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

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Outline

- *Motivation*
- *Baseline model*
- *Estimation and impulse-response functions*
- *The extended model: macroprudential policy*
- *Concluding remarks*

Motivation

- *Change of perspective in monetary policy frameworks: financial cycles accepted as part of the functioning of market economies (Borio, 2012)*
- *Consequences on stability have to be dealt with by central banks: involved in the execution of financial stability policy, if it is to be effective.*
- *Introduction of financial stability mandate: move from a single focus for monetary policy and a concern for individual performance of financial institutions, to multiple focused-central banks and systemic reach*
- *Need to incorporate in formal models a wider set of tools, such as macroprudential measures.*
- *Focus on interaction between both spheres of CB policy, monetary and macroprudential*
- *Following 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.*

Macroprudential policy: a primer

Financial regulation & supervision

Monetary policy framework

	Individual risk	**Systemic & macroeconomic risk**
Single focus	*Inflation targeting* *Microprudential policy*	
Multiple focus		*Monetary and financial stability* *Macroprudential policy*

Motivation

- *Macroprudential policy: generic, not well-defined concept; measures extending beyond safeguarding individual solvency or liquidity, to cover link with financial system and macroeconomic performance*
- *Many measures: capital and liquidity requirements as function of cyclical variables, loan-to-value ratios, dynamic provisions and others that incorporate the state of the financial system or the economy as an input to determine whether to soften or tighten regulations.*
- *Common features: limiting systemic risk and macro-financial spillovers; they take into account externalities of individual financial firms (interconnection, procyclicality, common exposures); financial system considered as a whole, systemic risk treated as endogenous.*
- *Prevention: CBs and supervisors should act before the "turn" of the cycle*
- *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. Foreign exchange regime may also be considered part of macroprudential toolkit in EMEs.*

Motivation

- *Integration of most widely used monetary policy analysis framework -the New Keynesian- with macroprudential tools: a pending task -no unified approach*
- *Angelini et al. (2010), Denis et al. (2010): interaction between monetary policy and macroprudential tools, introducing a new policy rule in coordination with monetary policy helps to reduce the variance of output and inflation.*
- *To what extent may both types of policy be considered complements or substitutes?*
- *Cecchetti and Kohler (2014): enlarged aggregate demand-aggregate supply system with interest rates and capital requirements, game-theoretic approach. Both instruments are full substitutes: if ability to use one is limited, the other can "finish" the job; under financial stability objective, this depends on the coordination between them.*
- *Agenor and Pereira da Silva (2013): monetary and macroprudential policies complementary (small macroeconomic model), and have to be calibrated jointly, accounting for credit market imperfections observed in middle income countries and for fact that macroprudential regimes may affect the monetary transmission mechanism.*

Motivation

- *Végh (2014): both foreign exchange intervention and reserve requirements act in the sense of allowing interest rate policy to achieve other goals: in a sudden stop, exchange rate intervention may be used to "defend" local currency (interest rates not raised), while reserve requirements are changed to influence credit market conditions --gives monetary policy higher degrees of freedom.*
- *Capital controls may be part of the macroprudential policy package: Escudé (2014) taxes on capital flows in a DSGE open economy model with foreign exchange intervention and interest rate policy; finds that the use of the three policies is optimal.*
- *Other recent contributions: Roldán et al. (2014), papers presented in the BIS CCA network on financial stability and central bank policy models.*

Our approach

- *We follow up on Aguirre and Blanco (2013). Model builds on previous work done for Argentina (Elosegui et al, 2007; Aguirre and Grosman, 2010), dealing with the financial dimension largely after Sámano Peñaloza (2011).*
- *Empirical approach, parameters should all be estimated ("letting the data speak"): contrast with implementation of large DSGE models, relying on calibration.*
- *Plus: smaller models forecast better than large ones (Canova, 2009).*
- *Place for small and large DSGE models in modelling architecture (Escudé, 2008; DSGE model with banks and forex policy)*
- *Descriptive and policy-oriented goals:*
  - *Enhance the depiction of an economy where real aspects may not be dissociated from financial ones. Relation between financial and macro dimensions*
  - *Does macroprudential policy lead to less variability of certain key variables? In particular, we include a capital requirements in addition to interest rates and foreign exchange intervention, so as to determine how it interacts with the other policy tools.*

Our approach

- *We augment 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.*
- *Aguirre and Blanco (2013:): forecast evaluation. Estimated model predicts quarterly output growth, annual interest rates and quarterly foreign exchange rate depreciation with significantly higher accuracy than alternative ones -evaluated for 1-, 2- and 4-step out-of-sample forecasts, and using RMSE and MAE.*
- *In this work, we present several improvements: commercial and consumption credit lines are distinguished (quantities and interest rates); and non-performing loans are endogenous, and also distinguished by credit and consumption lines.*
- *We introduce capital requirements under different 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.*

Our approach

- *First approximation*
  - *Parameter constancy for policy evaluation*
  - *Isomorphism between financial stability issues, at which macroprudential measures aim, and DSGE models (or models like ours, which are based on them). Non linearities (Bianchi et al., 2013)*
- *To the best of our knowledge, this work 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.*

Baseline model

- *Following work by Elosegui et al. (2007) and Aguirre and Grosman (2010): a small structural open economy model with a Taylor-type rule and foreign exchange market intervention, with the monetary effects that these imply.*
- *It 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).*

Baseline model – macroeconomic block

- *IS curve + Phillips curve + Taylor type rule*
- *IS: includes spread between the active rate of interest and the short term interest rate; as in Sámano Peñaloza (2011) and Szylagy et al (2013), this term captures the impact of credit market conditions on aggregate demand ("extra cost" above the short term interest rate that the non financial private sector has to pay in order to obtain resources).*
- *Phillips curve includes "imported" inflation.*
- *In addition to conventional interest rate response to prices and activity: a) concern for nominal exchange rate variability; b) 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.*

Baseline model – macroeconomic block

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

$$\begin{aligned} spread_t &= \xi^H * spread_t^H + \xi^F * spread_t^F \\ & where \\ spread_t^H &= \widehat{i}_t^{H,act} - \widehat{i}_t \\ spread_t^F &= \widehat{i}_t^{F,act} - \widehat{i}_t \end{aligned}$$

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

,

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

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

Baseline model – FX policy block

- *Modified UIP: 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.*
- *Endogenous RP 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 (Aguirre and Grosman, 2010; García Cicco, 2011).*

Baseline model – FX policy block

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

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

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

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

Baseline model – Financial block

- *Credit is basically a function of the output gap and the lending interest rate.*
- *Active (lending) rate is a function of the output gap, non performing loans and the short term rate; the spread emerges naturally as the difference between the lending and money market rate.*
- *We consider total credit to the private sector in terms of GDP, both for commercial (firms) and consumption (household) credit; and interest rates on both groups of loans. Non performing loans, in turn, are a function of economic activity.*
- *Credit as previously defined also feeds back into the "macroeconomic block" of the model through its inclusion in the interest rate rule.*

Baseline model – Financial block

$$
\begin{aligned}
\widehat{CR}_t^H &= A_1^H \widehat{g}_{t-1}^y - A_2^H \widehat{i}_{t-1}^{H,act} + A_3^H \widehat{CR}_{t-1}^H + \varepsilon_t^{HCR} \\
\widehat{CR}_t^F &= A_1^F \widehat{g}_{t-1}^y - A_2 \widehat{i}_{t-1}^{F,act} + A_3 \widehat{CR}_{t-1}^F + \varepsilon_t^{FCR} \\
\widehat{i}_t^{H,act} &= B_1 \widehat{Delinq}_t^H - B_2 \widehat{g}_{t-1}^y + B_3 \widehat{i}_t + \varepsilon_t^{Hact} \\
\widehat{i}_t^{F,act} &= B_1 \widehat{Delinq}_t^F - B_2 \widehat{g}_{t-1}^y + B_3 \widehat{i}_t + \varepsilon_t^{Fact} \\
\widehat{Delinq}_t^H &= \rho_1^{DH} \widehat{Delinq}_{t-1}^H + \rho_2^{DH} \widehat{g}_{t-1}^y + \varepsilon_t^{HDelinq} \\
\widehat{Delinq}_t^F &= \rho_1^{DF} \widehat{Delinq}_{t-1}^F + \rho_2^{DF} \widehat{g}_{t-1}^y + \varepsilon_t^{FDelinq}
\end{aligned}
$$

Baseline model – Identities

$$
\begin{aligned}
\widehat{e_t^{tri}} &\equiv \widehat{e^d}_t + c_1\widehat{e^{US,R}}_t + c_2\widehat{e^{US,E}}_t \\
\widehat{r}_t &\equiv \widehat{i}_t - E_t\widehat{\pi}_{t+1} \\
\widehat{\Delta e^d}_t &\equiv \widehat{\delta}_t + \widehat{\pi^*}_t - \widehat{\pi}_t \\
\widehat{g}_t^y &\equiv \Delta y_t + \widehat{g^{\bar{y}}}_t \\
\widehat{\mu}_t &\equiv \Delta\widehat{m}_t + \widehat{\pi}_t + \widehat{g}_t^y
\end{aligned}
$$

Baseline model – Exogenous variables

$$\begin{aligned}
\widehat{i^*}_t &= \rho_1 \widehat{i^*}_{t-1} + \varepsilon_t^{i^*} \\
\widehat{\lambda}_t &= \rho_2 \widehat{\lambda}_{t-1} + \varepsilon_t^{\lambda} \\
\widehat{\pi^*}_t &= \rho_3 \widehat{\pi^*}_{t-1} + \varepsilon_t^{\pi^*} \\
\widehat{e^{US,R}}_t &= \rho_4 \widehat{e^{US,R}}_{t-1} + \varepsilon_t^{e^{US,R}} \\
\widehat{e^{US,E}}_t &= \rho_5 \widehat{e^{US,E}}_{t-1} + \varepsilon_t^{e^{US,E}} \\
\widehat{sf}_t &= \rho_6 \widehat{sf}_{t-1} + \varepsilon_t^{sf} \\
\widehat{g^{\overline{y}}}_t &= \rho_7 \widehat{g^{\overline{y}}}_{t-1} + \varepsilon_t^{g^{\overline{y}}}
\end{aligned}$$

Estimation

- *We estimate the model completely through Bayesian techniques, based on quarterly data and for the 2003Q3-2011Q2 period;*
  - *this is the longest period spanning an homogeneous macroeconomic policy regime -the currency board regime adopted in 1991 was abandoned during the 2001-2002 crisis, after which a managed floating regime was adopted.*
- *Bayesian techniques prove particulary useful for this kind of situation: if one knows that structural change has taken place, this information can be included in a way not allowed by classical estimation methods.*
  - *We incorporate a priori information about the economy, thus potentially improving efficiency of estimates*
  - *Parameters are taken as random, data as fixed*
  - *Both features are relevant when the sample size is small due to structural breaks, as is the case of the period we focus on.*

Estimation

- *Define θЄΘ as the vector of parameters. Given the prior information g(θ), the observed data* $Y_T = [Y_1, Y_2, ..., Y_T]$
- *and the sample information* $f\left(Y_T/\theta\right)$ *the posterior density -transition from prior to posterior- of the parameters is given by Bayes' rule:*

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

- *Posterior draws of the distribution are obtained using a Random Walk Metropolis-Hastings algorithm (two chains of 50,000 replications each). The set of observed variables Y is*

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

Baseline model – Parameter estimates

parameters	prior mean	post. mean	conf. interval		prior	pstdev
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

Baseline model – Parameter estimates

standard deviation of shocks

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

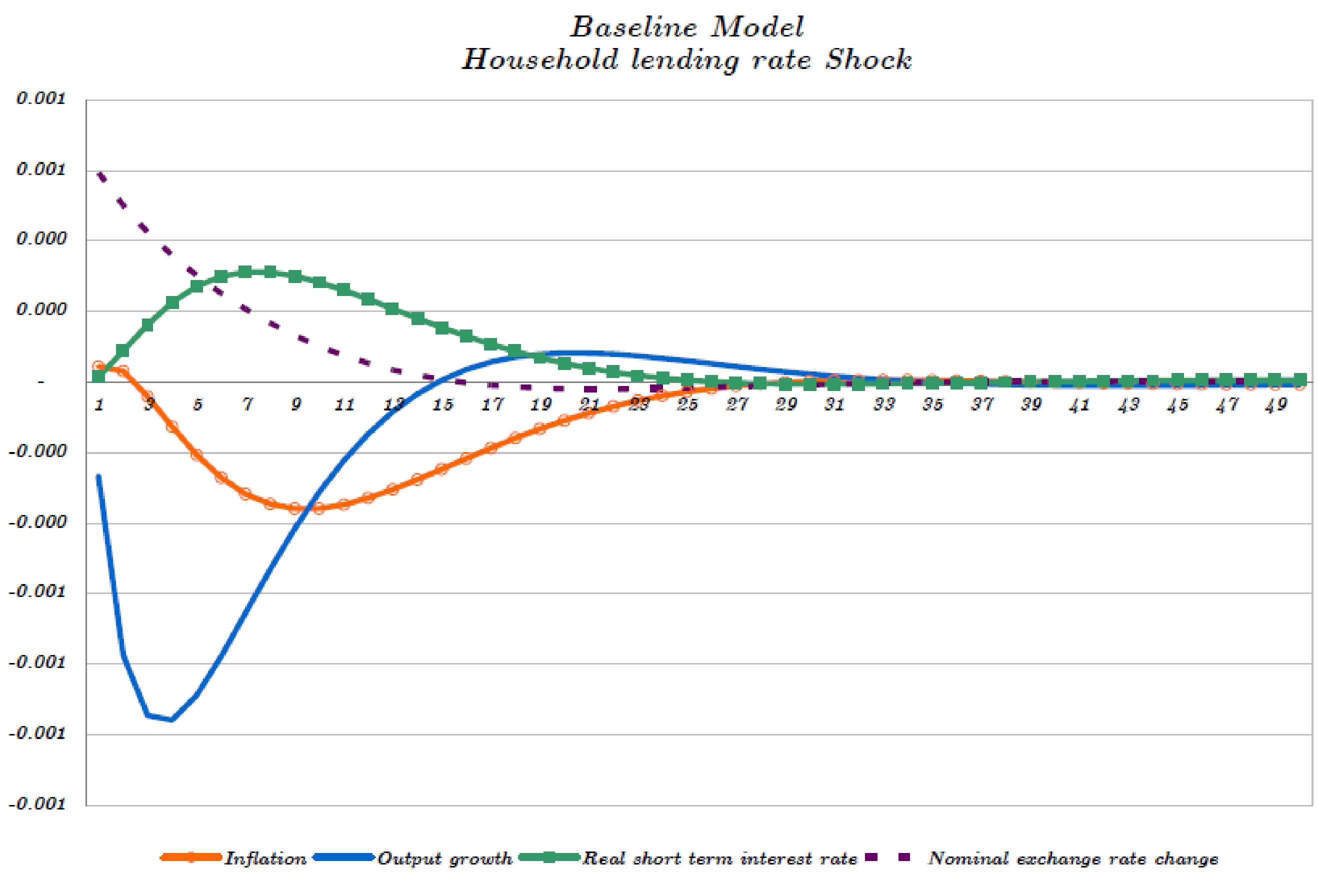
Observed and estimated standard deviations of selected variables

		Credit-to-GDP	Active rate	Short term rate
Std.Dev. 2003-2011	Observed	0.1003	0.0074	0.0085
	Estimated	0.1026	0.0091	0.0110

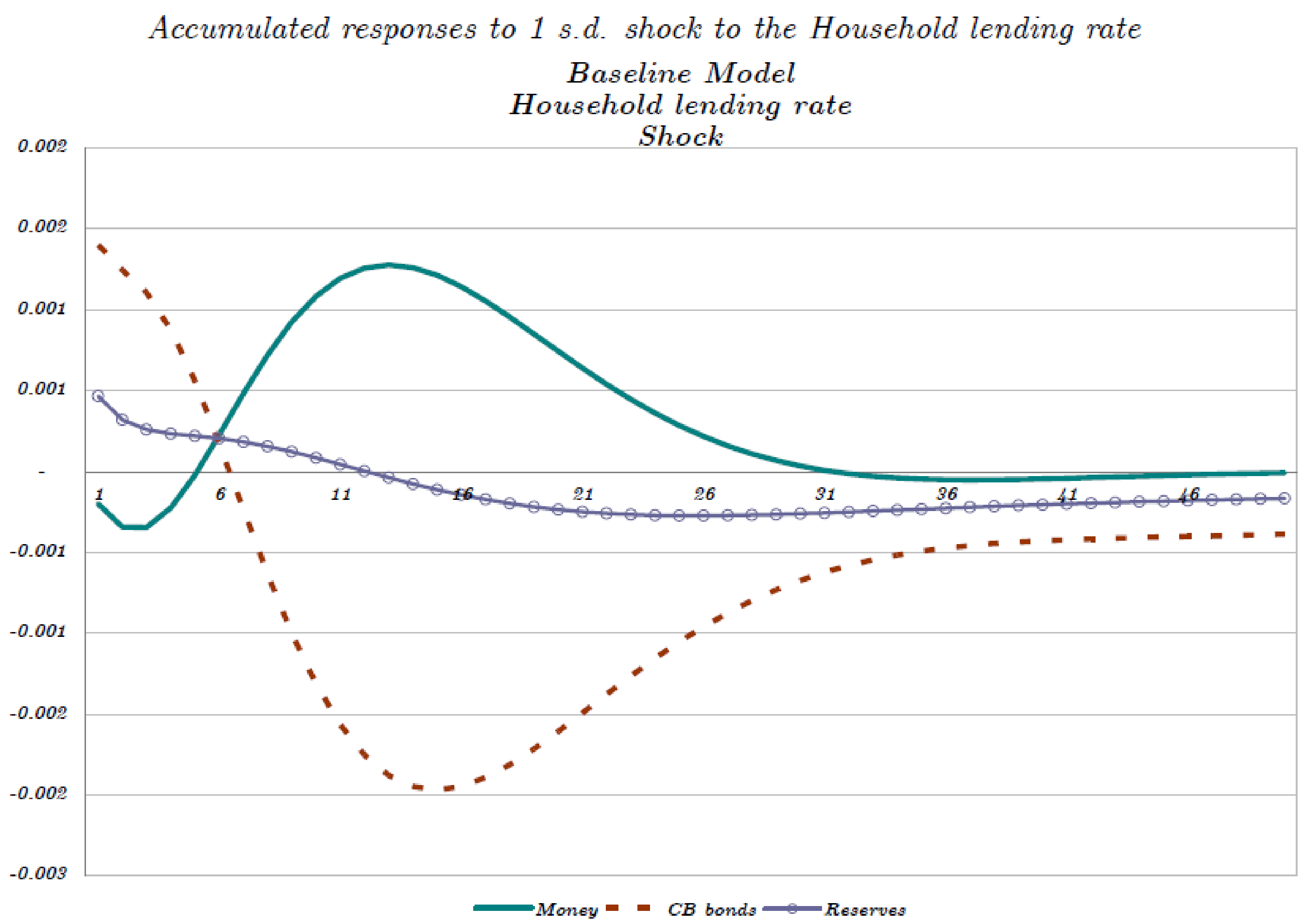
Results: Impulse Response Functions

- *Positive shock to lending rates: credit decreases and the interest rate spread increases -the short term interest rate increases, but to a lesser degree than the active rate.*
  - *This affects the real side of the economy, with a negative effect on output growth.*
  - *As the short term interest rate increases, the nominal exchange rate depreciates -the impact on UIP means that a higher local rate, with no change in the international interest rate, translates into a depreciation of the local currency.*
- *Pass-through from the exchange rate to domestic prices entails a fall on the real interest rate.*
  - *The central bank acts by gradually increasing the short term rate and intervening in the foreign exchange market to reduce foreign exchange volatility.*

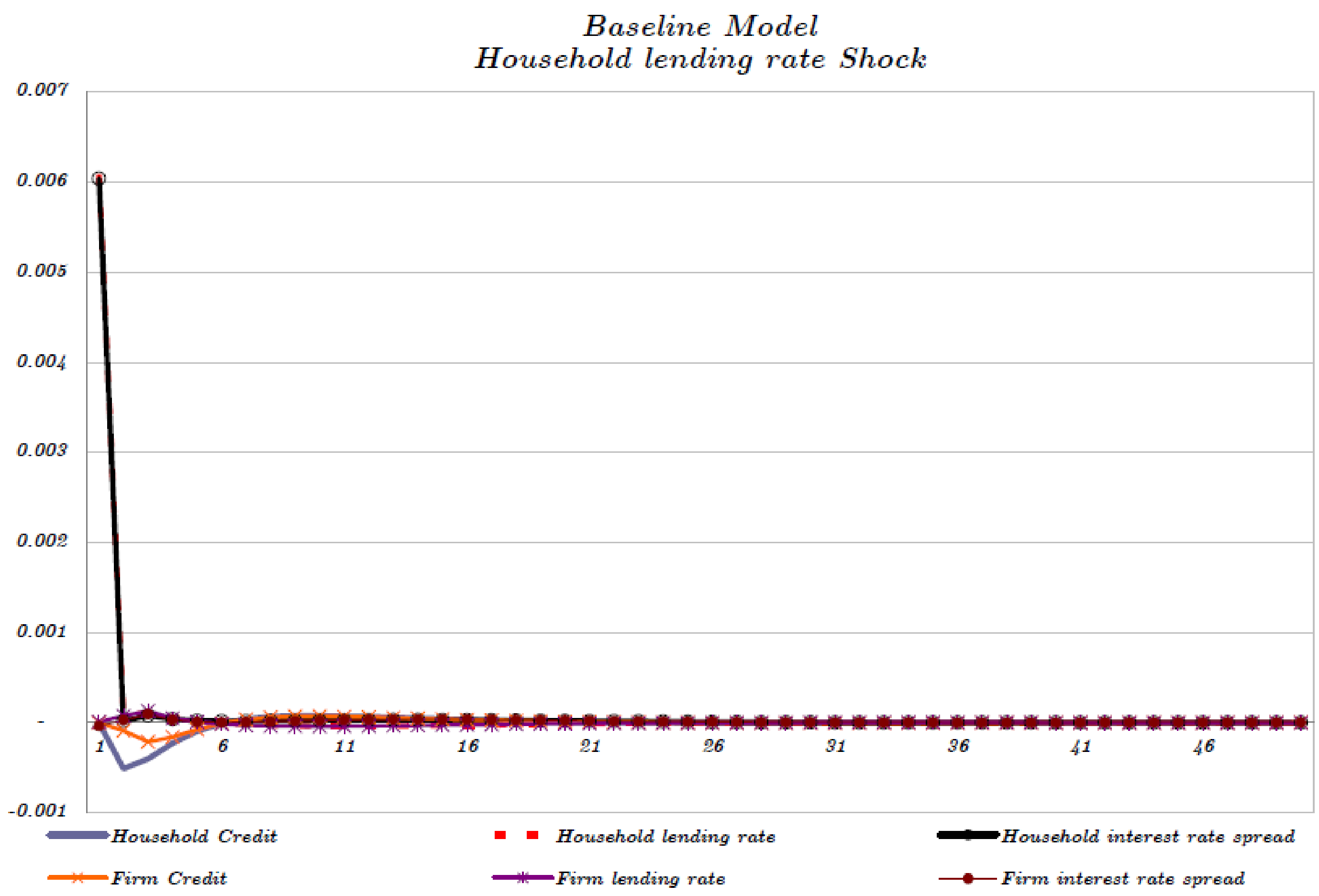
Results: Impulse Response Functions



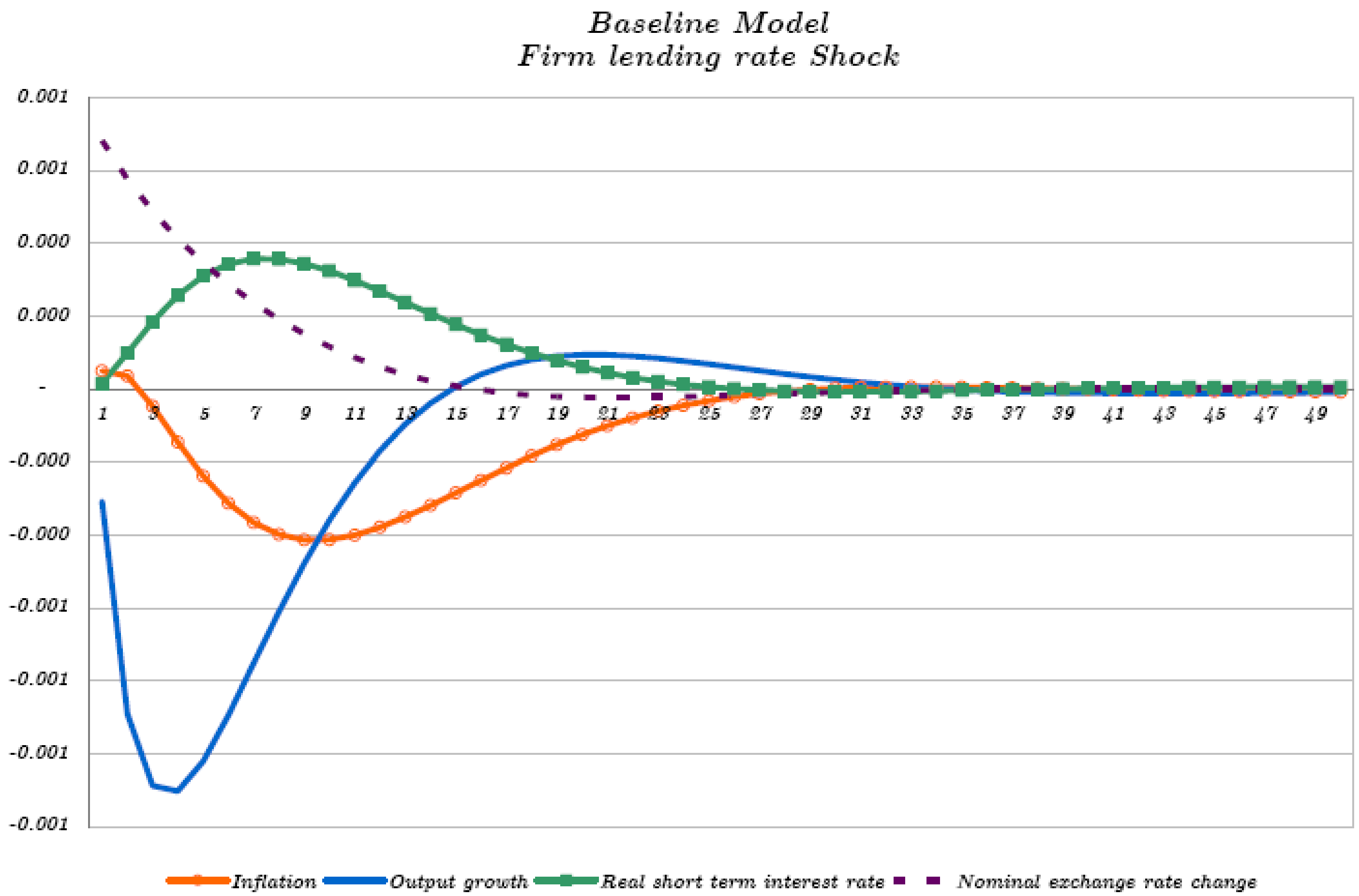
Results: Impulse Response Functions



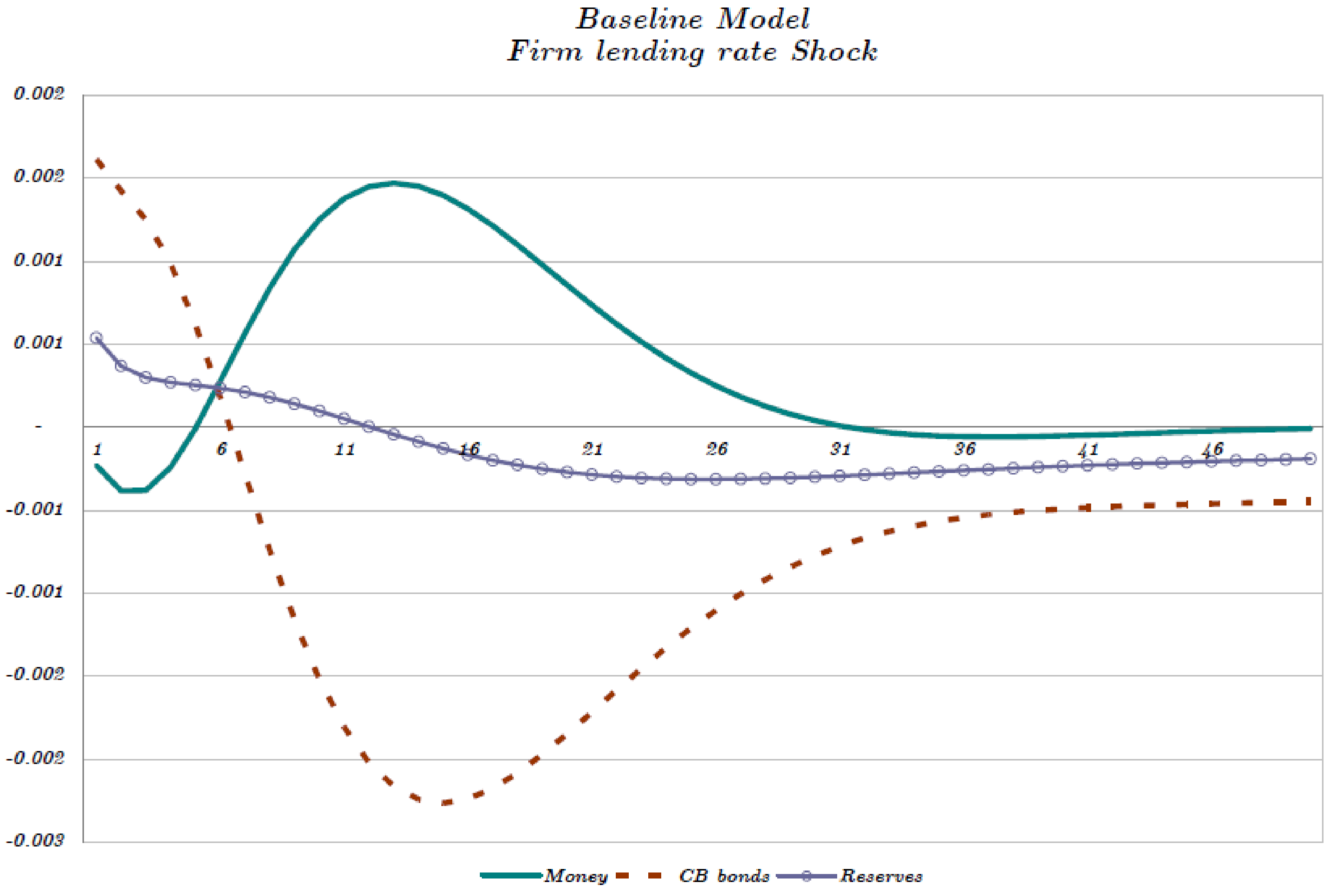
Results: Impulse Response Functions



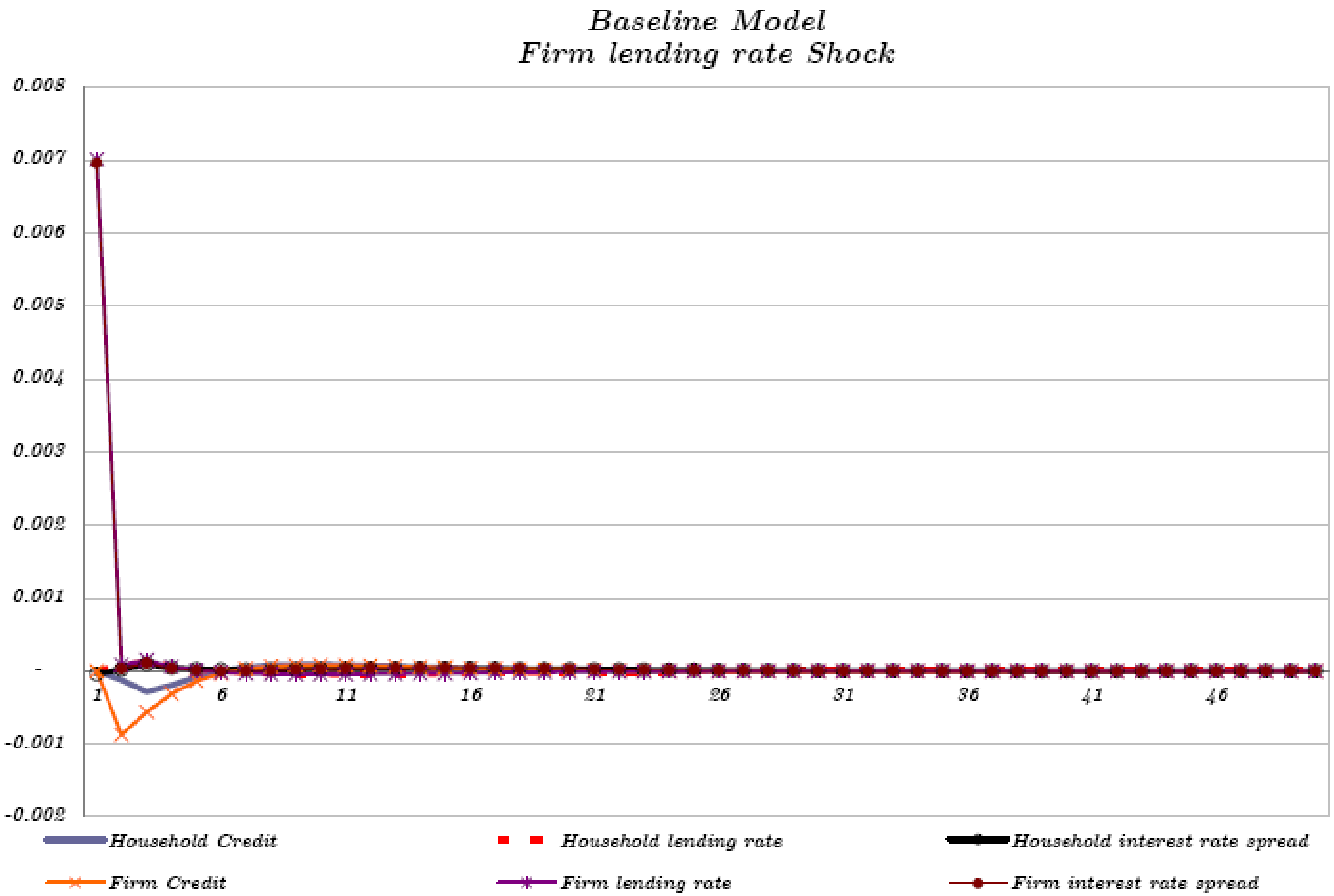
Results: Impulse Response Functions



Results: Impulse Response Functions



Results: Impulse Response Functions

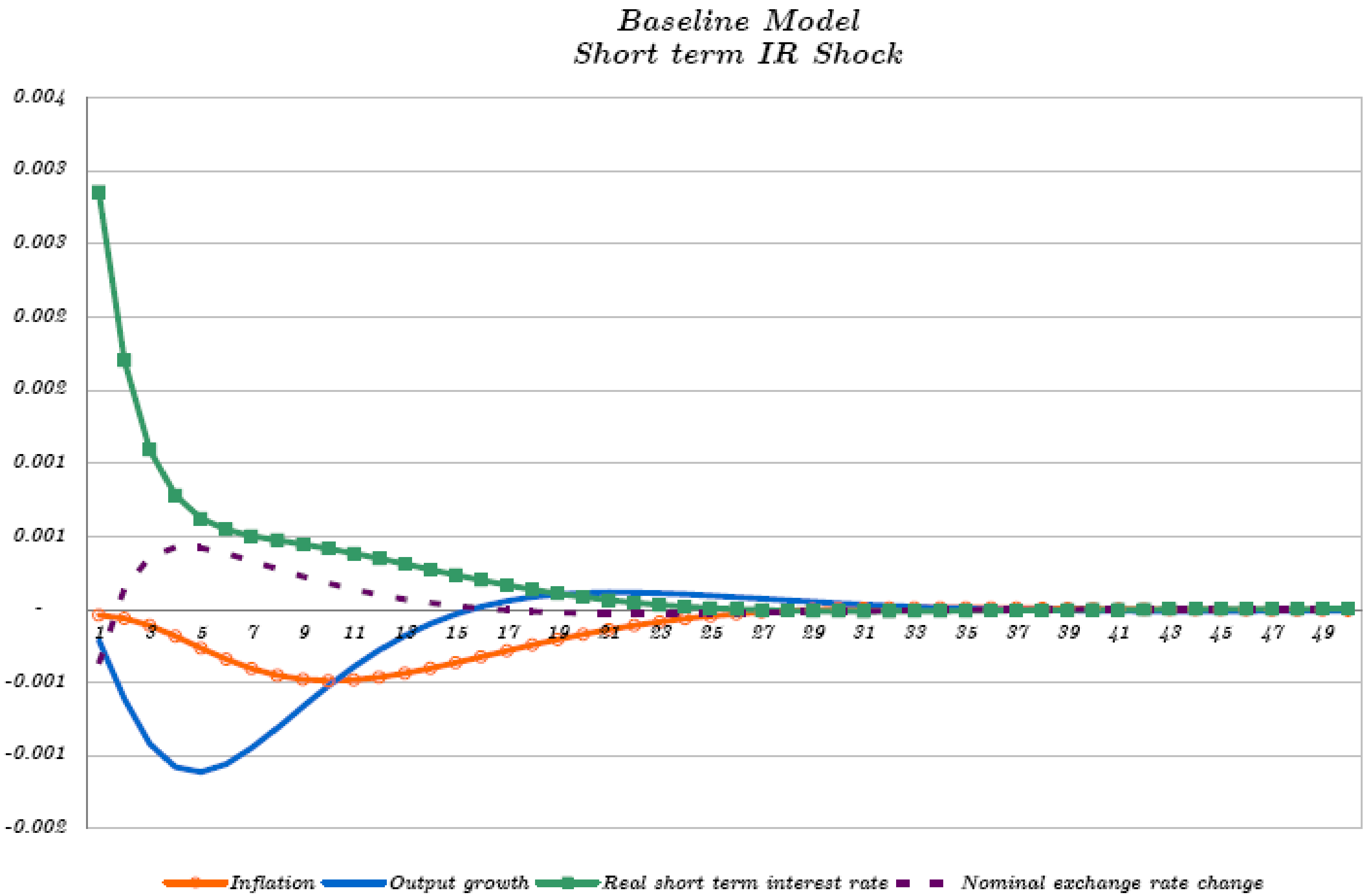


Results: Impulse Response Functions

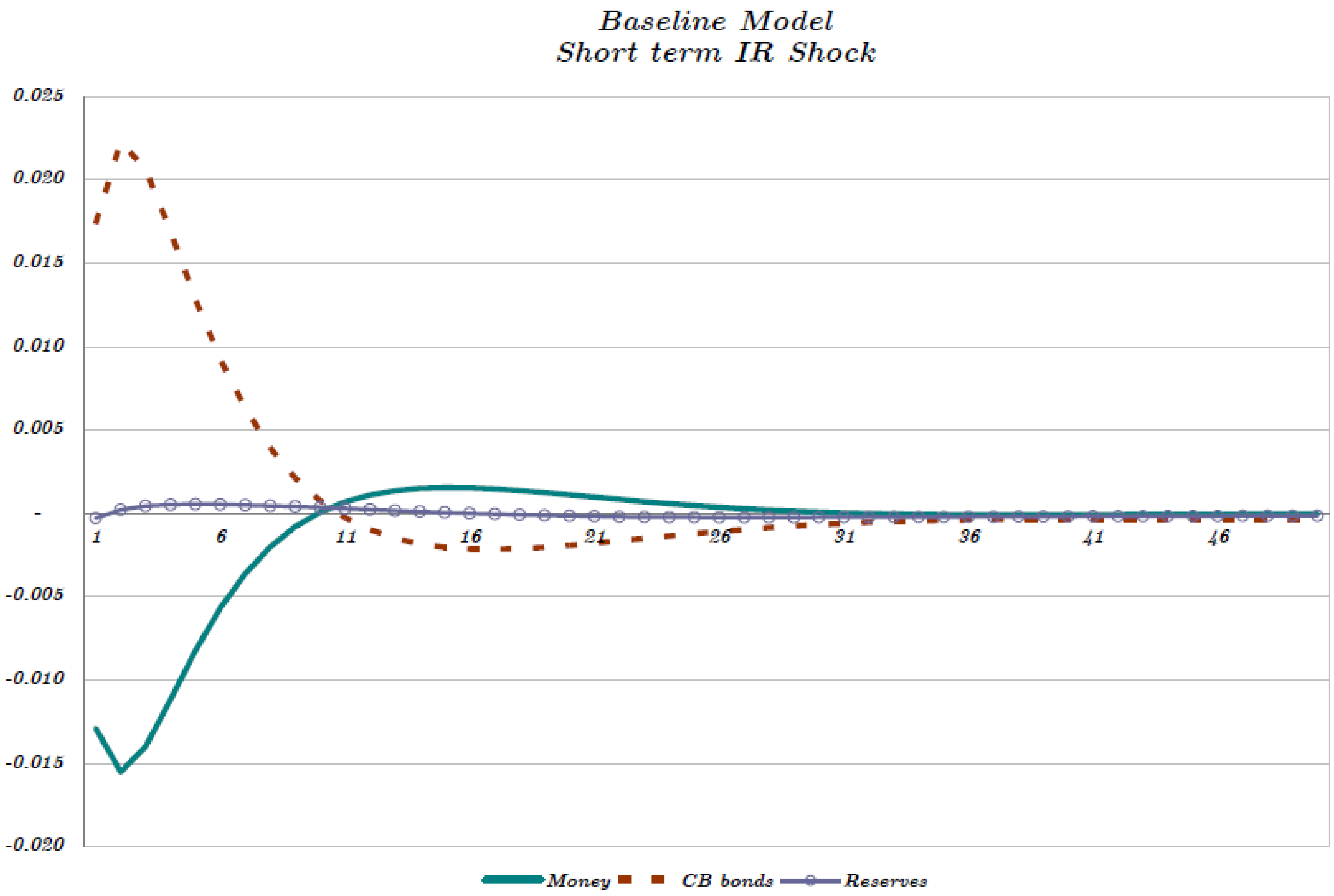
- *Shock to the passive rate: higher real (short term) interest rate, which goes together with nominal and real exchange rate appreciation.*
  - *Output is affected, but to a substantially lower degree than in the previous exercise.*
  - *The central bank reacts by (initially) buying reserves and sterilizing the monetary effect of its operations by issuing bonds.*
- *In the credit market, the lending rate goes up while credit diminishes -somewhat paradoxically, spread is reduced as the active rate is raised less than one-to-one with respect to the passive rate.*
- *We are aware that both exercises are just a crude approximation at describing the interplay between the credit market and the macroeconomy.*

Results: Impulse Response Functions

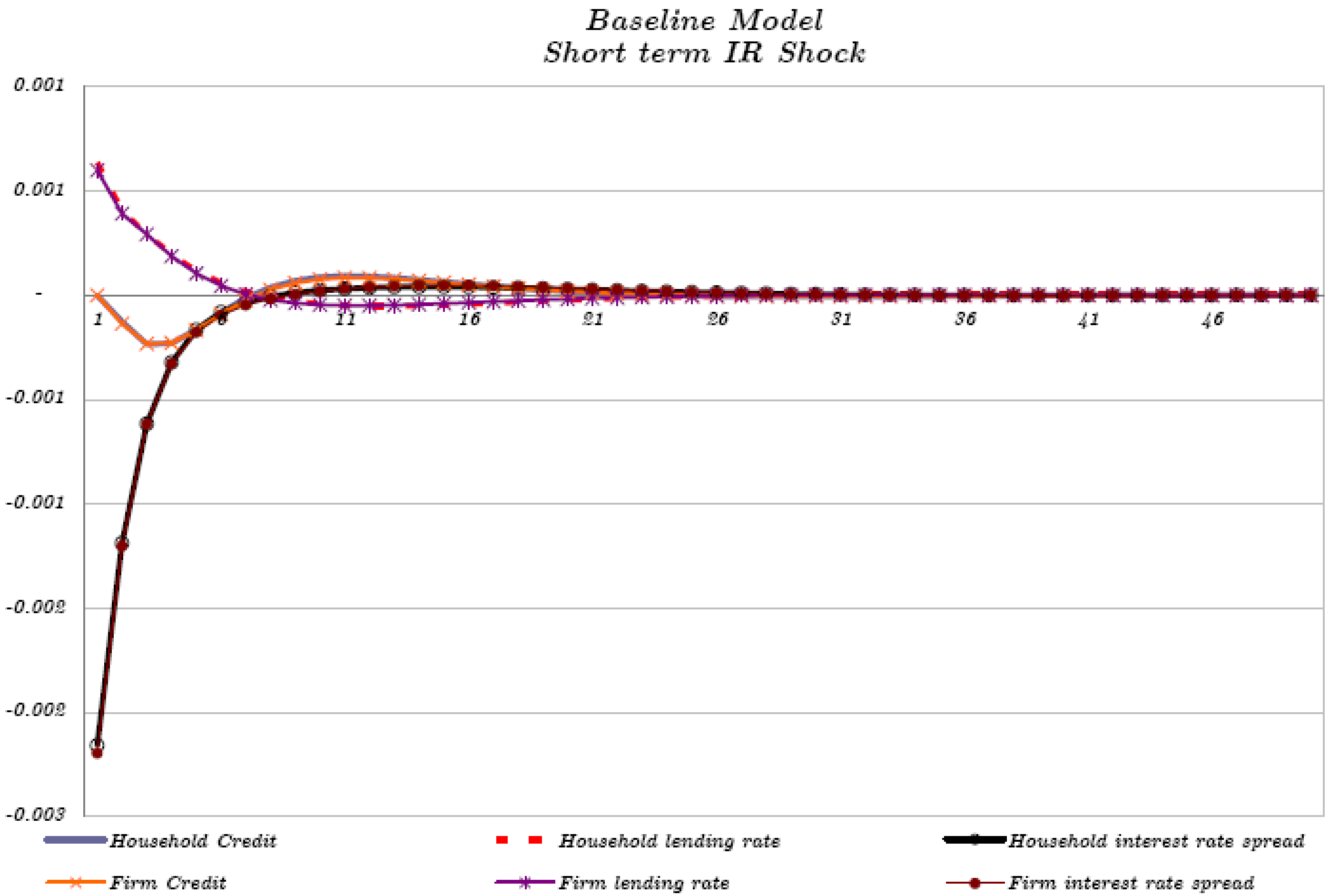
Accumulated responses to 1 s.d. shock to the short term interest rate



Results: Impulse Response Functions



Results: Impulse Response Functions



Results: Impulse Response Functions

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

Results: Impulse Response Functions

- *In the cases of shock to the lending rate and to output, the spread is countercyclical in the sense that higher (lower) spread entails lower (higher) credit and output*
- *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 interpretarion: 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*

Results: Impulse Response Functions

- *Output and credit shocks: relative impact from one to another*

Standard deviations of responses to shocks of selected variables after

	10 quarters	20 quarters	30 quarters
	Consumption credit		
Output	0.000151409	0.000221678	0.000222296
	Corporate credit		
Output	0.000286187	0.000416377	0.000419054
	Output growth		
Consumption credit	0.003384811	0.002514053	0.002036951
Corporate credit	0.002970155	0.002228947	0.001806152

Extended model: macroprudential policy

We will focus on one of the most basic "macroprudential" financial system regulations: a capital adequacy ratio (CAR). Several variants:

First Option: Exogenous

a purely exogenous ratio (akin to conventional prudential regulation; model 2)

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

Extended model: macroprudential policy

Second option: endogenous rules, according to which adequate capital depends on macroeconomic or financial system variables

- output gap (model 3) $\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 \hat{y}_t + \varepsilon_t^{CAR}$

- credit gap (model 4) $\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 \widehat{CR}_t + \varepsilon_t^{CAR}$

- interest rate spread (model 5) $\widehat{CAR}_t = \psi_0 + \psi_1 \widehat{CAR}_{t-1} + \psi_2 spread_t + \varepsilon_t^{CAR}$

The CAR is included in the equations describing the active rate:

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

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

Extended model: macroprudential policy

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

Extended model: macroprudential policy

standard deviation of shocks

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

Macroprudential policy: an empirical assessment

- *We compute standard deviations of macroeconomic and financial variables under models 1-5, plus a model with interest rate policy only (no fx or macroprudential policy).*
- *Lowest volatility during the estimation period under an endogenous capital requirement (output gap, model 3) for: international reserves, average, consumption and commercial lending interest rates, and consumption non-performing loans.*
- *Capital requirements as a function of interest rate spreads (model 5) deliver lower variability of growth, deposit interest rate, money growth and commercial non-performing loans than alternative policies.*
- *Capital adequacy based on credit-to-GDP gap (model 4): lowest variability for inflation, real exchange rate depreciation and capital requirements.*
- *“Exogenous" CAR (model 2): lowest standard deviations of average and commercial credit.*
- *No capital requirements, but monetary and foreign exchange policy (model 1) is associated to the lowest variability of consumption credit.*

Macroprudential policy: an empirical assessment

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

Macroprudential policy: an empirical assessment

- *Ad hoc loss functions*
- *Initially, equal weights to all components of the function: 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.*

Macroprudential policy: an empirical assessment

- *Loss functions that include only macroeconomic variables and interest rates: 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.*
- *Changing weights in the terms of the loss function: 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*

Macroprudential policy: an empirical assessment

Variables Considered in Loss Function	*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)
Equal weights $\left(\omega = \frac{1}{n}\right)$						
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
Weights: Macro variables $\omega^{g^y} = \omega^{\pi} = \omega^{e^{tri}} = \frac{4}{15}$; *Financial variables* $\omega^{i} = \omega^{i^{act,H}} = \omega^{i^{act,F}} = \frac{1}{15}$						
$g^y, \pi, i, e^{tri}, CR^H$	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
Weights: Macro variables $\omega^{g^y} = \omega^{\pi} = \frac{5}{12}$; *Financial variables* $\omega^{i} = \omega^{i^{act,H}} = \omega^{i^{act,F}} = \frac{1}{12}$						
$g^y, \pi, , i, i^{act,H}$	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**
Weights: Macro variables $\omega^{g^y} = \omega^{\pi} = \frac{2}{15}$ and $\omega^{e^{tri}} = \frac{1}{15}$; *Financial variables* $\omega^{i} = \omega^{i^{act,H}} = \omega^{i^{act,F}} = \frac{5}{15}$						
$g^y, \pi, i, e^{tri}, CR^H$	**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
Weights: Macro variables $\omega^{g^y} = \omega^{\pi} = \frac{1}{12}$; *Financial variables* $\omega^{i} = \omega^{i^{act,H}} = \omega^{i^{act,F}} = \frac{5}{12}$						
$g^y, \pi, i, i^{act,H}$	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

Macroprudential policy: an empirical assessment

- *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 put in place.*

Macroprudential policy: an empirical assessment

- *Rationalising lower variability of the exogenous CAR rule*
- *Size of the financial system: higher influence of the real economy on the financial system than otherwise?*
- *CAR rule actually in place during the estimation period is more similar to that of model 4 (exogenous): better fit to data?*
- *However, a measure of comparative fit suggests that the model with CAR as a function of credit would be the one of choice*

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

Concluding remarks

- *We estimated a small macroeconomic model of the Argentine economy, augmented to include explicit depiction of the credit market, active rates and interest rate spread; and an enriched description of monetary policy, with sterilized intervention in the foreign exchange market.*
- *The financial system is affected by macroeconomic shocks: in particular, credit behaves in a procyclical way (in line, for instance, with evidence by Bebczuk et al, 2011).*

Concluding remarks

- *We enhanced the baseline model to find out whether macroprudential policy (capital adequacy rules) helped macroeconomic performance in any meaningful way during the estimation period.*
- *Just as previous results show that macroeconomic volatility is reduced when foreign exchange intervention is implemented in addition to interest rate rules (Escudé, 2009; Aguirre and Grosman, 2010), we find that*
    - *capital requirements may contribute to desirable cyclical macroeconomic property --smoothing output, price, interest rate and credit volatility over the business cycle;*
    - *the interaction of monetary policy, foreign exchange intervention and prudential tools is, an a way, synergic.*
- *Further work: enriching specification, optimal policy computation, financial cycles; 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*

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

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Forecasting performance

- *We compare: a standard New Keynesian "three equation model" plus a UIP equation (model 1); a model augmented with sterilized intervention (model 2); the model augmented with credit market as described here (model 3).*
    - *Out-of-sample forecasts for horizons of one quarter, two quarters and one year (that is 1, 2 and 4 steps),*
    - *for annual inflation, quarterly output growth, the short term interest rate (annual percentage rate) and quarterly nominal exchange rate depreciation.*
- *We evaluated forecasts through root mean squared error (RMSE) and mean absolute error (MAE); as several out-of-sample forecasts were produced for 1 and 2 steps, we averaged RMSEs and MAEs*

Forecasting performance

Root Mean Squared Error (average of forecasts)			
	Model 1	Model 2	Model 3
	Inflation		
1q ahead	0.0001149	**0.0000637**	0.0000850
2q ahead	0.0012309	**0.0011084**	0.0013154
1y ahead	0.0041688	**0.0035105**	0.0043853
	short term interest rate		
1q ahead	0.0055903	0.0090191	**0.0020098**
2q ahead	0.0135622	0.0160373	**0.0097047**
1y ahead	0.0139850	0.0194395	**0.0094282**
	gdp growth		
1q ahead	0.0008466	0.0000465	**0.0000333**
2q ahead	0.0002925	0.0000247	**0.0000194**
1y ahead	0.0003280	0.0000564	**0.0000649**
	nominal depreciation		
1q ahead	0.0056831	0.0009209	**0.0000027**
2q ahead	0.0036519	0.0007410	**0.0000172**
1y ahead	0.0042373	0.0008688	**0.0002428**

Forecasting performance

Mean Absolute Error (average of forecasts)			
	Model 1	Model 2	Model 3
	Inflation		
1q ahead	0.0107183	**0.0079819**	0.0092219
2q ahead	0.0326056	**0.0310329**	0.0337317
1y ahead	0.0582519	**0.0538322**	0.0598371
	short term interest rate		
1q ahead	0.0290961	0.0215597	**0.0182471**
2q ahead	0.1163943	0.1263115	**0.0985099**
1y ahead	0.1181953	0.1387171	**0.0970527**
	gdp growth		
1q ahead	0.0290961	0.0021560	**0.0001825**
2q ahead	0.0170306	0.0049674	**0.0031620**
1y ahead	0.0174216	0.0060057	**0.0059572**
	nominal depreciation		
1q ahead	0.0238392	0.0303466	**0.0016453**
2q ahead	0.0848728	0.0384642	**0.0058586**
1y ahead	0.1140001	0.0508887	**0.0235807**

Forecasting performance

- *Results show that for 1, 2 and 4-quarter forecasts of output growth, short term interest rate and foreign exchange variability, model 3 (baseline with credit market) outperforms the rest under both evaluation criteria.*
- *For inflation and at all time horizons, model 2 (forex market) delivers the forecast with lowest average errors.*
- *hus, results confirm that models "enriched" to reflect foreign exchange operations, money market dynamics (model 2) as well as credit market conditions (model 3) imply gains in terms of out-of-sample forecasting of key macroeconomic variables.*
- *Differences between RMSEs and MAEs from the models are significant, as tested by the Giacomini-White procedure*

- *Is forecast performance improved by a structural macroeconomic model augmented with financial variables?*
  - *Yes: 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. T*
  - *The model with foreign exchange intervention, however, provides better forecasts of annual inflation.*