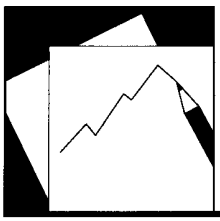
WP/13/142



IMF Working Paper

Risk Exposures and Financial Spillovers in Tranquil and Crisis Times: Bank-Level Evidence

Hélène Poirson and Jochen Schmittmann

INTERNATIONAL MONETARY FUND

 WP/13/142

IMF Working Paper

European Department and Monetary and Capital Markets Department

Risk Exposures and Financial Spillovers in Tranquil and Crisis Times: Bank-Level Evidence

Prepared by Hélène Poirson and Jochen Schmittmann[1]

Authorized for distribution by Peter Dattels and Edward Gardner

June 2013

Abstract

For a sample of 83 financial institutions during 2003–2011, this paper attempts to answer three questions: first, what is the evolution of banks' stock price exposure to country-level and global risk factors as approximated by equity indices; second, which bank-specific characteristics explain these risk exposures; third, are there clusters of banks with equity price linkages beyond market risk factors. The paper finds a rise in sensitivities to both country and global risk factors in 2011, although on average to levels still below those of the subprime crisis. The average sensitivity to European risk, specifically, has been steadily rising since 2008. Banks that are reliant on wholesale funding, have weaker capital levels and low valuations, and higher exposures to crisis countries are found to be the most vulnerable to shocks. The analysis of bank-to-bank linkages suggests that any "globalization" of the euro area crisis is likely to be channelled through U.K. and U.S. banks, with little evidence of direct spillover effects to other regions.

JEL Classification Numbers: G15, G21, F37

Keywords: Financial sector; financial institutions; banks; Europe; financial crisis; spillovers.

Author's E-Mail Address:hpoirson@imf.org; jschmittmann@imf.org

[1] The authors are grateful for guidance and feedback to Peter Dattels, Petya Koeva Brooks, Ashoka Mody, and seminar participants in the IMF European Department, and to Susan Becker for research assistance.

Contents Page

I. INTRODUCTION

Since 2007 banks' stock prices have been extraordinary volatile. The U.S. subprime crisis, the bankruptcy of Lehman Brothers, and the euro area (EA) sovereign debt crisis have weighed on bank equity returns. While bank stocks across all advanced economies have been hard hit, there has also been considerable heterogeneity in stock performance across banks and countries. In this paper we contribute to the understanding of banks' stock price dynamics by answering three questions. First, we use a factor-model approach to analyze the sensitivities of banks' stock returns to global and country factors (bank betas).[2] Second, we study how these bank betas are related to bank-specific characteristics such as the extent of exposures to European crisis countries, the degree of international operations, leverage, size, funding structure, and profitability. Third, we ask if there is evidence of significant exposures of banks, including in other regions, to Europe's largest banks (i.e., spillover effects or risk transmission from banks to banks) beyond the exposures to common factors.

Our dataset includes 83 banks incorporated in 21 countries, representing almost 75 percent of global banking system assets in 2008–09 (see Table 1) and covers the period from December 2002 to November 2011. Unlike recent studies, which focus mostly on contagion in Europe, our broad sample coverage allows us to investigate contagion globally. Our focus is on spillovers to/from European banks as we are mainly interested in shedding light on the issue of possible financial contagion effects from the EA crisis to other regions. We allow banks' factor sensitivities to vary over time by re-estimating our model for every half-year in the sample, in contrast with most earlier studies that assume unchanged risk exposures over the sample period. Time-varying risk exposures could reflect structural trends due to increased global financial integration and/or spillovers during crisis periods.[3] In particular, peaks in the estimated bank betas signal periods of generalized financial stress.[4] The results of a decomposition of the variance of stock returns into contributions from various factors helps uncover the sources of return volatility—whether the volatility arises primarily from the global market, the domestic market, or is unrelated to the observable factors.

In line with earlier studies, we find that the exposure to the global risk factor has played an important role in explaining both the volatility following the onset of the 2008–09 financial crisis and the more recent volatility during the EA debt crisis. Both episodes appear to have

[2] Throughout the paper, we use the terms "factor loadings", "risk exposures", and "bank betas" for the sensitivity of banks' share prices to movements in the world or respective country stock market return. This nomenclature is in line with the literature on the subject.

[3] There is a precedent for this approach: Bekaert et al. (2009) use a similar framework to study international stock return co-movements. They establish that parsimonious risk-based factor models with time-varying exposures capture the data covariance structure better than the popular Heston-Rouwenhorst (1994) model or more recent extensions such as Brooks and Del Negro (2005 and 2006) which allow for non-unitary but time invariant exposures.

[4] Dungey et al. (2005) allow bank betas to vary during crisis times compared to tranquil times via the inclusion of a crisis dummy. Our approach is less dependent on the accurate timing of the crisis as it lets the data endogenously determine the crisis periods.

had a global impact with bank betas peaking not only in the countries where the shock originated, but also in other regions.

This said, our results also indicate that the EA crisis has affected European banks more, and its impact on other regions has been less. We find that the sensitivity of French banks' stock returns to the global factor and, to a lesser extent, of German banks, have risen to historical highs in 2011. In contrast, sensitivities for banks in the United Kingdom (U.K.), the United States (U.S.), and rest of the world have risen much less. Regarding country-specific factors, French banks have become more sensitive to their home market in 2011. By contrast, German banks do not show a noticeable increase in country risk exposure.

The share of bank stock return volatility explained by the global risk factor has been rising since 2003 reaching about 50 percent in the second half of 2011, while the share of volatility accounted for by the idiosyncratic component has been shrinking to about 30 percent at the end of 2011. Across the entire sample the share of volatility explained by country factors has been relatively constant at about 20 percent from 2003 to 2011. In France, Germany, and the U.K. the share of volatility explained by the world factor has been rising over the sample period (to about 50 percent at end-2011) suggesting closer global integration of bank stocks. The share of volatility explained by the country factor is smaller in Germany and the U.S. than in the U.K. and France. In the case of Germany this is probably due to the low weight of financial stocks in the country's stock market. In the case of the U.S. the likely explanation is that many U.S. developments are already reflected in the world factor, given the large share of the U.S. in the world equity market.

Our findings of second-stage regressions of bank betas on bank characteristics point to dependence on wholesale funding as a key risk factor, both for country and world equity betas. Insufficient capital ratios are another bank-level weakness contributing to higher world risk exposure, including during the recent EA crisis. In line with earlier findings by Brooks and Del Negro (2006), the extent of foreign operations is positively correlated with sensitivity to world equity risk. Finally, low valuations increase the sensitivities of banks to both world and country equity risk. The other feature of significance for EA banks is their size, with rapid balance sheet growth during the 2000s driven by explosive growth in cross-border bank lending in Europe.[5] Pre-crisis (in 2006 H1), we find that size lowered estimated sensitivities of banks' stock returns to global shocks, possibly reflecting a too-big-to-fail effect and/or the more diversified nature of their operations. However with the worsening of the European sovereign debt crisis in 2011, the opposite result prevails in 2011 H1: larger institutions are perceived *ceteris paribus* as more vulnerable to global shocks, possibly reflecting their comparatively high exposure to potential losses in peripheral Europe.

Finally, the paper attempts to test for bank spillover effects, i.e. whether exposures to other banks matter over and above the exposures to common factors.[6] We find that spillover effects

[5] Cross-border assets and liabilities of EA banks increased nearly four-fold since 2002, following the introduction of the euro (Shin, 2011).

[6] We quantify and report gross spillovers, net of general factors affecting all banks, but not net of other banks.

for the large European banks have a strong regional dimension. For example, stock returns of German banks tend to co-move strongly with other German and European banks (notably French and U.K. banks and, to a lesser extent, Dutch, Swiss, and Belgian banks). French banks also co-move strongly with U.K. banks and exhibit tight linkages with Southern Europe banks (Italy and Spain) during the pre-crisis period, as well as with Belgian, Dutch, and Swiss banks. Evidence of bank-level interconnectedness between European and non-European banks is more limited. French and German banks co-move strongly only with selected U.S. financial institutions, while U.K. banks are connected strongly with both Asia (pre-crisis only) and the U.S. (in both periods). The results remain largely unchanged when we include a set of control variables for financial conditions. This last finding suggests that the estimated spillover effects capture pure risk transmission across banks (contagion) rather than shared sensitivities to macro-financial variables.

The remainder of the paper is as follows. Section II places the paper in the context of the related financial crisis and contagion literature. Section III presents the estimation framework. Section IV discusses the data, including variable definitions and sources used. Section V presents the results and Section VI concludes and draws policy implications from the findings.

II. Related Literature

A vast empirical literature on financial market contagion has attempted to disentangle interdependence (reflecting the exposure to similar macro shocks) from "proper" contagion. This literature broadly defines contagion as excess correlation— i.e., correlation over and above what one would expect from economic fundamentals. The definition of the fundamentals and the mechanism that links the fundamentals to asset correlation varies across studies.

A. Bank Exposures to Common Shocks

Several studies use a factor model approach to decompose returns into common vs. idiosyncratic shocks (see for example Bekaert et al., 2003 and 2011). Latent factor models leave the factors unidentified—this approach captures a substantial amount of covariation, but since the factors are unidentified, they are difficult to interpret economically (see Dungey et al. 2004 and 2005 for an application to the Asian and Russian crises). In some studies (see for example Brooks and Del Negro, 2005a and 2006), the latent factors are identified as global, country, industry and other factors by imposing restrictions on the variance-covariance matrix. Other studies simply relate stock returns to pre-specified variables (see below). This approach has the advantage that the factors are identified but their choice can be somewhat arbitrary.

Few studies have examined the question of whether the relative exposures to common shocks can be explained by firm-level fundamentals. Using firm-level regressions for a sample of individual companies in 20 countries, Brooks and Del Negro (2006) find that firms that operate globally are more vulnerable to global shocks. Every 10 percent rise in international sales causes a rise in the exposure of the stock return to global shocks by about 0.3 percent, and this link has grown stronger over time since the mid-1980s. By contrast, there is no

robust link between international exposure and exposure to country-specific shocks. Brooks and Del Negro (2005a and 2006) also find that observables explain only a small fraction of differences in exposures across firms (adjusted R-squared of 13–15 percent).

Several recent studies have focused on banks' equity returns during the current EA crisis, using regressions of changes in bank stock returns or CDS spreads on macroeconomic and bank-specific variables. Chan-Lau et al. (2012) find that bank equity returns have been driven mainly by weak growth prospects and heightened sovereign risk and to a lesser extent, by deteriorating funding conditions and investor sentiment. Banks with a greater reliance on wholesale funding and a low ratio of equity capital to assets are found to underperform their peers. The study finds that the ratio of Tier-1 capital to risk-weighted assets is not systematically related to bank's performance in crisis times, in line with studies that show substantial measurement issues with this ratio. Similarly, ECB (2011) shows banks' equity risk (measured by the beta of the bank's share price relative to the reference national index) to be significantly related to equity capital after controlling for bank and time fixed effects and other bank-specific indicators including: size, profitability, and regulatory balance sheet risk (measured by risk-weighted assets). Tressel (2011) confirms that reliance on wholesale funding and heightened sovereign risk raise the likelihood of a bank being affected by shocks, and also finds that the regulatory capital ratio is not a significant determinant of bank stocks' or CDS spreads' relation to risk measures.

B. Bank Exposures to Other Banks

The existing empirical literature on bank interdependence and contagion focuses on interdependencies between banks using market-based indicators such as CDS or equity prices. Recent studies have examined contagion within Europe, and only in few instances also contagion from the U.S., Asia, and emerging countries to Europe. The results suggest that (1) intra-European contagion has increased following the introduction of the euro and (2) spillovers tend to be regional, with only "core" European banks transmitting shocks beyond Europe to other regions. The studies are pure statistical exercises and to explain the patterns obtained with fundamentals remains an important avenue for future research. Another difficulty facing the existing approaches is distinguishing common (macro) shocks affecting two or more banks from contagion. Without eliminating at least some common shocks as a source for the concurrent presence of distress in more than one institution, the purely statistical approaches may overestimate the extent of bank-to-bank spillovers.[7]

A first popular approach produces a joint probability of distress for the system, viewed as a "portfolio of institutions" (see Segoviano, 2006a, 2006b, and Segoviano and Goodhart, 2009). It also yields an estimate of the contribution of individual institutions to systemic risk and of bank-to-bank spillovers, measured by averages of estimated conditional probabilities of distress. Chen et al. (2011), using daily CDS spreads, apply this methodology

[7] For a sample of 67 EU banks during 1991–2003, Gropp and Moerman (2003) observe significantly less instances in which banks experience a bottom tail event concurrently when using abnormal returns (controlling for macro shocks as measured by the local market return) vs. a baseline approach that fails to control for macro shocks.

to spillovers from EA to non-EA banks. They find that estimated spillovers from EA program country banks are large for other banks in the region but smaller for banks elsewhere. By contrast, core EA bank distress would be a systemic event impacting banks globally.

Yilmaz (2011) utilizes a simple univariate Value-At-Risk (VAR) model to identify intra-European spillovers transmitted via the equity markets. It defines a bank as being an originator (receiver) of contagion when the difference between the shocks transmitted to other banks and shocks received from others is positive (negative). The study finds that French and Spanish banks have been net transmitters of shocks for most of 2011, whereas banks from Belgium, Germany, and the Netherlands have been net receivers.[8] However, a simple VAR analytical framework fails to control for common factors and thus may result in an overestimation of the impact of shocks to banks' share prices on each other by attributing to other banks what may actually be the impact of a common shock.[9]

A related approach to bank contagion relies on distance-to-default to build an indicator of whether a bank is experiencing a large shock, and defines contagion as interdependencies in the tail of the distribution. For example, Gropp and Moerman (2003) apply this approach to a sample of 67 EU banks during 1991-2003. Net contagious influence of bank *j* is measured as a probability of distress of bank *j* given distress in other banks which is strictly less than the probability of distress in other banks given distress in bank *j*. Two German banks, one Danish bank, two Irish banks, two Dutch banks, and two U.K. banks are consistently identified as net transmitters of shocks. Two French banks, two Spanish banks, and a number of large U.K. banks also seem to have cross-country contagious influence, but the evidence is weaker.

Gropp et al. (2006) use a similar approach at the country level (using country equity indices). Their results suggest that Spanish banks are exposed to shocks from Italian banks, and in turn transmit shocks to German, French, Dutch, and U.K. banks; French banks have contagious influence on Italian banks; German banks on U.K. and U.S. banks; and U.K., U.S., and Dutch banks on German banks. When focusing only on the post-euro period, the results suggest that introduction of the euro has increased contagion. Contagion from Spain to the U.K. and France and bilateral contagion between the U.K. and Germany continues to prevail. However, there is no longer contagion from Dutch to German banks, from French to Italian banks and from Spanish to German banks. Instead, there is evidence of contagion from French to U.K. banks, Italian to Dutch banks, German to Spanish banks, U.K. to Spanish banks, and bilateral contagion between Germany and Italy.

[8] Swiss banks and Italian banks are an intermediate case: net receivers of shocks in the first half of 2011, and originators of shocks in the latter part of the year.

[9] Using principal components analysis to identify common factors in the movement of banks' credit default swap (CDS) spreads, Eichengreen et al. (2009) find that fortunes of international banks rise and fall together even in normal times along with short-term global economic prospects. Moreover, the importance of common factors rose steadily to exceptional levels during the 2008–09 global financial crisis.

Podlich and Wedow (2011) examine spillovers to and from Germany to other countries regions using weighted CDS spread indices in a GARCH model. The study finds evidence of contagion from the U.S. and European banking systems to the German banking system, and no effects from Asia and emerging countries. Their results additionally confirm that the set up of the financial rescue scheme in Germany partially shielded German banks but not insurance companies from contagion. Our proposed methodology builds on the existing factor model approaches to isolate the idiosyncratic shock from common (global and local) shocks. However, it takes an asset pricing perspective and uses market portfolio returns as the only relevant factors. This approach is more widely used in finance studies and is known as the capital asset pricing (CAPM) model. Specifically, we start with a world CAPM (with the MSCI World return as the sole factor) and add local factors to allow for only partial capital market integration. Following Bekaert et al. (2009), we orthogonalize the local factors with respect to the world factor using an OLS regression on the world factor to facilitate the interpretation of the factors. The error term of the regression is the new country-specific factor. This regression is conducted every half-year to allow for time-varying factor loadings. We allow time-varying factor exposures as Bekaert et al. (2003 and 2009) show that it provides improvements in the presence of contagion (i.e., an increase in exposures in crisis times compared to tranquil times).

The estimated factor loadings or risk exposures (bank betas) allow us to identify crisis periods where there is evidence of contagion (characterized by a rise in bank market risk unexplained by macro fundamentals), and to identify the sources of contagion (global vs. local). We also focus in a second stage on the identification of characteristics influencing bank betas, both during periods of financial market turbulence and during normal times. To do so, the paper follows a similar approach to Brooks and Del Negro (2005a and 2006); however, it allows for time- variation in exposures to uncover potential changes over time in this statistical relationship. Finally, we test whether the largest banks in systemic countries have significant contagious influence on other banks, once common shocks are controlled for. Unlike recent studies, which focus mostly on contagion in Europe, we also investigate contagion globally, using a broader sample of large, internationally active, banks.

An important caveat should be mentioned at the onset. The proposed use of stock returns and the derived betas as a measure of bank risk may not be well suited to measure certain types of shocks, such as increases in earnings volatility or leverage.

III. ESTIMATION FRAMEWORK

A. Factor Specification

We first estimate the sensitivity of individual banks' stock return to country-specific vs. global shocks (beta). To extract bank betas with respect to the global and country-specific shocks, we estimate a factor model of returns that includes both a global and a country factor. The model is a world-local CAPM that augments the world CAPM to allow for country-specific factors (partial integration). For each bank *i*, the excess return in period *t* (R_{it}) can be expressed as:

$$R_{it} = \alpha_{it} + \beta_{it}^{g} f_t^{g} + \beta_{it}^{c} f_{it}^{c} + \varepsilon_{it}, \qquad (1)$$

where f_t^g and f_{it}^c are the return on the world market and the bank's country market index,[10] respectively, and ε_{it} represents the idiosyncratic (non-systematic) shock to the return on stock *i*; β_i^g and β_i^c measure the sensitivity of the bank's returns to the returns on the world and market indices, respectively (thereafter called betas); and α_{it} is the excess return for bank *i*.

Following Bekaert et al. (2009), to simplify the interpretation of the betas, we orthogonalize the return of the country factor with respect to the world market by using an OLS regression on the world market.[11] The regression residual is the new country-specific f_t^c. The special case for which $\beta_i^c = 0$ is the world CAPM (perfect capital market integration). We re-estimate the model for each bank *i* using simple OLS every 6 months to allow for both bank-specific and time-varying factor loadings.

Model (1) is a simplified description of the sources of return comovement as it fails to disaggregate pure country effects into region and within-region country effects and omits other potentially relevant factors, such as size and style factors. Brooks and Del Negro (2005b) document the importance of region effects embedded within the pure country effects, finding that region effects account for roughly half of the return variation explained by country effects; and Bekaert et al. (2009) show that the added size and style factors significantly improve the ability of the model to match the sample correlation matrix. We leave the further decomposition of pure country effects into region and within-region country effects and the addition of size and style factors to further research and, following Brooks and Del Negro (2005a and 2006), assume that our focus on global and country-specific factors provides a good first pass at the data. However, to gauge the importance of the regional effect in the 2011 EA financial crisis, we also estimate an alternative model where the country factors are replaced by a Europe factor.

Model (1) implies that the covariance between two banks' returns can increase only through two channels: an increase in the factor loadings β and/or an increase in the factor volatilities.[12] In practice, those two factors may not capture all sources of return comovement (as discussed above). Eichengreen et al. (2009), for example, document that while global economic factors were the main drivers of the CDS spreads of international banks, financial variables—particularly those related to banks' credit and funding risks—acquired greater prominence around the time of the Lehman failure. This suggests that by only controlling for the economic factors embedded in market returns, equation (1) may not capture all the common sources of risk which could cause an observed increase in co-movement during times of crisis. As noted above, we test for that possibility in Section V.D., using additional financial risk variables as controls.

[10] Based on the country of incorporation.

[11] In contrast to Bekaert et al. (2009) we orthogonalize the country factor for each half year separately to ensure that the factors are exactly orthogonal in each period.

[12] Assuming covariance between the residuals ε is zero.

Model (1) also has implications for variances as it decomposes the variance for any bank into explained variance and idiosyncratic variance. Using the factor orthogonality assumption, the equation below defines the bank-level variance:

$$var(R_{it}) = \left(\beta_{it}^{g}\right)^{2} var\left(f_{t}^{g}\right) + (\beta_{it}^{c})^{2} var(f_{it}^{c}) + var(\varepsilon_{it}), \quad (2)$$

as the sum of the variances of the global and local market portfolios (weighted by their respective factor loadings) and the variance of the idiosyncratic component. The variance decomposition obtains by dividing the summands in the right hand side of equation (2) by the actual variance of bank *i*'s stock return.

B. Estimated Bank Betas: Relation with Bank Characteristics

After obtaining estimates of the global and country loadings β_i^g and β_i^c for each bank *i*, i.e., measures of their vulnerability to systemic risk, we investigate whether differences in bank risk vary systematically with certain bank fundamentals. We focus on seven broad categories of bank variables, as discussed in Section IV. These include foreign exposure (the degree to which firms operate internationally) and capital, two variables that have been highlighted in previous literature (as discussed in Section II). We also include variables measuring size, profitability, credit quality, liquidity, and exposure to European sovereign crisis countries (Greece, Italy, Ireland, Portugal, and Spain).[13]

In order to estimate the importance of these bank fundamentals in explaining the bank's risk exposure, we use the following specification:

$$\beta_{it}^{k} = \gamma_{it}^{k} + \sum_{f=1}^{F} \gamma_{it}^{f} X_{it}^{f} + \eta_{it}^{k}, k = g, c \quad (3)$$

where β_{it}^{k}, $k = g, c$, are the bank betas estimated in equation (1) that measure the effect of global and country shocks respectively on bank *i*; $X_{it}^{f}, f = 1, \ldots, F$, are the bank-specific characteristics that could affect risk exposures (such as capital ratio); γ_i^f is the coefficient on the bank-specific variable *f*, γ_i^k is a constant (intercept) term; and η_{it}^{k} is a normally-distributed error term. To minimize the problem of an estimated dependent variable on the left-hand side of equation (3), we estimate the model using OLS (cross-section) with White's heteroscedastic consistent standard errors, separately for two periods: pre-crisis (2006H1) and EA sovereign and banking crisis (2011H1).[14] The dependent variable is the bank beta

[13] The latter is available only for a reduced sample of mostly European banks.

[14] Aside from a loss of efficiency, the fact that the dependent variable is estimated can produce inconsistent standard error estimates if the sampling uncertainty in the dependent variable is not constant across observations (Lewis and Linzer, 2005). The regression errors will be heteroscedastic and running ordinary least squares (OLS) will usually lead to inefficient estimates and underestimated standard errors. Lewis and Linzer (2005) show that OLS with White's heteroscedastic consistent standard errors usually yields the best results in this situation.

estimated in equation (1) for the respective period, while the bank fundamentals are the averages of their quarterly values over the same period.

While the previous literature offers some guidance, the signs of the coefficients on bank fundamentals in equation (3) are a priori indeterminate and can only be ascertained empirically. Overall, earlier findings suggest that firm-level global risk exposures (thereafter, world betas) are positively associated with measures of international activity and negatively related to size. In the case of banks, vulnerability to global shocks has been found to increase with reliance on wholesale funding, and decrease with the share of loans in assets. Earlier findings also suggest that country risk exposures (thereafter, country betas) are negatively and significantly related to equity capital, profitability, size and the price-to-book value ratio. We additionally test for the impact of bank-specific variables including short-term funding needs, credit quality, and profitability on both country and world betas. The expected coefficients can be summarized as follows:

- For **foreign exposure** (measured in terms of share of foreign revenue or foreign assets in total revenue or assets), the coefficient for the world beta is expected to be positive, while there is little evidence that country betas are systematically related to foreign activity, based on Brooks and Del Negro (2005a and 2006). However, the expected sign is not clear-cut. It is also possible, for example, that banks that operate cross-border are judged more favorably by market participants as the diversification of revenue across borders lowers their overall risk.
- Also based on Brooks and Del Negro (2005a and 2006), **size** is expected to have a negative coefficient both for the world and the country beta, as ceteris paribus, diversification of revenue sources lowers a bank's risk. Large banks may also be perceived as benefiting from a "too-big-to-fail" effect (implicit government guarantee) which may lower their perceived risk. ECB (2011) confirms the negative coefficient of size on bank country betas.
- **Profitability** could have a negative coefficient on bank betas (both world and country) if it results from fundamentally higher growth opportunities. However, the coefficient could be positive if the high profitability results from higher risk-taking (e.g., higher levels of leverage and/or reliance on short-term wholesale funding). ECB (2011) finds a negative association between bank country betas and profitability.
- The **price-to-book value** ratio may proxy growth opportunities and thus its coefficient would be expected to have a positive sign, similar to profitability. Alternatively, a low price-to-book value ratio may signal a fundamental problem in the company, such as capital weakness. In that case, its coefficient is expected to have a negative sign, similar to capital ratios. Empirically, the earlier results in Brooks and Del Negro (2005a and 2006) suggest that there is little evidence of a systematic link between price-to-book and world betas; by contrast, country betas are negatively and significantly related to the price-to-book ratio.
- **Capital ratios** are expected to decrease the bank beta (both country and world beta); a higher capital ratio increases the banks' solvency and lowers its perceived risk. The results in ECB (2011) support a negative relationship between equity capital and country beta. However, Tressel (2011) finds no independent impact of capital ratios

on exposures to global risk (proxied by the VIX index) once wholesale funding needs, presence in derivative markets, importance of loans in total assets, and exposure to Italy are accounted for.[15]

- The results of Tressel (2011) suggest an expected positive sign for the **wholesale funding ratio** (ratio of non-deposit liabilities to total liabilities). Similarly, the coefficient of **loan-to-deposits** ratio (an alternative indicator of reliance on wholesale funding) would be expected to have a positive sign; however, Tressel (2011) finds that a similar indicator (the share of loans in total assets) has a negative sign.
- The ratio of **short-term debt** to total assets or total liabilities, which captures liquidity risk exposures, has an expected positively signed coefficient; conversely, the ratio of **cash holdings** to total assets (ability to meet liquidity needs from cash reserves) has an expected negatively signed coefficient.
- Finally, both the results of Tressel (2011) and Chan-Lau et al. (2012) suggest that the coefficient on **exposure to sovereign crisis countries** has an expected positive sign.

C. Bank to Bank Spillovers

Our empirical strategy to assess the importance of additional spillover effects (transmission of idiosyncratic shocks across banks), over and above the comovement due to common factor exposures, follows a similar approach to the one proposed in Eichengreen et al. (2009).[16] We add a third "bank factor" to the baseline model (1).

$$R_{it} = \alpha_{it} + \beta_{it}^{g} f_t^{g} + \beta_{it}^{c} f_{it}^{c} + \beta_{it}^{j} R_{jt} + \varepsilon_{it}, j \neq i \qquad (4)$$

where R_{jt} is the return on bank *j* (transmitter of spillover effects to bank *i* (receiver)). The bank factor is orthogonalized to the global and country factors to simplify its interpretation. This framework allows us to test whether there is significant information in the return of bank *j*, over and above that contained in the common factors. When investigating spillovers to U.S. or Latin American banks from European or Asian banks, we also tried an alternative specification which lags the return of the banks that are potential transmitters of spillovers by one period to account for the time difference, i.e. we replace R_{jt} with R_{jt-1}. The results were very similar with or without lags in the returns.

To account for the possibility that the return data exhibit a change in co-movement and/or spillovers over time, we estimate the model separately for two sub-periods: 2003H1-2007H1 (pre-subprime period) and 2007H2-2011H2 (post-subprime period). The choice of these two sub-periods is consistent with Eichengreen et al. (2009)'s finding that bank CDS data exhibit a break in the last week of July 2007. Our analysis of systemic vulnerabilities in this paper also confirms the finding that the period immediately following the outbreak of the subprime

[15] Chan-Lau et al. (2011) find evidence that higher capital ratios contributes to better equity return performance; however they do not directly test the impact on exposures to common risk factors.

[16] The "spillover test" in Eichengreen et al. (2009) was applied to bank CDS spreads rather than equity returns.

crisis (2007H2-2008H2) saw a marked increase in interdependencies, reflecting a rise in the importance of common factors to exceptional levels (see Section V.A).

The interpretation of the coefficient on the bank factor in equation (4) is similar to that of the coefficients on the global and country-specific factors, respectively. Finding a statistically significant coefficient β_{it}^{j} does not necessarily imply a causal relationship from bank *j* to bank *i*; however, it does suggest that the two banks' returns are synchronized, i.e. they tend to co-move together over and above the covariance accounted for by exposure to common economic factors. This co-movement could reflect common (unnamed) risk factors or, alternatively, it could reflect "true" contagion or what this paper calls negative spillovers. An important limitation of the approach is that it does not allow us to distinguish the two interpretations, although we do attempt (see Section V.D) to isolate the negative spillover effects by adding financial variables to control for common sources of financial risk.

IV. DATA

The data used to estimate the factor model of returns and the bank betas for each half-year were compiled from Datastream. Asset returns are measured by daily stock returns, in U.S. dollars. The global and country factors are also based on data series reported in Datastream. The country factors are returns for the respective country price indices compiled by Morgan Stanley Capital International (MSCI). The global factor is based on the world price index compiled by MSCI, and calculated as daily return. In order to minimize multi-collinearity and simplify the interpretation of the coefficients, we use the residual country returns after controlling for world stock returns.[17] The sample countries include fifteen of the Group of Twenty (G-20) major economies, plus six smaller European economies (Belgium, Netherlands, Denmark, Portugal, Sweden, and Switzerland).

For the second-stage regressions, when we estimate what the bank betas are capturing by relating them to observable characteristics, we compile data from a number of sources. In general, we start by collecting quarterly data from Datastream from 2002 Q4 to 2011 Q4 for each financial institution. To maximize sample coverage, we then augment this dataset with data sourced from SNL, Worldscope, and Bloomberg.

The bank indicators can be grouped in eight broad categories: (i) the extent to which institutions operate across countries; (ii) their size; (iii) their profitability; (iv) their price-to-book ratio; (v) their credit quality; (vi) their capital; (vii) their liquidity; and (viii) their exposures to sovereign losses.

To measure the extent of cross-border operations, we use two variables. First, we use a variable that measures the importance of foreign assets for each institution, as a share of total assets. We also construct an additional variable that measures the importance of foreign revenue for each institution, as a share of total revenue. The quarterly data for foreign assets, total assets, foreign revenue, and total revenue are compiled from Datastream.

[17] The residual returns are calculated separately for each half-year. See the discussion in Section III.A.

For size, we collect data from Datastream for quarter-end market capitalization, total assets, and total number of employees. To measure profitability, we use the following variables: net interest income (NIM), return on assets (ROA) and return on equity (ROE). Both are compiled directly from Datastream, Bloomberg, Worldscope, and SNL. We additionally construct cash flow return on equity as a measure of profitability (since cash flow is less susceptible to accounting manipulations). Quarterly cash flow data are sourced from Datastream. Credit quality is measured by the ratio of non-performing loans to total loans. This variable is compiled from Datastream, SNL, and Worldscope.

To gauge the level of solvency of the financial institution, we use two measures of regulatory capital: Tier 1 risk based and total risk based capital ratio. Both variables are sourced from Datastream, Worldscope, and SNL. In addition, we use two measures of leverage, which rely on total assets rather than risk weighted assets: common equity to total assets and market capitalization leverage (the ratio of total assets to market value capitalization). Two alternative measures of capital strength used in the study are the ratio of tangible common equity to tangible assets and the price-to-book value ratio.[18] The underlying quarterly data are compiled from the same three sources as above.

We use the wholesale funding ratio (WFR) to measure liquidity risk. The WFR compares the share of non-deposit to total liabilities. As an alternative indicator of liquidity, we use the loan-to-deposit ratio. To measure short-term funding needs and ability to meet them via cash reserves, we use several indicators: the short-term debt to assets, short-term debt to liabilities, short-term debt to tangible common equity, and cash holdings to assets ratios. The underlying data used to calculate the WFR, loan-to-deposit, short-term debt, and cash ratios are compiled from Datastream and SNL.

Total exposures to the GIIPS (Greece, Ireland, Italy, Portugal, and Spain) sovereigns are used to measure the extent of potential losses from sovereign debt holdings. The quarterly exposures data are compiled from Bloomberg. They are only available for 27 financial institutions in the sample, from 2010 Q4 to 2011 Q4, thus the inclusion of this variable in the regressions greatly reduces the degrees of freedom.

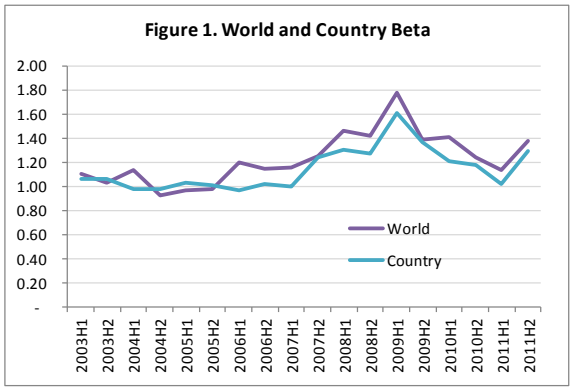
V. Regression Results: Financial Linkages from 2003H1 to 2011H2

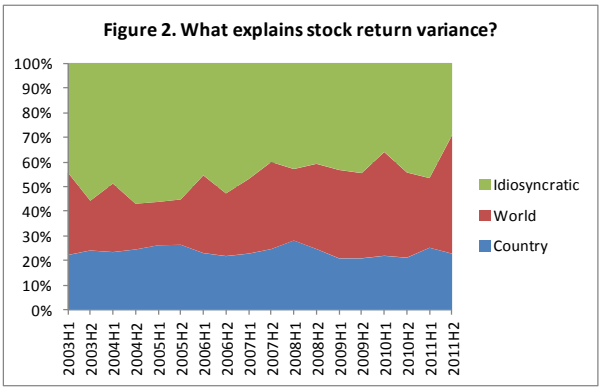
A. Global vs. Country Risk

We begin by using the dataset described in Section IV to estimate the base model in equation (1)—with controls for the world and country stock market returns. We re-estimate the model every 6 months with returns expressed in U.S. dollars. Figure 1 reports the corresponding simple average of the estimated world and country betas across all banks in the sample (the average of the semi-annual β_i^g and β_i^c coefficients). Figure 2 shows the variance decomposition for the average sample bank, over the full time period.

[18] The latter could also signal a growth opportunity; in this case, its interpretation would be similar to that of profitability indicators.

Average world and country betas are closely correlated (91 percent correlation), which suggests that banks' systemic vulnerabilities can comove even if risk factors do not.[19] This result might also reflect the preponderance of the U.S. factor, and its central role in the 2008-09 financial crisis (i.e., the rise in the average country beta during 2008-09 mostly reflects the rise in the exposure of U.S. banks to the U.S. factor, as discussed below when looking at country averages). In particular, there appears to be a clear "globalization" of financial returns (increase in co-movement) during the 2008-09 global financial crisis, a result similar to Eichengreen et al. (2009). The world beta reaches a sample peak in 2009 H1, in the months following the Lehman failure. Since 2011 H1, we also find on average a pick-up in both the world and country factors' loadings. However, this rise in the importance of systemic and country vulnerabilities is much less pronounced than during the 2008–09 episode, suggesting that while recent European developments have increased systemic risk, their systemic impact has been less so far than that of the U.S. during the subprime crisis.





Using the bank beta estimates combined with variances in the world and country market returns, to decompose the variance of stock returns, we find that banks have turned more global (Figure 2). Reflecting both the rise in stock-specific exposures to global shocks during the 2008–09 financial crisis and the greater volatility of financial conditions more recently, the world factor explains an increasing share of average bank-level return variance since end-2006 (over a third). By contrast, the share of return variance explained by the country factor has remained broadly stable throughout the sample period (about 23 percent on average), and bank idiosyncratic factors appear to matter less since end-2006.

The degree of commonality we observe for international banks appears higher than that found by earlier studies for a broader firm sample (including other industries). In particular, Brooks and Del Negro (2006) for an international firm sample find that the importance of the global factor has grown from 4.3 percent in the mid-1980s to 16.5 percent in the late-1990s. The authors also found that while the importance of country shocks had declined relative to that of global factors between 1985 and 2002, they still remained the most important source of return variation throughout the period. In contrast, our results for a more recent period and

[19] By construction, the country factor is orthogonal to the world factor.

for a sample restricted to financial firms suggest that global rather than country shocks account for a relatively larger share of return variation since end-2006.

When comparing our results to the Brooks-Del Negro model, it is important to bear in mind that the latter, unlike this study, does not account for time-varying exposures at the firm level, only for a change in the variance of the factors. This study documents that the increase in the importance of global factors since 2006 reflects in part the rise in exposures, rather than a change in the importance of global shocks over time.[20] In particular, we find a sharp rise in exposures during the 2008–09 financial crisis. Focusing on the information in CDS spreads, Eichengreen et al. (2009) also find that banks' comovement have increased during the subprime crisis. Using a latent factor model, they document the rise in the share of variance of CDS spreads explained by common factors (the first four principal components) from about 60 percent prior to July 2007 to about 80 percent by the time of the failure of Lehman Brothers. The greater degree of commonality that they find compared to our results could reflect the different methodology: by using a latent factor model, their study captures all possible unobserved common sources of shocks, whereas our model identifies these factors as the world and country market returns.

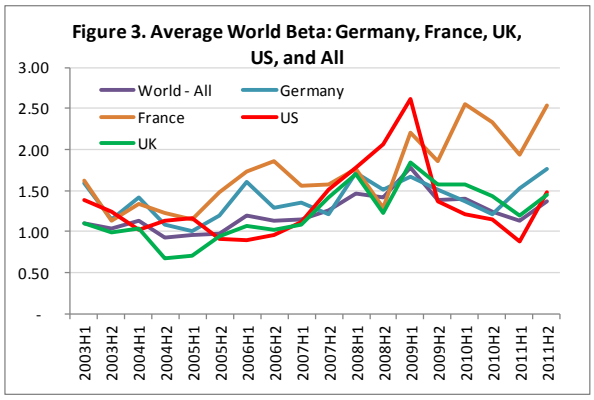
More recently (since end-2008), our results suggest that the degree of commonalities has continued to increase, despite the overall decline in banks' systemic and country vulnerability post-subprime crisis documented in Figure 1. This suggests that the increased importance of global shocks has more than offset the decline in bank vulnerabilities since 2008. Similarly, Tressel (2011) examines bank comovement during the past five years and also finds that common time factors tend to dominate the evolution of bank stock returns between April 2006 and November 2011. However, his methodology does not uncover whether the result is the outcome of the increased importance of global shocks or of higher exposures to common shocks.

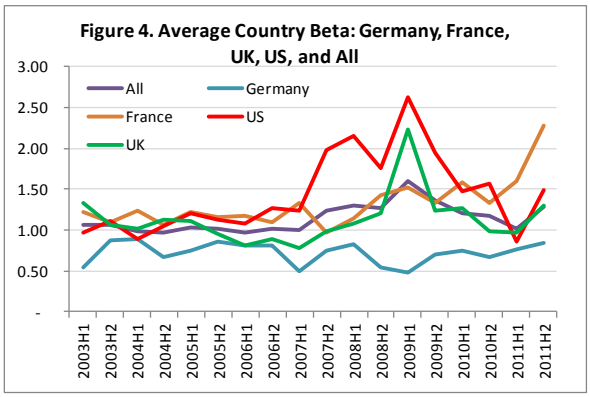
The sample averages shown in Figure 1 mask significant differences across countries. Specifically, our results suggest that:

- The level of systemic and country vulnerabilities (measured by the respective average bank betas) varies by country, with the U.S. contributing the bulk of the observed rise and fall in the sample banks' average systemic and country risk during 2008–09 (Figures 3 and 4). Figure 4 shows that the UK's financial sector also contributed a larger-than-average part of the increase in the sample's average country risk, consistent with the 2008–09 financial crisis originating mainly in the U.S. and U.K.
- In 2011, as noted above, the recent uptick in the sample's average systemic risk in 2011 appears to be mostly driven by developments in the eurozone's banks: German and French banks in particular show a more pronounced increase in systemic vulnerability since end-2010 than banks in either the U.K. or the rest of the world. U.S. banks also show a higher increase in risk than other regions, but from levels far below those of European banks.

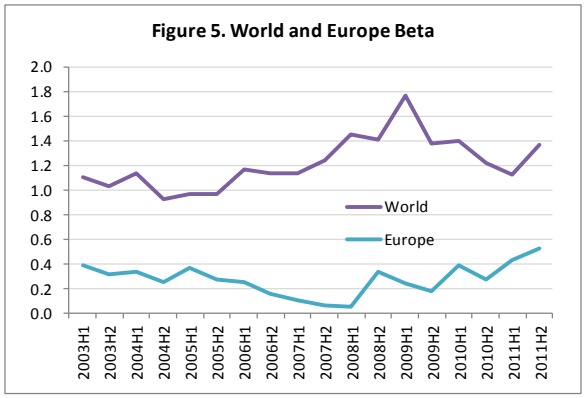
[20] This result should be qualified to the extent that the model relies on stock market returns to measure shocks; if common financial shocks were also included, the estimated rise in world bank betas would likely be lower.

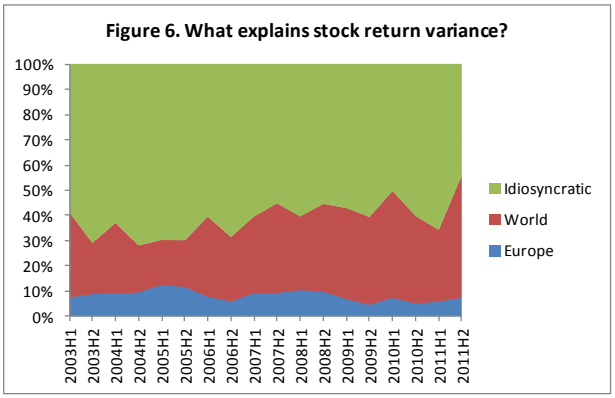
- In particular, while French banks demonstrated relative resilience in the early phase of the subprime crisis, their systemic vulnerability (as measured by exposure to global shocks) has been rising starkly since end-2008, reaching unprecedented levels during the euro crisis (Figure 3). In addition to global risk, the perceived country risk of French banks has also risen sharply more recently—in the second half of 2011 (Figure 4).
- By contrast, German banks' systemic vulnerability reflects mainly their rising exposure to global shocks; their exposure to country risk has remained comparatively low throughout the sample.



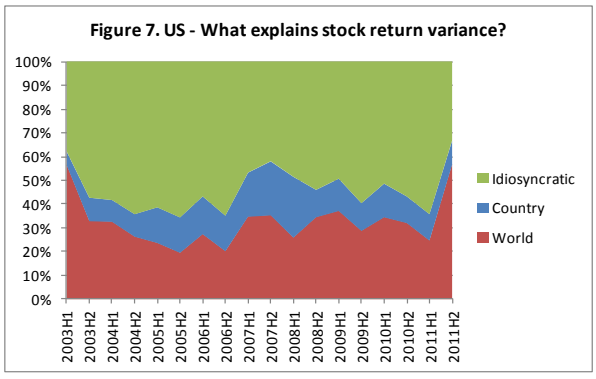


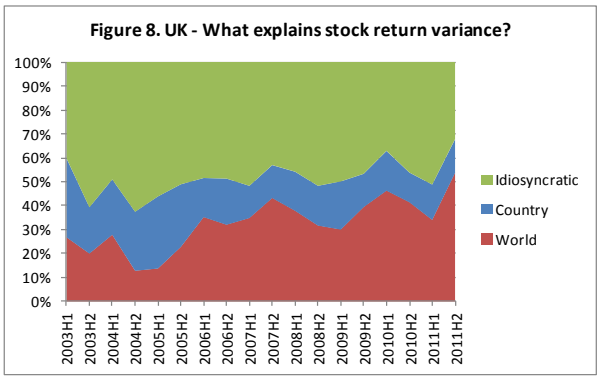
To isolate the "pure" regional effect during the recent financial turbulence, we estimated an alternative specification replacing the country factors in equation (1) with a Europe factor (measured by the returns on the MSCI Europe index). Correlations between the Europe factor and the European country factors are very high (Table 2). Thus the Europe factor largely captures the same information as the country factors already included in equation (1) and its inclusion is not expected to change significantly the results obtained from the base specification. However, including it separately allows us to illustrate any regional effect from the EA crisis, over and beyond that already captured in the world factor. Figures 5 and 6 show that while the average loading on the world factor as expected does not change in this alternative specification, the estimated impact of the Europe factor is on average very low. This suggests that the additional risk of shocks originating in Europe—over and beyond what is already reflected in the world factor for non-European banks—is relatively small. The result does not mean that European developments do not matter; on the contrary, the importance of the EA crisis for systemic risk is illustrated by the simultaneous pick-up in 2011 in the sample banks' average vulnerability to global and European shocks. In other words, similar to the case of the U.S. and U.K. during the subprime crisis, there are early indications that the EA crisis is fast becoming a global phenomenum.

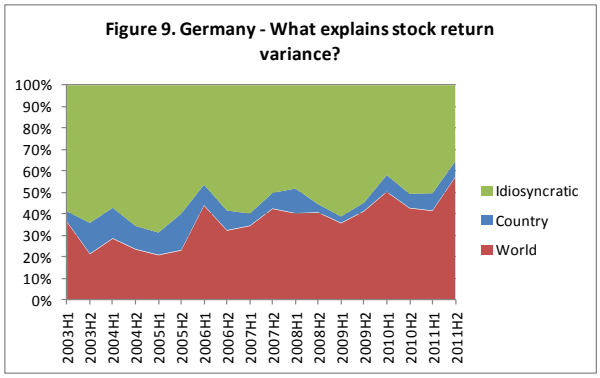


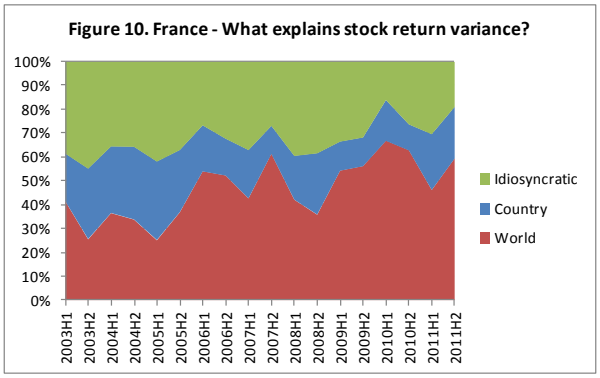


The "globalization" of banks' sensitivities related to the EA sovereign and banking crisis is also illustrated by our results for variance decomposition. The four systemic countries we analyzed showed somewhat contrasting variance decomposition results (figures 7 through 10). However, they all share a clear common trend: in all four countries, the share of financial stock volatility accounted for by global factors has displayed a rising trend over time since end-2005, similar to the sample average. Such globalization of financial stress implies that domestic financial stress in all four countries now owes primarily to volatile global financial conditions. In 2011 H2, global shocks accounted for 57 percent of bank stock volatility in Germany and the US, 59 percent in France, and 54 percent in the UK. However, country-level factors appear to have little relevance in the case of Germany's banking system (explaining only 9 percent of stock return variance on average over the sample, and only 7 percent in 2011 H2), whereas they explain about a fifth of stock return variance on average in the case of France and the UK, and about 14 percent of return variance in the case of the US. Idiosyncratic factors appear to matter increasingly less over time in all four countries, although in Germany's case, they still account for a sizeable 36 percent of stock return variance in the second half of 2011 and about one third of variance in the case of the U.S. and the U.K. (compared to only 19 percent in the case of France).









B. Bank Betas and Bank Characteristics

Next, we use the estimated world and country stock market betas to estimate equation (3) in order to identify the relation between bank-level characteristics and factor sensitivities. We start by examining the simple bivariate correlations between the world and country betas and the bank-specific characteristics that appear to have the most explanatory power for the cross-section variation in bank risk: size (market value capitalization), profitability (net interest income), price-to-book value, capital (tangible common equity to tangible common assets, thereafter, TCE ratio), wholesale funding ratio, foreign revenue share in total revenue, and foreign asset share in total assets (figures 11 through 14).[21] In 2006 H1, there is a negative association between a financial institution's vulnerability to global shocks and its size and a positive association between systemic vulnerability (measured by the world beta) and profitability – suggesting that the more profitable banks are also the riskiest. Banks that are highly international and those that rely more on wholesale funding also appear to have higher systemic vulnerability (Figure 11). The bivariate correlation between systemic vulnerability and capital (either quality of capital, as proxied by the price-to-book value ratio or quantity of capital, as measured by the TCE ratio) is unclear. Comparing the same scatterplots for 2011 H1 to those for 2006 H1, the main change is a reversal of the association between size and systemic vulnerability: in 2011, larger firms are perceived by equity market participants as having higher vulnerability to global shocks, possibly reflecting their higher absolute exposures to peripheral Europe. Other notable changes include: the bivariate relationship between profitability and systemic vulnerability becomes unclear; and a negative association between price-to-book value ratio and systemic vulnerability emerges, suggesting that low valuation firms in 2011 are also those perceived as the most exposed to global shocks.

The bivariate correlation results for country betas in 2006 H1 suggest a positive association between a financial institution's vulnerability to domestic developments (country risk) and its size, and to a lesser extent, its profitability. There is also a positive association between country risk and reliance on wholesale funding. In 2011 H1, by contrast, no clear relationship emerges from a simple bivariate look at the data.

[21] The full set of results for the other variables also considered as possible regressors (see Section IV) is available upon request from the authors.

To attempt a mapping of bank risk into specific bank fundamentals, we estimate multivariate OLS cross-section regressions with world and country betas as the dependent variable. Following Lewis and Linzer (2005), the regressions are estimated via OLS with White's heteroscedastic consistent errors to minimize the econometric issues associated with the use of an estimated dependent variable. We report the results for the world beta and country beta, and for two separate periods: 2006 H1 (tranquil times) and 2011 H1 (crisis time).

Table 3 reports coefficient estimates for the world stock market beta in 2006 H1 (tranquil times). Column (1) reports results based on the set of controls discussed above (i.e., the variables that were found to be the most statistically significant and were more widely available across banks). As discussed in Section II, earlier studies have established a strong link between measures of global integration and stock market betas. Therefore, we also include in columns (2) and (3) measures of exposure to global shocks (alternatively, foreign revenue share and foreign asset share) as additional controls, even though these variables are only available for a reduced set of financial institutions.

Table 4 reports regression results for 2011 H1. The first two columns show results based on the core set of controls, column (1) for the full sample and column (2) for a reduced sample of mostly European banks, to examine if the European banks were more affected differently than the rest of the sample during the EA crisis.[22] Given the recent literature examining how sovereign exposures can affect stock market returns and /or sensitivity of returns to global risk, the third column reports results including a measure of sovereign risk (sovereign exposures to total assets ratio) as an additional control. Inclusion of this variable, however, greatly reduces the sample size and degrees of freedom as it is only publicly available for a few banks in the sample.

The most consistent finding in Tables 3 and 4 is that the coefficient on *wholesale funding ratio* is positive and highly statistically significant (at the 1 percent level). This suggests that on average both in 2006 and 2011, the reliance on wholesale funding may have been the single most important bank characteristic determining the extent to which shocks to the world stock market affect individual banks.

The estimated coefficients on measures of firm-level globalization (*foreign revenue share* and *foreign asset share*) shown for 2006 H1 are also positive and highly statistically significant (at the 1 percent level) in the case of both variables (Table 3). This finding that global financial conditions are a more important source of return variation for stocks whose underlying company operates globally confirms the earlier findings of Brooks and Del Negro (2005a and 2006). However, we find a more muted quantitative impact, possibly because we control for a broader array of other potential determinants of stock market betas: in 2006 H1, our results imply that a financial institution that raises the international component of its assets by 10 percent raises the exposure of its stock return to the global shock by 0.1 percent,

[22] For conciseness, we do not report in Table 4 the results of regressions including the foreign revenue share and foreign asset share variables in 2011. Including these variables greatly reduces the sample coverage and thus the degrees of freedom, causing a drop in significance level. However, the size and the sign of the coefficients remain broadly the same as in 2006. The results are available from the authors upon request.

compared to 0.3 percent in Brooks and Del Negro (2006). For 2011 H1, the inclusion of the firm-level internationalization variables on the RHS yields similar qualitative results, although the significance level drops (results not shown in Table 4 for conciseness, see footnote 22).

The estimated coefficients on profitability (*net interest margin*) are generally positive and statistically significant (at least at the 10 percent level) in Table 3. The result holds in 2011, but only for the sample restricted to European banks. The positive link between world stock market betas and profitability could reflect the willingness/ability of more profitable banks to take higher risks on a global level.

The estimated coefficients on the capital ratio (*tangible common equity*) are generally negative and statistically significant (at the 10 percent level) in Table 3. The result holds in 2011 but again only for the European sub-sample. This is in line with similar findings in Chan-Lau et al. (2012).

In Table 3, the estimated coefficient on size (*market capitalization*) is negative and statistically significant at the 10 percent level while that on valuation (*price-to-book value ratio*) is never significant. These results are similar to those of Brooks and Del Negro (2005a) who also examine a pre-crisis period. By contrast, in the more recent period, size has a positive effect at the 10 percent level (Table 4). The size variable however becomes insignificant in column (3) of Table 4, which reports the results of additionally including the *exposure to sovereign risk* variable. The latter has the expected positive coefficient, but is not statistically significant. The fact that the size variable loses significance when the sovereign risk variable is included suggests that both variables might capture the same underlying risk. Also in Table 4, higher valuation has a negative and statistically significant effect on systemic vulnerability. A 10 percent decrease in price-to-book value ratio for the average financial institution in our sample in 2011 raises systemic vulnerability, measured by the exposure of its stock return to global shocks, by about 2 percent (first column in Table 4). The effect is even stronger for European banks: a 10 percent lower price-to-book value ratio raises the average European bank's systemic vulnerability by over 6 percent (second column in Table 4).

The full-sample regressions have an overall explanatory power of 22-28 percent, almost double that of Brooks and Del Negro (2006). The explanatory power rises to 60 percent for the 2011 regression restricted to the sub-sample of European banks, suggesting that this set of observables explain a large share of the cross-section variation in vulnerability to global financial conditions for that group.

Tables 5 and 6 report similar results for the estimated country betas, during 2006 H1 and 2011 H1, respectively. Based on the 2006 results, we find that *reliance on wholesale funding* has a positive and highly statistically significant coefficient (at the 1 percent level), i.e. increases vulnerability to country risk; however, the result is not robust across periods. *Size* also has a positive coefficient in both Tables 5 and 6, although only statistically significant coefficient (at the 5 percent level) in Table 5, suggesting that larger banks are relatively more exposed to country equity risk. Surprisingly, higher capital (*tangible common equity ratio*) is found to increase banks' vulnerability to country risk, during both periods.

The interpretation of this result is not clear and warrants further research. In Table 6, column (3), the *exposure to sovereign risk* has the expected positive coefficient and is statistically significant at the 10 percent level. Low *price-to-book value ratios* tend to increase country equity risk (similar to the result documented in Brooks and Del Negro, 2005a), but the coefficient is statistically significant only for the recent period. Finally, the estimated coefficients on *net interest income*, *foreign revenue share*, and *foreign asset share* are never significant. The finding that firm-level measures of globalization significantly increase bank global equity risk (measured by the beta of the bank's share price to the world index) but do not affect country equity risk (measured by the beta to the reference national index) is in line with the earlier findings of Brooks and Del Negro (2006).

The overall explanatory power of the regressions is about one fifth in 2006 and rises to almost one half of the cross-section variation in country betas in 2011. For 2006, this is double the explanatory power of regressions presented in Brooks and Del Negro (2006). Similar to the finding for banks' systemic vulnerability (exposure to world shocks), the result suggests that observables explain a large share of the cross-section variation in bank country equity risk, especially in the more recent period.

C. Bank Spillovers

In conducting "spillover tests" in this section, we focus on spillovers from ten of the largest European banks, namely the top five German banks by total assets, the top three U.K. banks, and the top two French banks. Our focus is on spillovers to/from European banks as we are mainly interested in shedding light on the issue of possible financial contagion effects from the EA crisis to other regions. To begin, we use the specification in equation (4): for each bank in the sample, we add the return of each German (respectively, UK, French) bank, one at a time, to the basic specification in equation (1). The model is estimated over two sub-periods, pre-subprime crisis and post-subprime crisis, to allow for the possibility of a structural break in the return data. For each bank (receiver), we test the significance of each large German (respectively, UK, French) bank (transmitter), adding their returns to the factor model one at a time. Table 7 lists, for each German bank and subperiod, the ten receiver banks with the highest estimated influence on their stock returns (as well as the level of statistical significance of that coefficient). Table 8 similarly lists, for each French and U.K. bank and subperiod the ten receiver banks which exhibit the largest co-movement with the transmitter bank.[23]

In 90 percent (all) of the reported cases for the first (second) subperiod, the estimated coefficient of the German banks is found to be statistically significant at least at the 5 percent level. While this result does not necessarily imply causality—it could simply mean that both banks are exposed to a common set of (unnamed) risk factors, for example due to a similar exposures or funding structure— it does suggest that the addition of this bank's return factor yields information over and above that contained in the broad market return factors. The result also implies that, in a relative sense, these banks' stock returns tend to be more

[23] The full set of results, including the size of the estimated coefficients, is available upon request from the authors.

synchronized than other pairs of banks. In other words, the estimation framework allows us to highlight the presence of "clusters" of interconnected banks that tend to co-move together more strongly than with other banks, either due to inter-bank linkages (counterparty relationships, interbank-lending) or the exposure to common vulnerabilities. Formally, we consider that two banks are part of a cluster if a two-way relationship can be detected between the two institutions based on the results in Tables 7 and 8.

The results in Table 7 suggest a strong regional dimension to the spillovers pattern from German banks. Specifically, we find that:

- Large German banks appear to co-move strongly either with other German banks or with other European banks.
- Spillovers from German banks to other European banks are most pronounced in the case of French and U.K. banks and, to a lesser extent, in the case of Dutch, Belgian, and Swiss banks.
- During the subprime crisis and in the post-crisis period, a Franco-German cluster can be detected comprising Deutsche Bank and BNP Paribas and a UK-German cluster comprising Commerzbank, Barclays, and RBS.
- None of the banks from peripheral crisis European countries (GIIPS) are found to co-move in a significant way with the largest German banks.[24]
- Spillovers from German banks to other regions appear limited to the US: prior to the subprime crisis, two of the large German banks seem to co-move significantly with banks in the U.S. (namely, Deutsche Bank with Lehman Brothers and Hypo Real Estate with Goldman Sachs)[25]; during and following the subprime crisis, Freddie Mac and Fannie Mae have synchronized returns with the largest German financial institutions (Deutsche Bank, Commerzbank, and Allianz), which in turn can be traced back to the latter's sizeable holdings of subprime portfolios and related exposures to US real estate.

Our framework of analysis allows us to reach only limited conclusions on the within-Germany spillovers dimension, especially in the period following the 2008-09 crisis, since our sample includes only listed, large, financial institutions which are limited in number in Germany and are not representative of the whole system. With those caveats, we can nevertheless draw the following tentative conclusions on intra-Germany spillovers:

- Clusters of interconnected financial institutions within Germany are apparent prior to the onset of the subprime crisis. A first cluster comprises Deutsche Bank, Commerzbank, HVB, and Allianz. A second cluster is also apparent, comprising HVB and Hypo Real Estate which was spun off by HVB in 2003.

[24] Our sample includes three banks from Italy, two banks from Spain, and one bank from Portugal, but no banks from Ireland or Greece since we limit ourselves to the top largest global institutions.

[25] The estimated spillovers to three Japanese banks and one Brazilian bank are also relatively large in the first period, but never significant at the 5 percent level.

- During the subprime crisis and in the post-crisis period, evidence of intra-Germany financial spillovers is more limited. This is in part because our sample is limited to the largest, listed, financial institutions and is thus reduced to four German institutions following the consolidation, bank mergers, and bank closures in the aftermath of the subprime crisis. Our results do provide empirical evidence of two-way relationships between Deutsche Bank and Commerzbank on the one hand and Deutsche Bank and Allianz on the other hand.

Table 8 shows that the estimated spillovers from French and U.K. banks are also statistically significant, at least at the 5 percent level, in all but two cases. For both France and the UK, there is an important within-country spillover dimension: French (respectively, UK) banks tend to co-move with other French (respectively, UK) banks. There are also strong inter-linkages between financial systems in the two countries. In particular, the results allow us to detect two clusters: the first one between the two French banks (in both sub-periods) and the second one comprising Société Générale, Barclays, and RBS (in the second sub-period only).

Within Europe, the results in Table 8 confirm the regional dimension of spillovers from French and U.K. banks, with France exhibiting tighter links with the Southern peripheral countries than the UK. Specifically, the results imply that banks in the GIIPS (Italy and Spain) tend to co-move strongly with French banks during the pre-crisis period. French banks also appear to generate important spillovers to Dutch and Swiss banks (in the pre-crisis period) and to Belgian banks (during both periods). Since the onset of the subprime crisis, Swiss and Belgian banks also co-move strongly with their counterparts in the UK. Finally, both French and U.K. banks appear to have an important spillover effect on their Russian counterparts pre-crisis, but that effect disappears in the more recent period.

Similar to German banks, the spillovers of French banks to other regions are largely limited to U.S. financial institutions and can only be detected since the onset of the subprime crisis. Prior to the crisis, the pattern of spillovers from French banks appears almost exclusively regional (with the exception of strong co-movement of one Chinese bank with BNP Paribas).

The financial spillovers of U.K. banks, by contrast, reach beyond Europe in both periods. Pre-crisis, there is empirical evidence of strong co-movement of US, Indian and Chinese banks with U.K. banks; during the subprime crisis and post-crisis, spillovers to U.S. banks are dominant and the analysis does not detect any co-movement with banks in other regions.

D. Robustness Check

The results on financial spillovers in Tables 7 and 8 still stand if we add control variables to allow for financial factors affecting all banks. We consider a first set of variables representing the real economy: the corporate default risk measured by the euro high-yield spread (HYS), the spread between government bonds with a maturity of 10 years and 3 months, and risk aversion (VIX). A second set of variables representing the banks' funding conditions include the level of risk-free rates (proxied by the 10-year U.S. yield), the credit risk spread (3-month EURIBOR minus overnight index swap), and an indicator of dollar funding conditions (the 3-month basis swap spread). In order to control for credit risk developments in the financial sector, we additionally include the iTraxx index for financial

firms (both senior and subordinated debt). Including these additional controls in the equation (4) used to estimate spillovers across banks leave both the coefficient of the transmitter bank variable and its significance level broadly unchanged.[26]

VI. Conclusions and Policy Implications

The paper finds that most of the recent banking equities downturn including in the large systemic countries (U.S., U.K., Germany, and France) is explained by global equity market conditions (both a rise in market volatilities and an increase in the beta of banks' share prices to the world market return) as banks worldwide appear to have turned more global. The documented increase in banks' sensitivity to global risk could reflect contagious influences and/or capture the influence of common unobserved financial factors that affect the financial industry but not other sectors. In the case of France and the U.K., and to a lesser extent, the U.S., higher sensitivities to country-specific factors has also been important in explaining the recent financial stress. By contrast, the country-specific factor has very little impact on the German financial system share price variance, which is dominated by the influence of global equity market conditions. It is important to note that this last result might not characterize the entire German financial system as it reflects the bias of our sample toward the largest, globally integrated, German financial institutions.

In comparing the recent EA crisis to the 2008-09 subprime crises originating in the U.S. and the U.K., we find that in both cases the crisis was a global phenomenum. While the rise in estimated sensitivities to global and/or country shocks increased more sharply in the countries/regions where the crisis originated, there was also in both cases an associated rise in the sensitivities of banks in other regions to global factors. Quantitatively, our results suggest that the effect of the EA crisis on banks' exposure to global risk, however, has been less pronounced than that of the subprime crisis.

The second-stage regressions of the world and country bank betas on observed bank characteristics help us identify which areas of weakness policy could focus on to protect their banking systems from broader market volatility and/or spillover effects. Our results suggest that higher sensitivity to global shocks is related to the extent of foreign operations as well as the reliance of banks' on wholesale funding (in line with previous findings). We also find evidence that banks with insufficient capital ratios are relatively more vulnerable to global market volatility, including during the recent EA sovereign crisis episode. For the recent period, the results also suggest that size and low market valuations (high discounts on book value) also increase sensitivities to global factors. To increase the financial system resilience to world shocks, strengthening capital, continuing with deleveraging efforts to reduce size and reliance on wholesale funding, and refocusing operations domestically may thus be a priority.

The regressions for country betas yield some results in line with the ones for world betas and with earlier findings in the literature. In particular, low valuations tend to increase banks'

[26] Results are not shown due to space constraints but available from the authors upon request.

vulnerability to local country risk, especially during the recent EA crisis. We also find that reliance on wholesale funding increases banks' sensitivity to local shocks, but only in the pre-crisis sample (2006 H1). The result that higher capital ratios increase banks' exposure to the national reference market is robust across periods and is more difficult to interpret; it may require further research.

Finally, the analysis of additional spillover effects at the bank-level—over and beyond the influence of common factors—points to a strong regional pattern in the case of German and French banks. Both German and French banks mostly transmit/receive shocks to other European banks, especially in the U.K. French and U.K. banks pre-crisis also appear to have strong spillovers to Russia. Outside of Europe, spillovers are largely confined to the U.S. In Germany's case, a few U.S. institutions including the two mortgage agencies since the onset of the subprime crisis show significant co-movement with developments in German banks' share prices, possibly reflecting similarities in portfolio exposures (to real estate). Confirming earlier results, we find little evidence of interconnectedness of share prices of German financial institutions with similar institutions in Asia or emerging countries. For French banks, significant spillovers to U.S. financial counterparts can only be detected since the onset of the subprime crisis.

The pattern of spillovers detected for U.K. banks is relatively more international. Like German banks, U.K. banks also appear tightly linked with their counterparts in the U.S., both pre-crisis and during the subprime crisis and post-crisis period. In contrast to German and French banks, there is empirical support for spillovers of U.K. banks to other regions (Asia). Notably, our results imply a strong co-movement of Indian and Chinese banks with U.K. banks pre-crisis, although that linkage is absent in the more recent period.

In summary, we can tentatively conclude from the analysis of bank-level spillovers that direct financial spillovers from the EA banking and sovereign debt crisis transmitted through the equity markets outside of Europe are likely to be confined to U.S. banks and financial institutions. Indirectly, however, given the role of the U.S. as a global financial hub, such spilllovers—if they were to intensify—could potentially transmit more widely to systemic banks in other regions (Asia, Latin America, and Middle East).

The analysis in this study leaves unspecified the channels of transmission of financial spillovers both within countries and across borders. While this undertaking is beyond the scope of this paper, it would be an important avenue for further research.

Table 1. Financial Institutions Sample

Financial Institution	Country	Market cap ($b) 2011 Q4	Total Assets ($m)	Date
Abbey National	United Kingdom	14.83	314,730	2003 Q4
ABN Amro	Netherlands	92.90	525,561	2011 Q4
Agricultural Bank of China	China	122.41	1,561,315	2010 Q4
American International Group (AIG)	United States	44.06	555,773	2011 Q4
Allianz	Germany	43.40	833,081	2011 Q4
Al Rajhi Bank	Saudi Arabia	27.70	49,298	2010 Q4
American Express	United States	54.79	153,337	2011 Q4
Australia & New Zealand Banking Group (ANZ)	Australia	56.38	577,197	2011 Q3
Axa	France	30.74	952,031	2010 Q4
Banca Monte dei Paschi di Siena	Italy	3.55	342,029	2011 Q3
Banco Bilbao Vizcaya Argentaria (BBVA)	Spain	42.52	776,219	2011 Q4
Banco Bradesco	Brazil	31.53	342,029	2011 Q3
Banco commercial portugues	Portugal	1.27	121,486	2011 Q4
Banco do Brasil	Brazil	36.41	481,179	2011 Q4
Banco Santander	Spain	65.28	1,625,357	2011 Q4
Bank of America	United States	56.36	2,129,046	2011 Q4
Bank of China	China	90.71	1,580,992	2010 Q4
Bank of Communications	China	23.28	597,541	2010 Q4
Mitsubishi UFJ Financial	Japan	60.16	2,739,729	2011 Q4
Bankgesellschaft Berlin AG	Germany	5.12	170,357	2011 Q4
Bank One	United States	57.01	299,303	2004 Q2
Barclays	United Kingdom	33.38	2,288,838	2010 Q4
Bear Stearns	United States	1.36	398,995	2008 Q1
BMO Financial Group	Canada	35.12	503,951	2011 Q4
BNP Paribas	France	47.58	2,552,316	2011 Q4
Canadian Imperial Bank of Commerce	Canada	29.04	386,347	2011 Q4
Capital One Financial Corporation	United States	19.44	206,019	2011 Q4
Charles Schwab	United States	14.30	108,553	2011 Q4
China Construction Bank	China	167.78	1,635,026	2010 Q4
China Merchants bank	China	33.32	363,410	2010 Q4
Chubb Corporation	United States	19.25	50,865	2011 Q4
Citigroup	United States	76.92	1,873,878	2011 Q4
Commerzbank	Germany	8.65	859,432	2011 Q4
Commonwealth Bank of Australia	Australia	79.79	713,651	2011 Q2
Crédit Agricole	France	14.14	2,238,452	2011 Q4
Credit Suisse Group	Switzerland	28.39	1,121,382	2011 Q4
Danske Bank	Denmark	11.87	598,484	2011 Q4
Deutsche Bank	Germany	35.38	2,810,390	2011 Q4
Dexia	Belgium	0.75	554,311	2011 Q3
Fannie Mae	United States	0.23	3,211,484	2011 Q4
Ageas	Belgium	4.09	132,679	2011 Q3
Freddie Mac	United States	0.14	2,147,216	2011 Q4
Goldman Sachs Group	United States	44.52	923,225	2011 Q4
Hannover Rueckversicherung	Germany	6.00	59,297	2010 Q4
Hartford Financial Services	United States	7.24	304,064	2011 Q4
Heritage Financial Group (HBOS)	United Kingdom	14.04	991,758	2008 Q4
HDFC Bank	India	18.82	61,849	2011 Q1
HSBC Holdings	United Kingdom	136.36	2,715,700	2011 Q3
Hypo Real Estate Holding	Germany	0.39	586,307	2008 Q4
HypoVereinskbank (HVB)	Germany	42.80	645,305	2008 Q4
Industrial & Commercial Bank of China (ICBC)	China	51.52	2,035,647	2010 Q4
ICICI Bank	India	14.86	118,609	2011 Q1
ING Group	Netherlands	27.65	1,644,131	2010 Q4

Table 1. Financial Institutions Sample (continued)

Intesa Sanpaolo	Italy	26.04	895,975	2011 Q3
Itau Unibanco	Brazil	41.58	438,756	2010 Q4
JPMorgan Chase	United States	126.34	2,265,792	2011 Q4
KBC Group	Belgium	4.52	370,626	2011 Q4
Lehman Brothers	United States	0.01	600,000	2008 Q3
Lloyds Banking Group	United Kingdom	27.67	1,508,699	2011 Q4
Metlife	United States	32.98	799,625	2011 Q4
Mizuho Financial Group	Japan	32.47	2,096,813	2011 Q4
Morgan Stanley	United States	29.16	749,898	2011 Q4
National Australia Bank*	Australia	53.61	730,392	2011 Q3
Nomura Holdings	Japan	11.58	435,182	2011 Q4
Nordea Bank	Sweden	31.44	930,135	2011 Q4
Royal Bank of Canada (RBC)*	Canada	73.50	799,188	2011 Q4
Royal Bank of Scotland (RBS)	United Kingdom	18.58	2,342,402	2011 Q4
Sberbank of Russia	Russia	52.99	282,009	2010 Q4
Scotiabank (Bank of Nova Scotia)	Canada	54.39	598,432	2011 Q4
Shinhan Financial Group	Korea	16.36	248,720	2011 Q4
Société Générale	France	17.33	1,534,249	2011 Q4
Standard Chartered	United Kingdom	52.20	567,706	2011 Q2
Sumitomo Mitsui Banking Corporation	Japan	39.40	1,651,515	2011 Q1
Toronto-Dominion Bank (TD)	Canada	67.62	737,725	2011 Q4
UBS	Switzerland	45.82	1,517,008	2011 Q4
UniCredit	Italy	16.06	340,122	2011 Q3
US Bancorp	United States	51.62	340,122	2011 Q4
Wachovia Corporation	United States	11.97	764,378	2008 Q3
Washington Mutual	United States	0.09	309,731	2008 Q2
Wells Fargo	United States	145.34	1,313,867	2011 Q4
Westpac Banking Corporation*	Australia	62.62	648,814	2011 Q3
State Street Corporation	United States	19.83	216,827	2011 Q4
Bank of New York	United States	24.14	325,266	2011 Q4

Table 2. Correlation of Daily Returns of MSCI Indices, 2003 H1-2011 H2

	World	Europe	France	Germany	Italy	Spain	UK	US
World	1							
Europe	0.8592	1						
France	0.8417	**0.9799**	1					
Germany	0.8413	**0.9369**	0.9338	1				
Italy	0.7954	**0.9362**	0.9378	0.8834	1			
Spain	0.7846	**0.9221**	0.9205	0.8642	0.9151	1		
UK	0.8212	**0.9610**	0.9090	0.8531	0.8587	0.8464	1	
US	0.8827	**0.5645**	0.5583	0.5931	0.5218	0.5173	0.5342	1

Table 3. Cross-sectional regressions of the world stock market betas on firm-level measures of fundamental characteristics: 2006 H1

VARIABLES	(1) _b_r_exc_world	(2) _b_r_exc_world	(3) _b_r_exc_world
ln_mvc_06	-0.151*	-0.158*	-0.127
	(0.076)	(0.081)	(0.096)
nim_06	0.190***	0.151*	0.173*
	(0.056)	(0.089)	(0.090)
btvb_06	-0.016	-0.025	0.065
	(0.072)	(0.080)	(0.109)
tce_06	-0.111**	-0.095*	-0.078
	(0.053)	(0.051)	(0.058)
wfr_06	0.011***	0.008***	0.005*
	(0.003)	(0.003)	(0.003)
frev_06		0.007***	
		(0.003)	
fassets_06			0.010***
			(0.002)
Constant	2.290**	2.402**	1.724
	(0.895)	(0.953)	(1.159)
Observations	61	53	44
Adjusted R-squared	0.279	0.173	0.262

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: The original sample includes 83 financial institutions, of which 22U.S.institutions, 7U.K.institutions, 7 German institutions, and 4 French institutions. However, the number of observations is constrained by data availability. *Ln_mvc*: market value capitalization (in log); *nim*: net interest income; *btvb*: price-to-book value ratio; *tce*: tangible common equity to tangible assets; *wfr*: wholesale funding ratio (share of non-deposit liabilities in total liabilities); *frev*: share of foreign revenues in total revenues; *fassets*: share of foreign assets in total assets.

Table 4. Cross-sectional regressions of the world stock market betas on firm-level measures of fundamental characteristics: 2011 H1

VARIABLES	(1) _b_r_exc_world	(2) _b_r_exc_world	(3) _b_r_exc_world
ln_mvc_11	0.118*	0.252***	0.219
	(0.067)	(0.078)	(0.135)
nim_11	-0.008	0.214***	0.036
	(0.060)	(0.070)	(0.242)
btvb_11	-0.199*	-0.687***	-0.670**
	(0.105)	(0.108)	(0.240)
tce_11	0.007	-0.119*	-0.058
	(0.045)	(0.066)	(0.111)
wfr_11	0.009***	0.002	0.004
	(0.002)	(0.002)	(0.010)
frev_11			
fassets_11			
xsovtoassets_11			0.056
			(0.045)
Constant	-0.260	-0.483	-0.407
	(0.680)	(0.695)	(1.108)
Observations	49	33	22
Adjusted R-squared	0.219	0.602	0.300

Robust standard errors in parentheses (White's heteroscedastic consistent)
*** p<0.01, ** p<0.05, * p<0.1

Notes: See Table 3. Regression (2) excludesU.S.and Japanese financial institutions.

Table 5. Cross-sectional regressions of the country stock market betas on firm-level measures of fundamental characteristics: 2006 H1

VARIABLES	(1) _b_res_country_stagged	(2) _b_res_country_stagged	(3) _b_res_country_stagged
ln_mvc_06	0.091**	0.089*	0.039
	(0.045)	(0.045)	(0.058)
nim_06	-0.004	-0.029	-0.016
	(0.023)	(0.041)	(0.051)
btvb_06	-0.023	-0.002	0.014
	(0.033)	(0.035)	(0.063)
tce_06	0.038	0.050*	0.031
	(0.025)	(0.027)	(0.027)
wfr_06	0.005***	0.005**	0.005**
	(0.002)	(0.002)	(0.002)
frev_06		0.001	
		(0.002)	
fassets_06			0.001
			(0.002)
Constant	-0.388	-0.451	0.066
	(0.535)	(0.540)	(0.753)
Observations	61	53	44
Adjusted R-squared	0.223	0.237	0.161

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: See Table 3.

Table 6. Cross-sectional regressions of the country stock market betas on firm-level measures of fundamental characteristics: 2011 H1

	(1)	(4)
VARIABLES	_b_res_country_stagged	_b_res_country_stagged
ln_mvc_11	0.087	0.078
	(0.067)	(0.087)
nim_11	-0.027	0.100
	(0.041)	(0.198)
btvb_11	-0.293***	-0.471**
	(0.089)	(0.204)
tce_11	0.144***	0.057
	(0.036)	(0.084)
wfr_11	-0.000	0.001
	(0.003)	(0.011)
frev_11		
fassets_11		
xsovtoassets_11		0.039*
		(0.021)
Constant	0.043	0.327
	(0.744)	(1.002)
Observations	49	22
Adjusted R-squared	0.468	0.366

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Note: See Table 3.

Table 7. Top Receivers of Spillovers from German Banks

Deutsche Bank

	2003H1-2007H1		2007H2-2011H2
***	Commerzbank	***	Commerzbank
***	HypoVereinskbank (HVB)	***	Societe Generale
***	Allianz	***	Royal Bank of Scotland (RBS)
***	Credit Suisse Group	***	Fannie Mae
**	Societe Generale	***	BNP Paribas
***	Standard Chartered	***	Barclays
***	Barclays	***	Credit Agricole
***	BNP Paribas	***	KBC Group
**	Lehman Brothers	***	Freddie Mac
***	UBS	***	Allianz

Commerzbank

	2003H1-2007H1		2007H2-2011H2
***	HypoVereinskbank (HVB)	***	Deutsche Bank
***	Hypo Real Estate Holding	***	Royal Bank of Scotland (RBS)
***	Deutsche Bank	***	Barclays
***	Allianz	**	Fannie Mae
***	Credit Suisse Group	***	KBC Group
	Sumitomo Mitsui Banking Corporation	***	Dexia
***	Credit Agricole	***	Lloyds Banking Group
***	UBS	***	Credit Agricole
	HDFC Bank	***	Societe Generale
**	ABN Amro	**	Freddie Mac

HVB

	2003H1-2007H1	2007H2-2011H2
***	Commerzbank	N/A
**	Hypo Real Estate Holding	
**	Allianz	
**	Hannover Rueckversicherung	
	UniCredit	
***	Credit Suisse Group	
**	Deutsche Bank	
**	Standard Chartered	
***	Axa	
	Banco do Brasil	

Table 7 (continued).

Allianz

	2003H1-2007H1		2007H2-2011H2
***	Hannover Rueckversicherung	**	Fannie Mae
***	Axa	**	Freddie Mac
***	Deutsche Bank	***	Commerzbank
***	Commerzbank	***	Deutsche Bank
***	Credit Suisse Group	***	Axa
*	Sberbank of Russia	***	Hannover Rueckversicherung
**	ING Group	***	Royal Bank of Scotland (RBS)
***	Standard Chartered	***	KBC Group
***	Societe Generale	***	Barclays
**	Barclays	***	ING Group

Hypo Real Estate

	2003H1-2007H1	2007H2-2011H2
***	Commerzbank	N/A
***	HypoVereinskbank (HVB)	
***	Banco Bradesco	
*	Sumitomo Mitsui Banking Corporation	
***	Hannover Rueckversicherung	
***	Goldman Sachs Group	
*	Sberbank of Russia	
	Bankgesellschaft Berlin AG	
	Mitsubishi UFJ Financial	
	Mizuho Financial Group	

Table 8. Top Receivers of Spillovers from French andU.K.Banks

BNP Paribas

	2003H1-2007H1		2007H2-2011H2
***	Societe Generale	***	Societe Generale
***	Credit Agricole	***	Credit Agricole
***	Industrial & Commercial Bank of China (ICBC)	***	Heritage Financial Group (HBOS)
***	ING Group	***	Barclays
***	Axa	***	Wachovia Corporation
***	UBS	***	Royal Bank of Scotland (RBS)
**	Sberbank of Russia	***	Deutsche Bank
***	UniCredit	***	Lloyds Banking Group
***	Banco Bilbao Vizcaya Argentaria (BBVA)	***	Commerzbank
**	Banca Monte dei Paschi di Siena	***	KBC Group

Societe Generale

	2003H1-2007H1		2007H2-2011H2
***	BNP Paribas	***	Heritage Financial Group (HBOS)
***	Credit Suisse Group	***	Credit Agricole
***	ING Group	***	Barclays
***	Credit Agricole	***	Royal Bank of Scotland (RBS)
***	Banca Monte dei Paschi di Siena	***	Lloyds Banking Group
***	Barclays	***	BNP Paribas
***	UBS	**	Wachovia Corporation
**	HypoVereinskbank (HVB)	***	Lehman Brothers
**	Standard Chartered	***	KBC Group
***	ABN Amro	***	Dexia

Barclays

	2003H1-2007H1		2007H2-2011H2
***	Heritage Financial Group (HBOS)	***	Royal Bank of Scotland (RBS)
***	Lloyds Banking Group	**	Bear Stearns
***	Royal Bank of Scotland (RBS)	***	Lloyds Banking Group
***	Standard Chartered	***	Heritage Financial Group (HBOS)
*	Sberbank of Russia	***	Wachovia Corporation
***	Axa	***	Societe Generale
***	Societe Generale	***	Credit Agricole
***	Industrial & Commercial Bank of China (ICBC)	***	UBS
*	HypoVereinskbank (HVB)	***	KBC Group
***	Banco Bradesco	***	Commerzbank

Barclays

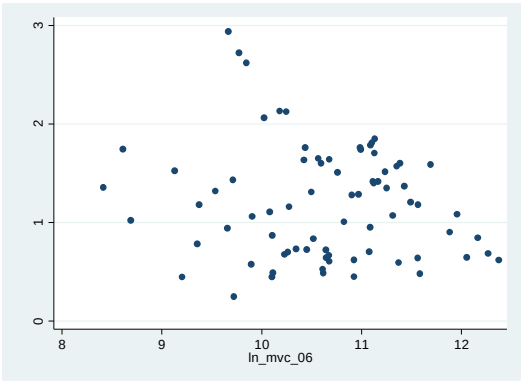
	2003H1-2007H1		2007H2-2011H2
***	Heritage Financial Group (HBOS)	***	Royal Bank of Scotland (RBS)
***	Lloyds Banking Group	**	Bear Stearns
***	Royal Bank of Scotland (RBS)	***	Lloyds Banking Group
***	Standard Chartered	***	Heritage Financial Group (HBOS)
*	Sberbank of Russia	***	Wachovia Corporation
***	Axa	***	Societe Generale
***	Societe Generale	***	Credit Agricole
***	Industrial & Commercial Bank of China (ICBC)	***	UBS
*	HypoVereinskbank (HVB)	***	KBC Group
***	Banco Bradesco	***	Commerzbank

HSBC

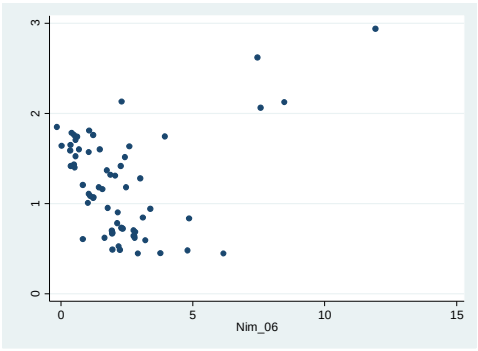
	2003H1-2007H1		2007H2-2011H2
***	Standard Chartered	***	Lehman Brothers
**	Sberbank of Russia	***	Royal Bank of Scotland (RBS)
***	Axa	***	Barclays
**	Barclays	**	Fannie Mae
**	Charles Schwab	***	Lloyds Banking Group
**	Credit Agricole	***	Freddie Mac
**	Lloyds Banking Group	***	Standard Chartered
**	Societe Generale	***	Wachovia Corporation
**	Danske Bank	***	Societe Generale
	HypoVereinskbank (HVB)	***	Bear Stearns

Figure 11. Bank World Beta and Bank Fundamentals, 2006 H1

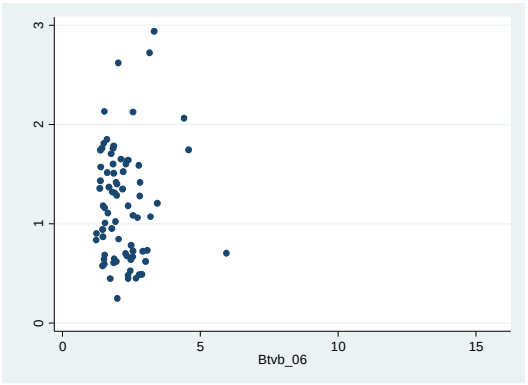
Market value capitalization



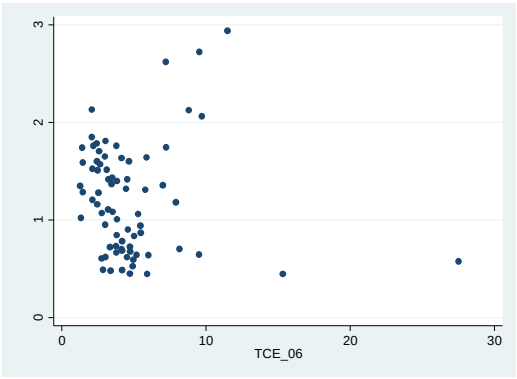
Net interest income



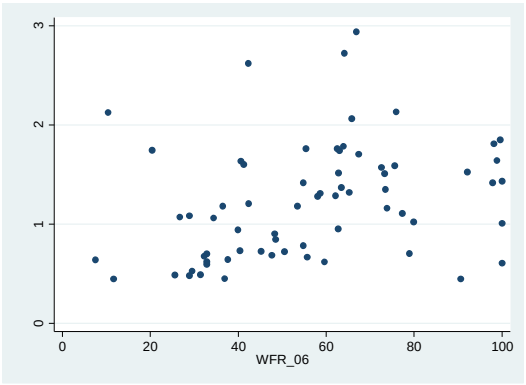
Price-to-book value ratio



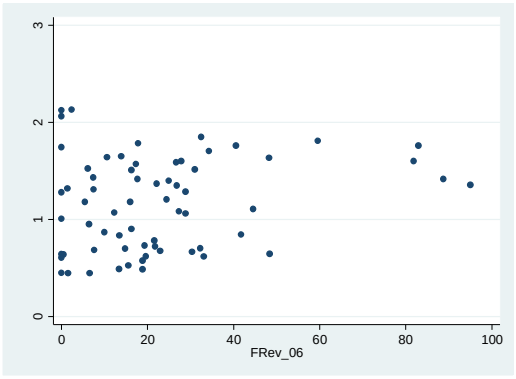
Tangible common equity ratio



Wholesale funding ratio



Foreign revenue share



Foreign asset share

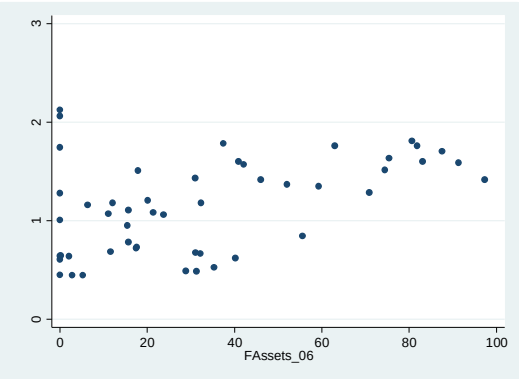
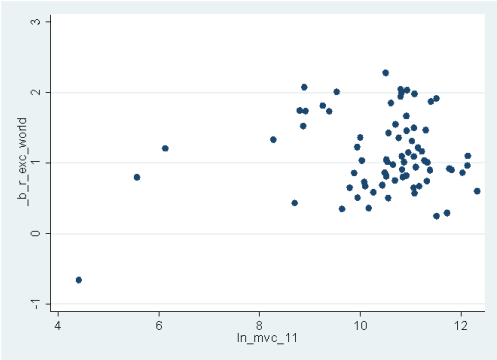
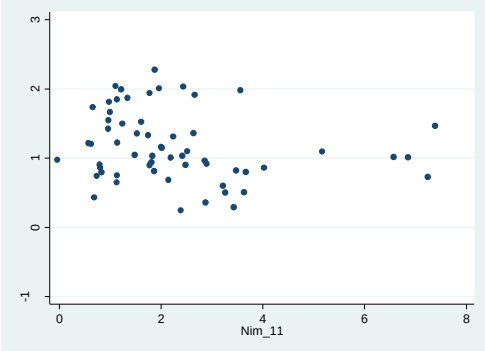


Figure 12. Bank World Beta and Bank Fundamentals, 2011 H1

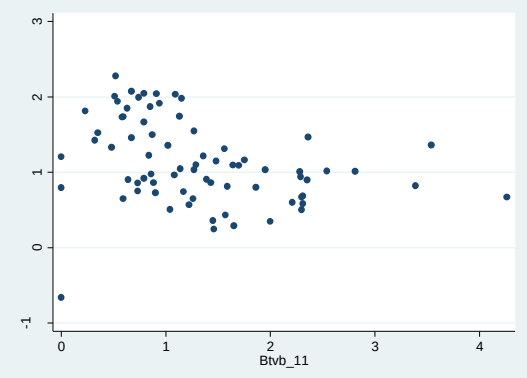
Market value capitalization



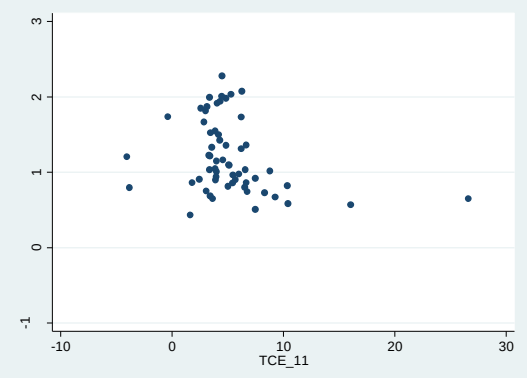
Net interest income



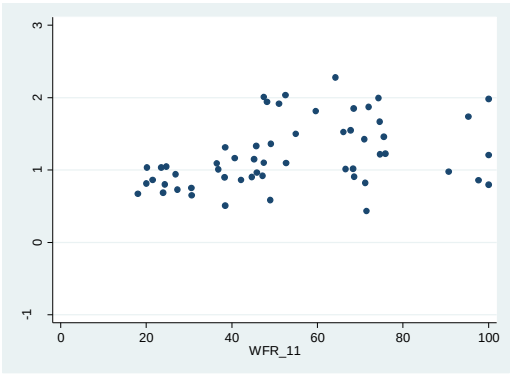
Price-to-book value ratio



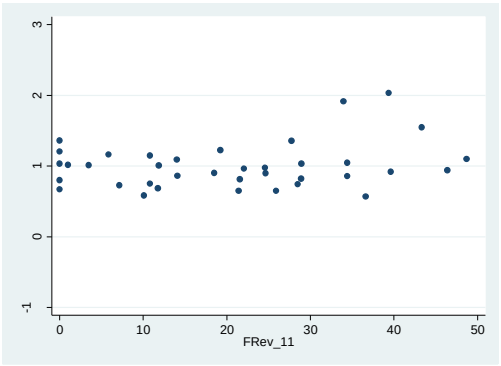
Tangible common equity ratio



Wholesale funding ratio



Foreign revenue share



Foreign asset share

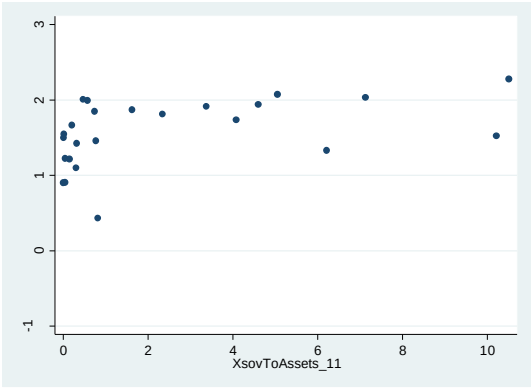
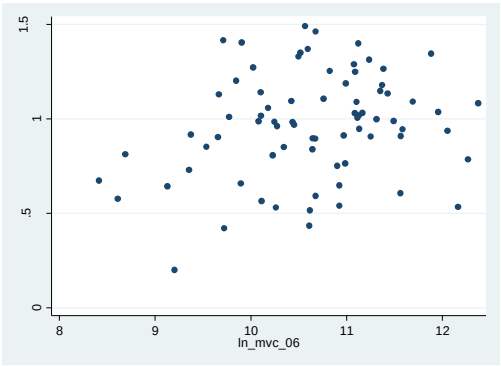
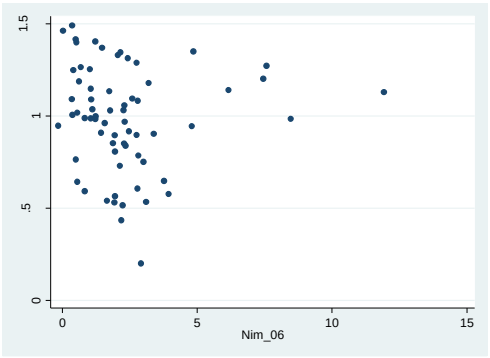


Figure 13. Bank Country Beta and Bank Fundamentals, 2006 H1

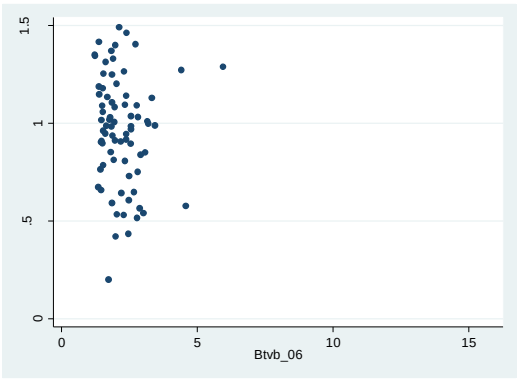
Market value capitalization



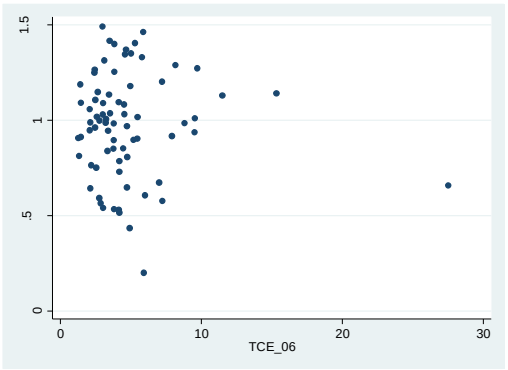
Net interest income



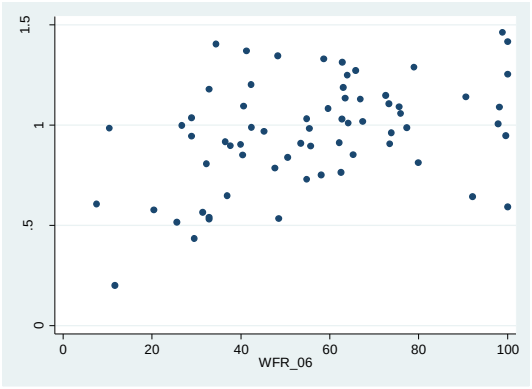
Price-to-book value ratio



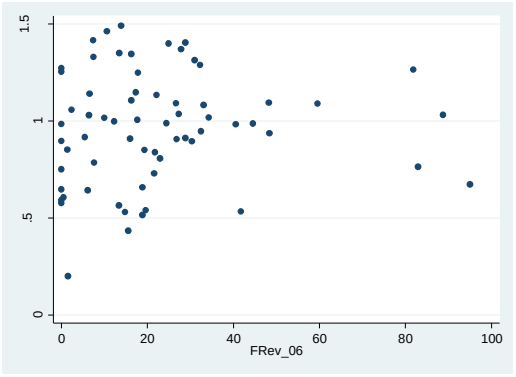
Tangible common equity ratio



Wholesale funding ratio



Foreign revenue share



Foreign asset share

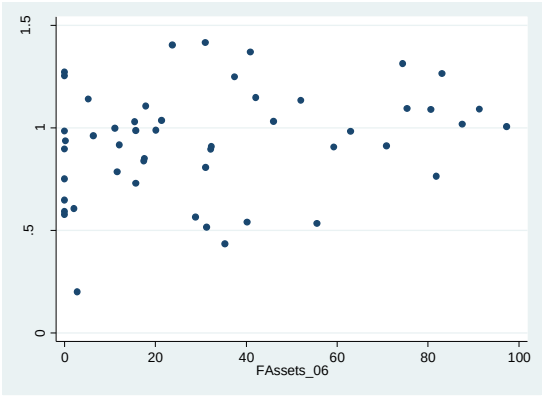
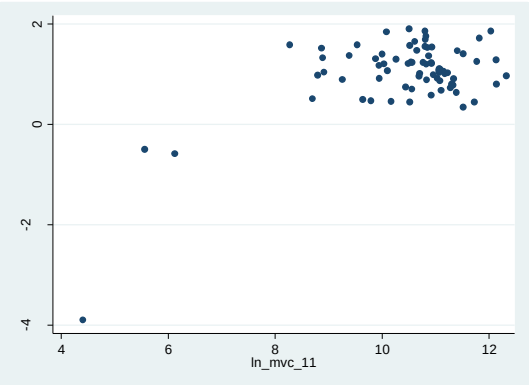
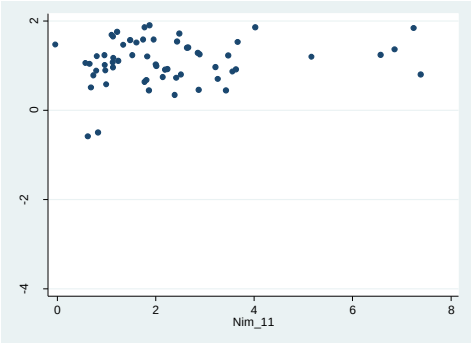


Figure 14. Bank Country Beta and Bank Fundamentals, 2011 H1

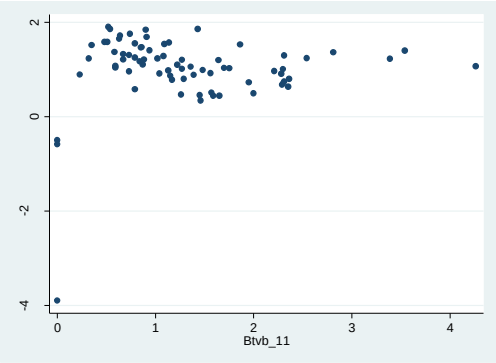
Market value capitalization



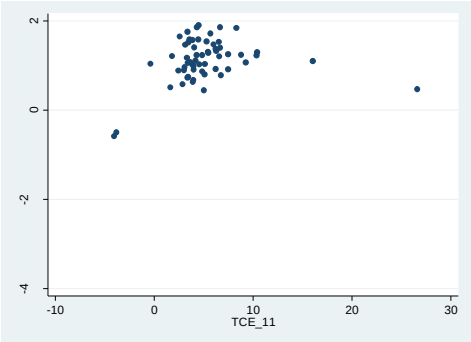
Net interest income



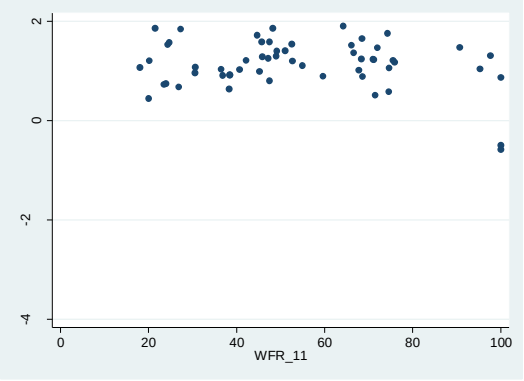
Price-to-book value ratio



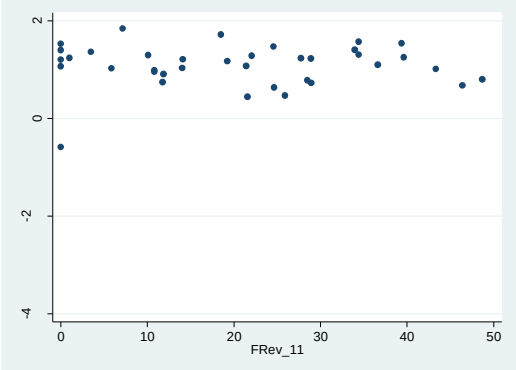
Tangible common equity ratio



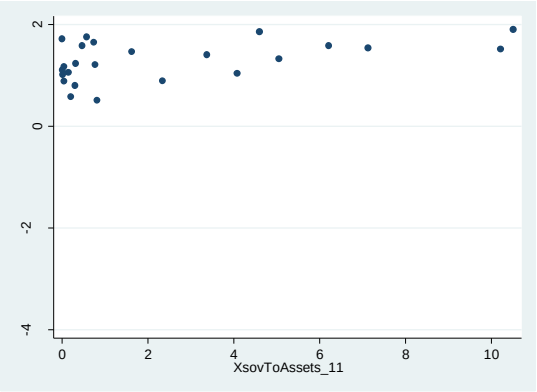
Wholesale funding ratio



Foreign revenue share



Foreign asset share



References

Aydin, Burcu, Myeong-Suk Kim, and Ho-Seond Moon, 2011, Financial Linkages across Korean Banks, IMF Working Paper WP/11/201.

Bekaert, Geert, Michael Ehrmann, Marcel Fratzscher, and Arnaud Mehl, 2011, Global Crises, and Equity Market Contagion, ECB Working Paper No. 1381.

Bekaert, Geert, Campbell R. Harfey, and Angela Ng, 2003, Market Integration and Contagion, NBER Working Paper 9510.

Bekaert, Geert, Robert Hodrick, and Xiaoyan Zhang, 2009, International Stock Return Comovements, *The Journal of Finance* 64 (6), 2591–2626.

Brooks, Robin and Marco Del Negro, 2005a, A Latent Factor Model with Global, Country, and Industry Shocks for International Stock Returns, IMF Working Paper WP/05/52.

Brooks, Robin and Marco Del Negro, 2005b, Country Versus Region Effects in International Stock Returns, *The Journal of Portfolio Management*, Summer, 67–72.

Brooks, Robin and Marco Del Negro, 2006, Firm Level Evidence on International Stock Market Comovement *Review of Finance* 10, 69–98.

Chan-Lau, Jorge, Estelle Liu, and Jochen Schmittmann, 2012, Equity Returns in the Banking Sector in the Wake of the Great Recession and the European Sovereign Debt Crisis, IMF Working Paper WP/12/174.

Chen, Sally, Mali Chivakul, Siret Dinc, Ola Melander, Mohamed Norat, and Malika Pant, 2011, Market Assessment of Spillovers from the Euro Area Based on Conditional Distress Probabilities, in *Euro Area Policies: Spillover Report for the 2011 Article IV Consultation and Selected Issues*, IMF Country Report No. 11/185.

Dungey, Mardi, Renée Fry, and Vance L. Martin, 2004, Currency Market Contagion in the Asia-Pacific Region, Australian Economic Papers.

Dungey, Mardi, Renee Fry, Brenda Gonzales-Hermosillo, and Vance L. Martin, 2005, Shocks and Systemic Influences: Contagion in Global Equity Markets in 1998, CAMA Working Paper 15/2005, The Australian National University.

ECB, 2011, Common Equity Capital, Banks' Riskiness, and Required Return on Equity, in *Financial Stability Review*, December, 125–31.

Eichengreen, Barry, Ashoka Mody, Milan Nedeljkovic, and Lucio Sarno, 2009, How the Subprime Crisis Went Global: Evidence from Bank Credit Default Swap Spreads, NBER Working Paper 14904.

Gropp, Reint, and Gerard Moerman, 2003, Measurement of Contagion in Banks' Equity Prices, ECB Working Paper No. 297.

Gropp, Reint, Marco Lo Duca, and Jukka Vesala, 2006, Cross-Border Bank Contagion in Europe, ECB Working Paper No. 662.

Heston, Steven, and K. Geert Rouwenhorst, 1994, Does Industrial Structure Explain the Benefits of International Diversification? *Journal of Financial Economics* 46; 111–157.

Lewis, Jeffrey B. and Drew A. Linzer, 2005, Estimating Regression Models in Which the Dependent Variable is Based on Estimates, *Political Analysis*, 13, 345–364.

Podlich, Natalia, and Michael Wedow, 2011, Credit Contagion Between Financial Systems, Discussion Paper No 15/2011, Deutsche Bundesbank.

Segoviano, Miguel, 2006a, "Consistent Information Multivariate Density Optimizing Methodology," Financial Markets Group, London School of Economics, Discussion Paper 557.

Segoviano, Miguel, 2006b, "The Conditional Probability of Default Methodology," Financial Markets Group, London School of Economics, Discussion Paper 557.

Segoviano, Miguel A. and Charles Goodhart, 2009, Banking Stability Measures, IMF Working Paper WP/09/04.

Shin, Hyun Song, 2011, Global Savings Glut or Global Banking Glut, available at www.voxeu.org.

Tressel, Thierry, 2011, What Is Driving Banking Sector Stress? Fundamentals or a Loss of Confidence?, mimeo, IMF.

Yilmaz, Kamil, 2011, Major European Bank Stocks are Connected in a State of High Volatility, available at www.voxeu.org.