THE G-20 REGULATORY AGENDA AND BANK RISK

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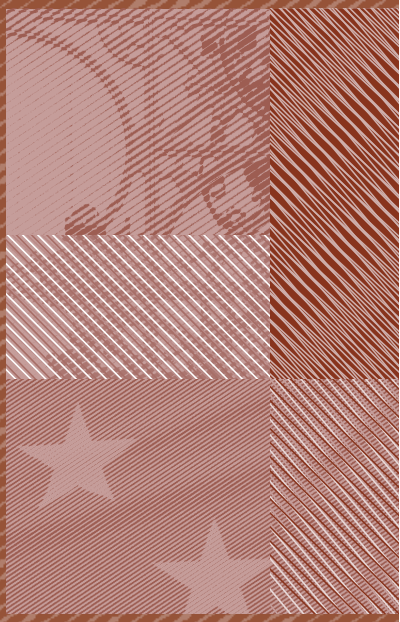

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THE G-20 REGULATORY AGENDA AND BANK RISK (*)

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Abstract

Using international listed banks from the United States, Europe, Japan and China from 2004 to 2014, we analyse the effect on bank risk of some of the most relevant new elements of the prudential regulatory framework proposed in the wake of the Great Financial Crisis. We measure risk by a market measure, namely the volatility of banks' stock returns. We also examine the effect of government support during the financial crisis and of designation as a G-SIB. We find little support for an association with government support and none for a negative relationship. We find support for a positive effect of designation as a G-SIB on risk. We find a positive association with securities trading and a negative association with capital. Banks' chosen liquidity is unimportant for this measure of risk.

Keywords: banks, regulation, financial crisis.

JEL Classification: G21, G38, G01.

Resumen

Utilizando una muestra de bancos cotizados de Estados Unidos, Europa, Japón y China durante el período 2004-2014, los autores analizan el impacto que el nuevo marco de regulación prudencial aprobado en el G-20 tras la gran crisis financiera tiene sobre el riesgo bancario. El riesgo se mide en función de la volatilidad de la cotización de los bancos. Los autores analizan también cómo influyeron las recapitalizaciones públicas durante la crisis así como la designación de G-SIB (banco de importancia sistémica global). Se llega a la conclusión de que hay evidencia que demuestra el impacto positivo que la designación de G-SIB tiene sobre el riesgo. No hay evidencia de una relación negativa entre riesgo y capitalización pública y sí de la relación positiva entre riesgo y actividad de negociación de valores. Los niveles de capital más altos reducen el riesgo, mientras que la liquidez no afecta de manera significativa al riesgo.

Palabras clave: bancos, regulación y crisis financiera.

Códigos JEL: G21, G38, G01.

1 Introduction

The Financial Crisis of 2007-2008 highlighted the weaknesses of the international regulatory architecture and was followed by a coordinated response by the G-20 countries represented at the Financial Stability Board (FSB). The FSB committed to improving financial regulation by implementing a major program of financial reforms with clear principles and timetables (FSB, 2009a). The stated objectives are to create a financial system that better supports balanced economic growth and limits moral hazard by institutions that are Too Big to Fail (TBTF). A large literature concludes that countries with better developed financial systems, particularly with efficient banks and well organized and smoothly functioning stock markets, tend to grow faster (Levine, Loyola and Beck, 2000).

The purpose of this paper is to present evidence on the likely effects of two aspects of government interventions – prudential regulation and government financial support – on the market's perception of banks' riskiness.[1] We use realized volatility as the empirical measure of ex post risk. This measure of risk can be interpreted as expected risk plus unexpected risk. It can be written $\sigma_t = E(\sigma_t) + \varepsilon_t$, where σ_t is the standard deviation of returns, $E(\sigma_t)$ is the expected standard deviation of daily returns conditional on information available before t, and ε_t is the unexpected part of the standard deviation. The major effect of using realized volatility as a measure of risk compared to expected risk is a lessening of the R^2 of the estimated regressions.[2]

The effects of some interventions such as bailouts can be examined based on the effects of past bailouts. The actual effects of some regulations cannot be estimated for some time precisely because they were not implemented during our study period. On the other hand, the regulations are being drafted with certain intended purposes and it is useful to know whether evidence from banks' behaviour is consistent with the regulations possibly having the intended effects.

Our empirical analysis covers the eleven years from 2004 through 2014. This period includes three years before the Financial Crisis of 2007-2008 and six years after the crisis.

The government interventions and regulatory measures examined in this period include:

- Government support through capital injections during and after the financial crisis. One part of our contribution is our analysis of the effect on realized volatility of both prudential regulatory actions and government financial support. In all instances, capital injections took place in the context of well-defined government programs for which all national banks were eligible.
- Financial Stability Board (FSB) designation of Globally Systemic Important Banks. The FSB has been publishing a list of Global Systemically Important Banks (G-SIBs) following BIS methodology since 2011. This is part of the G-20 actions aimed at reducing moral hazard associated with institutions that are TBTF and is a prudential regulation which has been put into practice. Table 1 shows the banks designated as G-SIBs from the first designation in 2011 until 2014 when our data end.

1 The optimal tradeoff between risk and stability is beyond the scope of this paper.
2 MacAleer and Medeiros (2008) provide an excellent review of the literature on realized volatility and references.

- Limitations on securities trading including limits on proprietary trading. The Fundamental Review of the Trading Book revised the minimum capital for market risk and, in parallel, is attempting to ring fence trading activities.[3]
- Requirement of an overall leverage ratio. Regulation is being revised to introduce an internationally harmonized capital leverage ratio in addition to a risk-based capital ratio.[4]
- Liquidity standards. The Liquidity Coverage Ratio (LCR) requires that banks have liquid assets which cover 100% or more of net cash outflows over a 30 day period. The Net Stable Funding Ratio (NSFR) requires that a minimum percentage of capital and long term liabilities provide a reliable source of funding for lending over one year.[5] We use two ratios of banks´ liquidity provided by Bankscope that measure, respectively, short term liquidity and the stability of sources of funding of bank lending. Bankscope does not provide information on the maturities of assets and liabilities or estimated outflow rates for assets; therefore, the variables cannot reflect these aspects of the regulations.

Our results indicate that capital injections by governments during the financial crisis are not associated with higher or lower risk. Banks designated as G-SIBs are regarded as riskier than other banks. Our results indicate that banks with larger trading books are perceived to be riskier. We find that a higher leverage ratio – capital relative to assets – is associated with banks having less risk as perceived by the market. There is little evidence of an association between banks´ chosen liquidity ratios and banks' riskiness.

The rest of the paper is divided into the following sections. Section 2 presents the relevant literature as well as the hypotheses to be tested in this paper. Our empirical approach and the variables included in the analysis are presented in Section 3. Section 4 presents our data and some univariate analysis and section 5 analyses the regression results. Section 6 presents a difference-in-difference analysis to provide additional evidence on the association of realized volatility with government support and designation as a G-SIB. The last section concludes.

3 In the United States, this is known as the Volcker Rule. At the time of writing this paper, the EU has abandoned the proposed separation of trading activities including proprietary trading from the traditional deposit taking activities. In the UK, the Prudential Supervisory Authority has recently published rules implementing the ring fencing of core UK financial services, which will become effective on January 1, 2019 (see http://www.bankofengland.co.uk/pra/Documents/publications/ps/2017/ps317app1.pdf accessed 6th June, 2017). In the United States, the ban on banks´ proprietary trading became effective in July, 2015 although revisions are in progress.

4 On November 23, 2016, the EU Commission proposed a package of regulatory reforms which included the introduction of a required leverage ratio of 3% of Tier 1 which was announced in 2015 and is expected to be fully implemented in 2019. This is in line with the Basel Committee of Banking Supervisors' timetable for internationally active banks (see http://www.bis.org/publ/bcbs270.htm accessed 6th June, 2017).

5 The LCR will was fully implemented January 1, 2018 and the NSFR (see http://www.bis.org/publ/bcbs274.htm accessed 6, June, 2017) will enter into force by 2019 (see http://www.bis.org/bcbs/publ/d295.htm accessed 6th June, 2017).

2 Literature review and testable implications

The various studies that we review in this section focus on the effect on different measures of bank risk and performance of prudential regulation of capital, liquidity or both in addition to government capital injections into banks. To our knowledge, only Berger et al. (forthcoming) explore the simultaneous effect of prudential regulatory actions and government financial support on banks' riskiness. They provide substantial evidence that both sorts of interventions decrease banks' risk taking. Their study differs from ours in several important ways. Berger et al. (forthcoming) use a regulatory accounting measure of bank risk – risk weighted assets over total assets – while we use the realized volatility of stock returns as a measure of risk. Regulatory interventions in Berger et al. (forthcoming) are specific actions taken by regulators, such as dismissing executives, levying fines, issuing cease-and-desist orders but not broad interventions and prudential regulatory requirements as in our analysis. We focus on some of the most relevant new elements of the prudential regulatory framework proposed after the crisis. We include structural prudential measures such as classification as a G-SIB and banks' characteristics such as their holdings of trading securities. We also examine government capital injections in 2007 and 2008. Their empirical results are based exclusively on German banks, and we examine an international sample of listed banks.

Following the review of the literature, we summarize hypotheses for our estimates of the effects of government interventions on banks´ risk.

2.1 Effect of government financial support and designation as a G-SIB

Diamond and Rajan (2005) develop a theoretical model in which recapitalizing failing banks can have negative effects on banks which are experiencing no difficulties. On the other hand, liquidity injections have no negative effect on banks with no difficulties but might be ineffective at salvaging troubled banks.

Garcia-Palacios et al. (2014) use a relatively standard Diamond-Dybvig style theoretical model to analyze the efficiency of recapitalization programs and taxes on early withdrawals at preventing financial turmoil. These measures have costs. Taxes on early withdrawals penalize agents facing liquidity shocks and recapitalization programs require higher taxes for the same level of government expenditures besides recapitalization. They show that when agents value public services, taxes on early withdrawals can be the best policy. On the other hand, recapitalization programs are preferred when there is little value placed on public goods.

We focus on the most recent empirical studies of the interventions in the recent crisis. Using a sample of European, U.S. and Asian banks from 2008 to 2010, Fratianni and Marchionne (2013) find that announcements of general public support in the United States were followed by positive abnormal returns and lower volatility of returns. Government rescue plans for individual banks were associated with negative abnormal returns and higher volatility of returns. This finding might reflect the intervention being a revelation of previously unknown financial difficulty. They also find, though, that their empirical results are sensitive to the econometric techniques to deal with the time-series and cross-section econometric issues.

Elyasiani et al. (2014) also examine the effect on stock returns of large capital injections into U.S. banks by the U.S. government. They conclude that banks' common stock

returns reacted positively to TARP bank capital injections in the short term, in contrast to the typical negative response to seasoned equity offerings.

Using an accounting measure of banks´ risk – Z Score – and 23 banking crises from 23 mostly developing countries, Hryckiewicz (2014) concludes that interventions increase the riskiness of banks.[6] The overall effect varies with the structure of the bailout program but nationalizations, blanket guarantees and restructuring vehicles such as "bad banks" are associated with higher risk. These results are robust to various modifications including risk measures, time periods and countries' characteristics.

Banks designated as systemic can receive an implicit subsidy due to the expectation of government support of TBTF banks when they encounter financial difficulties. Afonso et al. (2014) and Marques et al. (2013) provide evidence that heightened perceptions that a bank is TBTF result in the bank increasing its riskiness. The empirical literature typically focuses on the effect on riskiness of marginal changes in the probability of government support. The IMF (2014, p. 118, Table 3.1) provides a set of estimates based on the rating gain associated with government support. This rating gain is translated into a lower credit spread using the historical relationship between credit ratings and bond spreads. They find that decreases in credit spreads for G-SIBs are around 60 basis points (bps) for banks in the Eurozone, around 25 bps for Japanese banks, around 20 bps for British banks and around 15 bps for U.S. banks. Except in the Eurozone, the rating gains are larger for distressed G-SIBs.[7]

Since the recent financial crisis, international prudential regulators have focused on a common definition of Systemically Important Banks (G-SIBs) and a set of well-defined policy actions aimed at limiting both the probability and costs of these banks' failures (Kaufman, 2014). We are not aware of any studies which have examined the effect of designation as a G-SIB on the market's perception of a bank's risk.

2.2 Effects of capital and liquidity regulation

The starting point in assessing the effect of banking regulation is assessing its effect in mitigating or eliminating banking crises. There is a vast literature on capital regulation especially and we focus only on papers closely related to Basel III. Since the Financial Crisis of 2007-2008, liquidity has received quite a bit of attention by researchers as well as regulators.

Allen et al. (2012) analyze Basel III's provisions in detail and argue that higher capital and liquidity buffers can be consistent with more financial stability.

Focusing on the Basel III leverage ratio, Kiema and Jokivuolle (2014) study the effects of a required leverage capital ratio on lending strategies in a calibrated theoretical model of a banking system with banks specializing in high-risk and low-risk loans. They show that too low a required leverage ratio combined with model risk actually can increase bank failures because more banks make high-risk loans.

Papanikolau and Wolff (2014) examine the 20 largest U.S. banks before and after the Financial Crisis of 2007-2008. They measure the banks' riskiness by realized volatility, the quarterly standard deviation of the banks' daily stock returns. Among other things, they find that off-balance sheet items increased banks' riskiness before the crisis. They suggest that

6 The z-score is the sum of the average return on assets plus the ratio of equity capital to assets, both divided by the standard deviation of the return on assets.

7 The decreases in credit spreads for distressed G-SIBS are around 75 bps in Japan, Great Britain and the United States.

leverage requirements should reflect these off-balance-sheet assets as well as on-balance-sheet items. Bitar et al. (forthcoming) examine OECD banks to estimate the effects of capital regulation on banks' riskiness, profitability and efficiency. They measure risk by loan loss reserves relative to assets, to total loans and to impaired loans. They find that risk-weighted capital is not related to these measures of risk but that non-risk-weighted capital is positively related to loan loss reserves. They interpret this as reflecting a "higher precautionary reserve policy" (Bitar et al. forthcoming, p. 15).

Tirole (2011) applies his general theoretical analyses of liquidity to summarize issues concerning liquidity and the implications for interpreting the crisis and regulation. He points out that much is not known including whether the banks' liquidity is too low, too high or about right relative to some ideal. Goodhart (2008) discusses general issues that arise when central banks attempt to regulate liquidity. Walther (2015) develops a theoretical framework in which macroprudential regulation in terms of the liquidity coverage ratio (LCR) is beneficial when implemented jointly with micro-prudential regulation.

In a theoretical analysis, Allen and Gale (2004) conclude that banks' liquidity creation can increase their exposure to risk because banks' losses increase with the level of illiquid assets to satisfy depositors' redemptions. On a different line, Myers and Rajan (1998) and Morgan (2002) argue that more liquid banks can engage in trading activities that are are more opaque and therefore more difficult to monitor.

Empirical research on liquidity today inevitably is based on data from a period in which there is no direct regulation of liquidity as is contemplated in Basel III. Any implications for policy must be tempered by the knowledge that the variables are measured in one policy regime; a new policy regime with liquidity regulation can change those relationships. This is just an application of the Lucas Critique to what are at best reduced-form estimated relationships (Lucas 1976). This problem is compounded by the fact that required liquidity is not the same thing as banks' freely chosen liquidity. Just as Friedman emphasized for required reserve ratios (Friedman 1959, p. 46), required liquidity cannot be used absent a decrease in the denominator of the required liquidity ratio.[8]

Imbierowicz and Rauch (2013) provide empirical evidence that liquidity risk management, in addition to the asset quality and credit risk of a bank, is associated with the probability of default. Using two measures of liquidity risk and two of credit risk for U.S. banks from 1998 to 2010, they find that banks with higher credit risk and higher liquidity risk have higher probabilities of default. Curiously, they also find that the interaction of credit risk and liquidity risk increases the probability of default when that probability is low but decreases the probability of default when the probability of default is high.

Distinguin et al. (2013) find that banks decrease their regulatory capital when they have less liquidity as defined by the Basel III accord. This evidence is for publicly traded banks in the United States and Europe from 2000 to 2006. They also find that small banks behave differently in some respects, increasing regulatory capital when core deposits decrease.

8 Goodhart (2008, p. 41) makes this point nicely: The most salient metaphor and fable in prudential regulation is of the weary traveller who arrives at the railway station late at night, and, to his delight, sees a taxi there who could take him to his distant destination. He hails the taxi, but the taxi driver replies that he cannot take him, since local bylaws require that there must always be one taxi standing ready at the station. Required liquidity is not true, usable liquidity. Nor might I add, is required minimum capital fully usable capital from the point of view of a bank.

Hong at al. (2014) examine the effects of the Basel III liquidity requirements on U.S. banks. They distinguish between idiosyncratic and systemic liquidity risks and find that both have limited effects on bank failures even though liquidity problems are a major contributor to bank failures in 2009 and 2010. In contrast, King (2013) focuses on the Net Stable Funding Ratio, NSFR, using a sample of banks in 15 countries and shows that the required NSFR is associated with lower net interest margins at banks.

3 Empirical approach

Table 2 summarizes the hypothesis to be tested in our model and the expected signs of the coefficients in light of the literature.

We present two sets of regressions to test the hypotheses for two time periods. Four regressions are presented for the entire period 2004 to 2014 and three are presented for the post-crisis period 2008 to 2014. The dependent variable in all these regressions is the natural logarithm of the realized volatility of banks' stock returns. A bank's realized volatility of its stock return can be interpreted as an ex post measure of the market's perception of a bank's risk and a noisy measure of the ex ante risk. For each bank-year pair, we use daily stock returns to compute the standard deviation for six months after the closing date for financial statements. For example, if a bank's accounting year ends on December 31, 2010, we calculate the standard deviation of its daily stock returns using daily returns from January 2011 through June 2011.[9] The standard deviation of stock returns for bank *i* at date *t* is denoted $\sigma_{i,t}$. We match this variable with accounting variables for the date, 2010 in the previous example, and market realized volatility for the same time period as the bank's returns.

The explanatory variables are:

Government Support: Based on BIS data, we include a dummy variable that equals one if a bank received a capital injection during the financial crisis and zero otherwise.

Globally Systemically Important Bank (G-SIB): The dummy variable for G-SIBs is one if a bank is classified as a G-SIB by the FSB in the corresponding year and zero otherwise. This measure of systemic importance reflects not only size but also interconnectedness, substitutability, complexity and cross jurisdictional activity.[10] The first list was released in 2011, and it has been updated every November since. Table 1 shows the banks designated as G-SIBs for each year. For years before 2011, we set this dummy variable equal to zero.

Logarithm of Trading Securities to Total Assets (trading assets): We use the ratio of trading securities to total assets as a measure of a bank's securities trading activity. This number includes all assets and securities classified as held for trading whether for market making or for proprietary trading. The assets and securities are measured at fair value and derivatives are not included in the total.[11]

Logarithm of Leverage Ratio (leverage ratio): The leverage ratio as defined in the Basel III framework, which measures bank capitalization.[12] For IFRS banks, the ratio in percentage terms is

100 x (Equity / Total assets including off-balance sheet items)

9 This will be labelled as the standard deviation for the year 2010. Hryckiewicz (2014) uses four-year moving averages.

10 See BCBS (2014 and 2017) for the assessment methodology (http://www.bis.org/bcbs/publ/d296.pdf and https://www.bis.org/bcbs/gsib/) accessed 27th November, 2017.

11 Because many banks have no trading securities, we add 1 to the ratio for all banks before computing the natural logarithm of this ratio.

12 Our measure of off balance sheet items is an approximation to the Basel III definition of "exposure measure." It should be noted that in Dec 2014 the definition of the leverage ratio exposure measure was revised by introducing changes (e.g. differentiated Credit Conversion Factors for off-balance sheet items, netting of SFTs and recognition of cash variation margin for derivatives).

For U.S.-GAAP banks, the ratio in percentage terms is

$$100 \text{ x (Equity / (Total assets + off balance sheet items)}$$

Equity includes common equity, non-controlling interest shares and revaluation reserves.

Logarithm of Liquid Assets to Customer & Short Term Funding (liquidity coverage): This variable measures short term liquidity at banks. A higher ratio implies a higher level of liquidity. The ratio in percentage terms is measured as:

$$100 \text{ x} \frac{\text{Liquid assets}}{\text{Customer and short-term funding}}.$$

Liquid assets include cash, government bonds and short-term claims on other banks. This is a narrower definition of high-quality liquid assets than the Basel III definition of the Liquidity Coverage Ratio (LCR), which also includes other assets such as corporate bonds and covered bonds.[13] Customer and short-term funding is estimated by total customer deposits, deposits from banks, other deposits and short-term borrowings as defined by Bankscope. Differences in outflow rates are ignored due to a lack of data.[14] As for the LCR, a higher percentage of Liquid Assets to Customer & Short Term Funding is assumed to be associated with more liquidity and less vulnerablity to a run.

Logarithm of Total Deposits & Borrowings over Net Loans (stable funding): This second measure of banks´ liquidity reflects the stability of the financing of banks´ lending. It is a measure of the net stable funding ratio: the higher the ratio, the higher liquidity. This ratio in percentage terms is measured as:

$$100 \text{ x} \frac{\text{Customer and short-term funding} + \text{Other funding} - \text{Hybrid capital} - \text{Subordinated debt}}{\text{Loans}}.$$

Loans include retail, corporate, mortgage and commercial loans, as well as reserves against possible losses on impaired loans. This is a narrower definition than Basel III's definition of the denominator of the required net stable funding ratio (NSFR), which also includes trade finance, derivatives, securitizations and covered bonds and is weighted according to the stability of the financing needs.[15] Our sources of funding are broadly in line with the definition of available stable funding in the Basel III's definition of NSFR. They include Deposits and Borrowings which are part of that stable funding as well as other funding which is capital market funding not otherwise categorized. Hybrid capital includes preference shares and premium (additional paid in capital in excess of par value) as well as redeemable capital in cooperative banks. Subordinated debt includes all possible maturities for this type of debt. Sources of financing are not weighted according to the assumed stability of these sources of funding, which they are in the NSFR.

The logarithms of these ratios are included in the regressions.

13 The LCR also includes other assets such as corporate bonds and covered bonds in liquid assets. The LCR = High Quality Liquid Assets / Net cash outflows ≥ 100% (30 days). There are substantial haircuts for some securities included as liquid assets.

14 Outflow rates depend on the counterparties in addition to features of the deposits.

15 NSFR = Available stable funding ratio / required stable funds ≥ 100% (< 1 yr).

We also include, as controls, the following variables which are likely to be associated with the volatility of banks' stock returns for other reasons:

Logarithm of Total Assets (Assets): Total assets measure a bank's size. For banks reporting the information using U.S.-GAAP, we add their corresponding "Off Balance Sheet Items" to the reported total assets.

Return on Average Assets (ROAA): This ratio in percentage terms is 100 times net income over average total assets. ROAA shows banks´ profitability measured by the net income generated from the total average assets available to the bank. Average assets are the arithmetic mean of the values at the end of years *t* and *t*-1. "Net income" includes operating and non-operating profit, non-recurring income (expenses) and other non-operating income (expenses) net of taxes.

Logarithm of beta-adjusted standard deviation of the market return ($(|\beta_i|\sigma_m)$ and |Beta| x Market's realized volatility): The volatility of individual stocks' returns depends on the market volatility multiplied by the absolute value of the beta for the individual stock. The relationship between a bank's volatility and the market volatility depends on the beta in the Capital Asset Pricing Model and any other model of volatility that includes the market return as a risk factor with coefficients that vary across firms.[16] We estimated average betas for each bank over all the data from 2004 to 2014. While betas estimated for investment purposes varied over this long time period, we are attempting to measure a bank's typical sensitivity to market volatility. Using an average for the overall period attenuates any issues generated by using estimated betas on the right-hand side of the regression (Pagan 1984).[17] We use the absolute value of the beta for the bank multiplied by the standard deviation of the market return for the country in which a bank is headquartered. The timing of the market standard deviation is the same as for the dependent variable.

Real GDP growth rate (Δy_c): We include the annual growth rate of real GDP from year t-1 to t for country c in which a bank's headquarter is located. This information is from the World Bank and World Development Indicators.

Pre-crisis dummy variable: This dummy variable takes the value one from 2004 to 2007 and zero otherwise. It is used to examine changes in coefficients before and after the financial crisis.

Leverage $\geq$ *3% dummy variable* (leverage ratio $\geq$ 3%): This dummy variable takes the value one if a bank leverage's ratio is greater than or equal to 3%, which is the minimum regulatory requirement.

As mentioned above, we estimate seven panel regressions. All regressions include fixed effects for each year and each bank.

The baseline regression includes only the explanatory and control variables to assess their relationship with the market's perception of overall bank. The basic equation is

16 We are grateful to an audience member at the Infiniti conference for pointing this out.
17 It would be difficult at best to come up with convincing instrumental variables for beta.

$$\sigma_i = \alpha + \beta_1 \left(government\ support \right)_i + \beta_2 \left(G\text{-}SIB \right)_i + \beta_3 trading_i$$
$$+ \beta_4 leverage_i + \beta_5 liquidity_i + \beta_6 \left(stable\ funding \right)_i$$
$$+ \beta_7 assets_i + \beta_8 ROAA_i + \beta_9 1(|\beta_i| \sigma_m) + \beta_{10} \Delta y_c + \beta_{11} \left(pre-crisis \right)_i + \beta_{12} \left(leverage\ ratio \geq 3 \right)_i$$
$$+ \left(fixed\ effects \right) + \varepsilon_i$$

We omit the subscripts for time period from the equation above for simplicity; all variables are measured in the same time period as the dependent variable. All variables are measured in logarithms except the dummy variables (*government support, G-SIB, pre-crisis and* $leverage\ ratio \geq 3\%$), ROAA and Δy_c. Fixed effects for each year and each bank are included in all equations. The estimated parameters are given by α and β_i. The error term is ε_i.

The other three regressions for 2004 to 2014 are variants of this basic equation in which dummy variables are interacted with the financial variables. We define the "financial variables" as trading assets, leverage ratio, liquidity coverage and stable funding.

The second regression includes interactions between the financial variables and the G-SIB dummy variable. This regression makes it possible to assess whether variables have different effects for G-SIBs and other banks.

The third regression includes interactions between the financial variables and the government support dummy variable. This regression examines whether government capital support is associated with different effects of the financial variables:

The fourth regression includes interactions between the financial variables and the pre-crisis dummy variable. This regression examines whether there is a different effect of these financial variables on banks' risk before 2008 compared to later years.

We also run the regressions using only data for 2008 to 2014, the post-crisis period. While the fourth regression for the whole period permits shifts in the estimated coefficients of the financial variables by time period, these three regressions permit shifts in all coefficients and in the standard errors of the residuals in the regressions.

4 Data and descriptive analysis

4.1 Set of banks selected

The data include international, listed banks in the United States, Europe, Japan and China with financial information available in Bankscope. The data include 881 listed banks from 39 countries. Table 3 shows the number of banks for each country and year between 2004 and 2014. As shown in Table 3, some banks disappear between 2004 and 2014 and some new ones appear. Also, some explanatory variables are not available for all periods. For this reason, our dataset is an unbalanced panel with 5,630 bank-year observations. The data span the eleven years from 2004, the year of the adoption of the "*International Financial Reporting Standards*" (IFRS), to 2014, the last year with complete financial information when we started this research. Financial data are reported under IFRS for the non-U.S. banks. Financial data are reported under "*General Accepted Accounting Principles*" (GAAP) for most U.S. banks and we include financial data of U.S. banks using GAAP.[18]

Banks in this sample can be classified as bank holding companies, commercial and savings banks, investment and private banks, and mortgage and real estate banks.

The government interventions and regulatory measures examined in this paper include:

- Government support through capital injections.
- FSB designation of G SIBs.
- Limitations on securities trading including limits on proprietary trading. The Fundamental Review of the Trading Book revised the minimum capital for market risk and, in parallel, is attempting to ring fence trading activities.[19]
- Requirement of a capital leverage ratio.[20]
- Liquidity requirements.[21]

We use data on stock prices from Datastream to estimate each bank's realized volatilities and beta.[22] Some banks have estimated betas less than -2 or greater than 2 and are not included in our final dataset.[23] Figure 1 shows the density of the distribution of estimated betas used for our computations.[24] Our data on ex post government support refers exclusively to capital injections in banks from 2004 to 2014 (actually 2008 to 2010) and is from the Bank for International Settlements (BIS).

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18 We choose consolidated over unconsolidated accounting statements when possible.

19 In the United States, this is known as the Volcker Rule. At the time of writing this paper, the EU has abandoned the proposed separation of trading activities including proprietary trading from the traditional deposit taking activities. In the UK, the Prudential Supervisory Authority has recently published rules implementing the ring fencing of core UK financial services, which will become effective on January 1, 2019 (see http://www.bankofengland.co.uk/pra/Documents/publications/ps/2017/ps317app1.pdf accessed 6th June, 2017). In the United States, the ban on banks´ proprietary trading became effective in July, 2015.

20 On November 23rd 2016, the EU Commission proposed a package of regulatory reforms which included the introduction of a required banks´ leverage ratio of 3% of Tier 1 capital. This had been discussed since 2015 and is expected to be fully implemented in 2019. This is inline with the timetable of the Basel Committee of Banking Supervisors for internationally active banks (see http://www.bis.org/publ/bcbs270.htm accessed 6th June, 2017).

21 LCR will be fully implemented January 1, 2018 and the NSFR (see http://www.bis.org/publ/bcbs274.htm accessed June 6, 2017) will enter into force by 2019 (see http://www.bis.org/bcbs/publ/d295.htm accessed June 6, 2017).

22 We use banks' International Securities Identification Number (ISIN) and ticker symbols to match these sources of data.

23 A total of 125 observations were deleted. There were 353 remaining bank-year observations with negative betas, out of 5,630 observations. If the negative estimates are due to estimation error, they have less effect than it might seem at first because the regression includes the absolute value of the beta.

24 Our betas are estimated using the market index for the country in which the bank is headquartered as the measure of the market return.

Table 4 presents summary statistics for the variables included in our analysis. All of the variables are measured in natural units even though the logarithms of many of the variables are included in the regressions.

4.2 Descriptive analysis of the data

Table 5 presents the correlation matrix among the variables. Although not an entirely reliable guide to multicollinearity, the correlations do not show any extremely high correlations among the variables. No correlation of right-hand side variables exceeds the partly mechanical correlation of 0.49 between the leverage ratio and the dummy variable for leverage ratios of 3 percent or more.

Table 6 shows the coefficients for univariate regressions of the logarithm of volatility on the variables and their statistical significance. Government support is associated with higher volatility and designation as a G-SIB is associated with lower volatility. Larger banks also have lower volatility, which could be consistent with larger banks simply having lower perceived volatility rather than the importance of designation as a G-SIB. Of the financial ratios, having more trading assets is associated with less perceived volatility and riskiness, contrary to the regulatory argument of limiting this activity. A higher capitalization measured in terms of the leverage ratio is associated with lower volatility, which is consistent with the regulatory requirement of higher capital leverage ratios. A capital leverage ratio greater than or equal to three percent also is associated with lower volatility, although the independent contribution of these two functions of the leverage ratio is not immediately obvious. Liquidity coverage is not reliably associated with volatility, while stable funding is only marginally associated with lower volatility, at least in these univariate regressions.

5 Regression analysis

Table 7 presents the results for the full period, 2004 to 2014. All of the multivariate regressions include both bank and year fixed effects which control for any unobserved constant bank characteristics or effects associated with years which might affect the volatility of banks' stock returns.[25] Table 9 presents the results for the post crisis period (2008-2014). Tables 8 and 10 present associated estimates and p-values for testing for differences in the estimated coefficients for sub-groups or different time period.

5.1 Determinants of banks' stock-return risk

Government support of banks generally is positively associated with the market's perception of a bank's risk in the four regressions in Table 7 but also generally is not statistically significant. On the other hand, designation as a G-SIB is statistically significant in the baseline regression and is statistically significant in two of the three regressions allowing for interaction effects. [26] In the baseline regression, the estimate is not trivial, with a 33 percent increase in volatility if a bank is designated as a G-SIB.

Of the financial variables that are the subject of regulatory changes, trading assets is uniformly positively related to realized volatility of stock returns and the effects are substantial. A ten percent increase in the ratio of trading assets to total bank assets increases realized volatility by 13 to 22 percent depending on the specification.[27] The leverage ratio is uniformly negatively related to realized volatility of stock returns. A ten percent increase in the leverage ratio reduces realized volatility by about four percent. These results are consistent with the proposition that banks holding more trading securities and presumably trading more are riskier. They also are consistent with the proposition that banks with less capital are riskier. Neither the liquidity coverage nor stable funding ratios are statistically significant in the baseline regression. Only the stable funding ratio is statistically significant at the ten percent significance level in one of the four regressions.

Banks with higher ROAAs are less risky. Banks with higher risk premia as indicated by the Capital Asset Pricing Model are riskier. Leverage ratios of three percent or more are associated with less risk, although the relationship is not statistically significant. Real GDP growth is unimportant for the riskiness of bank's returns in all four regressions. This could reflect a variety of factors including the international operations of many banks and therefore the unimportance of real GDP growth in the country in which a bank is headquartered.

5.2 Interaction effects between financial variables on banks' stock-return risk

Table 8 presents information for testing whether or not the interaction effects in Table 7 are statistically significant. Table 8 also presents the estimated coefficients for the sub-group under consideration. There is a direct effect of being a G-SIB on riskiness, but there is only a little bit of evidence that the G-SIBs have a different relationship between the financial variables and riskiness. The p-value for testing the hypothesis that the coefficient of the stable funding ratio is zero for G-SIBs is 4.6 percent, marginally statistically significant at the five percent significance

25 To examine collinearity, we computed Variance Inflation Factors that quantify how much a coefficient's variance increases due to multicollinearity. None of the Variance Inflation Factors is above 2, which suggests that multicollinearity is unimportant.

26 We estimated the baseline regression without bank's sizes and obtained similar results with the effect of being designated a G-SIB still unimportant.

27 The regressions include the logarithms of these variables and therefore these changes are approximately percentage changes relative to the level before the change.

level. That said, as a block, a test whether all four financial variables have the same coefficients for G-SIBs and other banks is consistent with the data at the 20.8 percent significance level. Of the three interaction effects, only the government support dummy variable comes close to being statistically significant, with a p-value for the four different coefficients of 6.7 percent. There is some suggestive evidence of differences particularly for leverage suggesting that banks with lower capitalization that receive public support have higher volatility but there is not overwhelming support for the differences. The coefficients for the pre-crisis dummy variable also have statistically significant coefficients for leverage and a liquidity variable, the liquidity coverage variable, but the overall test for different coefficients has a p-value of 0.786.

5.3 Estimates for the post crisis period, 2008 to 2014

Table 9 presents results using only data for the period after the crisis (2008 to 2014). Table 10 shows that one cannot reject the null hypothesis of equality of the coefficients of the financial variables for G-SIBs and other banks. Similarly, one cannot reject the null hypothesis of equal coefficients for financial variables for banks that received government support and for other banks.

Given these results in Table 10, we focus on the baseline regression in Table 9. The baseline regression indicates that government support is associated with higher realized volatility in the aftermath of the crisis. Also, trading assets are associated with higher realized volatility and the estimated coefficient is even larger than for the whole period. Designation as a G-SIB is important only if different coefficients are estimated for G-SIBs and the magnitude of the coefficient is extraordinarily large.

As a robustness test, we modified the dependent variable by computing stock returns' volatilities using three months after accounting statements' closing dates. The variables which are statistically significant are almost the same.[28]

28 These tables are available upon request.

6 Government support and designation as a G-SIB

Higher realized volatility may be the reason for government support or for a bank being designated a G-SIB.[29] Realized volatility is measured after the right-hand-side variables are determined though and all the regressions include dummy variables for each bank which will reflect any constant differences in realized volatility and other variables. Every regression includes dummy variables for individual banks. Still, it is possible that the positive association of realized volatility with either designation as a G-SIB or government support is due to an effect of volatility on designation as a G-SIB or on receiving government support. In addition to that issue, the results for government support and designation as a G-SIB are ambiguous. For the whole period, it appears that designation as a G-SIB is important but not government support. For the period after the financial crisis, designation as a G-SIB does not appear so important but government support definitely is important.

To provide some additional evidence on this issue, we perform a univariate "difference in difference" analysis for the period 2004-2014. This analysis compares changes in volatility across "treated" and "untreated" groups. In our case, we compare the subsequent changes in volatility for banks that received government support during the financial crisis compared to the change in volatility for banks that did not receive government support. We also examine the subsequent change in volatility for banks designated G-SIBs compared to the change in volatility for banks not so designated. The test is Welch's t-test with unequal variances (Moser and Stevens 1992; Ruxton 2006).[30]

Table 11 presents the results of t tests for differences in means. The test examines whether the change in mean volatility for banks receiving government support or designated as G-SIBs is different from the change in mean volatility for banks that did not receive government support or were not designated as G-SIBs.[31] This test has advantages and disadvantages compared to the regression results. It examines changes and therefore is not affected by constant differences across banks. On the other hand, this test is univariate and there is no control for other variables, an obvious disadvantage. In addition, the test uses changes in volatilities, which are likely to have more noise than levels.

The tests are applied to the changes in mean volatilities for banks that received government support compared to banks that did not receive government support. This provides some control for the individual institutions' levels of volatility and differences in volatility for different time periods.

The data on government support provide little support for an effect of government support in 2008 and 2009 on subsequent volatility. The change in mean volatilities for

29 These should be less of a problem for the G-SIB designation, as the FSB followed a methodology prepared by the BCBS which is based on a quantitative and qualitative assessment. As we commented in the description of the variables, the indicators used are based on five criteria: size, interconnectedness, availability (or not) of substitutes for the services they provide, global activity (cross-jurisdictional activity), and complexity.

30 These tests provide additional evidence about the hypotheses. In the absence of completely exogenous changes in support and designations as G-SIBs which are randomly distributed across banks, the possibility of reverse causality cannot be eliminated.

31 The test for government support deletes one bank that received a capital injection in 2010, not a major effect with 46 observations. The test for G-SIBs includes only banks which are designated G-SIBs the entire period or are not designated G-SIBs during the entire period of analysis. As Table 1 indicates, including only banks that are G-SIBs the entire period is not restrictive. To eliminate effects of a changing sample, we run the test using only banks that exist from 2010 to 2014.

supported bank is smaller in 2010 and larger in 2011, both being statistically significant at the 5 percent significance level or close to it (5.2 percent). The changes in later years are smaller in magnitude. At least through 2014, this provides little support for a relationship between government support and the volatility of banks' stock returns. Given that the regressions for the entire period provided little support for an association between government support and volatility, we interpret this evidence as indicating that our data provide little support for such a relationship.

The results for G-SIBs indicate that banks initially designated as G-SIBs had larger increases in volatility after their designation as G-SIBs. The statistical significance of this negative development is lessened in more recent years although it is not clear that the economic significance is lessened. From 2010 to 2011 (first year of designation as G SIBs), the difference in the change in volatility is the largest. These results are somewhat mixed concerning whether being designated a G-SIB is associated with a subsequent increase in the volatility of banks' stock returns. On the other hand, the baseline regression for 2004 to 2014, which controls for other variables, shows a substantial relationship. We interpret the results in Table 11 as providing support for the results in the baseline regression and some support that the higher volatility is a result of the designation and not the reason for the designation.

There certainly is little to no evidence that being designated a G-SIB is associated with a decrease in the volatility in bank's stock returns. This result is in line with Sarin and Summers' (2016) results.

7 Conclusions

In the aftermath of the crisis, bank regulators agreed on safety and soundness requirements based on capital and liquidity requirements, which are not yet fully implemented. Furthermore, new prudential regulation focuses on structural aspects such as the systemic importance of banks, e.g., size and interconnectedness, and their securities trading activities including proprietary trading. Our paper analyses the implied effect on the realized volatility of banks´ daily stock returns of some of the most relevant new elements of the prudential regulatory framework agreed after the financial crisis yet to be fully implemented. We also analyze the association of banks' realized volatility with designation as a G-SIB and with government capital injections. We use bank's realized volatility of stock returns as our measure of banks' ex post risk.

Our results indicate that banks designated as G-SIBs have higher volatility and risk. The results of a test on the changes provides virtually no evidence that the volatilities of G-SIBs' returns have fallen compared to other banks after their designations as G-SIBs. On the contrary, there is evidence they have increased.

The estimates provide mixed evidence about whether government capital injections are associated with higher volatility of returns or there is no association.

It is possible, of course, that the designations as G-SIBs and government capital injections are due to forecasts of higher volatility, and volatility would have been even higher without these government interventions. That is possible. It also is fair to say that there is no evidence in these data which supports the proposition that volatility is lower due to these interventions. As a referee noted, a natural experiment might sort this out. On the other hand, maybe not. A natural experiment would involve exogenous changes in support distributed across banks independent of the banks' characteristics. Such an exogenous change is hard to imagine, but even so, such an exogenous change does not provide any evidence about a crucial aspect of the underlying issue: moral hazard, the effect of this support on banks' subsequent behaviour because they place a higher probability on support in the future if they get into financial difficulty. Similarly, designations of G-SIBs are dependent on banks' characteristics by construction.

In our judgement, the association of volatility with banks' leverage and liquidity is not as strong a guide to the effects of the regulations. The imposition of the leverage ratio and liquidity regulations may change the estimated coefficients in equations such as ours because the underlying source of the changes in variables is different with regulation. Even so, it seems to us that some evidence about proposed regulations is better than none.

Banks with higher trading assets have higher volatility of stock returns. This result is consistent across all specifications and is in line with the empirical results of Myers and Rajan (1998) and Morgan (2002).

The leverage ratio is negatively associated with ex post risk and the effect is not trivial. An increase in the capital leverage ratio decreases volatility, results which are in line with those of Kiema and Jokivuolle (2014).

Banks´ liquidity does not seem to have much relationship with realized volatility. The estimated association between volatility and stable funding is somewhat statistically significant, but the magnitudes of the coefficients are small. Given the important differences between the liquidity ratios used in our paper and the regulatory ratios, it is possible that the definitional issues are important. It also is possible that observed variation of liquidity is unimportant for risk.

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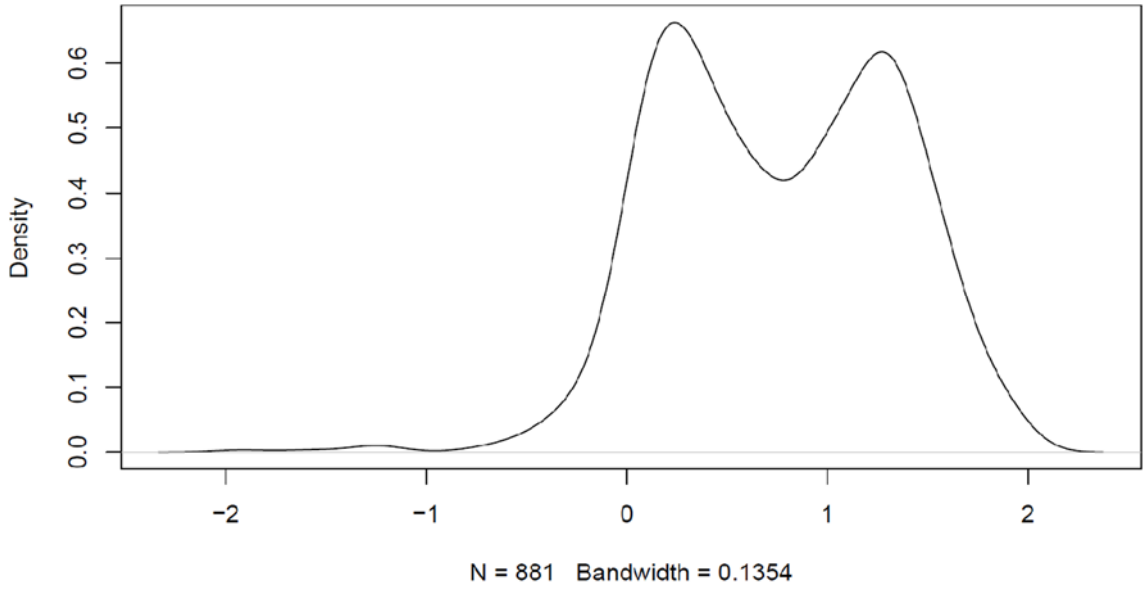
Figure 1
DENSITY OF ABSOLUTE VALUE OF THE BANKS' BETAS



This figure shows the distribution of the estimated β's for the banks. There are 881 banks with estimated β's in the ranged -2 to 2. The bandwidth is a measure of the smoothing applied to the estimate of a continuous distribution.

Table 1

G-SIBS DESIGNATED BY THE FINANCIAL STABILITY BOARD FROM 2011 TO 2014

Bank	Year			
	2011	2012	2013	2014
Agricultural Bank of China Limited				X
Banco Bilbao Vizcaya Argentaria SA		X	X	X
Banco Santander SA	X	X	X	X
Bank of America Corporation	X	X	X	X
Bank of China Limited	X	X	X	X
Bank of New York Mellon Corporation	X	X	X	X
Barclays Plc	X	X	X	X
BNP Paribas	X	X	X	X
Citigroup Inc	X	X	X	X
Commerzbank AG	X			
Crédit Agricole S.A.	X	X	X	X
Deutsche Bank AG	X	X	X	X
Dexia	X			
Goldman Sachs Group, Inc	X	X	X	X
HSBC Holdings Plc	X	X	X	X
Industrial & Commercial Bank of China			X	X
ING Groep NV	X	X	X	X
JP Morgan Chase & Co.	X	X	X	X
Lloyds Banking Group Plc	X			
Lloyds TSB Group Pl	X			
Morgan Stanley	X	X	X	X
Nordea Bank AB (publ)	X	X	X	X
Royal Bank of Scotland Group Plc (The)	X	X	X	X
Société Générale	X	X	X	X
Standard Chartered Plc		X	X	X
State Street Corporation	X	X	X	X
Sumitomo Mitsui Financial Group, Inc	X	X	X	X
UBS AG	X	X	X	X
UniCredit SpA	X	X	X	X
Wells Fargo & Company	X	X	X	X

SOURCE: Financial Stability Board, annual publications with various titles. Each "X" designates a year in which the bank was designated as a G-SIB by the Financial Stability Board.

Table 2
HYPOTHESIZED EFFECT ON THE VOLATILITY OF BANKS' STOCK RETURNS

Form of government intervention	Expected sign	Explanation
Government capital injection	Uncertain	(+) Markets perceive the subsidy as a revelation of potential unknown trouble (-) A confirmation on the bailout for the individual bank may reduce the perceived level of risk
Designation as a G-SIB	Uncertain	(+) A G-SIB benefits from an implicit message that the bank is too big to fail and takes more risk (-1) A G-SIB is more closely regulated and assumes less risk
Limitations on asset trading	Negative	(-) Reducing the extent to which banks can invest on their own account associated with lower risk
Leverage ratio	Positive	(-) Higher leverage is associated with higher risk
Liquidity regulation	Uncertain	(+) More liquid banks can engage in trading activities that are difficult to monitor (paradox of liquidity) (-) Higher liquidity reduces liquidity risk

Table 3

NUMBER OF BANKS BY COUNTRY AND YEAR

Country /Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
AUSTRIA	8	9	10	10	8	8	8	8	8	8	8	**93**
BELGIUM	2	3	3	3	3	3	3	1	2	2	2	**27**
BOSNIA-HERZE	0	0	0	0	0	0	0	0	0	1	0	**1**
BULGARIA	1	1	4	4	4	4	4	4	3	4	3	**36**
CHINA	0	1	5	6	8	8	11	11	12	13	10	**85**
CROATIA	9	12	13	14	12	10	8	13	12	11	9	**123**
CYPRUS	3	3	3	3	3	3	3	3	2	3	2	**31**
CZECH REPUBL	1	1	1	1	1	1	1	1	1	1	1	**11**
DENMARK	7	12	13	13	14	13	14	15	13	10	10	**134**
FINLAND	3	3	3	2	2	3	3	3	3	3	3	**31**
FRANCE	17	20	23	24	24	22	23	23	22	21	21	**240**
GERMANY	14	14	12	12	9	10	10	10	9	9	7	**116**
GREECE	7	8	13	12	12	12	12	4	3	5	5	**93**
HUNGARY	3	3	3	2	2	2	2	2	2	2	2	**25**
ICELAND	0	3	3	4	1	0	0	0	0	0	0	**11**
IRELAND	2	3	4	3	3	2	2	2	2	2	2	**27**
ITALY	14	23	30	26	24	25	24	24	23	22	20	**255**
JAPAN	0	0	1	0	0	1	1	2	2	2	2	**11**
LATVIA	1	2	2	2	2	1	1	0	0	0	0	**11**
LITHUANIA	3	4	4	4	4	3	3	2	1	1	1	**30**
LUXEMBOURG	3	2	2	2	2	1	2	2	2	2	1	**21**
MACEDONIA	0	0	0	0	0	1	1	1	2	2	2	**9**
MALTA	0	1	2	2	2	2	2	2	2	2	2	**19**
MONTENEGRO	0	0	0	0	0	0	0	1	1	1	1	**4**
NETHERLANDS	4	5	5	5	4	5	5	5	5	4	4	**51**
NORWAY	9	11	19	19	19	19	22	22	21	21	21	**203**
POLAND	11	11	13	14	15	15	14	15	15	15	14	**152**
PORTUGAL	4	5	5	5	5	5	4	3	4	5	4	**49**
ROMANIA	3	3	3	3	3	3	3	3	3	3	3	**33**
RUSSIAN FEDEI	3	5	5	7	8	8	11	12	13	10	10	**92**
SERBIA	0	0	0	0	0	2	2	1	2	1	1	**9**
SLOVAKIA	2	2	4	4	4	4	3	4	3	2	2	**34**
SLOVENIA	0	0	1	2	3	3	3	3	3	0	0	**18**
SPAIN	10	14	14	14	11	10	10	12	9	8	7	**119**
SWEDEN	3	5	6	6	5	4	4	4	4	4	4	**49**
SWITZERLAND	3	5	7	7	9	10	10	10	10	9	10	**90**
TURKEY	12	15	5	7	8	8	8	8	8	8	8	**95**
UKRAINE	0	0	1	2	2	3	2	2	3	4	3	**22**
UNITED KINGD	12	14	16	16	12	11	11	12	10	11	11	**136**
USA	282	312	315	297	271	300	278	269	260	240	210	**3034**
Total	**456**	**535**	**573**	**557**	**519**	**545**	**528**	**519**	**500**	**472**	**426**	**5630**

This table shows the number of banks for each country and year. An observation is the regressions is an observation for an individual bank in a particular year.

Table 4

SUMMARY STATISTICS FOR VARIABLES 2004 TO 2014

Variable	Mean	Standard deviation	Minimum	Maximum
Banks' realized volatility	0.026	0.034	$7.7x10^{-10}$	1.368
Government support	0.069	0.254	0	1
G-SIB	0.016	0.127	0	1
Trading assets	0.019	0.054	0	0.677
Leverage ratio	9.630	6.579	0.102	83.358
Liquidity coverage	22.197	51.508	0.010	992.080
Stable funding	89.697	53.033	0.060	908.510
Total Assets	$1.1x10^{8}$	$3.7x10^{8}$	$6.8x10^{3}$	$3.8x10^{9}$
ROAA	0.657	1.892	-55.875	28.390
|Beta| x Market's realized volatility	0.013	0.199	$3.9x10^{-6}$	14.881
Real GDP Growth rate	1.797	2.713	-17.955	14.162
Pre-crisis dummy variable	0.376	0.485	0	1
Leverage ratio $\geq$ 3%	0.971	0.169	0	1

There are 5630 observations for all variables. *Banks' realized volatility* is the realized volatility of banks' daily stock returns for six months after the announcement of banks' income statements and balance sheets. *Government support* is a dummy variable that is one if a bank received a capital injection during the financial crisis and zero otherwise. *G-SIB* is a dummy variable that is one if a bank is classified as a G-SIB by the FSB in the corresponding year and zero otherwise. *Trading assets* are the ratio of trading securities to total assets as a percentage. The *leverage ratio* is the ratio of equity to total assets as a percentage. The *liquidity coverage* is the ratio of liquid assets to customer and short-term funding as a percentage. The *stable funding* is the ratio of deposits and net borrowing to loans. *Total assets* includes off-balance sheet items. ROAA is the return on average assets as a percentage. *|Beta| x Market's realized volatility* is the absolute value of the bank's beta times the realized volatility of stock market returns in the major exchange in the country in which a bank's headquarter is located. The real GDP growth rate is the *real GDP growth* rate in the country in which a bank's headquarter is located. The *pre-crisis dummy variable* is a dummy variable equal to one for 2004 to 2007 and zero otherwise. The variable *Leverage ratio $\geq$ 3%* is a dummy variable equal to one if a bank has a leverage ratio greater than or equal to 3 percentage points and equal to zero otherwise.

The levels of these variables are presented in this table because summary statistics of the logarithms are less informative than summary statistics on the levels. The logarithms of variables other than dummy variables are used in all regressions.

Additional information on these variables and the sources is presented in the text.

Table 5

CORRELATIONS OF VARIABLES 2004 TO 2014

Variables	Banks' realized volatility	Gov't support	G-SIB	Trading Assets	Leverage ratio	Liquidity	Stable funding	Total assets	ROAA	|Beta| x Market's realized volatility	Real GDP growth rate	Leverage ratio ≥ 3%
Banks' realized volatility	1											
Government support	.027	1										
G-SIB	-.008	.307	1									
Trading assets	-.033	.091	.147	1								
Leverage ratio	-.072	-.170	-.101	-.096	1							
Liquidity coverage	-.009	.172	.166	.374	-.001	1						
Stable funding	-.022	.078	.160	.253	.049	.393	1					
Total assets	-.065	.374	.300	.251	-.358	.296	.193	1				
ROAA	-.117	-.085	-.017	.055	.388	.095	.036	.024	1			
|Beta| x Market's realized volatility	.138	.168	.082	.061	-.102	.190	.110	.420	-.045	1		
Real GDP growth rate	-.099	-.165	-.010	.044	.054	.019	.026	.020	.256	-.067	1	
Leverage ratio ≥ 3%	-.080	-.068	-.011	-.083	.488	-.102	-.144	-.181	.184	-.076	.052	1

Table 6

UNIVARIATE REGRESSIONS FOR REALIZED VOLATILITY 2004 TO 2014

Variable	Coefficient	Intercept
Government support	0.130**	-3.994***
G-SIB	-0.079	-3.984***
Trading assets	-0.859**	0.015
Leverage ratio	-0.174***	-3.614***
Liquidity coverage	0.009	-3.963***
Stable funding	-0.055*	-4.314***
Total Assets	-0.0345***	-3.435***
ROAA	-0.077***	-3.934***
|Beta| x Market's realized volatility	0.135***	-3.297***
Real GDP growth rate	-0.046***	-3.903***
Pre-crisis dummy variable	-0.165***	-3.922***
Leverage ratio $\geq$ 3%	-0.586***	-3.416*

Legend: * p<.1; ** p<.05; *** p<.01

This table presents univariate regressions of realized volatility on each of the right-hand-side variables for 2004 to 2014. The note to Table 4 provides the definitions of the variables and the text provides additional information and the sources of the data.

Table 7
DETERMINANTS OF RISK AT BANKS: 2004 TO 2014

Variable	Baseline Regression	Financial variables' coefficients different for G-SIBs	Financial variables' coefficients different with government support	Financial variables' coefficients different before crisis
Government support	0.209	0.208	-7.175	0.243*
G-SIB	0.327***	-0.401	0.338***	0.342***
Trading assets	1.299**	1.293**	1.111**	2.245***
Leverage ratio	-0.435***	-0.435***	-0.424***	-0.421***
Liquidity coverage	0.006	0.006	0.009	-0.053
Stable funding	-0.168	-0.166	-0.156	-0.232*
Total assets	0.299	0.300	0.295	0.289
ROAA	-0.030*	-0.030*	-0.030*	-0.032*
|Beta| x Market's realized volatility	0.347***	0.348***	0.342***	0.289**
Real GDP growth rate	0.013	0.013	0.014	0.007
Leverage ratio $\geq$ 3%	-0.277	-0.276	-0.262	-0.272
G-SIB x Trading assets		-0.069		
G-SIB x Leverage ratio		-0.070		
G-SIB x Liquidity coverage		0.161		
G-SIB x Stable funding		-0.087		
Government support x Trading assets			1.588	
Government support x Leverage ratio			0.089	
Government support x Liquidity coverage			-0.080	
Government support x Stable funding			-0.102	
Pre-crisis dummy variable				0.112**
Pre-crisis dummy x Trading assets				-2.141**
Pre-crisis dummy x Leverage ratio				0.038
Pre-crisis dummy x Liquidity coverage				0.115***
Pre-crisis dummy x Stable funding				0.107
Adjusted R-squared	.157	.156	.157	.160

This table presents regressions of realized volatility on the set of variables considered.

Legend: * p<.1; ** p<.05; *** p<.01

The dependent variable in each regression is the standard deviation of banks' daily stock returns for 6 months after the announcement of income statements and balance sheets. There are 5,630 observations in all regressions. All regressions include fixed effects for each bank and each year and use clustered standard errors.

The note to Table 4 provides the definitions of the variables and the text provides additional information and the sources of the data.

Table 8

THE COEFFICIENTS OF VARIABLES INCLUDING THE INTERACTION TERMS AND TESTS WHETHER THE INTERACTION TERMS ARE STATISTICALLY SIGNIFICANT 2004 TO 2014

Interaction terms with variables	Coefficient	p-value	p-value for F-test on all coefficients
G-SIB Dummy Variable			
Trading assets	1.224	.266	
Leverage ratio	-0.366	.113	.208
Liquidity coverage	0.167	.273	
Stable funding	0.253	.046	
Government Support Dummy Variable			
Trading assets	2.699	.043	
Leverage ratio	- 0.512	.018	.067
Liquidity coverage	-0.071	.587	
Stable funding	0.258	.226	
Pre-crisis Dummy Variable			
Trading assets	0.104	.850	
Leverage ratio	-0.459	.004	.786
Liquidity coverage	0.061	.035	
Stable funding	0.125	.215	

This table presents summary coefficients, tests whether the coefficients are zero and tests whether the respective dummy variables times this set of variables are statistically significantly different. The coefficients are the total coefficient for the observations in which the respective dummy variables are one. For example, the coefficient 1.224 for trading assets with the G-SIB dummy variable indicates that G-SIBs have a coefficient of 1.224 for trading assets. The p-value of 0.266 is the p-value for a test whether this coefficient is statistically significantly different than zero. The p-value for F-test is the p-value for a test whether the coefficients of all four variables are statistically significantly different than the coefficients in the baseline regression. This test has a p-value of 0.208, which indicates that the coefficients for GSIBs are not statistically significantly different.

The note to Table 4 provides the definitions of the variables and the text provides additional information and the sources of the data.

Table 9
DETERMINANTS OF RISK AT BANKS: 2008 TO 2014

Variable	Baseline Regression	Financial variables' coefficients different for G-SIBs	Financial variables' coefficients different with government support
Government support	0.568***	0.576***	6.655*
G-SIB	0.065	12.105***	0.116
Trading assets	1.982***	2.160***	2.212***
Leverage ratio	-0.423	- 0.417	- 0.429
Liquidity coverage	-0.001	-0.002	0.007
Stable funding	-0.323*	-0.345*	0.360
Total Assets	0.423	0.417	0.429
ROAA	-0.033	-0.033	-0.033
|Beta| x Market's realized volatility	-0.180	-0.185	-0.195
Real GDP growth rate	-0.034	-0.034	-0.031
Leverage ratio $\geq$ 3%	-0.027	-0.018	0.016
G-SIB x Trading assets		-2.611***	
G-SIB x Leverage ratio		-0.050	
G-SIB x Liquidity coverage		0.051	
G-SIB x Stable funding		0.013	
Government support x Trading assets			-0.876
Government support x Leverage ratio			- 0.408
Government support x Liquidity coverage			-0.072
Government support x Stable funding			-0.237
Adjusted R-squared	0.143	0.142	0.143

This table presents regressions of realized volatility on the set of variables considered.

Legend: * p<.1; ** p<.05; *** p<.01

The dependent variable in each regression is the standard deviation of banks' daily stock returns for 6 months after the announcement of income statements and balance sheets. There are 5,630 observations in all regressions. All regressions include fixed effects for each bank and each year and use clustered standard errors.

The note to Table 4 provides the definitions of the variables and the text provides additional information and the sources of the data.

Table 10

THE COEFFICIENTS OF VARIABLES INCLUDING THE INTERACTION TERMS AND TESTS WHETHER THE INTERACTION TERMS ARE STATISTICALLY SIGNIFICANT 2008 TO 2014

Interaction terms with variables	Coefficient	p-value	p-value for F-test on all coefficients
G-SIB Dummy Variable			
Trading assets	-0.451	.611	.621
Leverage ratio	-0.366	.241	
Liquidity coverage	0.049	.772	
Stable funding	0.358	.114	
Government Support Dummy Variable			
Trading assets	1.336	.099	.328
Leverage ratio	-0.679	.058	
Liquidity coverage	-0.065	.649	
Stable funding	0.123	.329	

This table presents summary coefficients, tests whether the coefficients are zero and tests whether the respective dummy variables times this set of variables are statistically significantly different. The coefficients are the total coefficient for the observations in which the respective dummy variables are one. For example, the coefficient -0.451 for trading assets with the G-SIB dummy variable indicates that G-SIBs have a coefficient of -0.451 for trading assets. The p-value of 0.611 is the p-value for a test whether this coefficient is statistically significantly different than zero. The p-value for F-test is the p-value for a test whether the coefficients of all four variables are statistically significantly different than the coefficients in the baseline regression. This test has a p-value of 0.621, which indicates that the coefficients for GSIBs are not statistically significantly different.

The note to Table 4 provides the definitions of the variables and the text provides additional information and the sources of the data.

Table 11

TESTS FOR DIFFERENCES IN CHANGES IN VOLATILITY BETWEEN GSIBS AND NON-GSIBS AND BANKS WHICH RECEIVED GOVERNMENT SUPPORT AND THOSE THAT DID NOT

Change to	Mean change	Standard deviation	Number of observations	Difference in Changes	t-statistic	p-value
Government Support						
Received Government Support						
2010	-0.340	0.222	46	-0.075	-1.972	0.052
2011	-0.023	0.340	46	0.128	2.259	0.027
2012	-0.358	0.345	46	-0.002	-0.035	0.972
2013	-0.500	0.380	46	0.085	-1.343	0.184
2014	-0.360	0.761	46	0.124	0.925	0.358
Did not receive Government Support						
2010	-0.265	0.360	346			
2011	-0.151	0.491	346			
2012	-0.356	0.504	346			
2013	-0.415	0.548	346			
2014	-0.484	1.366	346			
G-SIB						
G-SIBs by 2010						
2011	0.371	0.199	22	0.243	5.121	$<10^{-3}$
2012	0.059	0.176	22	0.150	3.379	0.002
2013	-0.201	0.139	22	-0.058	-1.501	0.140
2014	-0.112	0.200	22	0.167	1.665	0.096
Not GSIBs						
2011	0.128	0.420	385			
2012	-0.091	0.463	385			
2013	-0.143	0.489	385			
2014	-0.278	1.776	385			

This table presents tests of mean changes in volatility for banks that received government support in 2008 or 2009 and existed from 2009 to 2014. The test for Government Support is a test of differences in the changes in the realized volatility from 2009 to the year indicated.

The t-statistic is the t-statistic from Welch's t-test with unequal variances (Moser and Stevens 1992; Ruxton 2006).

This table also presents tests of mean changes in volatility for banks designated as G-SIBs which existed from 2010 through 2014. The test compares banks designated as GSIBs in 2010 which remained GSIBs through 2014 and banks not designated as GSIBs in 2010 which were not designated as GSIBs. Hence the test for G-SIBs is a test of differences in the changes in volatility from 2010 to the year indicated.

The fourth column with statistics is the change of volatility for banks receiving government or designated G-SIBs minus the change in volatility for banks not receiving government support or designated G-SIBs. The last two columns present the Welch t-test statistic with unequal variances (Moser and Stevens 1992; Ruxton 2006) and the p-value for the test.

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