 0.0162 | beta | 0.05 |
| ω_3 | | 1 | 0.2395 | 0.0016 | 0.4583 | norm | 1 |
| η_1 | | 1.2 | 0.952 | 0.8283 | 1.0614 | norm | 0.3 |
| η_2 | | 0.5 | 0.6917 | 0.5892 | 0.8204 | beta | 0.2 |
| η_3 | | 0.5 | 0.0273 | 0.0203 | 0.0349 | norm | 0.3 |
| η_4 | | 0.5 | 0.7375 | 0.6943 | 0.7793 | norm | 0.1 |
| κ_1 | | 0.7 | 0.9763 | 0.9535 | 0.9975 | beta | 0.2 |
| κ_2 | | 0.1 | 0.1283 | 0.1016 | 0.1558 | beta | 0.05 |
| A_1^H | | 0.3 | 0.3772 | 0.3595 | 0.3901 | beta | 0.05 |
| A_2^H | | 0.1 | 0.0975 | 0.0764 | 0.1217 | beta | 0.05 |
| A_3^H | | 0.3 | 0.414 | 0.3962 | 0.4357 | beta | 0.05 |
| B_1^H | | 0.3 | 0.0992 | 0.0751 | 0.1227 | beta | 0.1 |
| B_2^H | | 0.3 | 0.2543 | 0.2302 | 0.2809 | beta | 0.1 |
| B_3^H | | 0.3 | 0.2385 | 0.1592 | 0.3184 | beta | 0.1 |
| B_4^H | | 0.3 | 0.145 | 0.1195 | 0.1696 | beta | 0.1 |
| ρ_1^{DH} | | 0.5 | 0.8193 | 0.787 | 0.8496 | beta | 0.2 |
| ρ_2^{DH} | | 0.3 | 0.3741 | 0.3277 | 0.4185 | beta | 0.1 |
| A_1^F | | 0.3 | 0.3845 | 0.3534 | 0.4163 | beta | 0.05 |
| A_2^F | | 0.1 | 0.0994 | 0.07 | 0.1319 | beta | 0.05 |
| A_3^F | | 0.3 | 0.4594 | 0.4334 | 0.4887 | beta | 0.05 |
| B_1^F | | 0.3 | 0.0229 | 0.0112 | 0.0333 | beta | 0.1 |
| B_2^F | | 0.3 | 0.2437 | 0.1836 | 0.3019 | beta | 0.1 |
| B_3^F | | 0.3 | 0.2608 | 0.1857 | 0.3027 | beta | 0.1 |
| B_4^F | | 0.3 | 0.1336 | 0.0976 | 0.1706 | beta | 0.1 |
| ρ_1^{DF} | | 0.5 | 0.9074 | 0.8852 | 0.9316 | beta | 0.2 |
| ρ_2^{DF} | | 0.3 | 0.4726 | 0.4363 | 0.5095 | beta | 0.1 |
| ψ_0 | | 0.5 | 0.0107 | 0.01 | 0.0116 | beta | 0.2 |
| ψ_1 | | 0.7 | 0.3775 | 0.2881 | 0.4783 | beta | 0.2 |

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

| | prior | mean | post. | mean | conf. | interval | prior | pstdev |
|--------------------------|--------------|-------------|--------------|-------------|--------------|-----------------|--------------|---------------|
| ε^i | 0.05 | 0.003 | 0.0023 | 0.0037 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{g\bar{y}}$ | 0.05 | 0.0187 | 0.011 | 0.028 | <i>gamma</i> | 0.035 | | |
| ε^y | 0.05 | 0.0179 | 0.0138 | 0.0217 | <i>gamma</i> | 0.035 | | |
| ε^{i^*} | 0.05 | 0.0014 | 0.0011 | 0.0016 | <i>gamma</i> | 0.035 | | |
| ε^{π^*} | 0.05 | 0.0095 | 0.0076 | 0.0115 | <i>gamma</i> | 0.035 | | |
| ε^{RP} | 0.05 | 0.0353 | 0.024 | 0.0459 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{e^{US,R}}$ | 0.05 | 0.062 | 0.0535 | 0.0693 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{e^{US,E}}$ | 0.05 | 0.042 | 0.0352 | 0.049 | <i>gamma</i> | 0.035 | | |
| ε^π | 0.05 | 0.013 | 0.01 | 0.0162 | <i>gamma</i> | 0.035 | | |
| ε^m | 0.06 | 0.0306 | 0.0227 | 0.0377 | <i>gamma</i> | 0.035 | | |
| ε^{res} | 0.05 | 0.1092 | 0.0953 | 0.1221 | <i>gamma</i> | 0.035 | | |
| ε^{sf} | 0.05 | 0.0041 | 0.0033 | 0.0049 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{CR,H}$ | 0.1 | 0.1217 | 0.1105 | 0.1314 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{act,H}$ | 0.05 | 0.0067 | 0.0051 | 0.0082 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{Delinq,H}$ | 0.05 | 0.0077 | 0.0059 | 0.0095 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{CR,F}$ | 0.1 | 0.1669 | 0.1536 | 0.1791 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{act,F}$ | 0.05 | 0.0068 | 0.0051 | 0.0085 | <i>gamma</i> | 0.035 | | |
| $\varepsilon^{Delinq,F}$ | 0.05 | 0.0115 | 0.0087 | 0.0142 | <i>gamma</i> | 0.035 | | |
| ε^{CAR} | 0.05 | 0.0142 | 0.0109 | 0.0174 | <i>gamma</i> | 0.035 | | |

We use estimated models to try to gain some understanding of potentially 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.

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 behavior of agents, to assess alternative policies. As policies change, so do responses of agents, something not necessarily captured by our behavioral 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.

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 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 usually re-estimated or re-calibrated periodically, implicitly violating the same condition they are

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

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 trade-off 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 behavior 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 1-5, as well as with an alternative to the baseline model, where the central bank implements monetary policy through the interest rate, but without intervening in the foreign exchange market (model 0) .We do the exercise for: inflation, output growth, local short term interest rates, the real trilateral (trade-weighted) exchange rate, money growth, international reserves, credit (total and by line), lending interest rates (average and by credit line), non performing loans (by credit line) and capital requirements. The comparison in table 7 suggests the lowest volatility during the estimation period under an endogenous capital requirement (output gap, model 3) for the following variables: international reserves, average, consumption and commercial lending interest rates, and consumption non-performing loans. In turn, capital requirements as a function of interest rate spreads (model 5) deliver lower growth, deposit interest rate, money growth and commercial non-performing loans than alternative policies. When capital adequacy is implemented based on the credit-to-GDP gap (model 4), it shows the lowest variability for inflation, real exchange rate depreciation and capital requirements. An "exogenous" CAR (model 2) delivers the lowest standard deviations of average and commercial credit. Finally, using no capital requirements but monetary and foreign exchange policy (model 1) is associated to the lowest variability of consumption credit ¹²

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.

Table 7 : Observed and estimated standard deviations of selected variables

| | Model 0 Float | Model 1 Baseline | Model 2 Exogenous CAR | Model 3 Endogenous CAR (y) | Model 4 Endogenous CAR (cred) | Model 5 Endogenous CAR (spread) |
|-------------|------------------|---------------------|--------------------------|-----------------------------------|----------------------------------|------------------------------------|
| π | 0.0462 | 0.058 | 0.0307 | 0.0328 | 0.0292 | 0.0366 |
| i | 0.0122 | 0.0134 | 0.0116 | 0.0134 | 0.0199 | 0.0107 |
| g^y | 0.0577 | 0.057 | 0.0473 | 0.0587 | 0.0614 | 0.0418 |
| e^{tri} | 0.0831 | 0.0959 | 0.0572 | 0.0726 | 0.0453 | 0.0727 |
| m | 0.2201 | 0.2201 | 0.1836 | 0.1926 | 0.1514 | 0.1337 |
| res | 0.1343 | 0.5499 | 0.5065 | 0.5025 | 0.6613 | 0.6079 |
| CR | 0.2624 | 0.2621 | 0.2392 | 0.2516 | 0.2772 | 0.2522 |
| CR^H | 0.1281 | 0.1279 | 0.1372 | 0.1444 | 0.1411 | 0.1373 |
| CR^F | 0.2236 | 0.2235 | 0.1907 | 0.1958 | 0.232 | 0.2082 |
| i^{act} | 0.018 | 0.0173 | 0.0164 | 0.0131 | 0.0204 | 0.0172 |
| $i^{act,H}$ | 0.019 | 0.0183 | 0.0191 | 0.0138 | 0.0214 | 0.0183 |
| $i^{act,F}$ | 0.0183 | 0.0176 | 0.0152 | 0.0145 | 0.0208 | 0.0175 |
| $Delinq^H$ | 0.116 | 0.1152 | 0.0757 | 0.0689 | 0.0821 | 0.0692 |
| $Delinq^F$ | 0.1978 | 0.1972 | 0.1571 | 0.1285 | 0.1757 | 0.1278 |
| CAR | | | 0.0153 | 0.0319 | 0.0134 | 0.0349 |

In order to gain a comprehensive assessment of these results and the policies associated to them, we aggregate the different variability measures by summing up variances of the variables considered -thereby using ad hoc "loss" functions. As those functions are not derived from the utility of a representative consumer, they do not indicate anything in terms of social welfare, but we interpret them instead as embodying alternative evaluation criteria of an analyst or policymaker whose concern is for volatility of selected macroeconomic and financial variables. Generally, the loss function we use here is defined as follows.

We considered several loss functions, combining different macro (g^y, π, e^{tri}) and financial ($i, i^{act}, i^{act,H}, i^{act,F}, CR^H, CR^F, CAR$) variables. Thus, an example of loss function could be:

$$\mathcal{L} \equiv \omega^{g^y} * \sigma_{g^y}^2 + \omega^\pi * \sigma_\pi^2 + \omega^i * \sigma_i^2 + \omega^{CAR} * \sigma_{CAR}^2$$

where $\sigma_{g^y}^2$ is the variance of output gap, σ_π^2 is the variance of inflation, σ_i^2 is the variance of short term interest rate and σ_{CAR}^2 is the variance of the capital adequacy ratio, and ω are the corresponding weights such as $(\omega^{g^y} + \omega^\pi + \omega^i + \omega^{CAR}) = 1$.

Initially, we assign equal weights to all components of the function, considering in all cases inflation, output growth, the short term interest rate and real exchange rate depreciation, together with: consumption credit, commercial credit, and commercial credit and capital requirements. To consider lending rates, we also look at the sum of inflation, output growth, real exchange rate depreciation and: consumption lending rate and credit; commercial lending rate and credit. To focus on macroeconomic variables and central bank's instruments, we consider output growth, inflation, the short term interest rate and capital adequacy ratios. In all such cases, the lowest aggregate variability is obtained under "exogenous" capital requirements (table 8).

In order to gain a better understanding of what drives such result, we look at loss functions that include only macroeconomic variables and interest rates (table 8). In this case, capital requirements that vary with interest rate spreads show the lowest volatility, except when real exchange rate depreciation is included in the loss function -in this case, "exogenous" CARs deliver the lowest volatility, once again. This suggests that results that favour CARs not linked to macroeconomic or financial system variables directly have to do with reducing the volatility of the real exchange rate, something that appears relevant in an economy like Argentina.

A related exercise has to do with changing weights in the terms of the loss function: we compute aggregate volatility with higher weights either on macroeconomic variables (output growth, inflation, real exchange rate depreciation) or on financial system ones (interest rates, credit). As shown in table 8, with higher weights on macroeconomic variables, exogenous CARs show lower losses except when real exchange rate depreciation is factored in -there, it is CAR as a function of interest rate spread that exhibits lower volatility. When higher weight is put on financial system variables, the exogenous CAR rule is still found to yield lower losses than alternative ones, except for the case when consumption credit is included in the loss function -there, the model with interest rate rule only yields the lowest volatility.

Table 8: Loss Functions of alternative models

| Variables Considered in Loss Function | <i>Model 0</i> | <i>Model 1</i> | <i>Model 2</i> | <i>Model 3</i> | <i>Model 4</i> | <i>Model 5</i> |
|--|--|----------------|-----------------|---------------------------|--------------------------|----------------------------|
| | Float | Baseline | Exogenous CAR | Endogenous CAR (y) | Endogenous CAR (cred) | Endogenous CAR (spread) |
| | <i>Equal weights ($\omega = \frac{1}{n}$)</i> | | | | | |
| g^y, π | 0.00546 | 0.00661 | 0.00318 | 0.00452 | 0.00462 | 0.00309 |
| g^y, i^{act} | 0.00365 | 0.00355 | 0.00251 | 0.00362 | 0.00419 | 0.00204 |
| g^y, π, i^{act} | 0.00579 | 0.00691 | 0.00345 | 0.00469 | 0.00504 | 0.00338 |
| $g^y, \pi, i^{act}, e^{tri}$ | 0.01273 | 0.01614 | 0.00682 | 0.00998 | 0.00713 | 0.00871 |
| g^y, π, i, i^{act} | 0.00595 | 0.00710 | 0.00355 | 0.00491 | 0.00545 | 0.00351 |
| g^y, π, i, CAR | 0.00561 | 0.00679 | 0.00355 | 0.00572 | 0.00520 | 0.00442 |
| $g^y, \pi, i, e^{tri}, CR^H$ | 0.02893 | 0.03235 | 0.02541 | 0.03082 | 0.02698 | 0.02734 |
| $g^y, \pi, i, e^{tri}, CR^F$ | 0.06252 | 0.06594 | 0.04295 | 0.04831 | 0.06089 | 0.05183 |
| $g^y, \pi, i, e^{tri}, CR^F, CAR$ | | | 0.04319 | 0.04933 | 0.06107 | 0.05305 |
| $g^y, \pi, i^{act}, e^{tri}, CR^H$ | 0.02914 | 0.03250 | 0.02564 | 0.03083 | 0.02704 | 0.02756 |
| $g^y, \pi, i^{act}, e^{tri}, CR^F$ | 0.06270 | 0.06607 | 0.04305 | 0.04834 | 0.06093 | 0.05203 |
| <i>Weights: Macro variables $\omega^{g^y} = \omega^\pi = \omega^{e^{tri}} = \frac{4}{15}$; Financial variables $\omega^i = \omega^{i^{act,H}} = \omega^{i^{act,F}} = \frac{1}{15}$</i> | | | | | | |
| $g^y, \pi, i, e^{tri}, CR^H$ | 0.004402 | 0.005318 | 0.002984 | 0.004013 | 0.003134 | 0.003497 |
| $g^y, \pi, i, e^{tri}, CR^F$ | 0.006642 | 0.007558 | 0.004154 | 0.005179 | 0.005395 | 0.005130 |
| $g^y, \pi, i, e^{tri}, i^{act,H}$ | 0.003332 | 0.004250 | 0.001754 | 0.002636 | 0.001837 | 0.002263 |
| $g^y, \pi, i, e^{tri}, i^{act,F}$ | 0.003331 | 0.004249 | 0.001745 | 0.002637 | 0.001835 | 0.002261 |
| <i>Weights: Macro variables $\omega^{g^y} = \omega^\pi = \frac{5}{12}$; Financial variables $\omega^i = \omega^{i^{act,H}} = \omega^{i^{act,F}} = \frac{1}{12}$</i> | | | | | | |
| $g^y, \pi, i, i^{act,H}$ | 0.00232 | 0.00280 | 0.00137 | 0.00191 | 0.00200 | 0.00132 |
| $g^y, \pi, i, i^{act,F}$ | 0.00232 | 0.00280 | 0.00136 | 0.00192 | 0.00200 | 0.00132 |
| <i>Weights: Macro variables $\omega^{g^y} = \omega^\pi = \frac{2}{15}$ and $\omega^{e^{tri}} = \frac{1}{15}$; Financial variables $\omega^i = \omega^{i^{act,H}} = \omega^{i^{act,F}} = \frac{5}{15}$</i> | | | | | | |
| $g^y, \pi, i, e^{tri}, CR^H$ | 0.006708 | 0.007008 | 0.006962 | 0.007965 | 0.007522 | 0.007086 |
| $g^y, \pi, i, e^{tri}, CR^F$ | 0.017904 | 0.018205 | 0.012809 | 0.013793 | 0.018826 | 0.015251 |
| $g^y, \pi, i, e^{tri}, i^{act,H}$ | 0.001359 | 0.001666 | 0.000809 | 0.001078 | 0.001038 | 0.000914 |
| $g^y, \pi, i, e^{tri}, i^{act,F}$ | 0.001350 | 0.001658 | 0.000764 | 0.001084 | 0.001029 | 0.000904 |
| <i>Weights: Macro variables $\omega^{g^y} = \omega^\pi = \frac{1}{12}$; Financial variables $\omega^i = \omega^{i^{act,H}} = \omega^{i^{act,F}} = \frac{5}{12}$</i> | | | | | | |
| $g^y, \pi, i, i^{act,H}$ | 0.00067 | 0.00077 | 0.00047 | 0.00053 | 0.00074 | 0.00044 |
| $g^y, \pi, i, i^{act,F}$ | 0.00066 | 0.00075 | 0.00042 | 0.00054 | 0.00073 | 0.00043 |

In general, 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. As shown above, for a considerable set of macroeconomic and financial system variables, we find lower volatility associated to the implementation of capital adequacy ratio rules under different definitions. When measures of aggregate volatility are computed, capital requirements that are not explicitly modelled as functions of macroeconomic or financial system variables generally outperform no macroprudential policy or an endogenous formulation (depending on the credit gap, output growth or spread) of the capital adequacy ratios.

What do we make of these findings? 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 aggregating volatility of 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. Different endogenous rules, however, tend to show the lowest volatility for selected individual variables.

Rationalizing lower aggregate 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 2 (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 9). 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.

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 9
Log data densities of alternative models

| Model | Log data density |
|------------------------------|------------------|
| Baseline | 1207.6884 |
| Exogenous CAR | 1316.2976 |
| Endogenous CAR (y) | 1318.7722 |
| Endogenous CAR (cred) | 1324.8944 |
| Endogenous CAR (spread) | 1301.4448 |

5 Concluding Remarks

Based on our previous work (Aguirre and Blanco, 2013), 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. In this paper, we present a somewhat more detailed specification of the financial sector, distinguishing credit by type (commercial or consumption) and making non performing loans endogenous. Compared to current analyses of the interaction of monetary and macroprudential policy, we provide a framework that explicitly allows for the interaction of foreign exchange intervention, interest rate policy and macroprudential policy -something that, to our knowledge, is only dealt with by Escudé (2014) for the case of capital controls.

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 aggregate 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.

In Aguirre and Blanco (2013) we looked at forecast performance, showing 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 was evaluated for 1-, 2- and 4-step out-of-sample forecasts, and using RMSE and MAE forecast evaluation criteria. We also looked at whether macroprudential policy helped macroeconomic performance in any meaningful way during the estimation period. Here we advance further in this kind of evaluation, considering aggregate volatility of macroeconomic and financial system variables.

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, an a way, synergic; they enhance the findings of Agenor and Pereira da Silva (2013), who point out that for the sake of macroeconomic and financial stability, monetary and macroprudential policy are largely complementary; and illustrate the conclusion of Cecchetti and Kohler (2014), for whom the linkages between monetary policy and macroprudential tools open the way for the improvement of both macroeconomic and financial system performance. Our findings extend such notions in a possible sequence of availability of tools: from interest rates to foreign exchange intervention and capital requirements, more tools at the disposal of a central bank may help reduce volatility.

Thus, the discussion may not be so much between interest rate and macroprudential measures as complements or substitutes; instead, the question is whether counting on a larger set of tools helps the central bank achieve more desirable outcomes in terms of policymakers' preferences or objectives. Here, our findings are in line with the literature developed so far, which appears to point toward a positive answer –qualified, of course, by the different analytical settings and actual experiences on which each study has been developed. Even within the limitations of small structural models for simulation exercises, in our assessment results suggest a likely role for regulation of the financial system in dampening macroeconomic fluctuations in a developing economy like Argentina.

References

- [1] Agenor, P. R. and L. Pereira da Silva (2013): "Inflation Targeting and Financial Stability: A Perspective from the Developing World", Banco Central do Brasil Working Paper 324, September.
- [2] Aguirre, H., T. and E. Blanco (2013): "Credit and Interest Rate Spreads in a Small Macroeconomic Model of the Argentine Economy", BIS Consultative Council of the Americas' research network on "Incorporating Financial Stability Considerations in Central Bank Policy Models".
- [3] Aguirre, H., T. Burdisso, F. Grillo and E. Giupponi (2014): "Interest rate spreads in an emerging economy under different macroeconomic regimes", paper presented at the 5th BIS CCA research conference "Challenges from changing international financial conditions", Bogotá, May.
- [4] Aguirre, H. and N. Grosman (2010): "A Note on Managed Floating in a Small Economic Model", paper presented at the XLV annual meeting of the Argentine Economic Association, Buenos Aires.
- [5] Angelini, P., S. Neri and F. Panetta (2010): "Monetary and Macroprudential Policies", Discussion Paper, Bank of Italy.
- [6] 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.
- [7] Bianchi, J., E. Boz and E. Mendoza (2012): "Macroprudential Policy in a Fisherian Model of Financial Innovation", *IMF Economic Review*, Vol. 60, No. 2.
- [8] Borio, C. (2012): "The financial cycle and macroeconomics: What have we learnt?", BIS Working Papers No 395, Bank of International Settlements.
- [9] 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.
- [10] Carvalho, F., M. Castro and S. Costa (2013): "Traditional and Matter-of-fact Financial Frictions in a DSGE Model for Brazil: the role of macroprudential instruments and monetary policy", Banco Central do Brasil Working Paper 336, November.
- [11] Cecchetti, S. and M. Kohler (2014): "When Capital Adequacy and Interest Rate Policy Are Substitutes (And When They Are Not)", *International Journal of Central Banking*, Vol. 10 No. 3, September, pp. 205-231.
- [12] Committe on the Global Financial System (2011): "Practical approaches to designing and conducting macroprudential policy", Bank for International Settlements, January.
- [13] Dennis, B., L. Clerc and B. Mojon (2011): "Macroprudential Policy and the Conduct of Monetary Policy", Banque de France Occasional Paper.
- [14] Drehmann, M. and K. Tsatsaronis (2014): "The credit-to-GDP gap and countercyclical capital buffers: questions and answers," BIS Quarterly Review, Bank for International Settlements, March.

- [15] Elosegui, P., G. Escudé, L. Garegnani, J. Sotes (2007): "Un Modelo Económico Pequeño para Argentina", Serie Estudios BCRA, No. 3
- [16] Ericsson, N. y J. Irons (1995): "The Lucas critique in practice: theory without measurement", en K. D. Hoover (ed.), *Macroeconometrics: Developments, Tensions and Prospects*, Dordrecht: Kluwer Academic Press.
- [17] Escudé, G. (2008): "ARGEM: un modelo de equilibrio general dinámico y estocástico para la Argentina", Serie Estudios BCRA No. 5.
- [18] 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.
- [19] Galati, G. and R. Moessner (2011): "Macroprudential Policy - A Literature Review", BIS Working Paper no. 337.
- [20] Galí, J., and M. Gertler (1999): "Inflation dynamics: a structural econometric analysis", Journal of Monetary Economics, 44, pp. 195-222.
- [21] Galí, J. and T. Monacelli (2005): "Monetary policy and exchange rate volatility in a small open economy", Review of Economic Studies, vol 72(3) pp. 707-734
- [22] 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
- [23] González, A., F. Hamman and D. Rodríguez (2013): "Macroprudential policies in a commodity exporting economy", paper presented at the first plenary meeting of the of the BIS Consultative Council of the Americas' research network on "Incorporating Financial Stability Considerations in Central Bank Policy Models", Mexico, November.
- [24] Lim, C., F. Columba, A. Costa, P. Kongsamut, A. Otani, M. Saiyid, T. Wezel, and X. Wu (2011): "Macroprudential Policy: What Instruments and How to Use Them? Lessons from Country Experiences", IMF Working Paper WP/11/38, October.
- [25] 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.
- [26] Markovic, B.(2006): "Bank Capital Channels in the Monetary Transmission Mechanism," Bank of England Working Papers 313.
- [27] Roger, S. and Vlcek, J. (2011): "Macrofinancial Modeling at Central Banks: Recent Developments and Future Directions", IMF Working Papers 12/21, International Monetary Fund.
- [28] Sámano Peñaloza, D. (2011): "In the Quest of Macroprudential Policy Tools", mimeo, Banco de México.
- [29] Shin, H.S. (2013): "Procyclicality and the Search for Early Warning Indicators", IMF Working Papers 13/258, International Monetary Fund.
- [30] Sierra, J. (2008):"Imperfect financial integration, uncovered interest parity and central bank foreign exchange reserves", University of Southern California, mimeo.

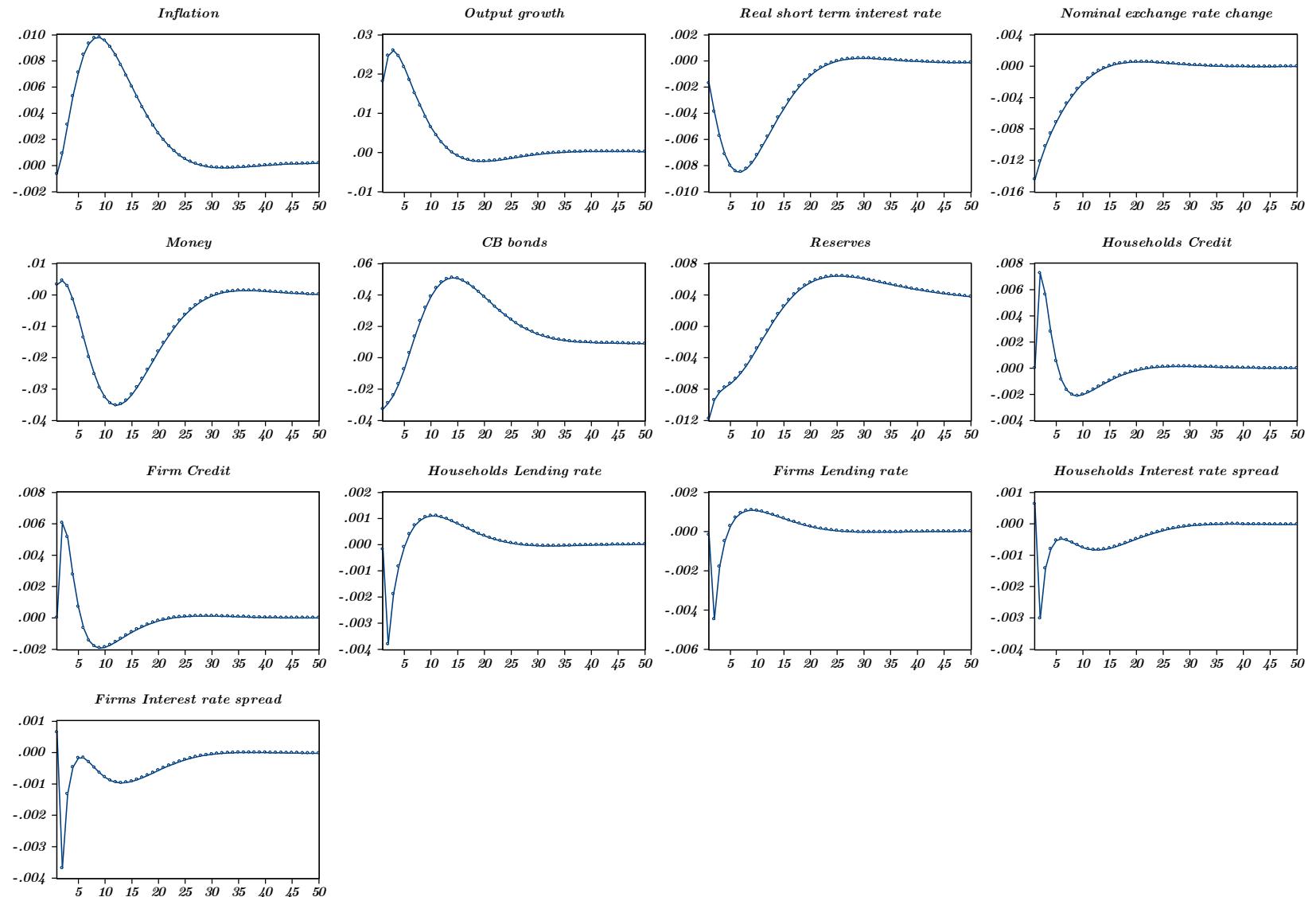
- [31] Szilágyi, K., Baksa, D., Benes, J., Horváth, A., Köber, C. and Soós G. (2013): “The Hungarian Monetary Policy Model”, MNB Working Papers 2013/1, Magyar Nemzeti Bank.
- [32] Végh, C. (2014): “Política cambiaria, monetaria y macroprudencial a través del ciclo económico”, presentation at the *XXIX Jornadas Anuales de Economía*, Banco Central del Uruguay, August.

Annex 1. Description of variables and data sources

Table A.1

| Variable | Description | Source |
|-------------|---|---------------------------|
| g^y | GDP growth seasonally adjusted, 1993 base year series | National accounts (INDEC) |
| π | Inflation, change in consumer price index and in composite index (wages and wholesale prices) | 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 (Households and Firms) to GDP | Central Bank of Argentina |
| CR^H | Household Credit: Pledge lending, Personal loans, Private securities and Accrued resources on loans (as a ratio to GDP) | Central Bank of Argentina |
| CR^F | Firm Credit: Overdrafts and Discounts loans in domestic and foreign currency (as a ratio to GDP) | Central Bank of Argentina |
| i^{act} | Interest rates on loans granted to the non-financial private sector - avg. $i^{act,H}$ and $i^{act,F}$ | Central Bank of Argentina |
| $i^{act,H}$ | Interest rates on Pledge lending, Personal loans, Private securities and Accrued resources on loans granted to the non-financial private sector | Central Bank of Argentina |
| $i^{act,F}$ | Interest rates on Overdrafts and Discounts loans granted to the non-financial private sector | 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. Accumulated responses to 1 s.d. shock to the IS curve



Annex 3. Parameter estimates of alternative models

Table Models 2-5: Posterior means

| | No CAR | Exogenous CAR | Endogenous CAR <i>output gap</i> | Endogenous CAR <i>credit gap</i> | Endogenous CAR <i>credit spread</i> |
|---------------|--------|------------------|-------------------------------------|-------------------------------------|--|
| α_1 | 0.264 | 0.2146 | 0.1837 | 0.2057 | 0.2425 |
| α_3 | 0.0779 | 0.0324 | 0.035 | 0.0091 | 0.0634 |
| α_4 | 0.0648 | 0.1413 | 0.0711 | 0.073 | 0.0751 |
| β_1 | 0.5257 | 0.3234 | 0.4454 | 0.3563 | 0.3525 |
| β_2 | 0.3971 | 0.4587 | 0.3829 | 0.493 | 0.3458 |
| β_3 | 0.1357 | 0.2174 | 0.1561 | 0.1723 | 0.1504 |
| β_4 | 0.1093 | 0.1584 | 0.1451 | 0.2654 | 0.164 |
| β_5 | 0.1134 | 0.1657 | 0.1279 | 0.1101 | 0.2062 |
| β_6 | 0.1229 | 0.2595 | 0.3107 | 0.2678 | 0.3736 |
| ρ_1 | 0.9372 | 0.9619 | 0.9624 | 0.968 | 0.9601 |
| ρ_2 | 0.7412 | 0.7094 | 0.8134 | 0.516 | 0.3698 |
| ρ_3 | 0.3202 | 0.3641 | 0.3071 | 0.3152 | 0.2234 |
| ρ_4 | 0.9719 | 0.9619 | 0.9677 | 0.9836 | 0.9713 |
| ρ_5 | 0.7114 | 0.9047 | 0.9117 | 0.9276 | 0.8513 |
| ρ_6 | 0.6576 | 0.2195 | 0.3629 | 0.2526 | 0.1664 |
| γ_1 | 0.573 | 0.6256 | 0.6159 | 0.8983 | 0.5555 |
| γ_2 | 0.0207 | 0.0127 | 0.0092 | 0.0386 | 0.0334 |
| γ_3 | 0.0246 | 0.0241 | 0.0297 | 0.0186 | 0.0275 |
| γ_4 | 0.0827 | 0.0766 | 0.0875 | 0.1302 | 0.1108 |
| γ_5 | 0.0073 | 0.0053 | 0.0076 | 0.0026 | 0.0084 |
| ω_1 | 5.9114 | 5.5952 | 5.9484 | 6.1957 | 5.6982 |
| ω_2 | 0.0078 | 0.0095 | 0.0103 | 0.0073 | 0.0096 |
| ω_3 | 0.1776 | 0.2395 | 0.1 | 0.1484 | 0.0975 |
| η_1 | 1.2028 | 0.952 | 0.9877 | 1.0017 | 0.96 |
| η_2 | 0.5528 | 0.6917 | 0.6209 | 0.7654 | 0.6175 |
| η_3 | 0.0309 | 0.0273 | 0.0275 | 0.029 | 0.024 |
| η_4 | 0.6645 | 0.7375 | 0.7437 | 0.4783 | 0.6624 |
| κ_1 | 0.9815 | 0.9763 | 0.9783 | 0.9867 | 0.9732 |
| κ_2 | 0.1377 | 0.1283 | 0.0652 | 0.1055 | 0.0712 |
| A_1^H | 0.4007 | 0.3772 | 0.4373 | 0.3352 | 0.3987 |
| A_2^H | 0.0664 | 0.0975 | 0.0582 | 0.1144 | 0.1168 |
| A_3^H | 0.3785 | 0.414 | 0.4637 | 0.4464 | 0.455 |
| B_1^H | 0.0685 | 0.0992 | 0.0925 | 0.1031 | 0.0793 |
| B_2^H | 0.1688 | 0.2543 | 0.2009 | 0.1869 | 0.2118 |
| B_3^H | 0.2279 | 0.2385 | 0.1274 | 0.243 | 0.1683 |
| B_4^H | | 0.145 | 0.2299 | 0.1534 | 0.1439 |
| ρ_1^{DH} | 0.8104 | 0.8193 | 0.7828 | 0.7965 | 0.8124 |
| ρ_2^{DH} | 0.472 | 0.3741 | 0.3041 | 0.3387 | 0.3962 |
| A_1^F | 0.3333 | 0.3845 | 0.3664 | 0.3881 | 0.3252 |
| A_2^F | 0.11 | 0.0994 | 0.0594 | 0.2112 | 0.0294 |
| A_3^F | 0.4096 | 0.4594 | 0.5526 | 0.3771 | 0.4396 |

Table (Cont.) Models 2-5: Posterior means

| | No CAR | Exogenous CAR | Endogenous CAR <i>output gap</i> | Endogenous CAR <i>credit gap</i> | Endogenous CAR <i>credit spread</i> |
|---------------|--------|------------------|-------------------------------------|-------------------------------------|--|
| B_1^F | 0.018 | 0.0229 | 0.028 | 0.0309 | 0.0226 |
| B_2^F | 0.2301 | 0.2437 | 0.2788 | 0.2254 | 0.2204 |
| B_3^F | 0.2146 | 0.2608 | 0.1621 | 0.2727 | 0.2716 |
| B_4^F | | 0.1336 | 0.2808 | 0.3169 | 0.1857 |
| ρ_1^{DF} | 0.9118 | 0.9074 | 0.898 | 0.8895 | 0.9116 |
| ρ_2^{DF} | 0.4546 | 0.4726 | 0.3156 | 0.4589 | 0.4163 |
| ψ_0 | | 0.0107 | 0.0104 | 0.0146 | 0.0113 |
| ψ_1 | | 0.3775 | 0.704 | 0.5871 | 0.2952 |
| ψ_2 | | | 0.1554 | 0.0246 | 0.1538 |
| ψ_3 | | | | | 0.7532 |