

Placing Bank Supervision in the Central Bank

Implications for Financial Stability Based on Evidence
from the Global Crisis

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WORLD BANK GROUP

South Asia Region

Office of the Chief Economist

June 2015

Abstract

Although keeping bank supervision independent from macroprudential supervision may ensure more checks and balances, placing bank supervision in the central bank could exploit synergies with macroprudential supervision. This paper studies whether placing microprudential supervision of banks, typically the systemic part of the financial system, under the same roof as financial stability policy, typically entrusted to the central bank, can improve financial stability. Specifically, the paper analyzes whether

having bank supervision in the central bank mitigated the likelihood of banking crises during 2007–12. The analysis conditions on crisis indicators commonly found in the early-warning models of banking crises, the quality of microprudential supervision, and the quality of macroprudential supervision. The authors find that countries with deeper financial markets and those undergoing rapid financial deepening can better foster financial stability when they put bank supervision in the central bank.

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Implications for Financial Stability Based on Evidence
*from the Global Crisis**

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Keywords: Central Banks, Macroprudential Supervision, Bank Supervision, Financial Stability, Banking Crises, the Global Financial Crisis.

JEL Classification: G21, G28, E58

* We thank Davide Salvatore Mare, Maria Soledad Martinez Peria, and Thierry Tressel for helpful comments on earlier drafts of the paper. The views expressed in this paper are those of the authors and do not reflect the views of the World Bank or its affiliated organizations.

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1. Introduction

The global financial crisis of 2007–12—and its lessons for financial policy—is still the elephant in the room for policy makers. One reason for the lingering uncertainty over how best to ensure the stability of the financial system is that policy makers in many countries have failed to see the big picture of their financial systems through a proper macroprudential lens. The big picture is derived from a good knowledge of many small pieces and their interconnectedness—that is, the microstructure of a system. Therefore, separating microprudential supervision of banks, typically the systemic part of the financial system, from macroprudential supervision could be suboptimal for fostering financial stability. Some countries, the United Kingdom, for instance, acknowledge this and have recently placed the microprudential supervision of banks under the same roof as the macroprudential supervision of their financial systems—that is, in the central bank. Other countries, Poland, for example, do not see this reform as a priority and continue with the status quo. In general, empirical evidence on the advantages of placing bank supervision in the central bank is lacking, to provide analytical underpinning for this kind of reform.¹

This paper examines whether placing the microprudential supervision of banks in the central bank can improve the management of systemic risk in the financial sector by helping prevent systemic banking crises. Specifically, the paper analyzes whether placing bank supervision in the central bank mitigated the likelihood of banking crises during 2007-2012. The analysis conditions on crisis indicators commonly found in the early warning models of banking crises, including the global financial crisis (Demirgüç-Kunt and Detraghiache, 1998 and 2005; Kaminsky and Reinhart, 1999; Berkman et al., 2009; Lane and Milesi-Ferretti, 2011 and 2012; Gourinchas and Obstfeld, 2012; and Frankel and Saravelos, 2012). Moreover, the hypothesis that keeping micro- and macroprudential supervision close together affects financial stability is tested alongside the importance of other two institutional factors: the quality of

¹ One may argue that macroprudential policy was not clearly defined before the global financial crisis. Regardless, central banks were the leading macrofinancial policy makers even before the crisis. Claessens et al. (2013) document that macroprudential policies were used by countries, and in particular their central banks, before the crisis and more commonly by emerging markets.

microprudential supervision (Anginer, Demirgüç-Kunt, and Zhu 2013) and the quality of macroprudential supervision (Čihák et al. 2012).

Our paper contributes to the literature on optimal institutional arrangements for financial sector oversight to foster financial stability and in early-warning models of banking crises by testing whether differences in financial sector institutions can help predict banking crises and by validating the relevance of macro and financial variables used in the literature for predicting banking crises during 2007–12. Overall, the literature on the optimal institutional arrangements for financial sector oversight debates the pros and cons of integrating the microprudential supervision across all financial subsectors and, in addition, placing this integrated supervisor either in or outside the central bank. We thus focus on a specific and, from the point of view of financial stability, perhaps the most important subset of the debate: that is, the possibility of placing bank supervision in the central bank.

The literature remains divided on whether placing bank supervision in the central bank is beneficial for financial stability. On the one hand, it argues for placing bank supervision under one roof with macroprudential supervision—that is, in the central bank—because of better coordination and possible synergies in systemic risk management, crisis preparedness, and crisis resolution (De Grauwe 2007; Cecchetti 2008; Claessens et al. 2010; Brunnermeier et al. 2009). This arrangement can capitalize on several factors: (1) the possibility for combining the knowledge of banking microstructures with the central bank’s expertise in evaluating macro and financial conditions; (2) the opportunity for monetary policy makers and bank supervisors to internalize and align each other’s objectives; (3) the potential for faster delivery of complete supervisory information about bank credit risk (solvency) to the lender of last resort in crisis times; and (4) the likely better capacity to coordinate cross-border supervision of regionally or globally systemic banks because of the greater role that central banks play in policy on international finance and management of the balance of payments.

On the other hand, there are arguments for separating the powers for microprudential and macroprudential supervision for several reasons: (1) potential conflicts of interest between the monetary

policy and supervisory mandates; (2) the reputational risk, as poor supervisory performance could damage the credibility of monetary policy makers; (3) the possible moral hazard effect, as banks can become less risk averse if the lender of last resort is also the supervisor; and (4) the potential that the bureaucratic powers of the central bank could become too big (Gerlach et al. 2009; Cecchetti 2008; Masciandaro 2009). The literature thus produces two alternative hypotheses for empirical work: the possible synergetic and positive effect on financial stability from placing bank supervision in the central bank versus the possible negative effect from the same arrangement because it lacks checks and balances.

The empirical literature that addresses the pros and cons of placing bank supervision in the central bank is only just emerging but is gaining importance. In one of the first studies, Masciandaro, Pansini, and Quintyn (2011) find that the degree of central bank involvement in supervision (with the highest involvement occurring when the central bank is the unified supervisor for all financial subsectors) did not significantly affect economic resilience (growth of real GDP, during 2008–09). They also find that unifying microprudential supervision, either in the central bank or in the financial supervisory authority, negatively affected the measure of economic resilience. For those reasons, Masciandaro, Pansini, and Quintyn (2011) argue for a supervisory architecture with adequate checks and balances that separates macroprudential supervision—typically in the central bank—from microprudential supervision of banks by placing the latter in an agency at arms’ length from the central bank. Eichengreen and Dincer (2011), analyzing the experience of 140 countries during 1998–2006, find that banking systems overseen by independent supervisors other than the central bank had lower ratios of nonperforming loans to GDP and were required to hold less capital against assets, suggesting superior efficiency of this arrangement. Boyer and Ponce (2012), using a formal model, argue that concentrating supervisory authority in the hands of a single supervisor could make the capture of the supervisor by banks more likely. Hence, full integration might not be the supervisory arrangement of social preference.²

² There is also a complementary empirical literature on the effect of microprudential regulation on bank soundness. In a bank-level study of EMDEs (Emerging Market and Developing Economies). Klomp and de Haan (2015) show that stricter regulation and supervision (especially on capital) reduce bank riskiness. Caprio et al. (2014) examine determinants of the 2007–09 banking

We assume, as is common in the literature (Masciandaro, Pansini, and Quintyn 2011), that the mandate for financial stability and macroprudential supervision is with the central bank. However, we acknowledge that, while the central bank typically had a mandate for the oversight of macroeconomic and financial stability before 2008, explicit mandates for macroprudential policy, together with broader macroprudential tools, were given to central banks only as a result of the global financial crisis. There is also an on-going debate on whether the central bank should be tasked with macroprudential policy or, rather, how to separate implementation of monetary and macroprudential policy functionally (Galati and Moessner 2011). In spite of the absent macroprudential policy mandates before the 2008 crisis and the on-going theoretical debates, central banks take on the role of the de facto macroprudential supervisor implicitly in association with their mandate for price stability or explicitly by setting financial stability as one of the goals in the central bank law (Borio and Shim 2007; Claessens, Ghosh, and Mihet 2013).

Our paper, therefore, attempts to shed light on whether placing bank supervision inside or outside the central bank (the macroprudential supervisor) could help achieve better outcomes—that is, more proactive and accurate policy on financial stability and greater resilience of the financial system. In particular, we try to shed light on questions such as: Can placing bank supervision in the central bank help because of the possible synergy effects? Or can it hurt because it may lack checks and balances? Or could the two theoretically opposite effects simply cancel each other out so that the data reveal no significant effect in general? And could the positive or negatives effects of this arrangement work only in a country-specific context (for example, at high levels of financial development)?

To identify whether microprudential supervision of banks was in the central bank prior to 2007, we rely on the data from Melecky and Podpiera (2013) and the 2003, 2007, and 2012 Bank Regulation and Supervision Surveys of the World Bank. For banking crisis classification, we rely on Laeven and Valencia's (2013) database and cross-check our results against the crisis classification by Reinhart and

crisis and find that higher regulatory restrictions on bank activities and private monitoring decreased the likelihood of crises. Barth, Caprio, and Levine (2004) provide empirical evidence that enforcing accurate information disclosure to empower private sector monitoring of banks and creating incentives for private agents to exert corporate control improve bank performance and stability.

Rogoff (2011). The conditioning set of variables in our model of banking crises is derived from Demirgüç-Kunt and Detraghiache (1998, 2005), Kaminsky and Reinhart (1999), Berkmen et al. (2009), Lane and Milesi-Ferretti (2011), Gourinchas and Obstfeld (2012), and Frankel and Saravelos (2012), among others. All explanatory variables are averaged over 2003–07 to capture average conditions during the economic and financial boom that preceded the global financial crisis.³ Broadly, we control for macroeconomic conditions, financial conditions, and institutional development. We use the real output gap (that is, deviations of real GDP from its potential), inflation, real interest rate, and change in the real exchange rate to approximate macroeconomic conditions.⁴ We employ the real private credit gap, the private credit-to-GDP ratio, the loan-to-deposit ratio, and financial openness to approximate the financial conditions. We further control for overall economic and institutional development using GDP per capita.

A question remains of how much the institutional setup for bank supervision matters in relation to the quality of bank microprudential supervision and the quality of macroprudential supervision. The institutional setup may be less relevant in practice, and the quality of supervision may matter most—even though the institutional setup may also affect the quality of supervision over time.⁵ To address the institutional development of financial sector supervision, we control for the quality of microprudential supervision using the index developed by Anginer, Demirgüç-Kunt, and Zhu (2013). This index assesses whether the supervisory authorities have the power and authority to take specific preventive and corrective actions.⁶ To control for the quality of macroprudential supervision, we use a variable

³ We determine 2003 as the start of the pre-2007 global boom period based on global credit growth, GDP growth, and credit-to-GDP cycles for the world economy.

⁴ An initial model included the ratio of government consumption to GDP. However, because of data scarcity and the initial results that show its insignificant impact on the likelihood of crises, we did not include the ratio in the set of macroeconomic variables.

⁵ The literature has also studied the effect of broader institutional reforms. Essid, Boujelbene, and Plihon (2014) find that political stability, voice and accountability, and the respect for the rule of law appear as important ingredients for banking stability in emerging countries. Demirgüç-Kunt and Detraghiache (2005) underline the importance of institutional development in mitigating the likelihood of crises prior to 2007, focusing on the general level of development as measured by GDP per capita and an index of law and order.

⁶ Note that this measure can have a weak relevance to the outcomes on financial stability in practice if the regulatory powers are not properly exercised and supervision and enforcement are weak. In other words, having the power to do things does not mean that in practice supervisors do them. Therefore, bank supervision can de facto be weak if there is forbearance and supervisors do not have the right incentives to exercise their powers.

measuring whether and for how long the central bank has published a financial stability report (FSR), based on Čihák et al. (2012).

We find that placing bank supervision in the central bank decreased the probability of banking crises during 2007–12, when conditioning on past crisis experience and controlling for the quality of microprudential supervision and the quality of financial stability oversight. When conditioning further on macroeconomic and financial variables, we find that placing bank supervision in the central bank continues to diminish the probability of the negative outcome; however, its effect is no longer statistically significant at common levels. The significantly reduced sample size available for estimation after controlling for a large set of macroeconomic and financial variables and the correlation of our variable of interest with some of the macrofinancial variables contribute to the lower significance level. Since the theoretically predicted positive and negative effects from placing bank supervision in the central bank could cancel out in practice, or because either of the two opposite effects could become significant only in certain country circumstances, we further interact the dummy for bank supervision in the central bank with selected macrofinancial variables. We find that placement of bank supervision in the central bank reduced the contribution of financial depth to banking crises.

The results survive several robustness tests of alternative definitions of the dependent variable, an alternative construction of our explanatory variables of interest, and an alternative estimation model, with a different functional form. We use the alternative definition of *banking crises* by Reinhart and Rogoff (2011) and Reinhart (2010). We also consider a separate class of borderline crises identified by Laeven and Valencia (2013). For an alternative construction of our explanatory variable of interest, we average the annual 1/0 dummies indicating whether bank supervision was/was not in the central bank over different time spans. In addition, we test the robustness of our baseline results against the assumed curvature of the cumulative distribution function in the logit model by estimating a probit model. All robustness tests support and, on occasions, reinforce our baseline results. Interestingly, when we use the

Reinhart and Rogoff (2011) definition of *banking crises*, placing bank supervision in the central bank appears to mitigate the likelihood of crises irrespective of the country context.

Our findings have important policy implications. Based on the lessons from the global crisis, several countries (including Belgium, Hungary, and the United Kingdom) went on to reform their institutions for financial sector supervision, including bringing bank supervision and macroprudential supervision under one roof. Other countries (including Poland and Turkey) have kept the status quo, partly because empirical evidence on which institutional arrangements work better in preventing or coping more efficiently with future banking crises is lacking. Other countries cannot reform because there is no political consensus and the reform requires broad support from the highest political levels (such as the parliament) for implementation. Our paper is the first to show that moving bank supervision into the central bank could generate substantial macroeconomic benefits by, at a minimum, helping countries with significant financial depth or those undergoing extensive financial deepening to greatly lessen their propensity for future systemic crises. In this way, our results could help build the needed political consensus for reform.

The remainder of the paper is organized as follows. Section 2 introduces the regression model and discusses the estimation methodology. Section 3 describes the data employed. Section 4 discusses the estimation results. Section 5 reports the results of robustness analysis. Section 6 concludes.

2. Regression Model and Estimation Methodology

We seek to identify variables that could have helped predict banking crises during 2007-12. We put an emphasis on identifying features of the supervisory architecture that could have lowered the probability of a banking crisis. Among these features, we focus on the placement of bank supervision in the central bank. We analyze this question using a cross-sectional regression model that employs data from 124 countries.

Regression Model

We use the systemic banking crisis database of Laeven and Valencia (2013) to identify banking crises in individual countries. We construct a binary variable that takes the value of 1 if a country experienced a systemic banking crisis after 2007 according to Laeven and Valencia (2013) and 0 otherwise. We relate this dependent variable to explanatory variables averaged over 2003–07. In addition, for the robustness tests, we use the banking crisis classification of Reinhart (2010) and Reinhart and Rogoff (2011).

More specifically, we estimate the following model to conduct our analysis:

$$y_i = \alpha + \sum_j \beta_j z_{ji} + \sum_p \delta_j x_{pi} + \varepsilon_i, \quad (1)$$

where i identifies the country, y is the binary (0/1) crisis measure, and z_j is a set of $j = 3$ institutional supervisory variables (a 1/0 dummy variable CMiMa indicating whether the bank supervision is in/out of the central bank, an index that measures the quality of microprudential supervision (Anginer, Demirgüç-Kunt, and Zhu 2013),⁷ and the 1/0 dummy indicating whether the central bank does/does not publish a financial stability report); and a separate variable indicating how many years the central bank has been publishing an FSR. The vector x_p is a set of $p = 10$ macroeconomic and financial variables used in the literature as established determinants of banking crises (Demirgüç-Kunt and Detraghiache 1998, 2005; Kaminsky and Reinhart 1999; Babecky et al. 2012) and the global financial crisis (Lane and Milesi-Ferretti 2011; Berkmen et al. 2009; Frankel and Saravelos 2012; Masciandaro, Pansini, and Quintyn 2011; Caprio et al. 2014; Eichengreen and Dincer 2011). And α , β , and δ stand for estimated coefficients; ε_i is an error term.

⁷ We followed the Anginer, Demirgüç-Kunt, and Zhu (2013) methodology and computed the index by aggregating the answers to 14 selected questions on supervisory powers that were collected in the 2003, 2007, and 2011 surveys conducted by Barth, Caprio, and Levine (2008).

The *macroeconomic variables* include GDP per capita, the real output gap,⁸ inflation, the real interest rate, and the change in the exchange rate. The *financial variables* in our model include the real private credit gap⁹ to identify credit booms, the private credit-to-GDP ratio, a liquidity indicator (ratio of private credit to deposits), and a measure of financial openness (Chinn and Ito 2007). In addition, we estimate an alternative regression that replaces the ratio of private credit to GDP with an alternative measure of financial depth: the ratio of deposits to GDP that we consider a more sustainable and robust measure of financial deepening than the credit-to-GDP ratio (see Panizza, 2014 for a criticism of the credit-to-GDP ratio as a measure of sustained financial deepening). We use gap measures instead of growth rates of real output and credit to be consistent with the measures of business and credit cycle overheating used in monetary policy models (Adolfson et al. 2008; Christiano, Eichenbaum, and Evans 2005; Smets and Wouters 2003) and Basel III.

We also condition on the cumulative number of past banking crises that a country experienced from 1970 to 2006 to allow for some historical dependence in the modeled crisis variable and investigate whether there could be a positive learning effect from the experience of past crises on a country's propensity to experience future crises.

Estimation methodology

We estimate the regression model explaining the probability of a banking crisis with a *binary choice logit* model (Green, 2003), using robust standard errors. Frankel and Saravelos (2012), in their meta-analysis, note that the most popular approach in the literature that models and forecasts crises is the linear regression and limited dependent variable techniques.¹⁰ Another significant number of studies, especially those seeking to identify early-warning indicators of crises, have used the signals approach, a

⁸ The trend was estimated using the Hodrick–Prescott filter for the period 1990–2011.

⁹ The trend was estimated using the Hodrick–Prescott filter for the period 1995–2011. The period is shorter than for the computations of the GDP trend due to data constraints.

¹⁰ The first studies to use this are Eichengreen, Rose, and Wyplosz (1995), and Frankel and Rose (1996). Demirgüç-Kunt and Detragiache (1998) was the first analysis to use this technique to study determinants of systemic bank distress.

nonparametric method first introduced by Kaminsky, Lizondo, and Reinhart (1998).¹¹ Davis and Karim (2008) assess the logit and signal-extraction early-warning systems (EWS) for banking crises and suggest that logit is the most appropriate approach for global EWS, as it has been able to predict a significant share of crises correctly. In contrast, the signal-extraction approach is more suitable for country-specific EWS.

Given the cross-country nature of the analysis, there is a risk of omitted relevant variables. We mitigate this risk by using a robust set of crisis predictors well established in the literature, which helps us achieve a satisfactory fit of the model to the data. We further assess this risk of incompletely specified model using standard statistical tests.

3. Data Description and Summary Statistics

Table A1 in the appendix provides a detailed data description. Table A2 in the appendix lists crisis countries—that is, the countries that met Laeven and Valencia (2013)’s banking crisis criteria in the period that we study. They define a crisis as systemic when two conditions are met: (1) “significant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and/or bank liquidations)”; and (2) “significant banking policy intervention measures¹² in response to significant losses in the banking system.” Our binary crisis variable takes the value of 1 if a country experienced a banking crisis and 0 if it did not. There are 25 crisis countries; hence, about 20 percent of the 124 countries in our sample suffered a banking crisis during 2007–12. Next, we describe our institutional variables of interest and the conditioning set of macroeconomic and financial variables.

¹¹ This type of method is currently used by the International Monetary Fund (IMF) in its crisis vulnerability exercise. Another important stream of modeling approaches categorized by Frankel and Saravelos (2012) combines qualitative and quantitative analysis and examines the behavior of various variables of both crisis and noncrisis groups of countries around the crisis occurrence.

¹² Policy interventions are considered to be significant if at least three of the following six measures have been used: (1) deposit freezes and/or bank holidays; (2) significant bank nationalizations; (3) bank restructuring of gross costs (at least 3 percent of GDP); (4) extensive liquidity support (5 percent of deposit and liabilities to nonresidents); (5) significant guarantees put in place; and (6) significant asset purchases (at least 5 percent of GDP) (Laeven and Valencia 2013).

Institutional variables

CMiMa, our main variable of interest, is the 2003–07 average of the binary variable that shows whether the bank supervision is located in the central bank, reflecting the closeness of micro- and macroprudential supervision during 2003–07. It derives from the database developed by Melecky and Podpiera (2013) and the Bank Regulation and Supervision Surveys carried out by the World Bank in 2003, 2007, and 2012.¹³ It takes the value of 1 if the banking supervision is placed under the central bank.¹⁴ Note that the value of 1 is assigned both to countries with an institutional arrangement of fragmented, sectoral supervision in which the banking supervision is under the central bank and to countries with a unified supervision of all subsectors under the central bank. In contrast, the value of 0 is assigned to countries if the bank supervision is in an agency other than the central bank, including a financial supervisory authority that oversees all main financial subsectors on a microprudential basis.

Figure 1 shows that the 2003–07 period saw little change in relocating banking supervision in or outside the central bank. During this period, integrating the supervision of main financial subsectors in one agency was the leading reform of supervisory structures. Specifically, countries with bank supervision in the central bank also tended to integrate the supervision of other subsectors into the central bank. In contrast, countries with bank supervision in an agency outside the central bank tended to integrate the supervision of other financial subsectors outside the central bank (Melecky and Podpiera 2013).

Figure 2 shows that in 2007, 60 percent of those countries that soon experienced a banking crisis had bank supervision outside the central bank. Evidently, the crisis period triggered reforms. The share of countries that experienced a banking crisis and subsequently placed bank supervision in the central bank increased from 40 percent to 48 percent from 2007 to 2011. Among the countries that did not experience a banking crisis, 65 percent had bank supervision in the central bank in 2007. This percentage increased

¹³ The links to the surveys can be found here.

¹⁴ Future research will focus on collecting microdata on the organizational structure within central banks and determining how effective the coordination and cooperation are between macroprudential and microprudential departments, as well as on cooperation of macroprudential supervisors with microprudential supervisors located outside the central bank.

further to 71 percent in 2011. Overall, the trend of placing bank supervision in the central bank seems to have increased for both crisis and non-crisis countries.

The supervisory quality index,¹⁵ our second institutional variable, was developed by Anginer, Demirgüç-Kunt, and Zhu (2013) and quantifies whether the supervisory authorities have the power and the authority to take specific preventive and corrective actions. They found that good bank supervision can foster systemic stability and lessen the unintended consequences of deposit insurance on systemic bank risk during good times. The average index does not differ significantly across “crisis” and “no-crisis” countries (figure 3).

Our third institutional indicator measures whether and for how long (in years) the central bank has been publishing a financial stability report. The underlying binary (0/1) variable of whether a central bank published an FSR in a given year was constructed by Čihák et al. (2012).¹⁶ They find that higher-quality FSRs tend to be associated with more stable financial environments but find only a weak empirical link between a simple publication of FSRs and financial stability. The data on FSR publication are available for only 78 countries, covering 22 of the 25 crisis countries. The data on the quality of FSRs as rated by Cihak et al. are not publicly available. We assume that quality can improve with time and use the length of FSR publication as a proxy for the quality of the reports.¹⁷ As of 2008, the average length (in years) of publishing an FSR was significantly higher for crisis countries than for the noncrisis countries (figure 4). At the same time, the shares of crisis and noncrisis countries that published an FSR in 2007 are similar—86 percent of the crisis countries and 82 percent of the noncrisis countries, respectively.

¹⁵ We followed Anginer, Demirgüç-Kunt, and Zhu’s (2013) methodology and computed the index by aggregating the answers to 14 selected questions on supervisory powers that were collected in the 2003, 2007 and 2011 surveys conducted by Barth, Caprio, and Levine (2008).

¹⁶ The methodology for assessing central banks’ FSRs was introduced by Čihák (2006) in the first worldwide survey of FSRs.

¹⁷ Alternatively, one could use as the control the availability or even better the actual implementation of macroprudential tools prior to the 2008 crisis. However, this type of data for the number of countries covered in this study is not available. See Claessens, Ghosh, and Mihet (2013) for an example of a study that collected data on the use of macroprudential tools for 48 countries.

Macroeconomic and financial variables

To adequately capture the change in macroeconomic and financial conditions over the boom period before the global financial crisis, we reviewed the cycles of global real GDP and credit growth (figure 5).¹⁸ Based on this review, we designated the year 2003 as the beginning of the global cycle and averaged the macroeconomic and financial variables over the period 2003–07 to capture the conditions before the global crisis period.

On average, the crisis countries in our sample are characterized by a higher level of development (GDP per capita), lower inflation, and a higher output (real GDP) gap than the countries that did not experience a crisis. In fact, the noncrisis countries showed, on average, a negative real GDP gap over 2003–07. Changes in the real exchange rate were also significantly different among the two groups of countries, showing, on average, local currency appreciation for crisis countries and local currency depreciation for noncrisis countries (table 1).

Turning to characterizing the financial variables in the five-year period preceding the global financial crisis, we found that the private credit-to-GDP ratio and the deposits-to GDP-ratio (financial depth variables), the degree of financial openness, and the private credit-to-deposits ratio (that is, the exposure to aggregate liquidity risk) were, on average, significantly higher in crisis countries than in noncrisis countries (table 2).

4. Discussion of Estimation Results

Table 3 shows the coefficients of the estimations that aim to identify determinants of the probability of a banking crisis. We report coefficients rather than marginal effects to circumvent the issue of averaging marginal effects over countries. This approach suits our study, as we are not interested in the magnitudes of the effects of the explanatory variables on the probability of crisis but rather the sign and

¹⁸ The global variables were computed using the data for the 124 countries for which the data were available. The cycle components were computed using a Hodrick-Prescott filter.

statistical significance. For the record, though, table A4 in the appendix also reports the marginal effects for the main parsimonious regressions.¹⁹ Table 3 consists of two blocks of variables: (1) the “all supervisory” block that accounts for the institutional variables of interest; and (2) the macrofinancial block of variables. In addition, we condition on the number of banking crises that a country has experienced since 1970 to allow for some historical dependence in the modeled crisis variable. For the explanatory variables that enter the parsimonious regression, we also consider their interaction with the CMiMa dummy. These interaction terms could help identify whether placing bank supervision in the central bank can have particularly significant effects in certain country circumstances.

Columns (1)–(3) of table 3 present the results of estimations that condition on the number of past crises and add successively our supervisory variables. We start with the CMiMa variable, as it has the greatest coverage for our sample of countries, (column (1)). Both the CMiMa variable and the number of past crises have negative and significant impacts on the probability of crises. Countries with bank supervision in the central bank had a lower probability of a banking crisis than countries that placed bank supervision in an agency other than the central bank. In addition, the more crises a country experienced before 2007, the lower the probability was that it would experience a banking crisis after 2007. That is, we find that a country’s experience of past crises increases its ability to prevent future crises, other things equal.²⁰ The country coverage of the variables measuring the quality of microprudential supervision (column 2) and the quality of macroprudential supervision (column 3) is much smaller than the country coverage of our dataset.²¹ Within these smaller samples, these two institutional variables do not appear to be significant in determining the probability of crises at common statistical levels. Because of their insignificance at common levels and limited data availability, we do not include these variables in the overall baseline regressions.

¹⁹ Note that the marginal effects are typically conducted at the sample mean of the respective explanatory variables. While this may be relevant for studies estimating marginal effects in normal times, for early-warning models of crisis, such an approach is not suitable because the marginal effects of variables at, for example, the 90th or 95th percentile value of the sample could be more pertinent.

²⁰ Note that this interpretation is consistent with the current policy emphasis on conducting crisis simulation exercises (war games) to improve coordination among stakeholders of the crisis preparedness and management framework and to build flexible institutions to cope with and mitigate materializing systemic risk.

²¹ The data for the FSR publication are available for only 70 countries.

Columns (4) and (5) show estimates of the regressions, including all macroeconomic and financial variables that we consider. The alternative regression in column (5) replaces the private credit-to-GDP ratio from the initial regression with the deposits-to-GDP ratio. In addition, we include the CMiMa and the number of past crises. Against such a comprehensive set of variables, the CMiMa loses its significance, while past crises retain their significant negative impact on the probability of crisis. Among the macrofinancial variables, the GDP gap and the private credit-to-deposits ratio stand out as the most significant, with several other variables marginally significant. We strive to derive a parsimonious estimation of the regression because of numerous significant cross-correlations among the macrofinancial variables (see the correlation matrix in table A3 in the appendix).

For this purpose, we first employ the Lasso (least absolute shrinkage and selection operator) penalized regression estimator of Tibshirani (1996), which has the effect of shrinking coefficients of unimportant variables to zero, as a variable selection tool to reduce the set of indicators. The Lasso method is supported by extensive theoretical work (see Zou 2006 for a literature review).²² Osborne et al. (1998) advise using Lasso for an initial selection, while Knight and Fu (2000) show that Lasso can pick up all the true predictors if the amount of data is sufficient. As a result of the Lasso variable selection, the inflation and the growth in real exchange rate were eliminated along with several other variables. The corresponding parsimonious regressions thus include the number of past crises, the GDP gap, the real interest rate, the ratio of private credit to GDP, the ratio of private credit to deposits, and the deposits-to-GDP ratio in the alternative regression (column 7). The baseline parsimonious regressions show a satisfactory fit to the cross-country data with the pseudo R squared reaching between 0.40 and 0.49. In addition, we tested for omitted relevant variables using Stata's linktest and could not reject that our model is properly specified.²³

²² See section 3.4 in chapter 3 of Hastie et al. (2009) for a detailed description of the Lasso. We performed this regression in Stata with the plogit procedure.

²³ The results are available from authors upon request.

The signs of the estimated coefficients in the parsimonious regressions are as anticipated and are mostly in line with the literature. First, we see that countries that experienced a higher number of past crises had a lower probability of experiencing another crisis after 2007, likely as a result of efforts to address macroeconomic, financial, and institutional vulnerabilities after the past crises. Second, countries with greater deviations of real GDP from its potential (greater output gap) showed a higher propensity to experience banking crises after 2007. This result agrees with results of other studies of banking crises, such as Kaminsky and Reinhart (1999) and Gourinchas and Obstfeld (2012) that estimated predictors of banking crises during 1973–2011, and with results of Frankel and Saravelos (2012), which investigated the determinants of the 2008 global crisis. Our results also show a negative impact of the real interest rate on the probability of a banking crisis: low real interest rates support excessive borrowing that can ultimately generate banking crises. Frankel and Saravelos (2012) also associate higher saving rates with lower incidence of crises. In contrast, Demirgüç-Kunt and Detragiache (1998, 2005) find that exposure to high real interest rates, which could intensify credit risk as well as negatively affect bank profits, was a source of bank fragility during 1980–2002.

Third, we confirm the results from earlier studies that countries with greater financial deepening (ratio of private credit to GDP) and countries taking greater aggregate liquidity risk (ratio of private credit to deposits) are significantly more prone to banking crises. Demirgüç-Kunt and Detragiache (2005), Gourinchas and Obstfeld (2012), Schularick and Taylor (2012), and Babecky et al. (2011) find, as we do, that the credit-to-GDP ratio is a consistent predictor of banking crises. In addition, Lane and Milesi-Ferretti (2011) find that the credit-to-GDP ratio and its change over 2004–07 could also help explain the intensity of the 2008–09 global recession.²⁴ Our finding that high aggregate liquidity risk increases the tendency toward banking crises confirms earlier results from Caprio et al. (2014).²⁵ The alternative

²⁴ This literature brings supporting evidence for Rajan's (2005) claim that larger, more complex financial systems may be inherently more risky.

²⁵ Berkmen et al. (2009) find that higher aggregate liquidity risk can explain a larger variation in the growth forecast revisions during the global crisis period, also a possible indicator of macrofinancial stability.

specification, including the deposits-to-GDP ratio (column 7), reconfirms the positive effect of high financial depth on the probability of banking crises found in the literature.

When conditioning on the broad set of macrofinancial indicators of banking crises, our variable of interest (CMiMa) loses its significance in helping predict crises. This result can reflect the dichotomous predictions from the theory but could also reflect the possibility that the positive or negative effects from placing bank supervision in the central bank materialize only in certain country circumstances. To examine this hypothesis, we interact the dummy for having bank supervision in the central bank (CMiMa) with the variables that enter the parsimonious regressions. For example, in countries with greater financial depth it might be more beneficial to house bank supervision under one roof with macroprudential supervision so that knowledge of the microsources of macroprudential risks could be more readily available for taking informed and timely policy action to mitigate systemic risk. Columns (8)–(12) show the results of estimations, including the individual interactive terms. The results show a significant coefficient on the CMiMa's interaction with the ratios of private credit to GDP and deposits to GDP. These estimates suggest that placing bank supervision in the central bank can help reduce the positive effect of a greater financial deepening on the probability of crises by more than a half (see the marginal effects presented in table A4). Therefore, it is the countries with deeper financial markets (banking sectors) that could benefit the most from the crisis-mitigating effect of placing bank supervision in the central bank.

5. Robustness tests

We test the robustness of our results through additional estimations in which we alter the following consecutively: (1) the definition of the dependent variable; (2) the construction of our explanatory variable of interest; and (3) the estimation method. We consider two alternative definitions of banking crises: that of Reinhart and Rogoff (2011) and Reinhart (2010) and a definition that distinguishes

the class of borderline crises identified by Laeven and Valencia (2013). As for the alternative construction of our explanatory variable of interest, we average the annual CMiMa dummy over different time spans. We consider whether the banking supervision was in the central bank at the beginning of the boom that preceded the global financial crisis by using the 2000–03 average of the CMiMa variable. And we use the average of the CMiMa variable over 2000–07 to cover both the preboom and boom periods in the run-up to the global crisis. And finally, we use also the average of CMiMa over 2000–11 to capture the effect of an anticipated move of bank supervision to the central bank that was approved earlier but implemented only during or after the crisis period. As the alternative estimation method, we use a probit model to test whether the assumed curvature of the cumulative distribution function in the logit model can have a material effect on the estimation results, especially because of a possibly different data fit around the extreme values of the explanatory variables.

Using different definitions of a banking crisis reconfirms the beneficial effect of placing bank supervision in the central bank from baseline estimation. Moreover, the alternative definitions show that the beneficial effect could be present irrespective of country circumstances. The crisis countries named in Reinhart (2010) and Reinhart and Rogoff (2011) are a subset of those identified by Laeven and Valencia (2013): Reinhart and Rogoff identify 17 crisis countries out of the 70 countries that Laeven and Valencia consider. The estimation results in table A5 reveal that CMiMa has a significantly negative (mitigating) effect on the propensity to banking crises even when we condition on the macrofinancial variables, columns (1) and (2). For the macrofinancial variables, the real interest rate and private credit-to-GDP ratio are again significant and have the same sign as in the baseline regressions, while the GDP gap and the liquidity variables are not significant. Other two variables seem to influence the probability of crisis positively: the real credit gap (a proxy for a credit boom) and financial openness. Moreover, the mitigating effect of higher real interest rates on the propensity to crises is further enhanced when bank supervision is in the central bank (column 3). The results of the regressions, including interaction terms, are similar to our main results, column (4). In addition, the positive effect of financial openness on the likelihood of crises is mitigated when bank supervision is housed in the central bank, column (5).

When classifying countries on their crisis experience, we follow Caprio et al. (2014) and consider three states as opposed to the two states considered in the baseline model. Specifically, eight crisis countries labeled by Laeven and Valencia (2013) as borderline cases constitute a separate state in this alternative estimation. We thus specify and estimate an ordered-choice logit model in which the dependent variable is a dummy that takes the value 0 for countries with no crisis, 1 for countries with borderline crises, and 2 for countries with systemic crises. The results are reported in table A6. They support our baseline findings that housing bank supervision in the central bank can mitigate the positive effect of financial deepening: the interactions of CMiMa with the credit-to-GDP and deposits-to-GDP ratios are negative and significant. Overall, the resulting parsimonious regressions comprise the same explanatory variables that appear in our baseline parsimonious model. However, the baseline regression fits the data better than the regressions.

Next, we consider the estimation results using the CMiMa variable averaged over alternative time spans: 2000–03, 2000–07 and 2000–11 (table A7). In all three cases, the estimation results are very similar to and support our baseline results. This observed robustness to different averaging could be explained partly by the fact that there were only a few instances when bank supervision was relocated into or outside the central bank during the period 2000–07 (see the transition matrix in table A3 of Melecky and Podpiera 2013). In all cases, the interactions between CMiMa with private credit to GDP and deposits to GDP, respectively, are negative and significant at the 10% level and 5% level, respectively.

Finally, we test the robustness of our baseline results to an alternative functional form of the model by estimating a probit model that is characterized by a slightly different curvature of the assumed cumulative probability function. As we see from the estimation results reported in table A8, the probit results support our baseline estimation results. The coefficients on the interaction between CMiMa and credit to GDP as well as CMiMa and deposits to GDP are significant and negative. They reinforce the benefits of placing bank supervision in the central bank.

6. Conclusion

This paper investigated the effect that the institutional setup of financial sector supervision can have on the ability of countries to prevent systemic banking crises. Specifically, the paper examined whether the possible synergy effects from having bank supervision in the central bank can help countries avoid banking crises. We used a standard early-warning model of banking crises with robust crisis predictors and data from around the time of global financial crisis for this investigation. We also controlled for the possibility that greater financial stability could be explained by the quality of bank microprudential supervision or by the quality of financial stability oversight rather than by the placement of bank supervision together with macroprudential supervision in the central bank. The literature has been divided about whether to place bank supervision in the central bank.

Our study provides evidence that countries with deeper financial markets and countries undergoing rapid financial deepening can benefit from having bank supervision in the central bank to better foster financial stability. This result holds regardless of whether rapid financial deepening occurs because of domestic credit policies influenced by the risk appetite of domestic policy makers for taking systemic risk or because of exogenous factors such as capital inflows after liberalization of external financial accounts. Especially in these circumstances, our results suggest that policy makers can benefit from having a good knowledge of the financial system's microstructure when safeguarding the stability of the financial system as a whole. Indeed, countries like the Netherlands and the United Kingdom, and most recently Hungary, have moved bank supervision into the central bank to reap these benefits. Other countries, such as Poland, Turkey, and several in Latin America, could find encouragement in our results to implement similar reform in the near future.

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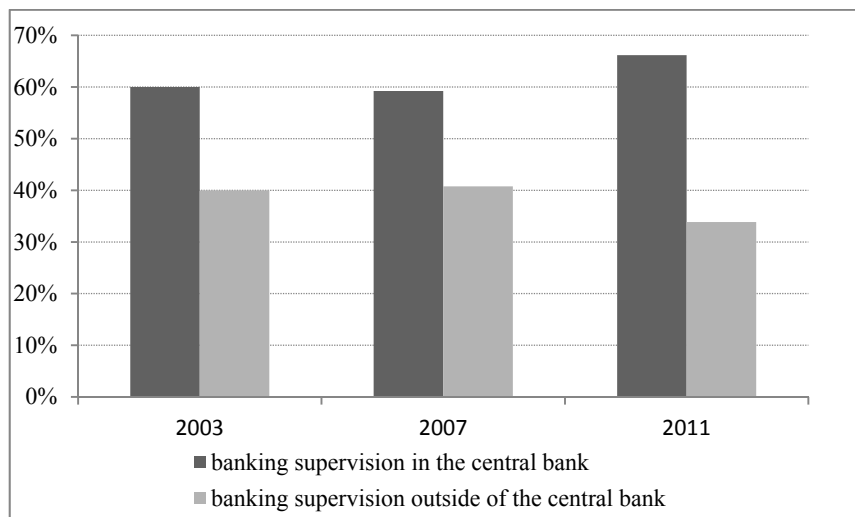
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Figures in the Main Text

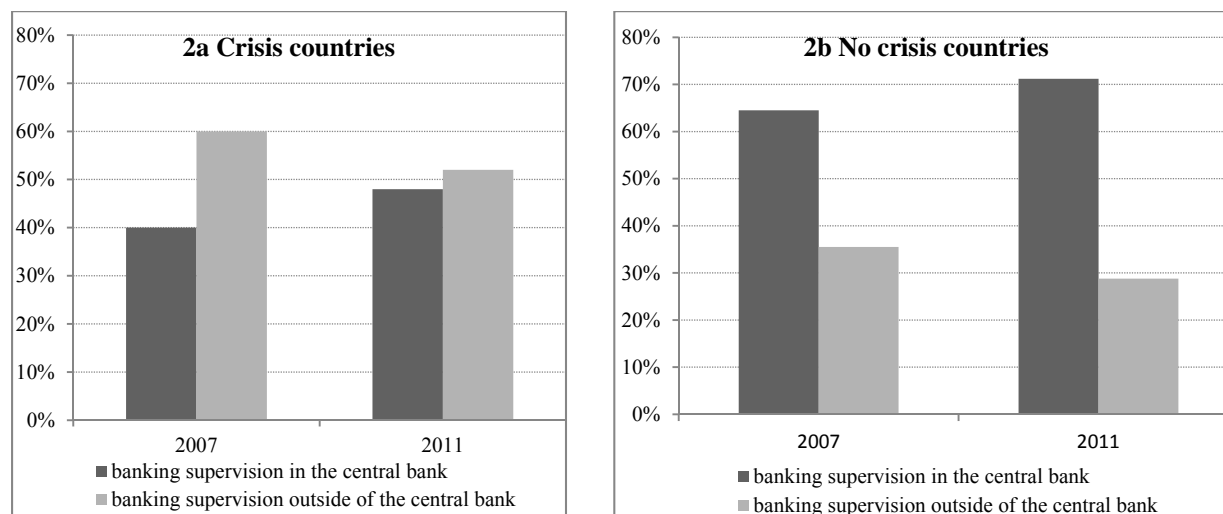
Figure 1. Share of Countries with Bank Supervision in the Central Bank and outside of the Central Bank



Source: Authors' calculations based on Melecky and Podpiera (2013) and World Bank's Bank Regulation and Supervision Surveys.

Note: The sample contains 124 countries.

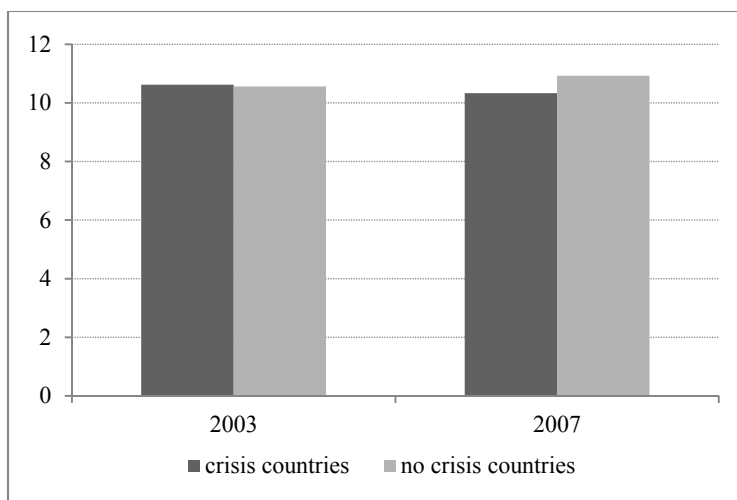
Figure 2. Location of Bank Supervision by Crisis Experience.



Source: The proportions of countries are calculated based on Melecky and Podpiera (2013), World Bank's Bank Regulation and Supervision Surveys, and Laeven and Valencia (2013).

Note: "Crisis countries" are those that experienced a financial crisis in 2008; "no-crisis countries" are those that did not. The sample contains 25 crisis countries and 122 no-crisis countries.

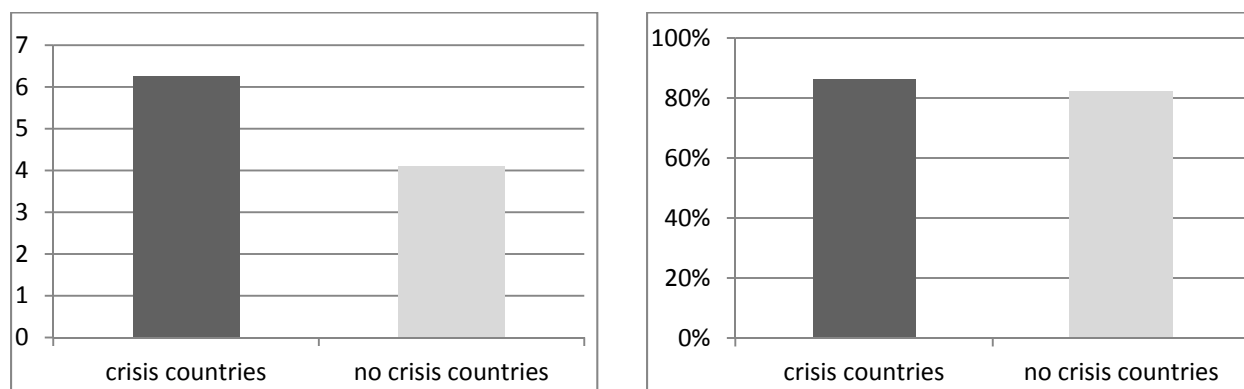
Figure 3. Average Index of Supervisory Quality by Crisis Experience.



Source: Authors' calculations based on Anginer, Demirgüç-Kunt, and Zhu 2013; Laeven and Valencia 2013. We followed Anginer, et al.'s (2013) methodology and computed the index by aggregating the answers to fourteen selected questions regarding supervisory powers that were collected in the 2003, 2007 and 2011 surveys conducted by Barth, Caprio, and Levine (2008).

Note: "Crisis countries" are those that experienced a financial crisis in 2008; "no-crisis countries" are those that did not. The sample contains 25 crisis countries and 122 no-crisis countries. The index is the aggregated answers to 14 selected questions on supervisory powers collected in 2003, 2007, and 2011 surveys (Barth, Caprio, and Levine, 2008).

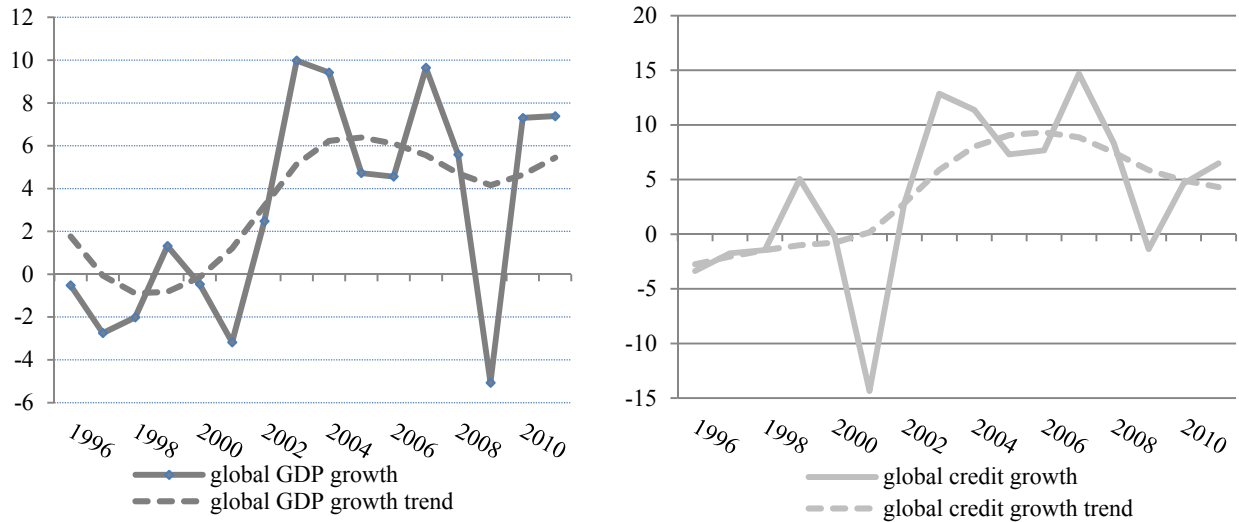
Figure 4. Average Number of Years before 2008 of Publishing a Financial Stability Report in Crisis and No-Crisis (left panel) Countries; and the Share of Crisis and No-Crisis Countries that Published a Financial Stability Report in 2007(right panel).



Source: Authors' calculations based on Čihák et al. (2012) and Laeven and Valencia (2013).

Note: "Crisis countries" are those that experienced a financial crisis in 2008; "no-crisis countries" are those that did not. The sample contains 25 crisis countries and 122 no-crisis countries.

Figure 5. Global Real GDP Growth (left panel) and Credit Growth (right panel), and Their Trends.



Source: Authors' calculations based on World Bank's World Development Indicators and FinStats databases.

Tables in the Main Text

Table 1. Summary Statistics for Macroeconomic Variables: Crisis and No-Crisis Countries

	Crisis countries		No-crisis countries		Difference		t-stat
	Mean	Std. err.	Mean	Std. err.	Mean	Std. err.	
GDP per capita	27277.72	2961.12	10944.51	1331.63	-16333.2	3017.5	-5.33
Real GDP gap	0.241	0.089	-0.173	0.076	-0.42	0.160	-2.58
Real interest rate	0.011	0.558	0.632	0.41	0.62	0.86	0.7
Real exchange rate change	-4.01	1.08	1.56	1.05	5.57	2.17	2.56
Inflation	4.14	0.65	6.01	0.506	1.87	1.069	1.75

Source: Authors' calculations based on World Bank's World Development Indicators and IMF's International Financial Statistics.

Note: "Crisis countries" are those that experienced a financial crisis in 2008; "no-crisis countries" are those that did not. Std. err. = standard error; GDP = gross domestic product.

Table 2. Summary Statistics for Financial Variables: Crisis and 'No-Crisis' Countries

	Crisis countries		No-crisis countries		Difference		t-stat
	Mean	Std. err.	Mean	Std. err.	Mean	Std. err.	
Real private credit gap	-1.96	0.75	-2.3	0.382	-0.33	0.85	-0.4
Private credit to GDP	101.04	11.16	41.02	3.41	-60.02	8.8	-6.8
Private credit to deposit	134.44	11.29	85.44	3.29	-48.99	8.65	-5.66
Deposits to GDP ratio	82.15	13.04	49.6	4.15	-32.56	10.5	-3.08
Financial openness	1.77	0.25	0.53	0.152	-1.23	0.335	-3.68

Source: Authors' calculations based on World Bank's FinStats database and Chinn and Ito (2007).

Note: "Crisis countries" are those that experienced a financial crisis in 2008; "no-crisis countries" are those that did not. Std. err. = standard error; GDP = gross domestic product.

Table 3. Estimated Determinants of the Probability of Banking Crisis

Explanatory variables		Dependent variable: Binary crisis measures (0/1 dummy)												
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
Supervisory Block	Number of previous crises	-1.3** (0.48)	-1.2** (0.49)	-1.9** (0.67)	-1.3 (0.82)	-1.553** (0.68)	-0.97* (0.56)	-1.206** (0.560)	-1.531* (0.895)	-1.002 (0.644)	-0.977 (0.638)	-1.144* (0.62)	-1.076 (0.661)	-1.408** (0.593)
	CMiMa	-1.15** (0.48)	-1.08** (0.5)	-1.23* (0.65)	-0.808 (0.76)	-0.823 (0.772)								
	Quality supervision		-0.113 (0.1)	-0.073 (0.125)										
	Length of FSR publication			0.187 (0.12)										
	GDP per capita				2.4e-05 (3e-05)	2.7e-05 (2.2e-05)								
	GDP gap				1.19** (0.586)	1.096* (0.569)	1.15** (0.45)	1.008** (0.432)	1.09** (0.517)	1.531 (1.084)	1.18** (0.534)	1.25** (0.51)	1.21** (0.529)	1.102** (0.481)
	Inflation				0.373 (0.24)	0.391* (0.18)								
Macro-financial block	Real interest rate				-0.173 (0.138)	-0.187 (0.167)	-0.3*** (0.09)	-0.26*** (0.088)	-0.25*** (0.0912)	-0.24*** (0.0935)	-0.200 (0.26)	-0.265*** (0.098)	-0.26*** (0.0925)	-0.271*** (0.0976)
	Change in real exchange rate				-0.161 (0.113)	-0.182* (0.085)								
	Real private credit gap				-0.166 (0.121)	-0.158 (0.133)								
	Private credit-to-GDP ratio				0.015* (0.08)		0.02*** (0.007)		0.02*** (0.008)	0.022** (0.008)	0.02*** (0.008)	0.028*** (0.008)	0.022*** (0.008)	
	Private credit-to-deposit ratio				0.02* (0.011)	0.03*** (0.009)	0.022** (0.008)	0.04*** (0.009)	0.024** (0.01)	0.021** (0.01)	0.022** (0.009)	0.022** (0.007)	0.023** (0.01)	0.037*** (0.01)
	Deposit-to-GDP ratio					0.0084 (0.007)		0.016** (0.005)						0.021*** (0.007)
	Financial openness				0.45 (0.335)	0.486* (0.25)								
Interactive terms	CMiMa*nr of prev crises							1.091 (1.035)						
	CMiMa*GDP gap								-0.483 (1.185)					
	CMiMa*real interest rate									-0.06 (0.289)				
	CMiMa*private credit to GDP										-0.012* (0.007)			
	CMiMa*private credit to deposits											-0.004 (0.006)		
	CMiMa*deposits to GDP												-0.013** (0.006)	
	Observations	130	111	70	121	121	124	124	124	124	124	124	124	
	Pseudo R-squared	0.098	0.108	0.245	0.474	0.466	0.404	0.395	0.413	0.406	0.405	0.428	0.408	

Notes: The shaded columns present the results of the estimations including deposit to GDP ratio. Robust standard errors in parentheses. CMiMa = a 1/0 dummy variable indicating whether the bank supervision is in/out of the central bank; GDP = gross domestic product; *** p<0.01, ** p<0.05, * p<0.1.