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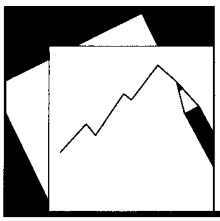

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Identifying Vulnerabilities in Systemically-Important Financial Institutions in a Macro-financial Linkages Framework

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Identifying Vulnerabilities in Systemically-Important Financial Institutions in a Macro-financial Linkages Framework

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Abstract

This paper attempts to identify the indicators that can demonstrate the vulnerabilities in systemically important financial institutions. The paper finds that (i) indicators on leverage, liquidity, and business scope can help identify the differences between the intervened and non-intervened financial institutions during the subprime crisis; (ii) the expected default frequencies react positively to shocks to leverage, inflation, global financial stress, and global excess liquidity, and negatively to return on assets and equity prices; and (iii) leverage has been the most robust factor with a long-run causal effect on the expected default frequencies.

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"If there is one common theme to the vast range of crises we consider in this book, it is that excessive debt accumulation, whether it be by government, banks, corporations or consumers, often poses greater systemic risks than it seems [to do] during a boom."

- Carmen Reinhart and Kenneth Rogoff, 2009

I. INTRODUCTION

During the subprime crisis, central banks and governments worldwide have taken unprecedented policy actions to stabilize banks' financial condition. One distinguishing policy action is government rescue of some troubled large financial institutions (FIs). Two questions naturally arise: Why are some institutions intervened while others are not? What are the macro-financial driving forces of the vulnerabilities in the systemically important FIs? A more detailed consideration of those questions involves a response to the following questions:

- What are the common factors among the FIs that have required public intervention? Did balance sheet data, especially traditional financial soundness indicators (FSIs), provide meaningful warnings?

- Can bank-specific indicators explain the development over time of the expected default frequencies (EDFs) for the systemically important FIs? What role does the macroeconomic and global situation play in this process? Can we find robust indicators that denote rising EDFs?

This paper responds to these questions by: (i) investigating balance sheet data well beyond the widely-used FSIs, and trying to find more "good" indicators that capture the key features of FIs; and (ii) constructing a group of panel data models (pertaining to different scenarios), which link the measures of the EDFs to a set of domestic and global macroeconomic and financial variables. In particular, we use panel cointegration to test the long-run causal effect of some important indicators, such as leverage (e.g., debt to common equity), on the EDFs.

The results, which are based on data from selected global FIs, demonstrate that traditional balance sheet data are only partially able to detect, ex ante, institutions at risk of failing.[2] In

[2] The 45 FIs have been selected on the basis of their systemic importance in terms of size, business scope, and possible regional/global impact, though proving this is beyond the reach of this paper. Intervened institutions are assumed to be those that have gone bankrupt, have received government capital injections or loans, have had assets purchased by government, have received official loans to facilitate a merger or acquisition. Central bank temporary liquidity injections are not considered to be a type of intervention. Intervened institutions and periods of intervention are detailed in Annex I.

addition, panel specifications show that macroeconomic variables (CPI inflation), bank-specific fixed effects, bank-specific variables (leverage, equity prices and ROA), and global variables (global excess liquidity and a global financial stress index) can help explain EDFs. There are some intuitive variations to these results when intervened and nonintervened FIs are investigated separately.

Any financial stability monitoring exercise would benefit from knowing the reasons behind the relative immunity of some FIs to government intervention during the subprime crisis. Thus, indicators that identify the key characteristics of the FIs are of considerable interest for analytical reasons as well as for understanding the implications of the differences between intervened and nonintervened FIs. In addition, these indicators could be helpful in identifying macro-financial linkages, promoting ongoing financial reforms, and designing crisis prevention initiatives.

This paper proceeds as follows. Section II gives an overview of the literature on the FSIs and macro-financial models that use the EDFs as a proxy for vulnerabilities in FIs. Section III presents a detailed picture of the evolution of the balance sheet data before and during the subprime crisis. Section IV discusses the methodologies and results of the panel specifications and panel cointegration. Section V concludes.

II. LITERATURE REVIEW

A substantial amount of theoretical and empirical work has documented how FSIs are used to capture vulnerabilities in firms and economies.

The financial crises of the late 1990s prompted the search for indicators of financial system soundness. Various studies have proposed early warning indicators of impending turmoil in banking systems (e.g., Demirgüç-Kunt and Detragiache, 1998, 1999, 2005; Hardy and Pazarbaşioğlu, 1999; Gonzalez-Hermasillo,1998; Hutchinson and McDill, 1999; Hutchinson, 2002; European Central Bank, 2005). The need for appropriate tools to assess strengths and weaknesses of financial systems led to efforts to define sets of so-called “core” and “encouraged” FSIs, designed to monitor the health and soundness of FIs and markets, and of their corporate and household counterparts (Sundararajan and others, 2002). The precise definitions of the core and encouraged FSIs were laid down in the Compilation Guide on Financial Soundness Indicators (IMF, 2004). In 2004, the IMF spearheaded a Coordinated Compilation Exercise (CCE), which was designed to coordinate the efforts of national authorities to compile and disseminate internationally comparable FSI data (and the related metadata).

Despite these advances, there is increasing evidence that some FSIs might not fully capture the sources of risk. For instance, by incorporating FSIs in an early warning model of banking crises, Cihak and Schaek (2007) illustrate that cross-country variation in regulatory capital does not send a strong signal in the run-up to a banking crisis. In addition, Poghosyan and Cihak (2009) further illustrate that relating regulatory thresholds only to capital adequacy is insufficient, and one needs to include combinations of several relevant variables (notably asset quality and profitability) to capture the level of risk of individual institutions. Similarly, country experiences have been gradually indicating that a set of FSIs only for the banking sector is too narrow. Problems may eventually show up clearly in the simple FSIs, but it is useful to know when potential problems are mounting before they are evident in the banks' accounts (Bergo, 2002). Moreover, since each FSI is designed to capture the sensitivity of the financial system to a specific risk factor (credit or market risk), none of these "piecewise approach" indicators can provide in and of itself a comprehensive assessment of the various sources of risk to which the financial sector is exposed (Sorge, 2004).

Rojas-Suarez (2001) provides evidence that the traditional CAMELS system has limitations in predicting bank failure, and needs to be complemented by other indicators.[3] Several studies based on U.S. bank data complement the FSI analysis by suggesting that market price-based indicators contain useful predictive information about bank distress that is not contained in the CAMELS indicators (e.g., Flannery, 1998; Curry, Elmer, and Fissel, 2001).

Besides the research on traditional balance sheet data, there is a growing body of literature that analyzes the macroeconomic determinants of banks' credit risks. A more data-intensive approach is to examine the impact of macro factors on corporate and/or household sector default risk and map these developments into banks' loan losses using various techniques. Chan-Lau (2006) reviewed a number of different fundamentals-based models—including macroeconomic-based models, credit scoring models, ratings-based models, and hybrid models—for estimating the EDFs for firms and/or industries, and illustrated them with real applications by practitioners and policy making institutions.

There are generally three approaches that can be used to link the EDFs with macro-financial indicators: (i) the Vector Autoregression (VAR) framework, (ii) probit and logit models, and (iii) panel models.

A. VAR Framework

Among the more recent contributions that use the VAR model to analyze the links between the macroeconomy and corporate sector credit quality are Alves (2005) and Shahnazarian

[3] CAMELS refers to capital adequacy, asset quality, management quality, earnings, liquidity, and sensitivity to market risk.

and Åsberg-Sommer (2007), who incorporate Moody's KMV EDF data in cointegrated closed-economy VAR models. They find cointegration relationships between the macro and EDF variables and identify significant relationships between the EDFs on the one hand and short-term interest rates, GDP, and inflation on the other. Sommar and Shahnazarian (2008) use a vector error correction model to study the long-term relationship between aggregate EDF and macroeconomic variables, namely CPI, industrial production, and the short-term interest rate. Aspachs and others (2006) use a VAR model that includes the banking sector EDFs and macroeconomic data on seven industrialized countries. They show that shocks to the probability of default and equity index of the countries' banking sectors can have an impact on GDP variables. Jacobson, Lindé, and Roszbach (2005) use the VAR approach to study the interactions between Swedish firms' balance sheets and the evolution of the Swedish economy. They find that macroeconomic variables are relevant for explaining the time varying default frequency in Sweden. Drehmann, Patton, and Sorensen (2005) analyze corporate sector defaults in a non-linear VAR framework for the UK economy and find that non-linearities matter for the shape of the impulse response functions. Pesaran, Schuermann, and Weiner (2006) adopt the Global Vector Autoregressive (GVAR) model to generate the conditional loss distributions of the credit portfolio of a large number of firms in various regions of the world. Finally, Castren, Dees, and Zaher (2008) use the GVAR model to construct a linking satellite equation for the firm-level EDFs. Their results show that the median EDFs react most to shocks to GDP, the exchange rate, oil prices, and equity prices.

B. Probit and Logit Models

The second approach is the use of probit and logit models to assess the EDFs. Virolainen (2004) provides a good summary of this approach. Bunn and Redwood (2003) examine the determinants of failure among individual UK companies, using a probit model to assess risks arising from the UK corporate sector. In addition to firm-specific factors like profitability and financial ratios, their explanatory variables also include macroeconomic conditions (proxied by the GDP growth rate). GDP growth proves to have a negative effect on the failure rate after controlling for the firm-level characteristics.[4] They find that the measure which uses firm-level information performs better in predicting actual debt at risk (ex post sum of all debt of failed firms) than a simple estimate that involves multiplying the average probability of failure by the total debt stock. Tudela and Young (2003) analyze the performance of a "hybrid model" by adding Merton-based default probability measures into a company account-data based probit model for individual firm failures. They find that the implementation of the Merton approach clearly outperforms a model based solely on

[4] The negative coefficients could be explained by interactions between companies or by a change in the behavior of banks. In times of recession, banks may be less willing to lend and quicker to close companies down.

company account data. Interestingly, they also find that, even after controlling for a Merton type default probability measure and company account variables, GDP has a significant effect on firm default. Virolainen (2004) uses data on industry-specific corporate sector bankruptcies and estimates a macroeconomic credit risk model for the Finnish corporate sector. The results suggest a significant relationship between corporate sector default rates and key macroeconomic factors including GDP, interest rates, and corporate indebtedness.

C. Panel Models

The third approach is the use of panel data models. Pain and Vesala (2004) employ a dynamic factor model to analyze the determinants of firm default risk, as measured by the Merton-based Moody's KMV EDFs, using a large panel of quoted EU area companies. Although the factor analytic approach does not allow them to identify the explanatory factors, Pain and Vesala conclude that EU-wide country and industrial sector effects seem to play only a minor role in explaining EDFs.

III. Differences Between Intervened and Nonintervened Financial Institutions

Regulators and supervisors typically use a set of FSIs to assess the stability of their financial system. Indeed, the Fund has promoted the construction and collection of a set of useful FSIs over the last several years. As a starting point for this paper's analysis, a small sample of major institutions is used to examine whether traditional FSIs and other balance sheet data were able to discriminate between institutions that would eventually require government intervention and those that were not intervened. This section seeks to identify the key indicators that are useful in differentiating between the intervened and nonintervened FIs.

The advantage of this approach is that some indicators are readily available and are widely used by financial regulators. In addition, we also investigate several additional indicators related to the characteristics of the subprime crisis, such as subprime products and business scope. However, these indicators are reported at low frequencies, are generally static and backward-looking, and focus on an individual FI without much regard for the spillovers from other institutions.

The sample comprises 36 key commercial and investment banks across the world (Annex 1).[5] This sample of FIs is divided into nonintervened commercial banks (NICBs), intervened

[5] The insurance companies were excluded from the analysis given their different business lines. The rationale for choosing these FIs is based on their systemic importance while keeping a balanced sample that is representative of the various regions around the world. Data constraints also played a role, as the sample chosen was limited to FIs for which balance sheet and market-based data were available.

commercial banks (ICBs), and intervened investment banks (IIBs). The periods covered are: (i) 1998Q1–2008Q1 (before the wave of government interventions), (ii) 2005Q1–2007Q2 (before the start of the current cycle and the beginning of the subprime crisis), and (iii) 2007Q3–2009Q1 (during the subprime crisis). A comparison of these indicators during 2007Q3–2009Q1 will enable us to capture the possible differences among the three groups of FIs and to see if the crisis has significantly changed the business and behavior of the FIs. Table 1 shows the following features of the intervened and nonintervened FIs.[6]

- **Capital adequacy ratios are unable to clearly identify institutions requiring intervention.** In fact, contrary to the common belief that a low capital adequacy ratio signals the weakness of an FI, all four capital adequacy ratios examined for ICBs were significantly higher than (or similar to) the NICBs as a whole (Figure 1).[7] In addition, during all subsample periods, the retained earnings to equity ratios for intervened FIs were much higher than for non-intervened FIs. This shows that the higher retained earnings to equity ratio does not necessarily reflect a healthier institution, but could demonstrate higher risks in FIs (Figure 2; capital adequacy panel in Table 1).[8]

- **Leverage indicators appear to be informative in identifying the differences among the institutions.**[9] The higher ratios of debt to common equity (Figure 3), debt to assets, long-term debt to capital, short-term and current portfolio long-term debt to total debt, and cost of debt in the ICBs and IIBs all indicate that these measures of leverage are especially informative about the differences.[10] This may reflect the fact that many FIs borrowed far more than the capital they had on hand to make additional investments in mortgage-backed securities, pocketing the 2–3 percent difference between mortgage rates and their cost of short-term capital (see leverage panel in Table 1).

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[6] Accounting definitions are explained in Annex III.

[7] The reasons that capital adequacy ratios are not always useful indicators of distress may reflect (i) difficulties in determining the actual riskiness of assets; (ii) deficiencies in mark-to-market accounting practices; and (iii) locating assets and contingent claims (e.g., derivatives) in off-balance sheet vehicles where they can receive lower risk-weights.

[8] The higher risks associated with the higher retained earnings to equity ratio indicate that it is unlikely that the use of retained earnings to build up capital, as being encouraged by European regulators, will prevent subsequent interventions (The Wall Street Journal, Sep 28, 2009).

[9] Here we check indicators on leverage rather than the formal leverage ratio—total assets to capital ratio and debt to capital ratio. The reason is that (i) capital includes too many items and does not distinguish among type of capital, although the capital in general acquires the regulatory minima; (ii) the formal leverage ratio may prove overly-optimistic since the use of leverage migrates to entities' balance sheets, requiring less capital but with higher risk; and (iii) the retained earning phenomenon is a signal that too much money is being made by the firms due to excessive risk-taking.

[10] Short-term debt and current portfolio long-term debt refer to that portion of debt payable within one year.

- **Traditional liquidity ratios are partially indicative of the differences between intervened and nonintervened institutions.** The ratio of deposits to assets for the intervened institutions was much lower than those in the NICBs, suggesting that elevated risks are associated with less dependence on retail deposits (or with greater dependence on wholesale funding), thus undermining the banks' capability to fend off liquidity shocks. In addition, the ratio of loans to assets for the intervened institutions was higher than that for the NICBs, suggesting that elevated risks are associated with a higher ratio of loans to assets. However, the ratio of loans to deposits was not indicative of the differences between the intervened and nonintervened. This may be partly due to the fact that the loan to deposit ratio may not be able to measure fully the wholesale funding risks (Figure 4; liquidity panel in Table 1).

- **Asset quality indicators show a mixed picture.** Similar to the capital adequacy ratios, the ratio of nonperforming loans (NPLs) to total loans for the ICBs was lower than for the NICBs, indicating that the NPL ratio is not a very reliable indicator of the deterioration in asset quality (Figures 5). However, the lower provisions for loan losses to loans ratio for the NICBs suggest that this is a better indicator than the NPL ratio (Figure 6, asset quality panel in Table 1).

- **The standard measures of earnings and profits show a mixed picture.** The return on assets (ROA) for the intervened institutions was much higher than that for the NICBs. This suggests that the higher ROA does not necessarily reflect a healthier institution, but indicate elevated risks (Figure 7). However, return on equity (ROE) has not captured any major differences between the FIs that were intervened and those that were not. This contrast between the effectiveness of the ROA and ROE likely reflects the high leverage ratios of intervened FIs, which typically rely on higher levels of debt to produce profits (earnings and profit panel in Table 1).[11]

[11] The ratio of ROE has to be interpreted with caution, since a high ratio may indicate both high profitability as well as low capitalization, and a low ratio can mean low profitability as well as high capitalization (IMF, 2000). This caveat further encourages the use of ROA as a better measure of earnings.

Table 1. Selected Indicators on Fundamental Characterisitics of Financial Institutions

	Nonintervened commercial banks			Intervened banks			Intervened investment banks		
	1998Q1–2008Q1	2005Q1–2007Q2	2007Q3–2009Q1	1998Q1–2008Q1	2005Q1–2007Q2	2007Q3–2009Q1	1998Q1–2008Q1	2005Q1–2007Q2	2007Q3–2009Q1
					Capital adequacy				
Capital/assets (%)	16.49	19.37	17.62	18.22***	21.21*	24.74***	17.39***	20.05	25.19***
Common equity/assets (%)	3.99	4.36	4.45	6.14***	6.13***	5.22***	3.70	3.72***	3.32
Tier 1 Capital/risk-weighted assets (%)	7.21	9.61	8.67	9.62***	10.87	10.06***	-	-	-
Tier 1 and 2 capital/risk-weighted assets (%)	10.65	14.12	13.42	12.92***	14.23	13.83	-	-	-
Retained Earnings/Equity (%)	37.73	45.89	51.43	60.97***	60.8***	57.04	75.54***	90.64***	72.24***
Cost of equity	2.90	6.13	-5.38	0.53	4.81	-16.50	13.38***	16.33***	-6.16
					Asset quality				
NPL ratio (%)	2.46	2.42	2.26	1.44***	0.86***	2.14	-	-	-
Provision for loan losses/loans (%)	0.09	0.06	0.17	0.21***	0.16***	0.58***	-	-	-
					Leverage				
Debt/assets	0.29	0.28	0.26	0.34***	0.35***	0.35***	0.47***	0.48***	0.48***
Debt/common equity	7.48	7.56	7.12	8.38***	9.02***	10.34***	13.32***	13.61***	14.84***
Long-term debt/capital (%)	58.63	62.15	63.34	61.74***	66.15***	72.36***	75.06***	79.74***	80.25***
Short-term debt and current portfolio long term debt/total debt (%)	45.67	50.70	59.01	67.06***	68.06***	59.01	68.11***	69.29***	58.45
Cost of debt	16.55	19.39	0.00	18.24***	21.42*	23.92***	17.27**	19.44	25.17**
					Liquidity				
Loans/deposits	1.25	1.33	1.23	1.20	1.33	1.31	-	-	-
Deposits/assets (%)	49.05	45.13	43.06	41.55***	38.88***	37.59***	-	-	-
Loans/assets (%)	54.83	49.48	48.83	51***	51***	50.00	-	-	-
					Earning and profit				
ROA (%)	1.18	1.24	1.04	1.78***	1.56***	1.17***	3.83***	4.11***	3***
ROE (%)	3.85	4.74	2.30	3.97	5.29	-2.84**	4.08	5.32	-14.74*
					Stock market performance				
PE	15.55	12.60	12.85	15.96	11.64	6.67***	15.56	13.08	10.03*
EPS	0.41	0.79	0.26	0.39	0.74*	-0.65***	1.12***	2.31***	-1.87
book value per share	11.40	17.52	21.53	11.41	16.35***	16.49***	31.27***	48.71***	54.36***
					Contagion				
Foreign loans/loans	0.26	0.28	0.21	0.16***	0.15***	0.18***	-	-	-
Interbank loans/loans	0.12	0.09	0.08	0.15	0.12***	0.11***	-	-	-
					Business scope				
Mortgage loans/total loans (%)	0.22	0.28	0.24	0.33***	0.38***	0.37***	-	-	-
Commision fee/operating income (%)	0.17	0.11	0.27	0.27***	0.24***	-1.94*	-	-	-
Net interest margin (%)	1.84	1.79	1.75	2.92***	3.2***	2.58***	-	-	-

Sources: Thomson Reuters; and IMF staff estimates.

Note: i) A t-test is performed to determine whether two samples are likely to have come from the same two underlying populations that have the same mean. The intervened commercial banks and the U.S. investment banks are compared to the nonintervened banks. *, **, and *** represent the statistically significant differences at the 10, 5, and 1 percent levels, respectively; ii) The ratios of nonintervened banks, intervened banks and intervened U.S. investment banks are the average of all institutions in each category.

- **Some stock market indicators are able to capture some differences.** Though higher than that of the ICBs, the book value per share of the NICBs has been generally lower than that of the IIBs. This suggests that a high book value does not necessarily reflect a healthier institution, but perhaps concomitant higher risks (Figure 8, stock market performance panel in Table 1).

- **The indicators on possible contagion show a mixed picture.** The ratio of interbank loans to total loans is much higher for the ICBs than for the NICBs, suggesting that elevated risks are also associated with higher interbank borrowing for the intervened banks, which might be more dependent on wholesale funding from other banks. However, the ratio of foreign loans to total loans was much higher for the nonintervened institutions than for the intervened ones, indicating that a lower level of foreign loans does not necessarily indicate lower risks (Figure 9, contagion panel in Table 1).

- **The indicators on business scope are able to capture the differences.** Net interest margin and the ratios of commission fees to operating income are much higher for the ICBs than for the NICBs, suggesting that elevated risks are associated with higher revenues from both off- and on-balance sheet businesses. This reflects the fact that intervened banks are more aggressive in doing off- and on- balance sheet business, which is naturally associated with higher risks. In addition, the ratio of mortgage loans to total loans was much higher for the ICBs than for the NICBs, suggesting that elevated risks are associated with a higher mortgage loans ratio in the banks' portfolios, echoing one of the features of the current crisis (Figure 10, business scope panel in Table 1).

Our analysis therefore finds that (i) (risk-weighted) capital adequacy ratios have generally not been informative in identifying financial firms that eventually required intervention (in fact, the intervened institutions sometimes had higher capital adequacy ratios than the nonintervened institutions); and (ii) several indicators, such as leverage, liquidity, and business scope have been better at discriminating between the intervened and nonintervened institutions.

Moreover, a further comparison among the three subgroups during the period 2007Q3–2009Q1 shows that most of these indicators did not experience a significant change in trend after the outbreak of the crisis, reflecting the FIs' difficulties in dealing with their long-existing problems in their business models. However, some indicators did experience great changes after the crisis. For instance, the cost of equity is much lower for the intervened institutions than for the NICBs; indeed, it is negative, suggesting that the intervened institutions have lowered their dividends or even eliminated them since the crisis.

In sum, based on the sample of institutions examined, it would be useful to include on the regulatory radar screen indicators on leverage (e.g., debt to common equity ratio), liquidity, and business scope, since they could provide a starting point for a deeper analysis of vulnerable institutions. Also, the current center-stage focus on regulatory capital adequacy

ratios may need to be redefined, especially if it can be shown that FIs were able to shift risks to off-balance sheet vehicles, which receive lower risk weights, and thus the risks on the balance sheet are under-representing those of the FI.

Although the analysis here has been partial and cursory, other studies have found similar issues with the application of FSIs, calling for further improvement in their collection and usage. On the other hand, for less sophisticated institutions and general financial sector analysis, the current FSIs are useful, since the ratios are the most readily available indicators to represent the FIs' level of risk. Finally, it is not necessarily the case that even those variables that identify vulnerabilities can be used separately. We need to check their usefulness in a macro-financial framework by putting them together with other bank-specific variables, and macroeconomic and global conditions. This will be the task in Section IV.

IV. Methodologies and Results of the Panel Specification and Panel Cointegration

As a robustness check on the usefulness of the indicators identified in Section III, this section attempts to take these indicators as the driving factors of the EDFs in a macro-financial framework by using the panel specification and panel cointegration techniques. Specifically, we estimate an econometric model that relates EDFs—our main object of interest—to the macro-financial variables, and then test the long-run causal effect of key factors (i.e., leverage) on the EDFs.

We make two contributions to the empirical literature on the driving forces of the EDFs. First, we employ quarterly data on three sets of factors as determinants of the EDFs: (i) domestic macroeconomic factors, including inflation, GDP growth, and the real effective exchange rate; (ii) bank-specific indicators, including leverage (i.e., the debt to common equity ratio), the total capital to total assets ratio, return on assets, and equity prices; and (iii) global factors, including global excess liquidity and IMF's Financial Stress Index.

Second, we use a conditional EDF, which is derived from nonstationary techniques of panel cointegration. In particular, the cointegrated panel specification framework provides us with a broader and more flexible approach, through which the statistical proxies, such as the fixed effects and heterogeneous trend components, can serve to capture a broad class of mechanisms in the long-run relations among cointegrated variables.

The data set for the panel models consists of 45 FIs from different regions in the world— the euro area, noneuro area, Asia, and the United States—covering banking, securities, and insurance (see details in Annex I). The data we use as a measure of these firms' credit quality are their EDFs (both the one-year and the five-year EDFs),[12] which are provided at the firm

[12] The difference between the two EDFs is that there is a higher relative variance of the one-year EDF compared to the five-year EDF.

level by Moody's KMV. EDFs, which are publicly available, measure the probability that a firm will default over a specified period of time. The EDFs are dynamic and forward-looking measures and are actual probabilities. When incorporated in the panel models, the shifts in the EDFs provide a measure of the conditional expectation of the FIs' default intensities. We also use quarterly observations during 1998Q1–2009Q1. In order to obtain quarterly frequencies for all data, we collapsed the daily data by taking the average of the observations of the quarter.

A. Panel Specification

We define a fixed-effects panel data specification to examine the factors driving the EDFs. Specifically, the three groups of factors are as follows:

(i) Domestic macroeconomic factors, which include inflation, real effective exchange rates, and real GDP growth.

(ii) Bank-specific factors, which include leverage, capital ratio, return on assets, equity prices.

(iii) Global factors, which include proxies for global excess liquidity (the difference between broad money growth and estimates for money demand in the euro area, Japan, and the United States) and the financial stress index.

The model is specified in terms of (log) differences of all macroeconomic and all global variables.

The two alternative specifications for the panel data are as follows:

$$\begin{aligned} \mathrm{D}EDF_{it} = & \\ & C + b_1 INFLATION_{it} + b_2 \mathrm{D}REER_{it} + b_3 \mathrm{D}GDP_{it} + b_4 \mathrm{D}CAPRATIO_{it} + b_5\, \mathrm{D}LEVERAGE\mathrm{RATIO}_{it} \\ & + b_6 ROA_{it} + b_7 \mathrm{D}MSCI_{it} + b_8 EXCLIQ_{it} + b_9 \mathrm{D}FSI_{it} + b_{10} CONDEDF_{it} + b_{11} INTERVENTION_{it} + e_{it} \end{aligned} \quad (1)$$

Where "D" denotes log differences

D INFLATION = Inflation rate
D EXCHRATE = Real Effective Exchange rate
D GDP = GDP growth
D TCTART = Total capital to total assets ratio
D DTCERT RATIO = Debt to common equity ratio
ROA =Return on assets
D MSCI = Morgan Stanley Capital International world index
EXCLIQ = Global excess liquidity
D FSI = the change of Financial Stress Index

CONEDF = Conditional Expected Default Frequencies, which are derived from panel cointegration among EDFs, leverage (debt to common equity ratio) and inflation
Dummy = Government intervention
ε = Residual

(See Annex IV and V for data transformation and the methodology of the panel specifications)

B. Panel Cointegration

The study employs nonstationary panel techniques to deal explicitly with the nonstationarities that are present in some individual time series that constitute the members of the panel. Then the regressions of the EDFs and nonstationary explanatory variables are run to obtain conditional EDFs, which are taken as inputs to the specification of the panel estimations. This combination of conventional and nonstationary panel techniques therefore allows us to focus explicitly on the stochastic and nonstochastic long-run trend features of the data and filter out the effects of short-run transitional dynamics.

The panel cointegration specification is as follows:

$$EDF_{i,t} = \alpha_{i,t} + \beta_{1i,t} CPI_{i,t} + \beta_{2i,t} DTCERT_{i,t} + e_{i,t} \qquad (2)$$

Where
$EDF_{i,t}$ = log of Expected Default Frequencies
$CPI_{i,t}$ = log of CPI
$DTCERT_{i,t}$ = log of Debt to Common Equity Ratio

If $EDF_{i,t}$ has a unit root (t=1,….,T, i represents the member of financial institutions), so that $EDF_{i,t} \sim I(1)$. And if $CPI_{1i,t}$ and $DTCERT_{2i,t}$ have a unit root (t=1,….,T), so that $CPI_{1i,t} \sim I(1)$, $DTCERT_{2i,t} \sim I(1)$. EDF, CPI, and Debt to common equity ratio are cointegrated if the residual, $e_{i,t} = EDF_{i,t} - \alpha_{i,t} - \beta_{1i,t} CPI_{i,t} - \beta_{2i,t} DTCERT_{i,t}$ is stationary, so that $e_{i,t} \sim I(0)$.

In this cointegrated panel specification framework, the combination of the extra dimension (the cross-sectional added to the time-series dimension) and the long-run properties of the cointegrating relationship provides us with a broader and more flexible approach, by which the statistical proxies such as the fixed effects and heterogeneous trend components can serve to capture a broad class of cross member heterogeneity.

Moreover, the nonstationary panel framework allows us to relax many of the strong assumptions that have typically been required in cross-sectional-based approaches. This framework relaxes the exogeneity assumptions and picks up the long-run relationships between the variables in a manner that is robust to the presence of short-run dynamics, and also the steady state relationships even in the presence of endogeneity among the right-hand

side variables. Overall, this cointegration framework allows for a broad set of cross member heterogeneity that may explain the EDFs across institutions.

C. Unit Root Tests and Panel Cointegration Test

Unit root tests show that the indicators used in panel cointegration tests—log of EDF, log of CPI, and log of Debt to Common Equity Ratio—are nonstationary (Table 2). According to the Pedroni panel cointegration tests performed on the log of EDF, log of CPI, and log of Debt to Common Equity Ratio, the statistics point to the conclusion that the variables are cointegrated (Table 3) (Pedroni 1995, 1999). Based on this cointegration relationship, we obtain conditional EDFs from the panel cointegration setup among log of EDF, log of CPI, and log of Debt to Common Equity Ratio. After we obtain the conditional EDFs, we incorporate them into the panel estimation.

Table 2. Unit Root Tests

	LOGEDF5	LOGDTCERT	LOGCPI
Levin-Lin rho-stat	-6.11**	-2.06**	2.55
Levin-Lin t-rho-stat	-0.73	0.50	1.83
Levin-Lin ADF-stat	-0.86	0.81	0.95
IPS ADF-stat	-4.74**	-0.67	0.67

Source:Thomson Reuters; Moody's KMV; and IMF staff estimates.

Note: The critical values are -1.28 (10 percent) and -1.64 (5 percent).

Table 3. Pedroni Heterogeneous Panel Cointegration

	LOG of Expected Default Frequencies, LOG of CPI and LOG of Debt to common equity ratio
Panel v-stat	6.25**
Panel rho-stat	-2.4**
Panel pp-stat	-2.05**
Panel adf-stat	-1.73**
Group rho-stat	-2.2**
Group pp-stat	-1.95**
Group adf-stat	-1.86**

Source:Thomson Reuters; Moody's KMV; and IMF staff estimates.

Note: The first four tests are pooled within-dimension tests and the last three tests are group mean between-dimension tests. Specifically, the first three statistics correct for serial correlation, the fourth parametric test similar to the ADF-type test allows the number of lags in the model to be estimated directly. The last three statistics treat the parameter of interest as varying across the members of the panel. The critical values for the variance statistic (v-stat) are 1.28 (significant at 10 percent level, denoted by *) and 1.64 (significant at 5 percent level, denoted by **), and those for all others are –1.28 (significant at 10 percent level, denoted by *) and –1.64 (significant at 5 percent level, denoted by **).

D. Panel Regressions

The estimation results for the full sample of 45 global FIs over the 45-quarter period suggest that, for a given institution, the EDFs are positively associated with inflation[13], leverage[14], global excess liquidity, and the global financial stress index, while having a negative relation to equity prices and ROA.[15] Moreover, the conditional EDFs are also significant across samples. A comparison of the two main groups of intervened and nonintervened FIs indicates that these factors can explain around 50 percent of the change in the EDFs of intervened and nonintervened FIs. Moreover, there appear to be stronger spillover effects for intervened FIs, as the two global market factors remain significant and with higher positive coefficients than in the full institution sample and the nonintervened FIs sample. However, the capital to assets ratio, REER, and GDP are generally insignificant (Table 4). [16]

In addition, we also test the significance of a dummy of government intervention. This is significant for the full sample panel specification and intervened institutions as well (Table 5).[17]

Given the increasing spillover (i.e., liquidity shock in the subprime crisis) among global FIs, a global macroeconomic model is well placed to capture the various shocks and interlinkages

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[13] Theoretically speaking, the link between inflation and EDF is mainly twofold, through factor prices and the prices that companies charge for their goods and services. On the one hand, higher factor prices lead to increased production costs of borrowers and tend to impair credit quality, thus leading to higher EDF. On the other hand, higher product prices can boost earnings and thereby improve creditworthiness, thus resulting in lower EDF. In this case, the empirical evidence shows that the effect of higher product prices outweighs that of higher factor prices, at least in the short run.

[14] Here again, the formal leverage ratio—total assets to capital ratio—is insignificant, further indicating it is less useful than some other leverage ratios.

[15] The negative association between ROA and EDF in the panel regressions is not in conflict with the fact that the ICBs have a higher ROA. This is because the ROA for the intervened institutions have declined quickly since late 2007, as indicated by Figure 7. This reflects the rising EDFs and is consistent with the panel analysis. The higher ROA value across 1998–2008 in Table 1 and Figure 7 overwhelm the decline in ROAs since the outbreak of the subprime crisis. In addition, this negative association shows the advantage of panel regressions, which incorporate the combined effects of various indicators during the long time span, and provide a more robust measure of their impact on EDFs.

[16] The general insignificance of GDP growth, though significant for intervened FIs, is not in line with the research of Bunn and Redwood (2003) using UK companies. This could be due to the fact that we use more countries in the sample, and the variation in GDP growth across countries could be large enough to produce an insignificant coefficient.

[17] As a robustness check, we also put those useful indicators identified in Section III into the panel regressions. The results show that book value per share (stock performance) is significant, while deposits-to-assets ratio (liquidity), and mortgage loans-to-total loans ratio (business scope) are generally insignificant.

that might affect FIs' EDFs. By taking into account a large set of linkages across macroeconomic and financial variables, the panel model is particularly suited for analysis of the transmission of real and financial shocks across regions and institutions.

E. Long-Run Causality Tests

This section exploits a cointegrated panel framework to check the direction of long-run causality and the sign of the long-run effect between leverage and EDFs. As shown in equation (2), Table 3, and Figure 11, leverage (ratio of debt to common equity) is positively cointegrated with EDFs. This subsection endeavors to explore these relations in more depth.

To undertake this exercise, we follow three steps: (i) we estimate the cointegrating relationship between the log of leverage and the log of EDF given in equation (2); (ii) we then estimate the error correction model; and (iii) we calculate the long-run causal effect of leverage on EDFs following Pedroni (2008) (see Annex VI for the details).

The results for each of these panel tests for the direction of long-run causality and the sign of the long-run causal effect are presented in Table 6, which also reports the results for the direction of long-run causality between leverage and EDFs. The results are reported for the panel as a whole, as well as for intervened and nonintervened subgroups.

Table 4. Fixed-Effects Panel Least-Square Estimation of the Determinants of the EDFs-Quarterly Observations (1998Q1–2009Q1), 45 Financial Institutions.

	45 Financial Institutions	Intervened	Nonintervened
Constant	-15.67	-18.11	-15.54
	(0.00)***	(0.00)***	(0.00)***
		Macroeconomic factors	
Inflation	3.56	6.29	6.18
	(0.06)*	(0.02)**	(0.03)**
REER	0.19	0.79	-0.28
	(0.65)	(0.19)	(0.64)
Real GDP	-0.91	-7.06	1.38
	(0.56)	(0.01)**	(0.50)
		Bank-specific factors	
Capital ratio	-0.02	0.06	-0.1
	(0.52)	(0.27)	(0.05)*
leverage	0.1	0.1	0.08
	(0.00)***	(0.01)**	(0.01)**
ROA	-1.5	-0.54	-1.75
	(0.00)***	(0.68)	(0.00)***
equity prices	-0.74	-0.39	-0.86
	(0.00)***	(0.08)*	(0.00)***
		Global market conditions	
global excess liquidity	12.35	12.94	11.81
	(0.00)***	(0.00)***	(0.00)***
financial stress index	3.9	7.06	1.35
	(0.00)***	(0.00)***	(0.14)
		Dummy	
Conditional EDF	9.89	10.67	9.03
	(0.00)***	(0.00)***	(0.00)***
Adjusted R^2	0.49	0.54	0.47
Time-series sample (quarterly)	1998Q1–2009Q1	1998Q1–2009Q1	1998Q1–2009Q1
No. of cross-section institutions	45	18	27
No. of observations	816	434	382

Sources: Bloomberg L.P.; Thomson Reuters; IMF WEO Database and Moody's KMV.

Note: Probability values are in brackets (***significant at 1 percent level; **significant at 5 percent level; *significant at 10 percent level).

Table 5. Fixed-Effects Panel Least-Square Estimation of the Determinants of the EDFs-Quarterly Observations with Government Intervention as Dummy (1998Q1–2009Q1), 45 Financial Institutions

	45 financial institutions	Intervened	Non-intervened
Constant	-18.75	-28.53	-15.95
	(0.00)***	(0.00)***	(0.00)***
		Macroeconomic factors	
Inflation	6.11	9.94	5.99
	(0.00)***	(0.00)***	(0.03)**
REER	0.07	0.51	-0.15
	(0.86)	(0.37)	(0.80)
GDP	0.7	-1.03	1.48
	(0.65)	(0.68)	(0.47)
		Bank-specific factors	
Capital ratio	-0.05	0.02	-0.1
	(0.14)	(0.65)	(0.04)**
Leverage	0.1	0.16	0.1
	(0.01)**	(0.15)	(0.02)**
ROA	-1.85	0.16	-1.78
	(0.00)***	(0.90)	(0.00)***
Equity prices	-0.73	-0.25	-0.88
	(0.00)***	(0.22)	(0.00)***
		Global market conditions	
Global excess liquidity	12.6	13.25	12.14
	(0.00)***	(0.00)***	(0.00)***
Financial stress index	2.7	5.37	1.21
	(0.00)***	(0.00)***	(0.18)
		Dummy	
Government Intervention	55.54	61.48	
	(0.00)***	(0.00)***	
Conditional EDF	6.71	5.57	8.83
	(0.00)***	(0.00)***	(0.00)***
Adjusted R^2	0.53	0.6	0.47
Time-series sample (quarterly)	1998Q1–2009Q1	1998Q1–2009Q1	1998Q1–2009Q1
No. of cross-section institutions	45	18	27
No. of observations	816	434	382

Sources: Bloomberg L.P.; Thomson Reuters; IMF WEO Database and Moody's KMV.

Note: Probability values are in brackets (***significant at 1 percent level; **significant at 5 percent level; *significant at 10 percent level).

Table 6. Long-Run Causality of Leverage to EDF

	λ_2: Leverage$_{it}$→EDF$_{it}$			λ_1:EDF$_{it}$ →Leverage$_{it}$			$-\lambda_2/\lambda_1$
	Estimate	Test	p value	Estimate	Test	p value	Median
All 45							
Group mean	0.26	0.57	0.72	-0.17	-1.48	0.07	0.22
Lambda-Pearson		169.26	0		241.75	0	0.45
Intervened							
Group mean	0.3	1.15	0.88	-0.19	-1.23	0.11	0.14
Lambda-Pearson		89.41	0		90.89	0	1
Nonintervened							
Group mean	0.23	0.19	0.57	-0.15	-1.64	0.05	0.26
Lambda-Pearson		79.85	0.01		150.87	0	0.46

Sources: Bloomberg L.P.; Thomson Reuters; IMF WEO Database and Moody's KMV.

Note: For each of these subgroups there are two rows, one for the group mean based tests, and one for the lambda-Pearson based tests. Columns 2–4 report these for tests based on the parameter λ_{2i}, which reflects the presence or absence of long-run causality running from leverage to EDF. The second column reports the panel point estimate, which exists only for the group mean, not for the lambda-Pearson. The third column reports the corresponding panel test statistics and the fourth column reports the p value for outcome of the panel test statistic. The next three columns repeat this same pattern for analogous tests based on the parameter λ_{1i}, which reflects the presence or absence of long-run causality running from EDF to leverage. Finally, the last column reports the group median point estimate of the sign ratio in the first row, with the simulated standard error reported in parentheses in the second row.

In Table 6, the group mean tests indicate that the average long-run effects of leverage on EDFs are zero for the 45 FIs, the intervened and the nonintervened FIs. However, the lambda-pearson tests clearly indicate that the long-run effects are pervasively non-zero individually for the 45 FIs and the two subgroups. Furthermore, the group median sign ratio tests in column 8 indicate that the level of leverage is associated with a positive causal effect pervasively among all FIs and the subgroups. The implication of these results is that the leverage level is positively associated with permanent long-run causal effects on the EDFs of the FIs. These results can be taken as further evidence of the damaging impact of higher leverage on EDFs.

In addition, Table 6 shows that the sign of the "estimate" of EDFs on leverage for three groups are all negative, indicating that the EDFs have a long-run negative causal effect on leverage. That is, higher (lower) EDFs tend to reduce (increase) leverage. The implication is that there will be a tendency for the leverage to rise as long as the default risks decline. Therefore, designing a mechanism to control leverage, among others, would be vital to reduce the EDFs.

V. CONCLUSIONS

This paper has provided the following key conclusions:

- Mixed results were found regarding the balance sheet data to highlight those firms that proved to be vulnerable in the current financial crisis. Leverage ratios were the most reliable indicator, and ROA and business scope can also provide predictive power. However, capital-to-asset ratios (including risk-adjusted ratios), and nonperforming loan data proved to be of little predictive power. In the current crisis, key vulnerabilities were unanticipated due to off-balance-sheet exposures and lenders' dependence on wholesale funding. Indeed, many "failed" institutions still met regulatory minimum capital requirements.[18] In particular, caution should be taken to encourage banks to increase retained earnings when boosting capital.

- Further econometric work using panel specifications and panel cointegration further strengthen the importance of some bank -specific indicators including leverage (e.g., debt to common equity ratio), ROA, stock market performance indicators (equity prices) in driving the changes in EDFs. In addition, leverage[19] has a long-run causal effect on the EDFs. This piece of evidence also suggests that measures to set up leverage constraints could pay significant dividends in restraining the rise in EDFs when designing a new regulatory framework.[20] Once again, some indicators that are widely taken as important to strengthen FIs and push forward future financial reforms, such as capital ratios, do not provide a useful indication of the rising EDFs.[21]

- Price stability matters. As the panel specifications show, inflation can exert an influence on the EDFs. This further underscores the importance of maintaining price stability, which is vital not only for monetary stability but financial stability as well.

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[18] However, FSIs are still helpful in assessing individual and systemic vulnerabilities when reliable market data may not be available—particularly in less-developed financial markets—as they can provide both an indication of rising vulnerabilities and as a check when other information reveals weaknesses. For countries with more sophisticated sources of information, FSIs could be usefully reevaluated, perhaps refocusing them on leverage ratios and ROA as a proxy for risk-taking. Of course, FSIs should be complemented by other measures and systemic stress tests, and be broadened to better capture off-balance-sheet exposures and liquidity mismatches.

[19] In theory, debt is a disciplining device because default allows creditors the option to force the firm into liquidation and thus exert pressure on the management to avoid borrowing too much. However, the tremendous gain from leverage could impose strong incentives for the management's borrowing to achieve excessive returns. The moral hazard associated with Too-Big-To-Fail would strengthen the incentives.

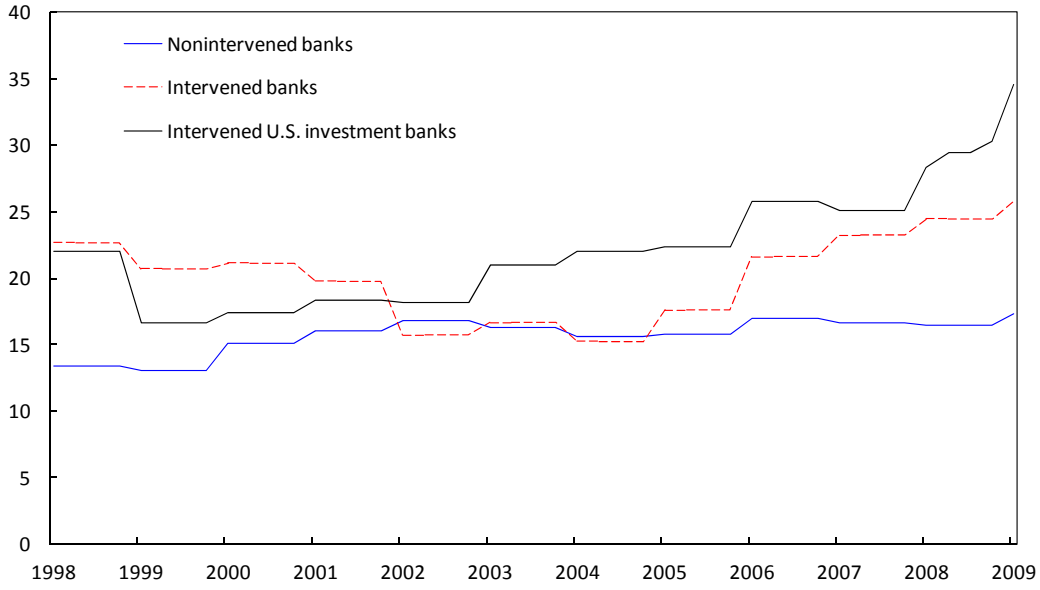
[20] Given the fact that the deleveraging process could trigger downward spirals in asset prices, regulators must consider leverage constraints when designing policies for capital regulation, and in fact, Basel III has done so.

[21] Higher capital ratios, on their own, do not necessarily stop banks from financing frothy asset purchases, and becoming vulnerable when a crisis occurs.

- Global macroeconomic conditions also matter. There is evidence that global excess liquidity and the financial stress index are significantly associated with the EDFs. This appears to suggest that global FIs are highly vulnerable to changes in global conditions. This means that better macroeconomic and global policies help to achieve lower EDFs, and, as a consequence, less financial instability.

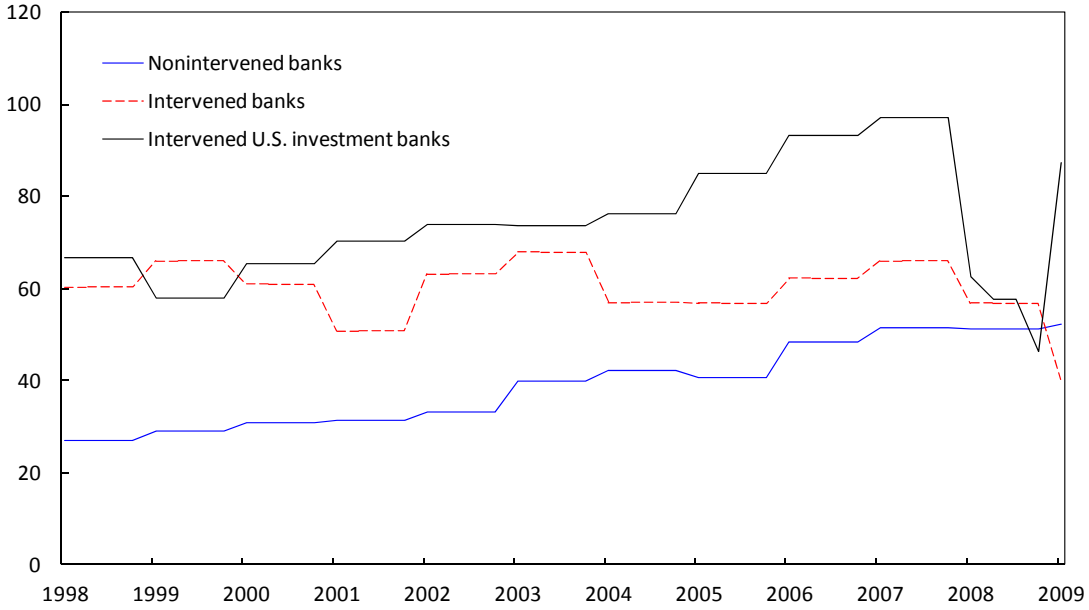
Overall, the panel specification and cointegration approach appears to be a useful tool for analyzing plausible global macro-financial shock scenarios designed for financial sector stress-testing purposes. The empirical analysis highlights several factors that would account for the vulnerabilities in the systemically important FIs. The results discussed above and the policy challenges associated with them point to the need to enhance the bank-specific indicators of financial soundness and improve the regulatory framework with a view to reducing the vulnerabilities emanating from the macroeconomic and global environment.

Figure 1. Capital-to-Assets Ratio
(In percent)



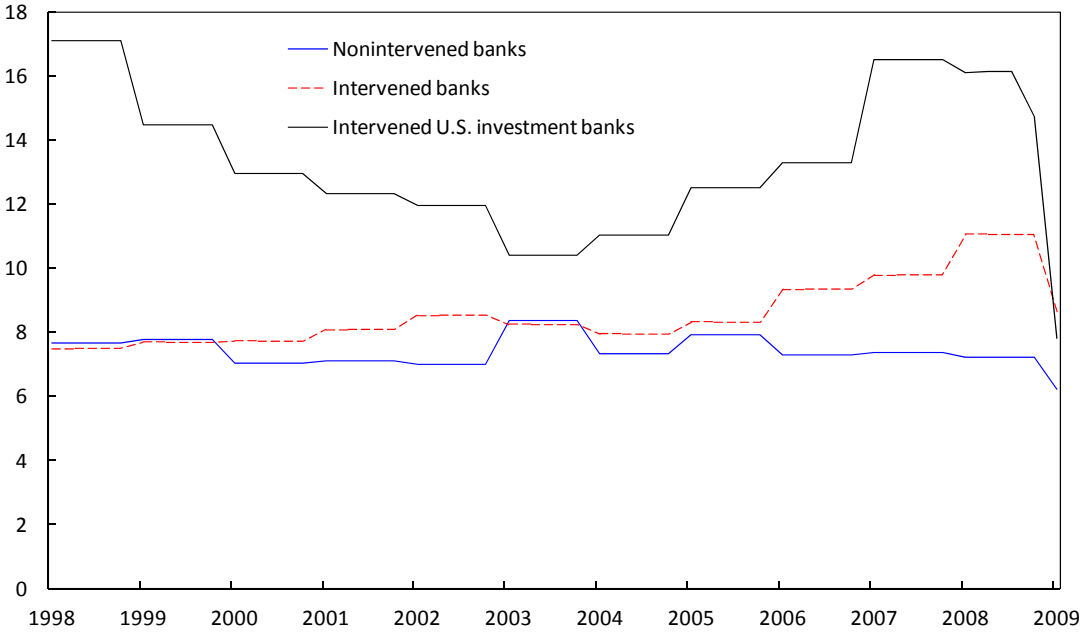
Sources: Thomson Reuters; and IMF staff estimates.
Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 2. Retained Earnings to Equity Ratio
(In percent)



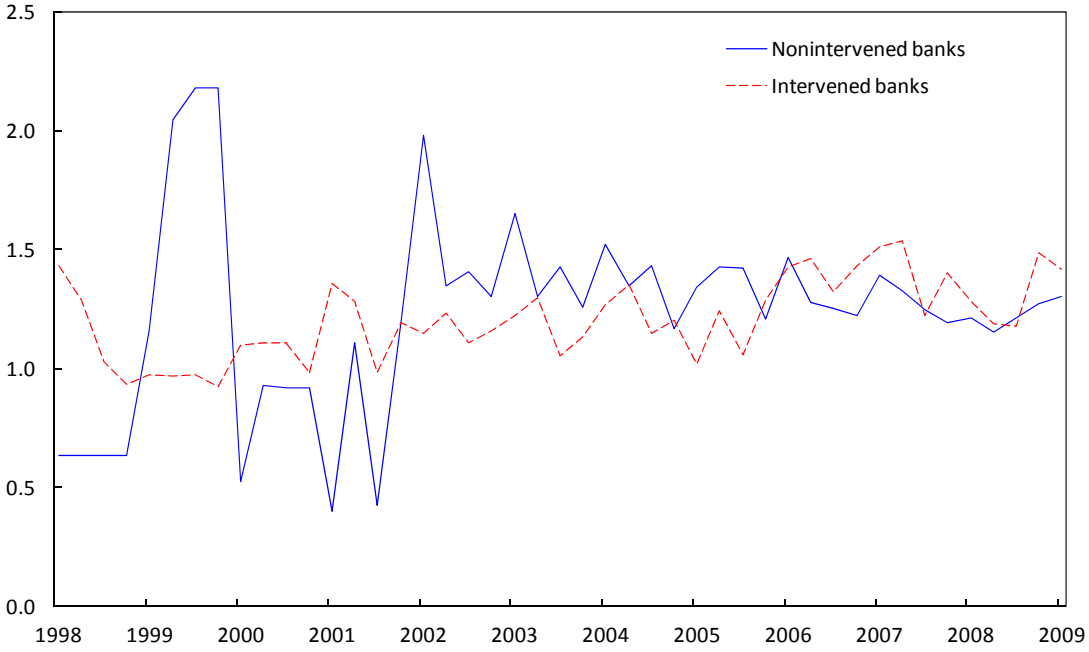
Sources: Thomson Reuters; and IMF staff estimates.
Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 3. Ratio of Debt to Common Equity



Sources: Thomson Reuters; and IMF staff estimates.
Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

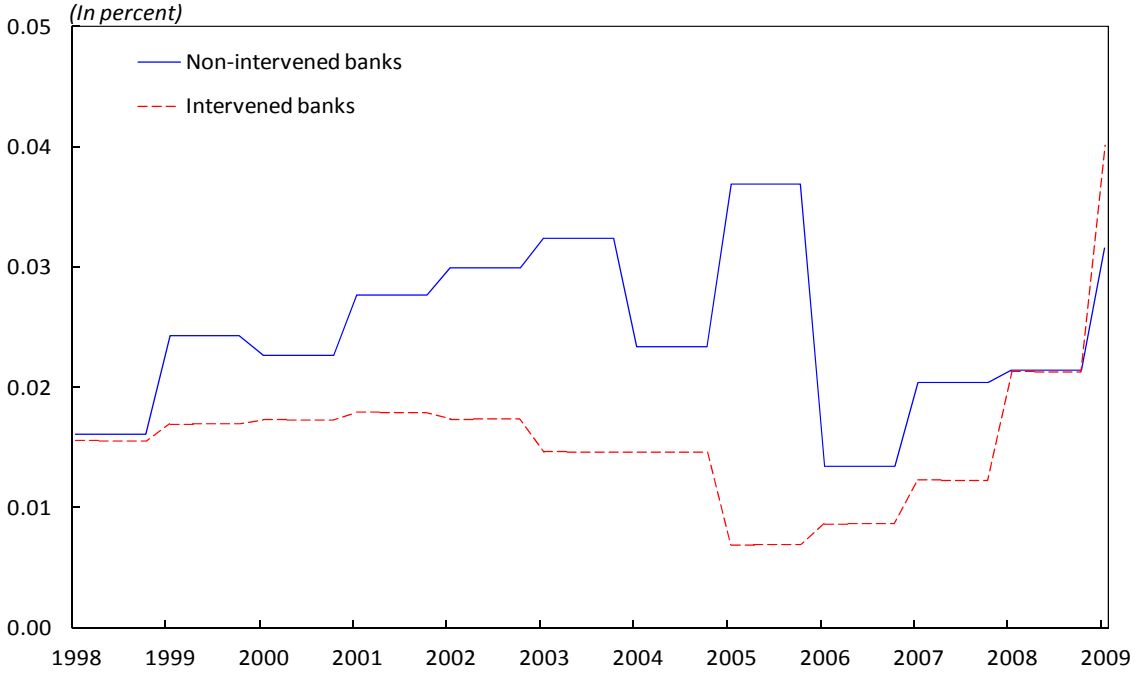
Figure 4. Loans-to-Deposits Ratio



Sources: Thomson Reuters; and IMF staff estimates.
Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 5. Nonperforming Loan Ratio

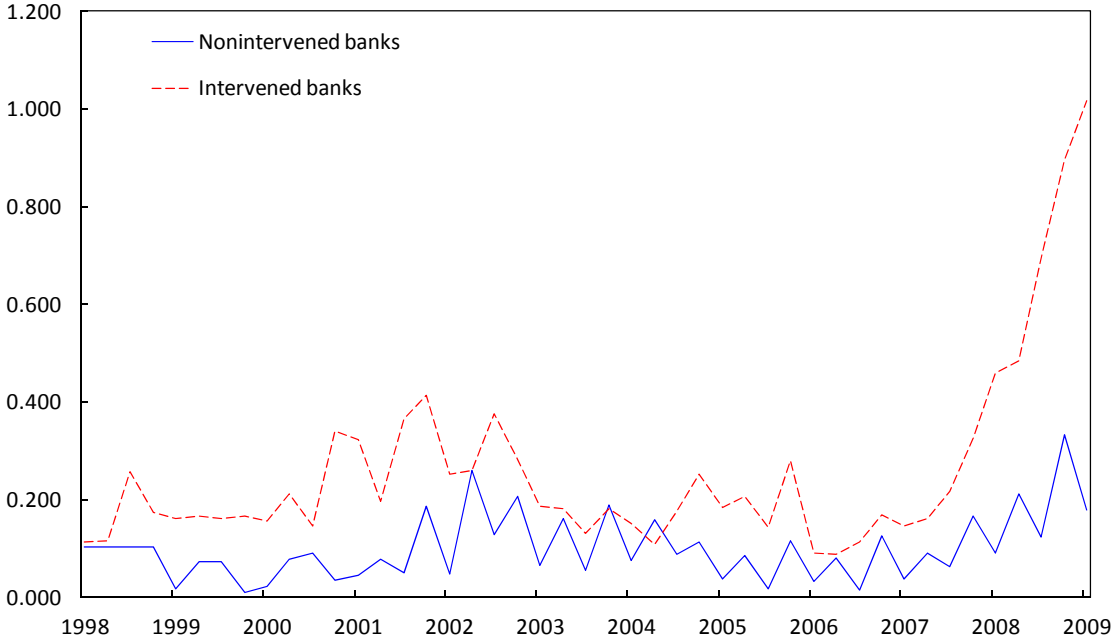
(In percent)



Sources: Thomson Reuters; and IMF staff estimates.
Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 6. Ratio of Provision for Loan losses to Loans

(In percent)

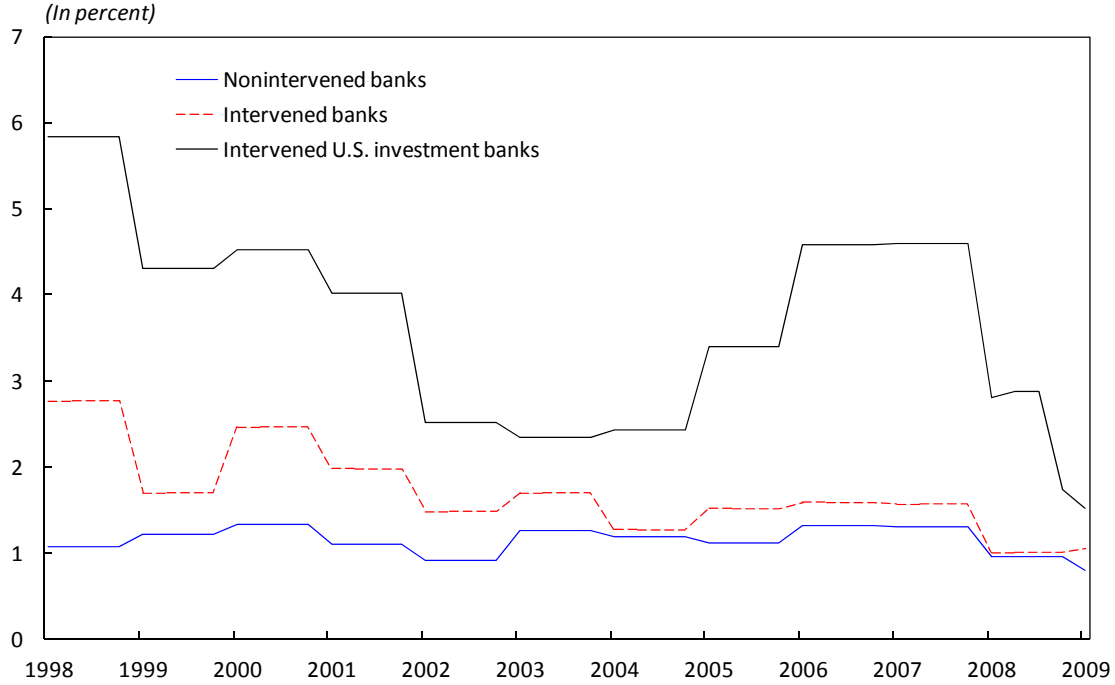


Sources: Thomson Reuters; and IMF staff esstimates.

Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 7. Return on Assets

(In percent)

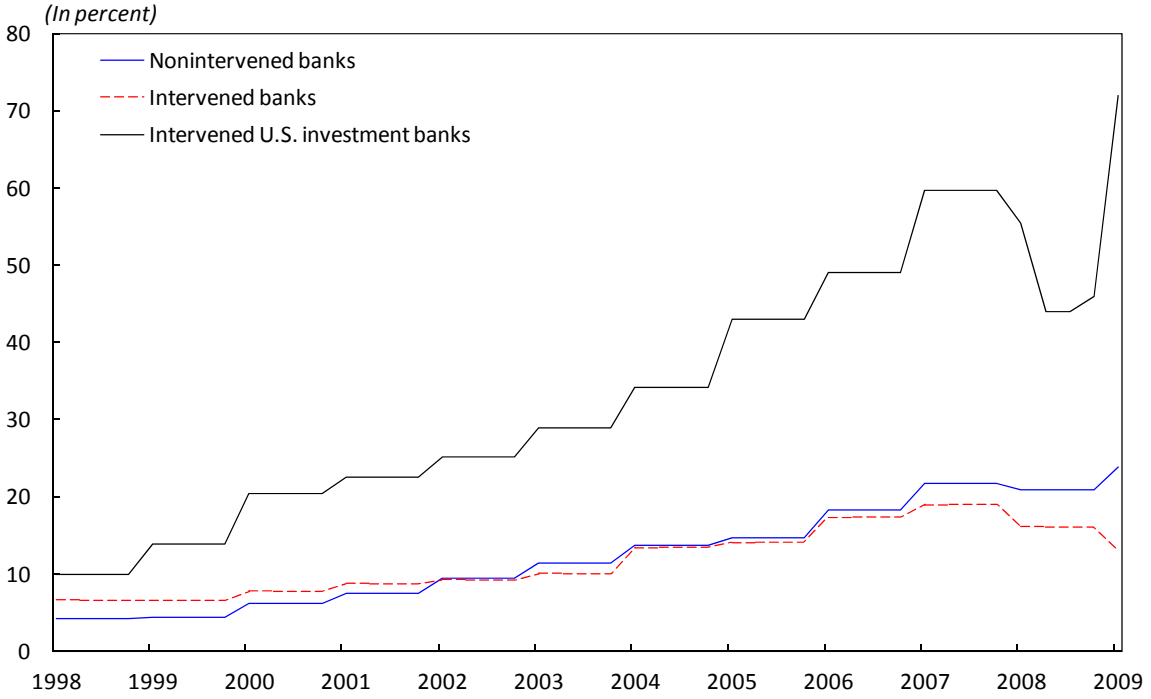


Sources: Thomson Reuters; and IMF staff estimates.

Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 8. Book Value Per Share

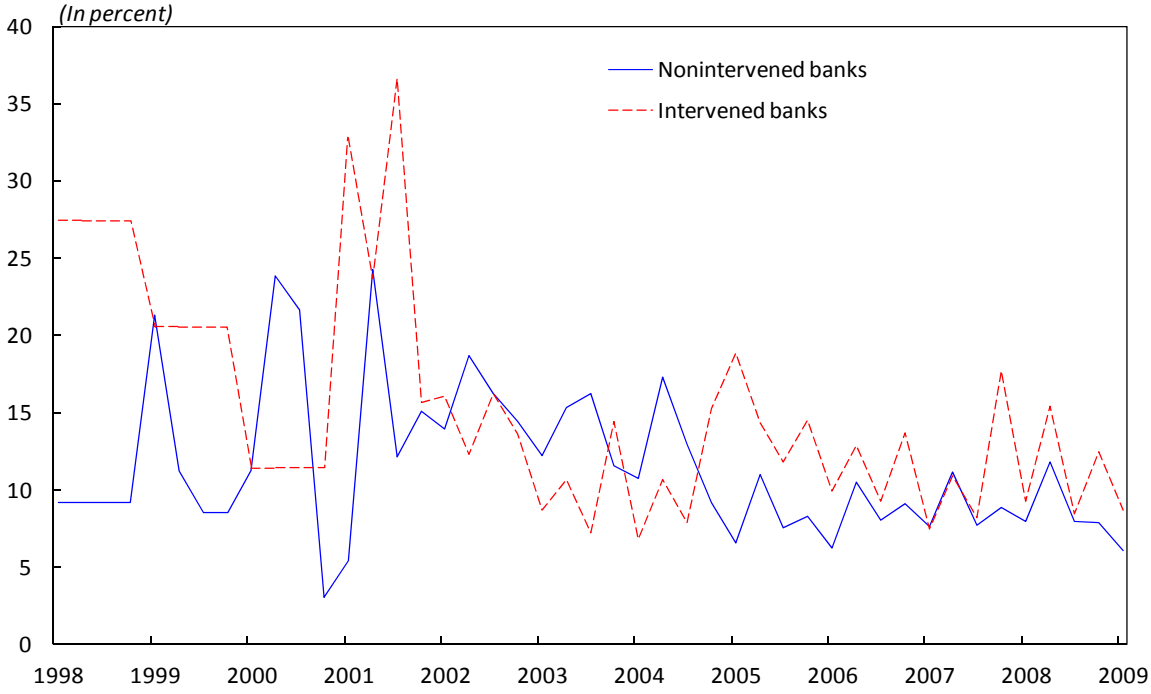
(In percent)



Sources: Thomson Reuters; and IMF staff estimates.
Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 9. Ratio of Interbank Loans to Total Loans

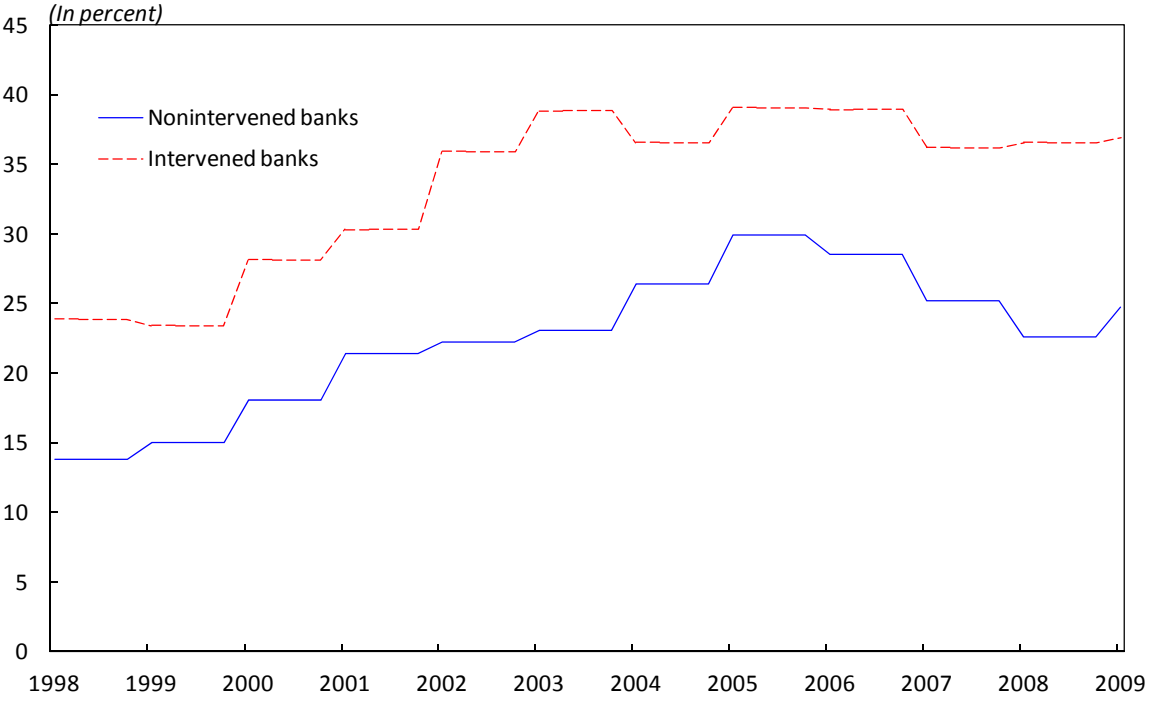
(In percent)



Sources: Thomson Reuters; and IMF staff estimates.
Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 10. Ratio of Mortgage Loans to Total Loans

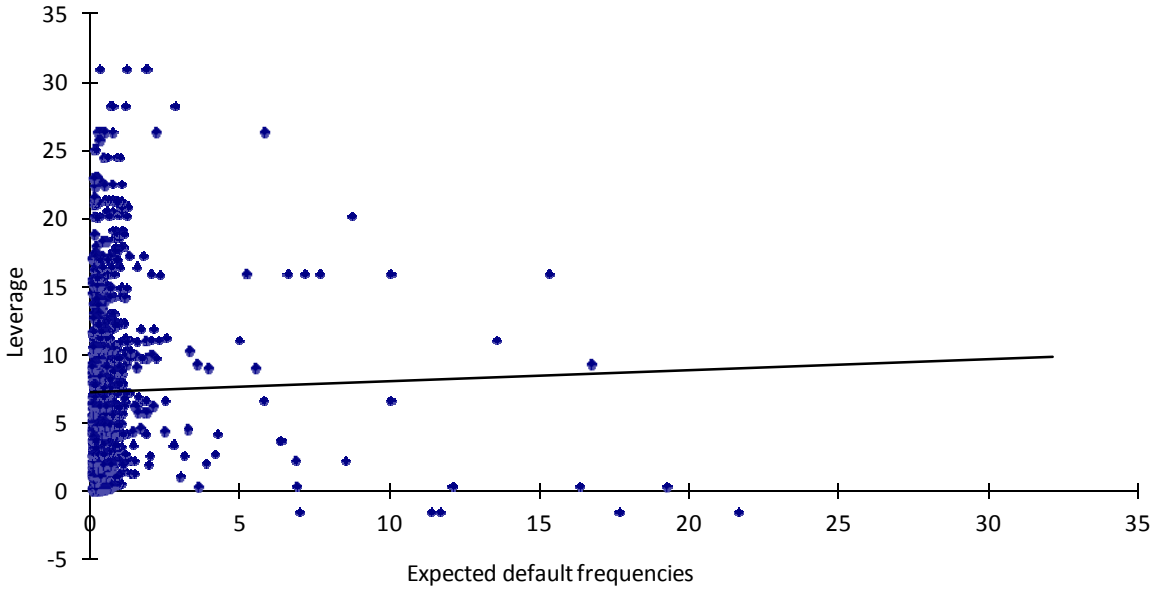
(In percent)



Sources: Thomson Reuters; and IMF staff estimates.

Note: The ratios of nonintervened banks, intervened banks, and intervened U.S. investment banks are the average of all institutions in each category.

Figure 11. Correlation Between Leverage and Expected Default Frequencies



Sources: Thomson Reuters; and IMF staff estimates.

Note: The leverage is the ratio of debt to common equity.

Annex I. List of Selected Financial Institutions

Regions		
Europe	**Asia/United States**	**Insurance Companies**
Euro area	**Asia**	AIG (AIG)
Intesa Sanpaolo (ISP)	Australia & New Zealand Banking Group (ANZ)	Allianz (ALV)
BNP Paribas (BNP)	Bank of China (BOC)	Ambac Financial (ABK)
Commerzbank (CBK)	DBS Group (DBS)	AXA (AXA)
Deutsche Bank (DBK)	ICICI Bank (IBN)	MBIA (MBI)
Fortis (FORB)	Industrial Bank of Korea (IBK)	Munich Re (MUV)
ING Group (INGA)	Mitsubishi UFJ Financial (MUF)	PMI (PMI)
Santander Hispano Group (SAN)	Nomura (NOM)	Prudential Plc (PRU)
Société Generale (GLE)	State Bank of India (SBIN)	Swiss Re (RUKN)
UniCredito (UCG)	Sumitomo Mitsui Financial (SUM)	
Non-Euro area	**United States**	
Barclays (BARC)	Bank of America (BAC)	
Credit Suisse (CSGN)	Bear Stearns (BSC)	
Danske (DANSK)	Citigroup (C)	
HBOS (HBOS)	Goldman Sachs (GS)	
HSBC (HSBA)	JPMorgan Chase & Co. (JPM)	
LloydsTSB (LLOY)	Lehman Brothers (LEH)	
Nordea (NDA)	Merrill Lynch (MER)	
Royal Bank of Scotland (RBS)	Morgan Stanley (MS)	
UBS (UBS)	Wachovia (WB)	

Annex II. List of Intervened Financial Institutions

Date (s) of Intervention	Country	Institution
Intervened institutions-banks		
9/29/2008	United States	Wachovia
9/29/2008	Belgium/ Netherlands/ Luxemburg	Fortis
10/3/2008	Belgium/Netherlands	Fortis
10/13/2008	United Kingdom	Royal Bank of Scotland, HBOS, LloydsTSB
10/16/2008	Switzerland	UBS
10/20/2008	Korea	Industrial Bank of Korea
10/28/2008	United States	JPMorgan Chase & Co.
10/28/2008	United States	Bank of America
11/24/2008	United States	Citigroup
1/19/2009	United Kingdom	Royal Bank of Scotland
1/9/2009	Germany	Commerzbank
Intervened investment banks		
3/14/2008	United States	Bear Stearns
9/15/2008	United States	Lehman Brothers
9/15/2008	United States	Merrill Lynch
10/28/2008	United States	Goldman Sachs
10/28/2008	United States	Morgan Stanley
Intervened insurance		
9/16/2008	United States	AIG

Annex III. Definition of Indicators

Variable	Definition
Total capital	The total investment in the company. It is the sum of common equity, preferred stock, minority interest, long-term debt, non-equity reserves and deferred tax liability in untaxed reserves. For insurance companies policyholders' equity is also included.
Total assets (banks)	The sum of cash & due from banks, total investments, net loans, customer liability on acceptances, investment in unconsolidated subsidiaries, real estate assets, net property, plant and equipment and other assets.
Total assets (Insurance Companies)	The sum of cash, total investments, premium balance receivables, investments in unconsolidated subsidiaries, net property, plant and equipment and other assets.
Total assets (Other Financial Companies)	The sum of cash & equivalents, receivables, securities inventory, custody securities, total investments, net loans, net property, plant and equipment, investments in unconsolidated subsidiaries and other assets.
Tier 1 capital	The primary capital supporting the lending and deposit activities of a bank. It includes: common stock; retained earnings; perpetual preferred stock; goodwill acquired before March 1988.
Tier 2 capital	The supplemental capital supporting the lending and deposit activities of a bank. It includes: limited life preferred stock; subordinated debt; loan loss reserves
Common equity	A measure of equity which only takes into account the common stockholders, and disregards the preferred stockholders. It is equal to shareholders' equity minus preferred equity.
Total capital to total assets ratio	Total capital divided by total assets
Tier 1 capital to total assets ratio	Tier 1 capital divided by total assets
Tier 1 and 2 capital to total assets ratio	Tier 1 and 2 capital divided by total assets
Nonperforming loans	The amount of loans that the bank foresees difficulty in collecting. It includes:Non-accrual loans, Reduced rate loans, Renegotiated loans and Loans past due 90 days or more It excludes Assets acquired in foreclosures and Repossessed personal property.
Total loans	The total amount of money loaned to customers before reserves for loan losses but after unearned income. It includes: Lease financing and Finance Receivables.
Nonperforming loans to total loans ratio	Nonperforming loans divided by total loans
Provision for loan losses	Losses that the bank expects to take as a result of uncollectible or troubled loans. includes: transfer to bad debt reserves and amortization of loans.
Provision for loan loss to loans ratios	Loan loss provisions divided by loans
ROA	Calculated as (Net Income before Preferred Dividends + ((Interest Expense on Debt-Interest Capitalized) * (1-Tax Rate))) divided by Last Year’s Total Assets * 100

Annex III. Definition of Indicators (Continued)

ROE	Calculated as (Income before preferred dividends-preferred dividends)divided by total common equity*100
Net interest income	The difference between the total interest income and total interest expense of the bank.
Cost of debt	Interest expenses on debt
Total deposits	The value of money held by the bank or financial company on behalf of its customers.
Total loans to total deposits ratio	Total loans divided by total deposits
Deposits to assets ratio	Deposits divided by total assets minus customer liabilities or acceptances
Debt to equity ratios	Debt divided by equity
Debt to assets ratios	Debt divided by assets
Assets to common equity ratios	Assets divided by common equity
Long term debt/capital	Long term debt divided by total capital
PE ratio	Equity price divided by earnings ratio-close
EPS	Earning per share
Book value per share	Book value (proportioned common equity divided by outstanding shares) at the company's fiscal year end for non-U.S. corporations and at the end of the last calendar quarter for U.S. corporations.
Mortgage-backed securities	An investment grade security backed by a pool of mortgage or trust deeds. These securities are secured by conventional mortgages and are guaranteed as to interest and principal.
Net interest margin	The difference between the average aggregate rate earned on a loan or investment portfolio less the average rate of aggregate liabilities and capital. This item may also be referred to as net interest yield or net interest income divided by net interest spread.
Total interest expenses	The total amount of interest paid by the bank. It includes (1) Interest expense on deposits; (2) Interest expense on federal funds; (3) Interest expense on commercial paper; (4) Interest expense on short term borrowing; (5) Interest expense on long term debt; (6) Interest expense on securities purchased under resale agreements
Total interest expenses to total deposits	Total interest expenses divided by total deposits
Short-term debt and current portfolio long term debt	The portion of debt payable within one year including current portion of long term debt and sinking fund requirements of preferred stock or debentures
Short-term debt and current portfolio long term debt to total debt ratio	Short-term debt and current portfolio long term debt divided by total debt

Sources: Bloomberg L.P.; Thomson Reuters.

Annex IV. Indicators in the Panel Specification

Series name	Description	Frequency	Underlying Sources	Transformation
EDF	Expected default frequencies (5 year)	Quarterly	Moody's KMV	Dlog
CPI	Inflation	Quarterly	WEO	Dlog
REER	Real Effective Exchange Rate	Quarterly	WEO	Dlog
RGDP	Real GDP	Quarterly	WEO	Dlog
Total capital /total assets	Capital ratio	Quarterly	Thomson Reuters	Dlog
ROA	Return on Assets	Quarterly	Thomson Reuters	Level
MSCI	Morgan Stanley Capital International world index	Quarterly	Thomson Reuters	Dlog
Long-term debt/capital	Leverage	Quarterly	Thomson Reuters	Dlog
Debt/common equity	Leverage	Quarterly	Thomson Reuters	Dlog
EXCLIQ	Global excess liquidity	Quarterly	IFS	Level
FSI	Financial stress index	Quarterly	IMF	Difference
Conditional EDF	Conditional Expected Default Frequencies	Quarterly	Moody's KMV; and Thomson Reuters	Level
Dummy	Government intervention	Quarterly	News	Level

Sources: Bloomberg L.P.; Thomson Reuters; IMF World Economic Outlook database; and Moody's KMV.

Annex V. Methodology for Panel Cointegration

Since panel techniques based on Instrument Variables (IV) or Generalized Method of Moments (GMM) estimation cannot correct for endogeneity induced by latent heterogeneity, we take Pedroni panel cointegration tests to allow complete endogeneity, heterogeneous dynamics and cointegrating vectors. The panel cointegration approach can provide desirable properties of cointegration since it is robust to endogeneity and many forms of omitted variables, simultaneity and measurement error. It can also isolate long-run steady state relationships from short-run dynamics. Pedroni (1995,1999) relaxed the assumption of homogeneity in that the slope coefficient β is allowed to vary across the individual members of the panel.

Specifically, the panel cointegration regression is as follows:

$$y_{i,t} = \alpha_i + \beta_{1i,t} X_{1i,t} + \beta_{2i,t} X_{2i,t} + \ldots + \beta_{ki,t} X_{ki,t} + \gamma_{i,t} + e_{i,t} \quad (3)$$

If $y_{i,,t}$= 1,….,T, *i* represents each institution, has a unit root, so that $y_{i,t} \sim I(1)$, and $X_{ki,,t}$,t = 1,….,T, has a unit root, so that $X_{ki,t} \sim I(1)$, then $X_{ki,t}$ and $y_{i,t}$ are cointegrated if some linear combination $e_{i,t} = y_{i,t} - \alpha_i - \beta_{ki,t} X_{ki,t}$ is stationary, so that $e_{i,t} \sim I(0)$.
Since the α_i and various β_i are allowed to vary across the members of the panel, this approach allows for considerable short- and long-run heterogeneity—in effect the dynamics and fixed effects can differ across the individuals in the panel and the cointegration vector can also differ across members under the alternative hypothesis (Richard Harris and Robert Sollis, 2003).

In the cointegrated panel specification framework, the combination of the extra dimension (by adding the cross-sectional to the time-series dimension) and the long run properties of the cointegrating relationship provide us with a broader and more flexible approach, through which the statistical proxies such as the fixed effects and heterogeneous trend components can serve to capture a broad class of unobserved mechanisms.

Moreover, the nonstationary panel framework allows us to relax many of the strong assumptions that have typically been required in cross sectional-based approaches. This framework completely relaxes the exogeneity assumptions and can also isolate long-run steady state relationships from short-run dynamics. Overall, this cointegration framework allows for a broad set of channels that may explain the EDFs across institutions.

To avoid the use of nonstationary variables and to maintain a relatively large sample, we performed the unit root test for all variables. For those that follow a stationary process, we use them in the panel specifications to examine the factors driving the EDFs. For those that are nonstationary, we run cointegration tests to uncover the stochastic and nonstochastic long-run trending features of the data.

Annex VI. Methodology for Long-Run Causal Effect

Since in each institution the series of leverage (e.g., debt to common equity ratio) and the EDFs are individually non-stationary but together are cointegrated, we know from the Granger representation theorem (Engle and Granger, 1987) that these series can be represented in the form of a dynamic error correction model. Following Pedroni (2008), we estimate the cointegrating relationship between the log of leverage and the log of EDF given in equation (4) for each institution. We use this estimated cointegrating relationship to construct the disequilibrium term, $e_{i,t}$, $e_{i,t} = EDF_{i,t} - \alpha_{i,t} - \beta_{i,t}\ LEVERAGE_{i,t}$

We then estimate the error correction model using equation (5) and (6).

$$EDF_{i,t} = \alpha_{i,t} + \beta_{i,t} LEVERAGE_{i,t} + e_{i,t} \quad (4)$$

$$\Delta LEVERAGE_{i,t} = C_{i,t} + \lambda_{1i} e_{i,t-1} + \sum_{j=1}^{k} \phi_{11ij} \Delta LEVERAGE_{i,t-j} + \sum_{j=1}^{k} \phi_{12ij} \Delta EDF_{i,t-j} + \varepsilon_{1i,t} \quad (5)$$

$$\Delta EDF_{i,t} = C_{2i} + \lambda_{2i} e_{i,t-1} + \sum_{j=1}^{k} \phi_{21ij} \Delta EDF_{i,t-j} + \sum_{i=1}^{k} \phi_{22it} \Delta LEVERAGE_{i,t-j} + \varepsilon_{2i,t} \quad (6)$$

The variable $e_{i,t}$ represents how far our variables are from the equilibrium relationship, and the λ's in the error correction mechanism estimates how this disequilibrium causes the variables to adjust towards equilibrium in order to keep the long-run relationship intact. The Granger representation theorem implies that at least one of the adjustment coefficients λ_{1i} or λ_{2i} must be non-zero if a long-run relationship between the variables is to hold. In addition, λ_{1i} and λ_{2i} are the speed of adjustment coefficients in the error correction representation.[22] The ratio,$-\lambda_{2i}/\lambda_{1i}$ represents the panel-based tests using group mean or lambda-Pearson based tests. We can exploit these pieces of information to test for the existence, and the sign, of any long-run causal effects running from innovations in log leverage to log EDF.

By exploiting the cointegrating relationship, we are able to summarize the long-run effects of the innovations in the variables in terms of two parameters, λ_{1i} and λ_{2i}. Here we only test for the existence and sign of long-run effects rather than obtaining a quantitative measure of the size of these effects. By exploiting the cointegrating relationships present in the data, and summarizing the long-run effects of our leverage model with a small number of parameters,

[22] The coefficient, λ2, on the lagged equilibrium cointegrating relationship in the dynamic error correction equation for $\Delta LEVERAGE_t$ and ΔEDF_t is zero if, and only if, innovations to log leverage have no long-run effect on the log of EDF. The null hypothesis is that there is no long-run effect of leverage on the EDFs in any institution of the panel.

we avoid the problems of inference. This is particularly important when we apply the test in a panel context, given the large number of parameters that would otherwise need to be estimated. This allows us to construct group mean and group median-based tests for the direction of long-run causality in panels with heterogeneous dynamics, and similarly allows us to construct group median-based tests for the sign of the long-run causal effect in such panels (For detailed analysis, see Canning and Pedroni (2008)).

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