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## Financial Soundness Indicators and Banking Crises

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**IMF Working Paper**

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**Abstract**

The paper tests the effectiveness of financial soundness indicators (FSIs) as harbingers of banking crises, using multivariate logit models to see whether FSIs, broad macroeconomic indicators, and institutional indicators can indeed predict crisis occurrences. The analysis draws upon a data set of homogeneous indicators comparable across countries over the period 2005 to 2012, leveraging the IMF's FSI database. Results indicate significant correlation between some FSIs and the occurrence of systemic banking crises, and suggest that some indicators are precursors to the occurrence of banking crises.

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## I. INTRODUCTION

Capturing early warning signals of potential financial or banking sector shocks has become increasingly important since the outbreak of the global financial crisis in 2007. In this regard, a critical need has arisen to test current regulatory tools and health indicators of the financial and banking sectors, and also to see how they can be improved.

Financial Soundness Indicators (FSIs) comprise of a set of indicators that measure the health of a country's financial system. In principle, the evolution of these indicators should indicate potential vulnerabilities of the financial sector and point out possible weaknesses, thereby functioning as tools of macroeconomic policy. However, in light of the recent crisis, it is clear that FSIs have not been used extensively for this purpose.

This paper tests the effectiveness of FSIs as indicators of potential banking crises, using multivariate logit models to see whether FSIs, broad macroeconomic indicators, and institutional indicators can indeed predict crisis occurrences. A two-stage model is estimated to test whether volatility in indicators is correlated with the occurrence of crisis events: in the first stage, linear regressions are run on FSIs against a time trend by country and residuals obtained; in the second stage logit regressions are run on banking crisis events against the FSI residuals, lagged year-on-year differences in macroeconomic indicators, and a composite governance indicator.

Following Laeven and Valencia (2012), banking crises are defined as systemic if: i) there are significant signs of distress in the banking system, evidenced through bank runs, losses or liquidations; and ii) there are significant banking policy intervention measures in response to losses in the banking system. The banking crisis variable used in the analysis is a binary variable encoded as '1' if a systemic banking crisis occurs in a given year, and a '0' otherwise.

The results indicate significant correlation between some FSIs and crises: specifically, regulatory capital to risk-weighted assets (CAR) and return on equity (ROE) show significant negative contemporaneous correlation with the occurrence of banking crises. Additionally, lagged ROE is a significant leading indicator of crises. While the sample period of this analysis corresponds to the global financial crisis of 2007, these results mirror the findings of Čihák and Schaeck (2007), who perform an analysis of global crises over the 1990s.

This paper is the first to make use of a data set of FSIs collected under an internationally accepted methodology. The use of a coherent consolidation basis methodology ensures that financial sector risk exposure within and beyond each country's economic territory is accurately measured by the indicators. Importantly, this means that FSIs are sensitive to economic and financial sector shocks that extend beyond a given domestic economy. Unlike any previous literature on FSIs, consistent accounting, aggregation and consolidation principles also allow better cross-country comparability of FSIs. While consolidation bases

can differ by country, the data are comparable across countries because all significant sources of financial risk are covered at the country level.

Additionally, this paper tests the usefulness of a broader set of FSI indicators than previously tested in existing literature. While currently available data allow an analysis of 6 core FSIs in this paper, the IMF collects data on 12 core and 28 encouraged FSIs, forming a rich basis for future research. As we run reduced-form models, we stress that the results indicate correlations between FSIs and crises, and we do not establish causality by estimating a derived structural model.

A number of studies exist on the determinants of banking crises. Demirgüç-Kunt and Detragiache (1998) use a multivariate logit model to explore which macroeconomic indicators are associated with the emergence of banking crises. Their results suggest that crises tend to occur in an environment of low growth, high inflation, and high real interest rates. Interestingly, they also find that countries with explicit deposit insurance schemes are particularly at risk.

The first study on the use of FSIs as indicators of potential banking sector crises is provided by Čihák and Schaeck (2007). They run the first tests on the ability of FSIs to explain the emergence of banking crises. However, they use FSIs that were not compiled under a commonly accepted international methodology. Therefore, some FSIs are not strictly comparable.<sup>2</sup> Similar to Demirgüç-Kunt and Detragiache (1998), they run a multivariate logit model, but they include FSIs as explanatory variables in addition to macroeconomic indicators. They find that the CAR and the NPL ratio provide signals for systemic banking problems, and that the ROE of banks serves as an indicator for the timing of a crisis.

Following the pioneering work of Čihák and Schaeck (2007), Babihuga (2007) tests FSIs against a number of macroeconomic indicators and finds that FSIs fluctuate strongly with the business cycle and the inflation rate. Sun (2011) investigates FSIs at the individual bank level for a list of global financial institutions, and finds that leverage indicators are the most reliable.<sup>3</sup>

Other studies look at the relationship between firm-specific indicators and financial stability. Bunn and Redwood (2003) use a probit model to assess the determinants of failure amongst UK companies, where their explanatory variables include firm-specific factors and macroeconomic conditions. They find a negative relationship between profitability and corporate failure, and a positive relationship between the debt to assets ratio and the

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<sup>2</sup> Differences within the data set include institutional coverage, inter-group consolidation adjustments, and accounting differences under the International Financial Reporting Standards (IFRS).

<sup>3</sup> Leverage indicators in the study include debt to common equity, debt to assets, long-term debt to capital, short-term and current portfolio long-term debt to total debt, and cost of debt.

probability of failure. By industry, they find that firms in the services sector are less likely to fail than those in manufacturing and utilities. Bonfim (2009) studies credit risk drivers in a panel data set of Portuguese firms, and finds that both firm-specific and macroeconomic conditions are important determinants of default probabilities over time.

The remainder of the paper is organized as follows. Section II discusses the usefulness of FSIs in the context of financial stability. Section III describes the data used in the econometric analysis. Section IV provides an overview and descriptive statistics of the data. Section V focuses on the empirical model and presents estimation results. Finally, Section VI concludes and discusses directions of further research.

## II. FSIS AND FINANCIAL STABILITY

FSIs are aggregate measures of the health of a country's financial sector that comprise a key and integral part of a regulatory authority's macroprudential surveillance toolkit. The collection of FSIs dates back to 1999, when the IMF and the World Bank launched the Financial Sector Assessment Program (FSAP) to monitor financial system fragility. A subset of FSIs was collected as part of the FSAP, but inconsistency in the data collection methodology hindered cross-country comparisons of data. Following broad consultations in 2000, the IMF, in collaboration with the International Accounting Standards Board (IASB), the Bank for International Settlements (BIS), the Basel Committee for Banking Supervision (BCBS), and other international and regional organizations drafted a guide on concepts, definitions, data sources, and techniques for FSI compilation.<sup>4</sup>

A consistent set of guidelines has since been established in the Financial Soundness Indicators Compilation Guide published in 2006 (FSI Compilation Guide) and its amendments,<sup>5</sup> and the IMF maintains an expanding database of countries that adhere to the methodology and standards specified in the guide. As the regional coverage of FSIs and the number of indicators increase, key regulatory concerns are whether FSIs are effective forward-looking indicators of financial sector distress, and if so, which FSIs are particularly effective.

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<sup>4</sup> See *Financial Soundness Indicators: Experience with the Coordinated Compilation Exercise and Next Steps* (<http://www.imf.org/External/NP/pp/2007/eng/101807a.pdf>); *Financial Soundness Indicators: Policy Paper* (<http://www.imf.org/external/np/mae/fsi/2001/eng/pp.pdf>); *Financial Soundness Indicators* (<http://www.imf.org/external/np/sta/fsi/eng/2003/051403.pdf>).

<sup>5</sup> The FSI guide is available from the IMF website: <http://www.imf.org/external/pubs/ft/fsi/guide/2006/index.htm>. Amendments to the FSI guide are available at: <http://www.imf.org/external/pubs/ft/fsi/guide/2008/pdf/071408.pdf>.

FSIs are split into two sets of core and encouraged indicators, and currently 80 countries report FSIs on a regular basis to the IMF.<sup>6</sup> The core FSIs are collected by all the reporting countries while encouraged indicators are collected on a country-by-country basis depending on financial sector sophistication and data availability. There are 12 core FSIs that span deposit-taking institutions, and these FSIs cover capital adequacy, asset quality, earnings and profitability, liquidity, and sensitivity to market risk.<sup>7</sup> Additionally, there are 28 encouraged FSIs defined for deposit-taking institutions, other financial corporations, nonfinancial corporations, households, market liquidity, and real estate markets.

The introduction of Basel III in response to the rapidly changing financial environment has resulted in some key forward-looking redefinitions of core and encouraged FSIs. These revisions are led by the IMF in close collaboration with a broad-based group of experts, international standard setting bodies, FSI-reporting countries, and concerned international organizations.<sup>8</sup> Basel III has placed a greater emphasis on common equity in regulatory capital calculations, and the method of measuring the capital base has changed in favor of a narrower definition. In addition, a new counter-cyclical buffer has been introduced. With regard to liquidity standards, Basel III has introduced two internationally harmonized global standards—the liquidity coverage ratio and the net stable funding ratio—as complements to the capital adequacy requirements. Further forward-looking revisions enhance the usefulness of FSIs by including distribution and concentration measures.

The fundamental value of FSIs lies in their properties potentially to indicate overall distress within a banking sector, and in their ability to differentiate between strong and weak banks through comparisons across indicators. FSIs for individual institutions would in principle help country authorities to address emerging issues in time. In addition to their signaling value, FSIs are useful tools for monitoring the overall health of a given banking sector. Even though defaults are likely to occur in the weaker institutions of the banking sector, a *systemic* crisis is likely to affect aggregate measures of the entire sector's health. Therefore, FSIs should be correlated with crisis episodes or banking sector shocks, and this paper examines which indicators exhibit the highest levels of correlation with past crises. Further, it explores whether some FSIs can be leading indicators of crises.

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<sup>6</sup> FSI data are publicly available from the IMF website: <http://fsi.imf.org/>.

<sup>7</sup> See Appendix I for details.

<sup>8</sup> See International Monetary Fund, 2013, *Modifications to The Current List of Financial Soundness Indicators*; International Monetary Fund, 2013, *Modifications to The Current List of Financial Soundness Indicators – Background Paper*.

### III. DATA

#### A. FSI and Macroeconomic Data

The core data set used in this study comprises of 80 countries that report FSIs to the IMF between 2005 and 2012.<sup>9</sup> The majority of the FSI reporting countries are European, and only 6 percent are African. Six FSIs are used in the econometric analysis, including CAR, NPLs net of provisions to capital, NPL ratio, ROE, interest margin to gross income, and non-interest expenses to gross income. While the IMF collects data for a larger set of core and encouraged FSIs, data limitations preclude an analysis of the remaining indicators. Further, while the first data points are available in 2005, some countries in the sample do not report FSI data until 2008.

Annual FSI data for core and additional indicators are combined with macroeconomic indicators—GDP growth, broad money to international reserves ratio, inflation rate, credit to the private sector, current account balance to GDP ratio, real effective exchange rate, sovereign credit default swap spreads, and the monetization ratio<sup>10</sup>—taken from the IMF’s International Financial Statistics database (IFS), the World Bank’s World Development Indicators database (WDI), and Bloomberg.

Additionally, governance indicators are added to the data set to account for cross-country institutional differences. Three indicators that are likely to have an impact on the banking sector—regulatory quality, rule of law, and control of corruption—are taken from the World Bank’s Worldwide Governance Indicators. Each indicator is normalized with a mean zero and a standard deviation of one. As the indicators are highly correlated, a composite index is created as the unweighted average of the three indicators for econometric analysis. The overall choice of macroeconomic and governance variables is driven by the existing empirical literature on the determinants of financial and banking crises, as well as data availability considerations.

The dependent variable in this analysis is a binary outcome indicating the occurrence of a banking crisis as described in Laeven and Valencia (2012). They describe a banking crisis as systemic if two conditions are met: 1) there are significant signs of distress in the banking system, evidenced through bank runs, losses or liquidations; and 2) there are significant banking policy intervention measures in response to losses in the banking system.

Following Boyd et al. (2009), this paper also defines a banking shock as a significant annual decrease in gross loans outstanding, taking thresholds of 10 percent and 20 percent over the

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<sup>9</sup> See Appendix IIA for details.

<sup>10</sup> The monetization ratio is defined as the ratio of broad money to GDP. Detailed variable definitions are given in Appendix VII.

period 2005–12. The authors pick this threshold on the basis that a policy response does not indicate the beginning of a crisis, but rather occurs with a significant time lag after a crisis begins. The details of crisis episodes using these two methods are identified in Appendix III. Notably, there is very little overlap in systemic crisis episodes identified between these methods, as Boyd et al. (2009) underscored.

The core data set is combined with additional FSI data collected for the IMF’s Global Financial Stability Report (GFSR) to create an extended data set covering 108 countries over the same time period.<sup>11</sup> Two sets of data are also collected for analysis on a temporal basis, an annual data set and a quarterly data set. Details on data collection and the treatment of data gaps are given in Appendix V.

## **B. Consolidation of FSI Data**

Financial systems are complex, and financial risks and exposure may span multiple economic territories. It is important to ensure that data are consolidated to capture financial exposure that may extend beyond a given country’s economic territory. Allowing a country to select the correct consolidation basis ensures a more holistic coverage of the financial sector on a country by country basis.

FSI are compiled using a consolidation methodology that is specified under the FSI Compilation Guide. There are five consolidation bases, namely: Domestically Consolidated (DC); Domestically Controlled, Cross-border, Cross Sector (DCCBS); Domestically Controlled, Cross-border (DCCB); Cross-border, cross-sector consolidation basis for all domestically incorporated entities (CBCSDI); and Cross-border consolidation basis for all domestically incorporated entities (CBDI). The most commonly used of all consolidation bases is DC, which refers to all deposit-taking entities (subsidiaries or branches) operating within the domestic economy. The other consolidation bases include deposit-taking foreign branches and subsidiaries; other branches and subsidiaries in financial intermediation beyond deposit-taking; and differentiate between domestically controlled and foreign controlled entities.

It is important to note that the use of different consolidation bases does not make FSI data incomparable across countries.<sup>12</sup> A country selects the most appropriate consolidation basis according to its financial system infrastructure, and a country may opt for a given consolidation basis simply because it estimates that its risk exposure across other dimensions is not significant. For example, advanced economies are likely to have significant cross-

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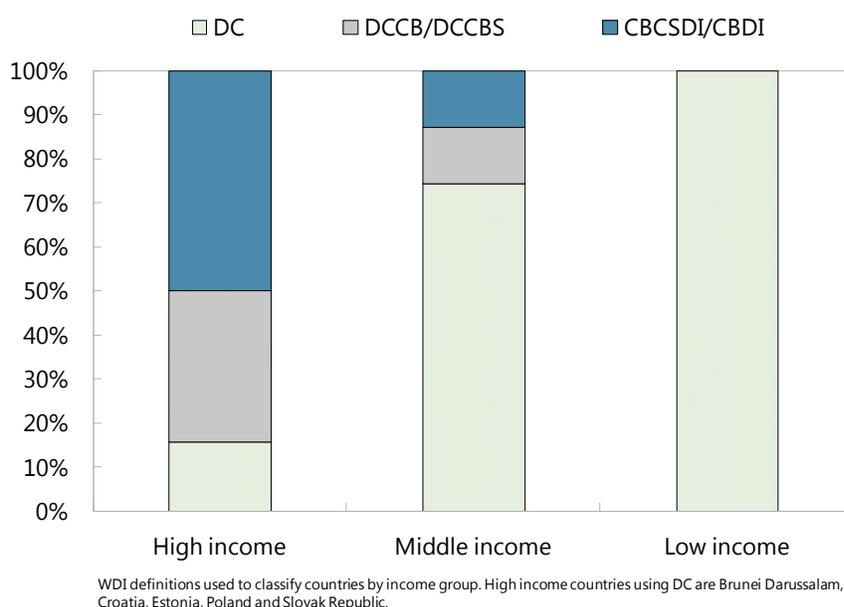
<sup>11</sup> The list of the additional countries included in the extended data set is provided in Appendix IIB.

<sup>12</sup> Within countries, different consolidation bases may be used for different indicators depending on data availability.

country exposure and significant exposure beyond deposit-taking institutions. These economies use the CBCSDI consolidation basis, which covers financial sector risks across borders and across sectors for all domestically incorporated financial institutions. Conversely, developing economies are likely to have most financial exposure concentrated within the domestic economy, and consequently use the DC consolidation basis.

The recommended consolidation bases within the FSI Compilation Guide are CBCSDI and DCCBS, as these have the largest coverage across sectors and borders. Figure 1 illustrates the distribution of consolidation bases by per-capita income across FSI reporting countries, which is likely to be correlated with the degree of financial system sophistication.

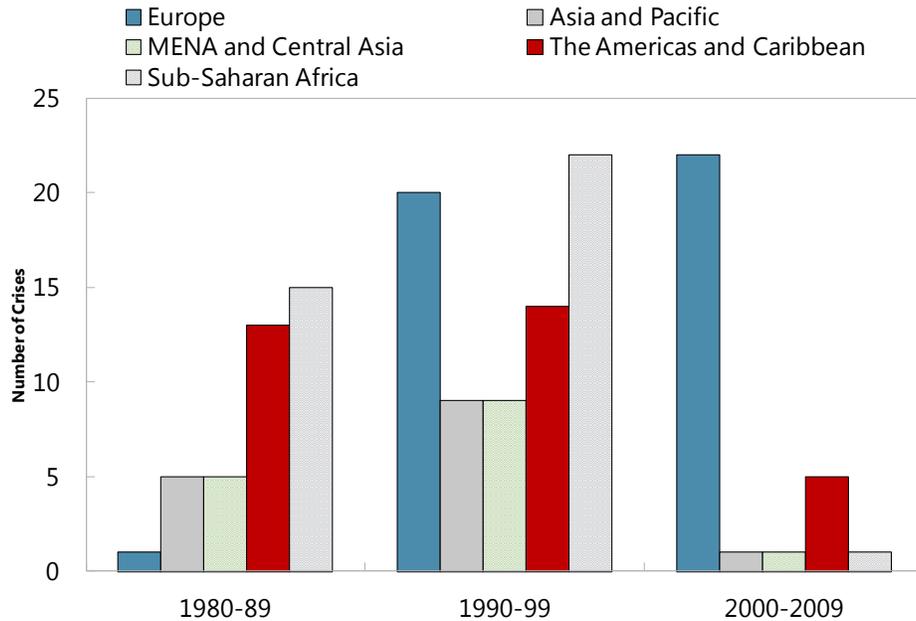
**Figure 1: Distribution of Consolidation Bases by Income Group**



## IV. SUMMARY STATISTICS

### A. A Comparison of Crisis and Non-Crisis Countries

In contrast to previous periods of banking sector fragility across the world, banking crises over the decade 2000–09 were concentrated in European countries (Figure 2). European countries have seen a steady increase in banking sector fragility since the 1980s, when they enjoyed the highest levels of banking stability. Almost three-quarters of all financial crises experienced over the decade 2000–09 were experienced in Europe. Of these crises, 55 percent occurred within Euro area countries. The extraordinary turmoil during this decade was also concentrated in 2008, when three-quarters of the crisis events occurred.

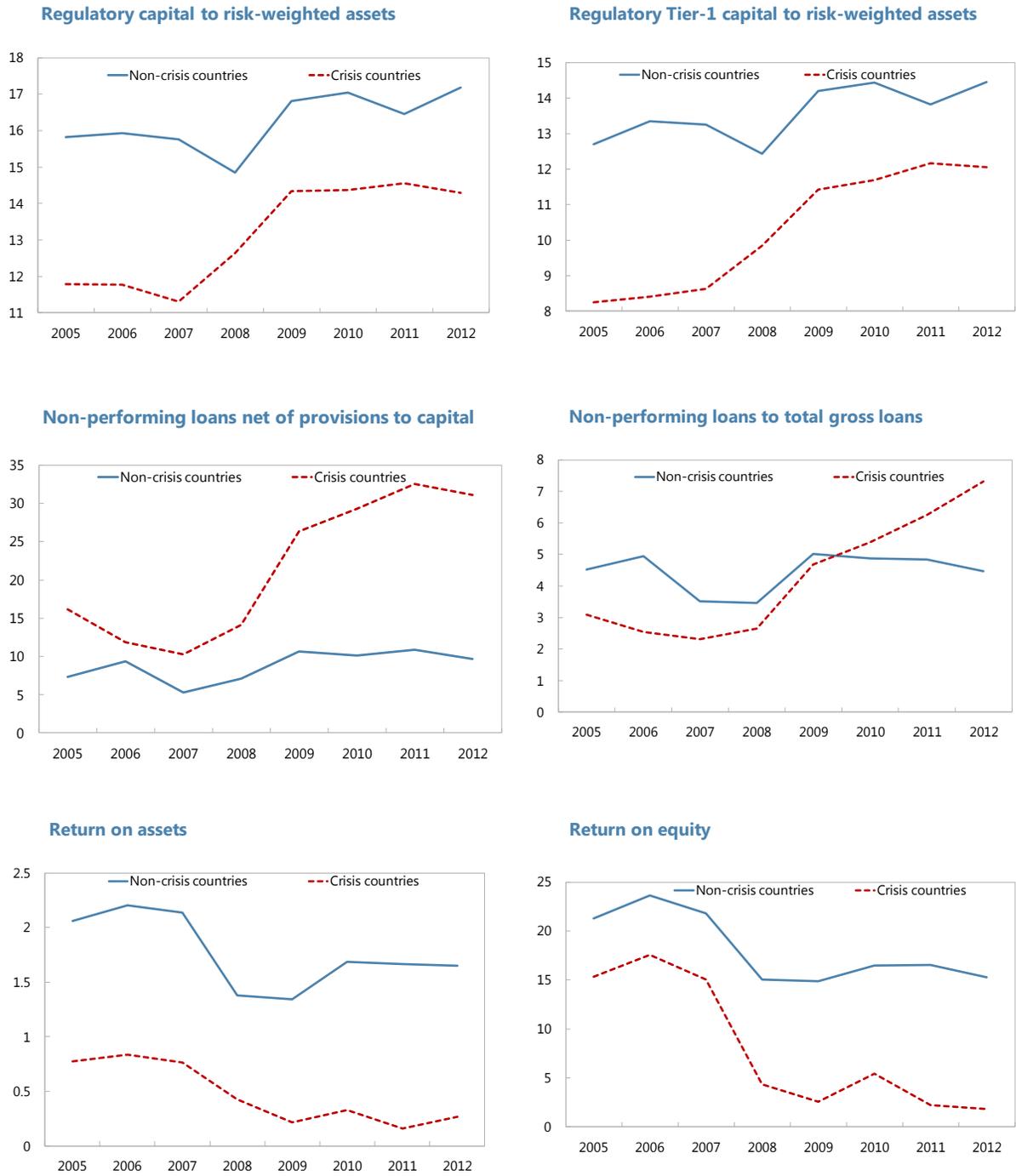
**Figure 2: Historical Timeline of Banking Crises**

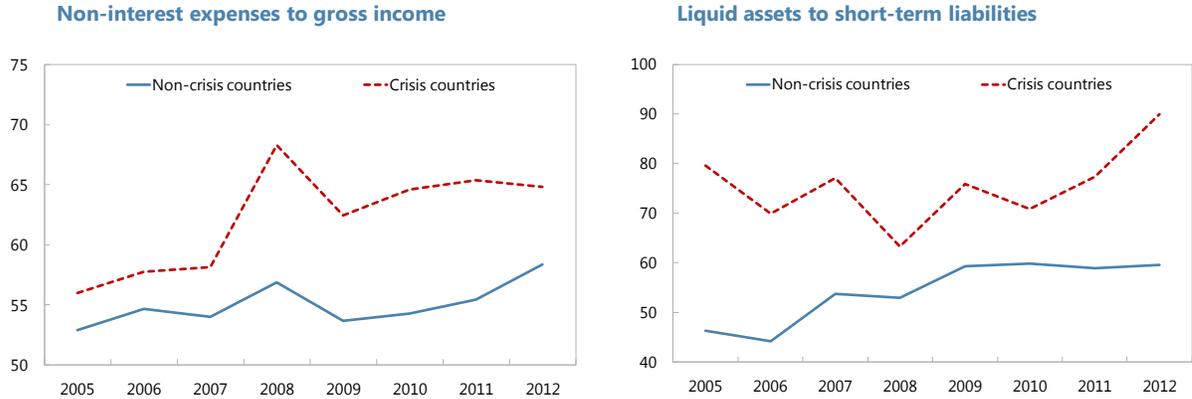
Notes & Sources: Banking crises are defined according to Laeven and Valencia 2012. IMF regions are used for categorization of countries.

Figure 3 illustrates the temporal evolution of FSIs amongst FSI reporting countries, where crisis countries are defined as those that experienced one or more banking crises between 2000 and 2009, and non-crisis countries are those that did not experience any crisis over the same period.<sup>13</sup> Crisis countries had on average lower levels of CAR than non-crisis countries, but all countries responded to the 2007 banking crisis with a marked increase in regulatory capital.

<sup>13</sup> A list of countries that experienced financial crises since 2005 is given in Appendix III. Additionally, Uruguay and the Dominican Republic experience crises in 2002 and 2003 respectively.

**Figure 3: FSIs over Time for Crisis and Non-Crisis Countries**





**Notes & Sources:** Graphs plot percent indicators versus years. FSI data from IMF database; banking crises are defined according to Laeven and Valencia (2012). Panels include: regulatory capital to risk-weighted assets; regulatory tier-1 capital to risk-weighted assets; non-performing loans net of provisions to capital; non-performing loans to total gross loans; return on assets; return on equity; non-interest expenses to gross income; and liquid assets to short-term liabilities. FSI data are based on 80 reporting countries. Outliers in the 1<sup>st</sup> and 99<sup>th</sup> percentile are excluded. Ukraine is excluded due to significant changes in methodology.

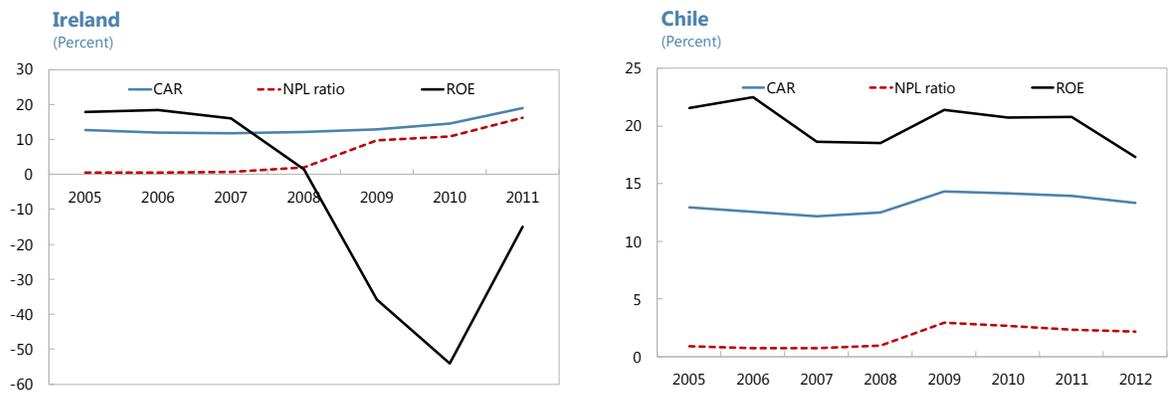
NPLs net of provisions to capital and the NPL ratio increased more rapidly in crisis countries after the 2007 banking crisis, and showed a sustained increase over subsequent years. Return on assets (ROA) and return on equity (ROE) were higher in non-crisis than in crisis countries, although both indicators declined prior to the beginning of the crisis. Non-interest expenses to gross income were higher in crisis countries, and the gap between the two groups increased during the crisis. Crisis countries had better coverage of liquid assets to short-term liabilities (liquidity coverage ratio), although both groups had liquidity coverage ratios below one.

With the exception of the liquidity coverage ratio, the above indicators are aligned with the theory and the existing literature. Non-crisis countries enjoy higher levels of liquid assets, but also maintain higher exposure to short-term liabilities than crisis countries. The liquidity coverage ratio is explained by the fact that crisis countries keep a higher relative level of liquid assets to cover liabilities than non-crisis countries. Within a signaling framework in a world of imperfect information, better banks are able to signal their quality through their performance and the levels of their indicators. A possible explanation for the higher liquidity coverage within crisis countries may be credit rationing. Given that weaker banks are likely to be credit rationed in the event of short-term liquidity shocks, weaker banks may be forced to maintain higher liquidity coverage ratios to overcome any shocks.

In comparison to Čihák and Schaeck (2007), NPL ratios and ROE follow similar patterns. Counter-intuitively, Čihák and Schaeck find that regulatory capital levels are higher in crisis than non-crisis countries within their sample.

Figure 4 illustrates a comparison of two countries: Ireland and Chile. Crisis shocks were concentrated within the Euro area, where Ireland was severely affected by the banking crisis. Conversely, Chile experienced a relatively moderate contraction. The figure compares CAR, NPL ratio and ROE for these countries. Of the indicators, ROE drops precipitously in Ireland, and remains negative for a prolonged period beginning in 2008. In contrast, ROE in Chile remains relatively stable over 2005–2012. The NPL ratio is below 1 percent in Ireland prior to 2008, but jumps significantly thereafter, and continues rising above 10 percent. In contrast, Chile’s NPL ratio increases in 2008 but subsequently stabilizes at a level below 5 percent. For both Ireland and Chile, the CAR does not exhibit a significant drop prior to the banking crisis, but there is an increase in each country’s CAR immediately following the crisis shock.

**Figure 4: Comparison of Ireland and Chile**



## B. Description of Core FSIs

The core FSIs used in the analysis exhibit a number of interesting patterns by region and income group. Capital adequacy levels were lowest in high income countries over the sample period. By region, CAR was lowest in Europe and highest in the MENA and Central Asia regions. NPLs net of provisions to capital levels were highest in low and middle-income countries before the crisis, but were surpassed by levels in high-income countries after the start of the crisis. Both NPLs net of provisions and the NPL ratio declined at the beginning of the crisis but subsequently increased across all regions and income groups.

ROE declined consistently during the crisis years, most visibly in Europe. ROE was consistently higher in low and middle-income countries between 2005 and 2012, and was highest in sub-Saharan Africa. Without exhibiting any clear patterns by region, interest margin to gross income showed an increasing trend throughout the sample period. Non-interest expenses to gross income ratios suggest that banks were more efficiently run in low and middle-income countries than in high-income countries as measured by this metric. Appendix IV gives summary statistics of the core FSI indicators used in this paper by income

and region. WDI definitions are used to classify countries by income, and IMF regions are used for regional classification.

## V. ECONOMETRIC ANALYSIS

The econometric analysis in this paper assumes that the true likelihood of a financial or banking crisis  $y$  is a function of a set of industry-specific indicators  $Z$ , and economy-wide indicators  $X$  as given by:<sup>14</sup>

$$y = \alpha + X'\beta + Z'\gamma + u$$

However, the observed likelihood of a banking crisis is given by economy-wide indicators  $X$  and  $Q$  as follows:

$$y = \tilde{\alpha} + X'\tilde{\beta} + Q'\tilde{\gamma} + v$$

where  $\forall z_i \in Z$

$$z_i = a_i + Q'b_i + e_i$$

and where  $e_i$  are error terms, and  $E(y | X, Z, Q) = E(y | X, Z)$ . Conditional on observing industry-specific indicators, the economy-wide indicators carry no additional information. If the industry specific indicators  $Z$  are unobserved then economy-wide indicators  $Q$  are used as proxy variables and the proxy variable coefficients are biased (a simple proof is given in Appendix VI). FSIs are industry-specific indicators that overcome the bias problem that arises when only economy-wide indicators are used to estimate the likelihood of a banking crisis.

To test the early warning properties of selected FSIs, this paper estimates a multivariate logit model to predict banking crises, where the likelihood of observing a crisis in country  $i$  at time  $t$  is modeled as a function of macroeconomic indicators and selected FSIs.

The dependent variable is encoded as a '1' if a crisis event occurs and as a '0' for a non-crisis period. The explanatory variables include a set of FSIs, as well as macroeconomic indicators.<sup>15</sup> Due to data constraints, the sets of FSIs and macroeconomic variables are limited. Six core FSIs are included in the analysis which measure capital adequacy, asset quality, and earnings and profitability. Due to the incidental parameters problem, maximum

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<sup>14</sup> Defaults in the banking sector can arise for a number of reasons. Exogenous shocks in other sectors to which the banking sector is exposed can trigger defaults. Within the banking sector itself, poorly capitalized or mismanaged banks can experience distress.

<sup>15</sup> Appendix VII provides details of explanatory variables.

likelihood estimates are inconsistent for a fixed effects logit model with fixed time  $T$ .<sup>16</sup> For a dependent variable  $y_{it}$ , Chamberlain (1980) shows that  $S_i = \sum_{t=1}^T y_{it}$  is sufficient for the incidental parameters, which correspond to the time invariant effects. However, the distribution of data conditional on  $S$  excludes all countries that do not experience any crisis over the sample period.<sup>17</sup> Following Demirgüç-Kunt and Detragiache (1998), this paper excludes country fixed effects to avoid selecting a biased sample of only countries that experienced crises.

Additionally, crisis episodes are concentrated around 2008 within the data set. This restricts the ability of the model to include time dummies as maximum likelihood estimates are unbounded for all years during which a crisis does not occur. For example, if there are no crisis events in 2005, then the probability of a crisis is zero, and the log-odds ratio is unbounded. Any other variables over which complete or partial separation occurs are also excluded, where separation refers to a rule that can partition the data set into two distinct crisis and non-crisis subsets for a given explanatory variable. For the above reasons, the paper selects a multivariate pooled logit model.<sup>18</sup>

Model estimation is carried out in two stages. In the first stage, regressions are run on FSIs against a time trend by country and residuals obtained. In the second stage, logit regressions are run on banking crisis events against the FSI residuals and lagged year-on-year differences in macroeconomic indicators and the governance composite indicator. This model specification tests whether volatility in indicators is correlated with the occurrence of crisis events, while correcting for time trends in the data. Year-on-year differences in FSIs are not used due to data constraints: of the countries that experience banking crises, many only start reporting FSIs on the year during which the crisis occurs.

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<sup>16</sup>Information about incidental parameters stops accumulating after a finite number have been taken. Neyman and Scott (1948) describe the general incidental parameters problem. Hsiao (2003) gives a simple illustration of inconsistency of the maximum likelihood estimates for a logit model with one regressor that is observed over two periods.

<sup>17</sup> Any country that experiences a crisis during every period of the sample would also be dropped. A simple illustration can be given for time  $T = 2$ . Conditional on  $y_{i1} + y_{i2} = 0$ , the probability that  $y_{i1}$  and  $y_{i2}$  are zero equals 1. Similarly, conditional on  $y_{i1} + y_{i2} = 2$ , the probability that  $y_{i1}$  and  $y_{i2}$  are 1 equals 1. The log likelihood for both types of observations is zero conditional on the sum of the dependent variable over  $T$  (Chamberlain, 1980). Thus, the terms add nothing to the conditional loglikelihood.

<sup>18</sup> For example, stock market volatility can be modeled by including the volatility index (VIX). However, in any year in which the sample does not have any crisis observations, the crisis variable is completely determined; that is, the probability of a crisis is zero conditional on the VIX observation for the year. The logit coefficient in this instance is minus infinity.

## Results

The results indicate significant correlation between some FSIs and crises; specifically, CAR and ROE show significant negative contemporaneous correlation with the occurrence of banking crises. Additionally, lagged ROE is a significant leading indicator of crises. While the sample period of this analysis corresponds to the global financial crisis of 2007, these results mirror the findings of Čihák and Schaeck (2007), who perform an analysis of global crises over the 1990s.

Logit model results are given in Table 1 for 80 countries that compile and report FSIs to the IMF following a consistent accounting and consolidation methodology. Estimates are given for six FSIs: CAR, NPLs net of provisions to capital, NPL ratio, ROE, interest margin to gross income, and non-interest expenses to gross income. Results are presented from an initial parsimonious specification in models I and II that includes common macroeconomic indicators and the composite governance indicator. Models III and IV expand the list of independent variables to include contemporaneous FSIs, and models V and VI include FSIs lagged by one period. Due to multicollinearity, regressions including both FSIs and lagged FSIs are not estimated.<sup>19</sup> There is significant variation in the number of crises included in models I through IV, and models V and VI respectively, due to data limitations. The regressions in models V and VI are therefore less indicative as they include almost half the number of crisis observations in models I through IV.

Model results show correlation between some FSIs and banking crises. The CAR, ROE and non-interest expenses to gross income show significant contemporaneous correlation with the occurrence of crises, and additionally, lagged ROE is a significant leading indicator of banking crises. Consistent with theory, the coefficients of CAR and ROE are negative, indicating that a decline of each of these FSIs corresponds to a potential crisis. The coefficients also suggest that small changes in CAR have large effects on the probability of default. Results also indicate that an increase in non-income expenses to gross income corresponds to a higher likelihood of banking crises. The coefficient of lagged ROE is positive, consistent with the theory that periods prior to banking crises correspond to high returns and high concomitant risk within the banking sector.

Of the macroeconomic control variables, inflation, monetization and the ratio of broad money to international reserves are positive and significant in some model specifications. However, no macroeconomic variables are consistently significant in all models. The composite governance indicator is insignificant.

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<sup>19</sup> Multicollinearity is identified due to high variance inflation factors between FSIs and lagged FSIs.

Logit model results are presented in Table 2 for three indicators that are included in the IMF's Global Financial Stability Report (GFSR). FSIs for an additional 28 countries are combined with the core FSI data set for a total of 108 countries. The additional FSIs are not guaranteed to follow a consistent methodology as followed within the core FSI data set, but the models are estimated due to the additional coverage by region and by size of economy over time. The FSIs included are CAR, NPL ratio and ROE. Similar to the core FSI data set, six model specifications are estimated.

Results of the analysis based on the extended data set suggest that CAR, NPL ratio and ROE for depository corporations provide signals of the likelihood of occurrence of banking crises. Of the lagged variables, only ROE seems to be an early warning indicator. The NPL ratio is significant with a negative sign, and may indicate the refinancing of loans or a transfer of poor quality loans off balance sheet during restructuring measures taken during periods of heightened distress. Of the macroeconomic control variables inflation and credit to the private sector are significant in some model specifications. No macroeconomic control variables are significant across all model specifications, and the composite governance indicator is insignificant across all specifications.

The performance of the logit regressions is assessed based on model chi-squared and Akaike's Information Criterion (AIC). The chi-squared suggests that the null hypothesis that all partial slope coefficients are equal to zero can be rejected for all model specifications of Tables 1 and 2. The AIC penalizes regression models for adding regressors, and the model with the lowest AIC is preferred. According to the AIC, specifications including FSIs tend to perform better than specifications without FSIs. All model specifications have a strong capacity to classify non-crisis events, but do not accurately classify crisis events. However, the classification accuracy of crisis events jumps significantly for model specifications that include FSIs in comparison to those specifications that do not include FSIs. The performance suggests that FSIs add predictive power beyond estimates obtained solely using macroeconomic indicators.

### **Robustness**

In addition to annual data, the analysis has been conducted using a quarterly data set over the period 2005 Q1 through 2012 Q4 for both FSI reporting countries and the GFSR set of countries. The results are in line with those given in Tables 1 and 2.

In addition to testing differences in FSIs, models are estimated to test the ability of FSI and macroeconomic variable levels to predict banking crises. Logit estimates are consistent but inefficient if there is time dependence, and Poirier and Ruud (1998) show that standard errors are wrong. This paper corrects the standard errors by using robust standard errors clustered around observations by country. Additionally, the duration since the last crisis and the

number of past crises in each country since 1970 are included as explanatory variables.<sup>20</sup> CAR and ROE remain significant in these models.

Additional robustness tests were conducted by including regional dummy variables, the Volatility Index (VIX), the ratio of external debt to GDP, and return on assets. Regional dummy variables and the VIX were dropped from the analysis due to separation within the annual data set. For example, there are no crisis observations within the Asia and Pacific, Middle East and Central Asia, and sub-Saharan Africa regions.<sup>21</sup> External debt to GDP is insignificant, and is dropped from the results as both the coefficient and standard error are quite large, indicating convergence problems. Return on assets is dropped from the analysis due to a strong positive correlation with return on equity.

A comparison of the same regression specifications as Čihák and Schaeck (2007) is given in Table 3. The Results show that contemporaneous CAR and NPL ratio, and lagged CAR and ROE for deposit taking institutions have significant explanatory power. Of the macroeconomic control variables, M2 to international reserves, real GDP per capita, and GDP growth are significant in some specifications. In contrast to Čihák and Schaeck (2007), the coefficient on lagged ROE is positive and the coefficient on contemporaneous NPL ratio is negative.

## VI. FINAL REMARKS

Our analysis adds to the burgeoning literature on the usefulness of FSIs. The analysis is the first to make use of a data set of FSIs collected under an internationally accepted methodology. Consistent accounting, aggregation and consolidation principles allow cross-country comparability of FSIs, and a coherent consolidation basis methodology ensures that indicators are sensitive to financial sector risk exposure both within and beyond each country's economic territory.

By estimating a simple multivariate logit model on FSI indicators and macroeconomic control variables, the paper demonstrates that FSIs are contemporaneously correlated with the occurrence of banking crises. Specifically, CAR and ROE show a negative correlation with crisis episodes across a number of model specifications. The analysis also indicates that

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<sup>20</sup> An alternative solution as shown by Beck et al. (1998) is to include a series of dummy variables marking the number of periods that have passed since the last crisis occurrence in each country. This specification is argued to be equivalent to a duration model. This solution is not adopted as the crisis variable is completely determined for a subset of the dummy variables.

<sup>21</sup> There are no crisis observations within the core data set for sub-Saharan Africa, but Nigeria is included in the extended data set. Observations for Kazakhstan are dropped in 2007 as FSIs are outliers in the 99.5<sup>th</sup> percentile.

lagged ROE may be a leading indicator of banking crises. These findings resonate with Čihák and Schaeck (2007).

While the results offer support for the usefulness of FSIs, the analysis was hampered by a lack of sufficient data to include a larger set of core and encouraged FSIs. Coverage of core and encouraged FSIs is limited by gaps in historical reporting of FSIs, and in many countries consistent reporting only begins after 2008. The analysis would benefit from compilation of historical FSI data for all countries with data gaps prior to the banking crisis shock. Macroprudential regulation and future research on FSIs will also benefit from increased coverage of FSIs across countries and across various sectors within financial intermediation going forward, as well as a longer time-series of data.

**Table 1: Logit Model Results for FSI Data**

<b>Variable and expected sign</b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>IV</b>	<b>V</b>	<b>VI</b>
Capital/risk weighted assets			-3.147*** (1.029)	-3.338*** (1.153)		
Nonperforming loans net provisions to capital			-0.109 (0.171)	-0.131 (0.180)		
Nonperforming loans/total loans			0.165 (0.675)	0.238 (0.704)		
Return on equity (banks)			-0.252** (0.117)	-0.255** (0.114)		
Interest margin to gross income			-0.100 (0.097)	-0.096 (0.102)		
Non-interest expenses to gross income			0.220** (0.105)	0.221** (0.107)		
<b>Risk-weighted assets</b>			0.100 (0.065)	0.102 (0.063)		
Capital/risk weighted assets (t-1)					-2.137 (1.388)	-2.286 (1.531)
Nonperforming loans net provisions to capital (t-1)					-0.414 (0.253)	-0.407 (0.256)
Nonperforming loans/total loans (t-1)					2.160 (1.663)	2.206 (1.770)
Return on equity (banks) (t-1)					0.435** (0.180)	0.487** (0.225)
Interest margin to gross income (t-1)					0.163 (0.176)	0.146 (0.171)
Non-interest expenses to gross income (t-1)					-0.178 (0.163)	-0.166 (0.157)
<b>Risk-weighted assets (t-1)</b>					0.190 (0.161)	0.170 (0.161)
GDP growth (real) (t-1)	-0.006 (0.085)	-0.005 (0.085)	-0.191 (0.171)	-0.205 (0.171)	0.171 (0.198)	0.164 (0.195)
Broad money/international reserves (t-1)	0.055 (0.042)	0.056 (0.041)	0.121* (0.063)	0.120* (0.063)	0.007 (0.076)	0.003 (0.077)
Inflation (t-1)	0.099 (0.110)	0.100 (0.110)	0.544* (0.279)	0.568** (0.284)	0.241 (0.271)	0.254 (0.267)
Credit to the private sector (t-1)	0.080 (0.067)	0.084 (0.068)	0.117 (0.120)	0.134 (0.123)	0.170 (0.159)	0.195 (0.170)
Current account balance / GDP (t-1)	-0.027 (0.126)	-0.024 (0.126)	0.175 (0.240)	0.202 (0.253)	0.489 (0.356)	0.447 (0.380)
Monetization (t-1)	0.072 (0.045)	0.071 (0.045)	0.143* (0.079)	0.136* (0.079)	0.060 (0.097)	0.054 (0.101)
Real exchange rate (t-1)	0.074 (0.056)	0.074 (0.056)	0.026 (0.102)	0.019 (0.104)	-0.008 (0.161)	-0.030 (0.163)
Credit default swap spread (t-1)	-0.001 (0.002)	-0.001 (0.002)	0.001 (0.004)	0.001 (0.004)	-0.008 (0.006)	-0.008 (0.007)
<b>Composite governance indicator (t-1)</b>		-0.950 (2.907)		-2.937 (5.562)		-3.637 (7.189)
Constant	-4.176*** (0.612)	-4.178*** (0.614)	-8.660*** (2.262)	-8.804*** (2.345)	-8.260*** (2.440)	-8.285*** (2.474)
N	231	231	231	231	205	205
Number of crises	11	11	11	11	7	7
Type I Error (percent)	0.46%	0.46%	0.46%	0.46%	0.00%	0.00%
Type II Error (percent)	90.91%	90.91%	36.36%	36.36%	42.86%	42.86%
Chi-squared	16.57**	16.69*	55.87***	56.18***	38.78***	39.08***
Akaike Information Criterion	0.389	0.397	0.28	0.287	0.265	0.273
McFadden R-squared	0.187	0.189	0.632	0.635	0.635	0.64

Notes & Sources: FSI data correspond to 80 reporting countries from IMF database; macroeconomic variables from WDI and IMF IFS; banking crisis data from Laeven and Valencia (2012). \*\*\*, \*\*, and \* are levels of significance at 1%, 5% and 10% respectively. Robust standard errors are given in parentheses. 1<sup>st</sup> and 99<sup>th</sup> percentiles of observations are excluded from the analysis. FSI variables are residuals from country-by-country regressions of FSIs to a time trend. Models III and IV include contemporaneous FSIs and Models V and VI include FSIs lagged by one period. All macroeconomic variables are year on year differences lagged by one period. The composite governance indicator is the unweighted average of regulatory quality, rule of law and control of corruption. Macroeconomic variable definitions are given in Appendix VII.

**Table 2: Logit Model Results for Extended FSI data**

Variable and expected sign	I	II	III	IV	V	VI
Capital/risk weighted assets			-0.563* (0.299)	-0.536* (0.305)		
Nonperforming loans/total loans			-0.649** (0.258)	-0.714*** (0.268)		
Return on equity (banks)			-0.113* (0.058)	-0.136** (0.063)		
Capital/risk weighted assets (t-1)					-0.417 (0.359)	-0.482 (0.365)
Nonperforming loans/total loans (t-1)					0.046 (0.328)	-0.013 (0.331)
Return on equity (banks) (t-1)					0.170** (0.068)	0.158** (0.069)
GDP growth (real) (t-1)	-0.038 (0.078)	-0.044 (0.080)	-0.075 (0.099)	-0.083 (0.104)	-0.061 (0.093)	-0.063 (0.096)
Broad money/international reserves (t-1)	0.054 (0.039)	0.052 (0.039)	0.050 (0.042)	0.051 (0.043)	0.031 (0.047)	0.029 (0.047)
Inflation (t-1)	0.116* (0.064)	0.117* (0.066)	0.066 (0.064)	0.062 (0.066)	0.092 (0.070)	0.093 (0.072)
Credit to the private sector (t-1)	0.116** (0.046)	0.112** (0.046)	0.088 (0.053)	0.080 (0.054)	0.0952* (0.057)	0.090 (0.058)
Current account balance / GDP (t-1)	-0.006 (0.095)	-0.013 (0.097)	0.039 (0.099)	0.033 (0.102)	0.058 (0.115)	0.056 (0.117)
Monetization (t-1)	0.039 (0.039)	0.041 (0.040)	0.067 (0.043)	0.070 (0.043)	0.060 (0.043)	0.062 (0.043)
Real exchange rate (t-1)	0.065 (0.044)	0.067 (0.044)	0.052 (0.048)	0.057 (0.050)	0.040 (0.054)	0.045 (0.055)
Credit default swap spread (t-1)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.001 (0.002)	-0.002 (0.002)	-0.002 (0.002)
Composite governance indicator (t-1)		1.512 (1.308)		2.384 (1.494)		1.845 (1.627)
Constant	-4.117*** (0.497)	-4.188*** (0.511)	-4.764*** (0.634)	-4.943*** (0.678)	-4.492*** (0.606)	-4.631*** (0.652)
N	331	331	331	331	325	325
Number of crises	16	16	16	16	14	14
Type I Error (percent)	0.00%	0.32%	0.64%	0.64%	0.32%	0.00%
Type II Error (percent)	87.50%	93.75%	81.25%	81.25%	85.71%	85.71%
Chi-squared	21.96***	23.17***	36.39***	38.64***	27.6***	28.75***
Akaike Information Criterion	0.375	0.378	0.35	0.349	0.344	0.347
McFadden R-squared	0.171	0.181	0.284	0.301	0.239	0.249

**Notes & Sources:** FSI data correspond to 80 reporting countries from IMF database and GFSR data for 28 additional countries; macroeconomic variables from WDI and IMF IFS; banking crisis data from Laeven and Valencia (2012). \*\*\*, \*\*, and \* are levels of significance at 1%, 5% and 10% respectively. Robust standard errors are given in parentheses. 1<sup>st</sup> and 99<sup>th</sup> percentiles of observations are excluded from the analysis. FSI variables are residuals from country-by-country regressions of FSIs to a time trend. Models III and IV include contemporaneous FSIs and Models V and VI include FSIs lagged by one period. All macroeconomic variables are year on year differences lagged by one period. The composite governance indicator is the unweighted average of regulatory quality, rule of law and control of corruption. Macroeconomic variable definitions are given in Appendix VII.

**Table 3: Logit Model Results – Comparison to Čihák and Schaeck**

<b>Variable and expected sign</b>	<b>I</b>	<b>II</b>	<b>III</b>	<b>V</b>	<b>VII</b>	<b>IX</b>
GDP growth (real)	-0.130*** (0.034)	-0.111*** (0.031)	-0.159** (0.064)	-0.135** (0.065)	-0.055 (0.076)	-0.067 (0.097)
Broad money/international reserves	0.00215* (0.001)	0.00237* (0.001)	0.001 (0.001)	0.002 (0.002)	0.000 (0.002)	-0.002 (0.002)
Real interest rate	-0.031 (0.046)	-0.011 (0.038)	0.020 (0.049)	0.018 (0.052)	0.109 (0.138)	0.201 (0.141)
Inflation	0.013 (0.032)	0.064 (0.056)	0.0743* (0.042)	0.097 (0.069)	-0.268 (0.242)	-0.140 (0.244)
GDP per capita (real)	0.0000617** (0.000)	0.0000608** (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Fiscal surplus /GDP	0.066 (0.049)	0.078 (0.058)	-0.013 (0.104)	-0.012 (0.109)	0.081 (0.069)	0.165* (0.088)
Credit to the private sector		0.002 (0.007)		-0.003 (0.007)		0.020 (0.012)
Credit growth (real)		-0.037 (0.028)		-0.037 (0.026)		-0.055 (0.061)
Capital/risk weighted assets			-0.232** (0.114)	-0.238* (0.127)		
Nonperforming loans/total loans			-0.406* (0.219)	-0.408* (0.218)		
Return on equity (banks)			-0.020 (0.026)	-0.019 (0.027)		
Capital/risk weighted assets (t-1)					-0.862*** (0.200)	-0.977*** (0.303)
Nonperforming loans/total loans (t-1)					-0.036 (0.160)	0.148 (0.207)
Return on equity (banks) (t-1)					0.0661** (0.032)	0.100** (0.049)
Constant	-3.852*** (0.878)	-4.017*** (0.801)	0.855 (1.580)	1.327 (1.854)	3.677 (4.053)	0.885 (3.770)
N	256	256	256	256	198	198
Number of crises	16	16	16	16	7	7
Type I Error (percent)	0.00%	0.00%	0.42%	0.42%	0.00%	0.52%
Type II Error (percent)	100.00%	100.00%	100.00%	87.50%	85.71%	71.43%
Chi-squared	16.92***	18.45**	29.42***	30.83***	24.74***	26.62***
Akaike Information Criterion	0.456	0.466	0.431	0.441	0.282	0.293
McFadden R-squared	0.141	0.154	0.246	0.258	0.409	0.44

**Notes & Sources:** FSI data correspond to 80 reporting countries from IMF database; macroeconomic variables from WDI and IMF IFS; banking crisis data from Laeven and Valencia (2012). \*\*\*, \*\*, and \* are levels of significance at 1%, 5% and 10% respectively. Robust standard errors are given in parentheses. 1<sup>st</sup> and 99<sup>th</sup> percentiles of observations are excluded from the analysis. Model numbers correspond to models in Čihák and Schaeck (2007), Table 4. Models IV, VI, VIII and X are excluded due to data constraints for corporate ROE and debt/equity FSIs.

## Appendices

### Appendix I: List of Core and Encouraged FSIs for Deposit-Takers

#### Core Set of FSIs

- 1 Regulatory Capital to risk weighted assets
- 2 Nonperforming loans net of provisions to capital
- 3 Sectoral distribution of loans to total loans
- 4 Return on equity
- 5 Noninterest expenses to gross income
- 6 Liquid assets to short-term liabilities
- 7 Regulatory Tier 1 capital to risk weighted assets
- 8 Nonperforming loans to total gross loans
- 9 Return on assets
- 10 Interest margin to gross income
- 11 Liquid assets to total assets (liquid assets ratio)
- 12 Net open position in foreign exchange to capital

## Encouraged Set of FSIs

### *Deposit-Takers*

- 1 Capital to assets
- 2 Geographical distribution of loans to total loans
- 3 Gross liability position in financial derivatives to capital
- 4 Personnel expenses to noninterest expenses
- 5 Spread between highest and lowest interbank rate
- 6 Foreign-currency-denominated loans to total loans
- 7 Net open position in equities to capital
- 8 Large exposures to capital
- 9 Gross asset position in financial derivatives to capital
- 10 Trading income to total income
- 11 Spread between reference lending and deposit rates
- 12 Customer deposits to total (non-interbank) loans
- 13 Foreign-currency-denominated liabilities to total liabilities

### *Other Financial Corporations*

- 14 Assets to total financial system assets
- 15 Assets to GDP

### *Nonfinancial Corporations*

- 16 Total debt to equity
- 17 Return on equity
- 18 Earnings to interest and principal expenses
- 19 Net foreign exchange exposure to equity
- 20 Number of applications for protection from creditors

### *Households*

- 21 Household debt to GDP
- 22 Household debt service and principal payments to income

### *Market Liquidity*

- 23 Average bid-ask spread in the securities market
- 24 Average daily turnover ratio in the securities market

### *Real estate markets*

- 25 Residential real estate prices
- 26 Commercial real estate prices
- 27 Residential real estate loans to total loans
- 28 Commercial real estate loans to total loans

## Appendix IIA: List of Countries Included in Core FSI Database

### Sub-Saharan Africa

1	Kenya	4	South Africa
2	Mauritius	5	Uganda
3	Seychelles		

### Asia and Pacific

6	Australia	13	Japan
7	Bhutan	14	Korea, Republic of
8	Brunei Darussalam	15	Malaysia
9	China, P.R.: Hong Kong	16	Philippines
10	China, P.R.: Mainland	17	Singapore
11	India	18	Sri-Lanka
12	Indonesia		

### Europe

19	Austria	39	Lithuania
20	Belarus	40	Luxembourg
21	Belgium	41	Macedonia, FYR
22	Bosnia and Herzegovina	42	Malta
23	Bulgaria	43	Moldova
24	Croatia	44	Netherlands
25	Cyprus	45	Norway
26	Czech Republic	46	Poland
27	Denmark	47	Portugal
28	Estonia	48	Romania
29	Finland	49	Russian Federation
30	France	50	Slovak Republic
31	Germany	51	Slovenia
32	Greece	52	Spain
33	Hungary	53	Sweden
34	Ireland	54	Switzerland
35	Israel	55	Turkey
36	Italy	56	Ukraine
37	Kosovo, Republic of	57	United Kingdom
38	Latvia		

### Middle East and Central Asia

58	Afghanistan, Islamic Republic of	63	Lebanon
59	Algeria	64	Pakistan
60	Armenia, Republic of	65	Uzbekistan
61	Georgia	66	West Bank and Gaza
62	Kazakhstan		

### Western Hemisphere

67	Argentina	74	El Salvador
68	Brazil	75	Honduras
69	Canada	76	Mexico
70	Chile	77	Paraguay
71	Colombia	78	Peru
72	Costa Rica	79	United States
73	Ecuador	80	Uruguay

## Appendix IIB: List of Additional Countries Included in Extended FSI Database

### Sub-Saharan Africa

1	Gabon	6	Nigeria
2	Ghana	7	Rwanda
3	Lesotho	8	Senegal
4	Mozambique	9	Sierra Leone
5	Namibia	10	Swaziland

### Asia and Pacific

11 Thailand

### Europe

12	Albania	14	Montenegro
13	Iceland	15	Serbia

### Middle East and Central Asia

16	Egypt	20	Oman
17	Jordan	21	Saudi Arabia
18	Kuwait	22	Tunisia
19	Morocco	23	United Arab Emirates

### Western Hemisphere

24	Bolivia	27	Panama
25	Dominican Republic	28	Venezuela
26	Guatemala		

### Appendix III: List of Banking Crises since 2005

<b>Country</b>	<b>Start of crisis</b>	<b>Date when systemic</b>	<b>Loss of 10 percent gross loans (date)</b>
Austria	2008	2008	
Belgium	2008	2008	2008
Denmark	2008	2009	
Estonia			2011
France	2008		
Georgia			2009
Germany	2008	2009	
Greece	2008	2009	
Hungary	2008		
Iceland	2008	2008	
Ireland	2008	2009	
Italy	2008		
Kazakhstan	2008	2010	2010
Latvia	2008	2008	
Lithuania			2011
Luxembourg	2008	2008	
Mongolia	2008	2009	
Netherlands	2008	2008	
Nigeria	2009	2011	
Portugal	2008		
Russian Federation	2008		
Slovak Republic			2009
Slovenia	2008		
Spain	2008	2011	
Sweden	2008		
Switzerland	2008		
Ukraine	2008	2009	
United Kingdom	2007	2008	
United States	2007	2008	

Notes & Sources: Banking crisis data from Laeven and Valencia (2012), and authors' calculations.

## Appendix IV: FSI Statistics by Income and Region

### Regulatory capital to risk-weighted assets

	Num. obs	2005-2007			2008-2009			2010-2012		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Entire Sample	614	9.97	30.05	15.02	9.36	32.10	15.67	7.77	30.42	16.26
Low income	23	17.00	19.35	18.17	18.87	20.84	19.86	19.44	23.55	21.39
Middle income	326	11.53	30.05	16.86	11.02	32.10	17.15	11.64	30.42	17.09
High income	265	9.97	16.34	12.14	9.36	22.32	13.94	7.77	20.52	14.88
Regions										
Sub-Saharan Africa	38	17.00	19.61	18.65	13.00	21.61	17.41	15.02	21.89	18.36
Asia and Pacific	95	10.11	21.45	15.26	11.35	21.09	15.60	11.58	18.83	15.62
Europe	303	9.97	23.73	13.63	9.36	32.10	14.73	7.77	30.42	15.90
MENA and Central Asia	68	11.53	30.05	17.32	12.22	28.43	19.38	11.64	24.26	18.65
The Americas and Caribbean	110	12.18	20.45	15.83	12.22	19.85	16.15	13.31	18.08	15.84

Source: Authors' calculations.

### Non-performing loans net of provisions to capital

	Num. obs	2005-2007			2008-2009			2010-2012		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Entire Sample	614	(18.53)	313.82	11.12	(16.61)	128.72	15.65	(9.33)	181.59	18.66
Low income	23	27.34	67.52	47.43	2.59	24.25	15.20	3.79	10.62	6.98
Middle income	326	(18.53)	313.82	8.88	(16.61)	128.72	12.30	(9.33)	80.94	10.87
High income	265	(11.80)	50.21	12.32	1.89	72.55	19.28	1.16	181.59	29.07
Regions										
Sub-Saharan Africa	38	8.91	67.52	34.59	2.59	47.59	21.27	3.79	31.02	13.50
Asia and Pacific	95	4.66	48.54	19.77	(2.14)	20.42	7.86	(4.00)	19.34	6.42
Europe	303	(11.80)	313.82	20.30	(6.18)	128.72	23.67	1.16	181.59	31.37
MENA and Central Asia	68	0.64	17.40	5.71	1.49	43.77	13.07	1.02	59.04	12.95
The Americas and Caribbean	110	(18.53)	11.88	(4.41)	(16.61)	23.38	(1.79)	(9.33)	17.59	(1.36)

Source: Authors' calculations

## Non-performing loans to total loans

	Num. obs	2005-2007			2008-2009			2010-2012		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Entire Sample	614	0.10	48.12	4.38	0.25	32.59	5.02	0.15	35.11	5.81
Low income	23	10.20	20.85	15.52	2.12	8.80	6.45	2.21	5.32	4.20
Middle income	326	0.75	48.12	4.94	0.51	32.59	6.13	0.53	35.11	6.15
High income	265	0.10	8.98	2.71	0.25	11.09	3.73	0.15	23.27	5.53
Regions										
Sub-Saharan Africa	38	4.36	20.85	11.80	2.12	8.80	5.13	2.21	5.32	3.96
Asia and Pacific	95	0.56	9.39	4.81	0.57	9.36	2.93	0.48	6.03	2.12
Europe	303	0.10	48.12	5.03	0.25	23.99	5.63	0.15	23.27	7.92
MENA and Central Asia	68	0.81	8.98	4.14	0.97	32.59	9.47	0.53	35.11	8.37
The Americas and Caribbean	110	0.42	7.61	2.78	0.51	4.96	2.78	0.62	3.78	2.45

Source: Authors' calculations

## Return on equity

	Num. obs	2005-2007			2008-2009			2010-2012		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Entire Sample	614	6.18	41.77	20.89	(59.57)	42.45	10.88	(64.51)	36.46	11.76
Low income	23	28.86	30.03	29.44	18.00	29.81	24.79	(14.03)	31.09	19.89
Middle income	326	6.18	41.77	21.44	(59.57)	42.45	12.94	(5.01)	36.46	15.39
High income	265	6.54	32.05	19.69	(35.83)	26.36	8.18	(64.51)	33.33	6.63
Regions										
Sub-Saharan Africa	38	28.86	41.07	33.32	18.00	35.28	23.86	17.86	31.09	23.81
Asia and Pacific	95	15.66	30.02	24.09	8.65	26.75	16.85	8.20	28.27	16.91
Europe	303	6.18	32.05	17.33	(59.57)	26.42	5.28	(64.51)	33.33	6.30
MENA and Central Asia	68	13.18	28.32	19.47	(12.61)	26.19	12.29	(14.03)	24.60	13.18
The Americas and Caribbean	110	9.31	41.77	24.00	1.81	42.45	18.70	2.25	36.46	17.76

Source: Authors' calculations

### Interest margin to gross income

	Num. obs	2005-2007			2008-2009			2010-2012		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Entire Sample	614	13.33	81.18	55.20	(99.61)	100.45	58.29	6.85	93.55	59.33
Low income	23	60.68	61.57	61.12	59.70	64.71	62.17	52.77	68.85	63.74
Middle income	326	13.33	81.18	54.32	7.37	100.45	58.43	6.85	85.33	58.47
High income	265	41.85	72.90	56.05	(99.61)	85.00	57.98	30.78	93.55	59.95
Regions										
Sub-Saharan Africa	38	60.68	67.42	63.22	39.50	68.95	57.79	41.56	68.85	60.97
Asia and Pacific	95	41.85	65.32	55.30	44.01	83.92	65.30	45.32	82.89	65.70
Europe	303	43.14	72.90	57.90	(99.61)	100.45	58.44	10.69	93.55	57.87
MENA and Central Asia	68	59.67	76.22	67.64	15.62	76.07	61.02	35.21	75.76	60.53
The Americas and Caribbean	110	13.33	81.18	47.43	7.37	83.71	51.44	6.85	85.33	56.76

Source: Authors' calculations

### Non-interest expenses to gross income

	Num. obs	2005-2007			2008-2009			2010-2012		
		Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Entire Sample	614	9.30	90.12	53.33	(135.47)	108.96	56.72	-	106.58	59.27
Low income	23	55.96	57.21	56.58	51.93	62.65	57.84	51.42	92.54	61.37
Middle income	326	9.30	90.12	50.22	4.84	108.96	54.22	-	94.22	56.03
High income	265	41.44	71.71	57.25	(135.47)	105.32	59.26	41.42	106.58	62.95
Regions										
Sub-Saharan Africa	38	42.48	57.21	51.88	38.93	63.41	51.39	38.75	58.11	50.78
Asia and Pacific	95	35.91	58.44	48.36	27.25	70.88	49.33	27.12	71.38	49.45
Europe	303	41.44	90.12	58.73	(135.47)	108.96	61.75	41.66	106.58	65.55
MENA and Central Asia	68	40.63	77.44	54.24	16.73	71.41	54.00	44.38	92.54	60.05
The Americas and Caribbean	110	9.30	71.71	46.97	4.84	77.70	50.10	-	67.82	52.09

Source: Authors' calculations

### Appendix V: Data Notes

Lending rates are not consistently defined across countries. Each country is required to report a lending rate to the IMF, but the IMF does not historically impose any restrictions on what the lending rate should be. More recently, more detailed lending data are collected. IMF IFS notes on countries missing lending rates data are as follows:

- Austria – Lending rate corresponds to rate on loans to enterprises up to one year
- Denmark – Calculated from interest accrued on krone-denominated loan accounts divided by average loan balance in the quarter
- France – Rate on short-term bank loans
- Germany – Rate on current-account credit in denominations of less than 500,000 euro
- Luxembourg – Minimum rate on mortgage loans by the Banque es Caisse d'Epargne de l'Etat
- Sweden – End-quarter average lending rate of 11 largest commercial banks
- Greece – Short-term loans to enterprises
- Ireland – Lower point of range of rates charged on short-term loans to large commercial customers by the associated banks
- Portugal – Weighted monthly average rate charged by commercial banks on 91- to 180-day loans and advances to nonfinancial private enterprises
- Spain – Rate charged by banks to discount three-month commercial bills
- Kazakhstan – None

The following series are substituted, and deflated with the GDP deflator:

- Austria – Corporations: stocks, up to 1 year
- Denmark – Mortgage bond yield (no corporate rate available)
- France – Corporations: stocks, up to 1 year
- Germany - Corporations: stocks, up to 1 year
- Luxembourg - Corporations: stocks, up to 1 year

- Sweden – Government bond yield (no corporate rate available)
- Greece - Corporations: stocks, up to 1 year
- Ireland - Corporations: stocks, up to 1 year
- Portugal - Corporations: stocks, up to 1 year
- Spain - Corporations: stocks, up to 1 year

Broad money growth is incomplete for a number of countries. Broad money is calculated using IMF IFS data for countries where data are missing, using the formula:

Broad money = Net Foreign Assets + Domestic Claims – Other Items Net

Data from Standard Report Form (SRF) countries are combined with data from non-SRF countries using a butt-splice methodology, as this methodology allows for the longest data series.<sup>22</sup> For countries where claims on private sector are unavailable, aggregate claims on other sectors are taken as an estimate, which include claims on other financial corporations, state and local government, and public non-financial corporations.

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<sup>22</sup> A backwards ratio splice was also considered but not used because a large number of countries did not have overlapping data to calculate the ratio.

### Appendix VI: Proof of Proxy Variable Coefficient Bias

This paper considers the true likelihood of a financial or banking crisis  $y$  as a function of a set of industry-specific indicators  $Z$ , and economy-wide indicators  $X$  as given by:

$$y = \alpha + X'\beta + Z'\gamma + u$$

for  $K$  economy-wide and  $L$  industry-specific indicators. The observed likelihood of a banking crisis is given by economy-wide indicators  $X$  and  $Q$  as:

$$y = \tilde{\alpha} + X'\tilde{\beta} + Q'\tilde{\gamma} + v$$

for  $M$  indicators  $Q$ , where  $\forall z_i \in Z$

$$z_i = a_i + Q'b_i + e_i$$

and where  $e_i$  are error terms. Stacking the equations for all  $z_i$  gives:

$$Z = A + Q'B + E$$

where  $A$  is  $L \times 1$ ,  $Q$  and  $B$  are  $L \times M$  and  $M \times L$  respectively, and  $E$  is  $L \times 1$ . Assuming that  $E(y | X, Z, Q) = E(y | X, Z)$  and  $E(e_i | X) = 0$  for all  $e_i$ , and substituting Equation 4 into Equation 1:

$$y = (\alpha + A'\gamma) + X'\beta + (Q'B)'\gamma + (u + E'\gamma)$$

where the intercept is  $\alpha + A'\gamma$ , the error term is  $u + E'\gamma$  and the economy-wide indicators are given by  $(Q'B)'\gamma$ . It follows that the intercept  $\tilde{\alpha}$  and the coefficients  $\tilde{\gamma}$  are biased, although the coefficients  $\tilde{\beta}$  remain unbiased.

## Appendix VII: Description of Variables

Variable	Definition	Source
<i>Financial Soundness Indicators</i>		
Regulatory capital to risk-weighted assets	Capital adequacy of deposit takers based on Basel Accord definitions	IMF FSI database; IMF GFSR database
Non-performing loans net of provisions to capital	Value of non-performing loans less the value of specific loan provisions, divided by capital and reserves	IMF FSI database
Non-performing loans to total loans	Value of non-performing loans divided by the total value of the loan portfolio	IMF FSI database; IMF GFSR database
Return on equity	Net income (gross income less gross expense) divided by the average value of capital over a given period	IMF FSI database; IMF GFSR database
Interest margin to gross income	Net interest income (interest income less interest expense) divided by gross income (interest income plus non-interest income)	IMF FSI database
Non-interest expenses to gross income	Non-interest expenses (including fees and commissions) divided by gross income (interest income plus non-interest income)	IMF FSI database
<i>Macroeconomic Indicators</i>		
GDP growth	Rate of real GDP growth	WDI (World Bank); IMF IFS database
Broad money / international reserves	Percentage change in ratio of broad money to international reserves	WDI (World Bank); IMF IFS database
Inflation	Annual rate of change of GDP deflator	WDI (World Bank); IMF IFS database
GDP per capita	US\$ real GDP (constant 2005) based on purchasing power parity divided by population	WDI (World Bank)
Fiscal surplus / GDP	Ratio of government surplus to GDP	WDI (World Bank)
Credit to the private sector	Percentage change in domestic credit to the private sector	WDI (World Bank); IMF IFS database
Current account balance / GDP	Ratio of current account surplus (or deficit) to GDP	WDI (World Bank); IMF IFS database
Sovereign credit default swap spread	Financial swap agreements referenced to sovereign defaults	Bloomberg
Real interest rate	Nominal interest rate divided by GDP deflator	WDI (World Bank); IMF IFS database

Monetization	Ratio of Broad Money to GDP for SRF countries. Ratio of Narrow Money and Quasi Money to GDP, for Non-SRF countries.	IMF IFS database
Real Exchange Rate	The purchasing power of a currency relative to another.	IMF IFS database
<i>Institutional Indicators</i>		
Regulatory Quality	Perceptions of government ability to formulate and implement sound policies and regulations that promote private sector development.	WGI (World Bank) Governance Indicators
Rule of Law	Perceptions of the extent to which agents have confidence in and abide by the rules of society, and the quality of contract enforcement.	WGI (World Bank) Governance Indicators
Control of Corruption	Perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption.	WGI (World Bank) Governance Indicators

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