# Calibrating the Single-Counterparty Credit Limit between Systemically Important Financial Institutions

March 4, 2016

BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM


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# Abstract

This paper explains the rationale for a more stringent single-counterparty credit limit as well as the calibration of the proposed tighter 15 percent limit for the largest and most systemically risky institutions. The analysis concludes that the more stringent credit limit would mitigate systemic risks posed by credit extensions between systemically important financial institutions (SIFIs).

Inter-SIFI credit extensions are characterized by a heightened degree of credit risk that is appropriately addressed by a single-counterparty credit limit that differentiates between SIFI and non-SIFI counterparties. SIFIs are engaged in a similar mix of global business lines that are subject to related risks so that a shock that impairs a credit-receiving SIFI could well be expected to also impair the credit-granting SIFI. These commonalities would likely be less salient in the event that a non-SIFI borrower, such as a non-financial corporate, came under stress and defaulted on a credit extension made by a SIFI. Accordingly, the heightened degree of correlation between a SIFI lender and SIFI borrower results in a greater degree of total credit risk on inter-SIFI credit extensions that must be reflected in single-counterparty credit limits to appropriately mitigate financial stability risks.

Single-counterparty credit limits are explicitly designed to limit the threat that a default by a large counterparty could pose to the viability of the creditor. In designing such limits, the potential effects of simultaneous defaults by both borrower and lender should be considered. The threat to financial stability that would be created by multiple SIFI defaults is likely many times larger than the financial stability risk posed by the default of a single SIFI and a single non-SIFI borrower. Accordingly, it is appropriate to set the limit on inter-SIFI credit exposures at a stringent enough level to ensure that the risk of multiple SIFI defaults is significantly lower than the risk of a SIFI default paired with a non-SIFI counterparty default.

The above considerations provide an important qualitative rationale for a more stringent credit limit on inter-SIFI credit extensions. This paper presents a quantitative credit risk model and calibrates that model with data to arrive at a range of inter-SIFI single-counterparty credit limits. A range of data-based model calibrations are considered and presented in recognition of the considerable and inherent uncertainties that exist in using any single model calibration for policy analysis. Credit default swap (CDS) data are analyzed and indicate that the correlation between SIFIs is larger than the correlation between a SIFI and non-SIFI. The heightened correlation between SIFIs is then used as an input to the quantitative credit risk model and results in more stringent single-counterparty credit limits on inter-SIFI credit exposures. The presented model and analysis indicate that a single-counterparty credit limit of 15 percent on inter-SIFI credit exposures is appropriate and mitigates systemic risk.

# Introduction

In an effort to address single-counterparty concentration risk among large financial companies, section 165(e) of the Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd-Frank Act)[1] directs the Federal Reserve Board to establish single-counterparty credit limits for bank holding companies and foreign banking organizations with total consolidated assets of $50 billion or more (covered companies) in order to limit the risks that the failure of any individual firm could pose to a covered company.[2] This section directs the Board to prescribe regulations that prohibit covered companies from having credit exposure to any unaffiliated company that exceeds 25 percent of the capital stock and surplus of the covered company or such lower amount as the Board may determine by regulation to be necessary to mitigate risks to the financial stability of the United States.[3]

As part of this process, the Board is considering a set of more stringent single-counterparty credit limits that would apply 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), as well as U.S. intermediate holding companies or U.S. operations of a foreign banking organization with total assets of $500 billion or more, collectively known as major covered entities. The proposal would establish a tighter 15 percent limit on the credit exposure of these major covered entities to any GSIB or any entity that has been designated as systemically important by the Financial Stability Oversight Council (FSOC), collectively known as major counterparties.

This paper explains the rationale for the more stringent credit limit as well as the calibration of the proposed tighter 15 percent limit. Because there is no single widely accepted framework for calibrating single-counterparty credit limits, the Board has considered several potential approaches. This paper focuses on a calibration approach that uses a portfolio credit risk model and explains the portfolio credit risk model in detail. It provides single-counterparty credit limit calibrations for credit exposures between major covered entities and major counterparties resulting from that framework under a range of plausible assumptions, incorporating the uncertainty that is inherent in the study of rare events such as the failure of SIFIs.

## Background

The failures and near-failures of SIFIs were key drivers of the 2007–08 financial crisis and the resulting recession. 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 institu-

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1 Pub. L. 111-203, 124 Stat. 1376–2223 (2010).

2 *See* 12 USC. 5365(e)(1). Section 165(e) also directs the Board to establish single-counterparty credit limits for nonbank financial companies designated by the Financial Stability Oversight Council (FSOC) for supervision by the Board. The provisions of the proposed rule would only apply to bank holding companies and foreign banking organizations. The Board intends separately to issue orders or rules imposing single-counterparty credit limits on each nonbank financial company designated by the FSOC for supervision by the Board.

3 12 USC 5365(e)(2).

tions 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.[4] Section 165(e) of the act requires the Board to impose single-counterparty credit limits as a mandatory enhanced regulatory standard for SIFIs and other large BHCs.

## Rationales for a More Stringent Credit Exposure Limit on Exposures between Major Covered Entities and Major Counterparties

The Dodd-Frank Act's mandate that the Board adopt enhanced prudential standards to mitigate the risk posed to financial stability by certain large financial institutions provides the principal statutory impetus for a more stringent credit exposure limit between major covered entities and major counterparties. 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 less systemically important, the single-counterparty credit limit that applies when a SIFI (major covered entity) faces another SIFI (major counterparty) must reflect the greater risk that arises in the context of such inter-SIFI credit exposures.

More specifically, SIFIs are characterized by a number of important similarities that make it relatively more likely that the default or distress of a SIFI counterparty (major counterparty) would coincide with events that simultaneously threaten the viability of the credit-granting SIFI (major covered entity). SIFIs are engaged in a similar mix of global business lines that are subject to related risks so that a shock that impairs a credit-receiving SIFI could well be expected to also impair the credit-granting SIFI. Moreover, entities that fund SIFIs may have incentives to pull their funding or otherwise pull back from SIFIs in the event of a failure of a SIFI, which would add additional significant stress to a credit-granting SIFI in the event that it has extended credit to a failing SIFI. None of these considerations are as salient when a SIFI makes a credit extension to a non-SIFI such as a non-financial corporate borrower. A shock that results in the default of a non-financial corporate would not generally be expected to coincide with events that independently threaten the viability of the credit-granting SIFI.

Accordingly, the credit risk that is inherent in inter-SIFI credit extensions is larger than the risk that is inherent in SIFI to non-SIFI credit extensions. Accordingly, applying the proposal's statutory 25 percent credit limit would result in a situation in which the total default risk incurred by a credit-granting SIFI on inter-SIFI credit extensions would be greater than the total default risk incurred by a credit-granting SIFI on SIFI to non-SIFI credit extensions. Such an approach would materially threaten financial stability given the potentially large adverse consequences of multiple SIFI defaults. As a result, to ensure that inter-SIFI credit extensions do not result in heightened credit risk relative to SIFI to non-SIFI credit extensions and thereby threaten financial stability, the single-counterparty limit on inter-SIFI credit extensions should be more stringent than the limit on SIFI to non-SIFI credit extensions.

In what follows, a calibrated quantitative credit risk model is employed to provide a range of credit exposure limits that would be expected to ensure that the resulting credit risk on an inter-SIFI credit extension is no greater than the credit risk that arises in the context of a SIFI to non-SIFI credit extension. Of course, as previously discussed, the default of multiple SIFIs is likely to be significantly more damaging to the economy and financial stability than the default of a SIFI resulting from the default of a non-SIFI counterparty. As a result, it would also be consistent with maintaining financial stability to require that the credit risk incurred from inter-SIFI credit extensions be significantly less than that incurred by SIFI to non-SIFI credit extensions. Accordingly, the range of single-counterparty credit limits that are presented should be viewed as an upper bound on the appropriate level of the inter-SIFI credit limit that is consistent with maintaining financial stability.

[4] Dodd-Frank Act section 165(a)(1).

# A Quantitative Credit Risk Model and Single-Counterparty Credit Limits

## Data and Calibration

Before describing the credit risk model in detail it is useful to discuss the key model parameter that will inform the calibration of the inter-SIFI credit concentration limit. The correlation between two SIFIs plays an important role in determining an appropriate credit limit in the model.

Correlation is a key risk management concept that has been instrumental in modeling and understanding risk since Markowitz's Nobel Prize winning model of portfolio selection.[5] A key insight of modern risk management theory is that assets that display a large and positive correlation with each other present more risk when paired in a portfolio than assets with a relatively low degree of correlation, even if each asset's risk level is the same when considered in isolation. A SIFI that makes a credit extension to another company that is highly correlated with the performance of the rest of the SIFI's assets results in greater risk than a credit extension to a company that exhibits a lower correlation with the rest of the SIFI's asset portfolio.

Given the importance of the correlation parameter to the results of the model, it is important to have an empirically based and theoretically sound estimate of the correlation between a SIFI and another SIFI and the correlation between a SIFI and a non-SIFI. There are a number of approaches that could be used to estimate these correlations. Data on the market value of assets among SIFIs and non-SIFIs could be analyzed. The correlation in equity values could also be analyzed as equity represents a claim on a firm's underlying assets. Data on underlying credit or CDS spreads could be also used.

This analysis considers CDS spreads, as they are directly informative about probability of default. Default probabilities are of direct relevance to the issue of credit concentration limits and the credit risk model that will be used to calibrate the inter-SIFI credit limit.

Weekly data on CDS spreads of 13 GSIBs and SIFIs that have been identified by the FSOC over the 2006–15 period are considered in this analysis.[6] The firms used in the analysis were chosen as a representative sample of SIFIs with high-quality and continuous CDS data over the entire sample period. In the analysis that follows, the weekly changes in these CDS spreads are used to form an estimate of the correlation between two SIFIs. Finally, note that among 13 SIFIs, there are 78 ((13x12)/2) distinct SIFI-to-SIFI pairings that can be considered in the analysis.

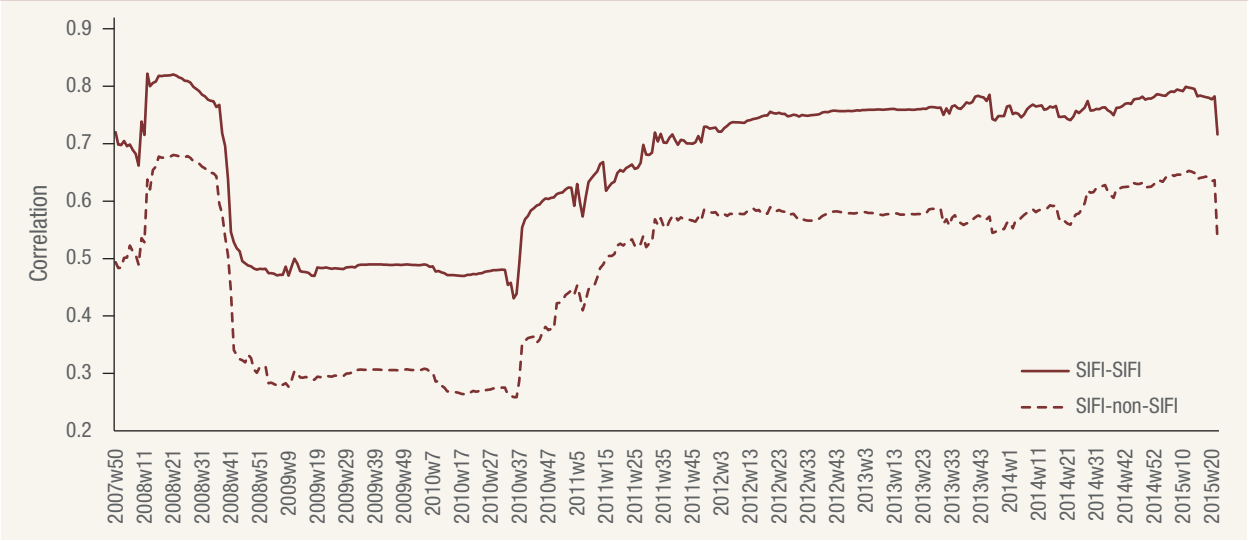
For non-SIFIs, weekly data on CDS spreads from 256 companies that are cleared by Intercontinental Exchange (ICE) Clear Credit and for which a continuous record of weekly CDS data over the entire 2006–15 sample period is available are used in this analysis. Attention is restricted to companies for which CDS are cleared by ICE Clear Credit to ensure that the underlying companies have relatively liquid CDS markets for which high-quality and reliable CDS data can be obtained. The companies used in this analysis are drawn from a range of industries including consumer goods, financials, industrials, and technology and represent a broad sample of the types of non-SIFI companies to which a SIFI may have a credit exposure. The data on non-SIFI CDS spreads is combined with the data on SIFI CDS spreads to estimate the correlation between a SIFI and non-SIFI. Finally, note that since there are 256 non-SIFI companies and 13 SIFIs considered in the analysis, there are 3,328 (13x256) distinct SIFI to non-SIFI pairings that can be considered in the analysis.

Figure 1 shows the average rolling two-year (100 week) correlation in the weekly change in CDS

[5] Harry Markowitz, "Portfolio Selection," *Journal of Finance*, Vol. 7, No. 1. (March 1952):77–91.

[6] The SIFI firms included in the analysis are AIG, Bank of America, Barclays, Citigroup, Deutsche Bank, GE Capital, Goldman Sachs, JP Morgan, MetLife, Morgan Stanley, Prudential, UBS, and Wells Fargo.

**Figure 1. Average Correlations 2007-2015: SIFI to SIFI and SIFI to non-SIFI**




spreads between each of the 78 SIFI-to- SIFI pairings (solid line) and the average rolling two-year (100 week) correlation in the weekly change in CDS spreads between each of the 3,328 SIFI to non-SIFI pairings (dashed line) over the sample period.

Figure 1 shows that throughout the sample period the average correlation between two SIFIs (solid line) was uniformly above that of the average correlation between a SIFI and non-SIFI (dashed line).[7] Moreover, while the absolute level of correlation does change over time, which is consistent with broad empirical evidence that correlations are time-varying, the relative ordering of the two correlation measures is stable. The average correlation among SIFIs is always larger than the average correlation among a SIFI and non-SIFI. The time-series average of the SIFI to SIFI correlation (solid line) is 0.67 while the time series average of the SIFI to non-SIFI correlation is 0.50.

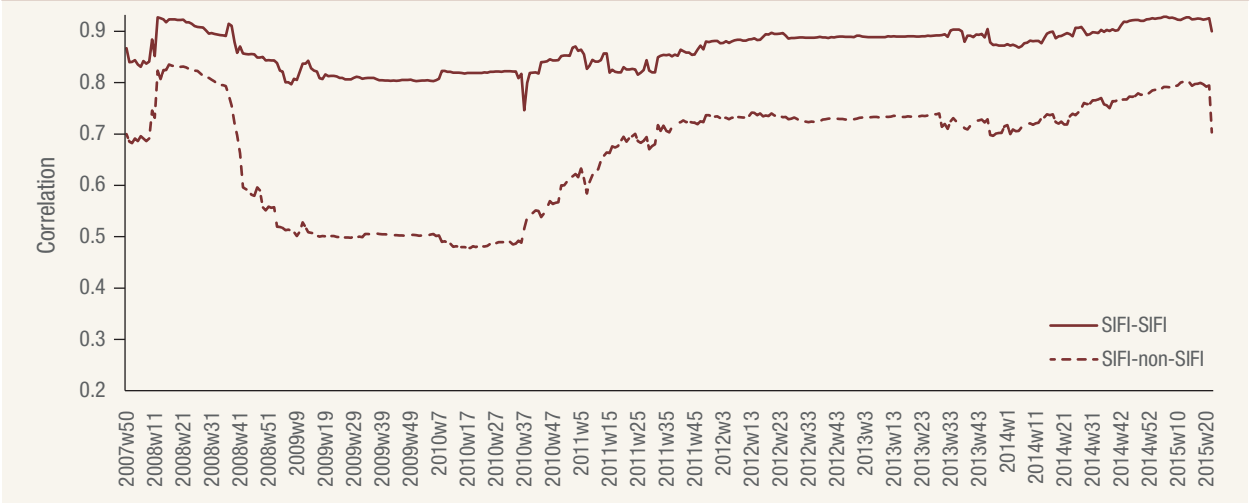
The results in figure 1 also accord with theoretical considerations that would suggest that two SIFIs would exhibit a higher correlation with each other than would a SIFI with a non-SIFI. As discussed earlier, SIFIs generally are engaged in a similar mix of business lines, share many counterparties in common, and rely on similar sources of funding. As a result, it is natural to expect that two SIFIs would exhibit a greater degree of correlation with each other than would be exhibited between a SIFI and non-SIFI company. More generally, it is quite common in empirical economic models to assume that companies within the same sector exhibit a higher degree of correlation than companies across sectors.

In the context of the credit risk model that will be used to calibrate the level of the inter-SIFI credit limit, what matters is the correlation between SIFIs during a period when the credit-granting SIFI's counterparty is either approaching or is in default. Empirical data analysis is limited in its ability to measure such correlations since SIFI defaults did not occur over the sample period. Also, even though the data sample covers the period of the financial crisis, the extraordinary government support that was provided over this period makes it difficult to rely on correlation estimates alone. Moreover, all of the economic forces that tend to result in a larger correlation between SIFIs in the weekly CDS data would likely be magnified in a period of stress if a SIFI defaulted, as the effects of the SIFI default spread throughout the capital markets and influenced counterparty relationships, funding costs, and overall financial conditions. Accordingly, there are sound economic considerations that would suggest that the increase in the SIFI to SIFI correlation relative to the SIFI to non-SIFI correlation may be even larger in a period of stress than that suggested by these data.

The correlation estimates presented in figure 1 represent, at each point in time, the average correlation between two SIFIs and the average correlation

[7] Note that the rolling correlation estimates in figure 1 do not begin until 2007, as 100 weeks or roughly two years of data are required to compute the initial correlation estimate. Thereafter, the rolling correlation estimate is updated each week of the sample.

**Figure 2. 90th Percentile Correlations 2007-2015: SIFI to SIFI and SIFI to Non-SIFI**




between a SIFI and non-SIFI. In practice, there are a range of correlations that exist between SIFIs and between a SIFI and non-SIFI. From a risk-management perspective, it is important to consider more than just the average correlation, since correlations that are above the average present more risk than that suggested by the average. Figure 2 shows a time series plot that is constructed in exactly the same manner as figure 1, except that instead of taking the average correlation at each point in time, the 90th percentile correlation among all possible company pairings is plotted. This figure provides a sense of the magnitude of the correlations that exist between companies that are more tightly connected than that depicted by the average correlation.

Figure 2 shows that the estimated correlation increases when considering companies that are more tightly connected than the average. This is true when considering both the SIFI to SIFI correlation and the SIFI to non-SIFI correlation. The time-series average of the SIFI to SIFI correlation depicted in figure 2 (solid line) is 0.87 while the corresponding time-series average for the SIFI to non-SIFI correlation (dashed line) is 0.67. Moreover, the difference in the correlation estimates shown in figure 2, which is roughly 0.2, is similar to the difference depicted in figure 1, which suggests that it is reasonable to assume that the SIFI to SIFI correlation exceeds the correlation between a SIFI and non-SIFI by roughly 0.2.

The correlation estimates and related discussion presented above indicate that there is a strong rationale for more stringent single-counterparty credit limits on inter-SIFI credit extensions. The financial performance of a SIFI is more tightly connected to other SIFIs than to non-SIFIs and so the total amount of risk that is incurred from SIFI to SIFI credit extensions is greater than that incurred by SIFI to non-SIFI credit extensions. In order to ensure that SIFI to SIFI credit extensions do not pose significantly greater risk to SIFI lenders, and ultimately financial stability, the single-counterparty credit limit on inter-SIFI credit exposures must be more stringent than that on SIFI to non-SIFI credit exposures.

In order to quantify an appropriate inter-SIFI credit limit, a quantitative model is required. The next section discusses the quantitative model employed and provides a range of inter-SIFI credit limits consistent with observed data and the model.

## Quantitative Credit Risk Model Description

The model described below considers a situation in which a SIFI with a pre-existing portfolio of assets extends a single loan to a counterparty. The case of extending a loan to a non-SIFI is described and then the case of extending a loan to a SIFI is described.

Consider a SIFI with a portfolio of assets that decides to extend a loan to a non-SIFI in an amount that is equal to the credit exposure limit of 25 percent of capital. Further normalize the assets of the bank

to $1 and assume that the bank's capital ratio is 10 percent. Accordingly, the size of the loan extended to the non-SIFI is given by:

$$a = 0.25 \times 0.10 = 0.025$$

and the size of the SIFI's remaining assets are given by:

$$A = 1 - a = 0.975$$

so that total assets of the SIFI are given by $A+a = 1$.

Further assume that the rate of return on all assets are log-normally distributed and have the same mean rate of return of 1 percent. The volatility of log assets is assumed to be 3 percent in the case of the SIFI's overall asset portfolio net of the loan, $A$, and 9 percent in the case of the individual loan, $a$. The increased risk of the individual loan relative to the remainder of the SIFI's assets is motivated on the grounds that a single loan carries significant idiosyncratic risk while the entirety of the SIFI's balance sheet benefits from substantial offsets and diversification across multiple borrowers and business lines such as trading, real estate loans, corporate loans, and consumer loans.

Under these assumptions, the value of each component of the SIFI's assets one period ahead in the future is given by,

$$\tilde{A} = Aexp(0.01 + 0.03\varepsilon)$$

$$\tilde{a} = aexp(0.01 + 0.09\upsilon)$$

and the correlation between the future value of the non-SIFI loan and the rest of the SIFI's assets is determined by the correlation between the shocks - $\varepsilon$ and $\upsilon$. These shocks should be interpreted as factors that either increase or decrease the value of the SIFI's assets and the loan over time. As an example, a negative shock to the borrower's product market that results in greatly diminished revenues and makes loan default more likely would be represented by a negative value of $\upsilon$. For the purposes of this exercise, it is assumed that the correlation between the value of the loan and the value of the remainder of the SIFI's assets, $\rho(\tilde{A},\tilde{a})$, is 65 percent, which is consistent with the empirical correlation analysis that was previously discussed. Specifically, a correlation value of 0.65 is consistent with the time-series average correlation depicted in figure 2 (dashed line), which presents the 90th percentile correlation between a SIFI and non-SIFI. A correlation value of 0.65 is also within the range of the time series of the average correlations presented in figure 1 (dashed line).

The probability that the SIFI enters default depends on the assumption that is made about the level of capital that is required to remain viable as a going concern. One assumption is that a SIFI can remain viable until all of its capital is exhausted. The financial crisis demonstrated, however, that SIFIs can become non-viable long before their entire capital stock is depleted. Once a SIFI's capital reaches a threshold value, their counterparties and funding providers begin to run, which can result in a downward spiral that, absent outside intervention, results in non-viability as a going concern and ultimately default. For the purposes of this exercise it is assumed that a SIFI is deemed to be non-viable and effectively in default whenever its capital level reaches 4.5 percent, which is consistent with existing minimum regulatory capital requirements. Accordingly, the probability of default is simply the probability that the total value of the SIFI's assets falls below a level that results in less than a 4.5 percent capital ratio. The SIFI's level of equity at the end of the period, $\tilde{E}$, is given by,

$$\tilde{E} = 0.10 - \left(1 - (\tilde{A} + \tilde{a})\right)$$

and the SIFI's capital ratio is given by,

$$\frac{\tilde{E}}{\tilde{A} + \tilde{a}}$$

so that the probability that the SIFI enters default is given by,

$$Pr\left(\frac{\tilde{E}}{\tilde{A} + \tilde{a}} < 0.045\right)$$

Now consider the same SIFI deciding instead to allocate the marginal loan to a SIFI counterparty rather than to a non-SIFI counterparty. The entire preceding analysis is unaffected except that the assumed correlation between the SIFI extending the credit and the SIFI that is receiving the credit is higher than the previously assumed correlation between the SIFI lender and the non-SIFI borrower.

As discussed previously, given the similarity in broad risk exposures and business lines among SIFIs, it is reasonable to expect that the correlation between the value of the loan made to a SIFI and the rest of the SIFI's assets is significantly higher than is the case when a loan is made to a non-SIFI. Specifically, drawing on the previous empirical correlation analy-

**Table 1. Model initial conditions and assumptions**

| | |
|---|---|
| **Model initial conditions** | |
| Initial value of assets | 1.0 |
| Initial value of loan | 0.025 |
| Initial capital ratio | 0.10 |
| **Model assumptions** | |
| Statistical distribution | Log-normal |
| Rate of return on assets | 0.01 |
| Volatility of value of (log) bank assets ex-loan (*A*) | 0.03 |
| Volatility of (log) loan asset (*a*) | 0.09 |
| Correlation between SIFI and non-SIFI borrower | 0.65 |
| Correlation between SIFI and SIFI borrower—lower than baseline | 0.70 |
| Correlation between SIFI and SIFI borrower—baseline | 0.85 |
| Correlation between SIFI and SIFI borrower—higher than baseline | 0.99 |

sis it is assumed that the correlation $\rho(\tilde{A},\tilde{a})$ is 85 percent. This heightened SIFI to SIFI correlation is consistent with the correlation analysis discussed above. Specifically, a correlation value of 85 percent is consistent with the time-series average correlation depicted in figure 2 (solid line) which presents the 90th percentile correlation between two SIFIs. A correlation value of 85 percent is also broadly consistent with the range of the time series of the average correlations that is presented in figure 1 (solid line). In particular, note that the relative increase in the inter-SIFI correlation is 0.2 (0.85 versus 0.65), which is consistent with the data presented in both figures 1 and 2. In what follows, the model will also be analyzed using a lower correlation assumption of 70 percent and a higher correlation assumption of 99 percent to gauge its sensitivity to this key input, but the value of 85 percent will serve as the baseline. Finally, before describing the model results, the model's key initial conditions and assumptions are summarized in table 1 for ease of reference.

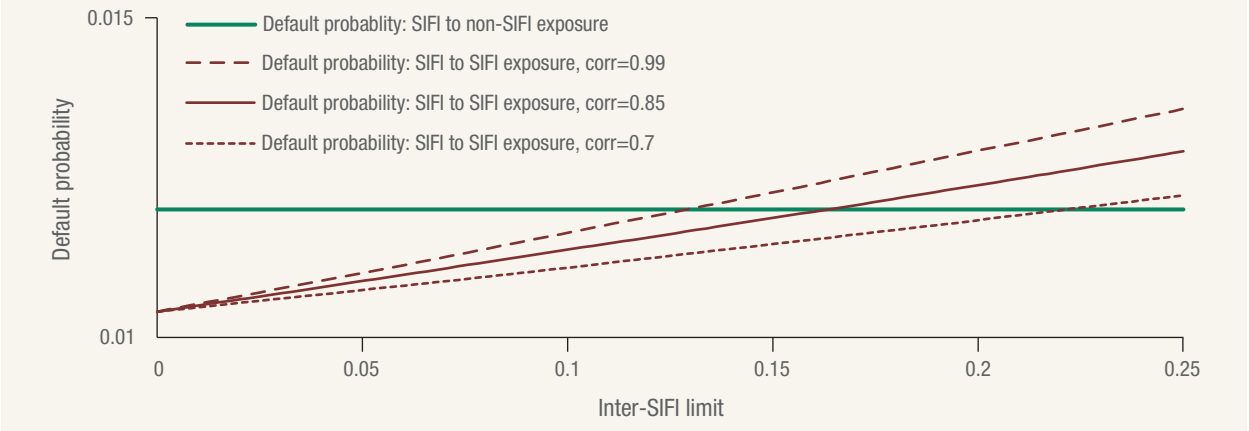
## Model Results and Calibrated Inter-SIFI Credit Limits

The model described above is simulated and figure 3 below depicts the resulting probability of the bank's default as a function of the stringency of the inter-SIFI limit. The horizontal green line depicts the default probability that results in the case of a SIFI to non-SIFI loan when the single-counterparty credit limit is 25 percent. This line is not sensitive to the inter-SIFI limit since the loan to a non-SIFI counterparty is not bound by the inter-SIFI limit.[8] The solid red upward sloping line represents the probability of default that arises in the context of a SIFI to SIFI loan as the inter-SIFI credit limit rises from 0 to 25 percent when the inter-SIFI correlation is set to the baseline level of 85 percent.

As shown in figure 3, setting the inter-SIFI limit at the original 25 percent limit results in a larger default probability than the SIFI to non-SIFI case, because the correlation between the assets of the credit-granting SIFI and the SIFI borrower are highly correlated relative to the non-SIFI borrower. As the inter-SIFI limit is tightened, the probability of default declines. The decline in default probability

[8] The magnitude of the default probability in the case that a SIFI extends a loan to a non-SIFI is slightly more than 1 percent. Model parameters including the mean rate of asset growth and asset volatility has been calibrated so that the resulting default probability is broadly consistent with observed data on the likelihood of large negative losses experienced by large BHCs.

**Figure 3. The Inter-SIFI Limit Under Alternative Correlation Assumptions**



occurs because, as the size of the loan to the SIFI declines, the bank is investing more of its assets in a less risky and more diversified pool of assets. Accordingly, an implicit assumption of this analysis is that assets that are not lent out to the borrower SIFI are re-invested back into the lender SIFI's asset mix in a proportional manner without creating another large exposure to a risky counterparty.

According to figure 3, the particular constellation of model parameters that are reported in table 1 under the baseline case indicates that reducing the inter-SIFI limit to a level of roughly 17 percent would equalize the total credit risk across loans made to a SIFI and a non-SIFI counterparty. Graphically, this is the point where the red and green lines intersect.

Of course, these results are generated from a model that has been calibrated in a particular way. In practice there is likely a range of parameters that could be used to calibrate the model and so a single calibration of the model should not be exclusively relied upon. Figure 3 also depicts the results from two additional calibrations of the model in which the correlation between the SIFI lender and SIFI borrower, a key model parameter, has been set to values above and below the baseline value of 85 percent. More specifically, figure 3 shows two additional dashed lines that depict how the default probability reacts to the inter-SIFI credit limit when the assumed correlation is 70 percent (dotted line below the solid red line) and 99 percent (dashed line above the solid red line). These correlation levels are roughly equidistant from the baseline level of 85 percent and are broadly within the range of observed inter-SIFI correlations that are presented in figures 1 and 2. The point of intersection between each dashed line and the solid green line identifies the inter-SIFI credit limit that would be consistent with the higher and lower assumed correlation value.

As shown in figure 3, a higher assumed correlation between SIFIs results in an even more stringent inter-SIFI credit limit as the dashed line above the solid red line intersects the solid red line at roughly 13 percent. Correspondingly, a lower assumed correlation between SIFIs results in a less stringent inter-SIFI credit limit as the dotted line below the solid red line intersects the solid red line at roughly 23 percent. Accordingly, this model combined with a data-based calibration indicates that an appropriate level for the inter-SIFI credit limit could range between 13 and 23 percent. The specific magnitudes are useful for providing a quantitative sense of the reasonable range over which such inter-SIFI credit limits may be set.

Finally, and importantly, it should also be noted that the preceding analysis does not explicitly make any adjustments to reflect the greater social costs associated with multiple SIFI defaults relative to a situation in which a SIFI enters default as the result of a default of a non-SIFI. The adverse effects on the financial system and economy are likely many times greater than the adverse effects of a SIFI default paired with the default of a non-SIFI. In addition, this analysis also excludes from consideration the additional knock on effects that could reverberate through the financial system following a multiple SIFI default event. All of these considerations suggest that an appropriate inter-SIFI credit limit could reasonably be set meaningfully more stringently than the levels that are indicated in figure 3.

# Summary and Concluding Remarks

In an effort to address the risk to financial stability posed by large financial companies, section 165(e) of the Dodd-Frank Act directs the Board to establish single-counterparty credit limits for large bank holding companies and foreign banking organizations. This section directs the Board to prescribe regulations that prohibit covered companies from having credit exposure to any unaffiliated company that exceeds 25 percent of the capital of the covered company or such lower amount as the Board may determine to be necessary to mitigate risks to U.S. financial stability.

The default of multiple SIFIs would clearly present considerable threats to financial stability. Moreover, the risk of multiple SIFI defaults increases when SIFIs extend credit to each other, because the range of activities in which SIFIs are engaged as well as their counterparties and funding sources all display a significant degree of commonality. As a result of the relatively high levels of correlation among SIFIs, it is appropriate to require that credit extensions between SIFIs be subject to a more stringent single-counterparty credit limit. It should also be noted that the existence of more stringent single-counterparty credit limits on inter-SIFI credit exposures does not necessarily limit the ability of a SIFI to transact with other SIFIs in the aggregate. SIFIs are free to generate exposures with individual other counterparties that are below the single-counterparty credit limit, and any exposures that would breach the limit may be reallocated to other SIFIs that are under the exposure limit. Accordingly, the presence of tighter inter-SIFI limits does not prevent SIFIs from engaging in conduct that is necessary to provide credit services to the economy.

A credit risk model is employed to provide quantitative guidance on the range of inter-SIFI credit limits that are appropriate in light of the considerations discussed above. The results indicate that the proposed credit limit of 15 percent is appropriate and consistent with the range of outcomes presented in the model. Since the model does not explicitly reflect the greater harm to financial stability that would result from multiple SIFI defaults, the appropriate level of the inter-SIFI credit limit may be somewhat more stringent than the levels presented in this analysis. Moreover, the specific quantitative model that has been employed is relatively simple and abstracts from a number of considerations that could be considered in the analysis. But, overall, a number of qualitative and quantitative factors indicate that the proposed inter-SIFI limit of 15 percent is appropriate and in keeping with the Dodd-Frank Act's requirement to prescribe more stringent limits when required to mitigate financial stability risks.

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