Calibrating the GSIB Surcharge

July 20, 2015

BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM

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Abstract

This white paper discusses how to calibrate a capital surcharge that tracks the systemic footprint of a global systemically important bank holding company (GSIB). There is no widely accepted calibration methodology for determining such a surcharge. The white paper focuses on the "expected impact" framework, which is based on each GSIB's expected impact on the financial system, understood as the harm it would cause to the financial system were it to fail multiplied by the probability that it will fail. Because a GSIB's failure would cause more harm than the failure of a non-GSIB, a GSIB should hold enough capital to lower its probability of failure so that its expected impact is approximately equal to that of a non-GSIB.

Applying the expected impact framework requires several elements. First, it requires a method for measuring the relative harm that a given banking firm's failure would cause to the financial system—that is, its systemic footprint. This white paper uses the two methods as set forth in the GSIB surcharge rule to quantify a firm's systemic impact. Those methods look to attributes of a firm that are drivers of its systemic importance, such as size, interconnectedness, and cross-border activity. Both methodologies use the most recent data available, and firms' scores will change over time as their systemic footprints change. Second, the expected impact framework requires a means of estimating the probability that a firm with a given level of capital will fail. This white paper estimates that relationship using historical data on the probability that a large U.S. banking firm will experience losses of various sizes. Third, the expected impact framework requires the choice of a "reference" bank holding company: a large, non-GSIB banking firm whose failure would not pose an outsized risk to the financial system. This white paper discusses several plausible choices of reference BHC.

With these elements, it is possible to estimate a capital surcharge that would reduce a GSIB's expected impact to that of a non-GSIB reference BHC. For each choice of reference BHC, the white paper provides the ranges of reasonable surcharges for each U.S. GSIB.

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Introduction

The Dodd-Frank Wall Street Reform and Consumer Protection Act[1] mandates that the Board of Governors of the Federal Reserve System adopt, among other prudential measures, enhanced capital standards to mitigate the risk posed to financial stability by systemically important financial institutions (SIFIs). The Board has already implemented a number of measures designed to strengthen firms' capital positions in a manner consistent with the Dodd-Frank Act's requirement that such measures increase in stringency based on the systemic importance of the firm.

As part of this process, the Board has proposed a set of capital surcharges to be applied to the eight U.S. bank holding companies (BHCs) of the greatest systemic importance, which have been denominated global systemically important bank holding companies (GSIBs). Setting such an enhanced capital standard entails (1) measuring the risk that a given GSIB's failure poses to financial stability (that is, the GSIB's systemic footprint) and (2) estimating how much additional capital is needed to mitigate the systemic risk posed by a firm with a given systemic footprint.

This white paper explains the calibration of the capital surcharges, based on the measures of each GSIB's systemic footprint derived from the two methods described in the GSIB surcharge final rule and discussed in detail in the preamble to the rule. Because there is no single widely accepted framework for calibrating a GSIB surcharge, the Board considered several potential approaches. This paper focuses on the "expected impact" framework, which is the most appropriate approach for helping to scale the level of a capital surcharge. This paper explains the expected impact framework in detail. It provides surcharge calibrations resulting from that framework under a range of plausible assumptions, incorporating the uncertainty that is inherent in the study of rare events such as systemic banking failures. This paper also discusses, at a high level, two alternative calibration frameworks, and it explains why neither seemed as useful as a framework for the calibration of the GSIB surcharge.

Background

The failures and near-failures of SIFIs were key drivers of the 2007–08 financial crisis and the resulting recession. They were also key drivers of the public-sector response to the crisis, in which the United States government sought to prevent SIFI failures through extraordinary measures such as the Troubled Asset Relief Program. The experience of the crisis made clear that the failure of a SIFI during a period of stress can do great damage to financial stability, that SIFIs themselves lack sufficient incentives to take precautions against their own failures, that reliance on extraordinary government interventions going forward would invite moral hazard and lead to competitive distortions, and that the pre-crisis regulatory focus on microprudential risks to individual financial firms needed to be broadened to include threats to the overall stability of the financial system.

In keeping with these lessons, post-crisis regulatory reform has placed great weight on "macroprudential" regulation, which seeks to address threats to financial stability. Section 165 of the Dodd-Frank Act pursues this goal by empowering the Board to establish enhanced regulatory standards for "large, interconnected financial institutions" that "are more stringent than the standards … applicable to [financial institutions] that do not present similar risks to the financial stability of the United States" and "increase in stringency" in proportion to the systemic importance of the financial institution in question.[2] Section 165(b)(1)(A)(i) of the act points to risk-based capital requirements as a required type of enhanced regulatory standard for SIFIs.

[1] Pub. L. No. 111-203, 124 Stat. 1376 (July 21, 2010).

[2] Section 165(a)(1).

Rationales for a GSIB Surcharge

The Dodd-Frank Act's mandate that the Board adopt enhanced capital standards to mitigate the risk posed to financial stability by certain large financial institutions provides the principal statutory impetus for enhanced capital requirements for SIFIs. Because the failure of a SIFI could undermine financial stability and thus cause far greater negative externalities than could the failure of a financial institution that is not systemically important, a probability of default that would be acceptable for a non-systemic firm may be unacceptably high for a SIFI. Reducing the probability that a SIFI will default reduces the risk to financial stability. The most straightforward means of lowering a financial firm's probability of default is to require it to hold a higher level of capital relative to its risk-weighted assets than non-SIFIs are required to hold, thereby enabling it to absorb greater losses without becoming insolvent.

There are also two secondary rationales for enhanced capital standards for SIFIs. First, higher capital requirements create incentives for SIFIs to shrink their systemic footprint, which further reduces the risks these firms pose to financial stability. Second, higher capital requirements may offset any funding advantage that SIFIs have on account of being perceived as "too big to fail," which reduces the distortion in market competition caused by the perception and the potential that counterparties may inappropriately shift more risk to SIFIs, thereby increasing the risk those firms pose to the financial system. Increased capital makes GSIBs more resilient in times of economic stress, and, by increasing the capital cushion available to the firm, may afford the firm and supervisors more time to address weaknesses at the firm that could reverberate through the financial system were the firm to fail.

The Expected Impact Framework

By definition, a GSIB's failure would cause greater harm to financial stability than the failure of a banking organization that is not a GSIB.[3] Thus, if all banking organizations are subject to the same risk-based capital requirements and have similar probabilities of default, GSIBs will impose far greater systemic risks than non-GSIBs will. The expected impact framework addresses this discrepancy by subjecting GSIBs to capital surcharges that are large enough that the expected systemic loss from the failure of a given GSIB better approximates the expected systemic loss from the failure of a BHC that is large but is not a GSIB. (We will call this BHC the "reference BHC.")

The expected loss from a given firm's failure can be computed as the systemic losses that would occur if that firm failed, discounted by the probability of its failure. Using the acronyms LGD (systemic loss given default), PD (probability of default), and EL (expected loss), this idea can be expressed as follows:

$$EL = LGD * PD$$

The goal of a GSIB surcharge is to equalize the expected loss from a GSIB's failure to the expected loss from the failure of a non-GSIB reference BHC:

$$EL_{GSIB} = EL_r$$

By definition, a GSIB's LGD is higher than that of a non-GSIB. So to equalize EL between GSIBs and non-GSIBs, we must require each GSIB to lower its PD, which we can do by requiring it to hold more capital.

This implies that a GSIB must increase its capital level to the extent necessary to reach a PD that is as many times lower than the PD of the reference BHC as its LGD is higher than the LGD of the reference BHC. (For example, suppose that a particular GSIB's failure would cause twice as much loss as the failure of the reference BHC. In that case, to equalize EL between the two firms, we must require the GSIB to hold enough additional capital that its PD is half that of the reference BHC.) That determination requires the following components, which we will consider in turn:

1. A method for creating "LGD scores" that quantify the GSIBs' LGDs
2. An LGD score for the reference BHC
3. A function relating a firm's capital ratio to its PD

Quantifying GSIB LGDs

The final rule employs two methods to measure GSIB LGD:

- **Method 1** is based on the internationally accepted GSIB surcharge framework, which produces a score derived from a firm's attributes in five categories: size, interconnectedness, complexity, cross-jurisdictional activity, and substitutability.
- **Method 2** replaces method 1's substitutability category with a measure of a firm's reliance on short-term wholesale funding.

The preambles to the GSIB surcharge notice of proposed rulemaking and final rule explain why these categories serve as proxies for the systemic importance of a banking organization (and thus the systemic harm that its failure would cause). They also explain how the categories are weighted to produce scores under method 1 and method 2. Table 1 conveys the Board's estimates of the current scores for

[3] Cf. Dodd-Frank Act section 165(a)(1), which instructs the Board to apply more stringent prudential standards to certain large financial firms "[i]n order to prevent or mitigate risks to the financial stability of the United States that could arise from the material financial distress or failure … of large, interconnected financial institutions." As illustrated by the financial crisis that led Congress to enact the Dodd-Frank Act, financial instability can lead to a wide range of social harms, including the declines in employment and GDP growth that are associated with an economic recession.

Table 1. Top eight scores under each method

Firm	Method 1 score	Method 2 score
JPMorgan Chase	473	857
Citigroup	409	714
Bank of America	311	559
Goldman Sachs	248	585
Morgan Stanley	224	545
Wells Fargo	197	352
Bank of New York Mellon	149	213
State Street	146	275

Note: These estimates are based on data sources described below. They may not reflect the actual scores of a given firm. Method 1 estimates were produced using indicator data reported by firms on the FR Y-15 as of December 31, 2014, and global aggregate denominators reported by the Basel Committee on Banking Supervision (BCBS) as of December 31, 2013. Method 2 estimates were produced using the same indicator data and the average of the global aggregate denominators reported by the BCBS as of the ends of 2012 and 2013. For the eight U.S. BHCs with the highest scores, the short-term wholesale funding component of method 2 was estimated using liquidity data collected through the supervisory process and averaged across 2014. Unless otherwise specified, these data sources were used to estimate all method 1 and method 2 scores included in this paper.

the eight U.S. BHCs with the highest scores. These scores are estimated from the most recent available data on firm-specific indicators of systemic importance. The actual scores that will apply when the final rule takes effect may be different and will depend on the future evolution of the firm-specific indicator values.

This paper assumes that the relationships between the scores produced by these methods and the firms' systemic LGDs are linear. In other words, it assumes that if firm A's score is twice as high as firm B's score, then the systemic harms that would flow from firm A's failure would be twice as great as those that would flow from firm B's failure.

In fact, there is reason to believe that firm A's failure would do more than twice as much damage as firm B's. (In other words, there is reason to believe that the function relating the scores to systemic LGD increases at an increasing rate and is therefore non-linear.) The reason is that at least some of the components of the two methods appear to increase the systemic harms that would result from a default at an increasing rate, while none appears to increase the resulting systemic harm at a decreasing rate. For example, because the negative price impact associated with the fire-sale liquidation of certain asset portfolios increases with the size of the portfolio, systemic LGD appears to grow at an increasing rate with the size, complexity, and short-term wholesale funding metrics used in the methods. Thus, this paper's assumption of a linear relationship simplifies the analysis while likely resulting in surcharges lower than those that would result if the relationship between scores and systemic LGD were assumed to be non-linear.

The Reference BHC's Systemic LGD Score

The reference BHC is a real or hypothetical BHC whose LGD will be used in our calculations. The expected impact framework requires that the reference BHC be a non-GSIB, but it leaves room for discretion as to the reference BHC's identity and LGD score.

Potential Approaches

The reference BHC score can be viewed as simply the LGD score which, given the PD associated with the generally applicable capital requirements, produces the highest EL that is consistent with the purposes and mandate of the Dodd-Frank Act. The effect of setting the reference BHC score to that LGD score would be to hold all GSIBs to that EL level. The purpose of the Dodd-Frank Act is "to prevent or mitigate risks to the financial stability of the United States that could arise from the material financial distress or failure, or ongoing activities, of large, interconnected financial institutions."[4] The following options appear to be conceptually plausible ways of identifying the reference BHC for purposes of establishing a capital requirement for GSIBs that lowers the expected loss from the failure of a GSIB to the level associated with the failure of a non-GSIB.

Option 1: A BHC with $50 billion in assets. Section 165(a)(1) of the Dodd-Frank Act calls for the Board to "establish prudential standards for … bank holding companies with total consolidated assets equal to or greater than $50,000,000,000 that (A) are more stringent than the standards … applicable to … bank holding companies that do not present similar risks to the financial stability of the United States; and (B) increase in stringency." Section 165 is the principal statutory basis for the GSIB surcharge, and its $50 billion figure provides a line below which it may be argued that Congress did not believe that BHCs present sufficient "risks to the financial stability of the United States" to warrant mandatory enhanced prudential standards. It would therefore be

[4] Section 165(a)(1).

reasonable to require GSIBs to hold enough capital to reduce their expected systemic loss to an amount equal to that of a $50 billion BHC that complies with the generally applicable capital rules. Although $50 billion BHCs could have a range of LGD scores based upon their other attributes, reasonable score estimates for a BHC of that size are 3 under method 1 and 37 under method 2.[5]

Option 2: A BHC with $250 billion in assets. The Board's implementation of the advanced approaches capital framework imposes enhanced requirements on banking organizations with at least $250 billion in consolidated assets. This level distinguishes the largest and most internationally active U.S. banking organizations, which are subject to other enhanced capital standards, including the countercyclical capital buffer and the supplementary leverage ratio.[6] The $250 billion threshold therefore provides another viable line for distinguishing between the large, complex, internationally active banking organizations that pose a substantial threat to financial stability and those that do not pose such a substantial threat. Although $250 billion BHCs could have a range of LGD scores based upon their other attributes, reasonable score estimates for a BHC of that size are 23 under method 1 and 60 under method 2.[7]

Option 3: The U.S. non-GSIB with the highest LGD score. Another plausible reference BHC is the actual U.S. non-GSIB BHC that comes closest to being a GSIB—in other words, the U.S. non-GSIB with the highest LGD score. Under method 1, the highest score for a U.S. non-GSIB is 51 (the second-highest is 39). Under method 2, the highest score for a U.S. non-GSIB is estimated to be 85 (the second- and third-highest scores are both estimated to be 75).[8]

Option 4: A hypothetical BHC at the cut-off line between GSIBs and non-GSIBs. Given that BHCs are divided into GSIBs and non-GSIBs based on their systemic footprint and that LGD scores provide our metric for quantifying firms' systemic footprints, there must be some LGD score under each method that marks the "cut-off line" between GSIBs and non-GSIBs. The reference BHC's score should be no higher than this cut-off line, since the goal of the expected impact framework is to lower each GSIB's EL so that it equals the EL of a non-GSIB. Under this option, the reference BHC's score should also be no *lower* than the cut-off line, since if it were lower, then a non-GSIB firm could exist that had a higher LGD and therefore (because it would not be subject to a GSIB surcharge) a higher EL than GSIBs are permitted to have. Under this reasoning, the reference BHC should have an LGD score that is exactly on the cut-off line between GSIBs and non-GSIBs. That is, it should be just on the cusp of being a GSIB.

What LGD score marks the cut-off line between GSIB and non-GSIB? With respect to method 1, figure 1 shows that there is a large drop-off between the eighth-highest score (146) and the ninth-highest score (51). Drawing the cut-off line within this target range is reasonable because firms with scores at or below 51 are much closer in size and complexity to financial firms that have been resolved in an orderly fashion than they are to the largest financial firms, which have scores between three and nine times as high and are significantly larger and more complex. We will choose a cut-off line at 130, which is at the high end of the target range. This choice is appropriate because it aligns with international standards and facilitates comparability among jurisdictions. It also establishes minimum capital surcharges that are consistent internationally.

A similar approach can be used under method 2. Figure 2 depicts the estimated method 2 scores of the eleven U.S. BHCs with the highest estimated scores.

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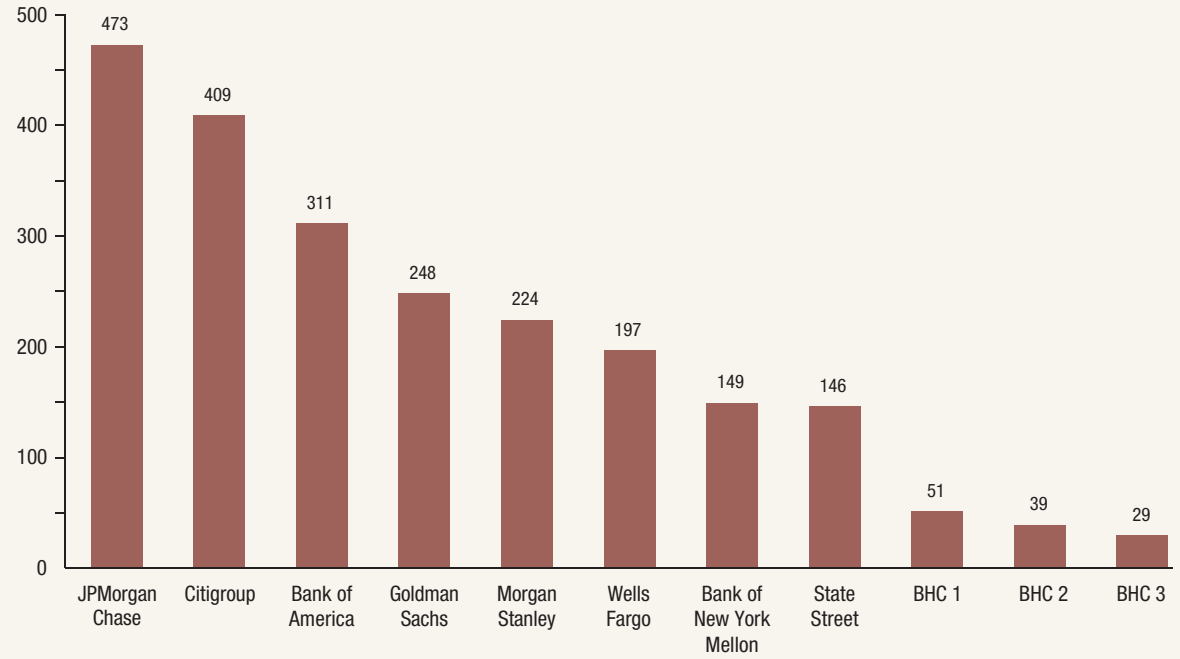
[5] These estimates were produced by plotting the estimated scores of six U.S. BHCs with total assets between $50 billion and $100 billion against their total assets, running a linear regression, and finding the score implied by the regression for a $50 billion firm. These firms' scores were estimated using data from the sources described in the general note to table 1, except that figures for the short-term wholesale funding component of method 2 were estimated using FR Y-9C data from the first quarter of 2015 and Federal Reserve quantitative impact study (QIS) data as of the fourth quarter of 2014. Scores for firms with total assets below $50 billion were not estimated (and therefore were not included in the regression analysis) because the Federal Reserve does not collect as much data from those firms.

[6] Advanced approaches banking organizations also include firms with on-balance sheet foreign exposures of $10 billion or more.

[7] These estimates were produced by applying the approach described in footnote 5 to 10 U.S BHCs with total assets between $100 billion and $400 billion. Bank of New York Mellon and State Street, which have total assets within that range, were excluded from the sample because they are GSIBs and the expected impact framework assumes that the reference BHC is a non-GSIB.

[8] These estimates were produced using data from the sources described in the general note to table 1, except that figures for the short-term wholesale funding component of method 2 were estimated using FR Y-9C data from the first quarter of 2015 and Federal Reserve quantitative impact study (QIS) data as of the fourth quarter of 2014.

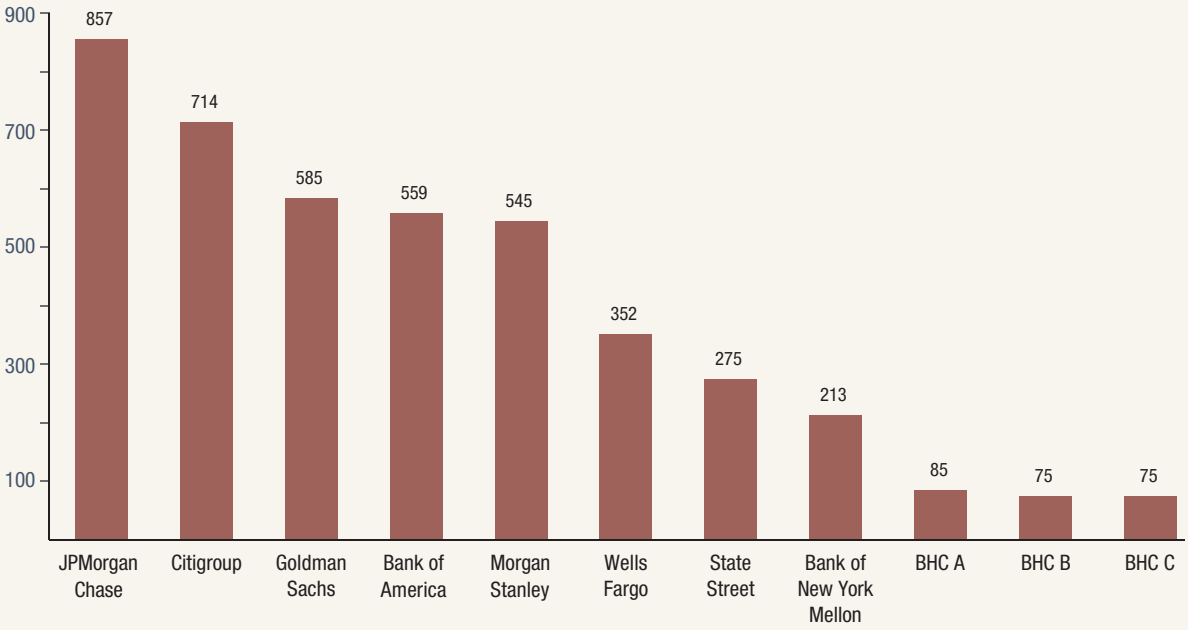
Figure 1. Estimated method 1 scores



A large drop-off in the distribution of scores with a significant difference in character of firms occurs between firms with scores above 200 and firms with scores below 100.

The range between Bank of New York Mellon and the next-highest-scoring firm is the most rational place to draw the line between GSIBs and non-GSIBs: Bank of New York Mellon's score is roughly

Figure 2. Estimated method 2 scores



251 percent of the score of the next highest-scoring firm, which is labeled BHC A. (There is also a large gap between Morgan Stanley's score and Wells Fargo's, but the former is only about 154 percent of the latter.) This approach also generates the same list of eight U.S. GSIBs as is produced by method 1. In selecting a specific line within this range, we considered the statutory mandate to protect U.S. financial stability, which argues for a method of calculating surcharges that addresses the importance of mitigating the failure of U.S. GSIBs, which are among the most systemic in the world. This would suggest a cutoff line at the lower end of the target range. The lower threshold is appropriate in light of the fact that method 2 uses a measure of short-term wholesale funding in place of substitutability. Specifically, short-term wholesale funding is believed to have particularly strong contagion effects that could more easily lead to major systemic events, both through the freezing of credit markets and through asset fire sales. These systemic impacts support the choice of a threshold at the lower end of the range for method 2.

Although the failure of a firm with the systemic footprint of BHC A poses a smaller risk to financial stability than does the failure of one of the eight GSIBs, it is nonetheless possible that the failure of a very large banking organization like BHC A, BHC B, or BHC C could have a negative effect on financial stability, particularly during a period of industry-wide stress such as occurred during the 2007–08 financial crisis. This provides additional support for our decision to draw the line between GSIBs and non-GSIBs at 100 points, at the lower end of the range between Bank of New York Mellon and BHC A.

Note that we have set our method 2 reference BHC score near the bottom of the target range and our method 1 reference BHC score near the top of the target range. Due to the choice of reference BHC in method 2, method 2 is likely to result in higher surcharges than method 1. Calculating surcharges under method 1 in part recognizes the international standards applied globally to GSIBs. Using a globally consistent approach for establishing a baseline surcharge has benefits for the stability of the entire financial system, which is globally interconnected. At the same time, using an approach that results in higher surcharges for most GSIBs is consistent with the statutory mandate to protect financial stability in the United States and with the risks presented by short-term wholesale funding.

Capital and Probability of Default

To implement the expected impact approach, we also need a function that relates capital ratio increases to reductions in probability of default. First, we use historical data drawn from FR Y-9C regulatory reports from the second quarter of 1987 through the fourth quarter of 2014 to plot the probability distribution of returns on risk-weighted assets (RORWA) for the 50 largest BHCs (determined as of each quarter), on a four-quarter rolling basis.[9] RORWA is defined as after-tax net income divided by risk-weighted assets. Return on risk-weighted assets provides a better measure of risk than return on total assets would, because the risk weightings have been calibrated to ensure that two portfolios with the same risk-weighted assets value contain roughly the same amount of risk, whereas two portfolios with total assets of the same value can contain very different amounts of risk depending on the asset classes in question.

We select this date range and set of firms to provide a large sample size while focusing on data from the relatively recent past and from very large firms, which are more germane to our purposes. Data from the past three decades may be an imperfect predictor of future trends, as there are factors that suggest that default probabilities in the future may be either lower or higher than would be predicted on the basis of the historical data.

On the one hand, these data do not reflect many of the regulatory reforms implemented in the wake of the 2007–08 financial crisis that are likely to reduce the probability of very large losses and therefore the probability of default associated with a given capital level. For example, the Basel 2.5 and Basel III capital reforms are intended to increase the risk-sensitivity of the risk weightings used to measure risk-weighted assets, which suggests that the risk of losses associated with each dollar of risk-weighted assets under Basel III will be lower than the historical, pre-Basel III trend. Similarly, post-crisis liquidity initiatives

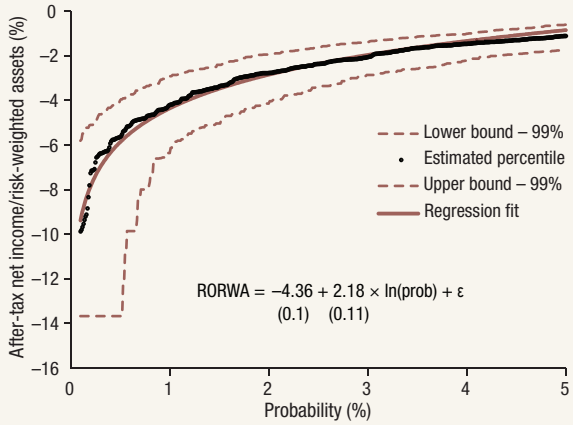
[9] Because Basel I risk-weighted assets data are only available from 1996 onward, risk-weighted assets data for earlier years are estimated by back-fitting the post-1996 ratio between risk-weighted assets and total assets onto pre-1996 total assets data. See Andrew Kuritzkes and Til Schuermann (2008), "What We Know, Don't Know, and Can't Know about Bank Risk: A View from the Trenches," University of Pennsylvania, Financial Institutions Center paper #06-05, http://fic.wharton.upenn.edu/fic/papers/06/0605.pdf.

(the liquidity coverage ratio and the net stable funding ratio) should reduce the default probabilities of large banking firms and the associated risk of fire sales. Together, these reforms may lessen a GSIB's probability of default and potentially imply a lower GSIB surcharge.

On the other hand, however, extraordinary government interventions during the time period of the dataset (particularly in response to the 2007–08 financial crisis) undoubtedly prevented or reduced large losses that many of the largest BHCs would otherwise have suffered. Because one core purpose of post-crisis reform is to avoid the need for such extraordinary interventions in the future, the GSIB surcharge should be calibrated using data that include the severe losses that would have materialized in the absence of such intervention; because the interventions in fact occurred, using historical RORWA data may lead us to underestimate the probability of default associated with a given capital level. In short, there are reasons to believe that the historical data underestimate the future trend, and there are reasons to believe that those data overestimate the future trend. Although the extent of the over- and underestimations cannot be rigorously quantified, a reasonable assumption is that they roughly cancel each other out.[10]

Figure 3 displays the estimated quantiles of ROWRA from 0.1 to 5.0. The sample quantiles are represented by black dots. The dashed lines above and below the estimated quantiles represent a 99 percent confidence interval for each estimated quantile. As shown in the figure, the uncertainty around more extreme quantiles is substantially larger than that around less extreme quantiles. This is because actual events relating to more extreme quantiles occur much less frequently and are, as a result, subject to considerably more uncertainty. The solid line that passes through the black dots is an estimated regression function that relates the estimated value of the quantile to the natural logarithm of the associated probability. The specification of the regression function is provided in

Figure 3. Returns on risk-weighted assets (RORWA) (Bottom five percentiles, 50 largest BHCs in each quarter, 2Q87 through 4Q14)



the figure which reports both the estimated coefficients of the regression function and the standard errors, in parentheses, associated with the estimated coefficients.

Figure 3 shows that RORWA is negative (that is, the firm experiences a loss) more than 5 percent of the time, with most losses amounting to less than 4 percent of risk-weighted assets. The formula for the logarithmic regression on this RORWA probability distribution (with RORWA represented by y and the percentile associated with that RORWA by x) is:

$$y = 2.18 * \ln(x) - 4.36$$

The inverse of this function, which we will label $p(RORWA)$, gives the probability that a particular realization of RORWA, $\tilde{R}$, will be less than or equal to a specified level over a given year. That function is:

$$p(\tilde{R} \leq RORWA) = p(RORWA) = e^{\frac{RORWA + 4.36}{2.18}}$$

Next, assume that a BHC becomes non-viable and consequently defaults if and only if its capital ratio k (measured in terms of common equity tier 1 capital, or CET1) falls to some failure point f. (Note that k is a variable and f is a constant.) We assume that RORWA and k are independent, which is appropriate because the return on an asset should not depend to a significant extent on the identity of the entity holding the asset or on that entity's capital ratio. We can now estimate the probability that a BHC with capital level k will suffer sufficiently severe losses (that is, a

[10] The concept of risk aversion provides additional support for this assumption. While the failure of a GSIB in any given year is unlikely, the costs from such a failure to financial stability could be severe. By contrast, any costs from higher capital surcharges will be distributed more evenly among different states of the world. Presumably society is risk-averse and, in a close case, would prefer the latter set of costs to the former. While this paper does not attempt to incorporate risk aversion into its quantitative analysis, that concept does provide additional support for the decision not to discount the historical probability of large losses in light of post-crisis regulatory reforms.

negative RORWA of sufficiently great magnitude) to bring its capital ratio down to the failure point f. We are looking for the probability that k will fall to f, that is, the probability that k + RORWA = f. Solving for RORWA, we get RORWA = f - k, which we can then plug into the function above to find the probability of default as a function of the capital ratio k:[11]

$$p(k) = e^{\frac{(f-k)+4.36}{2.18}} = e^{\frac{(f+4.36)-k}{2.18}}$$

Application

We can now create a function that takes as its input a GSIB's LGD score and produces a capital surcharge for that GSIB. In the course of doing so, we will find that the resulting surcharges are invariant to both the failure point f and the generally applicable capital level that the GSIB surcharge is held on top of, which means that we do not need to make any assumption about the value of these two quantities. Recall that the goal of the expected impact framework is to make the following equation true:

$$EL_{GSIB} = EL_r$$

Let k_r be the generally applicable capital level held by the reference BHC, and let k_{GSIB} be the GSIB surcharge that a given GSIB is required to hold on top of k_r. Thus, the reference BHC's probability of default will be $p(k_r)$ and each GSIB's probability of default will be $p(k_r + k_{GSIB})$, with the value of k_{GSIB} varying from firm to firm. Because $EL = LGD * PD$, the equation above can be expressed as:

$$LGD_{GSIB} * p(k_r + k_{GSIB}) = LGD_r * p(k_r)$$

This can be rewritten as:

$$\frac{p(k_r + k_{GSIB})}{p(k_r)} = \frac{LGD_r}{LGD_{GSIB}}$$

Plugging in our function $p(k)$, we obtain:

$$\frac{e^{\frac{(f+4.36)-(k_r+k_{GSIB})}{2.18}}}{e^{\frac{(f+4.36)-k_r}{2.18}}} = \frac{LGD_r}{LGD_{GSIB}}$$

The left side of this equation can be simplified as follows:

$$\frac{e^{\frac{(f+4.36)-(k_r+k_{GSIB})}{2.18}}}{e^{\frac{(f+4.36)-k_r}{2.18}}} = e^{\frac{f+4.36-k_r-k_{GSIB}-f-4.36+k_r}{2.18}} = e^{-\frac{k_{GSIB}}{2.18}}$$

As promised, the failure point f and the baseline capital level k_r prove to be irrelevant. This is a consequence of the assumption that the quantiles of the RORWA distribution are linearly related to the logarithm of the quantile. Thus, we have:

$$e^{-\frac{k_{GSIB}}{2.18}} = \frac{LGD_r}{LGD_{GSIB}}$$

We can now solve for k_{GSIB}:

$$k_{GSIB} = -2.18 * \ln\left(\frac{LGD_r}{LGD_{GSIB}}\right)$$

The appropriate surcharge for a given GSIB depends only on that GSIB's LGD score and the chosen reference BHC's LGD score. Indeed, the surcharge does not even depend on the particular values of those two scores, but only on the ratio between them. Thus, doubling, halving, or otherwise multiplying both scores by the same constant will not affect the resulting surcharges. And since each of our reference BHC options was determined in relation to the LGD scores of actual firms, any multiplication applied to the calculation of the firms' LGD scores will also carry over to the resulting reference BHC scores.

Note that the specific GSIB surcharge depends on the slope coefficient that determines how the quantiles of the RORWA distribution change as the probability changes. The empirical analysis presented in figure 3 suggests a value for the slope coefficient of roughly 2.18; however, there is uncertainty regarding the true population value of this coefficient. There are two important sources of uncertainty. First, the estimated value of 2.18 is a statistical estimate that is subject to sampling uncertainty. This sampling uncertainty is characterized in terms of the standard error

[11] This paper treats dollars of risk-weighted assets as equivalent regardless of whether they are measured under the risk weightings of Basel I or of Basel III. This treatment makes sense because the two systems produce roughly comparable results and there does not appear to be any objectively correct conversion factor for converting between them.

Table 2. Method 1 surcharge ranges for each reference BHC (%)

Firm	Method 1 score	$50 billion reference BHC	$250 billion reference BHC	Non-GSIB with highest LGD	Reference BHC LGD = 130
JPMorgan Chase	473	9.6, 12.4	5.7, 7.4	4.2, 5.5	2.5, 3.2
Citigroup	409	9.3, 12.1	5.5, 7.1	4.0, 5.1	2.2, 2.8
Bank of America	311	8.8, 11.4	4.9, 6.4	3.4, 4.4	1.7, 2.1
Goldman Sachs	248	8.4, 10.9	4.5, 5.8	3.0, 3.9	1.2, 1.6
Morgan Stanley	224	8.2, 10.6	4.3, 5.6	2.8, 3.6	1.0, 1.3
Wells Fargo	197	8.0, 10.3	4.1, 5.3	2.6, 3.3	0.8, 1.0
Bank of New York Mellon	149	7.4, 9.6	3.6, 4.6	2.0, 2.6	0.3, 0.3
State Street	146	7.4, 9.6	3.5, 4.5	2.0, 2.6	0.2, 0.3
Reference score		**3**	**23**	**51**	**130**

of the coefficient estimate, which is 0.11 (as reflected in parentheses beneath the point estimate in figure 3). Under standard assumptions, the estimated value of the slope coefficient is approximately normally distributed with a mean of 2.18 and a standard deviation of 0.11. A 99 percent confidence interval for the slope coefficient ranges from approximately 1.9 to 2.4.

Second, there is additional uncertainty around the slope coefficient that arises from uncertainty as to whether the data sample used to construct the estimated slope coefficient is indicative of the RORWA distribution that will obtain in the future. As discussed above, there are reasons to believe that the future RORWA distribution will differ to some extent from the historical distribution. Accordingly, the 99 percent confidence interval for the slope coefficient that is presented above is a lower bound to the true degree of uncertainty that should be attached to the slope coefficient.

We can now use the GSIB surcharge formula and 99 percent confidence interval presented above to compute the ranges of capital surcharges that would obtain for each of the reference BHC options discussed above. Table 2 presents method 1 surcharge ranges and table 3 presents method 2 surcharge ranges. The low estimate in each cell was computed using the surcharge formula above with the value of the slope coefficient at the low end of the 99 percent confidence interval (1.9); the high end was computed using the value of the slope coefficient at the high end of that interval (2.4).

Surcharge Bands

The analysis above suggests a range of capital surcharges for a given LGD score. To obtain a simple and easy-to-implement surcharge rule, we will assign surcharges to discrete "bands" of scores so that the surcharge for a given score falls in the lower end of the range suggested by the results shown in tables 2 and 3. The bands will be chosen so that the surcharges for each band rise in increments of one half of a percentage point. This sizing will ensure that modest changes in a firm's systemic indicators will generally not cause a change in its surcharge, while at the same time maintaining a reasonable level of sensitivity to changes in a firm's systemic footprint. Because small changes in a firm's score will generally not cause a change to the firm's surcharge, using sur-

Table 3. Method 2 surcharge ranges for each reference BHC (%)

Firm	Method 2 score	$50 billion reference BHC	$250 billion reference BHC	Non-GSIB with highest LGD	Reference BHC LGD = 100
JPMorgan Chase	857	6.0, 7.7	5.1, 6.5	4.4, 5.7	4.1, 5.3
Citigroup	714	5.6, 7.3	4.7, 6.1	4.0, 5.2	3.7, 4.8
Goldman Sachs	585	5.2, 6.8	4.3, 5.6	3.7, 4.7	3.4, 4.3
Bank of America	559	5.2, 6.7	4.2, 5.5	3.6, 4.6	3.3, 4.2
Morgan Stanley	545	5.1, 6.6	4.2, 5.4	3.5, 4.6	3.2, 4.2
Wells Fargo	352	4.3, 5.5	3.4, 4.4	2.7, 3.5	2.4, 3.1
State Street	275	3.8, 4.9	2.9, 3.7	2.2, 2.9	1.9, 2.5
Bank of New York Mellon	213	3.3, 4.3	2.4, 3.1	1.7, 2.3	1.4, 1.9
Reference score		**37**	**60**	**85**	**100**

charge bands will facilitate capital planning by firms subject to the rule.

We will omit the surcharge band associated with a 0.5 percent surcharge. This tailoring for the least-systemic band of scores above the reference BHC score is rational in light of the fixed costs of imposing a firm-specific capital surcharge; these costs are likely not worth incurring where only a small surcharge would be imposed. (The internationally accepted GSIB surcharge framework similarly lacks a 0.5 percent surcharge band.) Moreover, a minimum surcharge of 1.0 percent for all GSIBs accounts for the inability to know precisely where the cut-off line between a GSIB and a non-GSIB will be at the time when a failure occurs, and the surcharge's purpose of enhancing the resilience of all GSIBs.

We will use 100-point fixed-width bands, with a 1.0 percent surcharge band at 130–229 points, a 1.5 percent surcharge band at 230–329 points, and so on. These surcharge bands fall in the lower end of the range suggested by the results shown in tables 1 and 2.

The analysis above suggests that the surcharge should depend on the logarithm of the LGD score. The logarithmic function could justify bands that are smaller for lower LGD scores and larger for higher LGD scores. For the following reasons, however, fixed-width bands are more appropriate than expanding-width bands.

First, fixed-width surcharge bands facilitate capital planning for less-systemic firms, which would otherwise be subject to a larger number of narrower bands. Such small bands could result in frequent and in some cases unforeseen changes in those firms' surcharges, which could unnecessarily complicate capital planning and is contrary to the objective of ensuring that relatively small changes in a firm's score generally will not alter the firm's surcharge.

Second, fixed-width surcharge bands are appropriate in light of several concerns about the RORWA dataset and the relationship between systemic indicators and systemic footprint that are particularly relevant to the most systemically important financial institutions. Larger surcharge bands for the most systemically important firms would allow these firms to expand their systemic footprint materially within the band without augmenting their capital buffers. That state of affairs would be particularly troubling in light of limitations on the data used in the statistical analysis above.

In particular, while the historical RORWA dataset used to derive the function relating a firm's LGD score to its surcharge contains many observations for relatively small losses, it contains far fewer observations of large losses of the magnitude necessary to cause the failure of a firm that has a very large systemic footprint and is therefore already subject to a surcharge of (for example) 4.0 percent. This paucity of observations means that our estimation of the probability of such losses is substantially more uncertain than is the case with smaller losses. This is reflected in the magnitude of the standard error range associated with our regression analysis, which is large and rapidly expanding for high LGD scores. Given this uncertainty, as well as the Board's Dodd-Frank Act mandate to impose prudential standards that mitigate risks to financial stability, we should impose a higher threshold of certainty on the sufficiency of capital requirements for the most systemically important financial institutions.

Two further shortcomings of the RORWA dataset make the case for rejecting ever-expanding bands even stronger. First, the frequency of extremely large losses would likely have been higher in the absence of extraordinary government actions taken to protect financial stability, especially during the 2007–08 financial crisis. As discussed above, the GSIB surcharge should be set on the assumption that extraordinary interventions will not recur in the future (in order to ensure that they will not be necessary in the future), which means that firms need to hold more capital to absorb losses in the tail of the distribution than the historical data would suggest. Second, the historical data are subject to survivorship bias, in that a given BHC is only included in the sample until it fails (or is acquired). If a firm fails in a given quarter, then its experience in that quarter is not included in the dataset, and any losses realized during that quarter (including losses realized only upon failure) are therefore left out of the dataset, leading to an underestimate of the probability of such large losses.

Additionally, as discussed above, our assumption of a linear relationship between a firm's LGD score and the risk that its failure would pose to financial stability likely understates the surcharge that would be appropriate for the most systemically important

firms. As noted above, there is reason to believe that the damage to the economy increases more rapidly as a firm grows in size, complexity, reliance on short-term wholesale funding, and perhaps other GSIB metrics.

Finally, fixed-width bands are preferable to expanding-width bands because they are simpler and therefore more transparent to regulated entities and to the public.

Alternatives to the Expected Impact Framework

Federal Reserve staff considered various alternatives to the expected impact framework for calibrating a GSIB surcharge. All available methodologies are highly sensitive to a range of assumptions.

Economy-Wide Cost-Benefit Analysis

One alternative to the expected impact framework is to assess all social costs and benefits of capital surcharges for GSIBs and then set each firm's requirement at the point where marginal social costs equal marginal social benefits. The principal social benefit of a GSIB surcharge is a reduction in the likelihood and severity of financial crises and crisis-induced recessions. Assuming that capital is a relatively expensive source of funding, the potential costs of higher GSIB capital requirements come from reduced credit intermediation by GSIBs (though this would be offset to some extent by increased intermediation by smaller banking organizations and other entities), a potential loss of any GSIB scale efficiencies, and a potential shift of credit intermediation to the less-regulated shadow banking sector. The GSIB surcharges that would result from this analysis would be sensitive to assumptions about each of these factors.

One study produced by the Basel Committee on Banking Supervision (with contributions from Federal Reserve staff) finds that net social benefits would be maximized if generally applicable common equity requirements were set to 13 percent of risk-weighted assets, which could imply that a GSIB surcharge of up to 6 percent would be socially beneficial.[12] The surcharges produced by the expected impact framework are generally consistent with that range.

That said, cost-benefit analysis was not chosen as the primary calibration framework for the GSIB surcharge for two reasons. First, it is not directly related to the mandate provided by the Dodd-Frank Act, which instructs the Board to mitigate risks to the financial stability of the United States. Second, using cost-benefit analysis to directly calibrate firm-specific surcharges would require more precision in estimating the factors discussed above in the context of surcharges for individual firms than is now attainable.

Offsetting the Too-Big-to-Fail Subsidy

It is generally agreed that GSIBs enjoyed a "too-big-to-fail" funding advantage prior to the crisis and ensuing regulation, and some studies find that such a funding advantage persists. Any such advantage derives from the belief of some creditors that the government might act to prevent a GSIB from defaulting on its debts. This belief leads creditors to assign a lower credit risk to GSIBs than would be appropriate in the absence of this government "subsidy," with the result that GSIBs can borrow at lower rates. This creates an incentive for GSIBs to take on even more leverage and make themselves even more systemic (in order to increase the value of the subsidy), and it gives GSIBs an unfair advantage over less systemic competitors.

In theory, a GSIB surcharge could be calibrated to offset the too-big-to-fail subsidy and thereby cancel out these undesirable effects. The surcharge could do so in two ways. First, as with an insurance policy, the value of a potential government intervention is proportional to the probability that the intervention will actually occur. A larger buffer of capital lowers a GSIB's probability of default and thereby makes potential government intervention less likely. Put differently, a too-big-to-fail subsidy leads creditors to lower the credit risk premium they charge to GSIBs; by lowering credit risk, increased capital levels would lower the value of any discount in the credit risk pre-

[12] See Basel Committee on Banking Supervision (2010), *An Assessment of the Long-Term Economic Impact of Stronger Capital and Liquidity Requirements* (Basel, Switzerland: Bank for International Settlements, August), p. 29, www.bis.org/publ/bcbs173.pdf. The study finds that a capital ratio of 13 percent maximizes net benefits on the assumption that a financial crisis can be expected to have moderate permanent effects on the economy.

mium. Second, banking organizations view capital as a relatively costly source of funding. If it is, then a firm with elevated capital requirements also has a concomitantly higher cost of funding than a firm with just the generally applicable capital requirements. And this increased cost of funding could, if calibrated correctly, offset any cost-of-funding advantage derived from the too-big-to-fail subsidy.

A surcharge calibration intended to offset any too-big-to-fail subsidy would be highly sensitive to assumptions about the size of the subsidy and about the respective costs of equity and debt as funding sources at various capital levels. These quantities cannot currently be estimated with sufficient precision to arrive at capital surcharges for individual firms. Thus, the expected impact approach is preferable as a primary framework for setting GSIB surcharges.

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