Rationalizing the Global Market Shock

Greg Hopper | Oct. 17, 2023

Following the market turmoil in the latter half of 2008, the Federal Reserve conducted in 2009 the first supervisory market risk stress test as part of the Supervisory Capital Assessment Program (SCAP). Building on the SCAP, the Federal Reserve initiated the Comprehensive Capital Analysis and Review (CCAR) in late 2010, which formalized the market risk stress test as the Global Market Shock (GMS). At that time, the Basel I capital framework for market risk, which was still in force in the U.S., was widely understood to have been inadequate for measuring market risk during the crisis. Although Basel II.5, the current standard, corrected many of the problems in Basel I for market risk, it was not a perfect solution.

The introduction of the GMS in 2011 as part of CCAR was therefore an important and necessary step taken by the Federal Reserve to ensure that banks were adequately capitalized for market risk. From its inception, the GMS has consistently subjected banks with significant trading activity to an extreme stress test that resembles a financial crisis.[1] However, the new Fundamental Review of the Trading Book (FRTB), which is part of the Basel Finalization process, is also designed to assess market risk under extreme market stress conditions. Given the proposed changes to the market risk framework via the FRTB, the GMS has served its purpose and is no longer needed to do the work that the FRTB will do going forward.[2] Before Basel Finalization, the Federal Reserve has an opportunity to repurpose the GMS. This can be done by removing the extreme shocks included in the GMS that look backwards to a financial crisis and replacing them with shocks that look forward to the potential risks that might not be captured by the FRTB.

In this note, we focus on how the GMS shocks can be rationalized, using an empirically driven and objective methodology based on widely used econometric tools. We find that the GMS captures the same risk as the FRTB, extreme illiquidity in markets, with no trading possible for very significant periods during a market crisis. However, the implicit GMS liquidity assumptions are significantly inconsistent with the macroeconomic assumptions in CCAR. Moreover, since the FRTB already captures extreme illiquidity risk, we suggest how to replace the GMS assumption of no liquidity for long periods with the much more realistic assumption of limited liquidity for shorter periods that would also be more internally consistent with the rest of the macroeconomic CCAR scenario. The analysis suggests that the Federal Reserve can substantially reduce equity and CDS shocks in the GMS while still maintaining appropriate conservatism. U.S. equity shocks could be reduced by a factor of two while CDS shocks could be reduced by a factor of 10.

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[1] For additional details on the assumptions of the market shock component of the stress tests see "Policy Statement on the Scenario Design Framework for Stress Testing," (pages 20-21) available at https://www.federalreserve.gov/bankinforeg/bcreg20131107a1.pdf

[2] For more information about the overlap between the FRTB and the GMS, see Hopper (2023), "How Can the Global Market Shock More Effectively Complement the Fundamental Review of the Trading Book," available at https://bpi.com/how-can-the-global-market-shock-more-effectively-complement-the-fundamental-review-of-the-trading-book/

How Has the GMS Been Recently Calibrated?

The key idea behind the determination of the GMS shocks is that during a financial crisis, markets can become illiquid for extended periods. Over those periods of illiquidity, banks cannot hedge or close out positions. Changes in market prices when markets are frozen determine how much a bank will lose on its position. If the illiquidity horizon is calibrated from a stressed historical period, using a longer horizon will result in a larger shock. Alternatively, if the shocks are selected from some percentile of market moves, such as 99 percent, longer horizons will also produce larger shocks. Thus, selection of the period of illiquidity essentially determines the magnitude of the GMS shock.

For the SCAP exercise, the Federal Reserve used a transparent[3] calibration strategy: it applied the actual shocks observed over the six-month period from June 30, 2008 to Dec. 31, 2008 to the trading portfolios of the five firms with trading assets over $100 billion. The Federal Reserve used the same methodology for the 2011 market stress test. However, the calibration of the subsequent GMS tests became less clear. Earlier in the program, the Federal Reserve indicated that the GMS shocks for more liquid products were generally calibrated to movements in asset prices over various periods observed over the last half of 2008, with less liquid products receiving larger shocks. More recently, the Fed has refrained from characterizing the shocks in terms of the 2008 crisis, noting in the 2023 CCAR exercise, for example, that it defined the shocks according to time horizons that reflect the inability to sell or hedge exposures during a period of extreme market stress.[4] However, the Fed has not revealed in any detail what those horizons are or how they were determined.

Looking at the last three GMS exercises, it is unclear, for example, how the GMS shocks were calibrated for CDS spreads. Table 1 shows the values of the CDS IG index spreads on the as-of dates of the last three GMS tests. Chart 1 depicts the historical path of the CDS IG over the last half of 2008. As can be readily verified, the 2022 GMS stress drives the IG CDS spread to a level that was close to what was observed at the end of 2008. The 2022 stress seems to be producing a level close to the maximum observed value over the crisis period.

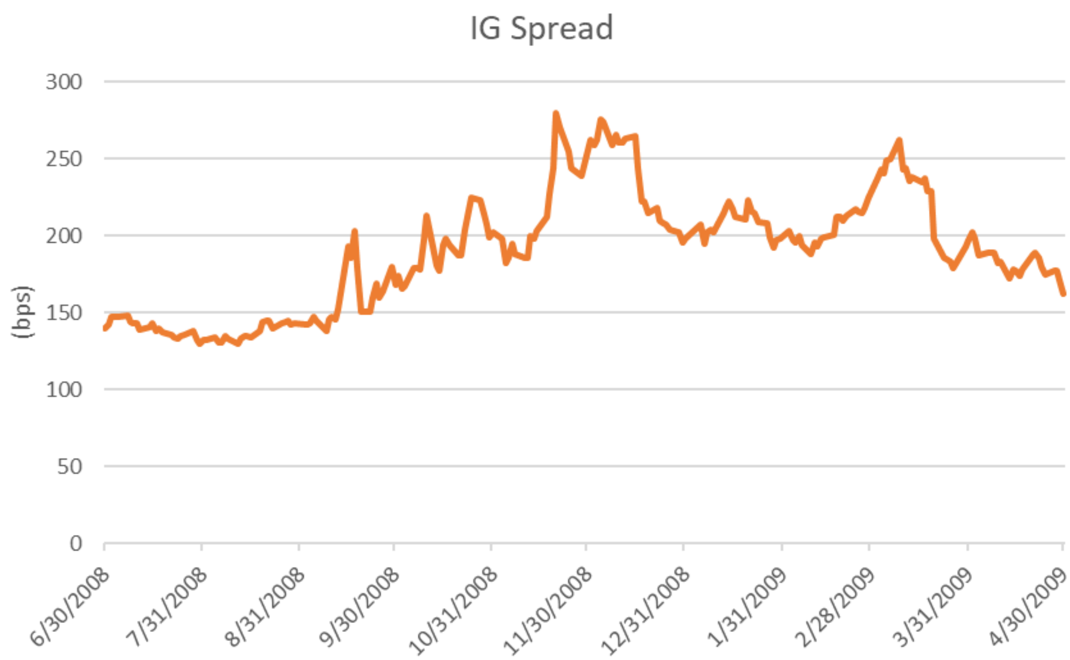
The stress for the 2021 GMS is larger, driving the spread to 344 bps, a level not observed over the financial crisis. That difference is likely explained by market conditions at the time the GMS was formulated, the fall of 2020. At that time, the effects of COVID were still highly uncertain and it is plausible to think that the GMS designers imposed extra conservatism judgmentally to target something close to the maximum spread that was observed at the beginning of December 2008. Overall, it appears that the Fed is still using essentially the six-month SCAP methodology supplemented by judgmental overrides. Taken literally, this methodology is assuming that global credit markets are closed for at least six months, with no ability to buy, sell, or hedge credit risk.

[3] See "The Supervisory Capital Assessment Program: Design and Implementation," April 24, 2009, Federal Reserve Board, available at https://www.federalreserve.gov/bankinforeg/bcreg20090424a1.pdf
[4] See "2023 Stress Scenarios"

Table 1

CCAR	Starting value (bps)	GMS shock	Ending Value (bps)
2023	104	177.4%	288
2022	54	326.7%	230
2021	53	548.2%	344

Chart 1



The GMS illiquidity assumption for CDS produces a very significant internal inconsistency in the CCAR stress test. The macroeconomic assumptions in the CCAR stress test generally assume a very bad recession after the GMS, somewhat akin to the severe downturn of 2008-09. If credit markets really did shut down globally for six months or more, however, the economic damage to the world economy would be massive, far worse than the downturn assumed in CCAR and far worse than anything observed in modern economic history, including the Great Depression.

The Federal Reserve has never explained how it reconciles the macroeconomic assumptions in the CCAR scenario with the apparent six-month market shutdown in key asset classes implicit in the GMS, nor has it been clear on exactly what illiquidity horizons it is currently using for many asset classes. Instead, it has suggested that it chooses illiquidity horizons "to capture the unpredictable liquidity conditions that prevail in a time of stress," offering as an example the unexpected loss of liquidity of AAA-rated private label RMBS during 2008.[5]

Although the motivation for this strategy for dealing with uncertainty is understandable, its justification is weak. There is no empirical basis for using a six-month move in the latter half of 2008 as an estimate for how long credit

[5] See "2023 Stress Scenarios"

markets could be closed in a future financial crisis. Six months is completely arbitrary. Why not use nine months or five months instead? Or why not use the largest move ever observed historically as the estimate?

In contrast, the FRTB makes explicit assumptions on how long credit markets will be effectively closed. For IG CDS, it assumes markets will be closed for 40 days and for HY CDS it assumes that credit markets will be closed for 60 days. The FRTB illiquidity assumptions are not justified in the Basel Finalization proposal, but they are clearly stated.

Since the proposal intends to use both the FRTB and the GMS to capitalize market risk, a key step in the rationalization of the GMS is to compare the FRTB and GMS illiquidity assumptions. This comparison is not straightforward, unfortunately. The FRTB assumes that IG CDS credit markets are closed for 40 days during an effective 99 percent move in the underlying CDS spread, a market move which is calibrated to the period of the worst one-year market conditions observed since 2007. We use 99 percent to translate from the ES assumption of 97.5 percent in the FRTB, since that confidence level was chosen to be equivalent to a 99 percent VaR with normally distributed return. The GMS assumes nominal six-month or longer periods of illiquidity under 2008 conditions in which markets are closed, but there is no percentile interpretation attached.

To rationalize the GMS, we need an empirically based and objective methodology to translate the GMS shocks into equivalent 99 percent moves over different periods of assumed illiquidity so that they can be compared directly to the FRTB illiquidity assumptions. We can develop such a methodology by using GARCH models, a widely used econometric approach to modeling financial time series.[6]

What are GARCH Models?

GARCH models were developed to statistically describe how the volatility of financial asset returns (daily percentage change in price) changes from day to day. Volatility is a measure of how frequently extreme daily returns are observed. To understand how GARCH models work, it may be helpful to consider an analogy. Suppose we wanted to explain what the return of the S&P 500 will be over the next day. We know that the return is random in some way. A simple statistical analogy is to think of the economy as spinning a giant roulette wheel each day. Above each pocket of the wheel is a return, either positive or negative (or zero). Every day, the wheel is spun and a return is chosen. If, for example, today's equity price is 100 and the return we obtained was 5 percent, then tomorrow's stock price will be 105. If tomorrow the market spins the wheel and gets a return of -1 percent, the stock price on the following day will be 103.95. In this way, spins of the roulette wheel generate the moves in stock prices observed over time. Of course, the returns are really determined by the buying and selling decisions of market participants, but we are summarizing the net effect of those decisions in a GARCH econometric model.

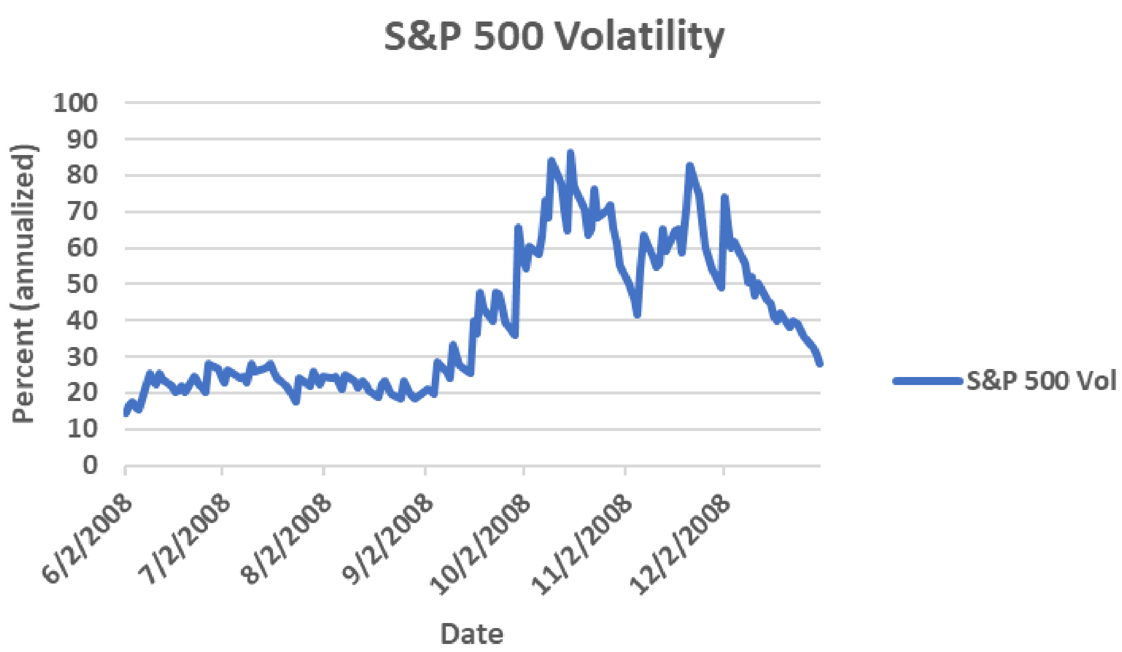
In terms of the roulette wheel analogy, volatility measures how frequently more extreme positive and negative returns are represented on the wheel. If the asset return is more volatile, the possible returns on the wheel will have higher positive and negative returns and with each spin of the wheel the asset price will move up and down more on average. Higher volatility implies more risk, since if we spin the wheel over and over, the asset can go up or down significantly over a period of many days.

Volatility is not constant but rather changes from day to day in a predictable way. In terms of our analogy, that means that every day we spin the roulette wheel, the wheel's volatility is different from what it was yesterday. GARCH models tell us how to update the volatility of the wheel each day. Empirically, the models find that if the volatility of yesterday's wheel was high, then today's volatility will be high as well. Alternatively, if yesterday's volatility was low, then today's volatility will tend to be low too.

[6] NYU Stern's V-Lab employs a wide variety of GARCH models to analyze the volatility of financial assets. See https://vlab.stern.nyu.edu/

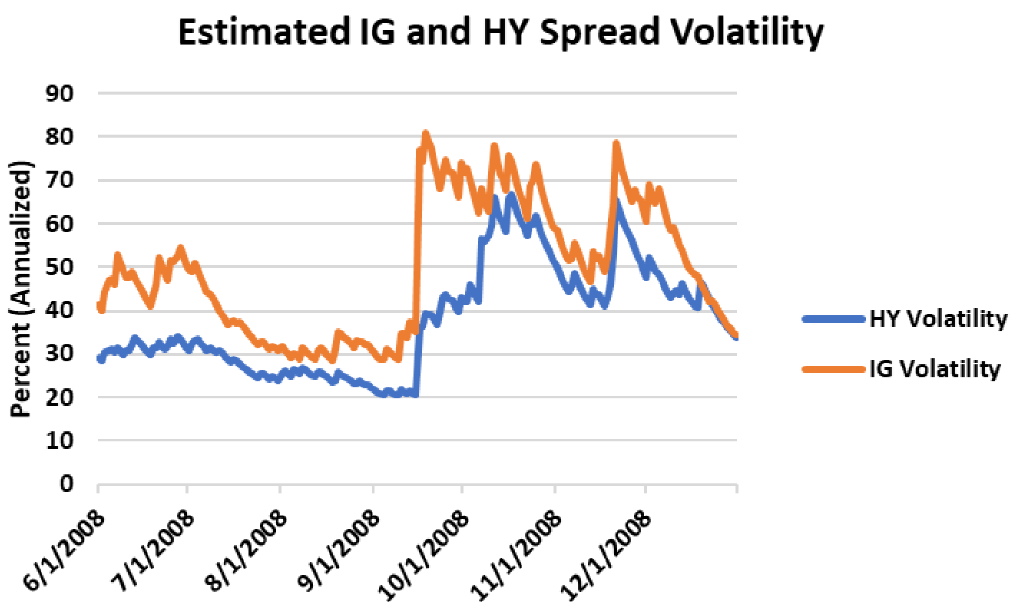
Because today's volatility is heavily determined by yesterday's volatility, daily volatility of asset returns tends to cluster. To see this effect, we estimate an EGARCH[7] model for daily returns on the S&P 500, the five-year on-the-run CDX IG spread index and the five-year on-the-run CDX HY spread index using data from 2007 to 2022. The EGARCH model is one of the class of GARCH models that are widely used by financial economists to analyze asset returns.[8] Charts 2 and 3 shows estimated annualized daily volatilities from the EGARCH model[9] over the last half of 2008, with the model reproducing the increase and clustering of high volatility during the period of market stress.

Chart 2



[7] See Nelson, D. (1991), "Conditional Heteroskedasticity in Asset Returns: A New Approach," Econometrica, Vol 59. No 2.
[8] For a textbook treatment, see Tsay, R., (2010), "Analysis of Financial Time Series," Wiley Series in Probability and Statistics.
[9] For the more technically minded reader, we estimate the EGARCH model using maximum likelihood under the assumption that the conditional error distribution is the Generalized Error Distribution, so that the conditional distribution is non-normal. Although estimates would be consistent using a normal distribution with quasi-maximum likelihood, we elected to use a non-normal conditional distribution to maintain conservatism when simulating the model. Estimated coefficients are strongly statistically significant when employing robust standard errors for all cases.

Chart 3



Comparing the GMS to the FRTB

To compare the GMS to the FRTB, we will work backwards: given that we know the GMS shocks, we need to determine to what illiquidity horizons they correspond to. To answer this question, we simulate equity and CDS prices using FRTB assumptions, i.e., at a 99 percent confidence level using data drawn from a period of extreme market stress. To take an example, if the GMS equity shock is -26 percent, then we simulate the equity price and find which horizon produces a -26 percent shock at some confidence level, such as 99 percent. That horizon is the implied liquidation assumption.

To understand how we use the EGARCH model to simulate equity prices and CDS prices, we return to the roulette wheel analogy. Simulating the EGARCH model over 20 days is analogous to spinning the roulette wheel on each of the 20 days. Given a starting equity price and a starting volatility, we spin the wheel to obtain a return. We calculate tomorrow's equity price from today's price and today's return. Then we use today's volatility and today's return to predict tomorrow's volatility. We put tomorrow's volatility on the wheel and spin it again. The return obtained can be used to project the equity price two days from now. We continue that process until we have a 20-day equity path. The EGARCH model estimates tell us at every stage exactly how we should update the volatility of the wheel on each day of the simulation.

To create a common yardstick to compare the GMS to the FRTB, we must use assumptions consistent with the FRTB in the simulations. The FRTB requires that the Expected Short (ES) fall be calculated using a one-year period of stressed data at the 97.5 percent confidence level, which is designed to be similar to a 99 percent confidence level when returns are normally distributed. The FRTB also requires that ES be estimated using the worst one-year of data since 2007. The motivation for the FRTB requirement, in terms of the roulette wheel analogy, is to exclusively use spins of the wheel that were experienced during financial crisis conditions and ignore the more benign outcomes that were seen under normal market conditions. We will impose the same conditions in the EGARCH simulations. The EGARCH estimation allows us to estimate the underlying historical random spins of the wheel on each day over 2008 and 2009. Rather than using all possible spins to simulate the model, we will instead use only the estimated random spins observed during the period June 30, 2008 to June 30, 2009.

To compare the results directly to specific GMS exercises, we will begin each simulation with the starting values of equity prices and CDS spreads on the as-of date of the last three GMS exercises. For example, to compute the 99% worst equity loss over 20 days for the S&P 500, we would simulate 20-day equity paths using as the starting value the S&P 500 on each of the as-of dates of the last three GMS tests. We perform 20,000 simulations for each GMS date and then select the 99 percent worst loss over the 20-day period.

Table 2: Simulated S&P 500 Spread Shocks

Compared to FRTB and GMS

	2023 GMS	2022 GMS	2021 GMS
Days	25	25	25
Shock	-43.2%	-42.6%	-43.2%
Days	20	20	20
Shock	-36.6%	-36.6%	-37.1%
Days	10	10	10
Shock	-25.3%	-24.9%	-23.9%
Actual GMS	-26.30%	-38.30%	-26%
FRTB Liquidity Assumption (days)	10	10	10

Table 2 shows the simulated EGARCH shocks the model produced at the 99 percent confidence level at various horizons for the S&P 500. For example, using a 20-day horizon, the 99 percent shock was -36.6 percent for the 2022 GMS. Thus, if we assumed that the period of illiquidity was 20 days, so that the S&P 500 could not be bought, sold, or hedged over that period, then a position that a bank is forced to sit on for 20 trading days would have lost 36.6 percent in value at the 99 percent confidence level. Judging from the vantage point of the EGARCH model, the 2022 GMS of -38.3 percent, is assuming a 20-day period of illiquidity.

Comparing the EGARCH shocks to the GMS shocks in general, we can see that over the last three GMS exercises, the U.S. public equity GMS stress seems to be calibrated to between a 10- to 20-day illiquidity horizon at a 99 percent confidence level under stressed market conditions. It is worth noting that the 2023 Stress Test Scenarios document issued by the Fed stated that public equity shocks were calibrated to a three-month liquidation period[10], but our results suggest the GMS shocks actually assumed a 10-day period of illiquidity in 2023 when stated in FRTB terms. Thus, the equity shock in the GMS, at least over the most recent GMS tests, is essentially repeating the FRTB illiquidity assumptions.

Turning to CDS, Table 3 shows the results for the five-year IG CDS spread.

[10] See "2023 Stress Scenarios"

Table 3: Simulated IG CDS Spread Shocks
Compared to FRTB and GMS

	2023 GMS	2022 GMS	2021 GMS
Days	126	126	126
Shock	187.2%	199.1%	189.7%
Days	90	90	90
Shock	156.5%	146.3%	150.2%
Days	60	60	60
Shock	110.7%	112.5%	105.8%
Days	40	40	40
Shock	83.7%	83.3%	83.1%
Days	20	20	20
Shock	54.5%	53.8%	55.2%
Days	10	10	10
Shock	37.5%	37.8%	37.2%
Actual GMS	177.40%	326.70%	548.20%
FRTB Liquidity Assumption (days)	40	40	40

Comparing the GMS shocks to the EGARCH shocks, the results suggest strongly that the GMS shocks for IG CDS spreads are indeed calibrated to a period of six months or longer when compared to the FRTB. We see the same result for HY CDS spreads, shown in Table 4. HY spread shocks seem to be calibrated to a six-month liquidation period at a 99 percent confidence level under stressed market conditions.

It is unclear why there is such a vast discrepancy between the illiquidity assumptions used for equities and CDS in the GMS. It is understandable that credit markets are assumed to be more illiquid than equity markets during a crisis, but the difference in assumptions is notable. A 10- or 20-day period of complete illiquidity for equities in the GMS is likely not consistent with the CCAR macroeconomic scenario, but it is not violently at odds. But a corresponding six-month or longer period of complete illiquidity for credit markets under a 99 percent market move is a very significant internal contradiction within the CCAR scenario.

When compared to the FRTB, the GMS equity shock repeats the FRTB. However, the GMS credit shocks repeat the FRTB many times over.

Table 4: Simulated HY CDS Spread Shocks

Compared to FRTB and GMS

	2023 GMS	2022 GMS	2021 GMS
Days	126	126	126
Shock	204.3%	200.8%	195.2%
Days	90	90	90
Shock	146.1%	142.8%	142.7%
Days	60	60	60
Shock	97.5%	101.1%	97.8%
Days	40	40	40
Shock	70.6%	69.5%	68.5%
Days	20	20	20
Shock	44.0%	42.5%	43.5%
Days	10	10	10
Shock	28.6%	29.0%	29.1%
Actual GMS	80.0%	206.8%	247.8%
FRTB Liquidity Assumption (days)	60	60	60

Limited Liquidity

A very simple way to rationalize the illiquidity assumption is to interpret the illiquidity horizon not as the period over which no trading can occur but rather as a period over which a trade can be closed out. For example, if we assume the period of illiquidity is 20 days, then that would imply that $1/20^{th}$ of the position could be closed out per day, so that the total position would take 20 days to sell or hedge. This assumption of limited liquidity is still quite conservative but is also a much more realistic representation of loss of liquidity during a period of market turmoil. During periods of illiquidity, the bid-ask spread may rise precipitously, inducing financial institutions to trade smaller pieces of a position over time. Or it may simply be impossible to sell or hedge more than a certain notional per day. Limited liquidity is a more reasonable assumption given the CCAR macroeconomic downturn assumptions.

To calibrate the new GMS shocks, we will assume that they will have an illiquidity horizon below the FRTB assumptions, with a floor of 10 days, in order to reduce the overlap between the capture of illiquidity risk. Thus, we will report a 10-day illiquidity horizon for equities, a 20-day and 10-day horizon for IG since the FRTB assumption is 40 days, and 40-, 20-, and 10-day horizons for HY, since the FRTB horizon is 60 days. Tables 5, 6, and 7 repeat Tables 2, 3, and 4 but also include results using the limited liquidity assumption. To estimate the shock under limited liquidity over N days, we close out 1/N of the position on each day at its simulated price. For the case of CDS, we calculate on each day the gain or loss of selling or hedging 1/N of the notional of a five-year at-the-money CDS trade. We determine the instantaneous CDS shock by finding the shock that would produce a loss on the entire CDS position that is the same as the cumulative loss calculated along the daily path when 1/N of the CDS trade is closed out on each day.

Table 5: S&P 500

	2023 GMS	2022 GMS	2021 GMS	Average
Days	10	10	10	10
Shock (no liquidity)	-25.3%	-24.9%	-23.9%	-24.7%
Shock (limited liquidity)	-14.9%	-10.8%	-14.5%	-13.4%
Actual GMS	-26.30%	-38.30%	-26%	
FRTB Liquidity Assumption (days)	10	10	10	

Table 6: IG Spreads

	2023 GMS	2022 GMS	2021 GMS	Average
Days	20	20	20	20
Shock (no liquidity)	54.5%	53.8%	55.2%	54.5%
Shock (limited liquidity)	36.0%	5.2%	19.0%	20.1%
Days	10	10	10	10
Shock (no liquidity)	37.5%	37.8%	37.2%	37.5%
Shock (limited liquidity)	34.4%	25.1%	14.8%	24.8%
Actual GMS	177.4%	326.7%	548.2%	
FRTB Liquidity Assumption (days)	40	40	40	

Table 7: HY Spreads

	2023 GMS	2022 GMS	2021 GMS	Average
Days	40	40	40	40
Shock (no liquidity)	70.6%	69.5%	68.5%	69.5%
Shock (limited liquidity)	40.9%	31.8%	23.3%	32.0%
Days	20	20	20	20
Shock (no liquidity)	44.0%	42.5%	43.5%	43.3%
Shock (limited liquidity)	25.0%	22.0%	22.6%	23.2%
Days	10	10	10	10
Shock (no liquidity)	28.6%	29.0%	29.1%	28.9%
Shock (limited liquidity)	12.1%	9.0%	22.5%	14.5%
Actual GMS	177.4%	326.7%	548.2%	
FRTB Liquidity Assumption (days)	60	60	60	

As can be seen, the implied shock with limited liquidity can vary across GMS exercises, since it is path-dependent. The HY limited liquidity shock over 10 days is an example. Two simulated 99% HY CDS paths could reach the same point at the end of the 10-day horizon, but one path could start out relatively flat for a while and abruptly rise towards the end while the other could move steadily upwards. The first path will have a lower shock, since a good portion of the trade can be closed out before CDS spreads rise appreciably. We thus take the average of the limited liquidity shocks on the three GMS dates to smooth out the volatility of the estimates.

Rationalizing the GMS

In order to rationalize the GMS shocks, we need to reduce them in a way that minimizes the overlap with the FRTB but is also consistent with the CCAR macroeconomic assumptions. We can accomplish this by incorporating the following recalibration principles:

- reduce the GMS illiquidity horizons to be under the FRTB assumptions, in order to minimize the GMS-FRTB overlap
- use the more realistic assumption of limited rather than no liquidity for the reduced horizons to address the CCAR scenario inconsistency

Using the above principles, and the "average" column for the limited liquidity case from Tables 5, 6 and 7, a reasonable GMS recalibration would be:

- U.S. equities: -15%
- IG CDS: 20-25%
- HY CDS: 15-30%

Thus, equity shocks could be reduced by a factor of two while CDS shocks could be reduced by a factor of 10. These are order-of-magnitude estimates of course. The EGARCH methodology could be used to recalibrate other GMS shocks as well.

Conclusion

An empirically based methodology suggests that the GMS shocks for equities should be reduced by approximately a factor of 2 and CDS shocks by approximately a factor of 10 before FRTB implementation. These changes will substantially reduce but not eliminate the overlap between the GMS and the FRTB and will make the GMS internally consistent with the CCAR macroeconomic assumptions. The updates will eliminate the legacy financial crisis calibration of the GMS, which will be handled going forward by the FRTB. Although necessary, these GMS shock changes will not by themselves make the GMS an effective complement to the FRTB. Once the Fed has rationalized the GMS, it should take the next step and subject the GMS to a fundamental redesign that captures forward-looking risks that may be missed by the FRTB.
