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Are Basel's Capital Surcharges For Global Systemically Important Banks Too Small?

By WAYNE PASSMORE AND ALEXANDER H. VON HAFFTEN*

The Basel Committee promulgates bank regulatory standards that many major economies enact to a significant extent. One element of the Basel III capital standards is a system of capital surcharges for global systemically important banks (G-SIBs). If the purpose of the surcharges is to ensure the survival of G-SIBs through serious crises (like the 2007–09 financial crisis) without extraordinary public assistance, our analysis suggests that current surcharges are too low because of three shortcomings: (1) the Basel system underestimates the probability that a G-SIB can fail, (2) the Basel system fails to account for short-term funding, and (3) the Basel system excludes too many banks from current surcharges. Our best estimate suggests that the current surcharges should be between 225 and 525 basis points higher for G-SIBs that are not reliant on short-term funding; G-SIBs that are reliant on short-term funding should have even higher surcharges. Furthermore, we find that, even with significant confidence in the effectiveness of other Basel III reforms, modest increases in surcharges appear needed. (*JEL:* G01, G18, G21; *Key words:* banks, Basel capital, bank capital, bank equity, bank regulation)

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Introduction

The Basel Committee on Banking Supervision (BCBS, the Basel Committee, or Basel) developed a methodology for identifying global systemically important banks (G-SIBs) and assessing a higher loss absorbency (HLA) requirement (BCBS, 2013a).[1] To accomplish higher loss absorbency, the BCBS standards currently would require G-SIBs to hold more Common Equity Tier 1 (CET1) capital. According to the Basel Committee, adding common equity reduces the probability of failure for these banks (BCBS, 2013a). Moreover, G-SIB capital surcharges are one of the additional regulations that are applied to G-SIBs to directly target "too big to fail" concerns surrounding the largest and most globally important banks.

As part of this process, the Financial Stability Board (FSB) publicly releases an annual list of banks that the Basel Committee has identified as G-SIBs; the FSB published an updated G-SIB list (table 1) on November 21, 2016 (FSB, 2016).[2] For each bank, the list provides the G-SIB score, which is the Basel Committee's measure of systemic losses should the bank fail (we provide more detail about this measure in section 2). The list also provides the capital surcharges that the Basel Committee believes will provide a sufficient equity cushion (or "loss absorbency") to equalize the expected social impact of the bank's failure with the social impact of the failure of a bank that is not a G-SIB.

One goal of G-SIB capital surcharges is to make government bailouts of G-SIBs less likely by having G-SIBs self-insure themselves against severe financial crises. Traditionally, either central banks would stand ready to lend to solvent banks on good collateral or the government would implement some other assistance (e.g., the Troubled Asset Relief Program) to mitigate the catastrophic losses stemming from severe financial crises. But if the goal is to avoid *all* public bailouts, banks must "self-insure" against all losses, even catastrophic losses. Such self-insurance might result in restrictive credit conditions during times without financial crisis, but this policy would reassure taxpayers that public funds would not be used to assist G-SIBs. Although higher bank capital lessens the probability of financial crises, a complete assessment of social welfare would also need to investigate the potential negative effects of higher capital requirements on bank lending and economic growth.

If the purpose of the surcharges is to "self-insure" G-SIBs through serious crises and to avoid extraordinary public assistance, we find that the current G-SIB capital surcharges are too small based on the experience of the 2007–09 financial crisis. Our best estimate of G-SIB capital surcharges would (1) raise capital requirements 375 to 525 basis points for banks currently subject to G-SIB capital surcharges, (2) create an additional surcharge of 225 basis points for very large and systemically important banks that

[1] According to the Basel Committee, "The BCBS is the primary global standard-setter for the prudential regulation of banks and provides a forum for cooperation on banking supervisory matters. Its mandate is to strengthen the regulation, supervision, and practices of banks worldwide with the purpose of enhancing financial stability" (BCBS, 2013b). "The Committee seeks to achieve its aims by setting minimum standards for the regulation and supervision of banks; by sharing supervisory issues, approaches and techniques to promote common understanding and to improve cross-border cooperation; and by exchanging information on developments in the banking sector and financial markets to help identify current or emerging risks for the global financial system" (BCBS, 2015).

[2] The Financial Stability Board (FSB) succeeded the Financial Stability Forum (FSF), which was established by the G-7 Finance Ministers and Central Bank Governors in 1999. To strengthen its mandate and increase membership, the G-20 replaced the FSF with the FSB in April 2009. For analysis of previously published G-SIB scores, see Glasserman and Loudis (2015) and Allahrakha and Loudis (2016).

are not currently subject to any G-SIB capital surcharge, and (3) include a short-term funding metric that further boosts capital surcharges 175 to 550 basis points for banks that fund assets with a high proportion of short-term funding.[3] For 2015, a back-of-the-envelope calculation implies that the banking system would have needed at least €175 billion more CET1 capital to survive a financial crisis similar to that of 2007 to 2009 without bailouts.[4] However, only a small number of G-SIBs account for this capital shortfall, and the bulk of this shortfall stems from a few institutions' heavy use of short-term funding.

Our best estimate does not account for other Basel III reforms.[5] Thus, we also estimate capital surcharges based on the 95 percent confidence intervals around our best estimate. The pessimistic bound may appeal to observers who doubt the effectiveness of regulation. These observers desire the highest capital levels that would have likely prevented G-SIB defaults during the last financial crisis. In contrast, the optimistic bound may appeal to observers who believe the other reforms of Basel III (and regulatory oversight generally) are effective. Thus, these observers perceive that the probability and social losses of G-SIB defaults are now smaller than during the 2007-09 financial crisis. However, since the optimistic capital surcharges are still higher than the surcharges currently implemented, our estimates suggest the Basel G-SIB capital surcharges are too small regardless of prior belief about the effectiveness of other Basel III reforms.

The Expected Impact Theory

The Basel Committee's approach to capital surcharges is based on the expected impact theory (BCBS, 2013; Board of Governors, 2015), which uses three key features to derive capital surcharges: (1) an estimation of probability of default, $F(\cdot)$; (2) a method of measuring social losses given default, $H(\cdot)$; and (3) a choice of reference bank, r. The probability of default estimation relates the level of capital held by a bank to the probability of its default. The social losses given default of a bank are the costs incurred by that bank's failure on the financial system and the wider economy. The expected impact of a bank's failure is the product of the probability of its default and its social losses given default. The reference bank defines the extent of social losses that can be borne by the public without a "bailout." In the expected impact theory, a bank is either a G-SIB, whose social losses given default are higher than that of the reference bank, or a "normal" bank, whose social losses given default are lower. Thus, the reference bank is the most systemically important bank that public authorities are willing to let fail; in other words, no public assistance would be provided to the reference bank should it default. In the expected impact theory, the purpose of the G-SIB capital surcharges is to reduce the probability of default of a G-SIB until its expected impact is equal to the expected impact of the reference bank, or the following:

[3] These capital surcharges are in the spirit of French et al. (2010), who recommend increased capital requirements based on size, asset liquidity, and short-term funding. The quoted range of increases is based on estimated continuous capital surcharge functions.

[4] This aggregate capital shortfall is the sum of individual Common Equity Tier 1 capital shortfalls for banks in the BCBS sample (that have data reported in Bankscope). The calculation is based on their current equity holdings, most of which are above regulatory minimums. For each bank, we calculate the level of Common Equity Tier 1 capital required under our best estimate as risk-weighted assets times the sum of the G-SIB capital surcharge, the high short-term funding boost (if the bank's short-term funding is more than 10 percent of its risk-weighted assets), the capital conservation buffer, and the minimum capital ratio (BCBS, 2010). If banks perceive current equity cushions above regulatory minimums as necessary to maintain, then the aggregate capital shortfall would be larger. In addition, since we estimate surcharges using data from the previous financial crisis, this aggregate capital shortfall presumes that governments take similar actions to shore up the financial system during a future crisis. If governments intervene in a less forceful manner, then the aggregate capital shortfall would again be larger.

[5] Basel III is a set of "reforms to strengthen global capital and liquidity rules with the goal of promoting a more resilient banking sector" and includes the countercyclical capital buffer, the leverage ratio, the liquidity coverage ratio, the net stable funding ratio, the total loss-absorbing capacity proposal, and resolution plans (see BCBS, 2010).

$$\frac{F(f - k_r - k_{GSIB})}{F(f - k_r)} = \frac{H(r)}{H(GSIB)} \leq 1,$$

where k_r is the capital held by the reference bank, k_{GSIB} is the capital surcharge, and f is a proxy for the failure point at which a bank can no longer operate.

By definition, it is impossible to observe the default of a G-SIB. During the 2007–09 financial crisis, governments took aggressive actions—mergers, asset purchases, guarantee programs, and equity injections—to prevent G-SIB defaults. Because historical defaults are difficult to observe, we use extremely low returns on risk-weighted assets (RORWAs) as indications of failure in implementing the expected impact theory (as in BCBS, 2013a, and Board of Governors, 2015). Thus, the RORWA that yields failure is:

$$k + RORWA' \leq f \text{ or } RORWA' \leq f - k.$$

Hence, an estimated distribution of RORWA appropriately describes the distribution of $f - k$. We estimate a Gumbel distribution—a special case of the generalized extreme value distribution—for RORWA (Gumbel, 1958; Forbes et al., 2011):[6]

$$F(RORWA) = e^{-t(RORWA)},$$
$$\text{where } t(RORWA) = e^{\frac{-(RORWA-\mu)}{\sigma}}.$$

Substituting in the Gumbel distribution and letting the capital conservation buffer, CC, be the difference between the capital held by the reference bank and the failure point, we solve for an explicit formula of the capital surcharge:[7]

$$\begin{aligned}
\ln[F(-CC - k_{GSIB})] &= \ln\left[\frac{H(r)}{H(GSIB)} F(-CC)\right] \\
-t(-CC - k_{GSIB}) &= \ln\left(\frac{H(r)}{H(GSIB)}\right) - t(-CC) \\
-e^{\frac{-(-CC-k_{GSIB}-\mu)}{\sigma}} &= \ln\left(\frac{H(r)}{H(GSIB)}\right) - e^{\frac{-(-CC-\mu)}{\sigma}} \\
-e^{\frac{CC+\mu}{\mu}} e^{\frac{k_{GSIB}}{\sigma}} &= \ln\left(\frac{H(r)}{H(GSIB)}\right) - e^{\frac{CC+\mu}{\sigma}} \\
e^{\frac{k_{GSIB}}{\sigma}} &= 1 - e^{\frac{-CC-\mu}{\sigma}} \ln\left(\frac{H(r)}{H(GSIB)}\right) \\
k_{GSIB} &= \sigma \ln\left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln\left(\frac{H(r)}{H(GSIB)}\right)\right].
\end{aligned}$$

[6] The expected impact theory, which translates the estimated RORWA probability distribution into capital surcharges, requires certain characteristics of the probability distribution's functional form. The Gumbel distribution is one such distribution. Although other distributions can be used, the Gumbel distribution easily and tractably results in capital surcharges.

[7] We discuss the capital conservation buffer in more detail in appendix 2.

This paper proceeds as follows: Section 1 estimates the probability of default (μ, σ in the previous equation) and analyzes short-term funding as a crucial element missing from the G-SIB assessment methodology. Section 2 describes the Basel method of measuring social losses given default ($H(\cdot)$ in the previous equation). Section 3 examines the choice of reference bank (r in the previous equation). Section 4 compares current Basel capital surcharges to capital surcharges based on our empirical analysis. Section 5 concludes.

1. Probability of Default

Probability of default relates the level of capital held by a bank to the likelihood of its failure. As set forth in the introduction, we use extremely low realizations of RORWA as indications of failure and assume the Gumbel distribution functional form. Starting from the capital surcharge function, we observe that a higher mean RORWA yields lower capital surcharges and higher variance of RORWA yields higher capital surcharges. The derivative of the capital surcharge formula with respect to μ yields the following:

$$\frac{\partial k_{GSIB}}{\partial \mu} = \sigma \left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right]^{-1} \left[0 - e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right] \left[\frac{-1}{\sigma}\right]$$

$$= \left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right]^{-1} \left[e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right]$$

$$= \left[\left[e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right]^{-1} - 1\right]^{-1},$$

where $\alpha = \frac{H(r)}{H(GSIB)}$. Because $e^{\frac{-CC-\mu}{\sigma}} > 0$ and $\ln(\alpha) < 0$, we know that

$$\frac{\partial k_{GSIB}}{\partial \mu} < 0.$$

Intuitively, higher average returns generate lower capital surcharges because banks are less likely to experience RORWAs that deplete their capital stock.[8]

The derivative of the capital surcharge formula with respect to σ is the following:

$$\frac{\partial k_{GSIB}}{\partial \sigma} = \ln\left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right] + \sigma \left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right]^{-1} \left[0 - e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right] \left[\frac{-(-CC-\mu)}{\sigma^2}\right]$$

$$= \ln\left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)\right] + \frac{-e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)}{1 - e^{\frac{-CC-\mu}{\sigma}} \ln(\alpha)} \left[\frac{CC+\mu}{\sigma}\right]$$

[8] While the parameter μ is not strictly the mean of the Gumbel distribution, μ is the location parameter, which strongly indicates the center of the distribution (the mean is $\mu + \sigma\gamma$, where γ is the Euler-Mascheroni constant).

$$= \ln\left[1 - e^{\frac{-CC-\mu}{\sigma}}\ln(\alpha)\right] - \left[\frac{CC+\mu}{\sigma}\right]\frac{1}{\left[e^{\frac{-CC-\mu}{\sigma}}\ln(\alpha)\right]^{-1} - 1}$$

$$= \ln\left[1 - e^{\frac{-CC-\mu}{\sigma}}\ln(\alpha)\right] + \frac{-CC-\mu}{\sigma\left[\left[e^{\frac{-CC-\mu}{\sigma}}\ln(\alpha)\right]^{-1} - 1\right]}.$$

Assuming that banking is profitable (i.e., $\mu > 0$), we know that

$$\frac{\partial k_{GSIB}}{\partial \sigma} > 0.$$

Thus, capital surcharges are higher when RORWA is more uncertain.

We use the Bankscope database to estimate μ and σ.[9] Our sample is composed of annual observations of commercial banks and bank holding companies larger than $50 billion in total assets from 2000 to 2015 and from countries with European Union or Basel membership.[10] The sample mean of RORWA is 1.07 percent, and the sample standard deviation is 1.68 percent. Figure 1 shows a time-series of mean RORWA and 95 percent confidence intervals. The shading indicates recessions as determined by the National Bureau of Economic Research.[11]

The G-SIB capital surcharge was developed in response to the 2007–09 financial crisis “to reduce the likelihood and severity of problems that emanate from the failure of global systemically important financial institutions” (BCBS, 2013a). Capital surcharges can be empirically calibrated either unconditional or conditional on financial system stress. This policy goal suggests that the empirical calibration of capital surcharges should focus on banks during times of financial distress.[12]

To determine the years of financial stress for the banking industry, we regress RORWA on lagged RORWA with time, country, and firm-type fixed effects.[13] Shown in the first column of table 2, the sign and the significance of the 2008 and 2009 fixed effects suggest a crisis period. This is consistent with the

[9] Provided by Bureau van Dijk, the Bankscope database contains detailed information about banks across the globe. As one of the most comprehensive publicly available databases of its type, Bankscope is widely used for research on banking at the international level, including Lepetit, Saghi-Zedek, and Tarazi (2015); Beck and Brown (2015); and Singh, Gómez-Puig, and Sosvilla-Rivero (2015). Although authors such as Bhattacharya (2003) have described limitations of the Bankscope database, our focus on large banks is well supported.

[10] Quoted in 2015 dollars, the total asset cutoff is deflated by world gross domestic product using IMF (2016). RORWA is limited to between +/- 30 percent. We use observations with the highest level of consolidation; when institutions have multiple entries for a given year, we use the most consolidated report available. To avoid double counting, we drop firms with owners that also appear in the sample based on Bankscope’s information about domestic and global ultimate owners.

[11] Recessions are shown from April 2001 to November 2001 and from January 2008 to June 2009 (NBER, 2016).

[12] Tarullo (2009) makes the case for adopting robust policies in non-crisis times: “First, no matter what its general economic policy principles, a government faced with the possibility of a cascading financial crisis that could bring down its national economy tends to err on the side of intervention. Second, once a government has obviously extended the reach of its safety net, moral hazard problems are compounded, as market actors may expect similarly situated firms to be rescued in the future. Both these observations underscore the importance of adopting robust policies in non-crisis times that will diminish the chances that, in some future period of financial distress, a government will believe it must intervene to prevent the failure of a large financial institution.”

[13] Countries with five or more banks have fixed effects. The bank holding company fixed effect equals one for bank holding companies and equals zero for commercial banks.

time-series in figure 1, which shows a substantial drop in RORWA from 2007 to 2008. Although statistically insignificant, the negative coefficients on fixed effects for the following years indicate an abnormal "post crisis" period for banking. Thus, we divide the sample into a "good" and "bad" period for banking. The second column drops observations from 2014 and 2015. The crisis year fixed effects remain negative and significant, while post-crisis fixed effects remain mostly negative. In the third column, we replace individual year fixed effects with a single crisis/post-crisis fixed effect, which equals zero for observations from 2000 to 2007 and one for 2008 to 2013. The significant negative coefficient on this fixed effect indicates lower returns on average in the crisis/post-crisis period. We divide the sample into a pre-crisis period and a crisis/post-crisis period based on the significantly negative crisis/post-crisis fixed effect.[14]

Figure 2 shows the bottom 10 percentiles of the empirical cumulative RORWA distribution for the combined sample, the pre-crisis period, and the crisis/post-crisis period. The *y* value of each point is the given observation's RORWA, and the *x* value is the portion of the sample (or subsample) with an RORWA less than or equal to that observation's RORWA. The gray round dots indicate the combined sample, the blue triangles indicate the pre-crisis period, and the orange squares indicate the crisis/post-crisis period. Consistent with the significantly negative crisis/post-crisis fixed effect in table 2, the crisis/post-crisis squares are lower than the combined sample or the pre-crisis period.

The Basel framework defines two ratios of book CET1 capital to risk-weighted assets: the minimum ratio and the conservation buffer.[15] Generally, if a bank has a 7 percent CET1-capital-to-risk-weighted-assets ratio, the bank is viewed as sound. If the bank's ratio falls to between 4.5 percent and 7 percent, regulators take actions to restrict dividends and stock repurchases. At a capital ratio below 4.5 percent, regulators are expected to take substantial actions either to turn the bank around or to close the bank (BCBS, 2010).[16]

The Basel framework suggests that an RORWA of negative 2.5 percent is a benchmark for significant losses; if a bank holds negligible capital beyond requirements, it would face significant regulatory scrutiny after such a loss. The dashed horizontal red line at negative 2.5 percent in figure 2 indicates this benchmark. Since the crisis/post-crisis sample crosses this benchmark at about 3.5 percent, about 3.5 percent of the sample experienced significant losses. For the combined sample and pre-crisis period, the crossing point is about 2.5 percent and 1 percent, respectively. This difference suggests that

[14] The pre-crisis sample contains 452 bank holding company (BHC) observations and 431 commercial bank observations; the crisis/post-crisis sample contains 421 BHC observations and 499 commercial bank observations. Of the combined sample, 40 percent of the observations are between \$50 and \$100 billion in total assets, 39 percent are between \$100 and \$500 billion, 12 percent are between \$500 billion and \$1 trillion, and 9 percent are over \$1 trillion. The combined sample contains 121 unique BHCs and 176 unique commercial banks from Australia, Austria, Belgium, Brazil, Canada, China, Cyprus, Denmark, Finland, France, Germany, Greece, Hong Kong, Hungary, Ireland, India, Italy, Japan, Luxembourg, the Netherlands, Portugal, Russia, Saudi Arabia, Singapore, South Africa, South Korea, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

[15] The BCBS framework also includes the countercyclical capital buffer, which "aims to ensure that banking sector capital requirements take account of the macro-financial environment in which banks operate. It will be deployed by national jurisdictions when excess aggregate credit growth is judged to be associated with a build-up of system-wide risk to ensure the banking system has a buffer of capital to protect it against future potential losses" (BCBS, 2010). See Drehmann, Borio, and Tsatsaronis (2011) for some analysis.

[16] As noted by many observers, regulatory bank capital is often substantially larger than market valuations, and market actions may impose failure on the G-SIB long before this ratio is reached. For recent commentary and analysis along these lines, see Bulow and Klemperer (2013), Haldane (2011), and Sarin and Summers (2016).

large banks in the crisis/post-crisis period were more than three times more likely to experience significant losses than in the pre-crisis period.

We estimate cumulative distribution functions (CDFs) on each sample's bottom 5 percent tail, which is marked by the vertical solid green line in figure 2.[17] For all three samples, 5 percent tails contain observations greater and less than the benchmark of significant losses. Using ordinary least squares (OLS), we estimate the Gumbel distribution location parameter, μ, and scale parameter, σ, as follows:

$$\ln F(RORWA) = -e^{\frac{-(RORWA-\mu)}{\sigma}}$$

$$\ln[-\ln F(RORWA)] = \frac{-RORWA+\mu}{\sigma}$$

$$\mu - \sigma \ln[-\ln F(RORWA)] = RORWA.$$

Table 3 and figure 3 (displayed like figure 2) show the estimated CDFs for each sample. Compared to the combined sample, the estimated parameters are significantly smaller for the pre-crisis period and larger for the crisis/post-crisis period. Shown in figure 3, the estimated parameters fit the 5 percent tails well, although they fit the whole distribution poorly. As expected, the crisis/post-crisis period parameters yield a thicker tail than the pre-crisis period and the combined sample. These differences reflect the higher and lower average returns during the pre-crisis and the crisis/post-crisis period, respectively.

In section 4, the best estimate of empirical capital surcharges uses the regression coefficients of the crisis/post-crisis probability of default parameters; the pessimistic and optimistic estimates use the upper and lower bounds of the 95 percent confidence intervals, respectively.

Short-Term Funding

The existing BCBS G-SIB methodology omits uninsured short-term funding (e.g., money market mutual funds, commercial paper, repurchase agreements, and securities lending) when estimating probability of default and when measuring social losses given default.[18] In general, large banks, which are already substantial contributors to systemic risk, use higher proportions of short-term funding than smaller banks (Laeven, Ratnovski, and Tong, 2014; Damar, Meh, and Terajima, 2013). Consistent with recent research describing the relationship among short-term funding, defaults, and financial stability, we find that higher proportions of short-term funding increase the probability of default of G-SIBs.[19] Thus, in

[17] Board of Governors (2015) also estimates probability of default using the bottom 5 percent tail.

[18] Basel's neglect of short-term funding is ironic because the bulk of the value from government intervention may lie in reducing the risk of runs by short-term funders (see Veronesi and Zingales, 2010). As outlined in Board of Governors (2015), the U.S. implementation of the BCBS G-SIB methodology includes short-term funding as an indicator in the G-SIB score. Scores are calculated both by the BCBS method (see section 2) and by replacing the substitutability category with a measure of reliance on short-term funding. For each bank, the larger of the resulting capital surcharges is used.

[19] McAndrews et al. (2014) show that more short-term funding increases social losses resulting from a bank failure; thus, short-term funding is not exclusively related to the probability of default. Specifically, banks may be forced to engage in asset "fire sales" to meet repayment demands. Both runs and fire sales further increase the social losses of failure because they force the rapid resolution or closure of banks as the government responds to investors (Shliefer and Vishny, 2011).

the spirit of the capital requirement recommendations proposed by French et al. (2010) and Tarullo (2015), higher short-term funding suggests higher G-SIB capital surcharges.

Overall, the relationship between RORWA and short-term funding is complex. In “normal” times (i.e., when access to short-term funding markets is uninhibited), the higher use of short-term funding will likely generate higher returns for banks because they can borrow over maturities shorter than they lend. In addition, because funders conduct little due diligence when banks have safe credit ratings or when their collateral is low risk (e.g., has a government guarantee), short-term funding may be relatively more inexpensive (Diamond, 1991; Gorton and Ordonez, 2014).[20] Finally, banks have an incentive to shorten a given debtholder’s contract maturity to pressure their other funders to provide better terms; this incentive can lead to a “maturity rat race,” which can leave banks with significant rollover risks (Brunnermeier and Oehmke, 2013).

In crisis periods, banks that rely heavily on uninsured short-term liabilities are vulnerable to runs (Gorton and Metrick, 2012; Martin, Skeie, and von Thadden, 2014). During a crisis, providers of short-term funding can deprive banks of funding or can raise capital and collateral demands for continued funding (Gorton and Metrick, 2012; Gorton and Ordonez, 2014). Moreover, investors can become skittish about lending to banks over longer maturities. As a result, the maturity of liabilities at a bank during financial turmoil can shorten very quickly. A well-capitalized bank may be able to avoid these difficulties.

These crisis dynamics of short-term wholesale funding substantially contributed to bank distress and default during the 2007–09 financial crisis. A detailed case study of the Lehman Brothers failure shows that Lehman had to substantially shorten the maturity of its liabilities once investors perceived it as undercapitalized; as a result, Lehman’s failure was fast and furious (Gorton, Metrick, and Xie, 2014). In general, banks that relied substantially on short-term wholesale funding experienced more difficulties during the crisis (Demirguc-Kunt and Huizinga, 2010). Such banks also contracted lending more severely than banks that relied more heavily on insured deposits (Ivashina and Scharfstein, 2010; Dewally and Shao, 2014).

Restrictions on short-term funding may or may not reduce vulnerabilities of banks to runs (Martin, Skeie, and von Thadden, 2014). As noted by Diamond and Rajan (2001), limiting short-term funding may enhance—rather than diminish—a crisis after banks have made illiquid investments funded by short-term liabilities. Holding higher capital is perhaps the best method for maintaining investor confidence and keeping funds flowing in order to finance assets with declining or uncertain prices.

In figure 4, we divide the sample by the median value of short-term funding each year and show the mean RORWA and 95 confidence intervals of each half of the sample.[21] Median values of short-term funding range from 15.08 percent of risk-weighted assets in 2001 to 6.4 percent in 2013. The high and low short-term funding time-series support the relationship of short-term funding and RORWA as previously described. During the pre-crisis period, banks that financed a high proportion of assets with short-term funding outperformed banks using lower levels of short-term funding. In 2008, however,

[20] More broadly, short-term funding may counteract costly asymmetric information about the asset side of bank balance sheets between investors and managers (Diamond and Rajan, 2001; Calomiris and Kahn, 1991).

[21] As a metric of short-term funding, we use “other deposits and short-term borrowing” divided by risk-weighted assets. “Other deposits and short-term borrowing” includes senior debt maturing in less than one year, money market instruments, certificates of deposit, commercial paper, corporate deposits, and margin deposits (Bureau van Dijk, 2016). Short-term funding data are missing for 27 percent for the combined sample, 32 percent for the pre-crisis period, and 22 percent for the crisis/post-crisis period.

banks using high levels of short-term funding fared far worse; even the mean RORWA is negative. Furthermore, based on the 95 percent confidence interval, the variance of RORWA for high short-term funders is generally higher than the variance for the low short-term funders throughout the sample period.

For each time period, we estimate the probability of default parameters conditional on short-term funding by splitting the sample by the lagged median value of short-term funding.[22] Using the estimation technique outlined previously, table 4 shows the OLS estimation for each split period, and figure 5 (displayed like figures 2 and 3) shows CDF tails based on estimated parameters. Shown in the top panel, estimated parameters based on banks with low short-term funding do not substantially vary between the pre-crisis and crisis/post-crisis period. However, as shown in the bottom panel, the estimated parameters of high short-term funders in the crisis/post-crisis period produce substantially fatter CDF tails than the pre-crisis high short-term funders. Both the higher returns associated with using high short-term funding in the pre-crisis period and the crisis dynamics of relying on short-term funding are apparent. Because of small sample sizes (see table 4), confidence intervals are wide, but these results suggest higher capital surcharges for banks that rely more on short-term funding.

In section 4, estimated capital surcharges include a high short-term funding boost. The boost is calibrated similarly to the estimated crisis/post-crisis probability of default. The best estimate uses the regression coefficients for high short-term funding during the crisis/post-crisis period from table 4; the pessimistic and optimistic estimates use lower and upper bounds of the 95 percent confidence intervals for those parameters.

2. Social Losses Given Default

Measures of social losses given default seek to capture negative social externalities associated with bank failures on the financial system and the wider economy. Both the lack of a definition of default for “too big to fail” banks and the lack of data directly measuring social costs of failure handicap this analysis. The Basel G-SIB score framework is best interpreted as a judgment by bank supervisors about which balance sheet measures are correlated with systemic importance. As a further consequence of the lack of data, the Basel G-SIB assessment methodology ranks banks by the social costs of their defaults relative to the reference bank.

As outlined in BCBS (2013a), Basel G-SIB capital surcharges are based on the G-SIB score, which is a measure of social losses given default. The G-SIB score is a weighted average of 12 indicators associated with the five dimensions (or “categories”) of systemic risk as identified by Basel: (1) size, (2) interconnectedness, (3) substitutability/financial institution infrastructure, (4) complexity, and (5) cross-jurisdictional activity.[23]

Size—The size of a bank straightforwardly measures its systemic importance. To replace a large failed bank, other institutions must finance more assets and provide more services. Also, the resolution of

[22] The median value of lagged short-term funding is 8.1 percent in the crisis/post-crisis period, 12.5 percent in the pre-crisis period, and 9.6 percent in the combined sample.

[23] Reporting templates also include a range of ancillary indicators, which may be additional indicators of systemic importance. A complete description of data collected by Basel can be found in BCBS (2016b). Recent academic research that develops metrics for measuring social losses given default primarily focuses on market valuation, tail risk, or both (Acharya and Pedersen, 2010; Adrian and Brunnermeier, 2014; Billio et al., 2012; Levy-Cariente et al., 2015; Das, 2015; Huang, Zhou and Zhu, 2011; Kritzman et al., 2011). Market-based models are not used in the Basel assessment methodology.

large failed banks requires more effort. Basel measures size with a single indicator, referred to as total exposures. Total exposures include on-balance sheet assets and some off-balance sheet credit exposures.

Interconnectedness—The failure of a bank has repercussions for its clients as well as its service providers. If a bank is interconnected with the rest of the financial system, its failure could distress other financial firms. Basel measures interconnectedness with three indicators: intra-financial assets, intra-financial liabilities, and outstanding securities. Intra-financial assets and liabilities have counterparties within the financial system. Securities outstanding reflects all outstanding securities issued by the reporting institution to any affiliated or unaffiliated institutions.

Substitutability/Financial Institution Infrastructure—Some banks play a significant role in the infrastructure of the financial system, although they may not be particularly large in terms of total exposures (or highly connected to other financial firms). For example, if a major provider of payment systems fails, social losses could stem directly from the disruption of payments services. Beyond payments activity, two other indicators measure substitutability: assets under custody and underwritten transactions in debt and equity markets.[24] Banks hold assets under custody for safekeeping but do not manage them as investments on behalf of the owners. Underwritten transactions in debt and equity markets are market making activities that, if impaired, could impose substantial losses on other parties.

Complexity—If a bank is more complex in terms of business model, structure, or operations, its resolution after failure may be more difficult. Basel complexity indicators are meant to capture illiquidity of assets, which are difficult to evaluate during significant financial stress. The complexity indicators include over-the-counter (OTC) derivatives, trading and available-for-sale (AFS) securities, and Level 3 assets. Traded outside of a formal exchange, OTC derivatives include a wide variety of non-standardized contracts. Trading and AFS securities, which include any equity or debt security that is not intended to be held to maturity, may be subject to fire sale valuations during periods of stress. Level 3 assets are assets that lack observable price measures (e.g., a market price).

Cross-Jurisdictional Activity—Banks with more cross-jurisdictional activity risk spreading distress to the financial systems of other countries. In addition, the resolution of international banks may be more costly and time-intensive, because regulators in different countries must coordinate. The cross-jurisdictional indicators are cross-jurisdictional claims and liabilities.

The 12 indicators are expressed as approximate global market shares.[25] For example, an indicator of 500 represents roughly a 5 percent global market share.[26] Basel estimates the global market size of indicators using proxies, each of which is the sum of an indicator for all banks in the Basel sample. The Basel sample of banks includes the largest 75 BHCs (as determined by total exposures) and any other BHC that was designated as a G-SIB in the previous year. These denominators are published annually; end-2015 denominators are shown in table 6.

[24] The substitutability category is capped at 500 basis points; after the first three years of data collection, Basel determined that the substitutability category contributed disproportionately to the overall G-SIB score. Instead of a cap, Benoit, Hurlin, and Pérignon (2016) present an alternative G-SIB score methodology that prevents individual indicators or categories from unduly influencing the aggregate score.

[25] Appendix 3 discusses management incentives created by the market share approach.

[26] Because the activity of all banks in the world is not fully captured, the market share is overestimated.

To aggregate the 12 indicators into a single score, indicators are weighted equally in a systemic risk category, and categories are weighted equally in the final score (see table 5).[27] For example, the interconnectedness category includes the intra-financial system assets, intra-financial system liabilities, and securities outstanding (denoted A, B, and C, respectively). The interconnectedness category sub-score for bank i is the equally weighted average of the three market share indicators:

$$\text{Interconnectedness Sub-score}_i = \frac{1}{3}\left(\frac{A_i}{A_1 + A_2 + \cdots} + \frac{B_i}{B_1 + B_2 + \cdots} + \frac{C_i}{C_1 + C_2 + \cdots}\right).$$

Because each category sub-score receives a 20 percent weight in the overall G-SIB score, the weights on the interconnectedness indicators fall to 6.7 percent ($.2 * .33\overline{3}$). Denoting the five category sub-scores as X_j (one of which is interconnectedness), the G-SIB score for bank i is the following:

$$\text{G-SIB Score}_i = \frac{1}{5}\sum_{j=1}^{5} X_{ij}.$$

In table 6, an example G-SIB score is derived for JPMorgan Chase & Co, which is the highest scoring BHC in FSB (2016). The balance sheet and denominator data are from the end of 2015. For each indicator, a market share is calculated, which reflects the proportion of the denominator held by JPMorgan. For example, JPMorgan holds 395 basis points (3.95 percent) of all total exposures. The category sub-score is the equally weighted average of the market share indicators associated with that category. The interconnectedness sub-score for JPMorgan is 402 basis points, the average of 364, 416, and 425 basis points. Finally, the G-SIB score is 464 basis points, the equally weighted average of the five category sub-scores (395 basis points for size, 402 basis points for interconnectedness, 500 basis points for substitutability, 710 basis points for complexity, and 316 basis points for cross-jurisdictional activity).[28]

How well does the G-SIB score measure social losses given default? As previously discussed, this question is challenging to answer due to a lack of data that directly measures social externalities of G-SIB defaults. Because of this shortcoming, our estimated G-SIB capital surcharges (in section 4) use the Basel G-SIB score as the measure of social losses given default.

In general, the total losses associated with a firm's default can be broken down into private losses covered by shareholders, private losses left uncovered, and social losses. We estimate a model in which social losses are correlated with uncovered private losses. Although uncovered private losses are not direct estimates of social losses given default, they may be a proxy for the relative size of social losses given default for each G-SIB. We use market-based estimates of uncovered private losses to provide a useful comparison to the G-SIB score, which solely reflects the views of bank regulators.

To assess error in regulatory assessment of systemic risk, we use the SRISK measure developed by Acharya and Pedersen (2010) as an independent market-based measure of uncovered private losses

[27] In appendix 1, we explore weighting schemes with logical foundations, including a market-based weighting scheme and a stable equilibrium weighting scheme. While the relative rankings of some G-SIBs change, these weighting schemes at most move G-SIBs up or down one capital surcharge bucket.

[28] G-SIB disclosure data is available from BCBS (2016b).

imposed on shareholders from a systemic crisis in the financial system. This measure considers "a firm systemically risky if it is likely to face a capital shortage when the financial sector itself is weak" (NYU Stern V-Lab, 2015). First, the long-run marginal expected shortfall is estimated, which is the loss in capital for each firm if the market suffers significant declines for six months. Then, the amount of capital needed to survive the crisis is estimated. SRISK is the percentage of the financial system capital shortfall each given firm experiences.[29]

We estimate a Cobb-Douglas equation relating the G-SIB score and SRISK:

$$GSIB\ Score = \alpha SRISK^{\beta} e^{\varepsilon},$$

where $\varepsilon \sim N(0, \sigma_{\varepsilon})$. Using OLS, we can estimate the equation:

$$\ln(GSIB\ Score) = \ln(\alpha) + \beta \ln(SRISK) + \varepsilon.$$

Table 7 shows the model estimation. The alpha coefficient and the beta coefficient imply a positive, concave down relationship. From figure 6, which shows the scatterplot, we see significant variation around the fitted line.

Given the residuals of the regression, confidence intervals for a given G-SIB score, x, can be estimated as:

$$e^{\ln(x) \pm CV_{\alpha} s_{\varepsilon}} = [x e^{-CV_{\alpha} s_{\varepsilon}}, x e^{CV_{\alpha} s_{\varepsilon}}],$$

where s_{ε} is the residual standard error of the regression and CV_{α} is the standard normal critical value associated with an $(1 - \alpha)$ level of confidence. In the next section, we will use this correlated loss model to evaluate the reference bank score.

3. Reference Bank

Currently set at a G-SIB score of 130 basis points, the choice of reference bank makes a distinction between G-SIBs and "normal" banks (or non-G-SIBs). Supposedly, G-SIBs are banks that governments would bail out in the event of failure, and non-G-SIBs are banks that governments would let fail. The expected impact of the failure of a non-G-SIB does not warrant increasing their common equity holdings to reduce the probability of their default. Choosing the reference bank and, therefore, choosing the demarcation line between G-SIBs and non-G-SIBs, substantially affects all G-SIB capital surcharges. A larger reference bank indicates that public authorities have a higher tolerance for the social losses created by G-SIB failures, and G-SIBs require less capital as a result. Because the expected impact theory equates the expected impact of each G-SIB given default to the expected impact of the reference bank given default, the choice of the reference bank's social losses given default is crucial both for which banks are subject to the capital surcharge and for the size of all capital surcharges.

By taking the partial derivative of the capital surcharge function, we derive the effect of changing the reference bank score:

[29] SRISK uses the GMES data set of exchange-traded top holders, for which iShares MSCI ACWI ETF is the reference index. Recommended capital requirements of 8 percent for Asian and American banks and 5.5 percent for European banks are used (NYU Stern V-Lab, 2016). Data are merged on the reporting month of the public G-SIB disclosure.

$$\frac{\partial k_{GSIB}}{\partial H(r)} = \sigma\left[1 - e^{\frac{-CC-\mu}{\sigma}}\ln\left(\frac{H(r)}{H(GSIB)}\right)\right]^{-1}\left[0 - e^{\frac{-CC-\mu}{\sigma}}\left(\frac{H(r)}{H(GSIB)}\right)^{-1}\right]\left[\frac{1}{H(GSIB)}\right]$$

$$= \sigma\left[1 - e^{\frac{-CC-\mu}{\sigma}}\ln\left(\frac{H(r)}{H(GSIB)}\right)\right]^{-1}\left[-e^{\frac{-CC-\mu}{\sigma}}\left(\frac{1}{H(r)}\right)\right]$$

$$= \frac{-\sigma e^{\frac{-CC-\mu}{\sigma}}}{H(r)\left[1 - e^{\frac{-CC-\mu}{\sigma}}\ln\left(\frac{H(r)}{H(GSIB)}\right)\right]}$$

$$= \frac{-\sigma}{H(r)\left[e^{\frac{CC+\mu}{\sigma}} - \ln\left(\frac{H(r)}{H(GSIB)}\right)\right]}.$$

Because $\frac{H(r)}{H(GSIB)} < 1$, $e^{\frac{CC+\mu}{\sigma}} > 0$, and $\sigma > 0$, we know that a ceteris paribus decrease in the reference bank score increases capital surcharges:

$$\frac{\partial k_{GSIB}}{\partial H(r)} < 0.$$

How does one choose the reference bank score, and is 130 basis points a good choice? We first consider the recent history of bank bailouts; where was the line between G-SIBs and non-G-SIBs drawn in the 2007–09 financial crisis? Because G-SIB indicator data (and therefore G-SIB scores) does not exist until 2012, we revert to total assets as an indicator of social losses given default.[30] White and Yorulmazer (2014) describe select large financial institutions that received government support between 2007 and 2012. The smallest of these institutions, Bradford & Bingley, held approximately €72.6 billion in total assets when it received support.[31] White and Yorulmazer also list five other institutions under €250 billion in total assets that received government support. The size of these observations may indicate the lower bound of bank size required to induce government intervention in the 2007–09 financial crisis.

How does the experience of the 2007–09 financial crisis compare to the division of banks delineated by the current Basel system? Currently, the group of non-G-SIBs still includes very large banks.[32] To get a sense of the potential systemic importance of banks in the Basel sample, figure 7 is a scatterplot of total exposures and G-SIB scores.

The largest non-G-SIB bank is Lloyds Bank with total exposures of €1.1 trillion and a G-SIB score of 97 basis points. The highest scoring non-G-SIB is Nordea Bank, with total exposures of €654.5 billion and a G-SIB score of 129 basis points. The smallest and lowest scoring bank is Shinhan Bank, with €223 billion in total exposures and a G-SIB score of 16 basis points.[33] Based on total exposures, the

[30] Note that total exposures includes total assets.

[31] "The U.K. government nationalized the institution [Bradley & Bingley] on September 29, 2009, selling the savings unit and branches to Banco Santander" (White and Yorulmazer, 2014).

[32] Basel collects the sample to approximate the global market size of each indicator; it includes the largest 75 BHCs and any BHC designated as a G-SIB in the previous year.

[33] The total exposures cutoff for the Basel sample for potential G-SIBs is €250 billion, but some borderline banks are included as a result of designation in the previous year or supervisory judgment.

median bank of non-GSIBs is China Everbright Bank, with a G-SIB score of 33 basis points and €446 billion in total exposures. Based on G-SIB score, the median bank is DNB ASA, with a G-SIB score of 52 basis points and €332.4 billion in total exposures.

The largest, smallest, and median banks (by either total exposures or G-SIB score) are well within the range of banks that received public support during the 2007–09 financial crisis. Basel's assertion that a bank with €1.1 trillion in total exposures—the size of the largest non-G-SIB—would not receive government support seems inconsistent with the experience of the 2007–09 financial crisis.

Furthermore, no substantial gap exists between G-SIB scores around 130 basis points, which would indicate a breakpoint. With Nordea Bank at 129 basis points and ING Group at 132 basis points, there is little "space" at the current breakpoint. The largest gap is between the Royal Bank of Canada at 122 basis points and Commerzbank at 107 basis points. Thus, the data does not suggest a "natural" split between G-SIBs and non-G-SIBs.

Our best estimate of capital surcharges adopts the regulatory assessment that G-SIBs are banks with G-SIB scores higher than 130 on average. But the correlated loss model suggests that the G-SIB score is an uncertain measure of social losses given default. Thus, we lower the reference bank score to account for error in the G-SIB score until there is only a 5 percent chance that a G-SIB has been classified as a non-G-SIB. The resulting reference bank score is 52 basis points. Based on the regression from figure 7, a G-SIB score of 52 basis points approximately corresponds to €525 billion in total exposures.

The optimistic capital surcharge estimate employs Basel's choice of the reference bank score of 130 basis points. This choice reflects the belief that regulators are correct and that only banks with G-SIB scores of higher than 130 basis points might warrant bailouts. A G-SIB score of 130 basis points roughly corresponds to €950 billion in total exposures. The pessimistic estimate uses 16 basis points (which corresponds to €325 billion in total exposures), the minimum of G-SIB scores in the Basel sample. Since all banks in the Basel sample are larger than the smallest banks that received bailouts in the 2007-09 financial crisis, this choice reflects skepticism that, in fact, the line between banks that would receive bailouts and banks that would not has shifted since the 2007-09 financial crisis.

4. Capital Surcharges

To produce an HLA requirement based on the G-SIB score, the BCBS adopts a bucketing approach (BCBS, 2013). Figure 8 shows the current buckets as solid blue boxes. Different buckets which encompass a 100 basis point range of G-SIB scores are associated with different capital surcharges; higher buckets indicate higher levels of systemic importance. The bucketing approach allows for small changes in indicators and denominators without resulting in major changes to capital requirements (provided the bank's score is not near a breakpoint between two buckets).

The current system of bucketing with the associated G-SIB scores and HLA requirements is shown in table 1. Starting at 130 basis points, the G-SIB scores are bucketed using threshold scores 100 basis points apart.[34] The G-SIB score of 130 is the reference bank score; only banks that score at least 130 basis points are considered G-SIBs and are thus subject to higher capital requirements.

Currently, populated buckets are Bucket 1, with G-SIB scores that range from 130 to 229 basis points; Bucket 2, with scores ranging from 230 to 329 basis points; Bucket 3, with scores ranging from 330 to 429 basis points; and Bucket 4, with scores ranging from 430 to 529 basis points. The current HLA requirement is 1 percent of CET1 capital for Bucket 1 and an additional 50 basis points for each larger bucket.[35]

There is an additional empty bucket, called Bucket 5, with an increase of 100 basis points from Bucket 4 instead of just 50 basis points. Figure 8 shows Bucket 5 crossed out. The purpose of this bucket is to provide an incentive for G-SIBs to avoid becoming more systemically important.[36] If Bucket 5 becomes populated in the future, Bucket 6 will be introduced with scores ranging from 630 to 729 basis points and an HLA requirement of 4.5 percent CET1 capital.

Empirical Capital Surcharges

Figure 8 illustrates the best estimate of G-SIB capital surcharges consistent with our empirical analysis of capital needed to avoid public bail-outs of G-SIBs during a severe financial crisis. However, note the costs of higher capital standards are much debated in the literature (see Myerson, 2014, and Dager et al., 2016). If capital is very expensive, then higher capital requirements must be weighed against the potentially higher loan rates.

Because our analysis does not suggest that the Basel G-SIB score itself is inadequate, this figure measures social losses given default using the Basel G-SIB score.[37] To calibrate capital surcharges for discrete buckets from continuous functions and vice versa, we use the capital surcharge associated with a bucket's midpoint G-SIB score. Estimated by minimizing the sum of squared error, the ball-and-chain dashed blue line represents the continuous approximation of the Basel system.

Reference bank—The short-dashed black line is the continuous capital surcharge function using a reference bank score of 52 basis points, which is the lower bound of the one-sided 95 percent confidence interval of the correlated loss model centered at the Basel reference bank score of 130 basis points. The shaded right-hatched yellow boxes show substantial increases in capital surcharges, including 175 basis points for Bucket 1 and Bucket 4. This choice of a lower reference bank score creates Bucket 0, which ranges between the new and old reference bank scores with a capital surcharge of 125 basis points.

Probability of default—The solid green line is the continuous capital surcharge function estimated using RORWA data from the crisis/post-crisis period (shown in table 3). The shaded left-hatched green

[34] BCBS (2013a) provides no justification for fixed-width 100 basis point buckets. For the most part, our estimated G-SIB capital surcharges adopt Basel buckets; an analysis of "optimal" bucket sizes would be desirable but is outside the scope of this paper.

[35] For the definition of risk-weighted assets and Common Equity Tier 1 capital, see BCBS (2010). The G-SIB capital surcharge is subject to a three-year phase-in period. Beginning in January 2016, the applicable surcharge increases each year by one-fourth of the total surcharge; thus, the total buffer will be completely phased in by January 2019.

[36] The primary purpose of the G-SIB capital surcharges is to decrease the possibility of default. Additionally, the surcharges aim to provide G-SIBs with an incentive to reduce their systemic footprints. For example, JPMorgan Chase took significant actions in 2015 to reduce its surcharge (Dimon, 2016).

[37] Because estimated surcharges use the G-SIB score, the ranking of G-SIBs by their relative social losses given default does not change. Using Bankscope data from 2015, the five banks in the BCBS sample with the highest proportion of short-term funding to risk-weighted assets are Handelsbanken, Sumitomo Mitsui Trust Holdings, Nordea, SEB, and Rabobank.

boxes are the associated surcharge increases, which include 100 basis points for Bucket 0, 200 basis points for Bucket 1, and 325 basis points for Bucket 4.

Short-term funding—The long-dashed red line is the continuous capital surcharge function estimated using RORWA data for banks using high levels of short-term funding from the crisis/post-crisis period (shown in table 4). The unshaded right-hatched pink boxes show the high short-term funding boost to capital surcharges. This additional capital requirement includes 175 basis points for Bucket 0, 350 basis points for Bucket 1, and 550 basis points for Bucket 4.

Figure 9 illustrates an alternative formulation of empirical capital surcharges. This formulation can be characterized as optimistic about the effectiveness of other Basel III reforms (and of regulatory oversight in general) in reducing the expected impact of G-SIB distress and default. With the belief that the regulatory assessment of the level of social losses given default necessary to initiate bailouts is correct, the reference bank score is set at 130 basis points. Thus, unlike the best estimate, capital surcharges do not increase from lowering the reference bank score. In addition, instead of using the best estimates (i.e., the regression coefficients from tables 3 and 4) for probability of default parameters (with and without short-term funding), these capital surcharges use the lower bounds of 95 percent confidence intervals of crisis/post-crisis probability of default estimates. *Although lower than the best estimate, these optimistic capital surcharges are still higher than the Basel capital surcharges.*

Figure 10 shows a third formulation of G-SIB capital surcharges; it is consistent with a pessimistic view about the effectiveness of regulatory oversight and other Basel III reforms. From this perspective, increasing capital is the strictly preferred method of decreasing the expected impact of G-SIB distress and default. Since all banks in the Basel sample are larger than the smallest banks that received bailouts in the 2007-09 financial crisis, the reference bank score is set at 16 basis points, which is the minimum G-SIB score of banks in the sample. The probability of default parameters (with and without high short-term funding) are the upper bounds of 95 percent confidence intervals. Accordingly, this approach yields historically high levels of capitalization.

Table 8 compares the three estimated G-SIB capital surcharge systems with the Basel system. For estimated capital surcharge buckets, two numbers are quoted. The first (and lower) value is the capital surcharge for banks using lower levels of short-term funding; the second (and higher) value is the capital surcharge for banks using higher levels of short-term funding. Based on the median level of short-term funding on which the crisis/post-crisis sample is split, the cutoff between low and high levels of short-term funding is approximately 10 percent of risk-weighted assets. All three estimated capital surcharge systems suggest that Basel's capital surcharges are too small.

How do our estimates of capital compare with some recent literature on bank capitalization?[38] Using an alternate approach, Dagher et al. (2016) estimate common equity to risk-weighted assets of between 15 and 23 percent to avoid failures similar to the previous financial crisis. As Basel III sets a capital floor of 4.5 and a capital conservation buffer of an additional 2.5 percent, their estimates suggest G-SIB capital surcharges should be between 8 and 15 percent. Similarly, Myerson (2014) suggests

[38] For capital comparison using total assets instead of risk-weighted assets, the following back-of-the-envelope calculation might be used. Based on 2010-2016 Bankscope data, risk-weighted assets are, on average, 75 percent of total assets. Thus, as a proportion of total assets, our best estimate would (1) raise capital requirements 275 to 400 basis points for banks in Buckets 1-5, (2) create Bucket 0 with a capital surcharge of 175 basis points, and (3) include a short-term funding metric that further boosts capital surcharges 125 to 425 basis points for banks that fund assets with a high proportion of short-term funding. Similarly, our pessimistic and optimistic estimates, as a proportion of total assets, would be deflated by 75 percent. With a minimum capital ratio of 4.5 percent and a capital conservation buffer of 2.5 percent of risk-weighted assets, comparable leverage ratios for current G-SIBs would range from 8.0 percent to 13.5 percent.

reasonable ratios of total capital to risk-weighted assets of at least 20 percent. The Minneapolis Plan (Federal Reserve Bank of Minneapolis, 2016) proposes initial minimum capital requirements of 23.5 percent of risk-weighted assets, which could increase to as high as 38 percent if banks remain systemically important. Finally, Bulow and Klemperer (2013) suggest that even a 14 percentage point increase in this ratio is grossly inadequate because of the deficiencies embedded in regulatory accounting. Overall, our best estimate of the G-SIB capital surcharges and our conclusion that they are too small seem in line with other recent studies of bank capital needed to survive a severe financial crisis.

5. Conclusion

Overall, our best estimate suggests that, although Basel's method of measuring systemic importance may be valid, its current G-SIB capital surcharges are too small based on the experience of the 2007–09 financial crisis. Our best estimate of an empirical implementation of the G-SIB capital surcharges would (1) raise capital requirements 375 to 525 basis points for banks currently subject to G-SIB capital surcharges, (2) create an additional lower bucket with a capital surcharge of 225 basis points for very large and systemically important banks that are not currently subject to any G-SIB capital surcharge, and (3) include a short-term funding metric that further boosts capital surcharges 175 to 550 basis points for banks that fund assets with a high proportion of short-term funding. Observers who are pessimistic about the Basel III reforms would desire even higher levels of capital surcharges. Although optimistic observers would suggest lower capital surcharges, our calculation of optimistic capital surcharges are still higher than current Basel G-SIB capital surcharges.

Appendix 1: Alternative Weighting Schemes for G-SIB Score

According to the Basel framework text, the "advantage of the multiple indicator-based measurement approach is that it encompasses many dimensions of systemic importance, is relatively simple, and is more robust than currently available model-based measurement approaches and methodologies that only rely on a small set of indicators or market variables" (BCBS, 2013a). However, little justification is provided for the weighting of the indicators within the score. All indicators are equally weighted within categories, and all categories are themselves equally weighted. Other than simplicity, it is difficult to find a strong argument for this weighting system. This system of equally weighting indicators is perhaps best described as the regulatory consensus.

Using data from the end of 2014, we estimate three alternative weighting schemes.[39] The first alternative accepts the current G-SIB score as an accurate measure of systemic losses given default but estimates weights that parsimoniously span the information provided by the indicators. The second alternative weighting scheme is based on a market-based measure of systemic losses given default. Finally, the third weighting scheme invokes economic theory describing how the distribution of firms within an industry reflects underlying competitive conditions.

Minimum variance regulatory consensus weights—The current G-SIB score reflects the consensus of regulators about what measures systemic losses given default. However, all indicators are highly correlated with total exposures. Identifying banks as "too big to fail" clearly implies that size intuitively indicates systemic risk. Thus, a prima facie measure of social losses given default would be a size measure like total assets or total exposures. Including other indicators widens the metric to include other activities associated with "too important to fail." Which indicators are distinct from total exposures?

To answer this question, we regress each indicator, X_j, on the total exposures:

$$X_{i,j} = \alpha_j * Total\ Exposures_i + \varepsilon_{i,j}, \tag{1}$$

where i is the firm index, and j is the indicator index (shown in table A2 and table A3). Thus, for each bank i, the predicted value ($\alpha_j * Total\ Exposures_i$) can be interpreted as the level of that activity that would be expected based on its size. The residual ($\varepsilon_{i,j}$) measures the deviation from that expected level. Then, we perform an orthogonal factor analysis on the residuals from all 11 indicators to determine m factors (factor loading shown in appendix table A4). Estimating orthogonal factors means that each factor provides unique information. These factors are linear combinations weighted to account for as much variation in the residuals as possible with the least number of variables. Each factor, $Factor_k$, is a linear combination of n_k indicator residuals, in which each residual, $\varepsilon_{i,j}$, is weighted by β_j:

[39] The sample is composed of end-2014 G-SIB public disclosures from banks in the main sample available at BCBS (2016b). It is missing all Australian banks (ANZ, Commonwealth, National Australian Bank, and Westpac), all Brazilian banks (Banco Bradesco, Banco do Brasil, Caixa, and Itaú Unibanco), select Chinese banks (Agricultural Bank, Industrial Bank, Shanghai Pudong, China Merchant, and Guangfua), and a Korean bank (Hana Bank). See Benoit, Hurlin, and Pérignon (2016) for another weighting scheme.

$$Factor_{i,k} = \sum_{j=1}^{n_k} \beta_j \, \varepsilon_{i,j}.$$

Our analysis results in four factors: a "capital markets activity" factor composed of underwriting activity and OTC derivatives, a "custodial activity" factor of payments activity and assets under custody, an "international activity" factor of cross-jurisdictional claims and cross-jurisdictional liabilities, and a "fire sale risk" factor of intra-financial system assets.[40] The factor analysis implies that intra-financial system liabilities, securities outstanding, trading and AFS securities, and Level 3 assets do not help explain variation in residuals after controlling for size.

Next, we regress the G-SIB score on total exposures and the four factors (shown in appendix table A5):

$$GSIB\ score_i = \delta_0 * Total\ Exposures_i + \sum_{k=1}^{m} \delta_k * Factor_{i,k} + \gamma_i. \qquad (2)$$

The coefficients, δ_k, estimate the importance of $Factor_k$ in explaining social losses given default. Finally, to derive indicator weights based on this factoring technique, we substitute equation 1 back in for each indicator. After algebraic manipulation, the result is a weighted average of the indicators:

$$\begin{aligned} \widehat{GSIB\ score}_i &= \delta_0 * Total\ Exposures_i + \sum_{k=1}^{m} \delta_k * \sum_{j=1}^{n_k} \beta_j \, \varepsilon_{i,j} \\ &= \delta_0 * Total\ Exposures_i + \sum_{k=1}^{m} \delta_k * \sum_{j=1}^{n_k} \beta_j \big(X_{i,j} - \alpha_j * Total\ Exposures_i\big) \\ &= \left[\delta_0 - \sum_{k=1}^{m} \delta_k \sum_{j=1}^{n_k} \beta_j \, \alpha_j\right] Total\ Exposures_i + \sum_{k=1}^{m} \delta_k \sum_{j=1}^{n_k} \beta_j \, X_{i,j}. \qquad (3) \end{aligned}$$

We find that all factors are significant, and table A7 shows the resulting weighting of the G-SIB score. By far, the most significant factor in the G-SIB score is the bank's size at 34 percent. The rest of the G-SIB score is approximately 21 percent capital markets activity, 9 percent custodial activity, 24 percent international activity, and 12 percent fire sale risk. As mentioned above, the factor analysis implies that the other indicators—intra-financial system liabilities, securities outstanding, trading and AFS securities, and Level 3 assets—do not add unique information. This metric is relatively simple compared to the current G-SIB index because it includes fewer indicators, and the weighting scheme has a logical foundation insofar that it reflects the smallest number of variables needed to capture the variation across banks that regulators consider related to "too important to fail." As shown in table A7, this factoring approach suggests that regulators could weight size and capital markets activities more

[40] Using the common rule of thumb from confirmatory factor analysis, we set the loading cutoff at 0.7.

heavily. This approach concisely describes the factors outside of total exposures that, in the view of regulators, are indicative of greater systemic losses given default.

Market-based weights—An independent measure of systemic losses is needed for a truly analytical approach to the weighting scheme. With no data on systemic losses, we replace the G-SIB score with market-based SRISK as the measure of social losses given default in equation 2 (Acharya and Pedersen, 2010).[41] Appendix table A6 shows this estimation.

Appendix table A7 displays the weighting (derived from equation 3) based on the estimation from appendix table A6. This metric is a weighted average of size (75 percent), custodial activity (-5 percent), and international activity (30 percent). The capital markets activity factor and the fire sale risk factor are not significant. As seen in the third column of table A7, the market highly weights size. Furthermore, contrary to the Basel rationale for including payments activity and assets under custody as measures of systemic risk, the negative weighting on these indicators implies that the market views custodial banks as more robust in a market downturn (after controlling for their size). While this greater robustness may reflect diversification or other benefits, it may also reflect investors' beliefs that government intervention is more probable for banks engaging in custodial activities.

The top panel of appendix figure A1 displays a scatterplot that compares the regulatory consensus weighting to the market-based weighting. The scores have a strong positive correlation, but variation is significant enough to produce different relative capital surcharges for the largest banks. The outliers below the regression line are U.S. banks that are highly involved in custodial activities, indicating that the market views these banks as more robust in a market downturn in comparison to the assessment of the regulatory consensus. Markets seem to expect that some European and Chinese banks, which are the upper outliers, will suffer greater private losses in a systemic crisis than assessed by the regulatory consensus. As noted previously, SRISK measures shareholders' private losses associated with a financial market downturn, and the value of this approach depends on the extent of the correlation between private uncovered losses and social losses since.

Stable equilibrium weights—Our third logical foundation for indicator weights is based on the stability of the equilibrium distribution of banks within a business line. The economic theory of the distribution of firm size has made significant advances in recent years. This theory suggests that certain industries that are stationary and competitive with minor restrictions on entry and exit will exhibit Zipf's law, i.e. firm size will be distributed as a power law distribution with a scale coefficient of approximately 1 (see Gabaix 1999, Gabaix 2016, Luttmer 2007). Furthermore, when firms or sectors are power law-distributed within the entire economy, Carvalho and Gabaix (2013) and Gabaix (2011) show that idiosyncratic firm-level or sector-level shocks do not create macroeconomic volatility. In this view, macroeconomic fluctuations arise when a few large firms distort the distribution of firms within a sector.

Crafting G-SIB scores from the perspective of a social planner, we adopt the goal of smoothing aggregate volatility in banking services. Thus, indicators are weighted higher if the business line, as measured by a G-SIB indicator, is not stable or competitive. In the spirit of this theory, a stable equilibrium index would be the following:

[41] See section 2 for more information about SRISK.

$$GSIB\ score_i = \sum_{j=1}^{n} (1 - \beta_j) X_{i,j} \ \text{ for } \beta_j < 1,$$

where i is the firm index, j is the index for a business line (that is, an indicator), and β_j is estimated from the following:

$$\ln\left[1 - \Pr\{X_{i,j} \geq X^*_{i,j}\}\right] = \alpha_j - \beta_j \ln\left[X_{i,j}\right].$$

β_j measures the competitiveness of industry structures or business lines. If β_j is equal to or greater than 1, the business line is stable enough that shocks to individual firms do not cause industry-level volatility. If β_j is less than 1, the indicator is concentrated heavily in a few large firms; shocks to these firms may result in fluctuations for the industry as a whole.

The resulting weights $(1 - \beta_j)$ are shown in the rightmost column of table A7. Since the market stability coefficient for total exposures is greater than 1, traditional lending is consistent with a competitive and stable distribution across banks. Beyond suggesting the removal of total exposures, this scheme weights assets under custody, underwriting activity, OTC derivatives, and Level 3 assets substantially higher than in the regulatory consensus.

The bottom panel of appendix figure A1 displays a scatterplot of scores employing regulatory consensus weights and stable equilibrium weights. Overall, because the two methods produce very similar G-SIB scores, the regulatory consensus weights effectively capture market stability concerns within more concentrated business lines. Because the weights on all three substitutability indicators are higher in the stable equilibrium weighting scheme, the concentration of firms in the substitutability indicators drives the small amount of variation between these two methods. The four outliers above the regression line—JPMorgan, Citigroup, BNY Mellon, and State Street—are heavily involved in assets under custody, underwriting activity, and/or OTC derivatives, which are the most concentrated business lines in the whole G-SIB framework.

Overall, our results suggest that the Basel G-SIB score weights are relatively consistent with two other methods of weighting the index. However, some banks' rankings might shift enough to move the bank up or down one capital bucket (i.e., individual capital surcharges might increase or decrease as much as 50 basis points). Furthermore, the discrepancies between the market and stable equilibrium weights highlight different perspectives on industry concentration. From the market's perspective, higher concentration seems to result in lower expected uncovered private losses during market downturns. In contrast, the stable equilibrium approach assumes that higher concentrations are associated with more volatile industry structures that can have macroeconomic consequences. Without an underlying theory, the current G-SIB weighting is best interpreted as a consensus approach by international bank regulators.

Appendix 2: Capital Conservation Buffer

Applied to G-SIBs and non-G-SIBs alike, the capital conservation buffer "is designed to ensure that banks build up capital buffers outside periods of stress which can be drawn down as losses are incurred" (BCBS, 2010). In this appendix, we describe how changes in the capital conservation buffer change G-SIB capital surcharges. Assuming that the reference bank holds the lowest required level of regulatory capital, the derivative of the G-SIB capital surcharge with respect to the capital conservation buffer is

$$\begin{aligned}\frac{\partial k_{GSIB}}{\partial CC} &= \hat{\sigma}\left[1 - e^{\frac{-CC-\hat{\mu}}{\hat{\sigma}}}\ln(\alpha)\right]^{-1}\left[0 - e^{\frac{-CC-\hat{\mu}}{\hat{\sigma}}}\ln(\alpha)\right]\left[\frac{-1}{\hat{\sigma}}\right] \\ &= \left[1 - e^{\frac{-CC-\hat{\mu}}{\hat{\sigma}}}\ln(\alpha)\right]^{-1}\left[e^{\frac{-CC-\hat{\mu}}{\hat{\sigma}}}\ln(\alpha)\right] \\ &= \frac{e^{\frac{-CC-\hat{\mu}}{\hat{\sigma}}}\ln(\alpha)}{1 - e^{\frac{-CC-\hat{\mu}}{\hat{\sigma}}}\ln(\alpha)} \\ &= \left[\frac{e^{\frac{CC+\hat{\mu}}{\hat{\sigma}}}}{\ln(\alpha)} - 1\right]^{-1}.\end{aligned}$$

Because $e^{\frac{CC+\hat{\mu}}{\hat{\sigma}}} > 0$ and $\ln(\alpha) < 0$, it follows that

$$\frac{\partial k_{GSIB}}{\partial CC} < 0.$$

Thus, G-SIB capital surcharges decrease, given an increase in the capital conservation buffer.

For some intuition, recall that the capital conservation buffer is the difference between the regulatory failure point and the level of capital the reference bank is required to hold. Consider lowering the failure point and keeping the capital held by the reference bank constant; this change increases the capital conservation buffer. Although the probability of default for both the reference bank and G-SIBs is reduced, the probability of default for G-SIBs decreases relatively more. Thus, the G-SIB capital surcharges decrease. Holding the failure point constant and raising the capital held by the reference bank yields a similar effect.

What is the proper level for the capital conservation buffer? As a rule of thumb, we set the capital conservation buffer based on the probability it absorbs losses is $1 - \alpha$ percent in a crisis period. Assuming returns on risk-weighted assets (RORWAs) are normally distributed with mean of μ and standard deviation of σ, we set the capital conservation buffer to the negative of the bound of the left α-percent tail of the distribution:

$$\begin{aligned}CC &= -(\mu - \theta_\alpha \sigma) \\ &= \theta_\alpha \sigma - \mu.\end{aligned}$$

where θ_α is the one-tailed critical value associated with a standard normal distribution.

Based on the RORWA distribution from the crisis/post-crisis period in section 1, the mean RORWA is 0.81 percent and the standard deviation is 1.69 percent. Under the current system, the capital conservation buffer of 2.5 percent results in $\theta_\alpha \approx 1.0$ and $\alpha \approx 16\%$. Thus, the likelihood of the current capital conservation buffer absorbing losses in a crisis is approximately 84 percent.

According to our model, increasing the conservation capital buffer to 3.5 percent would cover approximately 95 percent of RORWA realizations in a crisis period. Appendix figure A2 shows the effect on total capital from this increase compared to the effect on total capital from a change in the reference bank score. The solid green line shows the continuous capital surcharge function estimated in table 3. The short-dashed red line shows the effect of increasing the capital conservation buffer from 2.5 to 3.5 percent. The long-dashed blue line shows total capital held by banks if the reference bank score is halved. Although not directly pertaining to the size of G-SIB capital surcharges, the capital conservation buffer affects G-SIB capital surcharges and total capital.

Appendix 3: G-SIB Management Incentives

The Basel G-SIB score is a weighted average of market shares. If G-SIB capital surcharges motivate banks to cut their involvement enough in (Basel-identified) systemically important activities to substantially shrink these markets, then G-SIB scores could *increase* for banks that reduced their activity less than the aggregate market decrease. However, if the measure of systemic importance was based on levels of an activity rather than market shares, this odd result could not happen. Unfortunately, it is difficult to determine systemically important quantities without referencing market shares.

In this appendix, we illustrate these incentive problems. Importantly, we show that one way to maintain a system with proper incentives is to use denominators that cannot be influenced by G-SIBs. For example, using the median value of institutions in the BCBS sample not subject to capital surcharges as the denominator may resolve this problem (depending on the stability of the median).

As discussed in section 2, we denote the category j sub-score as X_{ij} for bank i and define bank i's G-SIB score as

$$GSIB\ score_i = \frac{1}{5}\sum_{j=1}^{5} X_{ij}.$$

Furthermore, the category sub-score is an equally weighted average of the market shares of each indicator:

$$X_{ij} = \beta_j \sum_{k=1}^{\beta_j} \frac{Z_{ik}}{M_k},$$

where β_j is the reciprocal of the number of indicators in category j, Z_{ik} is bank i's level quantity of activity in indicator k, and M_k is the worldwide sum of indicator k (i.e., the sum of Z_{ik} for all banks). Thus, bank i's score is a weighted average of the ratios of its activity, Z_{ik}, to the worldwide sum, M_k:

$$GSIB\ score_i = \frac{1}{5}\sum_{k=1}^{12} \beta_j \frac{Z_{ik}}{M_k}.$$

If Basel used continuous capital surcharges instead of buckets, bank i's G-SIB capital surcharge would be

$$k_{GSIB} = \sigma \ln\left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln\left(\frac{H(r)}{H(GSIB)}\right)\right]$$

$$= \sigma \ln\left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln\left(\frac{\frac{1}{5}\sum_{j=1}^{5} \beta_j \frac{Z_{rj}}{M_j}}{\frac{1}{5}\sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j}}\right)\right]$$

$$= \sigma \ln\left[1 - e^{\frac{-CC-\mu}{\sigma}} \ln\left(\frac{\sum_{j=1}^{5} \beta_j \frac{Z_{rj}}{M_j}}{\sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j}}\right)\right].$$

Now we define Q_i as

$$Q_i = \frac{\sum_{j=1}^{5} \beta_j \frac{Z_{rj}}{M_{all\ ij}}}{\sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_{all\ ij}}}.$$

As $Q_i \to 0$, the capital surcharge gets large. As $Q_i \to 1$, the capital surcharge tends toward zero. The smaller the gap between the systemic importance of the G-SIB and the systemic importance of the reference bank, the lower the capital surcharge.

Furthermore, in a well-designed system, it is important that

$$\frac{\partial Q_i}{\partial Z_{ij}} < 0.$$

In other words, if banks decrease activity, their capital surcharges decrease (because Q_i increases closer to one). The Basel system, however, fixes the reference bank to a constant market share. For some indicator k, we find

$$\frac{\partial Q_i}{\partial Z_{ik}} = \frac{\frac{\partial}{\partial Z_{ik}}\left(\sum_{j=1}^{5} \beta_j \frac{Z_{rj}}{M_j}\right) \cdot \sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j} - \frac{\partial}{\partial Z_{ik}}\left(\sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j}\right) \cdot \sum_{j=1}^{5} \beta_j \frac{Z_{rj}}{M_j}}{\left(\sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j}\right)^2}.$$

If we assume that bank i does not perceive any substitutability among indicators, then bank i's other indicators do not change because of a change of indicator k:

$$\frac{\partial Z_{il}}{\partial Z_{ik}} = \frac{\partial Z_{rl}}{\partial Z_{ik}} = \frac{\partial M_l}{\partial Z_{ik}} = 0 \text{ for indicators } k \neq l.$$

Thus,

$$\frac{\partial Q_i}{\partial Z_{ik}} = \frac{\frac{\partial}{\partial Z_{ik}}\left(\beta_k \frac{Z_{rk}}{M_k}\right) \cdot \sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j} - \frac{\partial}{\partial Z_{ik}}\left(\beta_k \frac{Z_{ik}}{M_k}\right) \cdot \sum_{j=1}^{5} \beta_j \frac{Z_{rj}}{M_j}}{\left(\sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j}\right)^2}$$

$$= \frac{\beta_k \left[\frac{\frac{\partial Z_{rk}}{\partial Z_{ik}} M_k - Z_{rk} \frac{\partial M_k}{\partial Z_{ik}}}{M_k^2}\right] \cdot \sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j} - \beta_k \left[\frac{M_k - Z_{ik} \frac{\partial M_k}{\partial Z_{ik}}}{M_k^2}\right] \cdot \sum_{j=1}^{5} \beta_j \frac{Z_{rj}}{M_j}}{\left(\sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j}\right)^2}.$$

We turn to an examination of incentives under different market structures.

Competitive Market

If G-SIBs were not large enough to affect the worldwide market or other financial institutions, we could assume that

$$\frac{\partial M_k}{\partial Z_{ik}} = 0 \rightarrow \frac{\partial Z_{rk}}{\partial Z_{ik}} = 0.$$

This equation implies that

$$\frac{\partial Q_i}{\partial Z_{ik}} = -\frac{\frac{\beta_k}{M_k} \cdot \sum_{j=1}^{5} \beta_j \frac{Z_{rj}}{M_j}}{\left(\sum_{j=1}^{5} \beta_j \frac{Z_{ij}}{M_j}\right)^2} < 0.$$

Under competitive conditions, the market-share-based G-SIB score system has the proper incentives; even if all banks with G-SIB capital surcharges cut their activities, capital surcharges fall.

Oligopoly

By definition, G-SIBs are large and systemically important; it is likely that their actions affect worldwide market shares and other financial institutions. More general conditions for the proper incentives are

$$\frac{\partial Z_{rk}}{\partial Z_{ik}} M_k - Z_{rk} \frac{\partial M_k}{\partial Z_{ik}} < 0$$

$$\frac{M_k - Z_{ik} \frac{\partial M_k}{\partial Z_{ik}}}{M_k^2} > 0,$$

which implies

$$\frac{\partial Z_{rk}}{\partial Z_{ik}} < \frac{\partial M_k}{\partial Z_{ik}} \frac{Z_{ik}}{M_k} < 1.$$

If the actions of a G-SIB cannot affect the reference bank (as in the current G-SIB system), then

$$0 < \frac{\partial M_k}{\partial Z_{ik}} \frac{Z_{ik}}{M_k} < 1.$$

Suppose that if one G-SIB cuts its activities, all other G-SIBs cut their activities as well, and the market falls by a greater amount relative to an individual G-SIB's decline, or

$$\frac{\partial M_k}{\partial Z_{ik}} > 1.$$

Then the market share of the G-SIB needs to be small to avoid the case in which its capital surcharge might increase.

One way to maintain a system with proper incentives is to use denominators that cannot be influenced by G-SIBs. Suppose, the denominator is defined as the median value of institutions in the BCBS sample not subject to capital surcharges (in 2014, this score is 52 basis points). These non-G-SIBs have no incentive to respond to G-SIB capital surcharges since they are not subject to them. In this case, G-SIB scores are not aggregated worldwide market shares but multiples of the median non-G-SIB. Then $M_k = Z_{rk}$ and

$$0 = \frac{\partial Z_{rk}}{\partial Z_{ik}} = \frac{\partial M_k}{\partial Z_{ik}} \cdot \frac{Z_{ik}}{M_k} < 1.$$

This approach incentivizes downsizing even when worldwide markets shrink.

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Table 1: Basel G-SIB Capital Surcharges

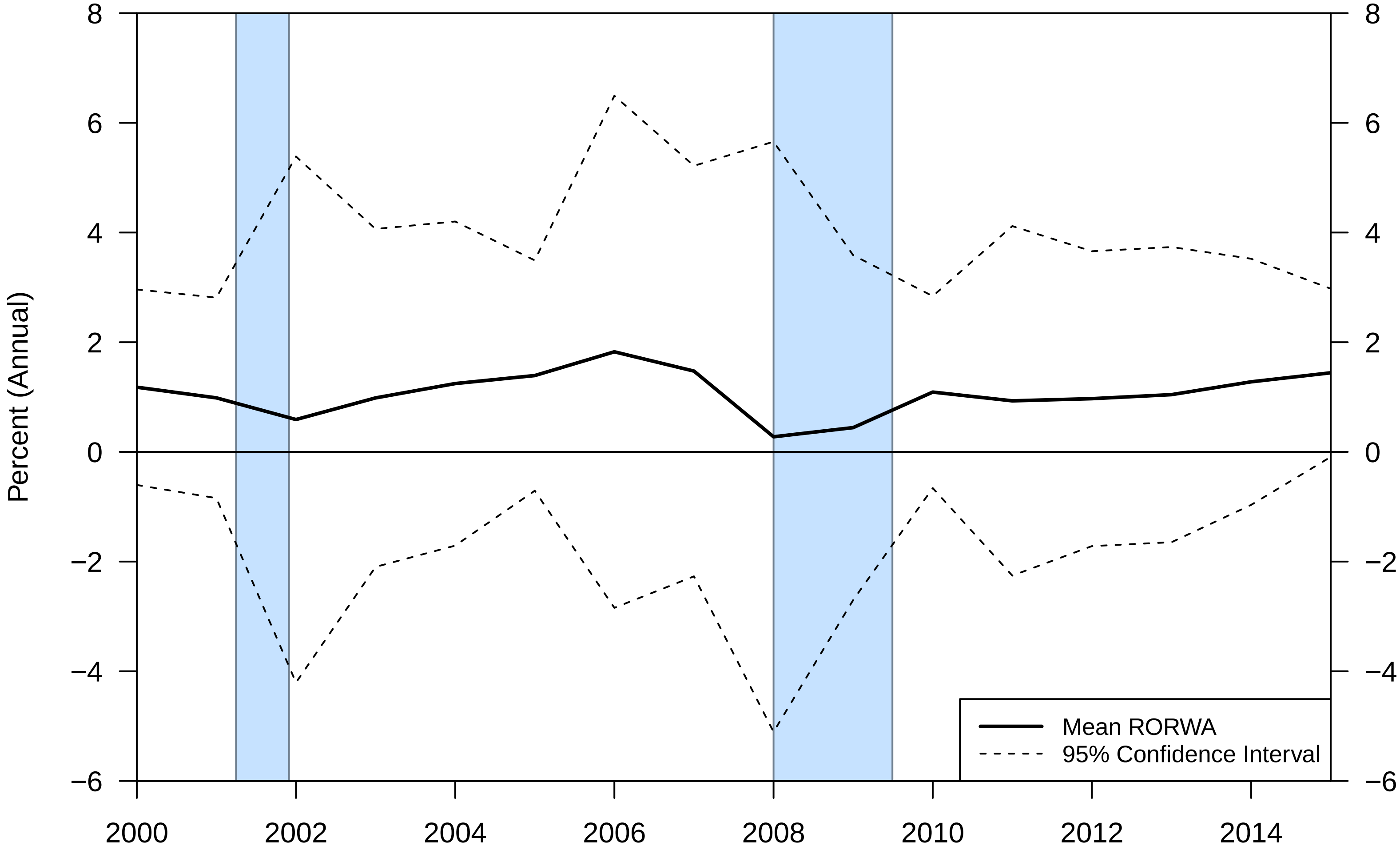
Bucket	Capital Surcharge (CET1)	G-SIB Score Range (in basis points)	2016 List of G-SIBs (in alphabetical order)
5	+ 3.5%	530–629	(empty)
4	+ 2.5%	430–529	Citigroup JPMorgan Chase
3	+ 2.0%	330–429	Bank of America BNP Paribas Deutsche Bank HSBC
2	+ 1.5%	230–329	Barclays Credit Suisse Goldman Sachs Industrial and Commercial Bank of China Mitsubishi UFJ FG Wells Fargo
1	+ 1.0%	130–229	Agricultural Bank of China Bank of China Bank of New York Mellon China Construction Bank Groupe BPCE Groupe Credit Agricole ING Bank Mizuho FG Morgan Stanley Nordea Royal Bank of Scotland Santander Societe Generale Standard Chartered State Street Sumitomo Mitsui FG UBS Unicredit Group

Note: G-SIB is Global Systemically Important Bank. CET1 is Common Equity Tier 1 capital.

Source: Financial Stability Board (2016).

Figure 1

Time−Series of Return on Risk−Weighted Assets



Note: Shaded bars indicate recessions from March 2001 to November 2001 and from December 2007 to June 2009.

Source: 2000−2015 annual data available from Bureau van Dijk (2016); recession dates available from National Bureau of Economic Research (2010).

Table 2: Return on Risk-Weighted Assets on Lag with Fixed Effects

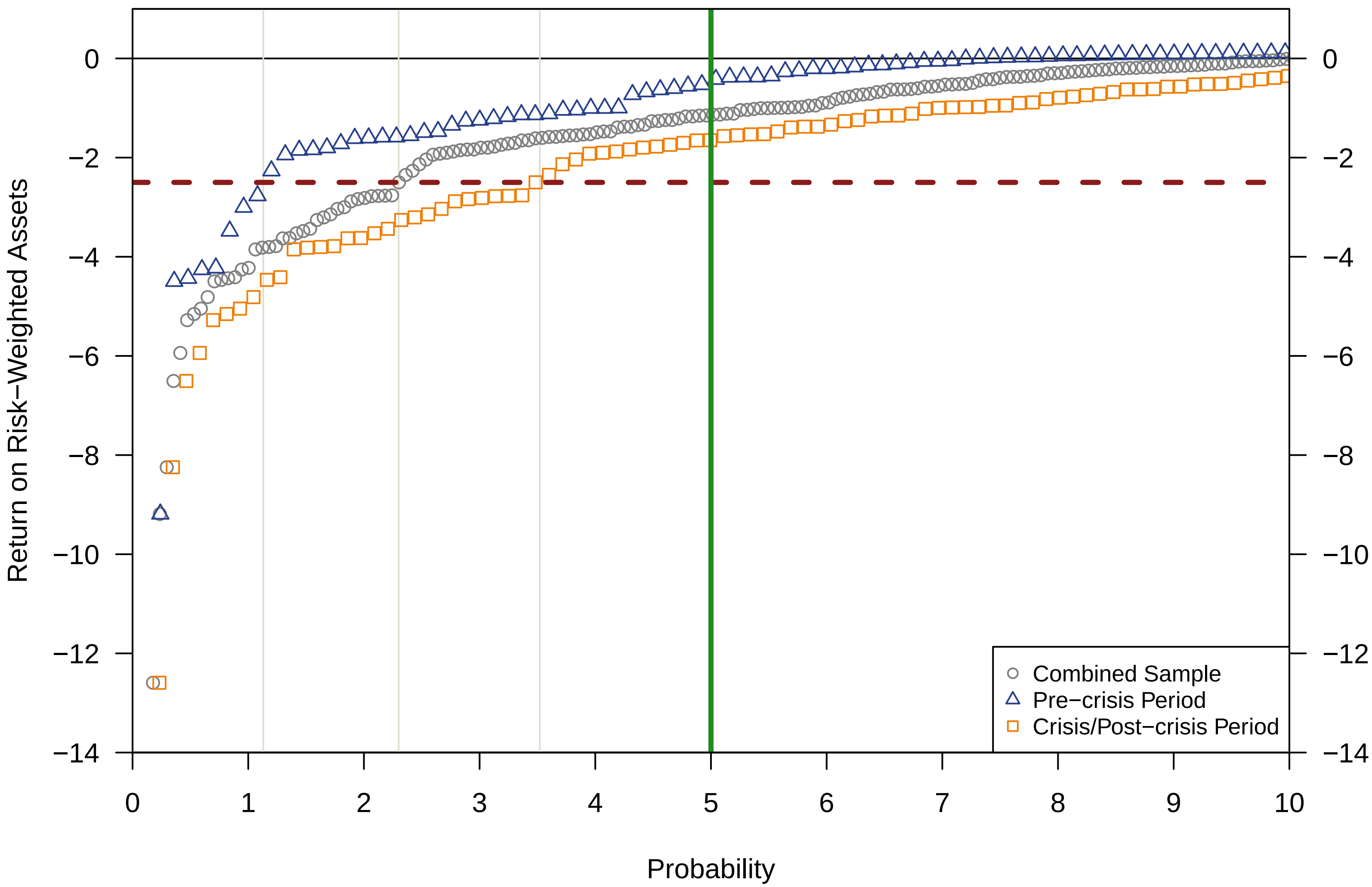
	Dependent Variable		
	Return on Risk-Weighted Assets (*RORWA*)		
	(1)	(2)	(3)
RORWA lag	0.38*** (0.02)	0.36*** (0.02)	0.35*** (0.02)
2002	0.001 (0.26)	−0.004 (0.27)	
2003	0.29 (0.25)	0.28 (0.26)	
2004	0.36 (0.25)	0.35 (0.26)	
2005	0.35 (0.24)	0.35 (0.25)	
2006	0.81*** (0.23)	0.80*** (0.24)	
2007	0.23 (0.23)	0.23 (0.24)	
2008	−0.90*** (0.23)	−0.91*** (0.24)	
2009	−0.26 (0.23)	−0.29 (0.24)	
2010	0.31 (0.23)	0.29 (0.24)	
2011	−0.14 (0.22)	−0.16 (0.24)	
2012	−0.03 (0.22)	−0.06 (0.23)	
2013	−0.01 (0.22)	−0.05 (0.23)	
2014	0.16 (0.22)		
2015	0.34 (0.29)		
Crisis/Post-crisis			−0.54*** (0.09)
Australia	0.31 (0.21)	0.39 (0.25)	0.36 (0.26)
Brazil	0.20 (0.45)	0.23 (0.50)	0.14 (0.50)
Canada	0.63** (0.30)	0.88** (0.42)	1.02** (0.42)
Switzerland	−0.05 (0.33)	−0.03 (0.39)	−0.004 (0.39)
China	0.25 (0.18)	0.34 (0.22)	0.40* (0.22)
Germany	−0.79*** (0.28)	−0.80** (0.31)	−0.84*** (0.32)
Spain	−0.22 (0.21)	−0.20 (0.24)	−0.18 (0.24)
France	−0.27 (0.24)	−0.25 (0.26)	−0.28 (0.27)
United Kingdom	−0.46** (0.22)	−0.43* (0.25)	−0.45* (0.25)
Italy	−1.06*** (0.24)	−1.00*** (0.26)	−0.97*** (0.27)
Japan	−0.56*** (0.12)	−0.61*** (0.14)	−0.66*** (0.14)
South Korea	−0.36 (0.33)	−0.33 (0.37)	−0.31 (0.37)
United States	−0.03 (0.12)	−0.02 (0.13)	−0.10 (0.13)
Bank Holding Company	0.20** (0.09)	0.22** (0.10)	0.25** (0.10)
Constant	0.66*** (0.21)	0.68*** (0.22)	1.06*** (0.13)
Observations	1,576	1,382	1,382
R^2	0.29	0.27	0.24
Adjusted R^2	0.27	0.26	0.24
Note:			*p<0.1; **p<0.05; ***p<0.01

Note: Column (1) uses data from 2000 to 2015, and columns (2) and (3) use data from 2000 to 2013. "Crisis/post-crisis" is one for observations from 2008 to 2013 and zero otherwise. Countries with at least five banks have fixed effects. Institutions either report as bank holding companies or commercial banks. $50 billion total asset cutoff (in 2015; deflated by world GDP for 2000 to 2014).

Source: 2000–2015 annual data available from Bureau van Dijk (2016).

Figure 2

Return on Risk−Weighted Assets Empirical Cumulative Distribution Function



Note: The bold dashed red line indicates an RORWA of −2.5 percent, which is the size of the capital conservation buffer from BCBS (2010). The vertical thin gray lines indicate the percentcile each sample crosses an RORWA of −2.5 percent. Models in table 3 are estimates on the bottom 5 percentiles, which is indicated by the vertical bold green line. The lowest RORWA observation has been cut off: Fortis Bank in 2008 had an RORWA of −26.04.

Source: 2000−2013 annual data available from Bureau van Dijk (2016).

Table 3: OLS Estimates of Gumbel Distribution Parameters

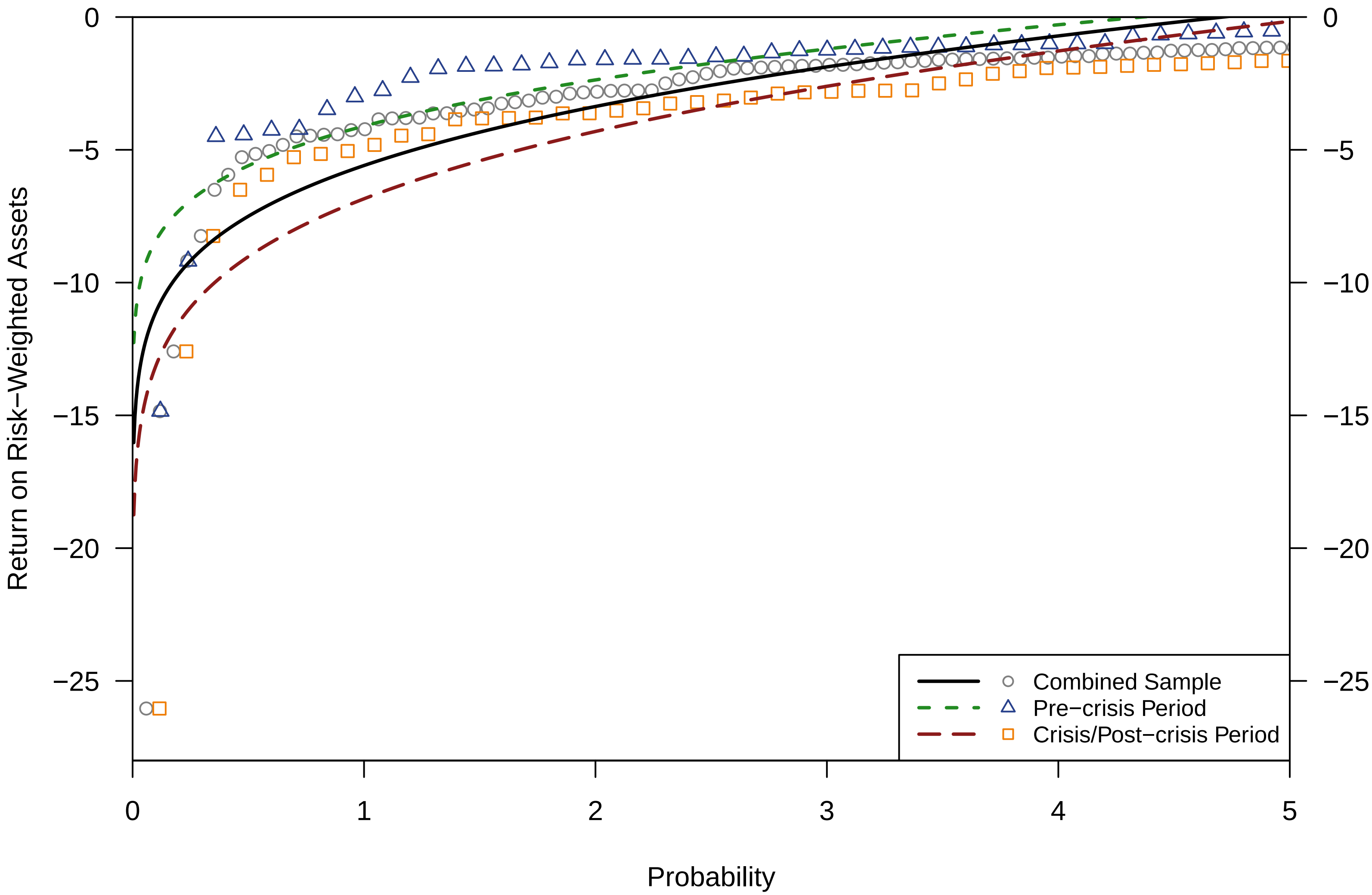
	Dependent Variable		
	Return on Risk-Weighted Assets (*RORWA*)		
	Combined Sample: 2000–2013	Pre-crisis Period: 2000–2007	Crisis/Post-crisis Period: 2008–2013
	(1)	(2)	(3)
$ln(-ln(Pr\{\widetilde{R} \leq RORWA\}))$	-13.627^{***}	-10.652^{***}	-15.543^{***}
	(1.014)	(1.105)	(1.861)
Constant	15.219^{***}	12.161^{***}	16.892^{***}
	(1.390)	(1.510)	(2.536)
Observations	84	41	43
R^2	0.688	0.704	0.630
Adjusted R^2	0.684	0.697	0.621
Note:			$^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$

Note: OLS is ordinary least squares. Models estimated using the bottom 5 percentiles of the sample.

Source: 2000–2013 annual data available from Bureau van Dijk (2016).

Figure 3

OLS Estimates of Gumbel Distribution

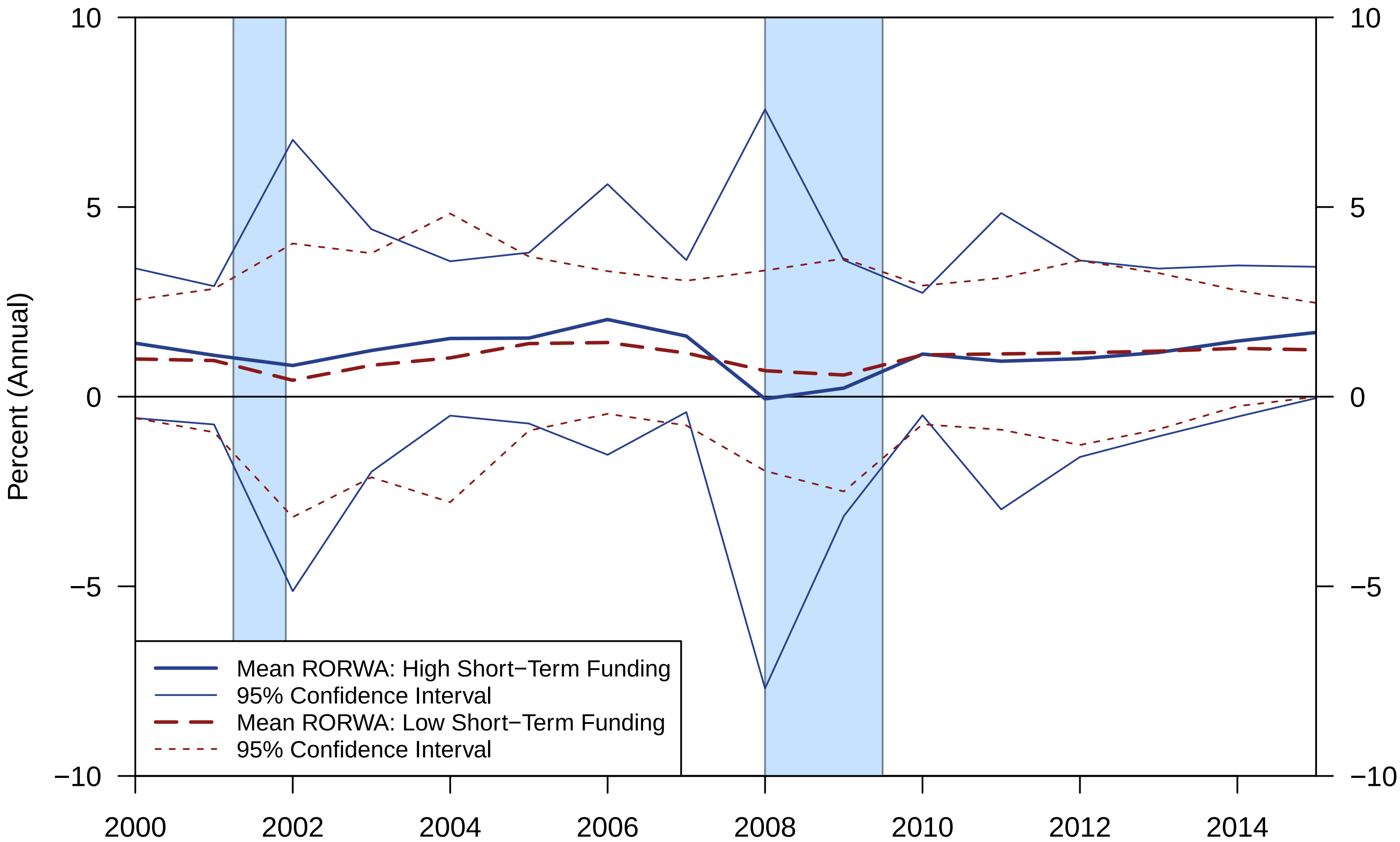


Note: OLS is ordinary least squares.

Source: 2000−2013 annual data available from Bureau van Dijk (2016).

Figure 4

Time−Series of Return on Risk−Weighted Assets: Short−Term Funding



Note: Shaded bars indicate recessions from March 2001 to November 2001 and from December 2007 to June 2009.

Source: 2000−2015 annual data available from Bureau van Dijk (2016); recession dates available from National Bureau of Economic Research (2010).

Table 4: OLS Estimates of Gumbel Parameters: Short-Term Funding

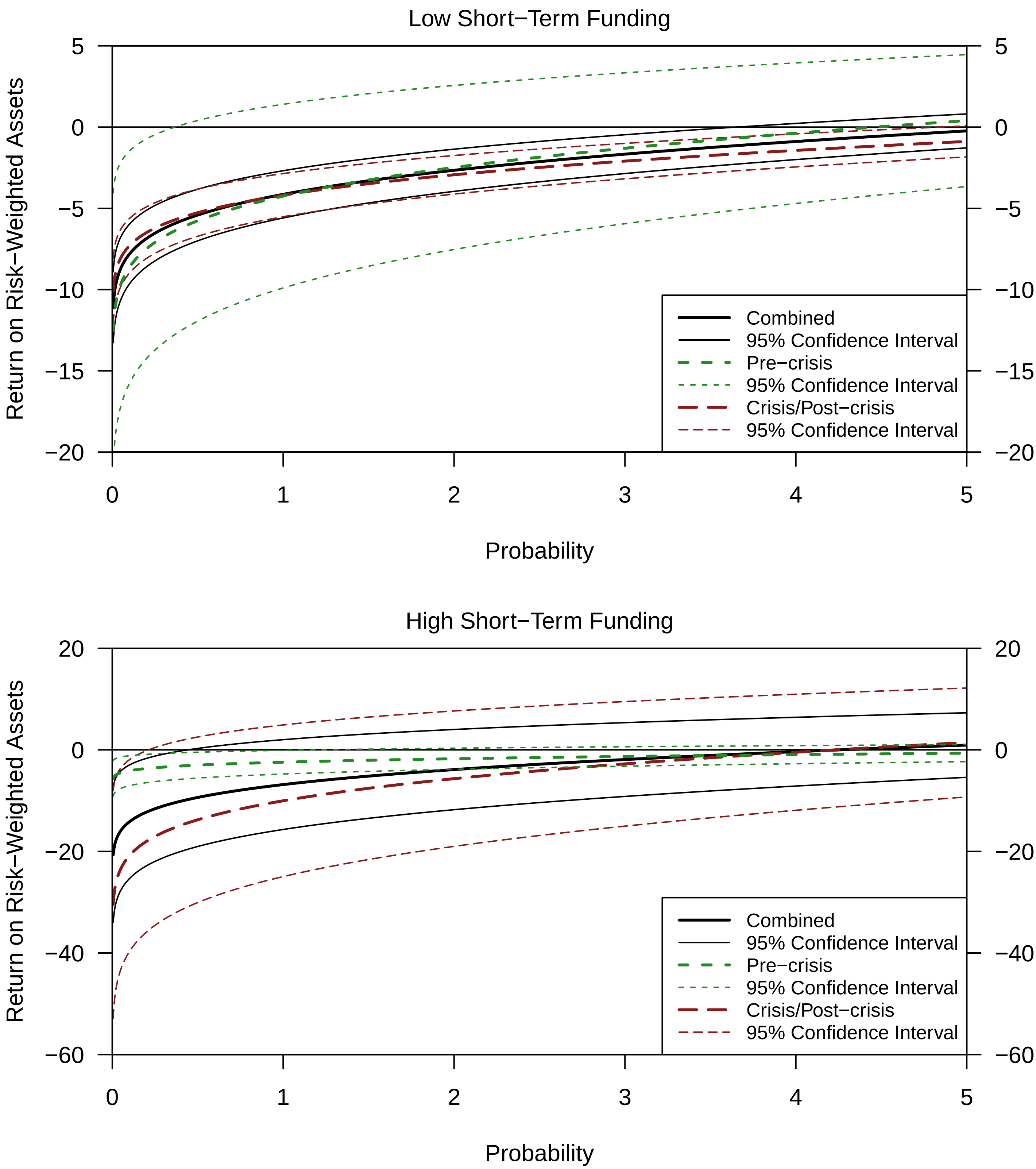
	Dependent Variable					
	Return on Risk-Weighted Assets (*RORWA*)					
	Combined: High	Combined: Low	Pre: High	Pre: Low	Crisis/Post: High	Crisis/Post: Low
	(1)	(2)	(3)	(4)	(5)	(6)
$ln(-ln(Pr\{\widetilde{R} \leq RORWA\}))$	-18.087^{***}	-9.077^{***}	-4.140^{***}	-10.810^{***}	-26.678^{***}	-7.691^{***}
	(2.954)	(0.486)	(0.778)	(1.888)	(4.987)	(0.444)
Constant	20.785^{***}	9.724^{***}	3.893^{***}	12.261^{***}	30.715^{***}	7.556^{***}
	(4.015)	(0.660)	(1.048)	(2.544)	(6.754)	(0.601)
Observations	30	30	13	13	16	16
R^2	0.572	0.926	0.720	0.749	0.672	0.955
Adjusted R^2	0.557	0.923	0.695	0.726	0.648	0.952
Note:						*p<0.1; **p<0.05; ***p<0.01

Note: The models are split on high/low based on the median value of lagged “Other Deposits and Short-term Borrowing / Repaired Risk-Weighted Assets” in the period. The models are estimated using the bottom 5 percentiles of the sample. OLS is ordinary least squares.

Source: 2000–2013 annual data available from Bureau van Dijk (2016).

Figure 5

OLS Estimates of Gumbel Distribution: Short−Term Funding



Note: OLS is ordinary least squares.

Source: 2000−2013 annual data available from Bureau van Dijk (2016).

Table 5: G-SIB Score Indicators

Category	Indicator	Indicator Weight
Size	Total Exposures	$1/5 = 20\%$
Interconnectedness	Intra-financial System Assets	$1/15 = 6.\overline{6}\%$
	Intra-financial System Liabilities	$1/15 = 6.\overline{6}\%$
	Securities Outstanding	$1/15 = 6.\overline{6}\%$
Substitutability/ Financial Institution Infrastructure	Payment Activity	$1/15 = 6.\overline{6}\%$
	Assets Under Custody	$1/15 = 6.\overline{6}\%$
	Underwriting Activity	$1/15 = 6.\overline{6}\%$
Complexity	Notional Amount of OTC Derivatives	$1/15 = 6.\overline{6}\%$
	Trading and AFS Securities	$1/15 = 6.\overline{6}\%$
	Level 3 Assets	$1/15 = 6.\overline{6}\%$
Cross-jurisdictional Activity	Cross-jurisdictional Claims	$1/10 = 10\%$
	Cross-jurisdictional Liabilities	$1/10 = 10\%$

Source: BCBS (2013a).

Table 6: G-SIB Score Example: JPMorgan Chase & Co for 2016

Category	Indicator	From Disclosure (million EUR)	End-2015 Denominator (million EUR)	Indicator (in bps)	Category Subscore (in bps)	G-SIB Score (in bps)
Size	Total Exposures	2,878,727	72,857,573	395	395	
Interconnectedness	Intra-financial System Assets	294,689	8,098,568	364	402	
	Intra-financial System Liabilities	370,432	8,898,527	416		
	Securities Outstanding	532,372	12,499,382	425		
Substitutability/	Payment Activity	263,080,075	2,262,439,199	1,163	1,093	
Financial Institution	Assets Under Custody	18,172,144	128,341,774	1,416	(500)	
Infastructure	Underwriting Activity	417,243	5,951,676	701		
Complexity	Notional Amount of OTC Derivatives	44,526,393	556,826,675	800	710	
	Trading and AFS Securities	273,561	3,254,574	841		
	Level 3 Assets	28,749	585,971	491		
Cross-jurisdictional	Cross-jurisdictional Claims	494,742	17,758,682	279	316	
Activity	Cross-jurisdictional Liabilities	561,578	15,884,108	354		
						464

Note: OTC derivatives are over-the-counter derivatives, and AFS securities are available for sale securities.

Source: G-SIB demoninators available from BCBS (2016a), and G-SIB disclosures available from BCBS (2016b).

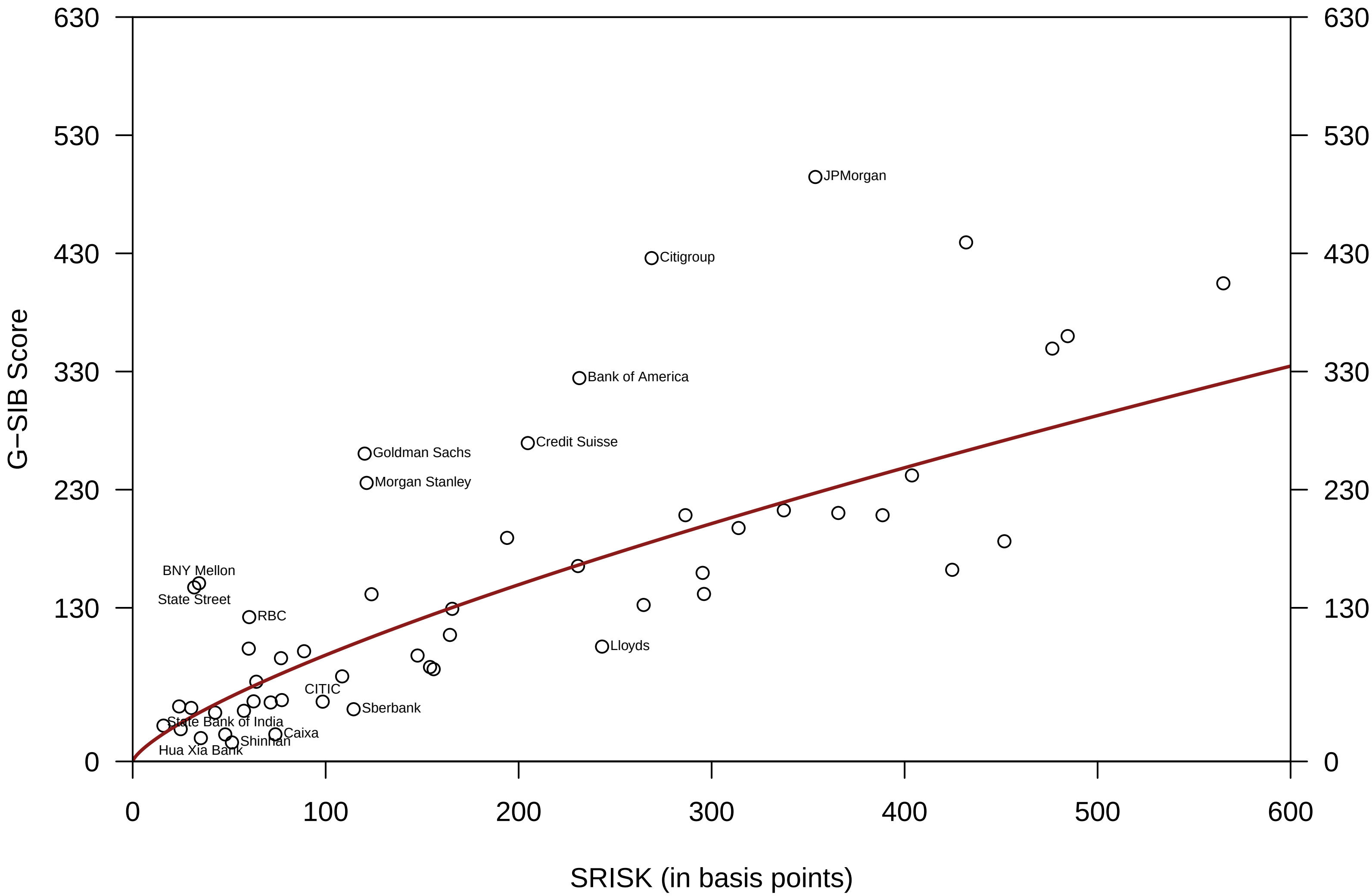
Table 7: Social Losses and Uncovered Private Losses Given Default

	Dependent variable:
	ln(G-SIB Score)
ln(SRISK)	0.733***
	(0.082)
Constant	1.124***
	(0.407)
Observations	53
R^2	0.610
Adjusted R^2	0.603
Residual Std. Error	0.555 (df = 51)
Note:	*p<0.1; **p<0.05; ***p<0.01

Source: G-SIB demoninators are available from BCBS (2016a), G-SIB disclosures available from BCBS (2016b), and SRISK from The Volatility Laboratory of the NYU Stern Volatility Institute (https://vlab.stern.nyu.edu) (2016).

Figure 6

Social Losses and Uncovered Private Losses Given Default

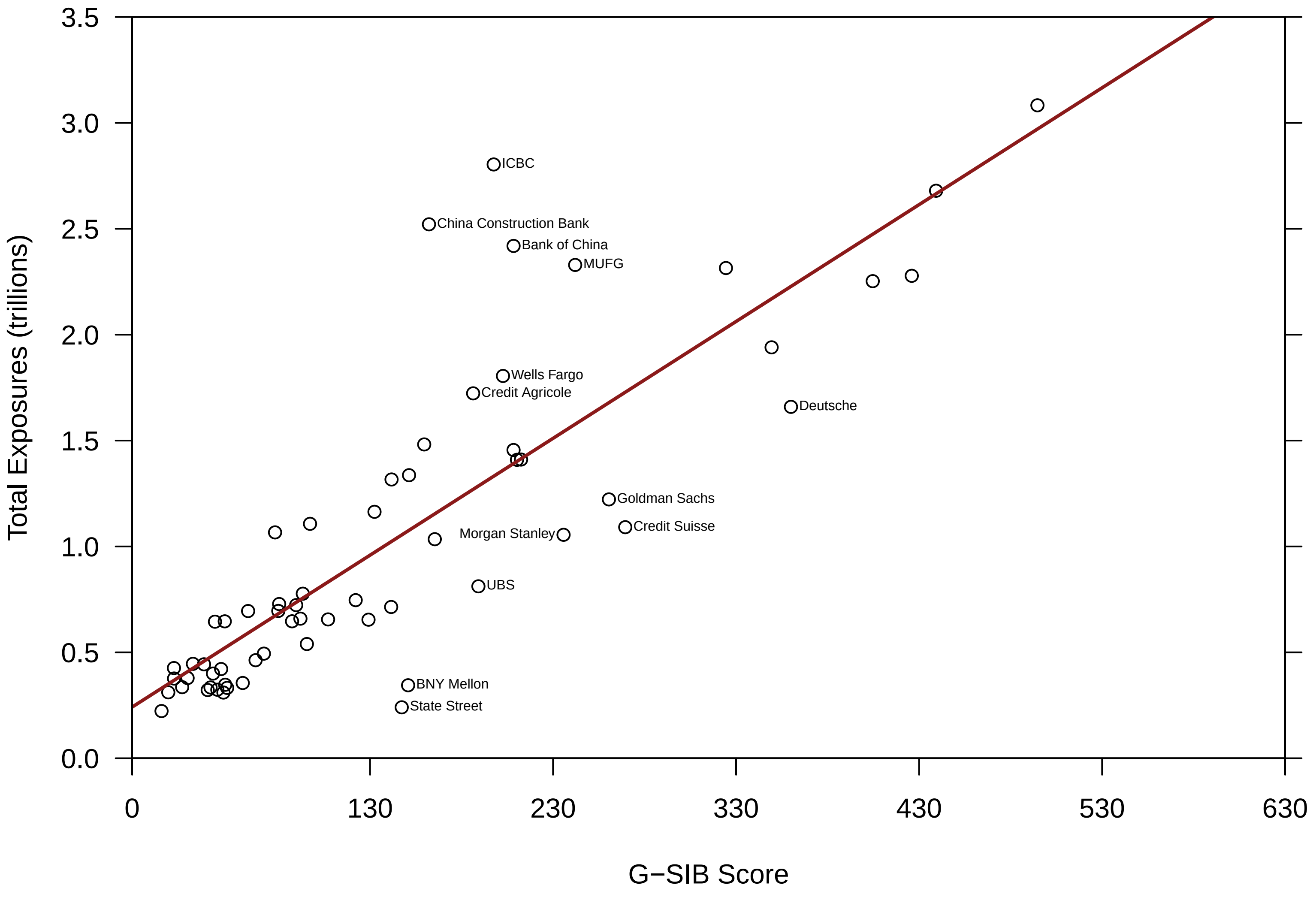


Note: The red line is the ordinary least squares log−log regression line.

Source: G−SIB demoninators are available from BCBS (2016a), G−SIB disclosures available from BCBS (2016b), and SRISK from The Volatility Laboratory of the NYU Stern Volatility Institute (https://vlab.stern.nyu.edu) (2016).

Figure 7

Size and Regulatory Consensus of Systemic Importance

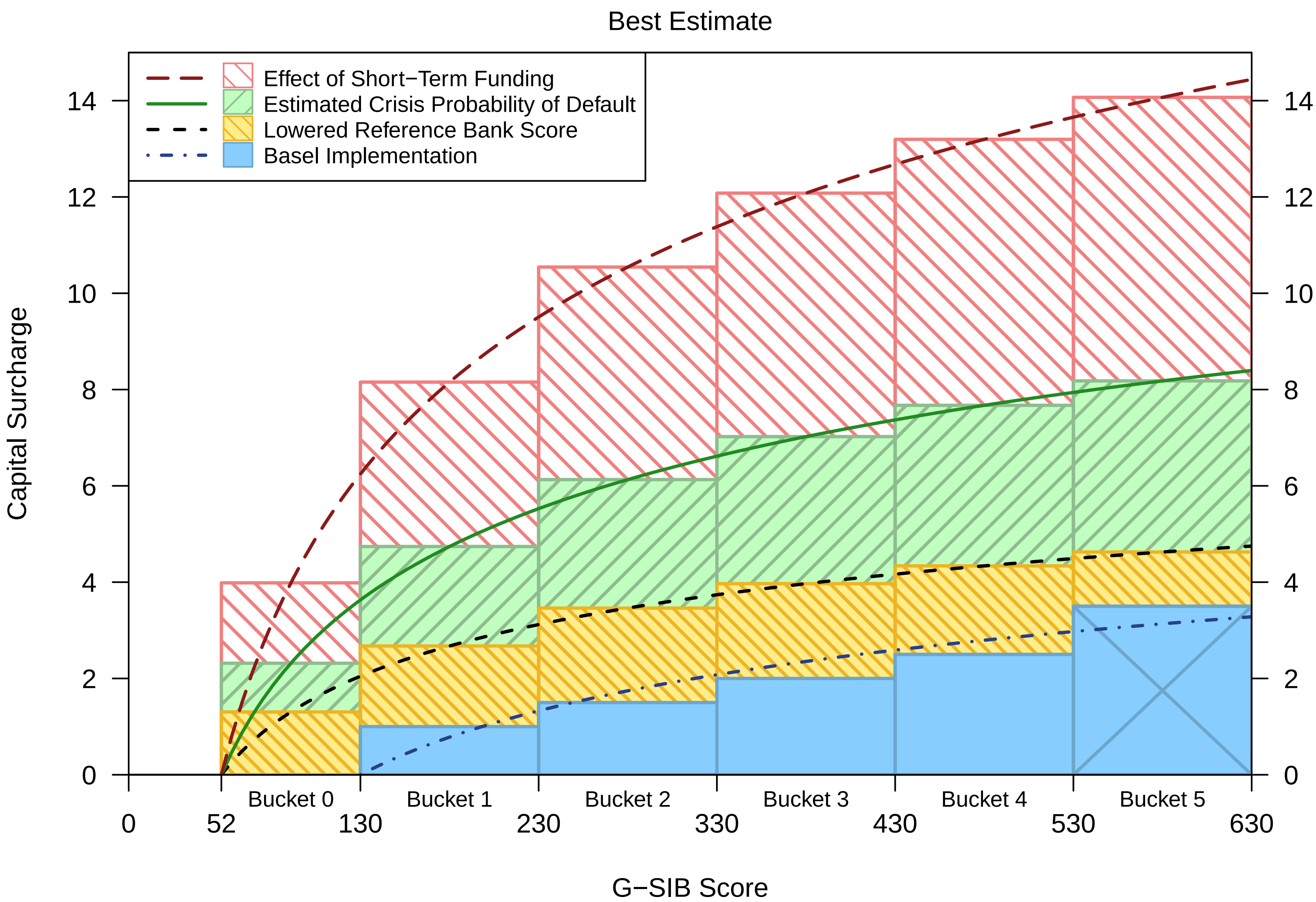


Note: The red line is the ordinary least squares regression line.

Source: G−SIB demoninators are available from BCBS (2016a), and G−SIB disclosures available from BCBS (2016b).

Figure 8

Estimated Global Systemically Important Bank Capital Surcharges

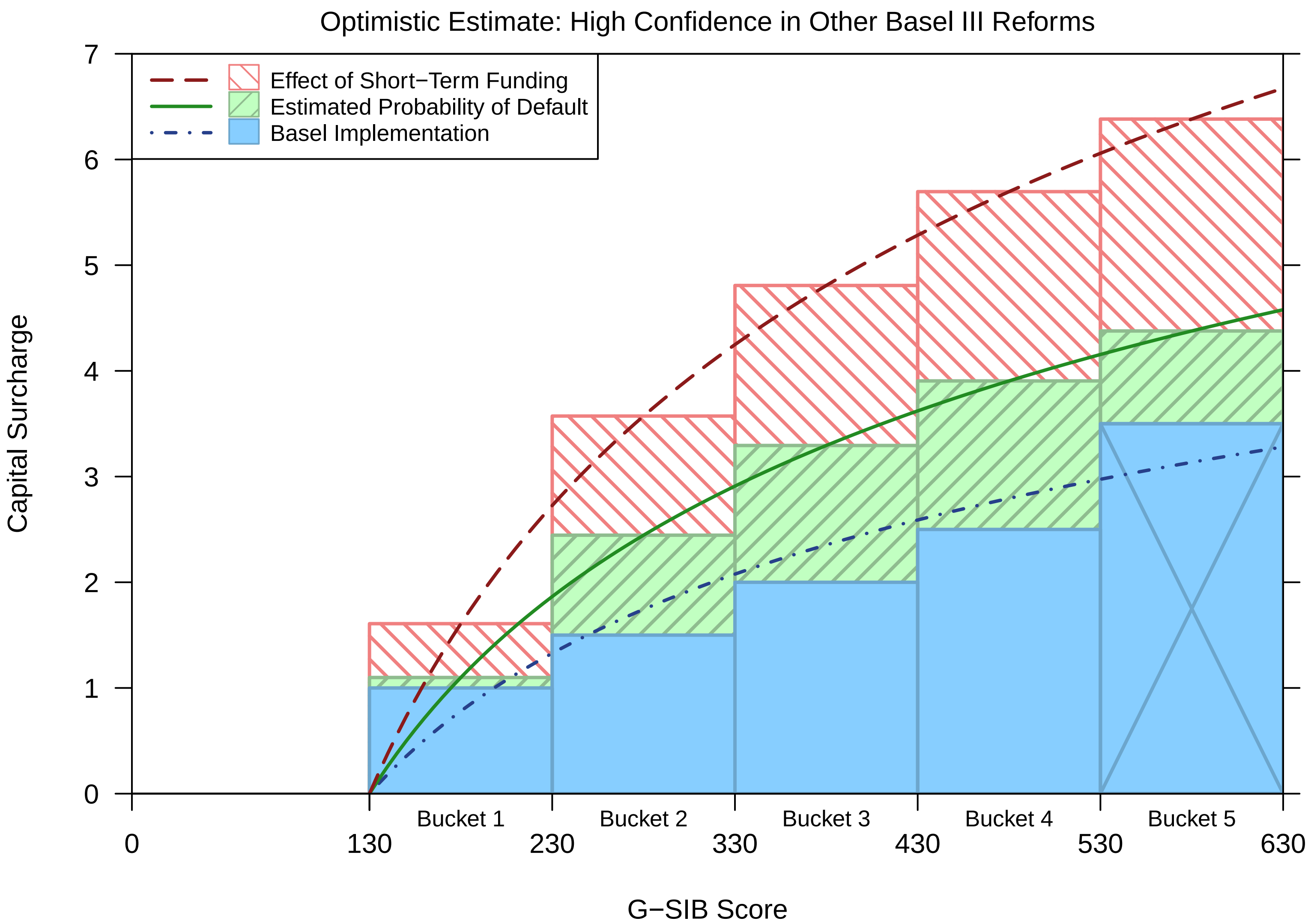


Note: See BCBS (2013) for details about the global systemically important bank (G−SIB) score. For Basel capital surcharges, the reference bank G−SIB score is 130 basis points; for the best estimate, the reference bank G−SIB score is 52 basis points, which is the lower bound of the one−sided 95 percent confidence interval of the correlated loss model centered at 130 basis points. Probability of default and the effect of short−term funding are estimated using the lower tail of the return on risk−weighted assets distribution from 2008−2013. Bucket 5 is crossed out to indicate that it is empty (Financial Stability Board, 2016). Continuous capital surcharges are based on a capital conservation buffer of 2.5 percent from BCBS (2010).

Source: Basel capital buckets available from BCBS (2013a), G−SIB demoninators are available from BCBS (2016a), G−SIB disclosures available from BCBS (2016b), and 2008−2013 annual data available from Bureau van Dijk (2016).

Figure 9

Estimated Global Systemically Important Bank Capital Surcharges

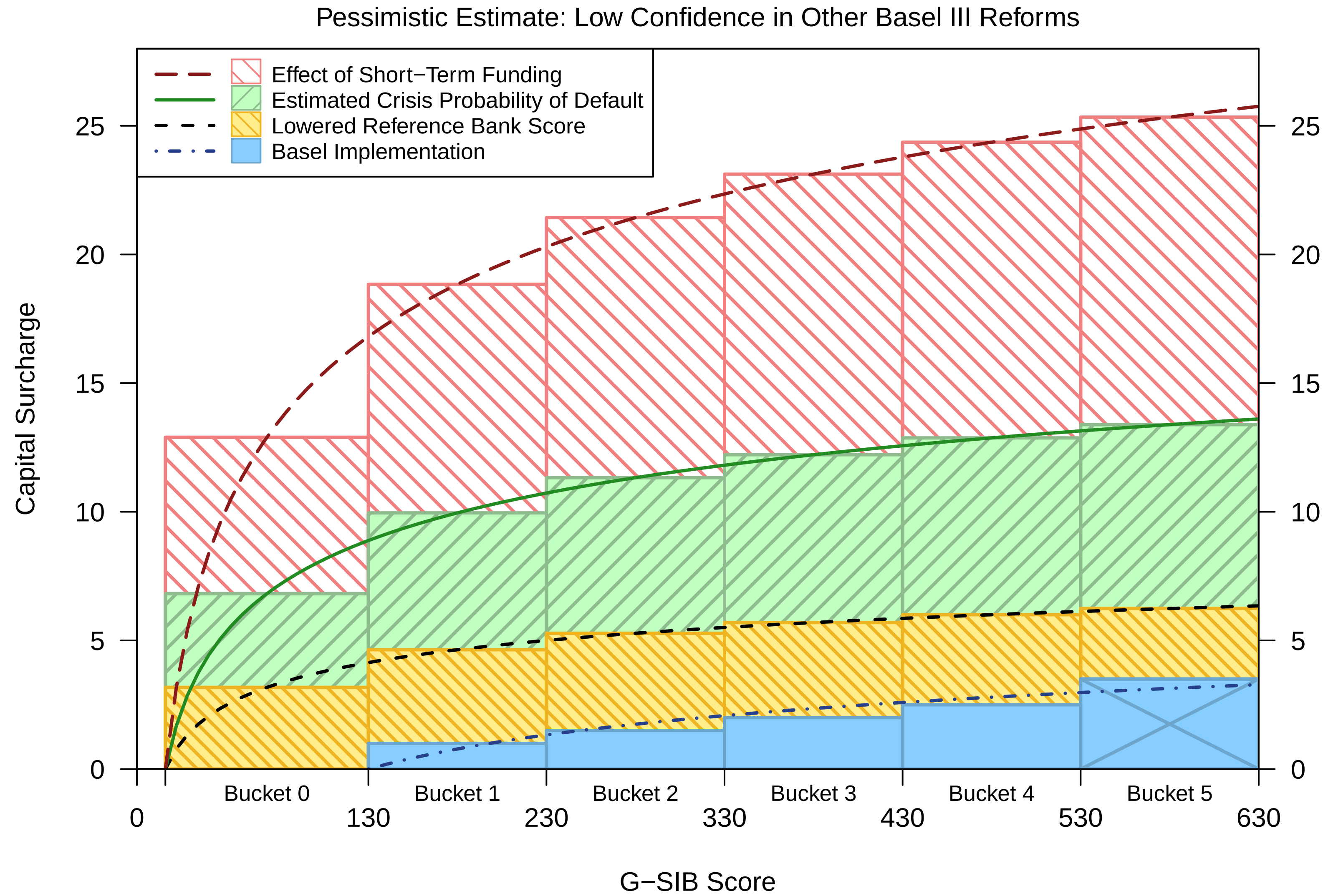


Note: See BCBS (2013) for details about the global systemically important bank (G−SIB) score. For Basel capital surcharges and the optimistic estimate, the reference bank G−SIB score is 130 basis points. Probability of default and the effect of short−term funding are estimated using the lower tail of the return on risk−weighted assets distribution from 2008−2013; the optimistic estimate uses the lower bounds of the 95 percent confidence intervals of estimated parameters. Bucket 5 is crossed out to indicate that it is empty (Financial Stability Board, 2016). Continuous capital surcharges are based on a capital conservation buffer of 2.5 percent from BCBS (2010).

Source: Basel capital buckets available from BCBS (2013a), G−SIB demoninators are available from BCBS (2016a), G−SIB disclosures available from BCBS (2016b), and 2008−2013 annual data available from Bureau van Dijk (2016).

Figure 10

Estimated Global Systemically Important Bank Capital Surcharges



Note: See BCBS (2013) for details about the global systemically important bank (G−SIB) score. For Basel capital surcharges, the reference bank G−SIB score is 130 basis points; for the pessimistic estimate, the reference bank G−SIB score is 16 basis points, which is the minimum G−SIB score in the Basel sample of banks. Probability of default and the effect of short−term funding are estimated using the lower tail of the return on risk−weighted assets distribution from 2008−2013; the pessimistic estimate uses the upper bounds of the 95 percent confidence intervals of estimated parameters. Bucket 5 is crossed out to indicate that it is empty (Financial Stability Board, 2016). Continuous capital surcharges are based on a capital conservation buffer of 2.5 percent from BCBS (2010).

Source: Basel capital buckets available from BCBS (2013a), G−SIB demoninators are available from BCBS (2016a), G−SIB disclosures available from BCBS (2016b), and 2008−2013 annual data available from Bureau van Dijk (2016).

Table 8: Comparison Between Basel and Estimated G-SIB Capital Surcharges

	G-SIB Score Range	Basel	Best	Optimistic	Pessimistic
Bucket 5	530 - 629	350	825 / 1400	450 / 650	1350 / 2525
Bucket 4	430 - 529	250	775 / 1325	400 / 575	1275 / 2425
Bucket 3	330 - 429	200	700 / 1200	325 / 475	1225 / 2300
Bucket 2	230 - 329	150	625 / 1050	250 / 350	1125 / 2150
Bucket 1	130 - 229	100	475 / 825	100 / 150	1000 / 1875
Bucket 0	x - 129	-	225 / 400	-	675 / 1300
			(x = 52)		(x = 16)

Note: Units for G-SIB scores and capital surcharges are basis points. See BCBS (2013) for details about the global systemically important bank (G-SIB) score. For the Basel implementation and the optimistic estimate, the reference bank G-SIB score is 130 basis points. For the best estimate, the reference bank G-SIB score is 52 basis points, which is the lower bound of the one-sided 95 percent confidence interval of the correlated loss model centered at 130 basis points. For the pessimistic estimate, the reference bank G-SIB score is 16 basis points, which is the minimum G-SIB score in the Basel sample of banks. Probability of default and the effect of short-term funding are estimated using the lower tail of the return on risk-weighted assets distribution from 2008-2013; the best, optimistic, and pessimistic estimates use the mean estimate, the lower bounds of the 95 percent confidence intervals, and the upper bounds of the 95 percent confidence intervals, respectively. For each estimated bucket, the smaller capital surcharge applies to banks that fund less than 10 percent of their risk-weighted assets with short-term funding, and the larger capital surcharge applies to banks that fund more than 10 percent of their risk-weighted assets with short-term funding. Bucket 5 is empty (Financial Stability Board, 2016). Estimated capital surcharges assume the capital conservation buffer of 2.5 percent from BCBS (2010).

Source: Basel capital buckets available from BCBS (2013a), G-SIB demoninators are available from BCBS (2016a), G-SIB disclosures available from BCBS (2016b), and 2000-2013 annual data available from Bureau van Dijk (2016).

Table A1: Risk-Weighted Assets on Total Assets

	Dependent Variable
	Risk-Weighted Assets (in billions)
Total Assets (in billions)	0.396***
	(0.006)
Constant	28.230***
	(5.005)
Observations	779
R^2	0.830
Adjusted R^2	0.830
Note:	*p<0.1; **p<0.05; ***p<0.01

Note: $50 billion total asset cutoff (in 2015; deflated by world GDP for 2000-2014).

Source: 2009-2015 annual data available from Bureau van Dijk (2016).

Table A2: Regressions of G-SIB Indicators on Total Exposures

	Dependent Variable					
			Market Share of			
	Intra-financial Assets	Intra-financial Liabilities	Securities Outstanding	Payment Activity	Assets Under Custody	Underwriting Activity
	(1)	(2)	(3)	(4)	(5)	(6)
Total Exposures	0.953***	0.893***	0.753***	1.234***	0.710	1.284***
	(0.073)	(0.088)	(0.069)	(0.250)	(0.438)	(0.186)
Constant	19.562	17.341	33.529***	−24.768	56.949	−26.584
	(12.652)	(15.220)	(11.959)	(43.279)	(75.700)	(32.154)
Observations	62	62	62	62	62	62
R^2	0.738	0.631	0.664	0.288	0.042	0.443
Adjusted R^2	0.734	0.625	0.658	0.276	0.026	0.433
Note:						*p<0.1; **p<0.05; ***p<0.01

Table A3: Regressions of G-SIB Indicators on Total Exposures

	Dependent Variable				
			Market Share of		
	OTC Derivatives	Trading/AFS Securities	Level 3 Assets	Cross-jurisdictional Claims	Cross-jurisdictional Liabilities
	(1)	(2)	(3)	(4)	(5)
Total Exposures	1.309***	1.117***	1.112***	0.913***	0.924***
	(0.243)	(0.172)	(0.155)	(0.153)	(0.151)
Constant	−24.311	−4.553	−15.825	26.790	23.423
	(42.026)	(29.659)	(26.836)	(26.509)	(26.120)
Observations	62	62	62	62	62
R^2	0.326	0.414	0.461	0.371	0.384
Adjusted R^2	0.314	0.404	0.452	0.361	0.374
Note:					*p<0.1; **p<0.05; ***p<0.01

Note: G-SIB is global systemically important bank, OTC derivatives are over-the-counter derivatives, and AFS securities are available for sale securities.

Source: G-SIB demoninators available from BCBS (2016a), and G-SIB disclosures available from BCBS (2016b).

Table A4: Factor Loadings of Residuals

Residuals of	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
Intra-financial Assets	0.432	0.048	0.177	0.785	0.060	0.014
Intra-financial Liabilities	0.103	0.628	0.372	0.332	0.004	0.226
Securities Outstanding	0.229	0.054	0.131	-0.017	0.521	-0.059
Payment Activity	0.301	0.816	0.029	-0.020	0.054	-0.012
Assets Under Custody	-0.015	0.968	0.002	0.011	0.158	-0.040
Underwriting Activity	0.741	0.142	0.198	0.167	0.354	-0.071
OTC Derivatives	0.880	0.173	0.226	0.214	0.219	0.076
Trading/AFS Securities	0.426	0.187	-0.001	0.225	0.569	0.247
Level 3 Assets	0.591	0.106	-0.057	0.377	0.346	0.040
Cross-jurisdictional Claims	0.189	0.044	0.921	0.076	0.089	0.133
Cross-jurisdictional Liabilities	0.060	0.097	0.975	0.085	0.097	-0.125

Note: The rotation method used is Varimax. OTC derivatives are over-the-counter derivatives, and AFS securities are available for sale securities.

Source: G-SIB demoninators available from BCBS (2016a), and G-SIB disclosures available from BCBS (2016b).

Table A5: Regression of G-SIB Score on Total Exposures and Factors

	Dependent Variable
	G-SIB Score
Total Exposures Indicator	0.947***
	(0.017)
Factor 1	0.120***
	(0.009)
Factor 2	0.045***
	(0.004)
Factor 3	0.117***
	(0.008)
Factor 4	0.140***
	(0.048)
Constant	10.944***
	(2.918)
Observations	62
R^2	0.987
Adjusted R^2	0.986
Note:	*p<0.1; **p<0.05; ***p<0.01

Note: Factors are weighted averages of residuals from table A3; loading cutoff is 0.7. G-SIB is global systemically important bank.

Source: G-SIB demoninators available from BCBS (2016a), and G-SIB disclosures available from BCBS (2016b).

Table A6: Regression of SRISK Share on Total Exposures and Factors

	Dependent Variable		
	SRISK Share (in bps)		
	(1)	(2)	(3)
Total Exposures Indicator	1.164***	1.169***	1.169***
	(0.097)	(0.097)	(0.096)
Factor 1	−0.060	−0.032	
	(0.051)	(0.041)	
Factor 2	−0.029	−0.031	−0.035*
	(0.021)	(0.021)	(0.021)
Factor 3	0.200***	0.206***	0.192***
	(0.048)	(0.047)	(0.044)
Factor 4	0.275		
	(0.301)		
Constant	10.490	9.140	8.947
	(17.356)	(17.265)	(17.202)
Observations	56	56	56
R^2	0.770	0.767	0.764
Adjusted R^2	0.748	0.748	0.750
Note:	*p<0.1; **p<0.05; ***p<0.01		

Note: Factors are weighted averages of residuals from table A3; loading cutoff is 0.7. G-SIB is global systemically important bank.

Source: G-SIB demoninators available from BCBS (2016a), G-SIB disclosures available from BCBS (2016b), and SRISK from The Volatility Laboratory of the NYU Stern Volatility Institute (https://vlab.stern.nyu.edu) (2016).

Table A7: Indicator Weights Estimated using Factor Analysis

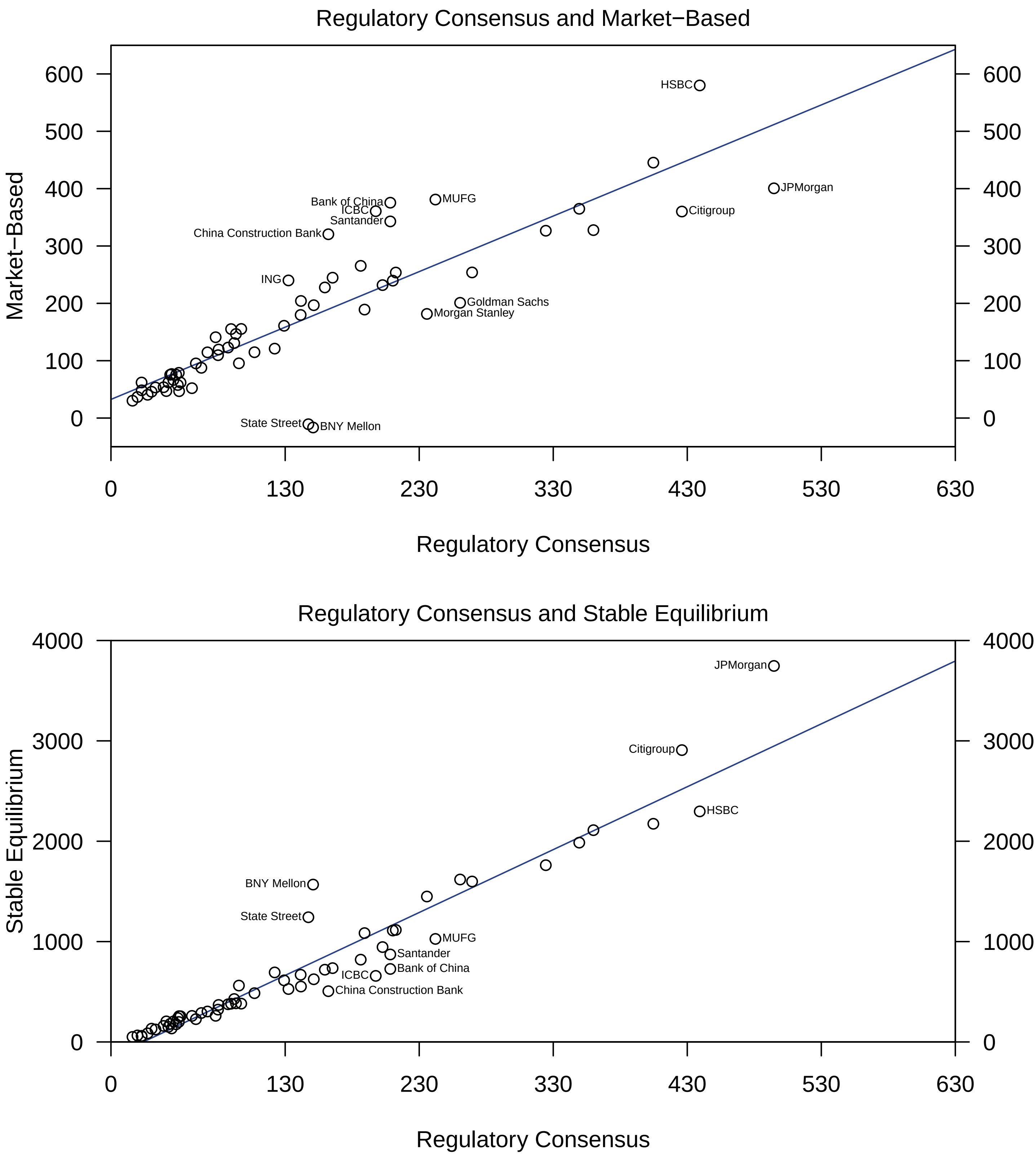
Indicator	Regulatory Consensus	Regulatory Consensus*	Market-Based*	Stable Equilibrium
Total Exposures	20.0	33.8	74.8	-
Intra-financial Assets	6.7	12.0	-	3.1
Intra-financial Liabilities	6.7	-	-	5.7
Securities Outstanding	6.7	-	-	2.3
Payment Activity	6.7	4.0	-2.4	7.6
Assets Under Custody	6.7	4.7	-2.8	12.3
Underwriting Activity	6.7	9.7	-	13.8
OTC Derivatives	6.7	11.5	-	12.6
Trading/AFS Securities	6.7	-	-	8.9
Level 3 Assets	6.7	-	-	11.7
Cross-jurisdictional Claims	10.0	11.8	14.8	11.8
Cross-jurisdictional Liabilities	10.0	12.5	15.6	10.3

Note: * indicates weights derived using factor analysis. Weights are in percent and scaled to sum to 100 percent. OTC derivatives are over-the-counter derivatives, and AFS securities are available for sale securities.

Source: G-SIB demoninators available from BCBS (2016a), G-SIB disclosures available from BCBS (2016b), and SRISK available from The Volatility Laboratory of the NYU Stern Volatility Institute (https://vlab.stern.nyu.edu) (2016).

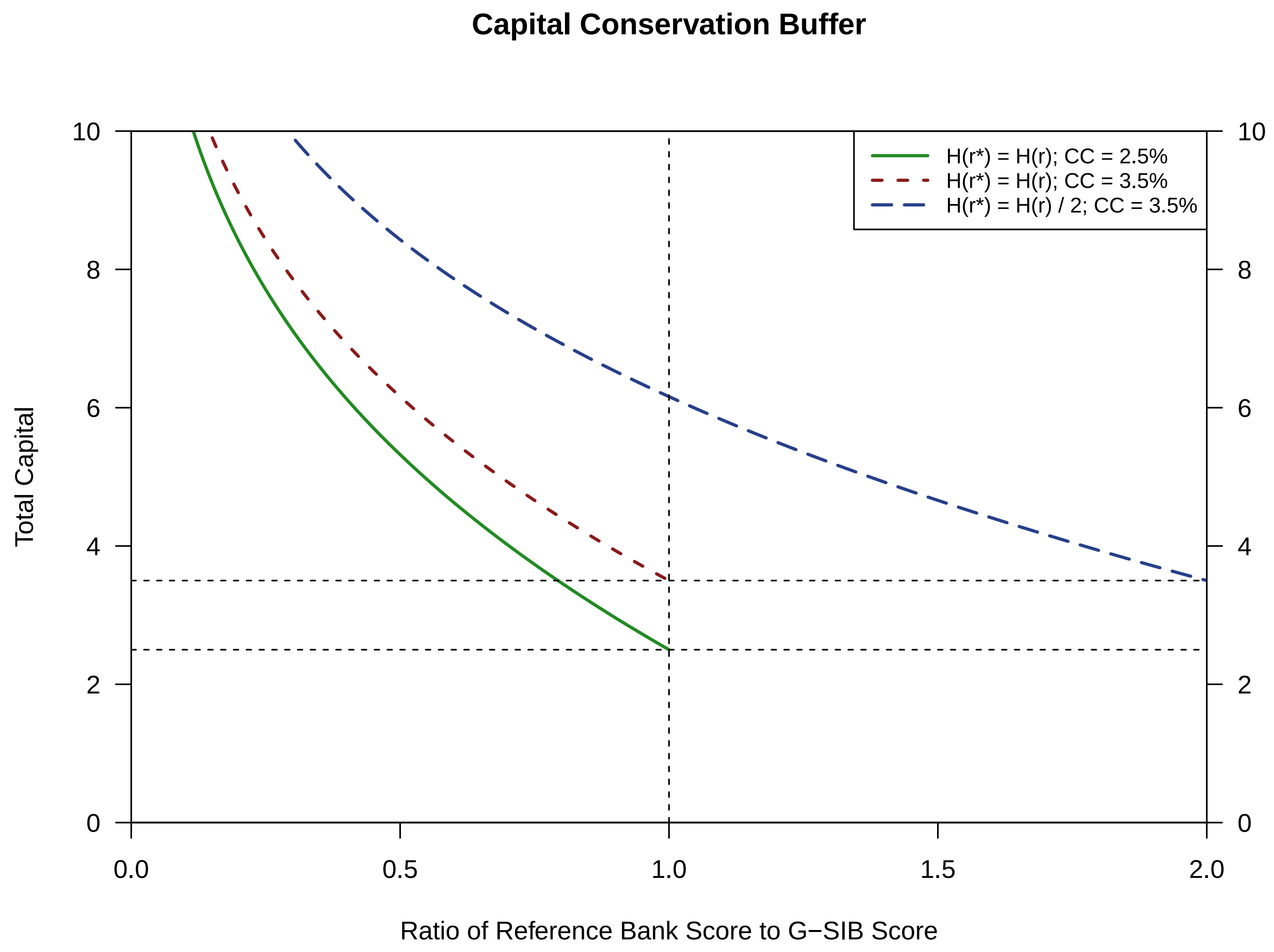
Figure A1

Alternate G−SIB Score Weights



Source: G−SIB demoninators are available from BCBS (2016a), G−SIB disclosures available from BCBS (2016b), and SRISK from The Volatility Laboratory of the NYU Stern Volatility Institute (https://vlab.stern.nyu.edu) (2016).

Figure A2



Note: Total capital is the sum of the capital conservation buffer (CC) and the G−SIB capital surcharge. Horizontal dashed lines indicate the current Basel capital conservation buffers of 2.5 percent and capital conservation buffer of 3.5 percent. The vertical dashed line indicates a reference bank score (H(r)) equal to the Basel's reference bank score. G−SIB is global systemically important bank.

Source: 2008−2013 annual data available from Bureau van Dijk (2016)