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Samano, Daniel

Banco de Mexico

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Daniel Sámano Peñaloza[†]
Banco de México

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Abstract

The global financial crisis of late 2008 could not have provided more convincing evidence that price stability is not a sufficient condition for financial stability. In order to attain both, central banks must develop macroprudential instruments in order to prevent the occurrence of systemic risk episodes. For this reason testing the effectiveness of different macroprudential tools and their interaction with monetary policy is crucial. In this paper we explore whether two policy instruments, namely, a capital adequacy ratio (CAR) rule in combination with a Taylor rule may provide a better macroeconomic outcome than a Taylor rule alone. We conduct our analysis by appending a macroeconometric financial block to an otherwise standard semistructural small open economy neokeynesian model for policy analysis estimated for the Mexican economy. Our results show that with the inclusion of the second policy instrument the central bank can obtain substantial gains. Moreover, we find that when the CAR rule is adequately designed the central authority can mitigate output gap shocks of twice the variance than the Taylor rule alone scenario. Thus, under this two rule case the central authority can isolate financial shocks and dampen their effects over macroeconomic variables.

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[†]Research Department, Banco de México. Contact: dsamano@banxico.org.mx. Address: Av. 5 de Mayo 18. Delegación Cuauhtémoc, México D.F., 06059, México.

> ...the experience of financial crisis, panic in September 2008 to March 2009, and nearly widespread collapse, has been so unnerving and shaking that there is likely to be far-reaching changes to the operation and regulation/supervision of the financial system in general, and to the role and functions of the Central Bank in particular... [Charles A.E. Goodhart, *"The Changing Role of Central Banks"*]

1 Introduction

The global financial crisis of late 2008 could not have provided more convincing evidence that price stability is not a sufficient condition for financial stability. In order to avoid the collapse of the financial system central banks around the globe instrumented exceptional policies, some of them with long lasting effects and lessons.[1] In these circumstances, central banks started a quest to redefine themselves in an environment in which price and financial stability must be pursued.

In this context, financial sector and banking regulatory bodies at domestic and international level strengthened regulatory standards aimed at making the financial sector more resilient. An example of this type of strengthening is Basel III whose main features are described in Caruana (2010). Despite this effort, the challenge of designing a richer array of policy tools to be implemented by financial authorities for macroprudential purposes still remains. As Galati and Moessner (2011) points out, this process mostly involves testing the effectiveness of macroprudential tools and exploring their coordination with monetary policy.

This topic is of great importance to central banks for a bunch of reasons. As Baily, Campbell, Cochrane, Diamond, Duffie, French, Kashyap, Mishkin, Rajan, and Shiller (2010) argues, the central bank is a natural choice as a systemic regulator based on four reasons: 1) given his daily trading relationship with market participants it is well placed to monitor problems in the financial system, 2) the objective of macroeconomic stability fits together with ensuring the stability of the financial system, 3) central banks are among the most independent government agencies, and 4) central banks are lenders of last resort. Thus, following the above article, in the present paper we assume that rules, including those to preserve financial stability, are set by the central bank.[2]

[1] See Borio and Disyatat (2010) for an excellent review of unconventional measures implemented by several central banks during the crisis.

[2] Cecchetti, Gyntelberg, and Hollanders (2009) and Angelini, Neri, and Panetta (2010)

The purpose of this paper is to explore whether two policy instruments, namely, a capital adequacy ratio rule ("CAR rule" from here on) in combination with a conventional Taylor rule may provide a better outcome than a Taylor rule alone from a macroeconomic point of view. In other words, the scope of this paper is to shed some light on the advantages and drawbacks of adding a CAR rule to the traditional monetary policy instrument. Nevertheless, given Basel requirements for capital to asset ratios, we should think of a CAR rule as an instrument for setting "buffers" of capital requirements that banks within a jurisdiction must comply with over time. That is, in this paper we assume that at all times, regardless of the adjustments that financial authorities make to capital requirements, these exhibit levels above those required by Basel.

Given the lack of a "canonical model" to study the connection between financial and real variables,[3] while the profession works on the microfoundations of real and financial linkages, for the moment we take a shortcut and append a macroeconometric financial block to an otherwise standard semi-structural small open economy neokeynesian model ("core" model) for policy analysis.[4]

The macroeconometric financial block is essentially a set of "reduced form" equations that allows us to bring into the analysis lending spreads, delinquency indexes and credit volumes (all these variables by sector: non-financial corporations, consumption and mortgages) to make them interact with the core model.[5] Like part of the work done by Macroeconomic-Assessment-Group (2010a), the channel in which the financial block impacts the core model is through the effect of lending spreads on the output gap.[6] Specifically, an increase in the lending spreads slows down economic activ-

argue that coordination between monetary and macroprudential policies achieves better results. We get around coordination problems in this paper by assuming that both policies are implemented by the central bank.

[3] Several attempts in this line are Curdia and Woodford (2010a), Curdia and Woodford (2010b), Gertler and Karadi (2009), Gertler and Kiyotaki (2010), Dib (2010) and Meh and Moran (2010).

[4] Among the features of this small open economy neokeynesian model is the fact that some of the structural equations are of hybrid type, that is, with backward and forward looking elements and agents are assumed to have rational expectations.

[5] See Barrell and Gottschalk (2006) for a macroeconometric block which also contains some financial variables.

[6] Notice that alternatively, the effect from the financial sector as represented by the financial block to the core model could have been through credit volumes or lending stardards. Nevertheless, preeliminary evidence for the case of Mexico presented in Banxico (2010) points out that credit volume does not Granger cause the output gap. For the case of Mexico, lending standards are available for a very short period of time. Hence, statistical inference is highly unprecise.

ity. This may be so since higher lending spreads tend to reduce spending by households and entreprises, reducing aggregate consumption and investment mainly in the short run. However, unlike in most of the models used in the previous study, we allow for feedback effects from the core model to the financial sector and the other way around as the core model and the financial block are integrated in this work.[7] In other words, shocks that hit variables in the financial block end up having an effect on the core model, which in turn feedback on financial variables and so on. The same is true for a shock that hits a variable in the core model. Given that we model equations with banking sector wide variables, this work attempts to contribute towards addressing the time-series dimension of financial stability rather than the cross-sectional dimension.[8]

This approach makes it possible to analyze the interaction of different policy instruments. In particular, we evaluate the performance of Taylor rules and CAR rules from a macroeconomic perspective. Our results show that with the inclusion of the second policy instrument the central bank can obtain substantial gains. Specifically, inflation and output volatility are greatly reduced without putting too much stress on the financial sector (measured by its variance).This is best achieved when macroprudential responses to financial sector distress do not offset traditional monetary policy at the macroeconomic level. In other words, an appropriate macroprudential policy tool should reinforce the stabilizing effect of monetary policy over output and inflation by isolating macroeconomic variables from financial sector shocks.

At this point it is useful to review some of the work in the literature close to the present one. An article which falls within this line is Angeloni and Faia (2009).[9] They find that a restrictive monetary policy leads to an increase in banks' capital ratio. This happens because a rise in the interest

[7] To the best of our knowledge, no stress test model that is capable of analyzing variables across banks is capable of feeding back the effects of the financial system to the macroeconomy. These models, although very rich in the processes that occur across banks, do not yet capture effects from the financial system to the macroeconomy. A state-of-the-art model in this category is the RAMSI model developed at the Bank of England (see Aikman, Alessandri, Eklund, Gai, Kapadia, Martin, Mora, Sterne, and Willison (2009)).

[8] See Galati and Moessner (2011) for this important distinction in the literature of macroprudential policy tools.

[9] Their article incorporates banks into a standard DSGE model to study their role in the transmission of shocks and determine what policy rules are optimal if a central bank wishes to consider financial stability as well as macroeconomic stability. This allows them to conduct some experiments of interest. One is to see the effect of an interest rate shock on banks' endogenous capital structure. Banks are modeled as intermediaries between entrepreneurs and households and bank capitalists which interact in a perfectly competitive financial market; this makes them vulnerable to runs.

rate (which is paid on households' deposits) increases the probability of a run on the banks, given the independent return on entrepreneurs' investment projects. Banks find it optimal to offset this risk by increasing their capital ratio. Furthermore, they determine whether it is optimal to set a pro-cyclical, counter-cyclical or fixed capital regime if the central authority wishes to use banks' capital ratio as a policy instrument. Therefore, they contrast three different regimes in which two policy instruments interact. In all cases, the capital ratio only responds to deviations of the output from its steady state value. They find that counter-cyclical rules dampen the business cycles whereas pro-cyclical regimes accentuate shocks. Banking sector risk is more stable under the fixed capital regime.

A similar study is conducted by Covas and Fujita (2009) which contrasts pro-cyclical and counter-cyclical regulations in capital requirements in a general equilibrium framework where banks participate in the economy as financial intermediaries between households and investment projects. Central to their model is the role of credit in satisfying entrepreneurs' liquidity needs. The key phenomenon concerning business cycle dynamics in their framework is that a productivity shock will be either amplified or dampened depending on the capital requirements regime. This is so because capital requirements directly influence loans and entrepreneurs' liquidity dependence, thus affecting investment. They find that output volatility is almost 26% higher under pro-cyclical regulation compared to an anti-cyclical case.

More closely related studies would be Angelini, Neri, and Panetta (2010) and Denis, Clerc, and Mojon (2011). Both use general equilibrium models to explore different forms of macroprudential policies. They both find that introducing a new policy rule in coordination with the usual monetary rule helps in reducing the variance of output and inflation. Moreover, in line with our results, Denis, Clerc, and Mojon (2011) finds that the second policy instrument works by shielding macroeconomic variables from financial sector shocks. In contrast with our work, they use the loan to value ratio as their additional policy instrument.

Although our results contribute to the debate on the design of macroprudential instruments and their macroeconomic assessment it is important to remark that further research is crucial to develop a fully microfounded workhorse model to analyze the type of issues addressed in this paper.

The rest of the article is organized as follows. Section 2 presents the model, section 3 presents the data used, section 4 shows some policy experiments and section 5 concludes.

2 The Model

Several attempts have been recently made in the literature to introduce models with financial intermediation. Nevertheless, at the moment there is not yet a "canonical" model to study the relationship between bank's capitalization, financial intermediation and economic activity. Moreover, as Galati and Moessner (2011) points out "both theoretical and empirical work linking the financial sector to the macroeconomy is far from a stage where it can be operationalized and used for risk analysis and policy simulations". Hence, a lot of research is expected to emerge in this line within the following years. Nonetheless, for the moment we take a shortcut appending a macroeconometric financial block to a standard semistructural small open economy neokeynesian model. Thus, our model consist of two main parts.

2.1 The Core Model

The core model is a standard semi-structural small open economy neokeynesian model.[10] In other words, the coefficients of the equations of this model are of reduced form although the specification of the equations have a solid theoretical background.[11] In principle this sort of model incorporates a minimum set of variables that allow us, among other things, to study the response of the monetary authority to shocks that hit the economy. The classical cases are "cost-push" shocks and demand shocks to which the central bank reacts by changing its policy rate.

The components of the core model are:[12]

1. A Phillips curve for wage inflation.[13]
2. Equations for inflation sub-indexes.
3. An IS curve for the output gap.
4. An equation for real exchange rate.[14]

[10] See for instance Freedman, Johnson, Kriljenko, Ivan, Garcia-Saltos, and Laxton (2009).

[11] See Clarida, Gali, and Gertler (1999) and Smets and Wouters (2003).

[12] The core model is very similar in terms of equations and coeficients to those in Sidaoui and Ramos-Francia (2008). We rewrite the equations in Appendix C.

[13] For further reference, see Erceg, Henderson, and Levin (2000).

[14] Uncovered interest rate parity.

5. A monetary policy rule (Taylor rule) which in this paper takes the following form:

$$i_t = f_1 i_{t-1} + (1 - f_1)[f_0 + f_2 x_t + f_3(\pi_t - \bar{\pi})] \quad (1)$$

where i_t is the nominal interest rate, x_t denotes output gap, π_t is the annual inflation rate and $\bar{\pi}$ is the central bank's inflation target; thus, the term $(\pi_t - \bar{\pi})$ is the inflation gap.

Although this model has been useful for guiding central bankers to set policy interest rates, it lacks a richer set of financial variables to which the financial stability authority, which in this paper we assume is the central bank, may need to react for macroprudential purposes. With the idea of setting a simple framework in which financial variables are of potential consideration for the reaction function of the monetary authority, we next lay down a small-scale macroeconometric financial block.

2.2 The Financial Block

In this block lending spreads are dependent on banks' delinquency indexes and capital. The idea here is that banks increase their lending spreads when they face higher delinquency indexes (so as to offset higher potential losses) and when they hold more capital as a share of risk weighted assets (so as to keep their return on equity, ROE, roughly constant besides adjustments in capital requirements). Delinquency indexes are modeled as function of their lagged values and the output gap, being the relationship between delinquency indexes and the output gap negative. That is, when the output gap expands (reduces) delinquency indexes fall (increase). This is the channel that allows for feedback from the core model to the financial block. Additionally, credit volume responds positively to changes in the output gap and negatively to lending spreads.

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 us to obtain optimal macroprudential instruments a central bank may need to set in order to procure financial stability along with macroeconomic stability. In particular, this framework lets us conduct a few exercises that may be helpful for guiding the discussion of whether central banks could attain lower social losses (to be defined later) by using a second policy instrument, namely, a CAR rule in combination with a Taylor rule, rather than the latter instrument alone. Moreover, this framework is helpful in exploring some characteristics of the business cycles under the two sets of proposed policy instruments.

The financial block consists of a set of estimated equations that interact with each other and with the core model. This block has the following components:

1. A modified IS equation to include lending spreads.[15]
2. Equations for lending spreads by sector.
3. Equations for delinquency indexes by sector.
4. Equations for a "credit gap" by sector.
5. A “rule” for the capital adequacy ratio.

The sectors that are considered are credit to non-financial corporations, credit to consumers and credit for mortgages. In the following subsections, we describe in detail the components of the financial block. The estimation is presented in Appendix A.

2.2.1 A Modified IS Equation

The channel in 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-Group (2010a). For this reason an additional argument is incorporated into the otherwise standard IS curve for a small open economy. Such an argument is the lending spread.[16] Hence, we propose the following IS specification:

$$x_t = b_0 + b_1 x_{t-1} + b_2 E_t x_{t+1} + b_3 r_{t-1} + b_4 x_{t-1}^{US} + b_5 \ln(rer_t) + b_6 spread_t + \varepsilon_{x,t} \quad (2)$$

where x_t is the output gap, r_t is the real interest rate, x_t^{US} is the output gap in the United States, rer_t is the bilateral real exchange between the United States and Mexico[17], $spread_t$ is the weighted lending spread, $E_t[\cdot]$ is the expectation operator with information at time t and $\ln(\cdot)$ is the natural logarithm. The term $\varepsilon_{x,t}$ is an i.i.d. disturbance with zero mean and variance σ_{ε_x}. In line with the Macroeconomic-Assessment-Group (2010a), we expect an increase in the lending spread to have a negative effect on the output gap,

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

[16] This variable is the overall lending spread of the three credit sectors analyzed in this paper. Thus, weights are calculated according to the net credit to each one of these three sectors.

[17] When the variable *rer* increases, we say that the real exchange rate of Mexico depreciates.

thus b_6 must be negative.[18] In other words, when the lending spread increases economic activity slows down. This may be so since higher lending spreads tend to reduce spending by households and entreprises, reducing 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 form of financial intermediaries apart from banks.

2.2.2 Equations for Lending Spreads by Sector

This component of the financial block is comprised by equations that translate levels of sector specific delinquency indexes and a banking system capital adequacy ratio (regulatory capital/risk weighted assets) 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 hold more regulatory capital as a share of their risk weighted assets. An assumption behind the previous specifications is that commercial banks keep their ROE roughly invariant to changes in potential losses they face and to the composition of their portfolio and bank capitalization which in turn affect the capital adequacy ratio. Thus, we have the following specification:

$$spread_t^j = \gamma_0^j + \gamma_1^j spread_{t-1}^j + \gamma_2^j delin_t^j + \gamma_3^j CAR_t + \varepsilon_{spread^j,t} \tag{3}$$

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 CAR_t is the capital adequacy ratio of the banking system. In line with the above arguments we expect γ_2^j,$\gamma_3^j > 0$ 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}.

2.2.3 Equations for Delinquency Indexes by Sector

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

$$delin_t^j = \varphi_0^j + \varphi_1^j delin_{t-1}^j + \varphi_2^j x_t + \varepsilon_{delin^j,t} \tag{4}$$

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

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 activity expansion come along with decreases in the level of delinquency indexes ($\varphi_2^j < 0$ for all j) as debtors default less. As mentioned before the impact from the output gap to delinquency indexes is key in this model to make the financial block and the core model interdependent.

2.2.4 Equations for the Credit Gap by Sector

This component of the financial block is comprised by the following specification:

$$cr_t^j = \mu_0^j + \mu_1^j cr_{t-1}^j + \mu_2^j spread_t^j + \mu_3^j x_t + \varepsilon_{cr^j,t} \tag{5}$$

for $j = \{corp, cons, mort\}$, where cr_t^j is the credit gap (to be explained below) of sector j, and the vectors $(\varepsilon_{cr^{corp},t}, \varepsilon_{cr^{cons},t}, \varepsilon_{cr^{mort},t})'$ are i.i.d. disturbances with zero mean and variance-covariance matrix Σ_{cr}. This specification is basically a demand for credit of each type. Thus, higher lending spreads reduce the credit gap and a higher output gap comes along with a higher credit gap.[19]

2.2.5 Identities

Finally, a few identities are needed to complete the financial block.

$$spread_t \equiv w_{corp} spread_t^{corp} + w_{cons} spread_t^{cons} + w_{mort} spread_t^{mort} \tag{6}$$

$$cr_t \equiv w_{corp} cr_t^{corp} + w_{cons} cr_t^{cons} + w_{mort} cr_t^{mort} \tag{7}$$

$$delin_t \equiv \delta_{corp} delin_t^{corp} + \delta_{cons} delin_t^{cons} + \delta_{mort} delin_t^{mort} \tag{8}$$

where w_j and δ_j for $j = \{corp, cons, mort\}$ are weights. The former set of weights are calculated according to the share of credit of each type; the second set are calculated by OLS.

[19] It is important to remark that the structure of the model so far places sectorial credit gaps as residual variables. The only case when they are no longer residual is when they are argument of the reaction functions of the monetary authority.

2.2.6 Capital Adequacy Ratio Rules

In this section we present two specifications that the capital adequacy ratio may take.

Baseline Capital Adequacy Ratio Equation This specification has the form:

$$CAR_t = \theta_0 + \theta_1 CAR_{t-1} + \varepsilon_{CAR,t} \tag{9}$$

where $\varepsilon_{CAR,t}$ are i.i.d. disturbances with zero mean and variance $\sigma_{\varepsilon_{CAR}}$. Notice that this specification attempts to capture in the simplest possible way the evolution of commercial banks' (at an aggregate level) capital adequacy ratios. In one of our specifications, the case of the Taylor rule alone, this would be the equation modelling the capital adequacy ratio since it is not an instrument of the central bank.

Central Bank Capital Adequacy Ratio Rule According to specification (9), this variable is exogenous for the monetary authority.[20] Nonetheless, one may think of this variable as an additional *instrument* used by the monetary authority to attain macroeconomic and macroprudential objectives. In this setting the authority would be in a position to *impose a level* for the capital to asset ratio for the banking system.[21] As a first step we propose a specification that combines the baseline capital equation (expression (9)) and the rule set by the monetary authority. The latter specification takes the form:

$$CAR_t = \theta_0 + \theta_1 CAR_{t-1} + CAR_t^R + \varepsilon_{CAR,t} \tag{10}$$

where CAR_t^R stands for the CAR *rule* required by the central bank in addition to the level of this variable determined by its baseline equation. For the CAR rule followed by the central bank, CAR_t^R, we propose the functional form:

$$CAR_t^R = \alpha_0 + \alpha_1 CAR_{t-1} + \alpha_2 z_t \tag{11}$$

[20] We assume that this variable is always above a minimum level set by the prevailing Basel agreement.

[21] Notice that in our setting we assume, for mathematical tractability, that the central bank sets a level for this variable rather than a minimum. One way banks could adjust this ratio, at least in the short run, could be by changing their risk profile so as to change the value of their risk weighted assets.

where z_t is a variable according to which the monetary authority sets banking system capital adequacy ratio.

Notice that if we substitute (11) into (10) we obtain:

$$CAR_t = \tilde{\theta}_0 + \tilde{\theta}_1 CAR_{t-1} + \tilde{\theta}_2 z_t + \varepsilon_{CAR,t} \tag{12}$$

where $\tilde{\theta}_0 \equiv \theta_0 + \alpha_0; \tilde{\theta}_1 \equiv \theta_1 + \alpha_1; \tilde{\theta}_2 \equiv \alpha_{2.}$ Anticipating the exercises of section, 4.1, z_t will be set equal to x_t, cr_t, and $spread_t$. That is, we will explore the performance of the CAR rule when the monetary authority sets this rule *optimally,* in addition to an optimal Taylor rule, as a function of the output gap, the credit gap and the lending spreads respectively. The notion of optimality that we employ will also be discussed in section 4.1.

3 The Data

In this section we describe the data set of the financial block. In total we have the following variables: lending spreads by sector, delinquency indexes by sector, credit volumes by sector and a measure of capital adequacy ratio. Recall that the sectors included in this analysis are credit to non-financial corporations, credit to consumers and credit for mortgages.[22] Our sample ranges from the first quarter of 2003 to the third quarter of 2010.

Lending spreads are constructed as the difference between the aggregate implicit lending rate by sector and the average cost of bank term deposits.[23] Delinquency indexes by sector are the "IMORA" indexes (adjusted delinquency indexes), 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 cycle component, or credit gap, of the credit volume by sector. Finally, the capital adequacy ratio measure is the ratio of Tier 1 capital to risk weighted assets. The source of all data is Banco de México.

Table 1 shows summary statistics of the data set. Although most of the data has a monthly frequency, we have transformed it into quarterly data since such is the frequency of the variables of the core model.

In Table 1 we can see that the average lending spreads of credit to consumers is several times higher than the average lending spread of credit to

[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% respectively.

[23]Data on "spot" lending rates is not available. Hence, we use implicit interest rates which are obtained as the revenue from loans to sector j divided by the assets of that sector in the banking system.

Table 1. Summary Statistics of the Financial Block Data Set
Period: 2003Q1-2010Q3

Variable	Mean	Std. Dev.	Min	Max	Correlation with output gap
Lending Spreads (%)	8.92	1.30	4.43	11.17	-0.56
Non-financial corporations	2.95	1.54	1.32	5.64	-0.60
Consumers	23.35	1.84	20.05	27.74	-0.23
Mortgages	4.70	1.58	1.50	7.68	-0.37
Delinquency Indexes	4.77	1.98	2.81	8.77	-0.44
Non-financial corporations	4.89	4.14	1.31	13.86	-0.47
Consumers	10.15	6.96	3.47	23.72	-0.16
Mortgages	6.35	3.64	2.90	15.81	-0.55
Credit Gap (%)	0.82	6.95	-10.49	12.22	0.60
Non-financial corporations	0.52	9.24	-15.90	17.60	0.37
Consumers	1.40	12.55	-21.90	19.71	0.89
Mortgages	0.67	6.66	-8.03	12.40	0.10
Capital Adequacy Ratio	15.49	1.01	13.89	17.31	0.07

non-financial corporations and mortgages, being the lending spread to non-financial corporations the lowest. Although levels are quite different, the standard deviation of these lending spreads is quite similar. Moreover, it is important to notice that all lending spreads are countercyclical. That is, periods in which the output gap is expanding, lending spreads are falling. This fact is seen in the column "Correlation with output gap" of Table 1.

Regarding delinquency indexes, it is important to remark that credit to consumption is the highest whereas credit to non-financial corporations is the lowest. The standard deviation varies considerably across credit sectors. Furthermore, delinquency indexes are countercyclical. In other words, episodes of output expansion come along with a decrease in delinquency indexes.

With respect to credit gaps we observe that on average the one corresponding to credit to consumption is the highest whereas the corresponding to non-financial corporations is the lowest. Also, notice that these variables exhibit considerable variance as seen in the standard deviation and in the minimum and maximum values. From Table 1, we also observe that the total credit gap as well as sectorial ones are procyclical.

Finally, notice that the average capital adequacy ratio is quite high throughout this period and exhibits moderate variability. As it will be seen later, this characteristic of the capital adequacy ratio brings up important considerations regarding the use of this variable as a policy instrument.

4 Numerical Exercises

In this section we first perform a macroeconomic evaluation of Taylor rules in combination with several specifications of a capital adequacy ratio as a policy instrument. As a benchmark to compare we also evaluate a Taylor rule alone. Next we show some impulse-response functions to illustrate the functioning of the model under alternative policy instruments.

4.1 Macroeconomic Evaluation of Policy Instruments

In this subsection we use the model described above to evaluate from a macroeconomic point of view a few combinations of policy instruments. To perform this evaluation we follow the traditional approach of setting a "loss function" to rank different combination of rules. In particular we are interested in evaluating whether two optimal policy instruments, namely, an optimal Taylor rule in combination with an optimal CAR rule (jointly optimized) achieve a better outcome than an optimal Taylor rule alone.[24] Thus, these exercises

[24] The notion of optimallity will be made explicit latter in the text.

shed some light on the advantages and drawbacks of adding a CAR rule to a traditional Taylor rule in a model economy in which the financial sector is also a source of shocks. Moreover, this setting is useful to study the interaction between the traditional monetary policy instrument with a macroprudential one.

The evaluation is done for four specifications of "simple" instruments:[25]

- Case 1: An optimal Taylor Rule.
- Case 2a: An optimal Taylor Rule and an optimal CAR rule that responds to the output gap, i.e. $z_t = x_t$ in expression (12).
- Case 2b: An optimal Taylor Rule and an optimal CAR rule that responds to the credit gap, i.e. $z_t = cr_t$ in expression (12).
- Case 2c: An optimal Taylor Rule and an optimal CAR rule that responds to lending spreads, i.e. $z_t = spread_t$ in expression (12).

We choose such specifications for the following reasons. Case 1 is the reference case in which the monetary authority operates with a single instrument. Case 2a provides the authority with a second instrument although the variable to which such an instrument reacts is also one of the arguments of the Taylor rule. Thus, the CAR rule reaction may be offset by the Taylor rule. In case 2b, we allow the capital adequacy ratio to respond to a financial variable, which in this case is the credit gap. This exercise is motivated by the work of Christiano, Ilut, Motto, and Rostagno (2010), which argues that an important element that Taylor rules should consider is credit expansion since it can generate sharp increases in asset prices. Nonetheless, as opposed to their work, we introduce the credit gap as an argument of the CAR rule and not as an extra argument of the Taylor rule. Finally, in case 2c we introduce lending spreads into the CAR rule since this variable is the one that, by construction in this model, impacts directly the output gap (see equation (2)).

To define a notion of optimality, we propose a loss function very similar to standard ones in the literature on optimality of Taylor rules. It is in this

[25] "Simple" refers to the fact that these rules are a function of a small number of variables. This contrasts with the approach implemented in other algorithms such as those in Soderlind (1999) in which the optimal rule is a function of all variables in the state vector of the model. Since the idea here is to shed light on variables to which a central bank may find important to react, we focus on simple rules.

sense that we evaluate from a macroeconomic perspective the performance of the aforementioned cases. Hence, we define the loss function, $\mathcal{L}$, as:[26]

$$\mathcal{L} \equiv \sigma_x^2 + \sigma_\pi^2 + \sigma_{\Delta i}^2 + \phi \sigma_{\Delta CAR}^2 \tag{13}$$

where σ_x^2 is the variance of the output gap, σ_π^2 is the variance of the inflation gap (annual inflation minus inflation target), $\sigma_{\Delta i}^2$ is the variance of the changes in the policy interest rate and $\sigma_{\Delta CAR}^2$ is the variance of the changes in the capital adequacy ratio. These variances correspond to the ones of the invariant distribution of the model. Notice that we have assigned the same weight to output, inflation gap variance and to the corresponding to $\sigma_{\Delta i}^2$. However, the weight assigned to $\sigma_{\Delta CAR}^2$ is different; this is so since for a tested case in which this coefficient was set to unity, the capital adequacy ratio exhibited a very high variance, clearly at odds with the data (see Table 1). Hence, to calibrate the parameter ϕ we match the variance of the capital adequacy ratio in the model to match the variance of the data. This procedure is presented in detail in Appendix B. The corresponding value of ϕ was found to be equal to 12.5.

On Table 2 the optimal parameters for the different rules are presented.[27] The first thing to notice is how similar the coefficients of the Taylor rule are among all specifications, denoting some kind of robustness of the optimal Taylor rule regardless of the specification of the CAR rule.[28] Next we should notice that in case 2a, in which the capital rule responds to the output gap, the algorithm found that it was optimal to set a countercylical policy, thus reinforcing what previous works have found (see for instance Goodhart (2009)). Nevertheless, the obtained coefficient is very small. Notice also that the reaction of the capital adequacy ratio to the credit gap is almost negligible; however, this could be explained by the lack of relevance of this variable in this model as it is a residual variable. Moreover, the rule responding to lending spreads is the one reacting the most to the additional CAR variable. Thus, according to the specification of case 2c, when lending spreads increase,

[26] Other loss functions could be considered. For instance, Angelini, Neri, and Panetta (2010) consider the variance of the loans to output ratio as one key argument of the loss function minimized by the macroprudential authority.

[27] We have used Dynare's osr (optimal simple rule) routine to find the optimal parameters. As in Angelini, Neri, and Panetta (2010) we also found dependence of the optimal parameters on initial conditions and proceeded by randomly selecting various initial conditions. We sampled 1,000 different initial conditions for each rule and select the coefficients which achieve minimum losses.

[28] For the case in which the financial block no longer has impact on the core model ($b_6 = 0$), the coeficients of the optimal Taylor rule are $f_1 = 0.7847$, $f_2 = 3.7420$ and $f_3 = 0.9646$.

the CAR rule induces a reduction in the capital to asset ratio in order to offset the increase in lending spreads which in turn mitigates the shock to the output gap. In other words, the negative impact on output from an increase in lending spreads is compensated by a fall in capital requirements so as to bring down lending spreads.[29]

4.1.1 Simulations' Results

To assess the performance of the different cases presented we have simulated stochastic shocks for 1,000 periods letting the optimal rules respond endogenously. We repeat this procedure 3,000 times and average out across repetitions for robustness. Results from the simulations are reported in Table 3. There it is clear that when a central bank has two policy instruments at its disposal it can achieve much better results than with a Taylor rule alone (case 1).

Our main finding can be seen in the "Loss function" row. On all cases where the central authority has a second instrument at its disposal the value of the loss function is close to 12% lower than the corresponding value of case 1. This is accomplished without introducing much more volatility in either the interest rate or the capital adequacy ratio.[30] The intuition behind these results is that by allowing the central authority to have a second instrument it can rely less on the interest rate to stabilize the economy. With a Taylor rule alone the central bank can only respond to shocks in the economy through adjustments in the interest rate. It must therefore employ it much more often. As a consequence, the variance of changes in the interest rate[31] is much higher than in cases 2a-2c. By including the capital adequacy ratio among the central bank's policy instruments it can be employed to respond to shocks originating in the financial sector. Thus, influencing the financial sector more directly and maintaining the interest rate more stable.

Additionally, it should be noted that the particular interaction between both policy instruments varies greatly depending on the variable to which the CAR rule responds. This has important implications for the performance of each rule. Table 3 shows that while the losses decrease with the inclusion of a second policy instrument less variance in changes to the interest rate

[29] Since what it is actually decreasing is the buffer of the capital adequacy ratio, we assume that this fall in banks' capital that comes after a negative shock to the output gap does not pose a threat to the soundness of the banking system.

[30] It should be noted that the variance of changes to the capital adequacy ratio does not account for these results. This is shown in Table E of Appendix D, where we provide analogous results for a scenario in which no financial sector shocks occur. Here, the variance of changes in the capital adequacy ratio is zero for case 1.

[31] Not reported.

Table 2. Simple Rules' Coefficients

	Taylor rule (Case 1)	Taylor rule + CAR rule (Case 2a)	Taylor rule + CAR rule (Case 2b)	Taylor rule + CAR rule (Case 2c)
Autoregressive Taylor (f_1)	0.7949	0.7973	0.8012	0.7873
Output gap (f_2)	4.0423	4.0892	4.1826	3.9127
Inflation gap (f_3)	0.9215	0.9546	0.9145	0.9581
Autoregresive CAR ($\tilde{\theta}_1$)	-	0.9376	0.9392	0.9392[†]
Additional variable CAR ($\tilde{\theta}_2$)	-	0.0176	0.0011	-0.2043

[†]Optimal autoregressive coeficient is greater than one. Simulations were run imposing the value of the equivalent parameter for the simple rule responding to the credit gap.

Table 3. Evaluation of Loss Functions and Variances under Different Rules[†]

	Taylor rule (Case 1)	Taylor rule + CAR rule (Case 2a)	Taylor rule + CAR rule (Case 2b)	Taylor rule + CAR rule (Case 2c)
Loss function	14.1967	12.5735	12.5669	12.4659
Variance of output gap	2.6190	2.6364	2.6328	2.5732
Variance of inflation gap	4.6184	4.6805	4.6714	4.6044
Variance of Real FX change	0.0181	0.0211	0.0203	0.0194
Variance of interest rate	10.7693	10.7845	10.9477	9.8302
Variance of lending spreads	5.3289	7.9718	7.8925	1.5195
Var of delinquency indexes	0.7141	0.7205	0.7169	0.6703
Variance of credit gap	106.0353	161.3593	157.8088	26.1848
Var of capital adequacy ratio	1.8669	2.8741	2.8201	0.9074
Corr(credit gap,output gap)	0.2187	0.2062	0.2037	0.2510
Corr(credit gap, delinquency index)	-0.8529	-0.8916	-0.8874	-0.6071
Corr(output gap, CAR)	-0.1599	-0.1557	-0.1738	-0.0646
Corr(credit gap, CAR)	-0.6013	-0.7124	-0.7058	0.0299
Corr(interest rate, CAR)	-0.1988	-0.1921	-0.2263	0.1635

[†]Simulations were performed by applying the same random shock scenario to all rules for a forecast of 1,000 periods. The number of repetitions was set at 3,000; reported figures are the average across repetitions.

does not translate automatically into a reduction of the variance of output and inflation gaps. This is explained by the negative correlation between the interest rate and the capital adequacy ratio, which implies that both policy instruments are offsetting each other to a certain extent.[32] Whereas, for case 2c the correlation is positive, which indicates that in this case both instruments serve as complements to each other in that they reinforce the policy effect on output and inflation. Thus, the central bank can reduce volatility in both output and inflation with more moderate instrument adjustments.

Case 2c is an important rule in its own right. We found that twice the variance of the shocks to the output gap would be required to get to the same value of the loss function attained by case 1. That is, case 2c can dampen shocks to the output gap twice the size (in terms of variance) of the one implied by residuals from equation (2).[33] By responding to lending spreads, given the structure of the model economy, the CAR rule reacts to financial sector shocks more efficiently as lending spreads are determined only by financial variables. For this same reason it greatly dampens their effect over macroeconomic variables. Furthermore, in this case financial variables display less variance than in the other cases considered. Indeed, for variables such as the credit gap and lending spreads the difference is very large. So, what this exercise suggests is that case 2c has the best performance because (i) it is a rule that has a direct effect on the channel through which financial sector shocks are transmitted to main macroeconomic variables, and (ii) responds to a variable which accurately reflects stress in the financial sector. These features together account for a large part of the gains observed and suggest that the overall dynamic is one of isolating financial shocks' effect over macroeconomic variables by efficiently reducing financial sector volatility.

In sum, two important insights should be drawn from this exercise. First, the inclusion of a CAR rule in combination with a Taylor rule allows the central bank to obtain lower losses from a macroeconomic point of view. This is so because it helps the central authority stabilize the economy with much less volatility in changes to the interest rate. Second, the performance of the different rules varies greatly depending on how the CAR rule is defined. The best results are obtained when the CAR rule is such that it is designed as to complement the interest rate rule. Our results suggest that this is achieved when the CAR rule responds to financial variables which accurately reflect distress in the financial sector while at the same time impacting directly main

[32]Recall that this variable has a positive effect on lending spreads which in turn provide the channel through which financial sector shocks are transmitted to macroeconomic variables.

[33]$\mathcal{L}(\sigma_x^2|\text{case1}) \approx \mathcal{L}(2\sigma_x^2|\text{case2c})$

macroeconomic variables.

4.1.2 Impulse-Response Functions

In this section we present impulse-response functions to illustrate the functioning of the model under all policy alternatives considered.

First we show the response of the economy to a typical headline inflation ("cost-push") shock; this is represented in Figure 1. The figure shows that the interest rate driven by the Taylor rules in all cases respond likewise. This should not be surprising since according to Table 2 the coefficients of Taylor rules in all cases are very similar. Moreover, notice that the impact of the output gap affects the delinquency index which in turn translates into variations in lending spreads and consequently the credit gap. This is what drives the different response of CAR rules to the original "cost-push" shock, although the effect on the output gap, headline inflation and the interest rate is quite modest. Therefore, although the shock to the core model does generate effects on the financial block, these are mild as it is well known that Taylor rules alone perform well in reaction to "cost-push" and demand shocks. Consequently, the feedback from the financial block to the core model is also moderate and the CAR rules of cases 2a-2c need not play a principal role in stabilizing macroeconomic variables.

Next we present a less familiar scenario where the source of macroeconomic disturbances is an exogenous shock to the delinquency indexes.[34] As can be seen in Figure 2, this case differs significantly from the one previously presented in that CAR rules play a more prominent role. The immediate effect of the shock is an increase in lending spreads which slows down economic activity (creating a fall in the credit gap) and places upward pressure on inflation. Notice that it is by lessening the magnitude of the impact of the shock on lending spreads that the use of CAR rules (cases 2a-2c) achieve better results relative to a Taylor rule alone (case 1). This is because the initial increase produced by the shock to the delinquency ratio in lending spreads is partially offset by the reduction in the CAR. This effect is almost negligible in cases 2a and 2b but for the case 2c, this drop is very noteworthy. In such a case, the fall in lending spreads is very sharp; thus, right after the shock, the output gap falls by less than what it does in the other cases (case 1 and cases 2a-2b) which in turn calls for a less abrupt reduction in the interest rate. However, due to smoothing in the CAR rule, the original reduction in the CAR of case 2c cannot be undone quickly and thus the economy experiences an increase in the output gap. This in turn leads to an increase in

[34] The shock is given to the delinquency index of the credit to consumption.

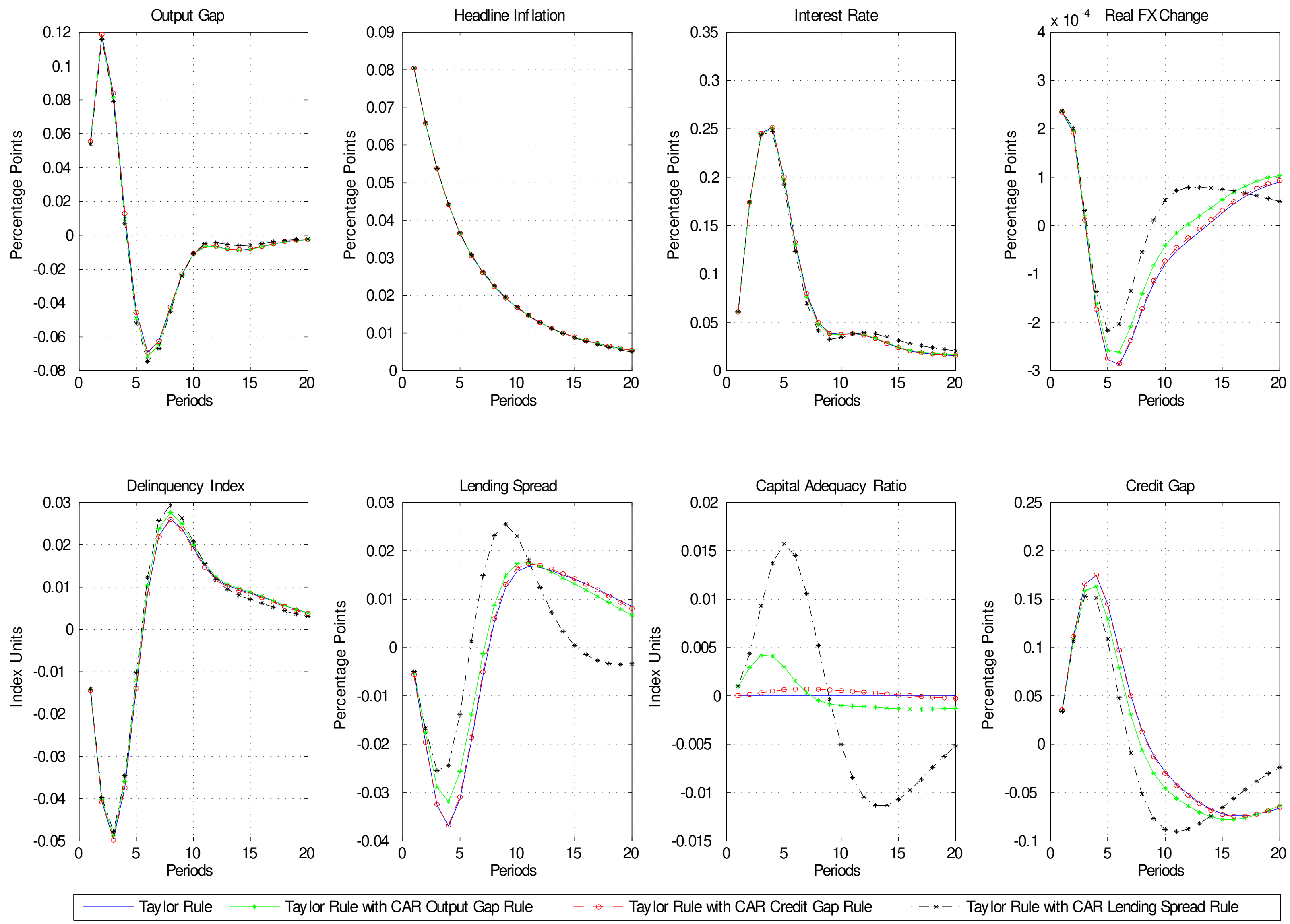

Figure 1. Impulse Response to a Shock to the Headline Inflation

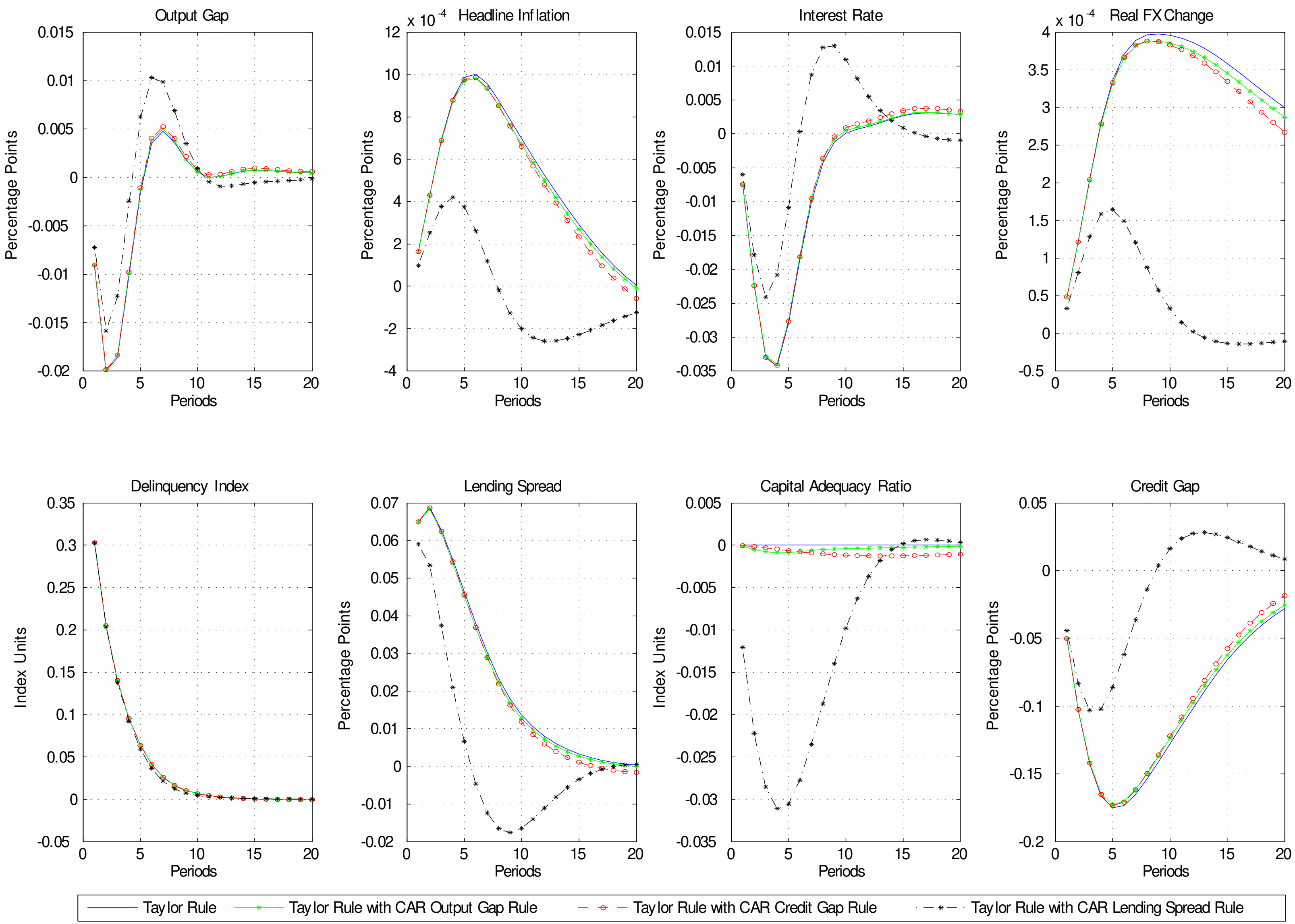

Figure 2. Impulse Response to a Shock to the Consumption Sector Delinquency Index

the interest rate and the credit gap, which is done while mantaining headline inflation more stable than in the other cases. Notice also that the interest rate component of case 2c converges much sooner to its steady state value. So, overall case 2c presents a significant lower level of the loss function when reacting to financial shocks.

The previous findings show that the reaction of the interest rate component amongst cases to a core model shock (here represented by a cost-push shock) is qualitatively the same. Given that the headline inflation and output gap are strongly influenced by the interest rate, the effect on these two variables between cases is similar. This implies that when reacting to this kind of shocks the CAR rule does not add much to stabilizing the economy. Instead, if the source of macroeconomic disturbances lies in the financial sector the CAR component plays an essential role in reducing the impact of the shock. Thus, the central authority can better accomodate shocks when it has a second instrument at its disposal.

5 Conclusions

In this paper we have appended a macroeconometric financial block to an otherwise standard semistructural small open economy neokeynesian model for policy analysis estimated for the mexican economy to explore whether two policy instruments, namely, a CAR rule in combination with a Taylor rule may provide a better outcome than a Taylor rule alone. Our results show that with the inclusion of the second policy instrument the central bank can obtain substantial gains from a macroeconomic perspective. Furthermore, we find that when the CAR rule is adequately designed the central authority can achieve a better all around performance. Specifically, inflation and output volatility are greatly reduced without putting too much stress on the financial sector (measured by its variance).

Even though we believe our approach implies that the structure of the model reflects some of the specific frictions present in the mexican economy's financial sector we trust that our main findings may hold for some other stylized economies where the financial sector is a relevant source of shocks. In general terms, if the central authority wishes to implement a second policy instrument, ideally, it should satisfy the following characteristics: i) an effective ability to influence the channel through which financial frictions affect macroeconomic variables and ii) it should respond to a variable which accurately captures the state of the financial sector. By satisfying these requirements in designing macroprudential policy tools central banks will be able to affect business cycle dynamics in a positive way. Specifically, the implementation of a simple policy rule in these terms allows the second instrument to complement a traditional Taylor rule by influencing financial variables. This complementarity requires that macroprudential responses to financial sector distress do not offset traditional monetary policy at the macroeconomic level. Rather, a well designed macroprudential policy tool should reinforce the stabilizing effect of monetary policy over output and inflation by isolating macroeconomic variables from financial sector shocks and reducing volatility in this sector.

As evidenced by the recent financial crisis, models used for policy analysis must incorporate financial sector variables in such a way as to contemplate the macroeconomic effects of shocks in this sector. Here we have done so while at the same time capturing feedback effects between these two sectors. Still, robustness checks about these results need to be done for economies in which there is more evidence in favor of credit volume or credit standards driving economic activity. Moreover, it is important to keep in mind that although the exercises presented may be a guideline for setting a system wide capital adequacy ratio, our methodology is silent regarding required capital adjustments across banking institutions. Further research in this direction is needed to complement the present analysis.

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Appendix

A Estimation of the Model

Here we present the estimation for the variables of the financial block. Given the possible correlation among the three sectors considered, we have employed a better suited method that allow us to use this information to obtain better estimators. That way, we have estimated the three lending spreads equations (3), the delinquency ratio equations (4) and the credit gap equations (5) using seemingly unrelated regressions (SUR). Results from the SUR on Lending Spreads are presented in Table A. All data was found to be stationary according to the usual set of tests used for this purpose.

Table A: SUR Lending Spreads

Non-financial corporations

$$spread_t^{corp} = \gamma_0^{corp} + \gamma_1^{corp} spread_{t-1}^{corp} + \gamma_2^{corp} delin_t^{corp} + \gamma_3^{corp} CAR_t + \varepsilon_{spread^j,t}$$

	Coef	t-stat	p-value
γ_0^{corp}	-9.7568	-4.9893	0.0000
γ_1^{corp}	0.6932	10.4009	0.0000
γ_2^{corp}	0.1521	5.2417	0.0000
γ_3^{corp}	0.6455	5.2842	0.0000
$R-squared$	0.8624	$Adj.\ R-squared$	0.8459

Consumption

$$spread_t^{cons} = \gamma_0^{cons} + \gamma_1^{cons} spread_{t-1}^{cons} + \gamma_2^{cons} delin_t^{cons} + \gamma_3^{cons} CAR_t + \varepsilon_{spread^j,t}$$

	Coef	t-stat	p-value
γ_0^{cons}	18.7293	3.9687	0.0000
γ_1^{cons}	0.1584	1.0595	0.2927
γ_2^{cons}	0.2115	4.5330	0.0000
γ_3^{cons}	-0.0769	-0.3056	0.7607
$R-squared$	0.7998	$Adj.\ R-squared$	0.7757

Mortgage

$$spread_t^{mort} = \gamma_0^{mort} + \gamma_1^{mort} spread_{t-1}^{mort} + \gamma_2^{mort} delin_t^{mort} + \gamma_3^{mort} CAR_t + \varepsilon_{spread^j,t}$$

	Coef	t-stat	p-value
γ_0^{mort}	-8.9867	-4.6882	0.0000
γ_1^{mort}	0.6695	11.2574	0.0000
γ_2^{mort}	0.1605	5.8436	0.0000
γ_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

On table B the results from the SUR on Delinquency Indexes are presented. An important remark should be done; for this estimation we have calibrated the coefficients of the output gap on the three delinquency indexes as to match the correlation between each sector and the output gap found in the data. Furthermore, for estimation purposes, in case of the consumption delinquency index we have estimated a coefficient for a trend in time as data shows a clear trend in the estimated period.

Table B: 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

On Table C the SUR estimators for the Credit Gap equations are presented. We should notice that all signs are the ones expected from theory and that the cycle does plays a major part in the behavior of credit, even when as previously noticed for the Mexican economy the interaction the other way around does not hold.

Table C: SUR Credit Gap

Non-financial corporations			
$cr_t^{corp} = \mu_0^{corp} + \mu_1 cr_{t-1}^{corp} + \mu_2^{corp} spread_t^{corp} + \mu_3^{corp} x_t + \varepsilon_{credit^{corp},t}$			
	Coef	t-stat	p-value
μ_0^{corp}	1.9251	1.6166	0.1097
μ_1^{corp}	0.8124	11.4760	0.0000
μ_2^{corp}	-0.8543	-2.2778	0.0253
μ_3^{corp}	0.3819	2.0481	0.0437
$R-squared$	0.8441	$Adj.\ R-squared$	0.8274

Consumption			
$cr_t^{cons} = \mu_0^{cons} + \mu_1 cr_{t-1}^{cons} + \mu_2^{cons} spread_t^{cons} + \mu_3^{cons} x_t + \varepsilon_{credit^{cons},t}$			
	Coef	t-stat	p-value
μ_0^{cons}	13.9016	3.2358	0.0017
μ_1^{cons}	0.8481	10.5990	0.0000
μ_2^{cons}	-0.6399	-3.4352	0.0009
μ_3^{cons}	0.9489	3.0698	0.0029
$R-squared$	0.9511	$Adj.\ R-squared$	0.9459

Mortgage			
$cr_t^{mort} = \mu_0^{mort} + \mu_1 cr_{t-1}^{mort} + \mu_2^{mort} spread_t^{mort} + \mu_3^{mort} x_t + \varepsilon_{credit^{mort},t}$			
	Coef	t-stat	p-value
μ_0^{mort}	2.0735	1.4356	0.1548
μ_1^{mort}	0.8615	19.1549	0.0000
μ_2^{mort}	-0.6449	-2.1344	0.0357
μ_3^{mort}	0.5638	3.2274	0.0018
$R-squared$	0.9302	$Adj.\ R-squared$	0.9227

Residual Covariance Matrix

	$\varepsilon_{credit^{corp}}$	$\varepsilon_{credit^{cons}}$	$\varepsilon_{credit^{mort}}$
$\varepsilon_{credit^{corp}}$	6.0336	-0.5301	-2.5992
$\varepsilon_{credit^{cons}}$	-0.5301	7.6862	1.6557
$\varepsilon_{credit^{mort}}$	-2.5992	1.6557	7.3865

Finally, for the specification of the baseline capital adequacy ratio equation, that is when it is exogenous to the central bank, we estimate equation (9) by an OLS regression.

OLS Capital Adequacy Ratio

$CAR_t = \theta_0 + \theta_1 CAR_{t-1} + \varepsilon_{CAR,t}$			
	Coef	t-stat	p-value
θ_0	1.7193	0.9493	0.3498
θ_1	0.8952	7.6705	0.0000
$R-squared$	0.6549	$Adj.R-squared$	0.6438

Finally, in order to calibrate the parameter b_6 from equation (2), we matched the response of the output gap to a one percent increase in the capital adequacy 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 =-0.1367.[35] 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.

B Optimal Rules à la Söderlind

In this section we calculate optimal rules following Soderlind (1999). This methodology has the advantage that one does not need to specify the form of the optimal instrument(s). Indeed, the optimal instrument(s) is a function of all the variables of the state-vector of the model.

We calculate optimal rules for two cases:[36] 1) the only instrument is the interest rate, and 2) both, the interest rate and the capital adequacy ratio are instruments. We specify the loss function as in expression (13) and calibrated the parameter ϕ, which penalizes changes in the capital adequacy ratio to 12.5. This was in order to closely match the variance of the capital adequacy ratio when the authority has two instruments available to the one observed in the data.[37]

Table D shows the results. First, notice that two instruments perform better than a single one. Most of the gains are attained through a reduction in the inflation gap rather than the output gap. It is important to highlight that when the capital adequacy ratio is an instrument the correlation of this

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

[36] The optimization was done using the discretion routine using a discount factor of 0.99.

[37] Notice that this variance is equal to 1.02.

variable with the output gap remains close to zero so dynamic provisioning does not arise optimally in this model. Finally, it is important to observe that the correlation of the interest rate with the capital ratio becomes about three times more negative when the latter variable is an instrument. This suggest that these two instruments, to some extent, offset each other.

C A Sketch of the Core Model

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

$$\pi_t^c = a_1 \pi_{t-1}^c + a_2 E_t[\pi_{t+1}^c] + a_3 x_t + a_4(\Delta e_t + \pi_t^{us}) + \varepsilon_{\pi^c,t}$$

$$x_t = b_1 x_{t-1} + b_2 E_t[x_{t+1}] + b_3 r_{t-1} + b_4 x_t^{us} + b_5 \ln(rer_t) + \varepsilon_{x,t}$$

$$rer_t = c_0 rer_{t-1} + c_1(E_t[rer_{t+1}] + (r_t^{us} - r_t)) + e_{rer,t}$$

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

where π_t^c is the core inflation, x_t is the output gap, e_t is the nominal exchange rate, π_t^{us} is the headline inflation in the the United States, r_t is the real interest rate rate, x_t^{us} is the output gap the the United States, rer_t is the real exchange rate, r_t^{us} is the real interest rate in the United States and π_t^{nc} is the non-core inflation. Finally, the model is closed with a Taylor rule as in expression (1).

D Additional Results

Table D. Evaluation of Loss Functions and Variances under Different Rules[‡]

	Optimal Interest Rate Rule	Optimal Interest Rate and CAR rule
Loss function	13.1318	7.7820
Variance of output gap	2.1552	2.1499
Variance of inflation gap	4.6567	4.2579
Variance of Real FX change	0.0211	0.0207
Variance of interest rate	8.9300	9.3438
Variance of lending spreads	4.5199	3.4502
Var of delinquency indexes	0.6553	0.6529
Variance of credit gap	82.3046	73.0740
Var of capital adequacy ratio	1.8669	1.0432
Corr(credit gap,output gap)	0.1615	0.1370
Corr(credit gap, delinquency index)	-0.8301	-0.8795
Corr(output gap, CAR)	-0.0148	0.0239
Corr(credit gap, CAR)	-0.5683	-0.7685
Corr(interest rate, CAR)	-0.2072	-0.4777

[‡]Simulation was realized by applying the same random shock scenario to all rules
for a forecast of 1,000 periods. The number of repetitions was set at 3,000; reported figures are the average across repetitions.

Table E. Evaluation of Losses Under Core Model Shocks
Only Core Model Shocks Are Considered

	Taylor rule (Case 1)	Taylor rule + CAR Rule (Case 2a)	Taylor rule + CAR Rule (Case 2b)	Taylor rule + CAR Rule (Case 2c)
Loss function	8.6838	7.1612	7.1477	7.2615
Variance of output gap	2.3855	2.3857	2.3858	2.3952
Variance of inflation gap	4.4125	4.4188	4.4148	4.4376
Variance of Real FX change	0.0074	0.0077	0.0075	0.0082
Variance of interest rate	7.9175	7.7832	7.8986	7.6088
Variance of lending spreads	0.3063	0.2089	0.2718	0.1514
Var of delinquency indexes	0.4063	0.4015	0.4009	0.4014
Variance of credit gap	10.6223	7.9820	9.2135	5.4790
Var of capital adequacy ratio	0	0.0073	0.0013	0.0780