Monetary and macroprudential policies: Interaction and complementarity*

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April, 2014

Abstract

After the financial crisis of 2008-2009, macroprudential policy has received a lot of attention from both academia and policymakers. The crisis made obvious the need to have a proper way to assess volatility of financial variables in such a way that the real economy is better shielded. In this context, and building on the framework proposed by Sámano (2011), in this paper we study the relationship between

*We thank Francisco Adame, Ana María Aguilar, Enrique Alberola, Fernando Ávalos, Roberto Chang, Andrés Fernández, Stefano Neri, Federico Signoretti, Claudio Raddatz, Alessandro Rebucci and participants of the "Macroeconomic Policies, Global Liquidity and Sovereign Risk" Conference at the Bank of Italy (2012) and of the Workshops "Towards a New Inflation Targeting Framework in Latin America and the Caribbean" at the IDB (2012) and "Rethinking Inflation Targeting in Latin America" at the Banco Central de Reserva del Perú (2013) for helpful comments. We are particularly grateful to an anonymous referee whose comments helped to significantly improve and redirect the approach of our analysis. We also thank Cid Rodríguez, José Manuel Rodríguez, Luis Simon and, specially, Francisco Adame for providing excellent research assistance. The views presented in this work are exclusively of the authors and do not necessarily reflect those of Banco de México.

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monetary and macroprudential policy tools. In particular, we analize the interaction and complementarity between monetary policy and a dynamic provisioning rule under different environments. Our findings suggest that, in our model, a policy committee through which both the monetary and macroprudential authorities coordinate, and in which a significantly high weigh is placed on the traditional objectives of the monetary authority as opposed to the ones of the macroprudential authority, is Pareto-improving vs. a situation in which monetary policy is the only instrument used to stabilize the economy. Thus, implying that in these cases, when monetary and macroprudential policies coordinate with each other, their complementarity improves the outcome. These results seem to be robust across different exercises and assumptions.

1 Introduction

One of the lessons that the global financial crisis of 2008-2009 brought with it was the need to rethink some of the established assumptions regarding monetary policy. In particular, price stability is not thought any longer as a sufficient condition for financial stability as it was perceived during the Great Moderation. In addition, it turned out that microprudential supervision was ill-equipped to contain the system-wide risks associated to the financial sector. In this context, macroprudential policies were regarded as an option to mitigate the sources of systemic risk that threatened financial stability (see Bank of England (2009)). Nevertheless, the pressing need for actions to counter these threats led policymakers to implement these policies without a formal scrutiny of the granularity characterizing them. Although the literature on the topic has surged ever since and analytical frameworks which support the introduction of macroprudential policies have been enriched with novel research aimed at answering fundamental questions about their use and potential, general consensus is still far from being reached. On the one hand, there are pending questions regarding the effectiveness of this type of policies that need to be answered; on the other, coordination issues between monetary and macroprudential policies have yet to be figured out (see Galati and Moessner (2013)).

This paper contributes to the latter strand of research. The study of coordination issues is important given that monetary and macroprudential policies interact with each other and, therefore, the institutional arrangement for their implementation matters for the macroeconomic outcome. Perhaps, during the Great Moderation, as financial shocks were practically absent in major advanced economies, this issue did not make much of a difference in terms of the macroeconomic outcome that was achieved. However, as financial shocks are now widely recognized as a potential disturbance for economies, it is pertinent to analyze the macroeconomic outcomes that could be attained when both policies are implemented.

Specifically, we analyze the implementation of a dynamic provisioning rule for banks in a setting where monetary policy is already at place. This is, we allow for a second authority to handle the referred macroprudential policy instrument while the monetary authority implements its policy by means of an optimal interest rate rule. Our objective is to estimate the gains that could be achieved by introducing this second instrument, namely an optimal banking coverage ratio rule defined as the ratio of loan-loss reserves to non-performing loans (CRR, from here on), set by the macroprudential authority. Introducing macroprudential policy into a setup where the monetary policy is the incumbent necessarily entails defining an institutional arrangement for their coexistence. The analysis focuses on examining an environment in which the monetary and macroprudential authorities belong to a policy committee designed in such a way that both of them are better off implementing their respective policies through it. We say that the two policies are set through a committee when they are set jointly in order to minimize an aggregate loss function or, in other words, when they are set in a coordinated way.[1] Throughout the paper, we refer to this environment as the *policy committee case*. Alternatively, we consider a situation in which the monetary and macroprudential authorities are not coordinated and, instead, each one of them minimizes its own loss function given the best response of its counterpart. We envision such a case as one in which each authority actively tries to reach the best macroeconomic outcome given the restrictions that the existence of the other authority imposes. We refer to this setting as the *case of uncoordinated policy*.

The rationale behind a dynamic provisioning instrument is the need to reduce the procyclicality of the financial system. Dynamic provisioning attempts to reduce this procyclicality by providing a buffer against bank losses that increases when the financial cycle is booming and allows for a softer landing when it goes bust. Commercial banks are forced to put aside resources to account for the possible losses incurred as credit quality deteriorates. Hence, the adoption of dynamic provisioning typically pursues three objectives: i) to allow during good times for the build-up of reserves that would serve as buffers in bad times; ii) to smooth credit growth throughout the business cycle; and, iii) to shield the real economy from shocks originated in the financial sector.

As the objective for macroprudential policy is clear, namely to prevent systemic risk episodes to ultimately avoid collapses in economic activity, there is not yet a canonical framework to study macroprudential policy issues. To get

[1] Throughout the paper, we use the idea of monetary and macroprudential policy coordination as a synonym for the fact that they are set jointly.

around this limitation while at the same time exploring timely policy issues, we extend the work by Sámano (2011) in which a financial block is appended to an otherwise canonical new Keynesian model for policy analysis. The financial block consists essentially of a set of reduced form equations that allows to bring into the analysis lending spreads, delinquency indexes and credit growth to make them interact with a core new Keynesian model. Following part of the work done by Macroeconomic Assessment Group (2010a), it is assumed that the linkage through which the financial block impacts the core model is the effect of lending spreads on the output gap. This approach allows the propagation, on the one hand, of macroeconomic shocks into the financial block and, on the other, of financial shocks into "traditional" macroeconomic variables. In particular, these linkages generate a feedback channel in which a shock arising in one sector is transmitted to the other which, in turn, feeds back the original sector disrupted by the shock. As commented above, we consider two authorities, each one adjusting its corresponding instrument, in order to optimize its particular or common objective function depending on the setup in which both authorities are assumed to interact. Hence, while the monetary authority determines the nominal interest rate, the macroprudential authority adjusts a CRR.

Our findings suggest that the policy committee case in which both the monetary and macroprudential policies interact could represent a Pareto-improvement when compared to the case in which monetary policy is set by the monetary authority optimally but no macroprudential instrument to mitigate the impact of financial shocks into the economy is used. Moreover, we show that for such a committee to deliver Pareto-superior allocations, it must place a rather high weigh on the traditional loss function of the monetary authority with respect to that placed to stabilize financial variables. This result follows from the fact that if the committee placed a significantly higher weigh on the stabilization of financial variables, this would occur at the expense of higher inflation volatility derived from a stressed effort to stabilize the output gap, therefore generating losses for the monetary authority. Although these results are intuitive –and robust across different exercises and assumptions in our framework–, it must be emphasized that they are likely model dependent; hence, further work on this agenda using alternative models is needed.

Several studies have proposed the inclusion of some form of dynamic provisioning in financial systems (Bouvatier and Lepetit (2008), Burroni et al. (2009) and Balla and McKenna (2009), among others). However, none of them analyze the specific way to implement this type of policy. In this venue, our contribution is to bring an analytical framework to study the interaction between this macroprudential policy and monetary policy under different arrangements for their implementation. The study of the interaction of monetary and macroprudential policies has also been analyzed, among others, by Angelini et al. (2010) who find that the benefits of macroprudential policy depend crucially on the source and magnitude of the shocks hitting the economy and on the degree of coordination with monetary policy.

The remainder of the paper is organized as follows. Section 2 sets out the structure of the model. Section 3 describes the different scenarios that we consider to examine the interaction of monetary and macroprudential policies. Section 4 comments on our main results. Finally, Section 5 provides concluding remarks.

2 The model

A growing literature that introduces financial intermediation into general equilibrium models for monetary policy analysis has emerged in the past years (Roger and Vlcek (2012) provide an extensive survey of models featuring financial frictions and intermediation that are used by central banks). Despite this, there is still no "canonical" framework within which to study the relationship between banks' capitalization, financial intermediation and economic activity.[2]

Given this lack of consensus, and following the work of others that attempt to shed light on the conduction of monetary policy taking into consideration financial stability issues in a suggestive rather than in a prescriptive way, we use a simple, reduced-form model that accounts for the interaction between a standard macroeconomic setup and some financial variables as framework for our analysis. Specifically, we follow the approach taken by Sámano (2011) and append a macroeconometric financial block to a standard semi-structural small open new Keynesian economy model. This approach features the introduction of macro-financial linkages which allows, on the one hand, the propagation of macroeconomic shocks into the financial block and viceversa and, on the other, the existence of a feedback channel in which a shock arising in one sector (real or financial) is transmitted to the other and then feed backs the original sector disrupted by the shock.

In what follows we describe the main building blocks of this macro-financial

[2] Indeed, as Galati and Moessner (2013) points out "[w]hile the literature on monetary policy has provided a common conceptual framework over the past two or three decades, research on macroprudential policy is still in its infancy and appears far from being able to provide an analytical underpinning for policy frameworks. (...) [This may be due to, among other reasons, the fact that] we lack a thorough understanding and established models of the interaction between the financial system and the macroeconomy." (Galati and Moessner (2013), page 854).

model, namely, the core model and the financial sector block. First, we describe the core model as in absence of any link with the financial sector. Then, we detail the structure of the financial block. Finally, we propose a feedback mechanism that can be introduced in order to propagate shocks into the economy as a whole.

2.1 The core model

As mentioned above, the core model is a standard semi-structural small open new Keynesian economy model. It consists of the following elements: i) a Phillips curve for core inflation, ii) equations for inflation sub-indexes, iii) an IS curve for the output gap, iv) an equation for the real exchange rate, and v) an optimal monetary policy rule.[3]

Models with a similar structure as the one just outlined have been useful for guiding central banks to set policy interest rates as they incorporate a minimum set of variables that allows to study, among other things, the response of the monetary authority to shocks to the economy –the classic ones being "cost-push" shocks and demand shocks. Furthermore, despite its simplicity, this set of specifications has as underpinning a solid theoretical background which resembles the microfounded new Keynesian approach proposed in Clarida et al. (1999) and Smets and Wouters (2003).[4] Notwithstanding, they lack a richer set of financial variables to which a macroprudential authority

[3] As in Sámano (2011), the first four components of the core model are similar in terms of equations and coefficients to Sidaoui and Ramos-Francia (2008) (see Appendix A). The main difference between our core model and the one presented in Sámano (2011) lies in the fact that the monetary policy rule that we use is optimal and, hence, contingent on the loss function associated to the monetary authority and on the relative strength of the different transmission channels of monetary policy implied by the magnitude of the coefficients of i) to iv).

[4] The real exchange rate equation arises from assuming that the uncovered interest rate parity holds.

may need to react for financial stability purposes. With the idea of setting a simple framework in which financial variables are of potential consideration for the reaction function of the macroprudent authority, we next lay down a small-scale macroeconometric financial block.

2.2 The financial block

The financial block consists of a set of estimated equations that interact with each other and with the core model. These estimated equations attempt to capture, in a stylized fashion, the elements that characterize the credit market in equilibrium.[5]

At the top of the supply side of credit, lending spreads depend on banks' delinquency indexes as well as on a coverage ratio rule (CRR). The CRR is defined as the ratio of loan-loss reserves to non-performing loans.[6] An increase in lending spreads occurs because either banks adjust these spreads in the face of higher delinquency indexes (so as to offset higher potential losses), or because they are required to build up more provisions. Thus, the banking sector transfers the cost of a deterioration in the quality of its assets and of regulation to consumers. Delinquency indexes are modeled as a function of their lagged values and of the output gap. The relationship between delinquency indexes and the output gap is negative, reflecting the fact that when economic activity expands (reduces) delinquency indexes fall (increase). Finally, as in the case of the monetary policy interest rate, the CRR is set as an optimal policy when the macroprudential authority is active.[7] Notice, though, that

[5] Appendix B presents the system of equations characterizing this block.

[6] As previously discussed, the macroprudential authority can potentially use the CRR as a policy instrument that it would adjust in good times so as to build up reserves which allow banks to cover their loan losses during bad times (see Balla and McKenna (2009)).

[7] All variables, except for the CRR, are incorporated in a disaggregated manner so as to

the prescribed policy functions will depend on the institutional arrangement in which the monetary and macroprudential policies are assumed to interact.

The demand side of credit is captured by a set of equations representing credit growth rates. Credit growth rates depend on their respective lagged values and are also positively related to changes in the output gap and negatively related to lending spreads.[8] This representation implies that a reduction in lending spreads and/or an increase in the output gap boost credit demand.

Admittedly, the financial block is a reduced-form specification and should not be considered a substitute for a model with deep parameters. This shortcut, however, allows to analyze the interaction between the monetary and macroprudential policies and its effects on macroeconomic variables in a simple environment. In particular, this framework lets us conduct exercises that may be helpful for guiding the discussion of whether better macroeconomic outcomes could be attained when the monetary and macroprudential authorities act in coordination.

2.3 The feedback mechanism

The feedback channel between the macroeconomic sector and the financial block is introduced by means of the following assumption: the IS curve in the core model reacts negatively to changes in lending spreads (see Macroeconomic Assessment Group (2010b)).[9] The feedback channel is composed of two macro-

capture the behavior of mortgage, consumption and corporate credit separately.

[8]Notice that we introduce credit growth rates as opposed to credit volume gaps as in Sámano (2011). The reason to do so is that credit growth rates are much better understood than credit volume gaps and are more closely followed by monetary and macroprudential authorities alike.

[9]Woodford (2012) introduces a similar assumption on the IS curve in order to integrate a macro-financial linkage based on the existence of financial frictions so as to analyse financial stability considerations.

financial linkages: i) the direct effect that the output gap has on the financial block (i.e. changes in deliquency indexes and CRR), and ii) the effect of lending spreads on the IS curve. Thus, the spirit of the feedback mechanism is that a shock arising in one sector can be propagated into the other and transmitted again to the sector in which the disruption arose. In order to illustrate this, take for instance the case of an exogenous negative shock to the IS curve: the negative effect on the output gap boosts an increase in delinquency indexes and in lending spreads which, in turn, slows down economic activity even further thus generating tighter conditions on the financial block.

3 The interaction of monetary and macroprudential policies

This section outlines the scenarios that will be used to analyze the interaction of monetary and macroprudential policies. Specifically, we only consider cases in which we assume that monetary policy is already at place, i.e. it is the incumbent, while the macroprudential authority introduces a policy aimed at stabilizing the financial sector of the economy. Restricting the analysis to examining cases in which the monetary authority is the incumbent allows to focus the discussion on setups where both the monetary and the macroprudential authorities coexist in a potential challenging environment.[10] Indeed,

[10] IMF (2013) provides a review of institutional arrangements that have been implemented in a number of countries in order to support macroprudential policies. The review identifies the prevalence of three stylized models for macroprudential policymaking. First, one in which "the macroprudential mandate is assigned to the central bank, with macroprudential decisions ultimately made by its Board." Second, one in which "the macroprudential mandate is assigned to a dedicated committee within the central bank structure." And, finally, a third one in which "the macroprudential mandate is assigned to a committee outside the central bank, with the central bank participating on the macroprudential committee" (see IMF (2013), page 30). The fact that the identified prevailing institucional arrangements put

while it is intuitive that any effort of the macroprudential authority to stabilize the financial sector will bring about gains for the economy as a whole, it is not clear that those gains will be translated into benefits for the monetary authority. In fact, the monetary authority could face trade-offs when a financial stabilization policy is introduced if the macroprudential authority's goals are met at the expense of higher losses in terms of the monetary authority's policy objectives.

Firstly, we describe a *baseline scenario* in which the monetary authority operates in solitude and no attention is paid to financial stability considerations, i.e. the macroprudential authority is inactive. This scenario will serve as a benchmark to evaluate the outcomes in which a macroprudential policy is considered.

Secondly, we describe what we call the *policy committee case* which aims at representing an environment in which the institutional framework of the economy allows the monetary and macroprudential authorities to interact while implementing their policies. Specifically, we consider the case in which the monetary and macroprudential policies are set jointly in order to stabilize the economic system as a whole or, in other words, when they are set in a coordinated way. We will argue that, of all the cases considered in our analysis, this is the one closest to the actual interaction between the monetary and macroprudential authorities observed in reality.

Finally, we describe a case in which the monetary and macroprudential authorities implement their optimal policies so as to reach the best macroeconomic outcome given the best response of their respective counterpart. Al-

into practice by a number of countries feature the monetary authority as having a role in the making of macroprudential policy, albeit in different extents, validate that we restrict the analysis to cases in which the monetary authority is the incumbent.

though it is difficult to think of such an environment as one that would actually materialize –since in practice the conduct of macroprudential policy often entails inter-agency coordination–, it is useful to consider it since it represents a limiting case in which the coexistence of both authorities implies no coordination between them whatsoever. We will refer to this form of coexistence as the *case of uncoordinated policy.*

3.1 Baseline scenario

The baseline scenario considers the case in which the monetary authority sets the optimal level of the short-term interest rate in order to stabilize "traditional" macroeconomic variables associated with the core model, while the financial block is let alone from any stabilization effort, i.e. the macroprudential authority is inactive.[11]

Within this context, the loss function of the monetary authority is defined as follows:

$$L_m \equiv \alpha_x \sigma_x^2 + \alpha_\pi \sigma_\pi^2 + \alpha_{\Delta i} \sigma_{\Delta i}^2 \qquad (1)$$

where m stands for the monetary authority; σ_x^2, σ_π^2 and $\sigma_{\Delta i}^2$ denote the variance of the output gap, the inflation gap and the change in the interest rate, respectively (each one of these terms are weighed out by the inverse of the variance of the corresponding historical series from 2003 to 2011), and α_x, α_π, and $\alpha_{\Delta i}$ represent the monetary authority's relative preferences for stabilizing each one of the elements of its loss function.

The optimization problem of the monetary authority can be, hence, rep-

[11] Since this is a case where the macroprudential policy plays no stabilizing role, we assume that the CRR follows an autorregressive process of order 1.

resented in the following way:

$$\begin{aligned} \underset{i}{Min} \quad & L_m \\ \text{s.t.} \quad & \text{equations A1 to A10} \\ & CRR_t = \rho_{CRR} CRR_{t-1} + \varepsilon_{CRR,t} \end{aligned}$$

where ρ_{CRR} is the autorregresive parameter of the CRR and $\varepsilon_{CRR,t}$ an i.i.d. disturbance with zero mean and variance $\sigma_{\varepsilon_{CRR}}$.

3.2 Policy committee case

The second scenario that we analyze is a *policy committee case.* It consists of an environment in which the monetary and macroprudential policies are set simultaneously in order to stabilize the economic system as a whole. Specifically, it assumes that a joint stabilization plan in which the monetary and macroprudential authorities participate is put in place by a policy committee.

According to Nier et al. (2011), two key desirables for macroprudential policy arrangements are, on the one hand, that the mandate for financial stability is given to a single institution whose other objectives, if any, are closely aligned with the objective of macroprudential policy and, on the other, that the implemented framework does not become a vehicle to compromise the autonomy of other established policies. As will be seen, the way in which this case is tailored can easily be interpreted as one in which both the monetary and macroprudential authorities are part of a financial stability council where, although each one of them is autonomous while implementing its own policy, they coordinate between each other so as to take into account their potential complementarities. Furthermore, we claim that it provides the most relevant setup to analyze the interaction of the monetary and macroprudential authorities in a realistic environment due to the fact that it accounts for the economic incentives that prevail in the institutional frameworks for financial stability identified in the literature and addressed in a number of policy statements.[12]

The joint stabilization plan put in place by the policy committee consists of:

1. An aggregate loss function, L_{co}, that accounts for both the monetary and the macroprudential authorities' loss functions is considered:[13]

$$L_{co} = \alpha L_m + (1 - \alpha) L_{mp}$$

   where the subscript co refers to the policy committee's case and $\alpha \epsilon [0, 1]$ is the weight of the monetary authority's objectives versus the macroprudential policy ones. Intuitively, α represents the level of intolerance to macroeconomic fluctuations vis-à-vis financial fluctuations.

2. An optimization problem that determines both the monetary and the

[12] FSB et al. (2011) reference a survey conducted by the IMF in late 2010 that take stock of the existing institutional setups for macroprudential policy in 60 of its country members. According to the survey, by then, the conduct of macroprudential policy often entailed inter-agency coordination and, in 44 percent of the cases, it also involved having in place or being in the process of establishing a financial stability committee or council. Regarding the relationship between macroprudential policies and monetary policy, for instance, IMF (2013) acknowledges that "(c)omplementarities explain why central banks have a strong interest in ensuring the effective pursuit of macroprudential policy and are often at the forefront in the push for the establishment of macroprudential frameworks. Interactions also call for some degree of coordination between monetary and macroprudential policies, while preserving the established independence and credibility of monetary policy." (IMF (2013), page 9).

[13] See (1) above and (2) below.

macroprudential policies:

$$\underset{i,CRR,\alpha\epsilon[0,1]}{Min} \quad \{\alpha L_m + (1-\alpha)L_{mp}\}$$
$$\text{s.t.} \quad \text{equations A1 to A10}$$
$$L_{mp} \leq \overline{L}_{mp}$$
$$L_m \leq \overline{L}_m$$

where the last two expressions represent the participation constraints that need to be fulfilled in order for both authorities to be willing to participate in the joint stabilization plan. $\overline{L}_m$ and $\overline{L}_{mp}$ denote the losses attained by each one of the policies under the baseline case.

Notice that $\overline{L}_{mp}$ is the implied loss derived from the volatility of the financial variables in the case where the financial sector lacks a stabilization policy. While it is obvious that including an additional instrument that accounts for the stabilization of financial variables into the baseline scenario would bring a lower L_{mp}, in contrast with the case in which such an objective does not exist, it is not necessarily the case that the monetary authority would be better off by participating in the joint stabilization plan. Indeed, on the one hand, it could enjoy the benefits provided by the macroprudential policy that blocks the propagation of shocks coming from the financial sector. Nevertheless, on the other hand, departing from the baseline scenario implies that the monetary authority transfers a share $(1-\alpha)$ of its intolerance to macroeconomic fluctuations for the sake of achieving financial stabilization. Hence, including the participation constraints in the optimization problem is crucial to induce policies that generate Pareto-improvements with respect to the baseline scenario. Moreover, it entails finding a range of α that supports the implementation of both optimal policies. Intuitively, and considering that monetary policy plays the role of the incumbent, this range provides a measure of how lenient a monetary authority is willing to become in terms of achieving its own goals when participating in a policy committee which includes financial stabilization considerations.[14]

3.3 The case of uncoordinated policy

Additionally, we consider a case in which the macroprudential authority sets its policy optimally, using a CRR as macroprudential instrument. In contrast with the *policy committee case*, in this setup the monetary and macroprudential authorities make their own decisions taking as given the reaction function of its counterpart. This is, each authority tries to reach the best macroeconomic outcome by setting its optimal policy as the best response to the economic environment and the other authority's optimal policy. Albeit unrealistic, it represents a limiting case in which the coexistence of both authorities implies no coordination between them, thus considering it as a reference point is worthwhile.

In particular, we assume that the macroprudential authority summarizes its goals by means of the following loss function:

$$L_{mp} \equiv \alpha_{delin}\sigma^2_{delin} + \alpha_{spread}\sigma^2_{spread} + \alpha_{\Delta CRR}\sigma^2_{\Delta CRR} \tag{2}$$

where the subscript mp refers to the macroprudential authority; σ^2_{delin}, σ^2_{spread}, and , $\sigma^2_{\Delta CRR}$ denote the variance of deviations of the delinquency index, lending

[14]The approach taken here contrasts with the one proposed by a different branch of research that to examine monetary policy and financial stability assumes that financial stability considerations can be captured, alternatively, by introducing concerns for financial imbalances explicitly as an additional objective of monetary policy. See, for instance, Disyatat (2010) and Agénor et al. (2013).

spreads and the coverage ratio rule from their respective steady-state (each one of them weighed out by the inverse of the variance of the corresponding historical series from 2003 to 2011 levels), and the coefficients α_{delin}, α_{spread}, and $\alpha_{\Delta CRR}$ represent the macroprudential authority's relative preferences for stabilizing each one of the elements of its loss function.[15]

The optimization problem of the macroprudential authority can be, hence, represented in the following way:

$$\begin{aligned} CRR^* = Arg\min_{CRR} \quad & L_{mp} \\ \text{s.t.} \quad & \text{equations A1 to A10} \\ & \text{given } i^* \end{aligned} \tag{3}$$

where i^* stands for the optimal monetary policy, this is:

$$\begin{aligned} i^* = Arg\min_{i} \quad & L_{m} \\ \text{s.t.} \quad & \text{equations A1 to A10} \\ & \text{given } CRR^* \end{aligned} \tag{4}$$

To compute the equilibrium, we run the following algorithm:

1. Guess initial values for $CRR_{(0)}$.

2. Taking $CRR_{(0)}$ as given, the monetary authority chooses $i_{(0)}$ so as to solve (4).

[15] We follow Angelini et al. (2010) in defining the macroprudetinal authority's loss function in terms of the variance of the financial variables. As pointed out by one of our anonymous referees, doing so as opposed to, for instance, considering the financial variables' levels may be considered an arbitrary choice. However, given the simplicity of our framework and the fact that the monetary authority's loss function is also defined in terms of the variance of the relevant macroeconomic variables, this seems a good starting point for exploring macroprudentail goals.

3. Taking $i_{(0)}$ as given, the macroprudential authority chooses $CRR_{(1)}$ so as to solve (3).

4. Use $CRR_{(1)}$ to repeat steps 2 and 3 until $\left|CRR_{(k)} - CRR_{(k-1)}\right| < \varepsilon$ and $\left|i_{(k)} - i_{(k-1)}\right| < \varepsilon$ where k is the number of iteration and ε is a very small number.

Notice that the solution to this coexistence arrangement is a Nash equilibrium. While this algorithm is intuitive and straightforward, its convergence depends on the initial values proposed for $CRR_{(0)}$.[16]

4 Results

The financial crisis highlighted the fact that price stability is not a sufficient condition for financial stability as it was perceived during the Great Moderation. As financial shocks are now widely recognized as a potential disturbance for economies, macroprudential policies have been implemented in order to mitigate the sources of systemic risk that threatened financial stability so that the real economy is better shielded against shocks generated in the financial sector. However, the coexistence of monetary and macroprudential policies have brought about questions regarding how they should interact. The preceding sections have outlined a macro-financial framework and different environments within which to study this interaction. In this section we analyze the macroeconomic outcomes that are attained in these environments. In order to do so, the values of the loss functions for both the monetary and macroprudential authorities corresponding to every case are estimated.[17] As a robustness

[16] According to Currie and Levine (1993), in an environment such as the one described above, a Nash equilibrium may not exist and if it does it may not be unique.

[17] Specifically, we simulate stochastic shocks disturbing the macro-financial model for several periods until all variables reach their invariant distribution. This allows us to compute

check of the results, variations in two dimensions are considered. First, we allow for different types of shocks to hit the economy. In particular, we analyze cases in which the economy is hit by both macroeconomic and financial shocks simultaneously, only by macroeconomic shocks and only by financial shocks. Second, we examine the effects of changing the importance that the monetary authority's attaches to inflation stabilization relative to output stabilization (i.e. of changing the relative size of α_π and α_x in the monetary authority's loss function).

First, we briefly comment on the main results obtained from comparing our *baseline case* with the *case of uncoordinanted policy.* Columns two and three in Table 1.A present the respective values of L_m and L_{mp} when the economy is hit by both macroeconomic and financial shocks simultaneously and the monetary authority assigns equal weighs to inflation and output stabilization. As can be noticed, the scenario in which both authorities act in an uncoordinated way represents lower values for both L_m and L_{mp} relative to the benchmark case. Although it is trivial to rationalize the improvements in L_{mp} since an optimal use of the CRR dominates any arbitrary use of it, the fact that the monetary authority is better-off, even if the improvement is considerably small, implies that the introduction of a macroprudential policy is Pareto-improving in our model. As can be seen, these results hold when the economy is only hit by either macroeconomic or financial shocks (Table 1.B and 1.C) and for different preference parameters of the monetary authority (Table 2 and Table 3).

As said before, the *policy committee case* described in Section 3.2 provides what we consider the most realistic setup within which to analyze the benefits that the interaction between monetary and macroprudential policies brings

the variance of the relevant variables that define the loss function of the authorities under different policy configurations.

about. Columns 4 to 13 in Table 1.A display the estimated values of L_m and L_{mp} in this scenario for different values of α, which account for different levels of relative intolerance to macroeconomic vis-à-vis financial fluctuations, when $\alpha_\pi = \alpha_x$. Comparing the values of L_m and L_{mp} between this and the benchmark case allows us to identify the institutional arrangement that makes the former Pareto-dominate the latter. This entails determining the range of values of α for which $L_{mp} \leq \overline{L}_{mp}$ and $L_m \leq \overline{\overline{L}}_m$. As can be seen, in our model, having $\alpha \in [0.92, 0.97]$ involves cases where Pareto-improvements are attained (values for α greater than 0.91 entail lower losses for the monetary authority while values for α lower than 0.98 entail lower losses for the macroprudential authority). As in the previous comparison, this result is robust to the type of shocks hitting the economy (Table 1.B and 1.C). In contrast, Table 2 and Table 3 show how the range of α that ensures Pareto-improvements in this environment changes as the monetary authority places different weighs to inflation stabilization relative to output stabilization. Firstly, when $\alpha_\pi > \alpha_x$ (Table 2), the range of α for which a committee can be implemented shrinks and shifts upward to $\alpha \in [0.94, 0.98]$. Secondly, when $\alpha_x > \alpha_\pi$ (Table 3), the range of α for which a committee can be implemented widens and shifts downward to $\alpha \in [0.90, 0.96]$. The intuition behind these results is that a monetary authority that is particularly intolerant (tolerant) to inflation fluctuations as opposed to output fluctuations finds relatively less (more) benefits to be complemented by a macroprudential authority. As we will see below, this happens due to the fact that the benefits of introducing a macroprudential instrument that shields the core macroeconomic sector against shocks generated in the financial sector are reduced (increased) since, in our model, this protection is primarily designed to stabilize the output gap.

Albeit it is important to emphasize that these results hinge upon the specification of our economy model and the values of its parameters, two things are worth noting about the interaction of monetary and macroprudential policies. First, the fact that while greater financial stability is attained by the implementation of macroprudential policy due to a decrease in the variance of both deliquency indexes and lending spreads, the main driver of the increased benefits of the monetary authority is the stabilization of the output gap. In line with the findings of Sámano (2011), the introduction of a macroprudential policy complements monetary policy by dampening the direct effects of financial shocks on the real economy. The role of "protective shield" that the macroprudential policy plays is showed in Figure 1, which depicts the dynamics of output, inflation, lending spreads and delinquency indexes, together with the evolution of the interest rate and the CRR set by the monetary and macroprudential authorities, respectively, when a negative shock to the financial sector that translates to an increase in lending spreads hits the economy –due, for instance, to an increase in the risk premium. The financial shock is transmitted to the core macroeconomic model through its effect on the output gap. Notice that when the macroprudential authority sets the CRR, the effect of the financial shock on lending spreads is immediately dampened after the shock, this prevents the output gap to decrease as much as in the benchmark case, hence, allowing monetary policy to react less aggressively, on the one hand, and mitigating the feedback loop of economic activity on the financial sector, on the other. To sum up, the presence of a macroprudential policy complements monetary policy while fostering an improvement in financial stability.

Second, the fact that the range of values of α that supports the willingness of the monetary authority to participate in the policy committee case are close to the upper bound of the feasible set implies that such a committee has to be leaned towards minimizing this authority's losses. Figure 2 illustrates how the value that α takes is nontrivial for establishing a policy committee in which the incumbent is willing to participate (i.e. in which $L_m \leq \overline{\overline{L}}_m$ holds). In particular, it displays the impulse response functions of the model to a negative financial shock under: i) the *baseline case*, ii) a *policy committee case with α high* enough so as to allow the participation of the monetary authority, and iii) a *policy committee case with α low* enough so as to discourage the participation of the monetary authority in such a committee. As before, the decrease in the output gap as a consequence of the financial shock is counter by a decrease in the interest rate. The drop of economic activity is reflected in an increase in delinquency indexes. When a committee is settled with a high enough α, macroprudential policy mainly reacts to mitigate the shock arising in the financial sector, which further stabilizes the macroeconomy. Alternatively, when the committee is settled with a low enough α, the interest rate is not only used as a tool to stabilize inflation and output but also as a financial sector stabilizer. This can be observed in the overreaction of the interest rate. Intuitively, in this hypothetical arrangement the monetary authority is pushed to lean-against-the-wind to counter financial stability at the expense of increasing inflation volatility.

5 Conclusions

In this paper we have analyzed the interaction and complementarity between monetary and macroprudential policy. Our findings suggest that, in our model, a policy committee through which both the monetary and macroprudential authorities coordinate, and in which a significantly high weigh is placed on the traditional objectives of the monetary authority as opposed to the ones of the macroprudential authority, is Pareto-improving vs. a situation in which monetary policy is the only instrument used to stabilize the economy. Thus, implying that for these cases, when monetary and macroprudential policies coordinate with each other, their complementarity improves the outcome.

The latter result follows from the fact that if the committee placed a significantly higher weigh on the stabilization of financial variables, this would occur at the expense of higher inflation volatility derived from a stress effort to stabilize the output gap which would therefore, generate losses for the monetary authority by allowing for greater inflation volatility.

Although our results seem to be robust across a variety of exercises and different parameterizations of the loss functions associated to both authorities and, thus, contribute to shed light on the interaction and complementarity of monetary and macroprudential policies in a suggestive way, they are model dependent and further work, both empirical and theoretical, must be done in order to generalize our findings.

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Appendix

A Sketch of the core model

In this appendix, we replicate the functional forms of Sidaoui and Ramos-Francia (2008).

$$\pi_t^c = a_1\pi_{t-1}^c + a_2E_t[\pi_{t+1}^c] + a_3x_t + a_4(\Delta e_t + \pi_t^{us}) + \varepsilon_{\pi^c,t} \tag{A1}$$

$$x_t = b_1x_{t-1} + b_2E_t[x_{t+1}] + b_3r_{t-1} + b_4x_t^{us} + b_5\ln(rer_t) + \varepsilon_{x,t}$$

$$rer_t = c_0rer_{t-1} + c_1(E_t[rer_{t+1}] + (r_t^{us} - r_t)) + \varepsilon_{rer,t} \tag{A2}$$

$$\pi_t = \omega_c\pi_t^c + \omega_{nc}\pi_t^{nc} \tag{A3}$$

where π_t^c is core inflation, x_t is the output gap, e_t is the nominal exchange rate (Mexican pesos per U.S. dollars), π_t^{us} is headline inflation in the U.S., r_t is the real interest rate, x_t^{us} is the output gap in the U.S., rer_t is the bilateral real exchange rate between Mexico and the U.S., r_t^{us} is the real interest rate in the U.S., π_t^{nc} is non-core inflation, $E_t[\cdot]$ is the expectation operator with information at time t and $\ln(\cdot)$ is the natural logarithm.[18] The term $\varepsilon_{j,t}$ is an i.i.d. disturbance with zero mean and variance σ_{j_x}, for $j = \{\pi^c, x, rer\}$.

The model is closed with an optimal monetary policy interest rate rule:

[18]Increases in e and rer denote a depreciation and a deterioration of the real exchange rate, respectively.

Tables and Figures

Table 1. Monetary and macroprudential authorities' loss functions*

Table 1.A.- Macroeconomic and Financial Shocks

	Baseline Case	**Uncoordinated Policy Case**	**Policy Committee Case** α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	212.64	209.99	201.79	205.83	207.69	208.92	209.89	210.73	211.51	212.25	212.97	213.68
σ_x^2	13.01	12.35	9.20	10.00	10.07	9.94	9.72	9.47	9.20	8.93	8.66	8.39
σ_π^2	180.79	178.69	173.15	176.71	178.64	180.09	181.36	182.52	183.63	184.70	185.75	186.79
$\sigma_{\Delta i}^2$	18.84	18.95	19.44	19.12	18.98	18.89	18.81	18.74	18.68	18.62	18.55	18.50
L_{mp}	113.86	69.54	342.52	145.65	99.51	80.42	69.89	62.97	57.86	53.79	50.37	47.41
σ_{delin}^2	71.15	66.53	49.56	52.76	52.27	50.77	48.91	46.93	44.92	42.94	41.01	39.14
σ_{spread}^2	42.71	2.00	181.74	58.19	29.69	18.67	13.25	10.16	8.22	6.92	6.01	5.33
$\sigma_{\Delta CRR}^2$	0.00	1.01	111.22	34.70	17.55	10.97	7.73	5.88	4.71	3.92	3.36	2.94

Table 1.B.- Macroeconomic Shocks

	Baseline Case	**Uncoordinated Policy Case**	**Policy Committee Case** α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	213.45	210.80	202.60	206.65	208.51	209.75	210.72	211.56	212.34	213.08	213.81	214.52
σ_x^2	13.04	12.39	9.24	10.03	10.11	9.97	9.75	9.50	9.23	8.96	8.68	8.42
σ_π^2	181.46	179.35	173.83	177.39	179.32	180.79	182.05	183.22	184.34	185.41	186.47	187.51
$\sigma_{\Delta i}^2$	18.94	19.05	19.54	19.22	19.09	18.99	18.91	18.84	18.78	18.71	18.65	18.59
L_{mp}	109.25	66.89	340.69	143.20	96.92	77.78	67.22	60.28	55.16	51.08	47.66	44.69
σ_{delin}^2	70.66	66.10	49.07	52.28	51.79	50.28	48.42	46.43	44.42	42.43	40.49	38.62
σ_{spread}^2	38.59	0.28	180.59	56.67	28.08	17.03	11.58	8.48	6.54	5.23	4.31	3.63
$\sigma_{\Delta CRR}^2$	0.00	0.51	111.03	34.25	17.06	10.47	7.22	5.37	4.20	3.41	2.85	2.44

Table 1.C.- Financial Shocks

	Baseline Case	**Uncoordinated Policy Case**	**Policy Committee Case** α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	213.45	210.80	202.60	206.65	208.51	209.75	210.72	211.56	212.34	213.08	213.81	214.52
σ_x^2	13.04	12.39	9.24	10.03	10.11	9.97	9.75	9.50	9.23	8.96	8.68	8.42
σ_π^2	181.46	179.35	173.83	177.39	179.32	180.79	182.05	183.22	184.34	185.41	186.47	187.51
$\sigma_{\Delta i}^2$	18.94	19.05	19.54	19.22	19.09	18.99	18.91	18.84	18.78	18.71	18.65	18.59
L_{mp}	109.25	66.89	340.69	143.20	96.92	77.78	67.22	60.28	55.16	51.08	47.66	44.69
σ_{delin}^2	70.66	66.10	49.07	52.28	51.79	50.28	48.42	46.43	44.42	42.43	40.49	38.62
σ_{spread}^2	38.59	0.28	180.59	56.67	28.08	17.03	11.58	8.48	6.54	5.23	4.31	3.63
$\sigma_{\Delta CRR}^2$	0.00	0.51	111.03	34.25	17.06	10.47	7.22	5.37	4.20	3.41	2.85	2.44

* α_i for $i = x, \pi, \Delta i, delin, spread, \Delta CRR$ in L_m and L_{mp} are set equal to 1/3.

Table 2. Monetary and macroprudential authorities' loss functions*

Table 2.A.- Macroeconomic and Financial Shocks

	Baseline Case	Uncoordinated Policy Case	Policy Committee Case α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	254.24	251.64	245.81	249.52	251.31	252.58	253.65	254.63	255.58	256.51	257.45	258.39
σ_x^2	14.55	13.39	10.31	11.13	11.19	11.05	10.83	10.56	10.28	9.99	9.71	9.42
σ_π^2	214.15	212.61	209.44	212.64	214.54	216.09	217.52	218.89	220.24	221.59	222.93	224.28
$\sigma_{\Delta i}^2$	25.54	25.65	26.06	25.76	25.58	25.44	25.31	25.18	25.06	24.93	24.81	24.69
L_{mp}	174.12	102.62	343.06	163.57	121.75	103.83	93.40	86.12	80.45	75.71	71.57	67.86
σ_{delin}^2	111.04	98.84	76.42	80.59	79.78	77.64	75.01	72.22	69.38	66.57	63.81	61.13
σ_{spread}^2	63.09	2.20	145.30	44.98	22.44	13.80	9.54	7.11	5.58	4.55	3.82	3.28
$\sigma_{\Delta CRR}^2$	0.00	1.58	121.34	38.00	19.52	12.39	8.84	6.79	5.48	4.59	3.94	3.45

Table 2.B.- Macroeconomic Shocks

	Baseline Case	Uncoordinated Policy Case	Policy Committee Case α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	255.26	252.66	245.81	249.52	251.31	252.58	253.65	254.63	255.58	256.51	257.45	258.39
σ_x^2	14.59	13.43	10.31	11.13	11.19	11.05	10.83	10.56	10.28	9.99	9.71	9.42
σ_π^2	214.99	213.44	209.44	212.64	216.09	217.52	218.89	220.24	221.59	222.93		224.28
$\sigma_{\Delta i}^2$	25.68	25.79	26.06	25.58	25.44	25.44	25.31	25.18	25.06	24.93	24.81	24.69
L_{mp}	169.84	100.20	343.06	163.57	121.75	103.83	93.40	86.12	80.45	75.71	71.57	67.86
σ_{delin}^2	110.80	98.65	80.59		80.59	77.64	75.01	72.22	69.38	66.57	63.81	61.13
σ_{spread}^2	59.05	0.49	145.30	44.98	22.44	13.80	9.54	7.11	5.58	4.55	3.82	3.28
$\sigma_{\Delta CRR}^2$	0.00	1.07	121.34	38.00	19.52	12.39	8.84	6.79	5.48	4.59	3.94	3.45

Table 2.C.- Financial Shocks

	Baseline Case	Uncoordinated Policy Case	Policy Committee Case α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	242.39	240.07	233.76	237.20	238.86	240.03	241.02	241.93	242.79	243.65	244.50	245.36
σ_x^2	12.21	11.19	8.39	9.15	9.23	9.12	8.93	8.71	8.48	8.23	7.99	7.75
σ_π^2	205.37	203.98	200.19	203.16	204.91	206.33	207.63	208.87	210.09	211.31	212.52	213.73
$\sigma_{\Delta i}^2$	24.80	24.90	25.18	24.89	24.72	24.59	24.46	24.34	24.22	24.11	23.99	23.88
L_{mp}	150.69	88.79	312.90	147.85	109.54	93.25	83.86	77.36	72.34	68.17	64.54	61.29
σ_{delin}^2	95.96	85.25	65.50	69.38	68.81	67.04	64.83	62.45	60.04	57.64	55.28	52.98
σ_{spread}^2	54.73	2.14	133.14	42.43	22.02	14.19	10.33	8.13	6.75	5.82	5.15	4.66
$\sigma_{\Delta CRR}^2$	0.00	1.41	114.25	36.04	18.70	12.02	8.70	6.78	5.55	5.18	4.10	3.65

* α_i for $i = \Delta i, delin, spread, \Delta CRR$ in L_m and L_{mp} are set equal to 1/3. The loss of the monetary authority is specified with a higher weight assigned to inflation stabilization relative to output stabilization, this is, α_π equals 2/3 while α_x equals 2/9.

Table 3. Monetary and macroprudential authorities' loss functions*

Table 3.A.- Macroeconomic and Financial Shocks

	Baseline Case	Uncoordinated Policy Case	Policy Committee Case α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	159.67	157.67	150.72	154.02	155.49	156.42	157.13	157.71	158.23	158.71	159.16	159.60
σ^2_x	9.45	9.42	7.33	7.78	7.77	7.64	7.45	7.25	7.04	6.83	6.63	6.44
σ^2_π	136.29	134.25	128.89	131.99	133.57	134.69	135.61	136.43	137.18	137.89	138.57	139.22
$\sigma^2_{\Delta i}$	13.92	14.01	128.89	14.25	14.15	14.10	14.06	14.03	14.01	13.98	13.96	13.94
L_{mp}	63.50	40.89	259.48	103.15	66.54	51.64	43.63	38.52	34.87	32.04	29.74	27.79
σ^2_{delin}	38.42	38.30	28.79	30.24	29.72	28.67	27.45	26.18	24.93	23.71	22.53	21.40
σ^2_{spread}	25.08	1.88	161.76	51.66	26.24	16.44	11.63	8.90	7.20	6.06	5.26	4.67
$\sigma^2_{\Delta CRR}$	0.00	0.71	68.93	21.25	10.58	6.53	4.55	3.44	2.74	2.28	1.95	1.71

Table 3.B.- Macroeconomic Shocks

	Baseline Case	Uncoordinated Policy Case	Policy Committee Case α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	160.26	158.26	151.32	154.62	156.09	157.02	157.73	158.31	158.83	159.32	159.77	160.21
σ^2_x	9.49	9.45	7.36	7.81	7.80	7.66	7.48	7.27	7.06	6.86	6.65	6.46
σ^2_π	136.77	134.73	129.38	132.48	134.06	135.19	136.12	136.93	137.69	138.40	139.08	139.74
$\sigma^2_{\Delta i}$	14.00	14.08	14.08	14.32	14.23	14.17	14.14	14.10	14.08	14.06	14.04	14.02
L_{mp}	58.60	38.01	257.21	100.44	63.74	48.80	40.78	35.67	32.01	29.19	26.89	24.94
σ^2_{delin}	37.70	37.64	28.10	29.57	29.05	28.00	26.79	25.52	24.27	23.05	21.88	20.76
σ^2_{spread}	20.90	0.16	160.58	50.12	24.62	14.79	9.96	7.22	5.51	4.36	3.56	2.97
$\sigma^2_{\Delta CRR}$	0.00	0.21	68.54	20.74	10.07	6.01	4.04	2.93	2.23	1.77	1.45	1.21

Table 3.C.- Financial Shocks

	Baseline Case	Uncoordinated Policy Case	Policy Committee Case α									
			0.99	**0.98**	**0.97**	**0.96**	**0.95**	**0.94**	**0.93**	**0.92**	**0.91**	**0.90**
L_m	150.51	148.72	142.43	145.42	146.77	147.62	148.26	148.80	149.27	149.71	150.13	150.53
σ^2_x	7.23	7.18	5.34	5.75	5.75	5.64	5.49	5.32	5.14	4.97	4.80	4.64
σ^2_π	129.78	127.96	123.02	125.86	127.29	128.30	129.14	129.87	130.55	131.18	131.79	132.37
$\sigma^2_{\Delta i}$	13.50	13.57	14.07	13.82	13.72	13.67	13.63	13.60	13.58	13.56	13.54	13.52
L_{mp}	55.28	35.54	233.55	92.21	59.07	45.60	38.37	33.78	30.51	27.99	25.94	24.21
σ^2_{delin}	33.17	33.05	24.54	25.89	25.46	24.56	23.50	22.41	21.31	20.25	19.22	18.24
σ^2_{spread}	22.12	1.85	145.50	46.76	23.88	15.05	10.70	8.23	6.69	5.27	4.94	4.40
$\sigma^2_{\Delta CRR}$	0.00	0.64	63.50	19.56	9.73	5.99	4.17	3.15	2.51	2.08	1.78	1.56

* α_i for $i = \Delta i, delin, spread, \Delta CRR$ in L_m and L_{mp} are set equal to 1/3. The loss of the monetary authority is specified with a lower weight assigned to inflation stabilization relative to output stabilization, this is, α_π equals 2/9 while α_x equals 2/3.

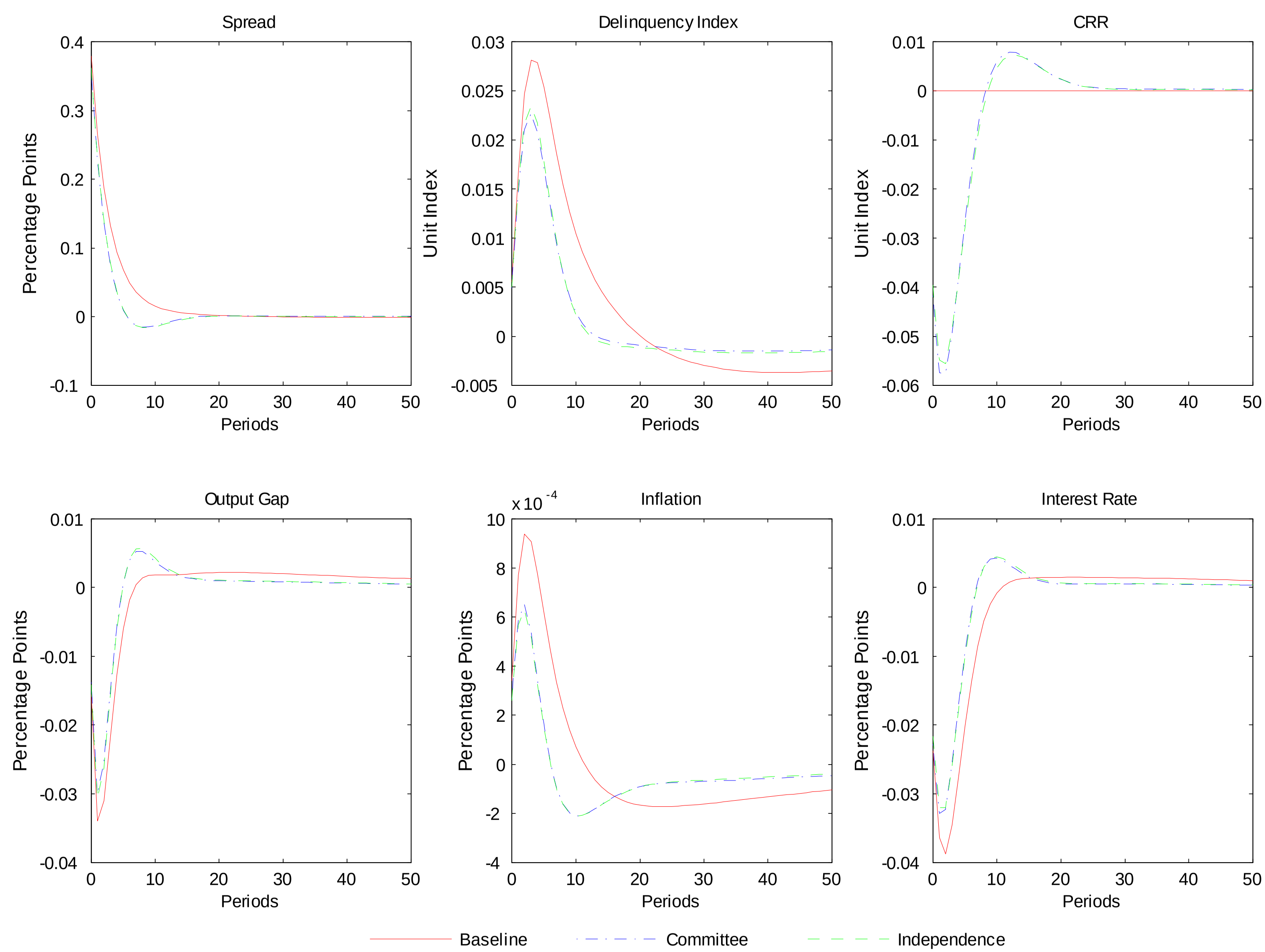

Figure 1. Impulse response function of a shock to consumption lending spreads.

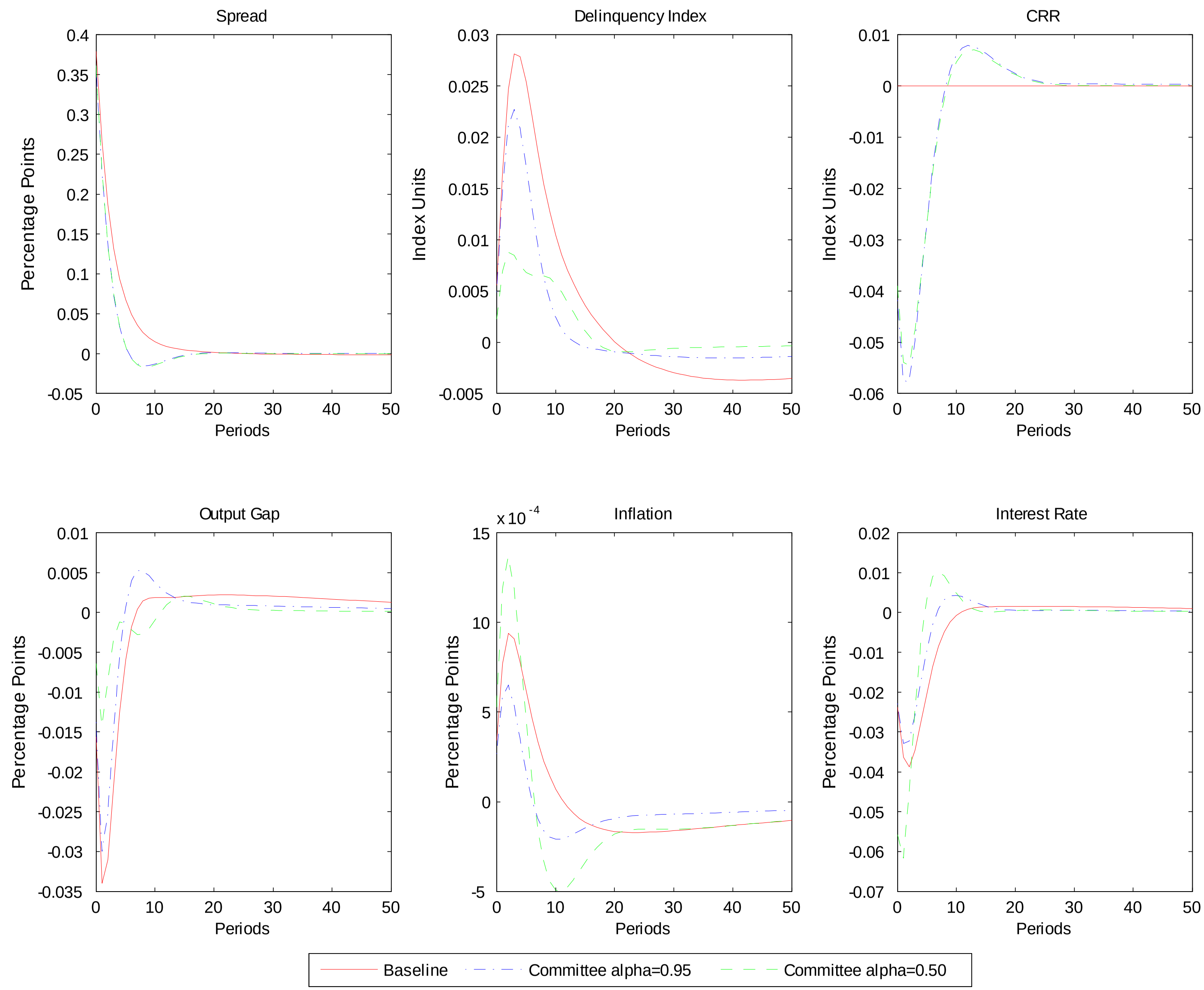

Figure 2. Impulse response function to a shock to consumption lending spreads for different levels of α.

$$i = f(monetary\ authority's\ loss\ funtion,\ the\ rest\ of\ the\ economy)$$

B The financial block

The financial block consists of a set of estimated equations that interact with each other and with the core model. The interaction between the financial block and the core model is allowed, on the one hand, by assuming that the financial block reacts to developments in output and, on the other hand, by assuming that the output gap is sensitive to developments in the financial system. The latter channel is introduced by modifying the IS curve of the core model. The augmented-core model has thus the following components:

1. A modified IS equation that includes lending spreads.[19]
2. Equations for lending spreads by sector.
3. Equations for delinquency indexes by sector.
4. Equations for credit growth by sector.

The sectors considered are: *i)* credit to non-financial corporations, *ii)* credit to consumers, and *iii)* credit for mortgages which account for the majority of private lending in the Mexican economy (in February of 2014 the share of direct credit to these sectors accounted for 95 percent of total credit).

Finally, the financial block is closed with an optimal CRR in those cases where the macroprudential authority is active:

[19] As mentioned above, an increase in lending spreads has a negative effect on economic activity.

$$CRR = f(macroprudential\ authority's\ loss\ funtion,\ the\ rest\ of\ the\ economy)$$

For the case in which it is assumed to be inactive (the baseline scenario in Section 3), the CRR follows an autorregressive proccess of order 1:

$$CRR_t = \rho_{CRR} CRR_{t-1} + \varepsilon_{CRR,t}$$

where ρ_{CRR} is the autorregresive parameter of the CRR and $\varepsilon_{CRR,t}$ an i.i.d. disturbance with zero mean and variance $\sigma_{\varepsilon_{CRR}}$.

B.1 The modified IS equation

The channel by which the financial block impacts the core model is through the effect of lending spreads on the output gap. This mechanism is in line with some of the work done in Macroeconomic Assessment Groups (2010b) as well as with Woodford (2012):

$$x_t = b_0 + b_1 x_{t-1} + b_2 E_t x_{t+1} + b_3 r_{t-1} + b_4 x_{t-1}^{US} + b_5 \ln(rer_t) + b_6 spread_{t-1} + \varepsilon_{x,t} \quad \text{(A4)}$$

where $spread_t$ accounts for the weighted lending spread in the economy and the term $\varepsilon_{x,t}$ is an i.i.d. disturbance with zero mean and variance σ_{ε_x}.

We expect an increase in the lending spread to have a negative effect on the output gap, thus b_6 must be negative.[20] In other words, when the lending spreads increase economic activity slows down. This may be so since higher lending spreads tend to reduce spending by households and enterprises, redu-

[20] Notice that when $b_6 = 0$, the core model does keep affecting the financial block but the latter no longer feedbacks into the former.

cing aggregate consumption and investment mainly in the short run. Moreover, the main impact would tend to fall on bank-dependent sectors: households and small and medium-sized enterprises as they most likely lack other forms of financial intermediaries apart from banks.

B.2 Equations for lending spreads by sector

This component of the financial block encompasses equations that translate levels of sector specific delinquency indexes and the levels of CRR into sectorial lending spreads. The idea behind these reduced form equations is that commercial banks increase lending rates when facing higher potential losses in the future and when they are required to set aside reserves in order to build preventive buffers. Thus, we have the following specification:

$$spread_t^j = \beta_0^j + \beta_1^j spread_{t-1}^j + \beta_2^j delin_t^j + \beta_3^j CRR_t + \varepsilon_{spread,t}^j \tag{A5}$$

for $j = \{corp, cons, mort\}$, where $corp$, $cons$ and $mort$ stand for credit to non-financial corporations, to consumers and for mortgages respectively; moreover, $delin_t^j$ is the delinquency index in sector j and CRR_t is the coverage ratio rule of the banking system. In line with the arguments above we expect β_2^j,$\beta_3^j > 0$ for all j. To capture the possible correlation between sectors we model the vector of disturbances $(\varepsilon_{spread^{corp},t}, \varepsilon_{spread^{cons},t}, \varepsilon_{spread^{mort},t})'$ as i.i.d. with zero mean and variance-covariance matrix Σ_{spread}.

B.3 Equations for delinquency indexes by sector

Next we present the specification for delinquency indexes by sector. For this component of the financial block we have the following specification:

$$delin_t^j = \varphi_0^j + \varphi_1^j delin_{t-1}^j + \varphi_2^j x_t + \varepsilon_{delin^j,t} \tag{A6}$$

for $j = \{corp, cons, mort\}$, and the vectors $(\varepsilon_{delin^{corp},t}, \varepsilon_{delin^{cons},t}, \varepsilon_{delin^{mort},t})'$ are i.i.d. disturbances with zero mean and variance-covariance matrix Σ_{delin}. The idea behind the previous specification is that episodes of economic expansion come along with a decrease in the level of delinquency indexes ($\varphi_2^j < 0$ for all j) as debtors default less. As mentioned before, the impact of the output gap on delinquency indexes is key in this model to make the financial block and the core model interdependent.

B.4 Equations for credit growth by sector

This component of the financial block has the following specification:

$$\Delta cr_t^j = \gamma_0^j + \sum_{i=1}^{2} \gamma_{1,i}^j \Delta cr_{t-i}^j + \gamma_2^j x_t + \gamma_3^j spread_t^j + \varepsilon_{\Delta cr,t}^j \tag{A7}$$

for $j \in \{corp, cons, mort\}$, where Δcr_t^j is the credit growth rate of sector j. This specification is basically a demand for credit of each type. Thus, higher lending spreads reduce the growth of credit and a higher output gap comes along with a higher credit rates of growth.[21] The term $\varepsilon_{\Delta cr,t}^j$ is an i.i.d. disturbance with zero mean and variance $\sigma_{\Delta cr}$ for all j.

[21] It is important to remark that the structure of the model so far places sectoral credit growth as residual variables.

B.5 Identities

The following identities define the aggregate level of these variables:

$$spread_t \equiv w_{corp}spread_t^{corp} + w_{cons}spread_t^{cons} + w_{mort}spread_t^{mort} \tag{A8}$$

$$\Delta cr_t \equiv w_{corp}\Delta cr_t^{corp} + w_{cons}\Delta cr_t^{cons} + w_{mort}\Delta cr_t^{mort} \tag{A9}$$

$$delin_t \equiv w_{corp}delin_t^{corp} + w_{cons}delin_t^{cons} + w_{mort}delin_t^{mort} \tag{A10}$$

where w_j for $j = \{corp, cons, mort\}$ are weights calculated according to the share of credit of each sector.

C The estimated financial block

The data used to estimate the financial block includes the following variables: lending spreads by sector, delinquency indexes by sector, credit growth by sector, and a measure of the coverage ratio. The sectors that we look at are credit to non-financial corporations, credit to consumers and credit for mortgages which account for the majority of private credit granted in the Mexican economy.[22] Although most of the data has a monthly frequency, it has been transformed into quarterly data given the frequency of the macro variables in the core model. Our sample ranges from the first quarter of 2003 to the fourth quarter of 2011. The source of all data is Banco de México and Comisión Nacional Bancaria y de Valores (CNBV).

Lending spreads are constructed as the difference between the aggregate implicit lending rate by sector and the average cost of bank term deposits.[23]

[22] From the total credit comprised by these three sectors, the shares of credit to consumption, mortgages and corporations are 24.77, 20.85 and 54.38 percent, respectively.

[23] Data on "spot" lending rates is not available for all the sample. Hence, we use implicit

Table A. Summary Statistics of Financial Block Data Set
Period: 2003Q1:2011Q4

Variable	Mean	Std. Dev.	Min	Max
Lending Spreads (%)	9.72	1.37	5.75	11.21
Non-financial corporations	4.04	0.58	2.69	4.79
Consumers	23.83	2.32	20.11	28.66
Mortgages	6.11	1.17	3.93	8.15
Delinquency Indexes	4.89	1.90	2.81	8.77
Non-financial corporations	4.46	3.80	1.31	13.86
Consumers	10.78	6.86	2.19	23.72
Mortgages	6.13	3.29	2.90	15.81
Credit Growth Rate (%)	12.29	11.05	-7.08	29.06
Non-financial corporations	11.58	10.19	-5.77	33.91
Consumers	21.36	23.69	-21.48	47.81
Mortgages	9.04	15.58	-12.43	49.70
Coverage Ratio (CRR)	1.94	0.28	1.32	2.45

Delinquency indexes by sector are the corresponding adjusted indexes constructed by Banco de México, which are the sum of overdue loans and loans written-off in the prior twelve months divided by total loans plus loans written-off in the last twelve months. The credit variable considered is the annual real growth of credit by sector. Finally, the variable capturing the coverage ratio (CRR) is the ratio of loan-loss reserves to non-performing loans for the Mexican banking system.[24]

Table A shows summary statistics of the data set, where it can be seen

interest rates which are obtained as the revenue from loans to each sector divided by the stock of outstanding credit to that sector in the banking system.

[24]Notice that to account for the CRR we consider a realized measure of the ratio of loan-loss reserves to non-performing loans as opposed to a legal capital requirement (as pointed out by Banco de México in its last Financial Stability Report –see Reporte sobre el Sistema Financiero, 2013–, capitalization indexes for the Mexican banking system are well above legal capital requirements). This allows us to quantify the empirical response of credit spreads to changes of this ratio and thus to propose a reasonable counterfactual to integrate a macroprudential authority in our setup. Balla and McKenna (2009) used a similar approach in order to test the possible benefits of using a countercyclical tool for loan-loss reserves during Great Recession in the U.S.

that the average lending spreads of credit to consumers is several times higher than for credit to non-financial corporations and mortgages, being the lending spread to non-financial corporations the lowest. Although the average levels are quite different, the standard deviation of these lending spreads is similar. Regarding delinquency indexes, it is important to point out that credit to consumption has the highest average whereas credit to non-financial corporations the lowest. Contrary to the case of lending spreads, the standard deviation of delinquency indexes varies considerably across credit sectors. Lastly, it can be seen that average credit growth rates follow the same pattern of previous variables, that is, the consumption sector captures the highest average level with the highest variability.

In what follows we present the estimation for the equations that are part of the financial block. Given the possible correlation among the three sectors considered, we estimate the three lending spreads equations (A5), the delinquency ratio equations (A6) and the credit growth equations (A7) using seemingly unrelated regressions (SUR). Results from the SUR on lending spreads are presented in Table B. All data was found to be stationary according to the usual set of tests used for this purpose. Table C summarizes the results from the SUR on delinquency indexes. An important remark should be done; for this estimation we calibrate the coefficients of the output gap on the three delinquency indexes so as to match the correlation between each sector and the output gap found in the data. Furthermore, for estimation purposes, for the case of the consumption delinquency index we estimate a coefficient for a trend in time as the data shows a clear trend in the estimated period.

As for the modified IS curve, we calibrate the parameter b_6 from equation (A4) in order to match the response of the output gap to a one percent increase in the coverage capital ratio so as to lie within the lowest decile of the distribution across models of the Macroeconomic Assessment Group (2010b). We do this for the eight year implementation period and the resulting estimated parameter is b_6 =-0433.[25] Although admittedly arbitrary, we believe that such a choice is reasonable due to the lack of development of the Mexican financial system as compared to other economies that were also studied.

Table D presents the estimation for the autorregressive process of the CRR in the baseline case.

[25] The calibration based on the four year implementation period delivers similar results.

Table B: SUR Lending Spreads

Non-financial corporations

$$spread_t^j = \beta_0^j + \beta_1^j spread_{t-1}^j + \beta_2^j delin_t^j + \beta_3^j CRR_t + \varepsilon_{spread,t}^j$$

	Coef	t-stat	p-value
β_0^{corp}	-9.7568	-4.9893	0.0000
β_1^{corp}	0.6932	10.4009	0.0000
β_2^{corp}	0.1521	5.2417	0.0000
β_3^{corp}	0.6455	5.2842	0.0000
$R-squared$	0.8624	$Adj.\ R-squared$	0.8459

Consumption

$$spread_t^{cons} = \beta_0^{cons} + \beta_1^{cons} spread_{t-1}^{cons} + \beta_2^{cons} delin_t^{cons} + \beta_3^{cons} CAR_t + \varepsilon_{spread^j,t}$$

	Coef	t-stat	p-value
β_0^{cons}	18.7293	3.9687	0.0000
β_1^{cons}	0.1584	1.0595	0.2927
β_2^{cons}	0.2115	4.5330	0.0000
β_3^{cons}	-0.0769	-0.3056	0.7607
$R-squared$	0.7998	$Adj.\ R-squared$	0.7757

Mortgage

$$spread_t^{mort} = \beta_0^{mort} + \beta_1^{mort} spread_{t-1}^{mort} + \beta_2^{mort} delin_t^{mort} + \beta_3^{mort} CAR_t + \varepsilon_{spread^j,t}$$

	Coef	t-stat	p-value
β_0^{mort}	-8.9867	-4.6882	0.0000
β_1^{mort}	0.6695	11.2574	0.0000
β_2^{mort}	0.1605	5.8436	0.0000
β_3^{mort}	0.6244	5.2177	0.0000
$R-squared$	0.8411	$Adj.\ R-squared$	0.8220

Residual Covariance Matrix

	$\varepsilon_{spread^{corp}}$	$\varepsilon_{spread^{cons}}$	$\varepsilon_{spread^{mort}}$
$\varepsilon_{spread^{corp}}$	0.3145	0.2570	0.2940
$\varepsilon_{spread^{cons}}$	0.2570	0.6551	0.3106
$\varepsilon_{spread^{mort}}$	0.2940	0.3106	0.3821

Table C: SUR Delinquency Indexes

Non-financial corporations

$$delin_t^{corp} = \varphi_0^{corp} + \varphi_1^{corp} delin_{t-1}^{corp} + \varphi_2^{corp} x_t + \varepsilon_{delin^{corp},t}$$

	Coef	t-stat	p-value
φ_0^{corp}	0.9933	1.8957	0.0616
φ_1^{corp}	0.7542	10.5646	0.0000
φ_2^{corp}	-0.8013$^\flat$	-	-
$R-squared$	0.6673	$Adj.\ R-squared$	0.6550

Consumption

$$delin_t^{cons} = \varphi_0^{cons} + \varphi_1^{cons} delin_{t-1}^{cons} + \varphi_2^{cons} x_t + \varphi_3^{cons} trend + \varepsilon_{delin^{cons},t}$$

	Coef	t-stat	p-value
φ_0^{cons}	-9.2659	-6.4382	0.0000
φ_1^{cons}	0.6518	12.0096	0.0000
φ_2^{cons}	-0.2413$^\flat$	-	-
φ_3^{cons}	0.3105	6.9364	0.0000
$R-squared$	0.9870	$Adj.\ R-squared$	0.9860

Mortgage

$$delin_t^{mort} = \varphi_0^{mort} + \varphi_1^{mort} delin_{t-1}^{mort} + \varphi_2^{mort} x_t + \varepsilon_{delin^{mort},t}$$

	Coef	t-stat	p-value
φ_0^{mort}	1.8144	3.4765	0.0008
φ_1^{mort}	0.6834	10.4434	0.0000
φ_2^{mort}	-0.6811$^\flat$	-	-
$R-squared$	0.6746	$Adj.\ R-squared$	0.6626

$^\flat$The coefficients multiplying the output gap were calibrated as to match the correlation found on the historical data.

Residual Covariance Matrix

	$\varepsilon_{delin^{cons}}$	$\varepsilon_{delin^{corp}}$	$\varepsilon_{delin^{mort}}$
$\varepsilon_{delin^{cons}}$	0.401	0.0665	0.0277
$\varepsilon_{delin^{corp}}$	0.0665	0.2553	0.0349
$\varepsilon_{delint^{mort}}$	0.0277	0.0349	0.0842

Table D: AR CRR

CRR

$CRR_t = \rho_{CRR} CRR_{t-1} + \varepsilon_{CRR,t}$

	Coef	t-stat	p-value
γ_0^{corp}	0.880	11.334	0.000
$R-squared$	0.966	$Adj.\ R-squared$	0.961