BOARD OF GOVERNORS OF THE FEDERAL RESERVE SYSTEM
WASHINGTON, DC 20551

Supervisory Stress Test Model Documentation

Market Risk Models

October 2025

This document summarizes the market risk models that the Board of Governors of the Federal Reserve System (Board) intends to use in the 2026 Supervisory Stress Test. The following sections provide an overview of the Securities, Fair Value Option, Yield Curve, Private Equity, Trading Profit and Loss, Trading Issuer Default Loss, Credit Valuation Adjustment (CVA), and Largest Counterparty Default (LCPD) Models. Each section includes a summary of the model, model components, and alternatives considered, along with other model-specific details. Documentation on the other models that the Board intends to use in the 2026 Supervisory Stress Test is available at the following link: https://www.federalreserve.gov/supervisionreg/dfa-stress-tests-2026.htm.

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A. Securities Model

i. Statement of Purpose

The Securities Model is important for accurately assessing whether firms are sufficiently capitalized to absorb losses on available-for-sale (AFS) debt securities, held-to-maturity (HTM) debt securities, and equity securities with readily determinable fair values not held for trading, during a period of severe stress.[1] Changes in unrealized gains and losses on AFS debt securities are adjusted for credit losses and applicable hedges and recorded in other comprehensive income (OCI). Credit losses on AFS and HTM securities, and unrealized gains and losses on equity securities with readily determinable fair values not held for trading, are recorded in pre-tax net income.

ii. Model Overview

The Securities Model generates projections for each applicable security and aggregates losses at the firm level using three steps. First, the fair value[2] of each AFS debt security[3] and public equity security is projected over the projection horizon, conditional on the hypothetical severely adverse macroeconomic scenario ("macroeconomic scenario"). Second, credit losses are projected for AFS and HTM securities. Finally, pre-tax unrealized gains and losses on AFS debt securities are calculated based on projected changes in fair value, adjusted for any projected credit losses and applicable hedges. OCI is determined outside of the Securities Model by the Capital Model,[4] and for a given quarter is equal to the quarterly change in pre-tax unrealized

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[1] The Securities Model is not applied to securities held for trading. Losses on these securities are projected by the Trading Profit and Loss Model. See Section E.

[2] Fair value is defined as the price that would be received to sell an asset or paid to transfer a liability in an orderly transaction between market participants at the measurement date (FASB ASC 320-10-20).

[3] AFS securities are investments not classified as either trading securities or as HTM securities (FASB ASC 320-10-20).

[4] See Section D in the Aggregation Models Documentation (Capital Model).

gains and losses on AFS debt securities adjusted for credit losses and hedges, and accounts for taxes and other adjustments. OCI is included in CET1 capital for certain firms.[5]

The Securities Model comprises the following components:

(i) the “Fair Value Model” projects fair values for AFS debt securities, and fair values for equity securities with readily determinable fair values not held for trading, where changes in equity fair values are recognized in pre-tax net income;

(ii) the “Credit Loss Model” projects credit losses for AFS and HTM debt securities, which the Provisions Model uses to compute provisions for credit losses that are recognized in pre-tax net income; and

(iii) the “OCI Calculation” uses projections from the Fair Value Model and Credit Loss Model to compute pre-tax unrealized gains and losses on AFS debt securities adjusted for credit losses and hedges, which the Capital Model uses to compute OCI.

Each of these three components is described in more detail in the following sections. Figure A-1 summarizes how gains and losses for each security type are incorporated into income.

[5] OCI is accounted for outside of net income. Under the Board’s regulatory capital rule, accumulated other comprehensive income (AOCI) that arises from unrealized changes in the value of AFS securities must be incorporated into CET1 capital for firms subject to Category I or II standards and other firms that do not opt out of including AOCI in regulatory capital.

Figure A-1 – income contributions by security type

Security type from FR Y-14Q, Schedule B.1 Security Description 1 (CQSCP084)	AFS debt securities: for certain firms, unrealized gains and losses that are included in OCI are included in CET1	Public equity and mutual funds: unrealized gains and losses are included in pre-tax net income	Credit-sensitive debt securities: provisions for credit losses are included in pre-tax net income
Agency MBS	AFS only	x	x
US Treasuries & Agencies	AFS only	x	x
Sovereign Bond	AFS only	x	AFS and HTM
Corporate Bond	AFS only	x	AFS and HTM
Covered Bond	AFS only	x	AFS and HTM
Municipal Bond	AFS only	x	AFS and HTM
Domestic Non-Agency Residential MBS (RMBS) (incl HEL ABS)	AFS only	x	AFS and HTM
Foreign RMBS	AFS only	x	AFS and HTM
Commercial Mortgage-Backed Securities (CMBS)	AFS only	x	AFS and HTM
Collateralized Debt Obligations (CDOs)	AFS only	x	AFS and HTM
Collateralized Loan Obligations (CLOs)	AFS only	x	AFS and HTM
Auto Asset-Backed Securities (ABS)	AFS only	x	AFS and HTM
Credit Card ABS	AFS only	x	AFS and HTM
Student Loan ABS	AFS only	x	AFS and HTM
Other ABS (excl Home Equity Loan (HEL) ABS)	AFS only	x	AFS and HTM
Preferred Stock (Equity)	AFS only	x	AFS and HTM
Auction Rate Securities	AFS only	x	AFS and HTM
Other	AFS only	x	AFS and HTM
Common Stock (Public Equity)	x	all positions	x
Mutual Fund	x	all positions	x

a. Fair Value Model Overview

The Fair Value Model projects fair values for AFS debt securities and equity securities with readily determinable fair values not held for trading, based on the macroeconomic scenario.[6] For securities where fair value projections cannot be generated, the average return or the tenth percentile of returns is assigned from the distribution of projected returns that quarter. For additional information on the methodology for assigning returns to securities where fair value projections cannot be generated, see section A(iii)(d)(1).

(1) AFS Debt Securities

For AFS debt securities, the model uses three methods to project fair values, depending on the type of security: a present-value calculation for Treasuries, full revaluation for Agency MBS using a third-party vendor model, and a duration-based approximation for all other debt securities. Fair values of Auction Rate Securities and Other securities are not modeled directly. Returns for these two security types are calculated as the firm's average projected returns across all AFS debt securities at a given quarter.

(2) Public Equity Securities

For public equity securities with readily determinable fair values, the model projects fair values using one of two methods, depending on the type of security. Common stock and non-money market mutual fund holdings follow the path of the U.S. Dow Jones Total Stock Market Index projected in the macroeconomic scenario, and money market mutual funds grow at the

[6] AFS and HTM securities are held in the banking book, which refers to bank assets that are not held for trading. See Basel Fundamental Review of the Trading Book (FRTB). Gains and losses on private equity securities meanwhile are forecast separately by the Private Equity Model as described in Section D.

three-month U.S Treasury rate projected in the macroeconomic scenario. Changes in fair value of equity securities are recorded in pre-tax net income and flow through to capital.

b. *Credit Loss Model Overview*

The Credit Loss Model projects credit losses for AFS and HTM securities over the projection horizon. Credit losses are projected based on the probability of default, recovery rate, and amortized cost[7] corresponding to a given security, and are used to compute two inputs for the calculation of provisions for credit losses. The first is charge-offs, which capture the amount deemed uncollectible in the current quarter. The second is allowance for credit losses, determined as the sum of projected credit losses over the next four quarters. Provisions for credit losses for securities are determined outside of the Securities Model, by the Provisions Model[8] (which also determines provisions for loans), and are included in pre-tax net income. Agency MBS, U.S. Treasuries & Agencies, Federal Family Education Loan Program (FFELP) student loan asset-backed securities, and pre-refunded municipal bonds are assumed to not be subject to credit losses.

c. *OCI Calculation Overview*

The OCI Calculation computes pre-tax unrealized gains and losses on AFS debt securities based on projected changes in fair value, accounting for any projected credit losses and applicable hedges. Projections for fair value are obtained from the Fair Value Model, and projections for credit losses are obtained from the Credit Loss Model. Unrealized gains and

[7] Amortized cost is defined as the amount at which a financing receivable or investment is originated or acquired, adjusted for applicable accrued interest, accretion, or amortization of premium, discount, and net deferred fees or costs, collection of cash, write-offs, foreign exchange, and fair value hedge accounting adjustments (FASB ASC 320-10-20).

[8] See Section B in the Aggregation Models Documentation (Provisions Model).

losses for an AFS security at a given point in time are equal to the security's fair value minus amortized cost. OCI is determined outside of the Securities Model by the Capital Model[9]. OCI is equal to the cumulative quarterly change in pre-tax unrealized gains and losses on AFS debt securities adjusted for credit losses and hedges, and accounts for taxes and other adjustments. OCI is included in CET1 capital for firms subject to Category I or II standards, and firms that do not opt out of including AOCI in regulatory capital.

Hedges are incorporated into the OCI Calculation as follows. A security-specific hedge ratio is computed for each AFS security. Hedged fair value is projected as a weighted average of the unhedged and fully hedged fair value projections, where the weight assigned to the fully hedged fair value is the security-specific hedge ratio that remains constant throughout the projection horizon.

Projections for unrealized gains and losses are adjusted for credit losses if certain conditions are met. In cases where the fair value of an AFS debt security is above its amortized cost, no adjustment is made to unrealized gains and losses. In cases where the fair value of an AFS debt security is below its amortized cost, the security is impaired, and the unrealized gains and losses are adjusted by the amount of the impairment that is related to credit losses. The amount of impairment related to credit losses is limited by the amount that the fair value is less than the amortized cost. Impairment related to credit losses is recorded through an allowance for credit losses, with any remaining impairment recorded in unrealized gains and losses.

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[9] *See* Section D in the Aggregation Models Documentation (Capital Model).

iii. Fair Value Model

a. *Model Specification*

The Fair Value Model projects fair values for AFS debt securities and equity securities with readily determinable fair values not held for trading, based on the macroeconomic scenario. For AFS debt securities, the model uses three methods to project fair values, depending on the type of security: a present-value calculation for Treasuries, full revaluation for Agency MBS using a third-party vendor model, and a duration-based approximation for all other debt securities. For public equity securities, the model projects fair values using one of two methods, depending on the type of security. Common stock and non-money market mutual fund holdings follow the path of the U.S. Dow Jones Total Stock Market Index projected in the macroeconomic scenario, and money market mutual funds grow at the three-month U.S Treasury rate projected in the macroeconomic scenario.

Figure A-2 shows the fair value projection methods for each security type specified on FR Y-14Q, Schedule B.1 (Securities 1, Main Schedule). Fair values of Auction Rate Securities and Other securities are not modeled directly. Returns for these two security types are calculated as the firm's average projected returns across all AFS debt securities at a given quarter.

Figure A-2 – fair value projection methods by security type

<table>
<tr><th>Security type from FR Y-14Q, Schedule B.1 Security Description 1 (CQSCP084)</th><th>Security Sub-Type</th><th>Fair Value Projection Method</th></tr>
<tr><td>Agency MBS</td><td>all</td><td>full revaluation using third-party vendor model</td></tr>
<tr><td rowspan="2">US Treasuries & Agencies</td><td>Treasuries</td><td>present value calculation</td></tr>
<tr><td>Agencies</td><td rowspan="16">duration based</td></tr>
<tr><td>Sovereign Bond</td><td>all</td></tr>
<tr><td>Corporate Bond</td><td>all</td></tr>
<tr><td>Covered Bond</td><td>all</td></tr>
<tr><td>Municipal Bond</td><td>all</td></tr>
<tr><td>Domestic Non-Agency RMBS (incl HEL ABS)</td><td>all</td></tr>
<tr><td>Foreign RMBS</td><td>all</td></tr>
<tr><td>CMBS</td><td>all</td></tr>
<tr><td>CDO</td><td>all</td></tr>
<tr><td>CLO</td><td>all</td></tr>
<tr><td>Auto ABS</td><td>all</td></tr>
<tr><td>Credit Card ABS</td><td>all</td></tr>
<tr><td>Student Loan ABS</td><td>all</td></tr>
<tr><td>Other ABS (excl HEL ABS)</td><td>all</td></tr>
<tr><td>Preferred Stock (Equity)</td><td>all</td></tr>
<tr><td>Common Stock (Equity)</td><td>all</td><td rowspan="2">Dow Jones return</td></tr>
<tr><td rowspan="2">Mutual Fund</td><td>non-MMMF</td></tr>
<tr><td>MMMF[10]</td><td>U.S. three-month T-Bill return</td></tr>
<tr><td>Auction Rate Securities</td><td>all</td><td rowspan="2">not modeled[11]</td></tr>
<tr><td>Other[12]</td><td>all</td></tr>
</table>

[10] MMMF refers to money market mutual fund.

[11] Fair values of Auction Rate Securities and Other securities are not modeled directly. Returns for these two security types are calculated as the firm's average projected returns across all AFS debt securities at a given quarter.

[12] The security type Other refers to any other securities that are not explicitly defined in the table.

(1) AFS Debt Securities

The Fair Value Model projects the fair value of AFS debt securities using one of three methods, depending on the type of security:

- for U.S. Treasuries, a simple present-value calculation is used;
- for Agency MBS, a full revaluation approach based on a third-party vendor model is used; and
- for all other debt securities, which include sovereign, municipal and corporate bonds as well as non-agency securitized products, a duration-based approximation is used.

(a) Present-Value Calculation for U.S. Treasuries

The Board projects the fair value of U.S. Treasuries classified as AFS using a discounted cash flow model. The model equates price with the present value of the security's cash flows, which are discounted using zero-coupon Treasury yields, as projected by the Yield Curve Model.[13] For each Treasury security, cash flows consist of semi-annual coupon payments and the face value, which is received at maturity. The size and timing of the cash flows remain the same for each quarter of the projection horizon. This is consistent with the model's constant portfolio assumption, where securities do not age with each passing quarter. The fair value projection for Treasuries without hedges is shown in Equation A-1:

Equation A-1 – projection of fair value for U.S. Treasuries without hedges

$$\mathrm{FV}_{i,t} = F_{i,0} \cdot \exp\left(-r\left[\tau_{i,k,t}, t\right] \cdot T_i\right) + \sum_{k=1}^{n} C_i \cdot \exp\left(-r\left[\tau_{i,k,t}, t\right] \cdot \tau_{i,k,t}\right)$$

Where:

[13] See the Yield Curve Model, Section C.

- $\text{FV}_{i,t}$ is the projection of fair value for Treasury security i at projection quarter t without hedges;
- $F_{i,0}$ is the current face value of security i at quarter 0[14] reported in FR Y-14Q, Schedule B.1, and remains constant for each quarter of the projection horizon;
- C_i is the dollar amount of each semi-annual coupon payment for Treasury security i and remains constant for each quarter of the projection horizon. C_i is equal to zero when security i is a Treasury bill;
- T_i is the remaining time to maturity in years for security i as of quarter 0, rounded to the nearest quarter of a year, and remains constant for each quarter of the projection horizon. If $T_i < 0.25$, then $\text{FV}_{i,t}$ is set equal to the quarter 0 market value reported in FR Y-14Q, Schedule B.1 for each quarter of the projection horizon;
- $\tau_{i,k,t}$ is the tenor, which is the remaining time in years until the kth cash flow is received for security i at projection quarter t, rounded to the nearest quarter of a year. The tenors and corresponding cash flows remain constant for each quarter of the projection horizon;
- $r[\tau_{i,k,t}, t]$ is the zero-coupon Treasury yield corresponding to each cashflow at tenor $\tau_{i,k,t}$ at projection quarter t, determined from Yield Curve Model projections as described in Section C; and
- n is the number of remaining semi-annual coupon payments for security i and remains constant for each quarter of the projection horizon.

Within the OCI Calculation, for each security, hedged fair value is projected as a weighted average of the unhedged and fully hedged fair value projections. The unhedged fair

[14] Quarter 0 is the last quarter before the start of the projection horizon.

value projections for Treasuries are described in the preceding text. For the fully hedged fair value projections, the portion of the change in fair value due to changes in interest rates is fully hedged, such that changes in fair value are due only to changes in credit spreads.[15] For Treasuries, changes in credit spreads do not impact Treasury valuations, and therefore the change in fair value due to changes in credit spreads is zero. As a result, the fully hedged fair value projections for Treasury security i remain constant at each quarter of the projection horizon, as shown in Equation A-2.

Equation A-2 – projection of fair value for U.S. Treasuries with interest rate risk fully hedged

$$\mathrm{FV}_{i,t}^{\mathrm{CREDIT}} = \mathrm{MV}_{\mathrm{i,0}}$$

Where:

- $\mathrm{FV}_{i,t}^{\mathrm{CREDIT}}$ is the fair value of security i at projection quarter t where changes in fair value are due only to changes in credit spreads. For Treasuries, the change in fair value due to changes in credit spreads is zero, so this value remains constant at each quarter of the projection horizon; and
- $\mathrm{MV}_{i,0}$ is the market value of security i at quarter 0.

(b) Full Revaluation for Agency MBS

The Board uses a third-party vendor model to project prices of Agency MBS classified as AFS. For a given security, the vendor model projects a price at each quarter of the projection horizon, which is expressed as a percentage of current face value at quarter 0. Each projected

[15] Credit spreads refer to the difference in interest rates on credit products above the corresponding interest rate on a "risk-free" instrument of similar maturity, typically a government bond. Spread widening is thus an increase in the rate demanded on a "risky" credit product relative to an equivalent "risk-free" product.

price is multiplied by the security's current face value at quarter 0, resulting in the projected fair value.

An important feature of Agency MBS is the embedded prepayment option, which is the right of the mortgage borrower to prepay the principal on their mortgage. A variety of factors influence a borrower's decision to prepay their mortgage, such as the current and historical rate environment, housing market developments, and broader macroeconomic conditions. Prepayments on the underlying mortgages create uncertainty in the size and timing of cashflows for Agency MBS, which is accounted for in the vendor model.

The third-party vendor model projects a security-specific price at each quarter of the projection horizon as follows: For a given security, Monte Carlo simulation is used to generate many interest rate paths, conditional on the projected macroeconomic scenario variables up to the valuation quarter. For a given interest rate path, expected prepayments are computed, which determine expected cash flows over the life of the security. Cashflows for a given path are discounted back to the valuation quarter at the zero-coupon U.S. Treasury rate plus an option-adjusted spread (OAS), resulting in the present value of the security for a single simulated path. The projected price of the security is equal to the average present value across all simulated paths, and is denoted by $P_{i,t}^{\mathrm{VEND}}$ in Equation A-3.

Equation A-3 – projection of price for Agency MBS

$$P_{i,t}^{\mathrm{VEND}} = f(\mathrm{OAS}_{i,0}, X_t^{\mathrm{MACRO}})$$

Where:

- $P_{i,t}^{\mathrm{VEND}}$ is the vendor-computed price of security i at projection quarter t, expressed as a percentage of security i's current face value at quarter 0, and changes each quarter of the projection horizon;

- $\text{OAS}_{i,0}$ is the vendor-computed OAS of security i at quarter 0 that equates $P_{i,t}^{\text{VEND}}$ to security i's market value at quarter 0 divided by its current face value at quarter 0; and
- X_t^{MACRO} denotes projections for macroeconomic scenario variables at projection quarter t that include: U.S. mortgage rate, U.S. prime rate, U.S. unemployment rate, U.S. Long-term House Price Index,[16] zero-coupon Treasury curve, Secured Overnight Financing Rate (SOFR) curve, U.S. Mortgage-Backed Securities Index for OAS projections applied to passthroughs, and U.S. Agency collateralized mortgage obligations (CMOs) index for OAS values applied to CMOs.[17]

The projected price $P_{i,t}^{\text{VEND}}$ at each quarter of the projection horizon is multiplied by its current face value at quarter 0, resulting in the projected fair value, as shown in Equation A-4.

Equation A-4 – projection of fair value for Agency MBS without hedges

$$\text{FV}_{i,t} = F_{i,0} \cdot P_{i,t}^{\text{VEND}}$$

Where:

- $\text{FV}_{i,t}$ is the projection of fair value for Agency MBS security i at projection quarter t without hedges;
- $F_{i,0}$ is the current face value of security i at quarter 0 reported in FR Y-14Q, Schedule B.1, and remains constant for each quarter of the projection horizon; and

[16] Projections for the U.S. Long-term House Price Index are generated for 40 quarters, where projections for quarters 1 through 13 are same as the U.S. House Price Index in the macroeconomic scenario.

[17] For additional information on the zero-coupon Treasury curve and SOFR curve, see Yield Curve Model in Section C. For additional information on the U.S. Mortgage-Backed Securities Index and U.S. Agency CMOs Index, see Auxiliary Scenario Variables in Section I.

- $P_{i,t}^{\mathrm{VEND}}$ is the vendor-computed price of security i at projection quarter t, expressed as a percentage of security i's current face value at quarter 0, and changes each quarter of the projection horizon.

Within the OCI Calculation, for each security, hedged fair value is projected as a weighted average of the unhedged and fully hedged fair value projections. The unhedged fair value projections for Agency MBS are described in the preceding text. For the fully hedged fair value projections, the portion of the change in fair value due to changes in interest rates is fully hedged, such that changes in fair value are due only to changes in credit spreads. For Agency MBS, although changes in option-adjusted spreads impact projections of unhedged fair value denoted by $\mathrm{FV}_{i,t}$, projections of fully hedged fair value denoted by $\mathrm{FV}_{i,t}^{\mathrm{CREDIT}}$ are assumed to be zero as a simplifying assumption. As a result, the fully hedged fair value projections for Agency MBS security i remain constant at each quarter of the projection horizon, as shown in **Equation A-5**.

Equation A-5 – projection of fair value for Agency MBS with interest rate risk fully hedged

$$\mathrm{FV}_{i,t}^{\mathrm{CREDIT}} = \mathrm{MV}_{\mathrm{i,0}}$$

Where:

- $\mathrm{FV}_{i,t}^{\mathrm{CREDIT}}$ is the fair value of security i at projection quarter t where changes in fair value are due only to changes in credit spreads. For Agency MBS, the change in fair value due only to changes in credit spreads is assumed to be zero as a simplifying assumption, so this value remains constant at each quarter of the projection horizon; and
- $\mathrm{MV}_{i,0}$ is the market value of security i at quarter 0 reported in FR Y-14Q, Schedule B.1.

(c) Duration-Based Approach for All Other Securities

The Board projects the fair value for AFS debt securities other than U.S. Treasuries and Agency MBS using a linear duration-based approximation. Under this approach, change in fair value is based on a security's price sensitivity to changes in interest rates and OAS, as well as projected changes in interest rates and OAS over the projection horizon. A security's price sensitivity is measured by effective rate duration and effective spread duration, which are defined as follows: Effective rate duration is the percentage change in a security's price for a given change in interest rates, and effective spread duration is the percentage change in a security's price for a given change in OAS. Both duration measures allow expected cash flows to vary at different interest rates and credit spreads due to embedded options.

The duration-based approach projects two fair value paths for each applicable credit-sensitive security: one in which changes in fair value are unhedged, and another in which the portion of the change in fair value due to changes in interest rates is fully hedged, such that changes in fair value are due only to changes in credit spreads. Within the OCI calculation, hedges are incorporated by computing a security's weighted average of the unhedged and fully hedged fair value projections, where the weight assigned to the fully hedged fair value is the hedge ratio. The text that follows first describes the methodology for unhedged fair value projections, followed by fully hedged fair value projections.

Unhedged changes in fair value are projected using two components: an interest rate component and credit spread component. The interest rate component captures the percentage change in fair value due to changes in interest rates and is equal to the security's effective rate duration multiplied by the change in projected interest rate. The credit spread component captures the percentage change in fair value due to changes in credit spreads, and is equal to the security's spread duration multiplied by the change in projected OAS. The interest rate component and credit spread component are added together, resulting in the projected percentage change in fair value without hedges of security i at projection quarter t as shown in Equation A-6.

Equation A-6 – duration-based projection of percentage change in fair value without hedges

$$\%\Delta \mathrm{FV}_{\mathrm{i,t}} = -\left(D_{i,0}^{\mathrm{RATE}} \cdot \Delta r_{i,t} + D_{i,0}^{\mathrm{SPRD}} \cdot \Delta \mathrm{OAS}_{i,t}\right)$$

Where:

- $\%\Delta \mathrm{FV}_{i,t}$ is the quarterly percentage change in fair value of security i at projection quarter t without hedges;
- $D_{i,0}^{\mathrm{RATE}}$ is the effective rate duration for security i as of quarter 0, which remains constant throughout the projection horizon, obtained from a third-party data vendor;
- $\Delta r_{i.t}$ is the quarterly change in interest rate corresponding to the maturity or weighted average life of security i at projection quarter t, as projected via Equation A-10;
- $D_{i,0}^{\mathrm{SPRD}}$ is the effective spread duration for security i as of quarter 0, which remains constant throughout the projection horizon, obtained from a third-party data vendor; and
- $\Delta \mathrm{OAS}_{i,t}$ is the quarterly change in the credit spread for security i at projection quarter t, as projected via Equation A-14 for corporate or covered bonds[18], via Equation A-15 for sovereign bonds, via Equation A-16 for preferred stock or via
- Equation ***A-18*** for other remaining credit-sensitive debt securities.

The projected fair value of security i at projection quarter t without hedges is shown in Equation A-7.

[18] Covered bonds are bonds issued by a bank or financial institution that are secured by a segregated pool of assets, against which investors have a preferential claim in the event of default.

Equation A-7 – duration-based projection of fair value without hedges

$$\mathrm{FV}_{i,t} = \begin{cases} \mathrm{MV}_{i,0} & \text{when } t = 0 \\ \mathrm{FV}_{i,t-1} \cdot \left(1 + \%\Delta\mathrm{FV}_{i,t}\right) & \text{when } t > 0 \end{cases}$$

Where:

- $\mathrm{FV}_{i,t}$ is the projection of fair value for security i at projection quarter t without hedges;
- $\mathrm{MV}_{i,0}$ is the market value reported for security i at quarter 0 reported in FR Y-14Q, Schedule B.1; and
- $\%\Delta\mathrm{FV}_{i,t} = -\left(D_{i,0}^{\mathrm{RATE}} \cdot \Delta r_{i.t} + D_{i,0}^{\mathrm{SPRD}} \cdot \Delta\mathrm{OAS}_{i,t}\right)$ is the percentage change in fair value of security i at projection quarter t without hedges, as described in Equation A-6.

In addition to projecting unhedged changes in fair value, the model generates projections where the portion of the change in fair value due to changes in interest rates is fully hedged, such that changes in fair value are only due to changes in credit spreads. The projected percentage change in fair value of security i at projection quarter t due only to changes in credit spreads denoted by $\%\Delta\mathrm{FV}_{\mathrm{i,t}}^{\mathrm{CREDIT}}$ is shown in Equation A-8.

Equation A-8 – duration-based projection of percentage change in fair value due only to changes in credit spreads

$$\%\Delta\mathrm{FV}_{\mathrm{i,t}}^{\mathrm{CREDIT}} = -D_{i,0}^{\mathrm{SPRD}} \cdot \Delta\mathrm{OAS}_{i,t}$$

The projected fair value of security i at projection quarter t where changes in fair value are only due to changes in credit spreads is given by Equation A-9.

Equation A-9 – duration-based projection of fair value due only to changes in credit spreads

$$\mathrm{FV}_{i,t}^{\mathrm{CREDIT}} = \begin{cases} \mathrm{MV}_{i,0} & \text{when } t = 0 \\ \mathrm{FV}_{i,t-1}^{\mathrm{CREDIT}} + \mathrm{FV}_{i,t-1} \cdot \%\Delta\mathrm{FV}_{\mathrm{i,t}}^{\mathrm{CREDIT}} & \text{when } t > 0 \end{cases}$$

Where:

- $\text{FV}_{i,t}^{\text{CREDIT}}$ is the fair value of security i at projection quarter t where changes in fair value are due only to changes in credit spreads;
- $\text{MV}_{i,0}$ is the market value of security i at quarter 0 reported in FR Y-14Q, Schedule B.1;
- $\text{FV}_{i,t-1}$ is the fair value without hedges from the prior quarter, as defined in Equation A-7; and
- $\%\Delta\text{FV}_{\text{i,t}}^{\text{CREDIT}} = -D_{i,0}^{\text{SPRD}} \cdot \Delta\text{OAS}_{i,t}$ is the change in the fair value of security i at projection quarter t due only to changes in credit spreads as defined in Equation A-8.

(i) Interest Rate Projection

The projection of quarterly interest rate changes, $\Delta r_{i,t}$, is used in the duration-based projection of fair value as shown in Equation A-6 and Equation A-7. The change in interest rate for security i is determined by the security type, as well as the maturity or weighted average life (WAL), according to Equation A-10.

Equation A-10 – projection for change in interest rate used in the duration model

$$\Delta r_{i,t} = \begin{cases} \Delta y_{\text{tsy}}(m_i, t) & \text{when } i \text{ is a direct obligation (other than a municipal bond)} \\ \Delta y_{\text{tsy}}(\text{WAL}_i, t) & \text{when } i \text{ is a securitized product} \\ \Delta y_{\text{muni}}^{\text{AAA}}(m_i, t) & \text{when } i \text{ is a municipal bond} \end{cases}$$

Where:

- $\Delta r_{i,t}$ is the quarterly change in the interest rate for security i used in the duration-based projection of fair value as shown in Equation A-6 and Equation A-7;
- $\Delta y_{\text{tsy}}(m_i, t)$ is the quarterly change in the U.S. Treasury yield corresponding to maturity m of security i at projection quarter t;
- $\Delta y_{\text{tsy}}(\text{WAL}_i, t)$ is the quarterly change in the U.S. Treasury yield corresponding to weighted average life WAL of security i at projection quarter t; and

- $\Delta y_{\text{muni}}^{\text{AAA}}(m_i, t)$ is the quarterly change in the U.S. AAA municipal yield corresponding to maturity m of security i at projection quarter t.

The U.S. Treasury yield is projected by the Yield Curve Model, as detailed in the Yield Curve Model Section C. The U.S. AAA municipal yield is projected by taking the U.S. Treasury yield corresponding to the maturity of the security and adding a spread term, as shown in **Equation *A-11***. The change in U.S. AAA municipal yield, $\Delta y_{\text{muni}}^{\text{AAA}}(m_i, t)$, is computed by taking the quarterly difference from one period to the next.

Equation A-11 – projection for AAA municipal yield

$$y_{\text{muni}}^{\text{AAA}}(m_i, t) = y_{\text{tsy}}(m_i, t) + \text{spr}_{\text{muni}}^{\text{AAA}}(10, t)$$

Where:

- $y_{\text{muni}}^{\text{AAA}}(m_i, t)$ is the U.S. AAA municipal yield corresponding to maturity m of security i at projection quarter t;
- $y_{\text{tsy}}(m_i, t)$ is the U.S. Treasury yield corresponding to maturity m of security i at projection quarter t; and
- $\text{spr}_{\text{muni}}^{\text{AAA}}(10, \text{t})$ is a spread term, defined as the ten-year AAA Municipal Yield[19] at projection quarter t minus the U.S. ten-year Treasury yield at projection quarter t.

The Schedule B.1 security types associated with the interest rate terms $\Delta y_{\text{tsy}}(m_i, t)$, $\Delta y_{\text{tsy}}(\text{WAL}_i, t)$, and $\Delta y_{\text{muni}}^{\text{AAA}}(m_i, t)$ from Equation A-10 are shown in Figure A-3.

[19] The ten-year AAA Municipal Yield is an Auxiliary Scenario Variable (see Section I).

Figure A-3 – changes in interest rates by security type used in the duration-based projection of fair value (Equation A-6 and Equation A-7)

<table>
<tr><th>Security type from FR Y-14Q, Schedule B.1 Security Description 1 (CQSCP084)</th><th>Security Sub-Type</th><th>Change in interest rate used in duration-based fair value projection</th></tr>
<tr><td>Agency MBS</td><td>all</td><td rowspan="2">not subject to duration model</td></tr>
<tr><td rowspan="2">US Treasuries & Agencies</td><td>Treasuries</td></tr>
<tr><td>Agencies</td><td rowspan="5">$\Delta \mathrm{y}_{\mathrm{tsy}}(m_i, t)$</td></tr>
<tr><td>Sovereign Bond</td><td>all</td></tr>
<tr><td>Corporate Bond</td><td>all</td></tr>
<tr><td>Covered Bond</td><td>all</td></tr>
<tr><td>Preferred Stock (Equity)</td><td>all</td></tr>
<tr><td>Municipal Bond</td><td>all</td><td>$\Delta y_{\mathrm{muni}}^{\mathrm{AAA}}(m_i, t)$</td></tr>
<tr><td>Domestic Non-Agency RMBS (incl HEL ABS)</td><td>all</td><td rowspan="9">$\Delta y_{\mathrm{tsy}}(\mathrm{WAL}_i, t)$</td></tr>
<tr><td>Foreign RMBS</td><td>all</td></tr>
<tr><td>CMBS</td><td>all</td></tr>
<tr><td>CDO</td><td>all</td></tr>
<tr><td>CLO</td><td>all</td></tr>
<tr><td>Auto ABS</td><td>all</td></tr>
<tr><td>Credit Card ABS</td><td>all</td></tr>
<tr><td>Student Loan ABS</td><td>all</td></tr>
<tr><td>Other ABS (excl HEL ABS)</td><td>all</td></tr>
<tr><td>Common Stock (Equity)</td><td>all</td><td rowspan="5">not subject to duration model</td></tr>
<tr><td rowspan="2">Mutual Fund</td><td>MMMF</td></tr>
<tr><td>all other</td></tr>
<tr><td>Auction Rate Securities</td><td>all</td></tr>
<tr><td>Other</td><td>all</td></tr>
</table>

(ii) Credit Spread Projection

OAS is the constant value added to a benchmark yield curve that makes the present value of a security’s cash flows equal to the observed market price, accounting for embedded options. OAS reflects additional risk not captured in the benchmark yield curve, such as credit risk. Projected changes in OAS are used in the duration-based projection of fair value as shown in

Equation A-6, Equation A-7, Equation A-8, and Equation A-9. The method for determining change in OAS for security i is based on security type:

- when i is a corporate bond or covered bond, projected changes in OAS follow Equation A-14;
- when i is a sovereign bond, projected changes in OAS follow Equation A-15;
- when i is preferred stock, projected changes in OAS follow Equation A-16;
- when i is any other type of credit-sensitive security, projected changes in OAS follow Equation A-18; and
- no credit projected changes in OAS are applied to U.S. Agency bonds or pre-refunded municipal bonds.

Figure A-4 provides a summary of how projected changes in OAS are determined for each security type in Schedule B.1 for which duration-based fair values are projected.

Figure A-4 – changes in OAS by security type used in the duration-based projection of fair value (Equation A-6, Equation A-7, Equation A-8, and Equation A-9)

Security type from FR Y-14Q, Schedule B.1 Security Description 1 (CQSCP084)	Security Sub-Type	Change in OAS used in duration-based fair value projection
Agency MBS	all	not subject to duration model[20]
US Treasuries & Agencies	Treasuries	
	Agencies	change in OAS is zero
Sovereign Bond	all	see Equation A-15
Corporate Bond	all	see Equation A-14
Covered Bond	all	
Municipal Bond	Pre-refunded[21]	change in OAS is zero
	all other	see Equation A-18
Domestic Non-Agency RMBS (incl HEL ABS)	all	
Foreign RMBS	all	
CMBS	all	
CDO	all	
CLO	all	
Auto ABS	all	
Credit Card ABS	all	
Student Loan ABS	all	
Other ABS (excl HEL ABS)	all	
Preferred Stock (Equity)	all	see Equation A-16
Common Stock (Equity)	all	not subject to duration model
Mutual Fund	MMMF	
	all other	
Auction Rate Securities	all	
Other	all	

[20] Refer to sections on fair value projections for U.S. Treasuries A(iii)(a)0(a) and Agency MBS A(iii)(a)0(b).

[21] Pre-refunded municipal bonds are municipal bonds where the funds to pay the bonds off at the call date are set aside in an escrow account.

(a) Corporate Bonds

For corporate and covered bonds, the change in the natural logarithm of OAS is specified according to Equation A-12. The regression is estimated using vendor-provided monthly historical bond-level and macroeconomic data. Each coefficient represents the estimated change in the natural logarithm of OAS associated with a unit change in the corresponding macroeconomic dependent variable.

Equation A-12 – corporate OAS estimation

$$\Delta\ln\left(\mathrm{OAS_{i,t}}\right) = \beta_{\mathrm{INT}} + \beta_{\mathrm{BBB}}\Delta\ln(\mathrm{CS}_t^{\mathrm{BBB}}) + \beta_{\mathrm{DJ}}\,\Delta\ln(\mathrm{DJ}_t) + \beta_{\mathrm{VIX}}[\Delta\ln(\mathrm{VIX}_t)]^{+} +$$

$$\beta_{DJ}^{\mathrm{FIN}}\Delta\ln(\mathrm{DJ}_t)\cdot I_i^{\mathrm{FIN}} + \beta_{DJ}^{\mathrm{UTL}}\Delta\ln(\mathrm{DJ}_t)\cdot I_i^{\mathrm{UTL}} + \beta_{\mathrm{BBB}}^{\mathrm{Mat}}\Delta\ln(\mathrm{CS}_t^{\mathrm{BBB}})\cdot m_i + \varepsilon_{i,t}$$

Where:

- $\Delta\ln\left(\mathrm{OAS_{i,t}}\right)$ is the change in the natural logarithm of OAS for bond i at month t;
- $\Delta\ln(\mathrm{CS}_t^{\mathrm{BBB}})$ is the change in the natural logarithm of the U.S. BBB corporate spread at month t, where the U.S. BBB corporate spread is the U.S. BBB corporate yield minus the U.S. ten-year Treasury yield;
- $\Delta\ln(\mathrm{DJ}_t)$ is the change in the natural logarithm of the U.S. Dow Jones Total Stock Market Index at month t;
- $[\Delta\ln(\mathrm{VIX}_t)]^{+}$ is the change in the natural logarithm of the U.S. Market Volatility Index at month t, where $[\Delta\ln(\mathrm{VIX}_t)]^{+} = \max(\Delta\ln(\mathrm{VIX}_t)\,, 0)$, such that only increases in stock market volatility influence spreads in the model, while decreases are reported as zero;
- I_i^{FIN} indicates whether the issuer of bond i is a financial sector entity;
- I_i^{UTL} indicates whether the issuer of bond i is a utilities sector entity; and
- m_i is the maturity of bond i in years.

Equation A-13 contains shorthand notation for the expected change in the natural logarithm of OAS, which is used in the corporate OAS projections. OAS is projected for covered and corporate bonds according to Equation A-14.

Equation A-13 – shorthand notation for the expected change in the natural logarithm of OAS, which is used in the corporate OAS projections

$$\boldsymbol{\beta} \cdot \boldsymbol{\Delta X}_t^{\mathrm{MACRO}} = \begin{bmatrix} \beta_{\mathrm{INT}} \\ \beta_{\mathrm{BBB}} \\ \beta_{\mathrm{DJ}} \\ \beta_{\mathrm{VIX}} \\ \beta_{DJ}^{\mathrm{FIN}} \\ \beta_{DJ}^{\mathrm{UTL}} \\ \beta_{\mathrm{BBB}}^{\mathrm{Mat}} \end{bmatrix}' \cdot \begin{bmatrix} 1 \\ \Delta\ln(\mathrm{CS}_t^{\mathrm{BBB}}) \\ \Delta\ln(\mathrm{DJ}_t) \\ [\Delta\ln(\mathrm{VIX}_t)]^+ \\ \Delta\ln(\mathrm{DJ}_t)\cdot I_i^{\mathrm{FIN}} \\ \Delta\ln(\mathrm{DJ}_t)\cdot I_i^{\mathrm{UTL}} \\ \Delta\ln(\mathrm{CS}_t^{\mathrm{BBB}})\cdot m_i \end{bmatrix}$$

Equation A-14 – projection for corporate OAS

$$\mathrm{OAS}_{i,t} = \begin{cases} \mathrm{OAS}_{i,0} & \text{when } t = 0 \\ \mathrm{OAS}_{i,t-1} \cdot \exp\left(\boldsymbol{\beta} \cdot \boldsymbol{\Delta X}_t^{\mathrm{MACRO}} + \dfrac{\sigma^2}{2}\right) & \text{when } t > 0 \end{cases}$$

Where:

- $\mathrm{OAS}_{i,t}$ is the option-adjusted spread for security i at projection quarter t;
- $\mathrm{OAS}_{i,0}$ is the OAS for security i at quarter 0, obtained from a third-party data vendor, floored at 0 bps and capped at 3000 bps;
- $\boldsymbol{\beta} \cdot \boldsymbol{\Delta X}_t^{\mathrm{MACRO}}$ is shorthand notation for the expected change in the natural logarithm of OAS as shown in Equation A-13; and
- σ is the residual standard deviation, which is approximated by the root mean square error of the regression estimated in Equation A-12, and multiplied by $\sqrt{3}$ to scale this value from the monthly frequency used for estimation to the quarterly frequency used for projections.

The coefficients and residual standard deviation used for quarterly projections of corporate OAS are shown in Figure A-5:

Figure A-5 – coefficients used for corporate OAS projections

Coefficient Name	Corresponding Variable	Coefficient Value	Standard Error
β_{INT}	intercept	-0.0014	0.0001
β_{BBB}	change in ln of BBB spread	$+0.6174$	0.0019
β_{DJ}	change in ln of stock market index	-0.7534	0.0032
β_{VIX}	change in ln of stock market volatility index (when positive)	$+0.0487$	0.0007
β_{DJ}^{FIN}	financial sector bond, stock market interaction	$+0.1070$	0.0061
β_{DJ}^{UTL}	utility sector bond, stock market interaction	$+0.3844$	0.0089
$\beta_{\text{BBB}}^{\text{Mat}}$	BBB spread, bond maturity interaction	-0.0082	0.0001
σ	Root mean squared error · $\sqrt{3}$	$+0.1952$ [22]	0.1127

(b) Sovereign Bonds

The change in sovereign bond OAS is projected based on high-percentile historical movements in sovereign bond spreads. For each credit rating and maturity grouping, historical data are used to compute annual changes in OAS on a monthly basis for sovereign bonds in that grouping, and the 93rd percentile is selected from the historical distribution.[23] Each sovereign bond reported in Schedule B.1 is assigned a change in OAS value from one of the maturity-rating groupings. If a security's maturity is missing, it is assigned a grouping that includes all

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[22] The root mean squared error from the regression of monthly observations is 0.1127. This value is multiplied by $\sqrt{3}$ to scale it from the monthly frequency used for estimation to the quarterly frequency used for projections, which is equal to $0.1127 \cdot \sqrt{3} = 0.1952$.

[23] The use of the 93rd percentile is discussed in the Specification Rationale and Calibration Section A(iii)(b)(a).

maturities. Similarly, if a security's credit rating is missing, it is assigned a grouping that includes all credit ratings.

For a given sovereign bond, the level of OAS linearly increases over the first four quarters of the projection horizon until it reaches its maximum value at quarter four. The level of OAS then linearly decreases from projection quarters four through nine. For a given sovereign bond i with rating R_i and maturity m_i, the change in OAS is determined according to Equation A-15.

Equation A-15 – projection for change in sovereign OAS

$$\Delta\text{OAS}_{i,t} = \begin{cases} \Delta\text{OAS}_{\text{P93}}^{\text{SOV}}[R_i, m_i]/4 & \text{when } t \leq 4 \\ -\Delta\text{OAS}_{\text{P93}}^{\text{SOV}}[R_i, m_i]/5 & \text{when } t > 4 \end{cases}$$

Where:

- $\Delta\text{OAS}_{i,t}$ is the quarterly change in option-adjusted spread for security i at projection quarter t; and
- $\Delta\text{OAS}_{\text{P93}}^{\text{SOV}}[R_i, m_i]$ is the historical 93rd percentile of annual OAS changes for sovereign bonds with credit rating R_i and maturity grouping m_i corresponding to security i.

Figure A-6 shows the historical 93rd percentile of annual changes in sovereign OAS computed monthly for each credit rating and maturity grouping, measured in basis points.

Figure A-6 – historical 93rd percentile of annual changes in sovereign OAS computed on a monthly basis for each credit rating and maturity grouping, measured in basis points

Maturity (years)	Credit Rating					
	AAA	AA	A	BBB	<BBB	All
< 3	171	148	267	188	416	220
$[3,5)$	148	150	218	192	354	188
$[5,7)$	132	129	177	168	337	161
$[7,10)$	100	126	139	185	287	142
$[10,15)$	86	117	113	183	213	128
≥ 15	69	106	85	153	240	106
All	109	124	165	175	315	151

(c) Preferred Stock

The change in OAS for preferred stock is based on the changes in corporate spreads projected by the Yield Curve Model.[24] For a given preferred stock holding i, with credit rating R, the quarterly change in OAS is determined as follows:[25]

Equation A-16 – projection for change in preferred stock OAS

$$\Delta \mathrm{OAS}_{i,t} = \Delta s_R(t)$$

Where:

- $\Delta \mathrm{OAS}_{i,t}$ is the quarterly change in OAS for security i at projection quarter t;
- $\Delta s_R(t)$ is the quarterly change in the corporate spread projection. $s_R(t)$ is the corporate spread projection corresponding to credit rating R projected by the Yield Curve Model, such that when R is an investment grade rating the corporate spread is based on changes in the BBB spread, and when R is a speculative grade rating the corporate spread is based

[24] More information on yield curve projections is provided in the Yield Curve Model Section C.

[25] Preferred stock may have characteristics similar to debt securities, equity securities, or both. The Fair Value Model treats all preferred stock as debt securities, and therefore fair value is influenced by corporate spreads.

on changes in OAS for high yield corporate bonds (see the Yield Curve Model Section C). [26] If a security's rating is missing, it is treated as a BBB-rated security.

(d) All Other

For all other credit-sensitive debt securities,[27] change in OAS is specified as follows: For investment grade positions, changes in OAS sub-indices by security type, rating, and maturity are regressed on changes in the corresponding OAS master index, as shown in Equation A-17. The six corresponding OAS master indices are Auxiliary Scenario Variables, and are shown in Figure ***A*-7**.[28] For speculative grade positions, the change in OAS for a given rating is based on changes in corporate spreads projected by the Yield Curve Model, regardless of security type or maturity.[29] Regressions are estimated using monthly observations.

Equation A-17 – estimation for change in OAS for all other investment grade credit-sensitive debt securities (other than corporate bonds, covered bonds, sovereign bonds and preferred stock)

$$\Delta \mathrm{OAS}_{a,R,m,t}^{\mathrm{SUB}} = \beta_{a,R,m} \cdot \Delta \mathrm{OAS}_{a,t}^{\mathrm{MASTER}} + \varepsilon_{a,R,m,t}$$

Where:

- $\Delta \mathrm{OAS}_{a,R,m,t}^{\mathrm{SUB}}$ is the change in OAS for the sub-index corresponding to master index a with credit rating R and maturity group m at time t;
- $\Delta \mathrm{OAS}_{a,t}^{\mathrm{MASTER}}$ is the change in OAS for master index a which is an Auxiliary Scenario Variable; and

[26] Investment grade refers to ratings of AAA, AA, A, and BBB, while speculative grades refers to ratings of BB, B, and CCC-C.

[27] All other credit-sensitive securities (other than corporate bonds, covered bonds, sovereign bonds and preferred stock) are comprised of the following security types: Municipal Bonds that are not pre-refunded, Domestic Non-Agency RMBS (incl HEL ABS), Foreign RMBS, CMBS, CDO, CLO, Auto ABS, Credit Card ABS, Student Loan ABS, and Other ABS (excl HEL ABS). See Figure A-4 for a list of all security types subject to the duration model. Exposure to all other credit-sensitive securities, as reflected in FR Y-14Q data, is relatively small.

[28] More information on auxiliary variables is provided in Auxiliary Scenario Variables Section I.

[29] More information on yield curve projections is provided in the Yield Curve Model Section C.

- $\beta_{a,R,m}$ is the sensitivity of the sub-index to changes in OAS of master index a.

Changes in OAS for all other credit-sensitive debt securities are projected according to Equation A-18.

Equation A-18 – projection for change in OAS for all other credit-sensitive debt securities (other than corporate bonds, covered bonds, sovereign bonds and preferred stock)

$$\Delta\text{OAS}_{i,t} = \begin{cases} \beta_{a,R,m} \cdot \ \Delta\text{OAS}_{a,t}^{\text{MASTER}} & \text{when } R \in \{\text{AAA, AA, A, BBB}\} \\ \Delta s_R(t) & \text{when } R \in \{\text{BB, B, CCC-C}\} \end{cases}$$

Where:

- $\Delta\text{OAS}_{i,t}$ is the quarterly change in OAS for security i at projection quarter t;
- $\Delta\text{OAS}_{a,t}^{\text{MASTER}}$ is the quarterly change in OAS for master index a which is an Auxiliary Scenario Variable; and
- $\Delta s_R(t)$ is the quarterly change in the corporate spread projection. $s_R(t)$ is the corporate spread projection corresponding to speculative credit ratings R projected by the Yield Curve Model, where the corporate spread is based on changes in OAS for high yield corporate bonds (see the Yield Curve Model Section C).

The OAS master index Auxiliary Scenario Variables and sub-index betas by security type, rating, and maturity, used to project OAS for all other investment grade credit-sensitive debt securities are shown in Figure ***A-7***.

Figure A-7 – OAS master index Auxiliary Scenario Variables and sub-index betas by security type, rating, and maturity, used to project OAS for all other investment grade credit-sensitive debt securities (other than corporate bonds, covered bonds, sovereign bonds and preferred stock).

Security Type from FR Y-14Q, Schedule B.1 Security Description 1 (CQSCP084)	Security Type from OAS Auxiliary Scenario Variable Master Index denoted by a	OAS Sub-index [30]	Rating R	Maturity m (yrs)	Beta $\beta_{a,R,m}$
Municipal Bond	Municipal Bonds	1-3 Year U.S. Municipal Securities	AAA-BBB	0-3	0.23
		3-5 Year U.S. Municipal Securities		3-5	0.28
		5-7 Year U.S. Municipal Securities		5-7	0.46
		7-10 Year U.S. Municipal Securities		7-10	0.44
		10-15 Year U.S. Municipal Securities		10-15	0.77
		15+ Year U.S. Municipal Securities		15+	1.32
(i) Foreign RMBS (ii) Domestic Non-Agency RMBS (incl HEL ABS)	Home Equity ABS	AAA U.S. Fixed Rate Home Equity Loan ABS	AAA	all	0.58
		AA-BBB U.S. Fixed Rate Home Equity Loan ABS	AA-BBB		1.24
(i) CMBS (ii) CLO	CMBS	0-3 Year AAA U.S. Fixed Rate CMBS	AAA	0-3	0.87
		3-5 Year AAA U.S. Fixed Rate CMBS		3-5	0.91
		5-7 Year AAA U.S. Fixed Rate CMBS		5-7	0.95
		7-10 Year AAA U.S. Fixed Rate CMBS		7-10	1.04
		10+ Year AAA U.S. Fixed Rate CMBS		10+	0.96
		0-3 Year AA U.S. Fixed Rate CMBS	AA	0-3	1.34
		3-5 Year AA U.S. Fixed Rate CMBS		3-5	1.53
		5-7 Year AA U.S. Fixed Rate CMBS		5-7	2.72
		7-10 Year AA U.S. Fixed Rate CMBS		7-10	3.11
		10+ Year AA U.S. Fixed Rate CMBS		10+	1.46
		0-3 Year Single-A U.S. Fixed Rate CMBS	A	0-3	2.14
		3-5 Year Single-A U.S. Fixed Rate CMBS		3-5	2.61

[30] Mappings are based on the closest available match of asset type, rating, and maturity.

Security Type from FR Y-14Q, Schedule B.1 Security Description 1 (CQSCP084)	Security Type from OAS Auxiliary Scenario Variable Master Index denoted by a	OAS Sub-index [30]	Rating R	Maturity m (yrs)	Beta $\beta_{a,R,m}$
		5-7 Year Single-A U.S. Fixed Rate CMBS		5-7	2.95
		7-10 Year Single-A U.S. Fixed Rate CMBS		7-10	4.06
		10+ Year Single-A U.S. Fixed Rate CMBS		10+	2.16
		0-3 Year BBB U.S. Fixed Rate CMBS	BBB	0-3	1.65
		3-5 Year BBB U.S. Fixed Rate CMBS		3-5	2.10
		5-7 Year BBB U.S. Fixed Rate CMBS		5-7	3.50
		7-10 Year BBB U.S. Fixed Rate CMBS		7-10	4.07
		10+ Year BBB U.S. Fixed Rate CMBS		10+	3.67
(i) CDO (ii) Student Loan ABS (iii) Other ABS (excl HEL ABS)	General ABS	AAA U.S. Asset Backed Securities	AAA	all	0.85
		AA-BBB U.S. Asset Backed Securities	AA-BBB		1.46
Credit Card ABS	Credit Card ABS	AAA U.S. Fixed Rate Credit Card ABS	AAA	all	0.97
		AA-BBB U.S. Fixed Rate Credit Card ABS	AA-BBB		1.51
Auto ABS	Auto ABS	AAA U.S. Fixed Rate Automobile ABS	AAA	all	0.83
		AA-BBB U.S. Fixed Rate Automobile ABS	AA-BBB		1.48

(2) Public Equity Securities

The Fair Value Model projects the fair value of public equity securities with readily determinable fair values using one of two methods, depending on the type of security. Common stock and non-money market mutual fund holdings follow the path of the U.S. Dow Jones Total

Stock Market Index projected in the macroeconomic scenario, and money market mutual funds grow at the three-month U.S Treasury rate projected in the macroeconomic scenario. Changes in fair value of equity securities are recorded in pre-tax net income and flow through to capital.

For a given public equity security that is common stock or a non-money market mutual fund holding, the projected fair value is calculated according to Equation A-19.

Equation A-19 – projection of fair value for common stock and non-money market mutual fund holdings

$$\mathrm{FV}_{i,t}^{\mathrm{EQ}} = \mathrm{MV}_{i,0} \cdot \frac{\mathrm{DJ}_t}{\mathrm{DJ}_0}$$

Where:

- $\mathrm{MV}_{i,0}$ is the market value of security i at quarter 0, as reported in Schedule B.1; and
- DJ_t is the level of Dow Jones U.S. Total Stock Market Index at projection quarter t.

For a given money market mutual fund holding i, the projected fair value is calculated according to Equation A-20.

Equation A-20 – projection of fair value for money market mutual fund holdings

$$\mathrm{FV}_{i,t}^{\mathrm{EQ}} = \begin{cases} \mathrm{MV}_{i,0} & \text{when } t = 0 \\ \mathrm{FV}_{i,t-1}^{\mathrm{EQ}} \cdot \dfrac{1}{1 - \left(\frac{1}{4}\right) \cdot d_{\mathrm{TBILL},t-1}^{3\mathrm{M}}} & \text{when } t > 0 \end{cases}$$

Where:

- $\mathrm{MV}_{i,0}$ is the market value of security i at quarter 0, as reported in Schedule B.1; and
- $d_{\mathrm{TBILL}}^{3\mathrm{M}}$ is the three-month U.S. T-Bill discount rate projected in the macroeconomic scenario.

Figure A-8 shows equity fair value projections by security type reported in Schedule B.1.

Figure A-8 – summary of equity fair value projection methods by security type

Security type from FR Y-14Q, Schedule B.1 Security Description 1 (CQSCP084)	Security Sub-Type	Fair value projection methodology
Common Stock (Equity)	all	U.S. equity market return
Mutual Fund	non-MMMF	
	MMMF	U.S. three-month T-Bill return

b. *Specification Rationale and Calibration*

(1) Treasuries and Agency MBS

U.S. Treasuries and Agency MBS together account for approximately 80 percent of the total AFS debt securities portfolio across firms. Due to the level of materiality, approaches that more accurately model changes in fair value are favored for these two security types, rather than simpler approaches that may not incorporate the same degree of complexity. A present value cash flow approach is appropriate for Treasury securities because they are option-free, have no prepayment, and all cashflows are known. For Agency MBS, rather than use an approximation or develop an internal Agency MBS valuation approach, the Board chose to use a third-party vendor model based on the following considerations. First, given the size of Agency MBS holdings across firms, an approximate fair value estimate, such as the linear duration-based approximation that is used for less material security types, was not favored.[31] Second, Agency MBS exhibit a level of complexity that warrants more sophisticated modeling techniques. Valuation is challenging due to the dependence of security cashflows on underlying borrower

[31] Agency MBS contain prepayment and embedded option characteristics. These characteristics are also influenced by various macroeconomic variables in addition to interest rate changes. Given movements in prepayment speeds and refinancing, a duration-based approximation is not as accurate a measure of fair value changes for Agency MBS due to the linear approximation approach having limited capacity to capture prepayment and embedded options.

behavior[32] and its interaction with the uncertain path of interest rates and the economy. As such, the use of existing, specialized pricing analytics, with a history of commercial application, was preferred, and considered to better reflect how security market values would change over time under a given scenario, relative to the Board undertaking the development and maintenance of its own Agency MBS valuation framework for use in the stress test.

(2) Duration-Based Approximation

The remainder of the AFS debt portfolio, beyond U.S. Treasuries and Agency MBS, is comprised of a variety of security types, each individually accounting for a small fraction of the overall AFS debt portfolio.[33] The Board, therefore, chose to adopt the duration approximation, specified in Equation A-7, as a simple and interpretable method of capturing the fair value impacts of interest rate and credit spread movements for these securities. This ensures consistency across the various product types without the complexity of introducing detailed pricing analytics specific to each type.[34] The linear duration approach is conservative in that it tends to overstate declines in fair value for a rise in interest rates or credit spreads and understate rise in fair value for a decline in interest rates or spreads. The full revaluation approach was also not implemented due to the complexities in obtaining and projecting cashflow schedules for many different securities.

[32] For example, borrowers may prepay or default on their mortgage, altering the horizon over which principal is returned to security borrowers as well as the amount of interest received in the interim.

[33] The remaining sixteen debt security type segments, around which Schedule B.1 reporting is organized, collectively account for approximately twenty percent of the AFS debt portfolio only.

[34] See the Board's Stress Test Policy Statement principles. 12 CFR part 252, Appendix B.

(a) Credit Spread Projection

Under the duration-based approximation, various methods are used to determine the spread shocks, depending on the rating and maturity that apply to each security type.

(i) Corporate Bonds

Equation A-12, is based on three macroeconomic scenario variables and two bond-specific variables. The three scenario variables are the ten-year BBB spread, the U.S. Dow Jones Total Stock Market Index, and the VIX. The bond-specific variables are the remaining time to maturity of the bond and the bond sector. The parameters for these variables were estimated based on monthly changes in OAS from a sample of corporate and high-yield bonds from a third-party data vendor. The corporate bonds and high-yield bonds correspond to the OAS of investment grade and speculative grade securities, respectively. The three scenario variables capture key elements of credit risk and the relationship with broader market risk return and volatility. The ten-year BBB spread serves as a proxy for credit risk in the corporate bond market, while changes in the spread reflect changes in the general risk sentiment or economic conditions or uncertainties. The Dow Jones Total Stock Market Index relates the corporate spreads to overall market trends, and the VIX index relates the corporate credit spreads to short-term market volatility and investor sentiment.

(ii) Sovereign Bonds

Sovereign bond OAS is projected based on high-percentile historical movements in sovereign bond spreads. For sovereign bonds, the model generates spread projections for a given rating and maturity segment based on historical one-year changes in OAS on a monthly basis (see Figure A-6).[35] These are observed at the 93rd percentile for a given rating and maturity segment. The 93rd percentile is chosen based on the historical frequency of severe recessions. Specifically, in the sixty years from 1956 to 2015, the Board identified nine global recessions, four of which were severe. Thus, the calculated frequency of severe recessions is 4/60 or approximately seven percent, suggesting that OAS shocks at the 93rd percentile of the historical OAS shock distribution are consistent with the severely adverse conditions modeled in the supervisory stress test. The 93rd percentile is also consistent with the chosen severe percentile in the Trading IDL and Operational Risk models.

(iii) Preferred Stock

Preferred stock[36] fair values are projected based on projections of generic corporate spreads by rating, which are produced by the Yield Curve Model. These are utilized in preference to developing and maintaining a spread projection specific to preferred stock. A fixed income model approach is applicable to preferred stocks, because they have fixed dividends, priority in liquidation, and lower volatility compared to common stocks.

(iv) All Other

For all other investment grade credit-sensitive debt securities, changes in OAS sub-indices by rating and maturity are regressed on changes in the corresponding OAS master index. For speculative grade positions, the change in OAS for a given rating is based on changes in corporate spreads projected by the Yield Curve Model, regardless of security type or maturity. Regressions are estimated using monthly observations, and estimated through the origin, such

[35] Due to the relatively smaller number of sovereign bonds rated below investment grade, bonds with ratings below BBB- were combined into a single rating bucket.

[36] Preferred stock accounts for approximately 0.1 percent of the AFS portfolio.

that an intercept term is not included in the model. This ensures that the expected change in spread projected for a given security is zero when the change in the corresponding scenario spread variable is zero.

c. *Alternative Approaches*

The Board has considered the following alternative frameworks for projecting the fair value of securities.

(1) Firm Calculation of Fair Value

The Board considered the use of firm-provided security fair value projections, conditional on the interest rate and credit spread scenario inputs, to determine OCI impacts on regulatory capital over the stress test horizon. Firms leverage their own internal models and calculate OCI gains / losses under these scenario inputs and report the results in FR Y-14A filings. In leveraging firms' valuation infrastructure, this approach could potentially allow security-specific features to be captured more accurately (along with, potentially, the OCI impact of security aging, paydown, and reinvestment, if the constant portfolio assumption is eventually relaxed, as discussed in Section A(v)(1)(1) (OCI Calculation). This is a paradigm that has been effective in the Global Market Shock (GMS) component of the stress test, where firm-provided mark-to-market (MtM) valuations conditional on market risk factor scenario shock inputs are used to determine GMS profit and loss.

However, there are some disadvantages associated with the potential use of firm-provided estimates for AFS security OCI impact determination. First, it is questionable whether reasonable consistency between firms could be achieved in the way scenario inputs are translated into fair value impacts. Second, there is potential for additional reporting burden, depending in part on the level of granularity at which AFS security OCI inputs would be requested in new reporting by firms. In view of these issues, the Board continues to project OCI using the Fair Value Model as specified, which values U.S. Treasury and Agency MBS securities (together accounting for approximately 80 percent of the AFS portfolio across firms) without material approximations and uses a simple and interpretable duration approximation for the remainder of the portfolio. This is considered to reasonably account for the impacts of rate and spread movements on less material security holdings.[37] Examining the tradeoff between complexity and materiality, simpler models are easier to understand and implement.

The Board is considering making changes to the framework for reinvestment of maturing and prepaying securities, and changes to the way securities' amortized costs are modeled over the projection horizon. These alternatives touch upon the Fair Value models and are discussed in more detail within Section A(v)(1)(1) (OCI Calculation).

d. *Data Adjustments*

(1) Securities Without Fair Value Projections

Fair value projections are not generated for certain securities for two reasons. The first reason is the firm-reported CUSIP or ISIN cannot be identified using a standard check-digit algorithm, which checks whether the reported CUSIP or ISIN has the correct number of characters and whether all characters are valid. The second reason is the firm-reported CUSIP or ISIN cannot be matched to the third-party vendor fields necessary to generate fair value projections.

For securities that do not pass the check-digit test and are private placements, and for securities that pass the check-digit test but cannot be matched to the necessary vendor fields,

[37] See the Board's Stress Testing Policy Statement, 12 CFR 252, Appendix B, Section 1.4 on simplicity.

returns are assigned for a given quarter as follows: The average return is assigned from the distribution of projected AFS and HTM returns at the firm-security type level, weighted by market value. If projected returns are unavailable at the firm-security type level, then the average of projected AFS and HTM returns across all firms at the security type level is used. This computation is performed separately for unhedged fair value returns and fully hedged fair value returns.

For securities that do not pass the check-digit test and are not private placements, returns are assigned for a given quarter as follows: The tenth percentile of returns is assigned from the distribution of projected AFS and HTM returns at the firm-security type level, weighted by market value. If projected returns are unavailable at the firm-security type level, then the tenth percentile of projected AFS and HTM returns across all firms at the security type level is used. This computation is performed separately for unhedged fair value returns and fully hedged fair value returns.

e. *Assumptions and Limitations*

Beyond the general constant portfolio assumption maintained across all sub-models, the Fair Value Model component embeds certain assumptions in duration and credit spread projection. These two key assumptions and limitations are as follows:

(1) Static Duration-Based Approach

A duration approach is one of the common ways to measure interest rate risk and is a critical factor in risk valuation. The duration-based approximation (Equation A-7) uses duration measures fixed as of quarter 0, when in practice the effective duration of a security at a future point in the stress horizon, even if assuming a fixed maturity / no aging, will vary with its current yield and the sensitivity of the value of any embedded options to yield changes. This assumption of constant risk and security characteristics allows the flexibility to apply duration estimates consistently across multiple security types. The duration-based approximation is a good estimate for most securities, and the approximation tends to be positive, because most securities have positive convexity. This means fair value will increase by more than the duration estimate when interest rates decrease and will decrease by less than the duration estimate when interest rates increase.

(2) Credit Spread Projection

Spread volatility is shown empirically to increase with spread level; however, for securities other than corporate bonds, projected OAS changes from the supervisory stress test macroeconomic scenario do not directly depend on the initial OAS of the security. As such, the model does not directly capture the propensity of bonds with higher spreads to exhibit higher spread shocks, because spread duration is held constant to the initial level in the stress horizon. It does, however, indirectly capture this propensity through segmentation of credit spread projections by initial credit rating. Additionally, projected spread shocks generally assume a constant credit rating for a given security and, therefore, may be less severe relative to a projection method that would account for rating migration.[38] When ratings are downgraded in a severely stressed environment, the change in OAS will be higher (larger negative shock) than if ratings were not downgraded.

[38] Rating migration refers to the change in credit rating over time. For example, a rating change from BBB to BB from one quarter to the next.

iv. Credit Loss Model

a. *Model Specification*

The Credit Loss Model projects credit losses for AFS and HTM securities over the projection horizon. Credit loss projections are used to compute two inputs for the calculation of provisions for credit losses. The first is charge-offs, which capture the amount deemed uncollectible in the current quarter. The second is allowance for credit losses, determined as the sum of projected credit losses over the next four quarters. Provisions for credit losses for securities are determined outside of the Securities Model, by the Provisions Model (which also determines provisions for loans), and included in pre-tax net income.

Credit losses are projected based on the probability of default, recovery rate, and amortized cost corresponding to a given security. The method used to determine the probability of default and recovery rate for a given credit-sensitive security depends on whether a security is a securitized product.[39] For debt securities that are not securitized products, projections for probability of default and recovery rate are tied to the macroeconomic scenario. For securitized products, constant probabilities of default and constant recovery rates are applied. Agency MBS, U.S. Treasuries & Agencies, Federal Family Education Loan Program student loan asset-backed securities, and pre-refunded municipal bonds are assumed to not be subject to credit losses.

Credit losses are projected according to the formula in Equation A-21. The subscript b denotes the security type from the historical probability of default data, while the subscript r indicates investment grade or speculative grade. See Figure A-9 for the mapping between the

[39] Credit-sensitive securitized products from FR Y-14Q, Schedule B.1 are Foreign RMBS, Domestic Non-Agency RMBS (incl HEL ABS), CMBS, CLO, CDO, Credit Card ABS, Auto ABS, Student Loan ABS, and Other ABS (excl HEL ABS). Credit-sensitive security types that are not securitized products from FR Y-14Q, Schedule B.1 are Sovereign Bond, Municipal Bond, Corporate Bond, Covered Bond, Preferred Stock (Equity), Auction Rate Securities, and Other.

security types from FR Y-14Q, Schedule B.1 and the security types from the historical probability of default data.

Equation A-21 – projection of credit losses

$$\mathrm{CL}_{i,t} = \begin{cases} \mathrm{AC}_{i,0} \cdot \mathrm{PD}_{b,r,t}^{\mathrm{MACRO}}/4 \cdot \left(1 - \mathrm{RR}_t^{\mathrm{MACRO}}\right) & \text{when } i \text{ is not a securitized product} \\ \mathrm{AC}_{i,0} \cdot \mathrm{PD}_{b,r}^{\mathrm{CONST}}/4 \cdot (1 - \mathrm{RR}^{\mathrm{CONST}}) & \text{when } i \text{ is a securitized product} \end{cases}$$

Where:

- $\mathrm{CL}_{i,t}$ is the credit loss for security i at projection quarter t and is a positive value;
- $\mathrm{AC}_{i,0}$ is the amortized cost for security i at quarter 0 reported in FR Y-14Q, Schedule B.1 and remains constant for each quarter of the projection horizon;
- $\mathrm{PD}_{b,r,t}^{\mathrm{MACRO}}$ is the annual probability of default corresponding to security type b and credit rating category r at projection quarter t and is based on the macroeconomic scenario;
- $\mathrm{RR}_t^{\mathrm{MACRO}}$ is the recovery rate for all debt securities that are not securitized products at projection quarter t based on the macroeconomic scenario;
- $\mathrm{PD}_{b,r}^{\mathrm{CONST}}$ is the annual probability of default corresponding to security type b and credit rating category r and remains constant for each quarter of the projection horizon; and
- $\mathrm{RR}^{\mathrm{CONST}}$ is the recovery rate for all securitized products, which equals 50 percent and remains constant for each quarter of the projection horizon.

$\mathrm{PD}_{b,r,t}^{\mathrm{MACRO}}$ and $\mathrm{RR}_t^{\mathrm{MACRO}}$ are modeled separately using a fractional logit model, where the dependent variable is the natural logarithm of the odds ratio and the independent variable is the BBB spread, which is defined as the BBB corporate yield minus the ten-year U.S. Treasury yield. For $\mathrm{PD}_{b,r,t}^{\mathrm{MACRO}}$, the specification shown in Equation A-22 is used to obtain coefficient estimates. Then Equation A-22 is rearranged to give the corresponding projection Equation A-23, which is used to generate the projected paths for the probability of default.

Equation A-22 – probability of default estimation

$$\ln\left(\frac{\mathrm{PD}_{b,r,t}^{\mathrm{MACRO}}}{1-\mathrm{PD}_{b,r,t}^{\mathrm{MACRO}}}\right) = \alpha_{b,r} + \beta_{b,r}\mathrm{BBB\ spread_t} + \varepsilon_{b,r,t}$$

Equation A-23 – probability of default projections

$$\mathrm{PD}_{b,r,t}^{\mathrm{MACRO}} = \frac{1}{1+\exp\left[-\left(\alpha_{b,r} + \beta_{b,r}\mathrm{BBB\ spread_t}\right)\right]}$$

Similarly, for $\mathrm{RR}_t^{\mathrm{MACRO}}$, the specification shown in Equation A-24 is used to obtain coefficient estimates. Then Equation A-24 is rearranged to produce the projection Equation ***A-25***, which is used to generate projections for the recovery rate.

Equation A-24 – recovery rate estimation

$$\ln\left(\frac{\mathrm{RR}_t^{\mathrm{MACRO}}}{1-\mathrm{RR}_t^{\mathrm{MACRO}}}\right) = \alpha + \beta\ \mathrm{BBB\ spread_t} + \varepsilon_t$$

Equation A-25 – recovery rate projections

$$\mathrm{RR}_t^{\mathrm{MACRO}} = \frac{1}{1+\exp[-(\alpha + \beta\ \mathrm{BBB\ spread_t})]}$$

The charge-off for security i at projection quarter t, denoted by $\mathrm{CO}_{i,t}$, captures the amount deemed uncollectible in a given quarter and is equal to the projected credit loss $\mathrm{CL}_{i,t}$ for that quarter as shown in Equation A-26.

Equation A-26 – projection of charge-offs

$$\mathrm{CO}_{i,t} = \mathrm{CL}_{i,t}$$

Allowance for credit losses for security i at projection quarter t, denoted by $\mathrm{ACL}_{i,t}$, is computed according to Equation A-27. For HTM debt securities, $\mathrm{ACL}_{i,t}$ is equal to the sum of the next four quarters of credit losses. For AFS debt securities, $\mathrm{ACL}_{i,t}$ is equal to the minimum of the following values: the sum of the next four quarters of credit losses and the amount that the fair value is less than the amortized cost, represented as a positive value.[40] If an AFS debt security's fair value $\mathrm{FV}_{i,t}$ is greater than its amortized cost $\mathrm{AC}_{i,0}$ then $\mathrm{ACL}_{i,t}$ is equal to zero.

Equation A-27 – projection of allowance for credit losses

$$\mathrm{ACL}_{i,t} = \begin{cases} \sum_{j=1}^{4} \mathrm{CL}_{i,t+j} & \text{when } i \text{ is an HTM debt security} \\ \min\left(\sum_{j=1}^{4} \mathrm{CL}_{i,t+j},\ \max\left(\mathrm{AC}_{i,0} - \mathrm{FV}_{i,t}, 0\right)\right) & \text{when } i \text{ is an AFS debt security} \end{cases}$$

Provisions for credit losses are determined outside of the Securities Model, by the Provisions Model. The computation of provisions for credit losses in a given quarter is shown in Equation A-28, and is included here in the Securities Model section for convenience. Each term in the formula represents a given firm's aggregate value across all credit-sensitive AFS and HTM debt securities. For a given firm, provisions for credit losses at projection quarter t are equal to charge-offs, plus the change in allowance for credit losses compared to the previous quarter, plus a term to reconcile differences between firm-reported and supervisory projections of allowance for credit losses at quarter zero, which is evenly distributed over the projection horizon. The Provisions Model calculates the cumulative quarterly change in provisions for credit losses.

[40] Limiting an AFS debt security's allowance for credit losses by the amount that the fair value is less than the amortized cost is consistent with U.S. GAAP as indicated in FASB ASC 326-30-35-2.

Equation A-28 – provisions for credit losses

$$\mathrm{PCL}_t = \mathrm{CO}_t + \mathrm{ACL}_t^{\mathrm{sup}} - \mathrm{ACL}_{t-1}^{\mathrm{sup}} + \frac{\mathrm{ACL}_0^{\mathrm{sup}} - \mathrm{ACL}_0^{\mathrm{firm}}}{9}$$

Where:

- PCL_t is the sum of provisions for credit losses across all applicable securities i for a given firm at projection quarter t and is equal to the sum $\sum_i \mathrm{PLC}_{i,t}$;
- CO_t is the sum of charge-offs across all applicable securities i for a given firm at projection quarter t and is equal to $\sum_i \mathrm{CO}_{i,t}$;
- $\mathrm{ACL}_t^{\mathrm{sup}}$ is the sum of the supervisory projection of allowance for credit losses across all applicable securities i for a given firm at projection quarter t and is equal to $\sum_i \mathrm{ACL}_{i,t}$; and
- $\mathrm{ACL}_0^{\mathrm{firm}}$ is the firm-reported allowance for credit losses at quarter 0 across all applicable securities and is obtained from FR Y-9C.

Figure A-9 shows the estimated coefficients and constant values for probabilities of default and recovery rates. Securities that are not securitized products use coefficient estimates from the fractional logit model, while securitized products use constant values. The mapping between the security types from Y-14Q, Schedule B.1 and the security types from the historical probability of default data are also shown.

Figure A-9 – estimated coefficients and constant loss rates for credit-sensitive securities

<table>
<tr><th rowspan="3">Estimated coefficients or constant values</th><th rowspan="3">Security type from FR Y-14Q, Schedule B.1 Security Description 1 (CQSCP084)</th><th rowspan="3">Security type from historical probability of default data series denoted by b</th><th colspan="4">Annual probability of default</th><th colspan="2" rowspan="2">Recovery Rate</th></tr>
<tr><th colspan="2">Investment grade</th><th colspan="2">Speculative grade</th></tr>
<tr><th>$\alpha_{b,r}$</th><th>$\beta_{b,r}$</th><th>$\alpha_{b,r}$</th><th>$\beta_{b,r}$</th><th>α</th><th>β</th></tr>
<tr><td rowspan="7">Estimated coefficients for security types that are not securitized products</td><td>Auction Rate Securities</td><td>Auction Rate Securities</td><td>-7.5077</td><td>0.4929</td><td>-4.1314</td><td>0.2177</td><td rowspan="7">0.4189</td><td rowspan="7">-0.3535</td></tr>
<tr><td>Corporate Bond</td><td rowspan="4">Corporate</td><td rowspan="4">-7.6284</td><td rowspan="4">0.3643</td><td rowspan="4">-3.9221</td><td rowspan="4">0.3458</td></tr>
<tr><td>Covered Bond</td></tr>
<tr><td>Preferred Stock (Equity)</td></tr>
<tr><td>Other</td></tr>
<tr><td>Municipal Bond</td><td>Municipal</td><td>-7.8833</td><td>0.4246</td><td>-3.8977</td><td>0.3787</td></tr>
<tr><td>Sovereign Bond</td><td>Sovereign</td><td>-7.5848</td><td>0.3474</td><td>-3.9498</td><td>0.2798</td></tr>
<tr><td rowspan="9">Constant values for securitized products</td><td>CMBS</td><td>Global CMBS</td><td colspan="2">0.0018</td><td colspan="2">0.116</td><td colspan="2" rowspan="9">0.5</td></tr>
<tr><td>CLO</td><td>Global CLO</td><td colspan="2">0.001</td><td colspan="2">0.008</td></tr>
<tr><td>CDO</td><td>Global Structured Credit</td><td colspan="2">0.001</td><td colspan="2">0.048</td></tr>
<tr><td>Foreign RMBS</td><td>Global Structured Finance</td><td colspan="2">0.002</td><td colspan="2">0.12</td></tr>
<tr><td>Domestic Non-Agency MBS</td><td>US RMBS</td><td colspan="2">0.0036</td><td colspan="2">0.156</td></tr>
<tr><td>Credit Card ABS</td><td rowspan="4">ABS</td><td colspan="2" rowspan="4">0.001</td><td colspan="2" rowspan="4">0.04792</td></tr>
<tr><td>Auto ABS</td></tr>
<tr><td>Student Loan ABS</td></tr>
<tr><td>Other ABS (excl HEL ABS)</td></tr>
</table>

b. *Specification Rationale and Calibration*

(1) Probability of Default and Recovery Rate Estimation

Probabilities of default and recovery rates are modeled separately for securitized products and security types that are not securitized products, as detailed below.

Security types that are not securitized products

Probabilities of default and recovery rates are modeled separately using a fractional logit model, as described in Equation A-22 and Equation A-24, respectively. The dependent variable is the natural logarithm of the odds ratio, and the independent variable is the BBB spread, which is defined as the BBB corporate yield minus the ten-year Treasury yield. A higher BBB spread is associated with increased default risk and lower recoveries. The fractional logit model reflects that probabilities of default and recovery rates are continuous variables on the [0,1] interval. This ensures that the model does not project negative credit losses or credit losses that exceed a bond's value.

Coefficients are estimated using annual probabilities of default and recovery rates observed on a quarterly basis, which are obtained from a third-party data vendor. The probability of default specification is estimated for each combination of security type b and credit rating category r. The security type is from the historical probability of default data, while the credit rating category is investment grade or speculative grade. This segmentation provides additional granularity and allows the model to better capture the characteristics of firm security holdings. See Figure A-9 for the estimated coefficients by security type and rating.

Recovery rates for all security types that are not securitized products are estimated based on a single series of historical observations, without segmentation. As a result, the same recovery rate is applied to all security types that are not securitized products for a given quarter of the projection horizon. The Board explored the possibility of using the same level of granularity for modeling recovery rates as is used for modeling probability of default, which would involve segmenting by security type and credit rating. However, average recovery rates were not significantly different across security types, and characteristics of the data supported aggregation rather than segmenting by investment-grade and speculative grade.

Securitized products

Constant default rates are applied to securitized products. Each security is assigned a fixed default rate corresponding to its security type and rating that remains constant throughout the projection horizon. The time period of the historical data used to determine the constant default rates is shorter than the period used for estimating the coefficients for security types that are not securitized products. This approach ensures the default rates used for securitized products reflect the reforms this sector has undergone in the years following the 2008 financial crisis. As with the security types that are not securitized products, the same recovery rate is applied to all securitized products, which is a constant.

c. *Alternative Approaches*

(1) Closer Alignment with CECL

The Credit Loss Model is based in part on the current expected credit loss (CECL) model detailed under Accounting Standards Update (ASU) 2016-13. The Credit Loss Model deviates from CECL in the timeframe for consideration of credit losses. Rather than estimating credit losses over the remaining lifetime of a bond as under CECL, the Credit Loss Model measures credit losses over a four-quarter look ahead period. The rationale for setting the look-ahead period to four quarters is to ensure this assumption is similar across securities and loans, which aligns with the Board's principle of consistency and comparability. To more closely align the new Credit Loss Model with CECL, the four-quarter look-ahead period would be replaced with a lookahead period equal to the remaining lifetime of the security.

d. *Data Adjustments*

For securities with missing credit ratings, an investment grade credit rating is assumed.

e. *Assumptions and Limitations*

(1) Securities Not Subject to Credit Losses

Agency MBS, U.S. Treasuries & Agencies, Federal Family Education Loan Program student loan asset-backed securities, and pre-refunded municipal bonds are assumed to not be subject to credit losses.

(2) Flat Balance Sheet Assumption

A flat balance sheet assumption is made by maintaining a constant balance sheet for each quarter of the stress test horizon. This assumption is consistent with the Credit Supply Maintenance policy found in the Policy Statement. This implicitly assumes that a firm originates new bonds each quarter with the same security type and broad rating to ensure that in aggregate each quarter's portfolio is identical.

(3) Credit Loss Projection Horizon Assumption

At each point in the projection horizon, allowance for credit losses are based on expected credit losses over the next four quarters. The implication of this assumption is that provisions for credit losses, which are predominantly determined by the changes in the allowance, are based on changing expectations for economic conditions over the four-quarter lookahead period. This approach is consistent with the way loan loss provisions are treated elsewhere in the banking book.

v. OCI Calculation

a. *Model Specification*

The OCI Calculation computes pre-tax unrealized gains and losses on AFS debt securities based on projected changes in fair value, accounting for any projected credit losses and applicable hedges. Projections for fair value are obtained from the Fair Value Model, and projections for credit losses are obtained from the Credit Loss Model. Unrealized gains and losses for an AFS security at a given point in time are equal to the security's fair value minus amortized cost. OCI is determined outside of the Securities Model by the Capital Model. OCI is equal to the cumulative quarterly change in pre-tax unrealized gains and losses on AFS debt securities adjusted for credit losses and hedges, and accounts for taxes and other adjustments. OCI is included in CET1 capital for firms subject to Category I or II standards, and firms that do not opt out of including AOCI in regulatory capital.[41]

A security-specific hedge ratio is computed for each AFS security according to Equation ***A-29***. This calculation incorporates fair value hedges that hedge interest rate risk and are not one-sided. The hedge ratio for a given security is defined as the summation of the amortized cost reported in FR Y-14Q, Schedule B.2 (Securities 2, Investment Securities with Designated Accounting Hedges) multiplied by the hedge percentage reported in FR Y-14Q, Schedule B.2, divided by the amortized cost reported in FR Y-14Q, Schedule B.1.

[41] While AOCI consists of several different components, the only components of AOCI projected by the Securities Model are unrealized gains and losses on AFS securities, adjusted for projected credit losses and fair value hedges. Components of AOCI that are not projected by the Securities Model are unrealized gains and losses on cash flow hedges, foreign currency translation adjustments, pension liabilities, and debt valuation adjustment.

Equation A-29 – hedge ratio calculation

$$H_i = \frac{\sum_j \mathrm{AC}_{i,j}^{\mathrm{B2}} \cdot \mathrm{PCT}_{i,j}^{\mathrm{B2}}}{\mathrm{AC}_{i,0}}$$

Where:

- H_i is the hedge ratio for security i at quarter 0 and remains constant for each quarter of the projection horizon;
- j indexes all fair value hedging relationships corresponding to security i that hedge interest rate risk and are not one-sided. In FR Y-14Q, Schedule B.2, fair value hedges are indicated by "Type of Hedge(s)" = 1, hedges against interest rate risk are indicated by "Hedged Risk" $\in \{1,2,5,6,8\}$,[42] and hedges that are not one-sided are indicated by "Sidedness" = 2;
- $\mathrm{AC}_{i,j}^{\mathrm{B2}}$ is the amortized cost of security i corresponding to hedging relationship j at quarter 0 reported in FR Y-14Q, Schedule B.2;
- $\mathrm{PCT}_{i,j}^{\mathrm{B2}}$ is the hedge percentage corresponding to hedging relationship j for security i at quarter 0 reported in FR Y-14Q, Schedule B.2; and
- $\mathrm{AC}_{i,0}$ is the amortized cost for security i at quarter 0 reported in FR Y-14Q, Schedule B.1.

For each security, hedged fair value is projected as a weighted average of the unhedged and fully hedged fair value projections. The weight assigned to the fully hedged fair value is the security-specific hedge ratio that remains constant throughout the projection horizon. For the fully hedged fair value projections, the portion of the change in fair value due to changes in

[42] 1 = Overall Change in Fair Value or Variability in Cash Flows, 2 = Interest Rate Risk, 5 = Interest Rate Risk & Foreign Exchange Risk, 6 = Interest Rate Risk & Credit Risk, 8 = Interest Rate Risk & Foreign Exchange Risk.

interest rates is fully hedged, such that changes in fair value are due only to changes in credit spreads.

Equation A-30 – projection for hedged fair value

$$\mathrm{FV}_{i,t}^{\mathrm{H}} = H_i \cdot \mathrm{FV}_{i,t}^{\mathrm{CREDIT}} + (1 - H_i) \cdot \mathrm{FV}_{i,t}$$

Where:

- $\mathrm{FV}_{i,t}^{\mathrm{H}}$ is the projection of hedged fair value for security i at projection quarter t;
- H_i is the hedge ratio for security i at quarter 0, as defined in Equation ***A-29***, and remains constant for each quarter of the projection horizon;
- $\mathrm{FV}_{i,t}^{\mathrm{CREDIT}}$ is the fair value of security i at projection quarter t, where changes in fair value are due only to changes in credit spreads. For securities covered by the duration model, this value is calculated in Equation A-9. For U.S. Treasury securities and Agency MBS, $\mathrm{FV}_{i,t}^{\mathrm{CREDIT}}$ is equal to the market value of the security at quarter 0 as reported in FR Y-14Q, Schedule B.1 and remains constant for each quarter of the projection horizon, as changes in fair value due to credit spreads are assumed to be zero for these two security types;[43] and
- $\mathrm{FV}_{i,t}$ is the projection of fair value for security i at projection quarter t without hedges as shown in Equation A-1 for U.S. Treasuries, Equation A-4 for Agency MBS, and Equation A-7 for securities covered by the duration model.

[43] For Agency MBS, projections of unhedged fair value denoted by $\mathrm{FV}_{i,t}$ incorporate changes in OAS (which capture prepayment uncertainty rather default risk), while projections of fully hedged fair value denoted by $\mathrm{FV}_{i,t}^{\mathrm{CREDIT}}$ assume changes in OAS are zero as a simplifying assumption. For U.S. Treasury securities, neither $\mathrm{FV}_{i,t}$ nor $\mathrm{FV}_{i,t}^{\mathrm{CREDIT}}$ incorporate changes in credit spreads. Agency MBS and U.S. Treasury securities are assumed to bear no credit risk.

Projections for pre-tax unrealized gains and losses are determined by the security's hedged fair value, amortized cost, and allowance for credit losses, as shown in the Equation A-31. Projections for unrealized gains and losses are adjusted for credit losses if certain conditions are met. In cases where the fair value of an AFS debt security is above its amortized cost, no adjustment is made to unrealized gains and losses. In cases where the fair value of an AFS debt security is below its amortized cost, the security is impaired, and the unrealized gains and losses are adjusted by the amount of the impairment that is related to credit losses. Impairment can be due to credit losses or other factors. For example, a decrease in fair value can be due to both an increase in credit losses and an increase in rates. The amount of impairment related to credit losses is limited by the amount that the fair value is less than the amortized cost. Impairment related to credit losses is recorded through an allowance for credit losses, with any remaining impairment recorded in unrealized gains and losses.[44]

Equation A-31 – projections for pre-tax unrealized gains and losses accounting for credit losses and hedges

$$\mathrm{UGL}_{i,t} = \mathrm{FV}_{i,t}^{H} - \left[\mathrm{AC}_{i,0} - \mathrm{ACL}_{i,t}\right]$$

Where:

- $\mathrm{UGL}_{i,t}$ is the unrealized gain and loss for security i at projection quarter t, accounting for any projected credit losses and applicable hedges;
- $\mathrm{FV}_{i,t}^{H}$ is the projection of hedged fair value for security i at projection quarter t as calculated in Equation A-30;
- $\mathrm{AC}_{i,0}$ is the amortized cost for security i at quarter 0 reported in FR Y-14Q, Schedule B.1 and remains constant for each quarter of the projection horizon; and

[44] This approach is consistent with FASB ASC 326-30-35-1 and FASB ASC 326-30-35-2.

- $\text{ACL}_{i,t}$ is the allowance for credit losses for security i at projection quarter t as calculated in Equation A-27, which is a positive value.

OCI is determined by the Capital Model, and is equal to the quarterly change in pre-tax unrealized gains and losses on AFS debt securities adjusted for credit losses and hedges, and accounts for taxes and other adjustments.

b. *Specification Rationale and Calibration*

(1) Constant Portfolio Assumption

The OCI Calculation generally assumes the size and duration[45] of the securities portfolio, as reported at quarter 0, remains constant over the nine-quarter supervisory stress test projection horizon. This is accomplished by holding the face value, amortized cost, and remaining maturity of each security constant each quarter without aging.[46] The Board chose to adopt a constant portfolio assumption as a simple and neutral way to maintain risk exposures and prevent balance sheet reductions without introducing behavioral assumptions for reinvestments.[47] This approach is consistent with the Stress Testing Policy Statement's principle of simplicity. Limitations of the constant portfolio assumption include not capturing the changes in risk resulting from the aging of securities, and not incorporating reinvestments for maturing securities into the modeling framework. This could result in OCI being higher over the projection horizon than it might be otherwise.

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[45] Agency MBS projections are an exception to the constant duration assumption because they capture the impact of the macroeconomic scenario on prepayment and duration.

[46] The remaining cash flows and duration of each security are held constant, except in the case of Agency MBS as noted.

[47] In a framework where securities pay down and mature throughout the projection horizon, reinvestments have the effect of increasing the size of the portfolio to offset balance sheet reductions.

c. *Assumptions and Limitations*

The OCI Calculation only incorporates certain components of AOCI, which are unrealized gains and losses on AFS securities, adjusted for projected credit losses and fair value hedges. Components of AOCI that are not projected by the Securities Model are unrealized gains and losses on cash flow hedges, foreign currency translation adjustments, pension liabilities, and debt valuation adjustment. Components that are not accounted for, such as foreign currency translation adjustments, can be material for firms with significant foreign business operations. However, the projected variables from the stress test scenarios do not meaningfully capture the effects of foreign currency translation adjustments, and, therefore, they are excluded from the Securities Model framework.

The OCI Calculation, and the component models that provide inputs to the OCI Calculation (the Fair Value Model and Credit Loss Model) utilize a "constant portfolio assumption," where, in general, aggregate security holdings are assumed to maintain a fixed face value, amortized cost, and time to maturity over the projection horizon. The constant portfolio assumption is used across various supervisory stress test models and is a simplified way of capturing reinvestment by a firm to maintain its portfolio maturity profile. The limitation of this assumption is that the forecast is prone to overestimate repricing sensitivity of securities due to the lack of a "pull-to-par," constant maturity, and prepayment effects. These effects can drive material differences in OCI estimates, especially in later quarters of the projection horizon. To maintain a simple modeling framework, the OCI Calculation does not take these effects into account.

Qualified accounting hedges are not independently valued. There is insufficient information in the current FR Y-14Q, Schedule B.2 to fully revalue the hedges. A reliance on the hedge percentage field under the current model construct has limitations in the case of partial term hedges and portfolio layer method hedges. The hedge percentage assumes that the portion of the security being hedged remains constant throughout the projection horizon. As interest rates change over the projection horizon, the fair value of hedges may not exactly offset the fair value changes of the underlying securities by a constant percentage.

Fair value accounting hedges of interest rate risk are assumed to be fully effective. This means the hedge perfectly offsets the specified portion of the change in the fair value of the security attributable to changes in rates. This assumption is reasonable given the hedge effectiveness conditions that must be met to qualify for U.S. GAAP hedge accounting.[48]

Interest rate hedges are treated the same regardless of the underlying floating rate (SOFR or other) without consideration of basis risk driven by potential changes in the underlying floating rate relative to SOFR. SOFR is the standard reference rate used in interest rate swaps. The model assumes that the hedges contain no additional spread that is added to the SOFR rate in the interest rate swap.

(1) Fair Value Hedges

The OCI Calculation credits U.S. GAAP-qualifying,[49] two-sided, fair value, security-level hedges of interest rate risk, assuming they are fully effective at mitigating interest-rate-driven fair value fluctuations. Hedges are incorporated at the security level through the hedge percentages reported in Schedule B.2. The hedge percentages are held constant at each quarter of the projection horizon, consistent with the constant portfolio assumption employed generally

[48] See FASB ASC 815: Hedge Accounting Improvements.

[49] A U.S. GAAP qualifying hedge is a hedging relationship that allows the user to apply specific hedge accounting treatment to fair value fluctuations in both the underlying hedged item and the hedging instrument. See FASB ASC 815.

by the model. The OCI calculation also grants credit for U.S. GAAP-qualifying portfolio layer method hedges used to hedge fair value fluctuations for closed portfolios of assets. See Section A(v)(d)(1) (OCI Calculation) for discussion of alternative approaches for granting hedge credit in the OCI Calculation, particularly concerning portfolio layer method hedges.

d. *Alternative Approaches*

(1) Reinvestment assumption

The current model construct for OCI projections relies heavily on maintaining two core concepts within the supervisory stress test modeling framework: a static balance assumption and constant risk characteristics. The static balance assumption assumes that each firm's investment portfolio balance remains static for each quarter of the projection horizon. The constant risk characteristics assumption assumes that the risk profile of each firm's investment portfolio remains constant for each quarter of the projection horizon.

The modeling approach currently employed preserves these core concepts by maintaining the security-specific balances at quarter 0 throughout each quarter of the projection horizon while also assuming the security-specific characteristics, such as time to maturity, are frozen at each quarter. As discussed in the Assumptions and Limitation section, Section A(v)(c), these modeling choices impact the trajectory of OCI and in many cases overstate the repricing sensitivity of securities, most notably in later quarters of the projection horizon. The current methodology for both the Fair Value Model and OCI Calculation are found in Section A(iii) and Section A(v), respectively.

The Board continues to explore alternative approaches for projecting OCI that could better incorporate the impact of important elements such as aging of securities or "pull-to-par." The "pull-to-par" impact is caused by the tendency of a security's fair value and amortized cost to drift closer to par as the security approaches its maturity date.[50] This alternative approach impacts both the Fair Value Model and the OCI Calculation. For simplicity, all changes have been detailed within this section.

The Board is considering an alternative approach for both the present value calculation of U.S. Treasuries and the full revaluation model of Agency MBS. This would materially change the OCI projections for both security types. The basic structures of these two models are kept intact where possible. However, changes are required to incorporate both aging and prepayments. The section that follows details the changes to the current model.

(i) Fair Value Projections for U.S. Treasuries

The fair value calculation would be changed to reflect the aging of each Treasury security throughout the projection horizon. Adjustments would be made to the time to maturity and number of coupon payments remaining at each quarter. For example, a Treasury with 3 years to maturity at quarter zero would have 2.75 years to maturity at quarter one, 2.5 years to maturity at quarter two, and so forth. Treasuries reaching maturity within the projection horizon would cease to contribute to OCI projections in subsequent quarters, and the proceeds of maturing securities would be reinvested in new securities which would be revalued each quarter. Under the alternative framework, the fair value of Treasury security i at projection quarter t without hedges would be projected according to Equation A-32.

[50] The terms par and face value are used interchangeably.

Equation A-32 – projection of fair value for U.S. Treasuries without hedges under alternative framework[51]

$$\mathrm{FV}_{i,t} = F_{i,0} \cdot \frac{1}{\left(1 + \frac{r[T_{i,t}, t]}{2}\right)^{2T_{i,t}}} + \sum_{k=1}^{n_{i,t}} C_i \cdot \frac{1}{\left(1 + \frac{r[\tau_{i,k,t}, t]}{2}\right)^{2\tau_{i,k,t}}}$$

Where:

- $\mathrm{FV}_{i,t}$ is the projection of fair value for Treasury security i at projection quarter t without hedges;
- $F_{i,0}$ is the current face value of security i at quarter 0 reported in FR Y-14Q, Schedule B.1, and remains constant for each quarter that projections are generated for security i;
- C_i is the dollar amount of each semi-annual coupon payment for Treasury security i and remains constant for each quarter that projections are generated for security i. C_i is equal to zero when security i is a Treasury bill;
- $T_{i,t}$ is the remaining time to maturity in years for security i at projection quarter t, rounded to the nearest quarter of a year, and decreases each quarter of the projection horizon as the security approaches maturity. If T_i < 0.25 then $\mathrm{FV}_{i,t}$ is set equal to the current face value at quarter 0 as reported in FR Y-14Q, Schedule B.1;
- $\tau_{i,k,t}$ is the tenor of the kth remaining coupon payment for security i at projection quarter t, rounded to the nearest quarter of a year. The tenors and corresponding cash flows change each quarter of the projection horizon as the security approaches maturity;

[51] This calculation employs discrete discounting, analogous to the FVO Model's treatment of fixed-rate loan fair value (see ***Equation B-12***) but with semi-annual rather than quarterly compounding.

- $r[\tau, t]$ is the zero-coupon Treasury yield corresponding to cashflow tenor τ as projected to quarter t by the Yield Curve Model;[52] and
- $n_{i,t}$ is the number of remaining semi-annual coupon payments for security i and changes each quarter of the projection horizon as the security approaches maturity.

(ii) Amortized Cost Projections for U.S. Treasuries

In the current OCI model, the static balance assumption requires that amortized cost is held constant for all securities. As a result, OCI is currently calculated using only forecasts of changes in security fair values. However, within a modeling approach that allows securities to age, pay down, and mature throughout the projection horizon, OCI forecasts would be measured using the change in the difference between fair value and amortized cost, which better aligns with current accounting practices. A new model for amortized cost would be needed under this approach.

The Board assumes a straight-line method for dynamic amortized cost based on the current face value and amortized cost reported in FR Y-14Q, Schedule B.1. Since Treasuries do not prepay, this approach is simple to implement and requires no additional security characteristics from reporting firms. In addition, the scenario effects on Treasury yields would only impact fair value. At maturity, the projected amortized cost is equal to current face value reported at quarter zero. The projected amortized cost for Treasury i at time t is shown in Equation A-33.[53]

[52] For more information on the Yield Curve Model, see Section C.

[53] If a Treasury reaches maturity within the projection horizon, it ceases to exist after maturity, and projections are not generated for this security in subsequent quarters. The proceeds of the matured security are reinvested into a new security that is revalued in each subsequent quarter.

Equation A-33 – projection of amortized cost for U.S. Treasuries

$$\mathrm{AC}_{i,t} = \mathrm{AC}_{i,0} + \left(\frac{F_{i,0} - \mathrm{AC}_{i,0}}{4 \cdot T_{i,0}}\right) \cdot t$$

Where:

- $\mathrm{AC}_{i,t}$ is the projected amortized cost for security i at projection quarter t and changes each quarter of the projection horizon;
- $\mathrm{AC}_{i,0}$ is the amortized cost for security i at quarter 0 reported in FR Y-14Q, Schedule B.1 and remains constant for each quarter that projections are generated for security i;
- $F_{i,0}$ is the current face value of security i at quarter 0 reported in FR Y-14Q, Schedule B.1 and remains constant for each quarter that projections are generated for security i;
- $T_{i,0}$ is the remaining time to maturity in years for security i as of quarter 0, rounded to the nearest quarter of a year, and remains constant for each quarter that projections are generated for security i; and
- t denotes the quarter of the projection horizon.

(iii) Assumptions and Limitations of Amortized Cost Projections for U.S. Treasuries and Agency MBS

Projecting amortized cost under the alternative framework to account for accretion / amortization throughout the projection horizon is a simplified approach, which has the following implications. The amortized cost reported in FR Y-14Q, Schedule B.1 is an adjusted value that incorporates the effect of other items, including fair value hedges. This adjusted amortized cost would provide an imprecise measure of the accretion / amortization schedule. The securities most impacted by this adjustment would be those securities with fair value hedges in place. Additionally, for Agency MBS, the accretion / amortization calculation methodology below relies on an estimate of weighted average life for bonds with embedded optionality. For scenarios where interest rates decline and prepayments increase, this assumption would result in a slower pull-to-par effect than if the accretion / amortization schedule were calculated using the then-current weighted average life estimate.

As discussed in the section on fair value projections for Agency MBS (Section A(iii)(a)0(b)), principal payments are an important element to incorporate. Under the new modeling approach, these partial principal payments would be incorporated into the amortized cost forecasts and impact the trajectory of OCI.

(iv) Fair Value Projections for Agency MBS

Under the existing framework, a third-party vendor model is used to project prices of Agency MBS that are classified as AFS.[54] Price projections under the current approach incorporate the passage of time, changing characteristics of the underlying collateral and security, and balance declines. The current model multiplies the projected price at projection quarter t expressed as a percentage of the current face value at quarter 0, by the current face value of the security at quarter 0. Under the alternative approach, the face value would change at each quarter of the projection horizon. The adjusted face value would reflect projected principal paydowns occurring prior to each quarterly revaluation.

The change in fair value $\Delta\mathrm{FV}_{i,t}$ is composed of three components: the partial premium / discount due to paydowns $\Delta\mathrm{FV}_{i,t}^{\mathrm{PAYDOWN}}$, the change in fair value of the remaining balance $\Delta\mathrm{FV}_{i,t}^{\mathrm{OUTSTANDING}}$, and the paydown itself denoted by $\mathrm{paydown}_{i,t}$. The face value is reduced by the dollar amount of the paydown, such that the premium / discount associated with the paydown

[54] See Fair Value Model Section A(iii)(a)0(b) for additional information on the third-party vendor model used to price Agency MBS.

will be recognized in the period in which the paydown occurs. Given $P_{i,t}^{\text{VEND}}$, which is the price expressed as a percentage of remaining face value $F_{i,t}$ for security i at projection quarter t (i.e., $F_{i,t}$ is the remaining face value at projection quarter t after paydowns in prior periods), the partial premium / discount is calculated as follows:

Equation A-34 – partial discount/premium due to paydowns on Agency MBS

$$\Delta\text{FV}_{i,t}^{\text{PAYDOWN}} = \text{paydown}_{i,t} \cdot \left(1 - P_{i,t-1}^{\text{VEND}}\right)$$

The change in fair value associated with the market impact on the remaining balance $\Delta\text{FV}_{i,t}^{\text{OUTSTANDING}}$ is as follows:

Equation A-35 – change in fair value of outstanding Agency MBS balance

$$\Delta\text{FV}_{i,t}^{\text{OUTSTANDING}} = \left(P_{i,t}^{\text{VEND}} - P_{i,t-1}^{\text{VEND}}\right) \cdot F_{i,t}$$

The total change in fair value $\Delta\text{FV}_{i,t}$ is the sum of the partial premium / discount associated with the paydown and the market impact on the remaining balance minus the total paydown, as shown below.

Equation A-36 – total change in fair value of Agency MBS

$$\Delta\text{FV}_{i,t} = \Delta\text{FV}_{i,t}^{\text{PAYDOWN}} + \Delta\text{FV}_{i,t}^{\text{OUTSTANDING}} - \text{paydown}_{i,t}$$

For clarity, the alternative approach would not impact the duration-based approach, which applies to all securities other than Treasuries, Agency MBS, Equities, and Mutual Funds.[55]

[55] See Fair Value Model Section A(iii)(a)0(c) for additional information on the duration-based approach.

(v) Accretion / Amortization of the Discount / Premium for Agency MBS

Security-specific amortized cost accretion / amortization can be estimated using the following inputs for security i: face value $F_{i,t}$, amortized cost $\mathrm{AC}_{i,t}$, a maturity date for a bullet pay bond, and weighted average life estimate at quarter zero denoted by $\mathrm{WAL}_{\mathrm{i,0}}$ for a bond with embedded optionality, such as Agency MBS. The change in amortized cost $\Delta\mathrm{AC}_{i,t}$ is composed of three components: the accelerated amortization of the discount / premium due to early paydown $\Delta\mathrm{FV}_{i,t}^{\mathrm{PAYDOWN}}$, the change in amortized cost due to the remaining outstanding balance $\Delta\mathrm{FV}_{i,t}^{\mathrm{OUTSTANDING}}$, and the early paydown itself $\mathrm{paydown}_{i,t}$.

When early paydowns occur, the discount or premium associated with the paydown is amortized, creating a pull-to-par effect. Face value is adjusted for prior paydowns, so the calculation depends on the face value and amortized cost in the prior period, denoted by $F_{i,t-1}$ and $\mathrm{AC}_{i,t-1}$, respectively.

Equation A-37 – amortization of discount/premium of paydown on Agency MBS

$$\Delta\mathrm{AC}_{i,t}^{\mathrm{PAYDOWN}} = \mathrm{paydown}_{i,t} \cdot \left[1 - \frac{\mathrm{AC}_{t-1}}{F_{i,t-1}}\right]$$

The change in amortized cost associated with the remaining balance follows the straight-line method based on the weighted average life at quarter zero for those securities with partial prepayments.

Equation A-38 – change in amortized cost of remaining balance of Agency MBS

$$\Delta\mathrm{AC}_{i,t}^{\mathrm{OUTSTANDING}} = \left[F_{i,t} - \left(\mathrm{AC}_{i,t-1} + \Delta\mathrm{AC}_{i,t}^{\mathrm{PAYDOWN}} - \mathrm{paydown}_{i,t}\right)\right] / \left(4 \cdot \mathrm{WAL}_{\mathrm{i,0}}\right)$$

The full change in amortized cost at time t is the sum of the three components described above.

Equation A-39 – total change in amortized cost for Agency MBS

$$\Delta \mathrm{AC}_t = \Delta \mathrm{AC}_{i,t}^{\mathrm{PAYDOWN}} + \Delta \mathrm{AC}_{i,t}^{\mathrm{OUTSTANDING}} - \mathrm{paydown}_{i,t}$$

(vi) Agency MBS without Vendor Pricing

Securities classified as Agency MBS for which prices are not available from the third-party vendor model will receive the following treatment. No partial principle paydowns will be assumed, and the amortized cost calculation will utilize the time to maturity $T_{i,0}$ as of quarter 0 rather than the weighted average life. Amortized cost would then be calculated as:

Equation A-40 – amortized cost for Agency MBS without vendor pricing

$$\mathrm{AC}_{i,t} = \mathrm{AC}_{i,0} + \left(\frac{F_{i,0} - \mathrm{AC}_{i,0}}{4 \cdot T_{i,0}}\right) \cdot t$$

Fair values for Agency MBS without vendor pricing are assigned as follows. For Agency MBS that do not pass the check-digit test and are private placements, and that pass the check-digit test but for which prices are not available from the third-party vendor model, the median return is assigned from the distribution of projected returns for Agency MBS at the firm level, weighted by market value. If projected Agency MBS returns are unavailable at the firm level, then projected Agency MBS returns across all firms are used. For Agency MBS that do not pass the check-digit test and are not private placements, the tenth percentile of returns is assigned from the distribution of projected Agency MBS returns at the firm level, weighted by market value. If projected Agency MBS returns are unavailable at the firm level, then projected Agency MBS returns across all firms are used.

(vii) Reinvestment Methodology

To maintain the constant balance sheet assumption, a firm must purchase new securities during the projection horizon to offset the impact of securities maturing or decreasing in balance due to partial paydowns. In the supervisory stress test, the Board's approach must be applicable to all firms, which, consistent with the Policy Statement, favors simple and broadly applicable reinvestment assumptions.

The current reinvestment assumption is a hypothetical Treasury security with one year to maturity. This instrument is assumed to be purchased at face value, issued on the purchase date, and has a coupon rate equal to the corresponding yield from the par Treasury curve at the forecast quarter in question. Projections of both fair value and amortized cost will be generated for the proxy reinvestment instrument, which will produce unrealized gains/losses. No hedges will be assumed to be placed on reinvestments.

The alternative reinvestment framework detailed above is a simplified approach, which has the following implications. The assumption that proceeds from maturing securities are reinvested into one-year Treasuries could differ from the firm's current Treasury maturity profile and change the firm's portfolio repricing sensitivity as a result. The one-year maturity for Treasuries was favored to be generally in line with post-hedge Treasury holdings across all firms. Additionally, the decision to reinvest proceeds from maturing assets uniformly into Treasuries could change a portfolio's exposure to both interest rates and spread risk. Given the number of security types, designing a granular approach that could be applicable across all firms is challenging. The assumption to not apply fair value hedges to reinvestments made during the projection horizon could change the OCI profile for firms that apply fair value hedges to a higher proportion of securities; however, determining the appropriate amount of fair value hedges to place against reinvestments would require firm-specific assumptions about forward asset liability management strategies. As a result, the simplifying assumption of no hedges on reinvestments is favored.

(viii) OCI Calculation

The unrealized gain and losses calculation at a given quarter of the projection horizon is based on fair value minus amortized cost. Under the current approach, fair value projections vary each quarter while amortized cost is held constant throughout the projection horizon. Under the alternative framework, projections for both fair value and amortized cost vary at each quarter of the projection horizon. Projections for pre-tax unrealized gains and losses on AFS debt securities adjusted for credit losses and hedges are shown in Equation A-41.[56]

Equation A-41 – projections for pre-tax unrealized gains and losses accounting for credit losses and hedges for Treasuries and Agency MBS under the alternative framework

$$\mathrm{UGL}_{i,t} = (1 - H_i) \cdot \left(\mathrm{FV}_{i,t} - \mathrm{AC}_{i,t}\right) + H_i \cdot \left(\mathrm{FV}_{i,0} - \mathrm{AC}_{i,0}\right)$$

Where:

- $\mathrm{UGL}_{i,t}$ is the unrealized gain and loss for security i at projection quarter t, accounting for any projected credit losses and applicable hedges;
- $\mathrm{FV}_{i,t}$ is the fair value of security i at projection quarter t, which changes each quarter; and
- $\mathrm{AC}_{i,t}$ is the amortized cost of security i at projection quarter t, which also changes each quarter; and H_i is the hedge ratio, which remains constant at each quarter.

[56] Because the second term $H_i \cdot \left(\mathrm{FV}_{i,0} - \mathrm{AC}_{i,0}\right)$ in ***Equation A-41*** is a constant for U.S. Treasuries and Agency MBS, it does not impact OCI and is omitted from calculations in practice. It is included here to emphasize consistency with the treatment of hedges under the constant portfolio assumption, which would still apply to credit-sensitive securities under this alternative approach, where H_i is the weight applied to the unrealized gain / loss driven by credit spreads only (see ***Equation A-30***).

OCI is calculated by the Capital Model and is equal to the quarterly change in pre-tax unrealized gains and losses on AFS debt securities adjusted for credit losses and hedges, and accounts for taxes and other adjustments.

For clarity, the Fair Value Model changes described above do not impact the duration model. As a result, the existing methodologies for both fair value estimates and the resulting OCI estimates detailed in the respective model specification sections would still apply to all debt securities other than Treasuries and Agency MBS.

(2) Valuing Portfolio Layer Method Hedges Using Firm-Provided Sensitivities

Under this approach, firm-provided sensitivities would be used to compute the change in fair value of each swap that is part of a Portfolio Layer Method hedge (PLM) relationship. Hedges that are not part of a PLM hedging relationship, such as single-security hedges, would be incorporated through the existing methodology, in which a fixed hedge ratio that remains constant over the projection horizon is applied to each security.

DV01 (dollar value of a basis point) is defined as the change in dollar value of a swap associated with a one basis point parallel shift in the yield curve. This approach computes the change in value of each PLM swap on an individual basis using firm-provided DV01s. The change in the fair value of the swap is equal to DV01 times the change in yield measured in basis points from one quarter to the next.

Equation A-42 – change in fair value projection for interest rate swaps using DV01

$$\Delta \mathrm{FV}_{\mathrm{i,t}}^{\mathrm{PLM}} = \mathrm{DV01_i} \cdot \Delta \mathrm{y}$$

Where:

- $\Delta \mathrm{FV}_{\mathrm{i,t}}^{\mathrm{PLM}}$ is the change in fair value of PLM swap *i* from one quarter to the next;
- $\mathrm{DV01_i}$ is the dollar value of a basis point for swap i; and

- Δy is the change in yield from one quarter to the next measured in basis points, where yield is defined as a combination of the SOFR curve (0–1-year maturity) and interest rate swap curve (1–10-year maturity) as projected by the Yield Curve Model.[57]

Change in yield is computed at the closest maturity point associated on the curve associated with the remaining maturity of the swap. The change in fair value of each PLM swap would be computed at each quarter, and the total amount would be netted at the firm level against unrealized gains and losses on AFS securities.

(3) Valuing Portfolio Layer Method Hedges Using a Discounted Cash Flow Method

Under this approach, each PLM swap would be revalued at each quarter of the projection horizon using a discounted cash flow method. Hedges that are not part of a PLM hedging relationship, such as single-security hedges, would be incorporated through the existing methodology, in which a fixed hedge ratio that remains constant over the projection horizon is applied to each security.

A plain vanilla interest rate swap involves one party paying a series of fixed cash flows while the other party pays a series of floating cash flows. The value of the swap is equal to the present value of the fixed cash flows netted against the present value of the floating cash flows.

Equation A-43 – fair value projection for interest rate swaps using full revaluation

$$\mathrm{FV}_{\mathrm{i,t}}^{\mathrm{PLM}} = \mathrm{PV\ floating\ cash\ flows}_{\mathrm{i,t}} - \mathrm{PV\ fixed\ cash\ flows}_{\mathrm{i,t}}$$

Where:

- $\mathrm{FV}_{\mathrm{i,t}}^{\mathrm{PLM}}$ is the fair value of a pay-fixed, receive floating PLM swap i at projection quarter t;

[57] Reference the Yield Curve Model, Section C.

- $\text{PV floating cash flows}_{i,t}$ is the present value of the floating-rate leg cash flows of swap i at projection quarter t; and
- $\text{PV fixed cash flows}_{i,t}$ is the present value of the fixed-rate leg cash flows of swap i at projection quarter t.

Cash flows would be discounted using the zero-coupon SOFR / interest rate swap curve, which is a combination of the SOFR curve (0–1-year maturity) and interest rate swap curve (1–10-year maturity), as projected by the Yield Curve Model.[58] The change in fair value of each PLM swap would be computed at each quarter, and the total amount would be netted at the firm level against unrealized gains and losses on AFS securities.

e. *Data Adjustments*

As part of the OCI Calculation, a security-specific hedge ratio is computed for each AFS security according to Equation ***A-29***. Hedge ratios are capped at one and floored at zero, as a robustness contingency against data reporting errors leading to spurious hedge ratio values. Capping the hedge ratio at one allows the model to avoid the issue of over-hedging exposures to more than 100 percent while flooring the hedge ratio at zero ensures there are no negative hedge exposures.

vi. <u>Question</u>

Question A1: The Board seeks comment on the alternative reinvestment assumption as described in Section A(v)(d)(1), as compared to the Board's current approach that assumes the portfolio composition, balances, and security characteristics remain constant at each quarter of the projection horizon.

[58] Reference the Yield Curve Model, Section C.

B. Fair Value Option Model

i. Statement of Purpose

The Fair Value Option (FVO) Model (FVO Model) projects gains and losses on loans subject to fair value accounting. The FVO Model's projections enter as "other losses / gains" into the Board's calculation of pre-tax net income in the supervisory stress test. The FVO Model is important for accurately assessing whether firms would be sufficiently capitalized to absorb losses in the fair value of loans resulting from significant market interest rate and credit spread movements, which typically coincide with severely stressed economic conditions.

ii. Model Overview

The FVO Model projects mark-to-market profit and loss (P&L) on (i) loans accounted for under the FVO, (ii) loans classified as held-for-sale (HFS) and (iii) certain loan hedges. The aggregate mark-to-market P&L, projected in respect of FVO and HFS loans, net of hedges, flows to net income for each quarter of the projection horizon.

FVO and HFS are accounting classifications under U.S. GAAP. Under the FVO classification, loans are marked to market; under the HFS classification, they are marked to the lower of cost or market value (LOCOM). The FVO Model uses these classifications to identify loans subject to fair value accounting. The model does not differentiate in its treatment of FVO versus HFS loans and equates capital impact with change in fair value in both cases; market-driven changes in fair value are recognized in projected income in either case and flow through earnings at the time of revaluation.

Firms elect whether to treat loans for accounting purposes under either the FVO or HFS classification. Firms may elect the FVO or HFS classification for a variety of reasons, including:

(i) loans a firm has originated or is holding with the intent to sell, including via securitization or syndication; and

(ii) loans against which a firm holds fair value hedges, to align with the fair value accounting of the hedges and better reflect their economic impact in reducing P&L volatility.

The FVO Model contains three sub-models:

(i) a wholesale loan model (Wholesale Model): used to project P&L on FVO / HFS corporate loans, as well as commercial real estate (CRE) loans;

(ii) a retail loan model (Retail Model): used to project P&L on FVO / HFS residential mortgages and other consumer loans; and

(iii) a model of loan hedges (Loan Hedge Model): used to project P&L on banking book loan hedges not qualifying as accounting hedges, covering both hedges placed against HFS/FVO loans (FVO Hedges) and hedges against accrual loans (AL Hedges).

All three sub-models utilize a "constant portfolio assumption," where aggregate loan and hedge positions are assumed to maintain a fixed, non-amortizing notional value and time to maturity over the projection horizon. The constant portfolio assumption is used across various supervisory stress test models and is a simplified way of capturing reinvestment by a firm to maintain its portfolio maturity profile.

Further summary information in respect of each sub-model is provided immediately below (while more detailed specification and supporting rationale is provided in Sections B(iii), B(iv) and B(v), for the Wholesale Model, Retail Model and Loan Hedge Model, respectively).

a. *Wholesale Model*

The Board projects mark-to-market gains and losses on FVO / HFS wholesale loans and commitments by revaluing each loan or commitment each quarter to determine changes in fair value over the projection horizon. The key loan characteristics that affect projected losses include:

- loan rating;
- interest rate of the loan; and
- maturity date.

The key macroeconomic variables that enter the model are:

- credit spreads; and
- interest rates.

The Board models fair value separately for fixed-rate and floating-rate loans. For fixed-rate loans, the Board uses a standard bond pricing formula. For floating-rate loans, the Board uses a linear approximation.

For fixed-rate loans, the bond pricing formula discounts future cash flows using a discount yield that depends on loan rating and maturity date. To project fair value, the model assumes the discount yield for a given loan can change due to (i) changes in the loan's rating as well as (ii) credit spread and interest rate changes.

The model infers a starting point discount yield for each loan i at the start of the projection horizon using the firm-reported fair value. This discount yield is then projected over the stress test horizon according to Equation B-1:

Equation B-1 – Discount yield for loan i in projection quarter t

$$y_{i,t}(R_0, R_t) = y_{i,0} + \Delta s_{i,t}(R_0, R_t) + \Delta r_{i,t}$$

Where:

- i represents the loan;
- t represents projection quarter ($t = 0, 1, \dots, 9$) and t_0 denotes the fourth quarter of the year containing the jump-off point for a given stress test;

- R_0 represents loan rating at the start of the projection horizon;
- R_t represents loan rating in quarter t;
- $y_{i,t}(R_0, R_t)$ represents projected discounted yield;
- $y_{i,0}$ represents inferred yield at the start of the projection horizon;
- $\Delta s_{i,t}(R_0, R_t)$ represents projected change in the credit spread since the start of the projection horizon (which incorporates the rating transition from R_0 to R_t); and
- $\Delta r_{i,t}$ represents the change in the interest rate applicable to the loan, since the start of the projection horizon.

For floating-rate loans, a linear CS01 approximation is used to project fair value changes, as further described below—where CS01 credit spread sensitivities are approximated using a fixed rate equivalent discount yield that depends on loan rating and maturity date, and fair values are then projected using this CS01 in conjunction with changes in scenario credit spreads.[59] The Board projects benchmark risk-free interest rates and credit spreads on FVO / HFS wholesale loans by reference to key interest rate and credit spread variables included in the macroeconomic scenario[60] to determine loan-specific discount yields (via Equation B-1) for all possible rating changes over the projection horizon. The Wholesale Model then uses these projected discount yields in conjunction with, for fixed-rate loans, a bond pricing formula and, for floating-rate loans, a linear present value approximation to compute rating-path-specific fair values. An expectation over these rating-specific fair value projections determines the final expected fair value projection for a given loan, where probabilities of rating changes are taken

[59]The CS01 approximation estimates the change in a loan's value resulting from a one basis point increase in the credit spread. *See* Tuckman, B. and Serrat, A., 2011. Fixed Income Securities. (John Wiley & Sons).

[60] *See* Risk-Free Rate Projection, Section B(iii)(a)(1) and Credit Spread Projection Section B(iii)(a)(2).

from a historical empirical rating transition matrix as discussed further in the Wholesale Model Specification section, Section B(iii)(a).[61] Support for the specifications of the model are described in the Wholesale Model Specification Rationale and Calibration section, Section B(iii)(b).

b. *Retail Model*

FVO / HFS retail loans include first- and second-lien mortgages, student loans, credit cards, and auto loans.[62] The Board calculates gains and losses on FVO / HFS retail loans over the projection horizon using a duration-based approximation. This approach uses total loan balances as reported in the FR Y-14Q, estimates of portfolio weighted-average durations, and quarterly changes in scenario Treasury yields and loan spreads. Estimates are calculated separately by vintage and loan type. Further detail and supporting rationale are provided in Sections B(iv)(a) and B(iv)(b), respectively.

Gains and losses on FVO / HFS retail loans of a particular loan type and vintage in a projection quarter are specified as follows:

Equation B-2 – cumulative P&L on FVO / HFS retail loans by projection quarter

$$\mathrm{cP\&L}_{j,t}(v) = \mathrm{CV}_j(v)\left[D_j^{\mathrm{rate}}(v) \cdot \Delta r_t + D_j^{\mathrm{spr}}(v) \cdot \Delta s_{j,t}\right]$$

Where:

- j represents loan type;
- v represents loan vintage;
- t represents projection quarter;

[61] For loans that are projected to transition into default, a loss given default assumption is applied.

[62] The Board assumes zero losses for residential mortgages under forward contracts with Freddie Mac, Fannie Mae, and Ginnie Mae.

- $\mathrm{cP\&L}_{j,t}(v)$ represents cumulative gain or loss to projection quarter t, for loans of type j and vintage v;
- $\mathrm{CV}_j(v)$ represents initial carrying value as reported in FR Y-14Q, Schedule J (Retail Fair Value Option / Held for Sale (FVO / HFS));
- $D_j^{\mathrm{rate}}(v)$ and $D_j^{\mathrm{spr}}(v)$ represent measures of rate and loan spread duration;[63] and
- Δr_t and $\Delta s_{j,t}$ represent the change in the five-year Treasury yield and loan spread, respectively, since the start of the projection horizon.

Spreads on FVO / HFS retail loans are projected by reference to relevant asset-backed security indices included in the macroeconomic scenario—see the Credit Spread Projection Section B(iv)(a)(2).

c. *Loan Hedge Model*

The Board calculates the quarterly P&L for FVO Hedges and AL Hedges[64] by combining a set of scenario-specific risk-factor projections with corresponding risk factor P&L sensitivities submitted by firms. Aggregate hedge gains and losses for each firm enter pre-tax net income as "other losses / gains" alongside projected gains and losses on wholesale and retail exposures. Further specification detail and supporting rationale are provided in Sections B(v)(a) and B(v)(b), respectively.

d. *Aggregate P&L Projection*

To produce a final aggregate P&L projection, the FVO Model combines projected P&L with respect to wholesale, retail, and loan hedges—the aggregate P&L projected by the FVO

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[63] Duration is the first-order or linear sensitivity of P&L to interest rate or credit spread movements. For FVO / HFS retail loans other than mortgages, the rate duration term $D_j^{\mathrm{rate}}(v)$ is assumed to be zero.

[64] *See* instructions to FR Y-14Q, Schedule F for full definitions of FVO Hedges and AL Hedges.

Model, flowing to net income in each projection quarter t, is the sum of P&L determined by the Wholesale Model, Retail Model, and Loan Hedge Model:

Equation B-3 – FVO Model aggregate P&L projection by quarter

$$\mathrm{P\&L}_t^{\mathrm{TOT}} = \mathrm{P\&L}_t^{\mathrm{WHS}} + \mathrm{P\&L}_t^{\mathrm{RET}} + \mathrm{P\&L}_t^{\mathrm{HDG}}$$

Where:

- $\mathrm{P\&L}_t^{\mathrm{WHS}}$ represents fair value gain / loss in quarter t on wholesale FVO / HFS loans, further detailed in the Wholesale Model Specification Section B(iii)(a);
- $\mathrm{P\&L}_t^{\mathrm{RET}}$ represents gain / loss in quarter t on retail FVO / HFS loans, as further detailed in the Retail Model Specification Section B(iv)(a); and
- $\mathrm{P\&L}_t^{\mathrm{HDG}}$ represents gain / loss in quarter t on hedges of FVO loans and accrual loans, further detailed in the Loan Hedge Model Specification Section B(v)(a).

Throughout this FVO Model description, t_0 is used to denote the FR-Y14Q fourth quarter-end effective date, as of which positions are reported for a given stress test exercise.

iii. Wholesale Model

a. *Model Specification*

As described above, the Board projects mark-to-market gains and losses (P&L) on FVO / HFS wholesale loans and commitments by revaluing each loan or commitment in each quarter of the projection horizon. The Wholesale Model covers corporate and CRE loans, for which firms submit loan-level data in the FR Y-14Q, Schedule H (Wholesale).

For each loan, the model derives a t_0 fair value, using information from Schedule H. P&L is then projected by re-pricing the loan in each projection quarter to reflect changes in the following fair-value drivers:

- the credit rating of the loan;

- the credit spread corresponding to the loan's rating and maturity; and
- the swap rate corresponding to the loan's maturity (significant for fixed-rate loans only).

The resulting dollar P&L projections for corporate and CRE loans, respectively $\text{P\&L}_t^{\text{CORP}}$ and $\text{P\&L}_t^{\text{CRE}}$, are normalized against t_0 utilized exposure amounts U_0^{CORP} and U_0^{CRE} (totaled over corporate and CRE loan-level records reported in Schedule H) to obtain P&L rates per dollar of initial exposure $\text{P\&L}_{\text{t}}^{\text{P}}/U_0^P$ (with $P \in \{\text{CORP}, \text{CRE}\}$ indexing portfolio), which are then multiplied against comprehensive t_0 balances B_0^{CORP} and B_0^{CRE} reported in FR Y-14Q, Schedule M (Balances), to arrive at the final dollar gain / loss projection for wholesale loans:

Equation B-4 – the Wholesale Model, which is the total wholesale loan gain / loss projection

$$\text{P\&L}_t^{\text{WHS}} = B_0^{\text{CORP}} \cdot \left(\frac{\text{P\&L}_t^{\text{CORP}}}{U_0^{\text{CORP}}}\right) + B_0^{\text{CRE}} \cdot \left(\frac{\text{P\&L}_t^{\text{CRE}}}{U_0^{\text{CRE}}}\right) - \begin{bmatrix} B_0^{\text{AG}} \\ B_0^{\text{SL}} \end{bmatrix}' \cdot \begin{bmatrix} L_{\text{qtr}}^{\text{AG}} \\ L_{\text{qtr}}^{\text{SL}} \end{bmatrix}$$

Where:

- B_0^{CORP} & B_0^{CRE} are the aggregate HFS / FVO t_0 balances, reflected in FR Y-14 Schedule M (reported as tabulated in Figure B-2);
- U_0^{CORP} & U_0^{CRE} are utilized t_0 exposure amounts, summed at the loan level in Schedule H.1 and H.2 (as per Figure B-2);
- $\text{P\&L}_t^P$ for $P \in \{\text{CORP}, \text{CRE}\}$, is dollar fair value gain / loss, projected for quarter t, on loans within portfolio P, as specified in Figure B-2; and

- B_0^{AG} and B_0^{SL} are aggregate HFS / FVO t_0 balances, reflected in Schedule M, for (i) agricultural loans and (ii) securities lending (reported as per Figure B-2), associated with constant loss rates per quarter of $L_{\mathrm{qtr}}^{\mathrm{AG}} = 1.50\%/4$ and $L_{\mathrm{qtr}}^{SL} = 0.25\%/4$.[65]

For each portfolio $P \in \{\mathrm{CORP}, \mathrm{CRE}\}$, and projection quarter t, the aggregate gain / loss $\mathrm{P\&L}_t^{\mathrm{P}}$ is derived from loan-level changes in expected fair value, summed over each loan $i \in P$:

Equation B-5 – P&L in quarter t for FVO / HFS wholesale loans

$$\mathrm{P\&L}_t^{\mathrm{P}} = \sum_{i \in P} \left(\mathbb{E}\left[V_{i,t}\right] - \mathbb{E}\left[V_{i,t-1}\right] \right)$$

where $\mathbb{E}\left[V_{i,t}\right]$ denotes loan i's expected fair value at quarter t. $\mathbb{E}\left[V_{i,t}\right]$ is defined as the following expectation over rating-conditional loan values[66] $V_{i,R,t}$ for $R \in$ $\{\mathrm{AAA}, \mathrm{AA}, \mathrm{A}, \mathrm{BBB}, \mathrm{BB}, \mathrm{B}, \mathrm{CCC\text{-}C}, \mathrm{D}\}$:

Equation B-6 – expected fair value of loan i in quarter t

$$\mathbb{E}\left[V_{i,t}\right] = \sum_{R} \Pi_t\left(R_0^i, R\right) \cdot V_{i,R,t}$$

Where:

- $\Pi_{\mathrm{t}}(R_0^i, R)$ are stressed state transition probabilities (as specified in Equation B-11), measuring the chance of attaining each given rating R, in projection quarter t, starting from loan i's initial rating R_0^i; and

[65] Loan-level information is not reported in FR Y-14Q, Schedule H.1 for agricultural loans and securities lending facilities, however aggregate balances are reported in Schedule M. To properly account for these exposures, the constant loss rates are applied to the balances. These loss rates are chosen to be broadly consistent with annualized credit losses assigned in the stress test for similar loans measured at amortized cost, (as specified in Section A(ii)(d)(2) (Corporate Model Loss Aggregation) of the Credit Risk Models Documentation).

[66] "Expectation over rating-conditional loan values" refers to the loan fair value expected, on average, after accounting for the different credit ratings R a loan may receive in a projection quarter, weighing by probabilities of transitioning to each potential such rating. These probabilities are outlined in the Rating Transition Probabilities Section B(iii)(a)(3).

- $V_{i,R,t}$ are the rating-conditional loan values and are calculated via:

Equation B-7 – dollar value of wholesale loan i at horizon t assuming attained rating R

$$V_{i,R,t} = \begin{cases} N_i \cdot \min\left(RR, \frac{V_i}{N_i}\right) & \text{if } i \text{ is in default} \\ N_i \cdot \mathrm{PV}_{i,R,t}^{\mathrm{FIX}} & \text{if } i \text{ is a fixed-rate loan, not in default} \\ N_i \cdot \mathrm{PV}_{i,R,t}^{\mathrm{FLT}} & \text{if } i \text{ is a floating loan, not in default} \end{cases}$$

Where:

- $RR = 0.5$ is the model's global recovery rate assumption, as discussed in Section B(iii)(b)(4);
- $\mathrm{PV}_{i,R,t}^{\mathrm{FIX}}$ and $\mathrm{PV}_{i,R,t}^{\mathrm{FLT}}$ are the fair value per dollar of notional, projected to quarter t, for the fixed- or floating-rate loan i, respectively, calculated per Equation B-12 and **Equation *B-14***, under the rate and spread shocks $\Delta r_{i,t}$ and $\Delta s_{i,R,t}$ applicable to loan i, assuming attained (non-default) rating R; and
- N_i and V_i are, respectively, the t_0 utilized (i) dollar par notional and (ii) dollar fair value of loan i, which both incorporate an assumed draw rate, represented by a loan-equivalent-factor (LEQ), against undrawn commitments at t_0. N_i and V_i are calculated as follows:

Equation B-8 – loan i's fair value and par amount, incorporating assumed draw rate, LEQ

$$V_i = U_i^{\mathrm{FV}} + \mathrm{LEQ}_{P[i]} \cdot \left(C_i^{\mathrm{FV}} - U_i^{\mathrm{FV}}\right)$$

$$N_i = U_i^{\mathrm{PAR}} + \mathrm{LEQ}_{P[i]} \cdot \left(C_i^{\mathrm{PAR}} - U_i^{\mathrm{PAR}}\right)$$

Where:

- U_i^{FV} and C_i^{FV} are utilized and committed fair values for loan i, respectively, (as reported per Figure B-2);
- U_i^{PAR} and C_i^{PAR} are utilized and committed par values for loan i, respectively, (reported per Figure B-2); and

- $\text{LEQ}_{\text{CORP}} = 0.65$ and $\text{LEQ}_{\text{CRE}} = 1.00$ are the loan-equivalent factors assumed for corporate and CRE loans, respectively;

(1) Risk-Free Rate Projection

The FVO Model uses risk-free rates produced by the Yield Curve Model, as described in detail in Section C(iv), as an input to the projection of fair value changes in respect of fixed- and floating-rate loans. The Yield Curve Model projects a fixed SOFR - U.S. Treasury spread that is maintained over the projection horizon for each given maturity. The Yield Curve Model's SOFR projections are used to determine risk-free rate shocks applied to the discount yields of fixed-rate (Equation ***B-13***) and floating-rate (Equation B-15) loans.

The risk-free rate shock applicable to loan i, with maturity τ_i, in projection quarter t is given by:

Equation B-9 – risk-free rate shock[67]

$$\Delta r_{i,t} = \text{SOFR}_{\tau_i}(t) - \text{SOFR}_{\tau_i}(0)$$

with SOFR_{τ_i} the SOFR rate for maturity τ_i determined by the Yield Curve Model, as described in Section C(iv)(a)—see Equation C-5.

(2) Credit Spread Projection

Cumulative changes in credit spreads are an input to the FVO Model's fixed- and floating-rate loan fair value calculations. For fixed-rate loans, credit spread changes are used to project discount yields (Equation ***B-13***). For floating-rate loans, credit spread changes are the key driver of projected fair value outcomes (**Equation *B-14***), but credit spread levels are also used in estimating CS01, which depends on discount yield (Equation B-15).

[67] For a given maturity, this projected change in SOFR rate is generally the same as the projected change in Treasury rate (since SOFR and Treasury rates are assumed to move in parallel by the Yield Curve Model, up to zero lower bound artifacts).

The cumulative change in credit spread, between t_0 and t, attributed to loan i, assuming i has transitioned from initial rating $R_{i,0}$ to R, is calculated via:

Equation B-10 – credit spread shock

$$\Delta s_{i,R,t} = s_t[R] - s_0[R_{i,0}]$$

With $s_t[R]$ taken as an input from the Yield Curve Model, which projects a set of corporate spreads by rating and quarter t—see Yield Curve Model, Section C(v)(a) and Equation C-7.

(3) Rating Transition Probabilities

A rating transition matrix is used to set probabilities of a loan attaining different credit ratings by a given projection quarter t, and these probabilities enter the expected loan value calculation in Equation B-6. Credit ratings are projected using a quarterly rating transition matrix, derived from rating transition rates observed during the 2008 financial crisis—as described further in Rationale and Calibration, Section B(iii)(b)(3). The transition matrix is applied to the initial rating of the loan $R_{i,0}$ that has been mapped onto the rating scale used by the model, $R_0 \in \{\text{AAA, AA, A, BBB, BB, B, CCC-C}\}$. The probability of occupying rating R in quarter t, conditional on an initial rating R_0, is determined from the quarterly credit rating transition matrix M (shown in Figure B-1), raised to the power of t:

Equation B-11 – credit rating transition probability

$$\Pi_{\mathrm{t}}(R_0, R) = M^t_{I[R_0],I[R]}$$

Where $I[R_0]$ and $I[R]$ index the ratings R_0 and R within the list $\{\text{AAA, AA, A, BBB, BB, B, CCC-C, D}\}$ and hence are the row and column numbers, within the transition matrix M^t, corresponding to the transition from R_0 to R.

Figure B-1 – matrix, M, of quarterly credit rating transition probabilities

FROM/TO:	AAA	AA	A	BBB	BB	B	CCC-C	D
AAA	88.6%	11.3%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
AA	0.0%	92.9%	7.1%	0.0%	0.0%	0.0%	0.0%	0.0%
A	0.0%	0.1%	96.0%	3.7%	0.0%	0.2%	0.0%	0.0%
BBB	0.0%	0.0%	0.3%	97.8%	1.6%	0.2%	0.0%	0.2%
BB	0.0%	0.0%	0.0%	1.2%	93.7%	4.4%	0.1%	0.5%
B	0.0%	0.0%	0.0%	0.0%	1.0%	92.7%	4.5%	1.8%
CCC-C	0.0%	0.0%	0.0%	0.0%	0.0%	1.9%	90.4%	7.6%
D	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	100.0%

(4) Fixed-Rate Loan FV

For fixed-rate loans, the calculation of fair value per dollar of notional $\mathrm{PV}_{i,R,t}^{\mathrm{FIX}}$ (introduced in Equation B-7) is described in the following equation. Fair value for each fixed-rate loan i conditional on attained rating R is determined with respect to a quarter-end coupon and principal payment schedule, via:

Equation B-12 – fair value, per dollar of notional, of fixed-rate loan i, in quarter t

$$\mathrm{PV}_{i,R,t}^{\mathrm{FIX}}[y_{i,R,t}, c_i, \tau_i] \quad = \frac{1}{\left(1 + \frac{y_{i,R,t}}{4}\right)^{4\tau_i}} + \left(\frac{c_i}{4}\right) \cdot \sum_{k=1}^{4\tau_i} \frac{1}{\left(1 + \frac{y_{i,R,t}}{4}\right)^{k}}$$

Where:

- τ_i is time to maturity, measured in years from t_0 to m_i (rounded to the nearest multiple of 0.25), with m_i being loan i's maturity date (reported as per Figure B-2);
- c_i is loan i’s annual coupon rate (reported as per Figure B-2), assumed to be paid quarterly;
- $y_{i,R,t}$ is the discount yield (as summarized in the Model Overview, Section B(ii), and specified in full in Equation ***B-13***) applicable to loan i, assuming attained rating R, calculated as:

Equation B-13 – discount yield, for fixed-rate loan fair value calculation

$$y_{i,R,t} = y_{i,0} + \Delta s_{i,R,t} + \Delta r_{i,t}$$

Where:

- $y_{i,0}$, is the initial yield, inferred from loan i's initial draw adjusted fair value and par amounts, V_i and N_i (given in Equation B-8 above), such that $y_{i,0}$ solves $\mathrm{PV}_{i,t}^{\mathrm{FIX}}\left[y_{i,0}, c_i, \tau_i\right] = V_i/N_i$;
- $\Delta r_{i,t}$ is the change in risk-free rate shock applicable to maturity τ_i, determined by the Yield Curve Model (as defined above in Equation B-9); and
- $\Delta s_{i,R,t} = s_t[R] - s_0\left[R_{i,0}\right]$, is the cumulative change in credit spread, between t_0 and t, attributed to loan i (introduced above in Equation B-10), assuming i has transitioned from initial rating $R_{i,0}$ to R, calculated from a set of generic corporate spread projections, by rating and quarter t (produced by the Yield Curve Model, see Section C(v)(a) and Equation C-7).

(5) Floating-Rate Loan FV

For floating-rate loans, the calculation of fair value per dollar of notional, $\mathrm{PV}_{i,R,t}^{\mathrm{FLT}}$ (introduced in **Equation *B-14***) is described in the following. Floating-rate loan fair value is determined (similarly as for fixed-rate loans) by mapping each given loan i onto a quarter-end coupon and principal payment schedule, and estimating credit spread driven changes in fair value via:

Equation B-14 – fair value, per dollar of notional, of floating-rate loan i, in quarter t

$$\mathrm{PV}_{i,R,t}^{\mathrm{FLT}}\left[y_{i,R,t}^{\mathrm{FE}}, \Delta \mathrm{s}_{i,R,t}, \tau_i\right] = V_i/N_i + 10^4 \cdot \mathrm{CS01}\left[y_{i,R,t}^{\mathrm{FE}}\right] \cdot \Delta \mathrm{s}_{i,R,t}$$

Where:

- τ_i is time to maturity, measured in years from t_0 to m_i (rounded to the nearest multiple of 0.25), with m_i being loan i's maturity date (reported as per Figure B-2);
- $\Delta s_{i,R,t} = s_t[R] - s_0\left[R_{i,0}\right]$ is the cumulative change in credit spread, between t_0 and t, attributed to loan i (introduced above in Equation B-10), assuming i has transitioned from initial rating $R_{i,0}$ to R, calculated from a set of generic corporate spread projections, by rating and quarter t (produced by the Yield Curve Model, see Section C(v)(a) and Equation C-7);
- V_i and N_i are initial draw adjusted fair value and par amounts for loan i (per Equation B-8 above), respectively; and
- CS01 is the credit spread sensitivity of loan i, approximated via

$$\mathrm{CS01}\left[y_{i,R,t}^{\mathrm{FE}}\right] = -(10^{-4}/4) \cdot \frac{1 - 1/(1 + y_{i,R,t}^{\mathrm{FE}}/4)^{4\tau_i}}{y_{i,R,t}^{\mathrm{FE}}/4}$$

  with $y_{i,R,t}^{\mathrm{FE}}$ the "fixed-rate equivalent" discount yield applicable to loan i, assuming attained rating R, calculated (analogously to Equation ***B-13*** for fixed loans) as:

Equation B-15 – discount yield, for floating-rate loan fair value calculation

$$y_{i,R,t}^{\mathrm{FE}} = y_{i,0}^{\mathrm{FE}} + \Delta s_{i,R,t} + \Delta r_{i,t}$$

Where:

- $\Delta r_{i,t}$ is again the change in risk-free rate applicable to maturity τ_i, determined by the Yield Curve Model (introduced above in Equation B-9); and
- $y_{i,0}^{\mathrm{FE}}$ solves $\mathrm{PV}_{i,t}^{\mathrm{FIX}}\left[y_{i,0}, c_i^{\mathrm{FE}}, \tau_i\right] = V_i/N_i$ with $c_i^{\mathrm{FE}} = c_i^{\mathrm{SPR}} + r_0[\tau_i]$ being the "fixed-rate equivalent" coupon for loan i, calculated as the sum of:

1. c_i^{SPR}, the interest rate spread for loan i (reported as per Figure B-2)

   and

2. $r_0[\tau_i] = \text{SOFR}_{\tau_i}(0)$, the initial SOFR rate applicable to maturity τ_i, derived from Term SOFR or SOFR swap rate observations, averaged over t_0 (the fourth quarter of the year containing the jump-off point for a given stress test) as further described in the Yield Curve Model, Section C(iv)(a)—see Equation C-5.

(6) FR Y-14Q Data

The following table summarizes FR Y-14Q input data used by the Wholesale Model.

Figure B-2 – FR Y-14Q reporting locations for Wholesale Model terms[68]

Term	Loan Type	14Q Sch	Line / Field #	Line / Field Name
B_0^{CORP}	CORP	M.1	1.c	"Secured by farmland"
			2.a-c	"C&I loans"
			5.a	"Loans to foreign governments"
			5.d	"Loans to financial institutions"
			5.e-f	"Other commercial loans/leases"
B_0^{AG}	CORP	M.1	5.b	"Agricultural loans"
B_0^{SL}	CORP	M.1	5.c	"Securities lending"
B_0^{CRE}	CRE	M.1	1.b.(1)	"Construction and land development"
			1.b.(2)	"Multifamily real estate"
			1.b.(3)	"Nonfarm nonresidential"
U_0^{CORP}	CORP	H.1	25	"Utilized Exposure Global"
U_0^{CRE}	CRE	H.2	3	"Outstanding Balance"
U_i^{PAR}	CORP	H.1	106	"Utilized Exposure Global Par Value"
	CRE	H.2	67	"Outstanding Balance Par Value"
U_i^{FV}	CORP	H.1	108	"Utilized Exposure Global Fair Value"
	CRE	H.2	69	"Outstanding Balance Fair Value"
C_i^{PAR}	CORP	H.1	105	"Committed Exposure Global Par Value"
	CRE	H.2	66	"Committed Exposure Global Par Value"
C_i^{FV}	CORP	H.1	107	"Committed Exposure Global Fair Value"
	CRE	H.2	68	"Committed Exposure Global Fair Value"

[68] Further explanations of these field names can be found in the FR Y-14Q instructions.

Term	Loan Type	14Q Sch	Line / Field #	Line / Field Name
c_i	CORP	H.1	38	"Interest Rate"
	CRE	H.2	27	"Interest Rate"
c_i^{SPR}	CORP	H.1	40	"Interest Rate Spread"
	CRE	H.2	29	"Interest Rate Spread"
m_i	CORP	H.1	19	"Current Maturity Date"
	CRE	H.2	65	"Current Maturity Date"
R	CORP	H.1	10	"Obligor Internal Risk Rating"
	CRE	H.2	15	"Internal Rating"

b. *Specification Rationale & Calibration*

The wholesale component of the FVO Model generally functions as a simple calculator, mechanically translating macroeconomic scenario path inputs for risk-free rates and credit spreads into loan fair value impacts without relying on econometric estimates. Calibration detail for the limited empirical estimates used by the model along with qualitative rationale for consequential framework choices are given below.

(1) Risk-Free Rate Projection

Risk-free rates by maturity and quarter are taken as inputs from the macroeconomic scenario, with some expansion of granularity performed by the Yield Curve Model to add the following:

(i) U.S. Treasury yields for all maturities out to thirty years, supplementing the three-month, five-year, and ten-year U.S. Treasury yield projections included in the macroeconomic scenario. This is achieved by using a Nelson-Siegel level, slope, and curvature parametric form with fixed shape parameter to uniquely interpolate / extrapolate the three yields provided into a full yield curve. Full quantitative detail for this scenario expansion step is provided in the Yield Curve Model Section C(iii).

(ii) SOFR rates (Term SOFR for maturities up to one year and SOFR swap rates thereafter) are projected by assuming static spreads by maturity to the U.S. Treasury yield curve held constant over the projection horizon. These static spreads are calibrated to averages observed over t_0 (the fourth quarter containing the jump-off point of the stress test), as further detailed in the Yield Curve Model Section C(iv).

(2) Credit Spread Projection

Credit spreads by rating and quarter are similarly taken from the macroeconomic scenario. The Yield Curve Model expands them to add U.S. corporate credit spreads for all ratings $R \in \{\text{AAA}, \text{AA}, \text{A}, \text{BBB}, \text{BB}, \text{B}, \text{CCC-C}\}$ and produces the nine-quarter projection spread paths. This is achieved by scaling the quarterly changes of spread paths in the scenario using "beta" sensitivities specific to each rating, and then adding the scaled spread changes to an initial jump-off spread level to produce a full nine-quarter spread projection. The initial jump-off spreads are averages observed over t_0, and the beta values are determined via regression of historically observed month-on-month spread changes. These credit spread projections are further detailed in the Yield Curve Model description in Section C(v).

(3) Rating Transition Probabilities

The quarterly credit rating transition probabilities utilized by the model (provided in Figure B-1 and represented by matrix M in Equation B-11) are calibrated to the 2008 and 2009 historical experience, reported by a third-party data vendor, in the form of:

- a 2008 rating transition matrix[69], M_{08}, summarizing rates of rating transition observed in 2008, and separately

[69] *See **Figure B-1*** for an example of a rating transition matrix, where rows represent initial rating levels, columns represent new rating levels and each cell contains the corresponding quarterly transition probability.

- an analogous 2009 rating transition matrix, M_{09}.

The transition matrices reported for 2008 and 2009 are combined by multiplication to produce a two-year cumulative transition matrix, reflective of stressed rating transition dynamics over the full course of 2008-2009. M is then the 8th root of this two-year transition matrix, perturbed to a nearby stochastic matrix:[70]

Equation B-16 – quarterly credit rating transition calibration

$$M \cong (M_{08}M_{09})^{1/8}$$

(4) Recovery Rate Assumption

The model assumes a stressed global recovery rate of fifty percent. This is calibrated to historical loan recovery outcomes recorded by a third-party data vendor. The vendor data cover historical loan recovery rates since 1989 and show that annual average recovery rates have fluctuated over economic cycles and typically declined during periods of stress; the fifty percent recovery assumption is chosen to be broadly consistent with the annual average recovery rates observed during stress periods. The Board is considering an alternative dynamic loss given default (LGD) model, as described in Section B(iii)(c)(1), to capture the expected fluctuations in loan recoveries conditional on the macroeconomic scenario.

(5) LEQ Assumptions

The FVO Model's loan-equivalent-factor (LEQ) assumptions, $\text{LEQ}_{\text{CORP}} = 65\%$ and $\text{LEQ}_{\text{CRE}} = 100\%$, represent assumed draw rates against unused loan commitments and are used

[70] The rating transition matrix is "perturbed", meaning it is minimally altered to result in a stochastic matrix. A stochastic matrix, in this context, is one in which (i) all elements represent transition probabilities, and hence must fall between zero and one, and (ii) each row contains the probabilities for a mutually exclusive and exhaustive set of transition outcomes and hence must sum to one.

to set jump-off fair value and par exposure amounts in the wholesale module (per Equation B-8) for corporate and CRE loans, respectively.

The LEQ factors are applied to all corporate and CRE loans, at the start of the stress test horizon, to incorporate fair value risk on commitments within the constant loan balances projected by the model.

LEQ factors were calibrated primarily based on analysis of loan-level data reported in FR Y-14Q, Schedule H since 2018, as described for CRE and corporate loans, respectively, below.

(a) CRE LEQ of 100 percent

The FR Y-14Q, Schedule H.2 data evidence that CRE loan-utilization rates, since 2018, have averaged close to ninety percent across reporting firms. Given this high baseline, only a small relative increase in utilized dollar amount is typically required to achieve the fully drawn status implied by an $\mathrm{LEQ}_{\mathrm{CRE}}$ assumption of 100 percent, which the Board therefore considers to reasonably capture potential draw behavior in the context of a severe recession. This slight upward adjustment in the context of a severe recession is consistent with the principles of simplicity and conservatism described in the Policy Statement.

(b) Corporate Loan LEQ of 65 percent

The FR Y-14Q, Schedule H.1 data evidence that corporate loan-utilization rates, since 2018, have averaged closer to forty-five percent across reporting firms (half the rate observed for CRE loans). Given this materially lower baseline, the Board determined an LEQ below 100 percent to be appropriate. Utilization rates are shown to depend on borrower financial condition, with troubled firms tending to draw down credit lines heavily when approaching default and higher line utilization observed more broadly for riskier borrowers and during economic downturns.[71] Since the Wholesale Model projects behavior in a severe recession, using an LEQ that applies uniformly to all potential degrees of credit deterioration that may transpire (under the rating- migration-driven expected value paradigm employed by the model), the Board chose to calibrate $\mathrm{LEQ}_{\mathrm{CORP}}$ to a default-consistent level, as implicit in firm estimates of exposure at default (EAD) reported in FR Y-14Q, Schedule H.1. Firm-modeled EAD estimates, on average across all reported FVO / HFS loans, or when restricting attention to defaulting borrowers, are found to exceed utilized exposure by approximately sixty-five percent of unfunded commitment amounts. Given these observations from the FR Y-14Q, Schedule H.1, the FVO Model sets the LEQ to sixty-five percent for corporate loans.

(6) Bond Spread Shocks Applied to Loans

The model sets FVO / HFS loan spreads equal to projected corporate bond credit spreads for equivalent ratings. The Board determined this to be a reasonable assumption based on an analysis of:

(i) historical loan spreads from a third-party vendor's leveraged loan indices relative to

(ii) historical bond spreads from a third-party vendor's high yield corporate indices (OAS to Treasuries),[72]

which evidenced comparable spread dynamics over the credit cycle. Historically, loan spreads have generally tracked the direction and magnitude of relative change exhibited by bond spreads, including during the 2008 financial crisis and with respect to sub-investment loans and bonds.

[71] *See* Moody's, 2019. Usage and Exposures at Default of Corporate Credit Lines: An Empirical Study. Available at https://www.moodys.com/web/en/us/insights/credit-risk/usage-and-exposures-at-default-of-corporate-credit-lines.html.

[72] In each case, "historical loan spread data" refers to data the Board has accrued, at least annually, to support the preparation of the supervisory stress tests. These data begin in the year 2000 in most cases.

c. *Alternative Approaches Considered*

(1) Dynamic LGD Model

In place of the model's static fifty percent uniform recovery rate (RR) assumption, the Board considered a dynamic model for LGD ($LGD = 1 - RR$). This model would project variation in LGD over the stress test horizon, based on macroeconomic scenario variable paths and certain loan-level characteristics. One benefit of this approach would be greater risk sensitivity for loan losses, particularly to underlying collateral characteristics, as loans with no or less liquid collateral typically have higher losses after default. The approach would also produce losses that are sensitive to the macroeconomic scenario. However, the Board chose the static fifty percent assumption for its simplicity, broad consistency with stressed economic conditions, and to achieve parity between LGDs projected for loan and associated corporate credit hedge positions (for which position-level information is not available for use in the model).

d. *Data Adjustments*

Certain adjustments are made to account for missing or spurious data inputs as described below. The FVO Model makes conservative adjustments that reasonably reflect historic observations from the FR Y-14Q.

(1) Loan Interest Rates

- **Interest Rate Variability:** For corporate loans, when the FR Y-14Q, Schedule H field Interest Rate Variability is reported as "NA," the model overrides this and assumes the loan is floating rate (corresponding to “2” in the FR Y-14Q, Schedule H instructions). For CRE loans, “NA” observations are overridden as fixed rate (“1” in the instructions).[73]

- **Interest Rate:** If interest rate variability is reported as or overridden to fixed rate, but no interest rate is provided, then the interest rate is set to zero.
- **Interest Rate Spread:** If the interest rate variability is reported as or overridden to floating rate, but no interest rate spread is provided, then the interest rate spread is set to zero.

Overriding missing interest rate and interest rate spread values with zero is a conservative approach, as it maximizes duration of the adjusted loan, which, in turn, increases the loan’s interest rate or credit spread sensitivity.

(2) Loan Maturity Dates

When the FR Y-14Q maturity date is reported as “NA” or reported as less than or equal to the as-of-date for a reported loan, the model assumes a conservative maturity date. For corporate loans, the model sets the maturity date to seven years from the as-of-date. For CRE loans, the model sets the maturity date to thirty years after the as-of-date. These conservative assumptions are informed by the maturity distributions of corporate and CRE loans in the FR Y-14Q.[74] For both corporate and CRE loans, if the maturity date is listed as “9999-01-01,” the loan is considered a demand loan, and the maturity is set to one year from the as-of-date.

[73] The interest rate variability adjustment assumptions reflect historic observations from the FR Y-14Q, Schedule H. The most frequently observed interest rate variability type is floating for corporate loans and fixed for CRE.

[74] The seven-year corporate loan and thirty-year CRE fallback assumptions both correspond to the upper tail of the observed maturity distribution.

(3) External & Internal Obligor Ratings

Firm-provided concordance mapping tables are used to translate internal ratings reported in FR Y-14Q, Schedule H into the whole letter rating scale used by the model $R \in \{\text{AAA}, \text{AA}, \text{A}, \text{BBB}, \text{BB}, \text{B}, \text{CCC-C}, \text{D}\}$. Observations with reported ratings of "NA" or "NR" (not rated) are mapped to the "CCC-C" bucket. This is a conservative assumption, as the "CCC-C" bucket is the lowest non-defaulted whole letter rating in the FVO Model.

(4) CCC-C Transition Probabilities

The FVO Model groups all loans rated "CCC", "CC" or "C" into a combined "CCC-C" rating bucket. This is done because many of the speculative grade inputs to the model do not distinguish between the individual ratings in this group. The annual credit rating transition rates, $\pi(R_1, R_2)$, reported by a third-party data vendor for 2008 and 2009, tabulated by initial rating R_1 and attained rating R_2, however, do distinguish between the credit migration behavior of "CCC"- and "CC-C"-rated obligors. To collapse the third-party data vendor's reported transition rates specific to "CCC" and "CC-C" ratings into aggregate rates pertaining to "CCC-C" (a necessary step in constructing the matrices M_{08} and M_{09}, referenced in Equation B-16), the model assumes that the weight, f_{ccc}, of "CCC"-rated obligors within the full "CCC-C" population is a constant ninety-one percent and drives aggregate transition rates for the "CCC-C" bucket via:

Equation B-17 – combining "CCC" and "CC-C" transition rates

$$\pi(\text{CCC-C}, R) = f_{\text{ccc}} \cdot \pi(\text{CCC}, R) + (1 - f_{\text{ccc}}) \cdot \pi(\text{CC-C}, R)$$

$$\pi(R, \text{CCC-C}) = \pi(R, \text{CCC}) + \pi(R, \text{CC-C})$$

where $f_{\text{ccc}} = 91\%$ is calibrated to a historical panel dataset of corporate obligor expected default probabilities from a third-party data vendor.

(5) Default Definition

The FVO Model considers both rating- and non-rating-based criteria for determining if a loan is in default. Loans satisfying any of the following criteria are considered by the model to be in default and hence do not contribute to fair value P&L variation over the projection horizon:[75]

- Reported loan rating maps to "D" (as its equivalent rating within the model's rating scale)
- Loan is ninety or more days past due
- Loan has a defined non-accrual date (reported as something other than "9999-12-31")
- Loan rating maps to the "CCC-C" rating bucket and loan charge-off amount is greater than zero.

(6) Loan Number

When a loan's internal rating is mapped to multiple external ratings, that loan is split up into as many pieces as there are mapped external ratings. These pieces are referred to as "loanlets" and are created by dividing all of a loan's exposures equally across the number of pieces it is being broken up into—this is how exposures at t_0 are determined for each loanlet. More specifically, in cases where a loan's internal rating is mapped to $N > 1$ external ratings $R_1, \ldots, R_n$ the model creates N loanlets to represent the credit quality of the loan with:

- ratings $R_1, \ldots, R_n$
- all balance measures, committed and utilized ($U_i^{\mathrm{PAR}}, U_i^{\mathrm{FV}}, C_i^{\mathrm{PAR}}, C_i^{\mathrm{FV}}$ and contributions to U_0^{CI} or U_0^{CRE}), set to $1/N^{th}$ the size of the corresponding measures for the original loan.

[75] In addition to being written down to the model's global recovery rate assumption in PQ0 when applicable, the first criteria for default—having a rating that maps to "D"—is unique to the FVO Model. The other criteria are consistent with the stress test treatment of equivalent loans carried at amortized cost. ***Equation B-7*** details how default loans are treated by the FVO Model in fair value projections.

Once created, these loanlets are then otherwise subject to the same loss generation algorithm as any other reported loan.

(7) Loan Balances

The following adjustments are made in respect of reported balance measures:[76]

- Utilized Exposure: when utilized exposure is reported as "NA," it is overridden to zero.
- Committed Exposure: when committed exposure is less than utilized exposure, it is overridden to equal utilized exposure.
- Committed Exposure Global Par Value: if the reported par value is "NA" then it is overridden to equal the committed exposure global fair value. If the reported par value is less than zero, then it is set to zero.
- Committed Exposure Global Fair Value: if the committed fair value is less than the utilized fair value, then it is overridden to equal the utilized fair value.
- Utilized Exposure Global Fair Value: if the utilized fair value is "NA" or less than zero, it is overridden to zero.
- Utilized Exposure Global Par Value: if the utilized par value is "NA" or less than zero, it is overridden to zero.

(8) Fallback Loss Rate for Incomplete Loan Data

In cases where FR Y-14Q, Schedule H loan-level data are missing or materially incomplete, the Board may use a fallback projection $\text{P\&L}_{\text{FB},t}^{\text{WHS}}$ derived from P&L rates per dollar of initial exposure determined for peer firms with complete data, as follows:

[76] These checks are also performed on the firm-submitted FR Y-14Q, Schedule H data prior to being used by the FVO Model.

Equation B-18 – fallback total wholesale loan gain / loss projection

$$\mathrm{P\&L}^{\mathrm{WHS}}_{\mathrm{FB},t} = B^{\mathrm{CI}}_0 \cdot \mathrm{FB}^{\mathrm{CORP}}_t + B^{\mathrm{CRE}}_0 \cdot \mathrm{FB}^{\mathrm{CRE}}_t - \begin{bmatrix} B^{\mathrm{AG}}_0 \\ B^{\mathrm{SL}}_0 \end{bmatrix}' \cdot \begin{bmatrix} L^{\mathrm{AG}}_{\mathrm{qtr}} \\ L^{\mathrm{SL}}_{\mathrm{qtr}} \end{bmatrix}$$

Where:

- B^{CI}_0, B^{CRE}_0 and $B^{\mathrm{AG}}_0, B^{\mathrm{SL}}_0$ are Schedule M balance items, as tabulated in Figure B-2 and as defined previously for the primary total wholesale loan gain / loss projection, in Equation B-4;
- FB^P_t, for $P \in \{\mathrm{CORP}, \mathrm{CRE}\}$, are fallback quarterly loss rate projections for loans of type P calculated to correspond to percentile pct of cumulative P&L rates $\{C^P_{f,t}\}$ to projection quarter t, estimated for peer firms f who provided complete data, via Equation B-19; and
- $L^{\mathrm{AG}}_{\mathrm{qtr}}$ and $L^{\mathrm{SL}}_{\mathrm{qtr}}$ are constant loss rates per quarter for agricultural loans and securities lending, respectively, also as defined previously in Equation B-4.

The percentile pct is taken from P&L rates by firm $\{C^P_{f,t}\}$ and $\{C^P_{f,t\text{-}1}\}$, cumulative to quarters t and t-1, respectively, to determine the quarterly fallback loss rate projection FB^P_t specific to each portfolio $P \in \{\mathrm{CORP}, \mathrm{CRE}\}$:

Equation B-19 – fallback wholesale P&L rates

$$\mathrm{FB}^P_t = Q_{\mathrm{pct}}\left\{C^P_{f,t}\right\} - Q_{\mathrm{pct}}\left\{C^P_{f,t\text{-}1}\right\}$$

where the cumulative P&L rate $C^P_{f,t}$ for each peer firm f with complete data is given by:

Equation B-20 – cumulative wholesale loss rate for

$$C^P_{f,t} = \left(\frac{\sum_{T=1}^{t} \mathrm{P\&L}^P_{T,f}}{U^P_{0,f}}\right)$$

with $U^P_{0,f}$ and $\mathrm{P\&L}^P_{T,f}$ as defined previously (without the firm subscript f) for the primary total wholesale loan gain / loss projection, in Equation B-4.

The percentile pct is:

- ten percent for "material" portfolios—those with t_0 carrying value over \$5 billion or ten percent of CET1 capital[77]
- fifty percent for "immaterial" portfolios—those that are not material.

These percentiles are chosen for conservatism, with material portfolios receiving a tail percentile of cumulative loss rate, while immaterial portfolios receive the median cumulative loss rate.

e. *Assumptions and Limitations*

Beyond the general constant-portfolio assumption maintained across all sub-models, the Wholesale Model component embeds certain key assumptions and limitations, itemized as follows:

- Historical transition rates observed empirically during the 2008 financial crisis, with respect to corporate loans, are assumed to adequately capture stressed credit transition behavior for corporate and CRE loans equally. To assess the transition matrix assumption, FR Y-14Q, Schedule H data are used to construct empirical transition matrices based on firm-reported internal rating paths for corporate and CRE loans. These matrices are compared to a third-party data vendor's corporate transition data via a distance metric that measures differences in average probabilities of migration between the matrices.[78] This analysis supports the continued use of the third-party data vendor's stressed transition matrices.

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[77] Relative and absolute materiality thresholds are similar to those set in the FR Y-14Q for Category IV firms. They differ in that the FR Y-14Q instructions considered the average balances from the four preceding quarters, while the FVO Model only considers the balances at jump-off for materiality.

[78] *See* Jafry, Y. and Schuermann, T. 2004. Measurement, Estimation and Comparison of Credit Migration Matrices (Journal of Banking & Finance 28/11).

- Internal credit ratings provided by firms are assumed to adequately capture obligor credit risk and internal-to-external rating concordance mappings provided by firms are assumed to be accurate. As covered in Section B(iii)(d)(5), the default definition utilized in the model considers several non-rating factors, like non-accrual status, that supplement the reliance on internal credit ratings for this important subset of loans.
- Loan credit spread dynamics are assumed to be reasonably proxied by bond credit spreads for equivalent ratings. Analysis undertaken to test this assumption is outlined in Section B(iii)(b)(6).
- Loan duration risk, on aggregate, is assumed to be reasonably approximated by a generic bullet maturity structure.
- A linear CS01 P&L calculation is assumed to reasonably approximate the fair value impact of credit spread shocks on floating-rate loans.
- Loan fair value risk is assumed to be reasonably estimated in response to a given macroeconomic scenario, based on credit rating, maturity, and fixed / floating coupon type, without broader consideration of loan attributes such as currency of denomination, obligor industry, seniority, or collateral.

iv. <u>Retail Model</u>

a. *Model Specification*

As described above, FVO / HFS retail loans include first- and second-lien mortgages, student loans, credit cards, and auto loans. The Board calculates gains and losses on FVO / HFS retail loans over the projection horizon using a duration-based approximation.

Retail loan portfolio fair value gains and losses are projected in segments, organized by loan category $j \in \{\text{Mortgage}, \text{Student Loans}, \text{Credit Card Loans}, \text{Auto Loans}, \text{Other}\}$ and annual vintage v consistent with the carry value-reporting segmentation utilized in FR Y-14Q, Schedule J. For each loan type and vintage segment, a duration-based fair value gain / loss projection $\text{P\&L}_t^{j,v}$ is calculated. In the case of mortgages, both interest rate and credit spread duration are incorporated. For all other loan categories, the projection incorporates credit spread duration only. Once determined, segment-level projections $\text{P\&L}_t^{j,v}$ are aggregated into two broad categories:

(i) residential mortgages, with $\text{P\&L}_t^{\text{MG}} = \sum_v \text{P\&L}_t^{\text{j},v}$ for $j = \text{Mortgage}$

(ii) all other consumer loans, with $\text{P\&L}_t^{\text{CN}} = \sum_j \sum_v \text{P\&L}_t^{j,v}$ for $j \neq \text{Mortgage}$

These category-level projections $\text{P\&L}_t^{\text{MG}}$ and $\text{P\&L}_t^{\text{CN}}$ are then normalized against initial carrying value totals within each category CV_0^{MG} and CV_0^{CN} to obtain P&L rates per dollar of initial exposure by category $\text{P\&L}_t^{\text{P}}$ (with $P \in \{\text{MG}, \text{CN}\}$ indexing the two categories), which are then multiplied against comprehensive t_0 balances B_0^{MG} and B_0^{CN} reported in FR Y-14Q, Schedule M to arrive at the final dollar gain / loss projection for retail loans:

Equation B-21 – the Retail Model, which is the total retail loan gain / loss projection

$$\text{P\&L}_t^{\text{RET}} = B_0^{\text{MG}} \cdot \left(\frac{\text{P\&L}_t^{\text{MG}}}{CV_0^{\text{MG}}}\right) + B_0^{\text{CN}} \cdot \left(\frac{\text{P\&L}_t^{\text{CN}}}{CV_0^{\text{CN}}}\right)$$

Where:

- B_0^{MG} and B_0^{CN} are aggregate HFS/FVO t_0 balances, reflected in FR Y-14Q, Schedule M pertaining to (i) residential mortgages and (ii) other consumer loans, respectively, reported as tabulated in Figure B-3;

- $\mathrm{CV}_0^{\mathrm{MG}}$ and $\mathrm{CV}_0^{\mathrm{CN}}$ are corresponding t_0 carry values (for residential mortgages and consumer loans) summed at the segment level in FR Y-14Q, Schedule J, Table 2; and
- $\mathrm{P\&L}_t^P$ for $P \in \{\mathrm{MG}, \mathrm{CN}\}$ is the dollar fair value gain / loss, projected for quarter t, on loans within portfolio P, using the duration approximation specified in Equation B-22.

While Equation B-21 defines the aggregate retail profit and loss projection, the duration approximation (as summarized in the model overview Section B(ii)(b) at the start of this model description) used to determine component P&L by retail loan category is specified as follows:

Equation B-22 – category-level retail loan gain / loss projection

$$\mathrm{P\&L}_t^{\mathrm{P}} = \sum_{j \in P} \sum_{v} \mathrm{CV}_j(v) \cdot \left[D_j^{\mathrm{rate}}(v) \cdot \Delta r_t^{5\mathrm{Y}} + D_j^{\mathrm{spr}}(v) \cdot \Delta s_{j,t} \right]$$

Where:

- $P \in \{\mathrm{MG}, \mathrm{CN}\}$ indexes retail loan category;
- j indexes loan type, with the mapping of loan types to categories as tabulated in Figure B-3;
- v indexes vintage year, with $v \in \{\text{before } 2007, 2007, 2008, \dots, \mathrm{YR}[t_0]\}$, i.e., covering yearly vintages starting in 2007 and running up until the year of a given stress test $\mathrm{YR}[t_0]$. Yearly vintages prior to 2007 are grouped into the “before 2007” category;
- $\mathrm{CV}_j(v)$ is carrying value for loan category j and vintage v, reported in FR Y-14Q, Schedule J, Table 2, as per Figure B-3;
- Δr_t^{5Y} is the quarterly change in five-year U.S. Treasury yield, as projected in a given macroeconomic scenario, from quarter t-1 to quarter t;
- $\Delta s_{j,t}$ is the quarterly change in credit spread, applicable to loan type j, as further defined in Equation B-23; and

- $D_j^{\text{spr}}(v)$ and $D_j^{\text{rate}}(v)$ are credit spread and interest rate durations, respectively, assumed for category j and vintage v, as provided in Figure B-5 and Figure B-6.

(1) FR Y-14Q Data

The following table summarizes FR Y-14Q data used by the Retail Model.

Figure B-3 – FVO / HFS loan type segments utilized by the Retail Model component

Loan Category P	Initial Balance B_0^{P}: Schedule M.1 items	Loan Type j	Carrying Value $\text{CV}_j(v)$: FR Y-14Q, Schedule J, Table 2 items
Mortgage	1.a Residential real estate (1-4 family)	Mortgage	(B) Residential Loans (Repurchased with FHA/VA Insurance)
			(C) Residential Loans (Not in (A) or (B))
Other Consumer	3. Credit Cards 4. Other loans and leases	Student Loans	(E) Student Loans (Not in Forward Contract)
		Credit Card Loans	(F) Credit Card Loans (Not in Forward Contract)
		Auto Loans	(G) Auto Loans (Not in Forward Contract)
		Other	(H) All Other Non-Residential Loans Not Included in (D),(E), (F) or (G)

(2) Credit Spread Projection

The FVO Model derives credit spread projections from Auxiliary Scenario Variables, which represent credit spreads on various benchmark structured product indices (as detailed in Section I). Specifically, generic credit spread changes $\Delta s_{j,t}$ by retail loan type j and quarter t, are determined via:

Equation B-23 – retail loan credit spread projection

$$\Delta s_{j,t} = \beta_j \cdot \left(\tilde{s}_t^j - \tilde{s}_{t-1}^j\right)$$

Where:

- $\tilde{s}_t^j$ is an Auxiliary Scenario Variable (see Section I), reflecting OAS pertaining broadly to loan type j (as tabulated in Figure B-4); and

- β_j is the modeled sensitivity of loan type $j's$ credit spread to changes in the Auxiliary Scenario Variable OAS (as also tabulated in Figure B-4).

Figure B-4 shows the Auxiliary Scenario Variables $\tilde{s}_j^j$ used in projecting OAS for each loan category j along with associated sensitivities β_j. Empirical calibration details for β_j are given in the Specification Rationale & Calibration Section B(iv)(b)(3).

Figure B-4 – spread sensitivities β_j by retail loan type j, as determined for the stress test with jump-off-point in 2024:Q4, along with the Auxiliary Scenario Variables used to project each loan-type-specific spread

Loan Type j	Modeled Spread Sensitivity β_j	OAS Auxiliary Scenario Variable $\tilde{s}_t^j$
Mortgage	0.58	Home Equity ABS
Student	0.85	General ABS
Credit Card	0.97	Credit Card ABS
Auto	0.83	Auto ABS
Other	0.85	General ABS

(3) Duration Assumptions

FR Y-14Q, Schedule J contains vintage-level carrying values by loan type but lacks duration information. Retail loan durations are derived from third-party vendor data on structured finance tranches by asset category and vintage—see Section B(iv)(b)(1) for discussion of this estimation step. The resulting spread durations are summarized in Figure B-5. Interest rate sensitivity is only captured for mortgage loans and is set to zero for all other retail loan categories.

(a) Spread Durations

Figure B-5 – spread duration, summary of assumptions by loan type and vintage

Vintage	Loan Type				
	Mortgage	Student	Credit Card	Auto	Other
< 2010	3.9	2.2	6.1	1.9	5.5
2010–2014	4.8	2.3	3.4	1.9	2.7
2015–2019	5.7	2.9	3.1	1.7	3.2
2020–2024	5.7	3.1	1.8	1.4	2.0

(b) Rate Durations

Figure B-6 – rate duration, summary of assumptions by loan type and vintage

Vintage	Loan Type				
	Mortgage	Student	Credit Card	Auto	Other
< 2010	3.6	zero rate duration assumed			
2010–2014	4.7				
2015–2019	5.7				
2020–2024	5.4				

b. *Specification Rationale and Calibration*

The Retail Model uses a simple duration approximation to assign credit spread shocks to retail loans by type and vintage, and, in the case of mortgages, to assign interest rate shocks. The model utilizes aggregate retail loan carry value information, submitted in FR Y-14Q, Schedule J and assumes that the loan population represented within each segment is granular enough to present spread or interest rate duration risk, consistent with the industry-level diversified collateral pools underlying representative ABS indices (summarized in Figure B-7), matched by loan type and vintage.

(1) Duration Estimates

Retail loan duration estimates by loan category and vintage are determined from weighted average durations of structured financial products that are constituents[79] of the structured finance indices tabulated below, matched by category and vintage:

Figure B-7 – retail loan durations by loan category and vintage are determined from weighted-average durations of structured financial products that are constituents of the structured finance indices summarized here (obtained from a third-party vendor), matched by category and vintage.

Retail Loan Category *j*	Duration Calibration Vendor Index - ABS Population
Mortgage	US Mortgage-Backed Securities
Student	US Student Loan Asset-Backed Securities
Credit Card	US Credit Card Asset-Backed Securities
Auto	US Automobile Asset-Backed Securities
Other	US General Asset-Backed Securities

(2) Inclusion of Interest Rate Risk for Mortgages

For mortgages, both interest rate and spread duration are incorporated into projections, while for all other consumer loans only credit spread duration is considered. Interest rate duration is included specifically for mortgages, given the prevalence of thirty-year fixed-rate mortgages, with typical interest rate durations on the order of five years. The Retail Model uses the macroeconomic scenario's five-year treasury U.S. Treasury Rate projection to apply rate shocks to mortgages. This is supported by the vendor calibration index referenced in Figure B-7, where the underlying mortgage collateral has a median weighted-average life of approximately

[79] Constituents refer to securities that are included in the index.

five years. Interest rate duration assumptions, $D_j^{\text{rate}}(v)$ in Equation B-22, are not imputed for non-mortgage loans for simplicity, as fair value for other types of retail loans is predominantly driven by credit spreads.[80]

(3) Credit Spread Projection

OAS projections $\Delta s_{j,t}$ by retail loan category j are determined from OAS Auxiliary Scenario Variables $\tilde{s}_t^j$ capturing ABS spreads[81] for different loan categories (see Section I), as tabulated in Figure B-4. Due to their design, ABS typically have higher systematic risk than non-structured securities with similar expected loss.[82] As such, projected changes in the ABS OAS variables $\tilde{s}_t^j$ may be overly volatile as applied to whole loan exposure since ABS spreads are expected to respond more strongly to systematic shocks than whole loans. As a qualitative adjustment to account for this difference in volatility, shocks projected for each ABS spread variable $\tilde{s}_t^j$ are scaled by coefficients β_j before being applied to retail loan exposures. The β_j are calibrated to reflect the lower OAS shocks observed historically for AAA-rated ABS via the following linear regression:

Equation B-24 – spread beta estimation regression

$$\Delta s_{j,t} = \beta_j \cdot \Delta \tilde{s}_t^j + \varepsilon_{j,t}$$

Where:

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80 The FR Y-14Q, Schedule J collects carry values by loan type and vintage but lacks duration information. Based on third-party vendor duration calibration indices summarized in ***Figure B-7***, rate durations for non-mortgage products were less than two years, whereas the mortgage index rate duration is greater than five as-of 2024:Q4.

81 The weighted-average spread on all tranches of a securitization approximates the spread on the pool of underlying loans.

82 *See,* e.g., Coval, J., Jurek, J., and Stafford, E., 2009. The Economics of Structured Finance. (Journal of Economic Perspectives 23/1); and Hamerle, A., Liebig, T., and Scheule, H., 2004. Forecasting Credit Portfolio Risk. (Bundesbank Series 2 Discussion Paper No. 01/2004).

- $\Delta s_{j,t}$ is the historical monthly change, to month end t, in the level of the AAA ABS calibration index for loan type j, as tabulated in Figure B-8;
- $\Delta\tilde{s}_t^j$ is the historical monthly change, to month end t, in the level of the rating-agnostic OAS Auxiliary Scenario Variable pertaining to loan type j, as also tabulated in Figure B-8; and
- t indicates monthly data, starting in 1990 and continuing until the most recent year-end preceding a given stress test effective date,[83] used in the regression estimates.

An expanding calibration window (with fixed start point) is chosen to support stability in estimates while ensuring the inclusion of relevant historical stress periods (the 2008 financial crisis as well as the COVID period) within the calibration data over time.

By using monthly data, the regression aims to: (i) avoid the confounding effects of transient / short-term market microstructure noise, which is more prevalent in higher frequency observations and less relevant to the forecast horizon of the stress test (where losses are projected on a quarterly basis); but also (ii) maintain a sufficient volume of data points to support a stable estimate as well as sufficient resolution to capture the peaks and troughs of relevant stress events occurring in the calibration window. Monthly time series data achieve a reasonable balance between these two objectives.

[83] For example, a stress test with 2030:Q4 as the jump-off point would utilize monthly OAS data covering 1997–2029 (inclusive) to calibrate beta.

Figure *B-8* – *AAA ABS calibration indices by loan type* j*, used in regression Equation B-24*

Type j	Third-Party Vendor OAS Calibration Index $\Delta s_{j,t}$	Auxiliary Scenario Variable $\tilde{s}_t^j$
Mortgage	AAA Home Equity ABS	Home Equity ABS
Student	AAA General ABS	General ABS
Credit Card	AAA Credit Card ABS	Credit Card ABS
Auto	AAA Auto ABS	Auto ABS
Other	AAA General ABS	General ABS

c. *Alternative Approaches Considered*

(1) Convexity in the Retail Mortgage Model

An alternative specification of the retail mortgage model was considered to include higher-order interest rate and credit spread effects. This approach was not adopted due to the insignificant impact on FVO / HFS mortgage loss projections. The Board conducted analysis showing that mortgage losses were only marginally lower when extra terms were added to Equation B-22 to capture convexity in P&L sensitivity to interest rate and credit spread movements. In view of the demonstrated immaterial impact, the Board determined to maintain the simpler linear specification.

d. *Data Adjustments*

(1) Fallback Loss Rate for Incomplete Loan Data

In cases where FR Y-14Q, Schedule J loan-level data are missing or materially incomplete, the Board may use a fallback projection $\mathrm{P\&L}_{\mathrm{FB},t}^{\mathrm{RET}}$ derived from P&L rates per dollar of initial exposure determined for peer firms with complete data, as follows:

Equation B-25 – fallback total retail loan gain / loss projection

$$\mathrm{P\&L}_{\mathrm{FB},t}^{\mathrm{RET}} = B_0^{\mathrm{MG}} \cdot \mathrm{FB}_t^{\mathrm{MG}} + B_0^{\mathrm{CN}} \cdot \mathrm{FB}_t^{\mathrm{CN}}$$

Where:

- B_0^{MG} and B_0^{CN} are Schedule M balances for retail mortgages and other consumer loans, respectively, as tabulated in Figure B-3, and as defined previously for the total retail loan gain / loss projection, in Equation B-21; and
- FB_t^P, for $P \in \{\mathrm{MG}, \mathrm{CN}\}$, are fallback quarterly loss rate projections, for retail loans of type P, calculated to correspond to percentile pct of cumulative P&L rates $\{C_{f,t}^P\}$ to horizon t, estimated for peer firms f who provided complete data, via Equation B-26.

The percentile pct is taken from P&L rates by firm $\{C_{f,t}^P\}$ and $\{C_{f,t\text{-}1}^P\}$, cumulative to horizons t and t-1, to determine the quarterly fallback loss rate projection FB_t^P specific to each portfolio $P \in \{\mathrm{MG}, \mathrm{CN}\}$:

Equation B-26 – fallback retail loan P&L rates

$$\mathrm{FB}_t^P = Q_{\mathrm{pct}}\left\{C_{f,t}^P\right\} - Q_{\mathrm{pct}}\left\{C_{f,t\text{-}1}^P\right\}$$

where the cumulative P&L rate $C_{f,t}^P$ for each peer firm f with complete data, is given by:

Equation B-27 – cumulative retail loss rate

$$C_{f,t}^P = \left(\frac{\sum_{T=1}^{t} \mathrm{P\&L}_{T,f}^P}{\mathrm{CV}_{0,f}^P}\right)$$

with $\mathrm{CV}_{0,f}^P$ and $\mathrm{P\&L}_{T,f}^P$ as defined previously (without the firm subscript f) for the primary total retail loan gain / loss projection, in Equation B-21.

The percentile pct is:

- ten percent for "material" portfolios—those with t_0 carrying value over \$5 billion or ten percent of CET1 capital;[84] and
- fifty percent for "immaterial" portfolios—those that are not material.

e. *Assumptions and Limitations*

Beyond the general constant portfolio assumption maintained across all sub-models, the Retail Model component embeds certain key assumptions and limitations, itemized as follows:

- Retail loan portfolio spread durations are assumed to be reasonably proxied by durations derived from indices of structured finance tranches referencing the same collateral type and vintage.
- Retail loan credit spread dynamics are assumed to be reasonably proxied by credit spread dynamics of AAA-rated structured finance tranches of matching collateral type.
- A linear duration-based P&L projection is assumed to reasonably approximate the response of retail loan fair values to credit spread or interest rate shocks.

v. <u>Loan Hedge Model</u>

a. *Model Specification*

As described in Section B(ii), the Board calculates the quarterly P&L for hedges on FVO loans and on loans measured at amortized cost by combining a set of scenario-specific risk-factor projections and associated risk-factor P&L sensitivities submitted by firms. Aggregate hedge

[84] Relative and absolute materiality thresholds are similar to those set in the FR Y-14Q for Category IV firms. They differ in that the FR Y-14Q instructions consider the average balances from the four preceding quarters while the FVO Model only considers the balances at jump-off.

gains and losses for each firm enter pre-tax net income as "other losses / gains" alongside projected gains and losses on wholesale and retail exposures.

The Loan Hedge Model is applied to hedge positions held outside of the trading book that do not qualify as accounting hedges under FASB Accounting Standards Codification (ASC) topic 815 on Derivatives and Hedging.[85] This population comprises both (i) FVO Hedges and (ii) AL Hedges, and includes positions placed against a variety of risks—including corporate credit, interest rate, equity and securitized product hedges.

In general, quarterly hedge P&L is determined[86] by applying macroeconomic scenario risk-factor projections against associated firm-provided risk-factor sensitivities or market values, which are reported in FR Y-14Q, Schedule F and are segmented by hedge population (FVO Hedge and AL Hedge). The specific P&L calculations employed by the Loan Hedge Model vary by broad hedge type:

- for equity and interest rate risk hedges, quarterly gains and losses $\mathrm{P\&L}_t^{\mathrm{EQ}}$ & $\mathrm{P\&L}_t^{\mathrm{IR}}$, respectively, are determined by linear interpolation of firm-submitted P&L grids;[87]
- for securitized product hedges, quarterly gains and losses $\mathrm{P\&L}_t^{\mathrm{SP}}$ follow a duration-based approximation; and

[85] Per Y-14Q, Schedule F instructions, which define "FVO Hedges" and "AL Hedges" to exclude accounting hedges.

[86] P&L is determined in a manner broadly analogous to the Trading P&L Model's calculation of GMS MtM impacts on trading book positions.

[87] A "P&L grid" is a connected series of P&L estimates (along the y-axis) generated in response to a series (along the x-axis) of incrementally increasing shocks to a given risk factor. For example, the series $\{P\&L_{50}, P\&L_{100}, P\&L_{150} \ldots\}$ of MtM impacts resulting from yield curve shocks $\Delta y_i \in$ {50bps, 100bps, 150 bps…}.

- for corporate credit hedges, the projection of gains and losses $\mathrm{P\&L}_t^{\mathrm{CC}}$ mirrors the Wholesale Model treatment of loans (see Section B(iii)(a)) and utilizes the same credit transition matrix and generic credit spread projections by rating.

The final output of the Loan Hedge Model $\mathrm{P\&L}_t^{\mathrm{HDG}}$ is the sum of gains and losses $\mathrm{P\&L}_t^k[B]$ projected for each hedge type $k \in \{\mathrm{EQ}, \mathrm{IR}, \mathrm{SP}, \mathrm{CC}\}$ within each book type $B \in \{\mathrm{FVO\ Hedges}, \mathrm{AL\ Hedges}\}$:

Equation B-28 – total loan hedge gain / loss projection

$$\mathrm{P\&L}_t^{\mathrm{HDG}} = \sum_B \left(\mathrm{P\&L}_t^{\mathrm{EQ}} + \mathrm{P\&L}_t^{\mathrm{IR}} + \mathrm{P\&L}_t^{\mathrm{SP}} + \mathrm{P\&L}_t^{\mathrm{CC}}\right)[B]$$

where the four hedge type P&L components, are determined as follows:[88]

- P&L for equity hedges $\mathrm{P\&L}_t^{\mathrm{EQ}}$ is calculated according to Equation B-29;
- P&L for interest rate hedges $\mathrm{P\&L}_t^{\mathrm{IR}}$ is calculated via Equation ***B-30***;
- P&L for securitized product hedges $\mathrm{P\&L}_t^{\mathrm{SP}}$ is calculated via **Equation *B-31***; and
- P&L for corporate credit hedges $\mathrm{P\&L}_t^{\mathrm{CC}}$ is calculated via Equation B-33.

(1) Equity Hedges

For a given book type $B \in \{\mathrm{FVO\ Hedge}, \mathrm{AL\ Hedge}\}$ the equity hedge P&L calculation utilizes firm-submitted P&L grids $\mathrm{GRD}_c^{\mathrm{EQ}}$ reported by country c, in FR Y-14Q, Schedule F.1 (Equity by Geography), which depict equity hedge P&L in response to percentage declines in broad market prices. These firm-provided, country-level P&L grids are aggregated together to produce a global equity hedge P&L grid $\mathrm{GRD}_{\mathrm{GLB}}^{\mathrm{EQ}} = \sum_c \mathrm{GRD}_c^{\mathrm{EQ}}$ that is then used as a starting

[88] Since these calculations are applied identically to determine P&L for the FVO Hedge or AL Hedge population, the book type indicator B is dropped in what follows for notational clarity.

point to project overall equity hedge P&L by quarter t, based on the domestic public stock returns depicted in the macroeconomic scenario:

Equation B-29 – equity hedge P&L

$$\mathrm{P\&L}_t^{\mathrm{EQ}} = \mathrm{GRD}_{\mathrm{GLB}}^{\mathrm{EQ}}[rDJ_t] - \mathrm{GRD}_{\mathrm{GLB}}^{\mathrm{EQ}}[rDJ_{t-1}]$$

Where:

- rDJ_t is the cumulative percent-return of public equity through projection quarter t and is derived from Dow Jones Total Stock Market Index levels (DJ_t) specified in the macroeconomic scenario via $rDJ_t = DJ_t/DJ_0 - 1$; and
- $\mathrm{GRD}_{\mathrm{GLB}}^{\mathrm{EQ}}[rDJ_t]$ denotes P&L in respect of price return rDJ_t, interpolated from the P&L grid for global equity prices $\mathrm{GRD}_{\mathrm{GLB}}^{\mathrm{EQ}}$.

(2) Interest Rate Hedges

For a given book type $B \in \{\text{FVO Hedge}, \text{AL Hedge}\}$ the interest rate hedge P&L calculation utilizes firm-submitted directional[89] DV01s $D_{c,m}$ reported by interest rate curve c and maturity m in FR Y-14Q, Schedule F.6 (Rates DV01), depicting interest rate hedge P&L, generated by curve c, resulting from a -1bps directional move in rates, at maturity m. The directional DV01s are summed over curves to produce global directional DV01s by maturity $D_m^{\mathrm{GLB}} = \sum_c D_{c,m}$, which are then used to determine overall interest rate hedge P&L by quarter t, based on the path of domestic risk-free rates depicted in the macroeconomic scenario:[90]

[89] Firms submit sensitivities divided into "directional risks" and "basis risks." The hedge calculations only use directional risk sensitivities as the macroeconomic scenario does not specify rate basis shocks.

[90] The fair value change is calculated as the product of DV01, the change in a portfolio's dollar value resulting from a one basis point parallel shift downward in interest rates, and the rate change ($\Delta r_{t,m}$).

Equation B-30 – interest rate hedge P&L

$$\text{P\&L}_t^{\text{IR}} = -\sum_{\tau} D_m^{\text{GLB}} \cdot \Delta r_{t,m}$$

Where:

- $\Delta r_{t,m} = r_{t,m} - r_{t\text{-}1,m}$ is quarterly change in domestic risk-free rates at maturity m, determined by the Yield Curve Model, which utilizes a Nelson-Siegel level, slope, and curvature formulation to interpolate and extrapolate the macroeconomic scenario-provided U.S. Treasury yields for three-month, five-year, and ten-year maturities, and further assumes that SOFR rates maintain a fixed spread to Treasury yields throughout the projection horizon (as further detailed in the Yield Curve Model, Section C, Equation C-5).

(3) Securitized Product Hedges[91]

For a given book type $B \in \{\text{FVO Hedge}, \text{AL Hedge}\}$ the securitized product hedge P&L calculation utilizes firm-provided[92] hedge instrument market values $\text{MV}_{R,j}$ reported by product group j and rating R, with -$\text{MV}_{R,j}$ depicting the maximum hedge payoff that could be generated, assuming a total loss in the value of collateral referenced by the hedge instrument. Securitized product hedge P&L, by quarter t, is projected under a duration approximation, where the hedge market value change is a linear function of securitized product credit spreads projected in the macroeconomic scenario:

[91] Currently the Securitized Product hedges are processed by an overlay. The Board expects it to be part of the official model in the future.

[92] For GMS firms, the Securitized Product hedges are reported in FR Y-14Q, Schedule F. For non-GMS firms the Board currently relies on a special data collection.

Equation B-31 – securitized product hedge P&L

$$\text{P\&L}_t^{\text{SP}} = \sum_j \sum_R \left(\Delta s_{j,R,t} \cdot D_j \cdot \text{MV}_{R,j}\right)$$

Where:

- j indexes the seven product groups tabulated in Figure B-9;
- $\Delta s_{j,R,t}$ is the change in spread, from quarter t-1 to t, for product group j and rating R, determined from macroeconomic scenario projected spreads, as per Equation B-32; and
- D_j is the spread duration for product type j.

Figure B-9 – duration assumptions by product group j defined with respect to the product categories and sub-categories tabulated in FR Y-14Q, Schedule F.14 (Securitized Products).

Securitized Product Group j		Duration D_j
Category	*Sub-Category*	
RMBS	All	3.0
ABS	Auto	1.5
ABS	Credit Card	1.5
ABS	All Other	2.1
CMBS	All	3.7
Corporate CDO / CLO	CLO	3.8
Corporate CDO / CLO	Other / Unspecified	2.1

The change in spread, from quarter t-1 to t, for product group j and rating R is determined as:

Equation B-32 – securitized product spread projection

$$\Delta s_{j,R,t} = \begin{cases} \tilde{s}_{j,t}^{\text{IG}} - \tilde{s}_{j,t\text{-}1}^{\text{IG}} & \text{when } R \in \{\text{AAA, AA, A, BBB}\} \\ s_t[R] - s_{t-1}[R] & \text{when } R \in \{\text{BB, B, CCC-C}\} \end{cases}$$

Where:

- $\tilde{s}_{j,t}^{\text{IG}}$ is the OAS Auxiliary Scenario Variable (see Section I), used to infer spread dynamics for investment grade positions within product group j, as tabulated in Figure B-10; and

- $s_t[R]$ is taken as an input sourced from the Yield Curve Model, which projects a set of corporate spreads by rating and quarter t (see the Corporate module within the Yield Curve Model, Section C(v)(a) and Equation C-7), such that hedge positions with a sub-investment-grade rating receive the same generic rating-based spread shocks utilized by the Wholesale Model component (see Equation B-10).

Figure B-10 – OAS Auxiliary Scenario Variables (see Section I) used to infer spread dynamics for investment-grade securitized product hedge positions, within each product group j.

Securitized Product Group j		Auxiliary Scenario Variable OAS $\tilde{s}_{j,t}^{\mathrm{IG}}$
Category	Sub-Category	
RMBS	All	Home Equity ABS
ABS	Auto	Auto ABS
ABS	Credit Card	Credit Card ABS
ABS	All Other	General ABS
CMBS	All	CMBS
Corporate CDO / CLO	CLO	CMBS
Corporate CDO / CLO	Other / Unspecified	General ABS

(4) Corporate Credit Hedges

For a given book type $B \in \{\text{FVO Hedge}, \text{AL Hedge}\}$ the corporate credit hedge P&L calculation utilizes firm-submitted[93] P&L grids $\mathrm{GRD}_{g,c,R_0}^{\mathrm{CC}}$ reported by

- Region, $g \in \{\text{Advanced Economies}, \text{Emerging Markets}\}$,
- Instrument type, $c \in$

$$\{\text{Single Name CDS}, \text{Loan CDS}, \text{Indices}, \text{Index Tranches}, \text{Index Options}, \text{Bonds}, \text{Loans}, \text{Covered Bonds}, \text{Other/Unspecified}\}$$

[93] Data are sourced from FR Y-14Q, Schedule F, sub-schedules F.18 and F.19.

- and initial rating or index category R_0,[94]

where each grid depicts hedge gains in response to a sequence of credit spread widenings. Broadly, hedge P&L is determined from these grids by applying the same generic corporate spread projections by rating, as introduced for the Wholesale Model (see Equation B-10), allowing for the same credit rating transitions but introducing divergence between CDS and cash spreads for the same rating. More specifically, spread shocks $\Delta s^{c}_{R_0,R}(t)$ (varying by instrument category c,[95] initial rating R_0, horizon t, and attained rating R), are applied to firm-provided P&L grids to interpolate rating-conditional cumulative hedge gains $G^{c,g}_{R_0,R}(t)$ specific to each potential attained rating R. Expectations over these rating-conditional gain amounts are then taken, with rating probabilities governed by the credit transition matrix M_t (introduced in Equation B-11), to determine a cumulative P&L to horizon t, for each region, instrument type and initial rating, from which a total quarter-on-quarter P&L can be derived as follows:

Equation B-33 – P&L in quarter t for corporate credit hedges

$$\mathrm{P\&L}^{\mathrm{CC}}_t = \sum_g \sum_c \sum_{R_0} \mathbb{E}\left[G^{c,g}_{R_0}(t)\right] - \mathbb{E}\left[G^{c,g}_{R_0}(t\text{-}1)\right]$$

where $\mathbb{E}\left[G^{c,g}_{R_0}(t)\right]$ denotes the following expectation over rating-conditional hedge gain values $G^{c,g}_{R_0,R}(t)$ for $R \in \{\mathrm{AAA, AA, A, BBB, BB, B, CCC\text{-}C, D}\}$:

[94] To assign rating-based credit spread shocks, investment grade index exposures are treated as BBB positions and high yield index positions are treated as B positions.

[95] Projected spreads are assumed to be lower when c is a category of a credit default swap instrument, i.e., $c \in \{\text{Single Name CDS, Loan CDS, Indices, Index Tranches, Index Options}\}$. *See* ***Equation B-36***.

Equation B-34 – expected cumulative corporate credit hedge gain, to quarter t

$$\mathbb{E}\left[G_{R_0}^{c,g}(t)\right] = \sum_{R} \Pi_t(R_0, R) \cdot G_{R_0,R}^{c,g}(t)$$

with $\Pi_{\mathrm{t}}(R_0, R)$ being stressed state transition probabilities (as specified in Equation B-11), measuring the chance of attaining each given rating R, in projection quarter t, starting from initial rating R_0, and where the rating-conditional hedge gains $G_{R_0}^{c,g}(t, R)$ are calculated via:

Equation B-35 – rating-conditional cumulative corporate credit hedge gain, to quarter t

$$G_{R_0,R}^{c,g}(t) = \begin{cases} N_{g,c,R_0} \cdot \mathrm{RR} & \text{when } R = D \text{ (defaulted)} \\ \mathrm{GRD}_{g,c,R_0}^{\mathrm{CC}}\left[\Delta s_{R_0,R}^{c}(t)\right] & \text{when } R \neq D \end{cases}$$

Where:

- N_{g,c,R_0} is the firm-reported position notional, and RR is the model's global 50 percent recovery rate assumption discussed in Section B(iii)(b)(4);
- $\mathrm{GRD}_{g,c,R_0}^{\mathrm{CC}}\left[\Delta s_{R_0,R}^{c}(t)\right]$ is an interpolated hedge gain, under the spread shock $\Delta s_{R_0,R}^{c}(t)$, using the firm-reported corporate credit P&L grid $\mathrm{GRD}_{g,c,R_0}^{\mathrm{CC}}$, specific to region g, instrument category c and rating R_0; and
- $\Delta s_{R_0,R}^{c}(t)$ is the macroeconomic scenario-based spread shock, determined via Equation ***B-36***.

(a) Credit Spread Projection

Spread shocks $\Delta s_{R_0,R}^{c}(t)$ by instrument category c, initial (attained) ratings R_0 (R), and quarter t, are derived from the corporate spread projections by rating $s_t[R]$ introduced for the Wholesale Model (see Equation B-10), but with a scale factor applied when $c \in$ CDS, to achieve lower spread shocks for CDS instruments relative to bonds and loans:

Equation B-36 – credit spread shock, applied to corporate credit hedges

$$\Delta s^{c}_{R_0,R}(t) = \begin{cases} s_t[R] - s_0[R_0] & \text{when } c \notin \text{CDS} \\ (s_t[R] - s_0[R_0]) \cdot F_R^{\text{CDS}} & \text{when } c \in \text{CDS} \end{cases}$$

Where:

- F_R^{CDS} is a scale factor capturing differences in spreads between CDS and cash positions, differences that empirically vary by rating (as discussed in Section B(v)(b)(2))

$$F_R^{\text{CDS}} = \begin{cases} 0.3 \text{ when } R \in \{\text{AAA, AA, A, BBB}\} \\ 0.6 \text{ when } R \in \{\text{BB, B, CCC-C}\} \end{cases} \text{; and}$$

- $s_t[R]$ is the corporate spread projection by rating defined for whole loan exposures above (see Equation B-10).

b. *Specification Rationale and Calibration*

Given the overlap between loan hedge instruments and the broader set of derivatives held in the trading book, the Loan Hedge Model generally determines hedge P&L via a method analogous to the Trading P&L Model's treatment of general trading book positions, as described in Section E—utilizing firm-provided hedge P&L sensitivities in respect of various risk factors (reported in FR Y-14Q, Schedule F (Trading)), in conjunction with scenario shocks for those risk factors. The primary points of divergence in methodology are as follows:

(i) the Loan Hedges Model utilizes macroeconomic scenario-based shocks that evolve over the nine-quarter stress test horizon, whereas the Trading P&L Model utilizes shocks that occur abruptly, without a profile over time, as specified in the global market shock component of the supervisory severely adverse scenario (GMS)

(ii) the Trading P&L Model treats corporate credit exposure by applying GMS credit spread shocks, to interpolate P&L impacts, from firm-provided P&L grids, reported in respect of credit spread widening for different types of corporate credit instrument (e.g., bonds, loans or credit default swaps); whereas the Loan Hedge Model, though broadly following the same method, additionally incorporates credit rating migration, mirroring the Wholesale Model's treatment of FVO / HFS loans, to project credit dynamics consistently between loans and their related hedges (thereby avoiding spurious hedge effectiveness outcomes between wholesale FVO / HFS loans and their related hedges).

(1) Securitized Product Duration Assumptions

Securitized product durations, by product group j, are used by the model to translate Auxiliary Scenario Variables OAS projections (under the macroeconomic scenario), into market value impacts for hedge exposure within each product group. They are calibrated to spread durations of constituent securities within the indices tabulated in Figure B-11, obtained from a third-party vendor as of t_0 for a given exercise.

Figure B-11 – duration assumptions by product group j, (with each group defined with respect to the product categories and sub-categories tabulated in FR Y-14Q, Schedule 14 (Securitized Products)) are calibrated to average spread durations over constituents of the indices tabulated here, reported as-of Q4 end by a third-party vendor.

Securitized Product Group j		Vendor Calibration Index
Category	*Sub-Category*	
RMBS	All	Home Equity ABS
ABS	Auto	Auto ABS
ABS	Credit Card	Credit Card ABS
ABS	All Other	General ABS
CMBS	All	CMBS
Corporate CDO / CLO	CLO	CMBS
Corporate CDO / CLO	Other / Unspecified	General ABS

For each product group j, the duration assumption is determined as a weighted average over durations of the constituent securities for each calibration index.

(2) Bond vs CDS Basis Parameter

Scale factors F_R^{CDS}, by rating R, are used to adjust (per Equation ***B-36***) corporate bond spread paths, derived from the macroeconomic scenario, before they are applied to credit default swap (CDS) hedge positions. These adjustments serve to lower spread shocks projected for CDS positions, relative to those applicable to bonds (or loans) of the same rating, and are motivated by the empirical observation that bond spreads tend to widen more than CDS spreads during market stress events since bond transaction prices are sensitive to liquidity risks in addition to the obligor credit risk considerations that more narrowly dictate CDS prices. The scale factors are set to 0.3 for investment grade credit spreads and 0.6 for high yield credit spreads:

$$F_R^{\mathrm{CDS}} = \begin{cases} 0.3 \text{ when } R \in \{\mathrm{AAA}, \mathrm{AA}, \mathrm{A}, \mathrm{BBB}\} \\ 0.6 \text{ when } R \in \{\mathrm{BB}, \mathrm{B}, \mathrm{CCC\text{-}C}\} \end{cases}$$

based on the troughs of observed spread shock ratios between the indices tabulated below during the 2008 financial crisis and during pandemic-driven market dislocations in early 2020:

Figure B-12 – indices used to calibrate bond CDS spread scale factors

Rating Quality	Bond Index	CDS Index
Investment Grade	US IG Bonds	CDX NA IG
High Yield	US HY Bonds	CDX NA HY

c. *Alternative Approaches Considered*

The following alternative frameworks to determine loan hedge P&L have been considered.

(1) Full Revaluation

As noted in the Trading P&L Model description, Section E, losses could be estimated using a full revaluation approach, utilizing individual hedge position-level detail to project P&L.

This approach, if implemented correctly, would potentially be more accurate than the current sensitivity-based approach; however, the collection, storage, and re-pricing of position-level data required under such an approach was considered by the Board to be both impractical from an operational and resource perspective and also burdensome for firms, hence the Board's preference for a sensitivity-based calculation.

(2) Firm Calculations

In addition, the Board considered an approach that would rely on firms' own estimates of hedge P&L, conditional on macroeconomic core and Auxiliary Scenario Variable paths proscribed by the Board. These estimates could be consumed directly as inputs into capital projections used to calibrate firms' stress capital buffer (SCB) requirements,[96] replacing the risk factor sensitivity-based P&L produced by the Loan Hedge Model. The benefits of this approach would be a more accurate capture of hedge instrument-specific features with potential reporting and operational simplifications; however, the Board selected the current model specification because its reliance on intermediate calculations (i) is more transparent regarding the key risks driving hedge P&L, (ii) allows the Board to independently determine hedge P&L results over a wide range of potential macroeconomic scenarios, and (iii) is more robust to reporting fidelity issues, as input sensitivity data items can be individually tracked over time and checked for reasonability.

[96] The SCB requirement is the additional capital requirement determined by the results of the annual supervisory stress test. *See* 12 CFR 225.8(f).

d. *Data Adjustments*

(3) Conversion from Absolute to Relative Spread Shock Units

Per Equation B-35, corporate credit hedge P&L is derived from firm-reported grids $\mathrm{GRD}_{g,c,R_0}^{\mathrm{CC}}$ of spread sensitivities,[97] reported by geography $g \in \{\text{Advanced Economies, Emerging Markets}\}$, instrument category $c \in \{\text{bonds, loans, CDS, ...}\}$ and rating or index R_0, as-of period t_0. The projected spread shocks $\Delta s_{R_0,R}^{c}(t)$ (defined in Equation ***B-36***) used to interpolate P&L are specified in absolute spread change units by default. Firms may, however, elect to report grids $\mathrm{rGRD}_{g,c,R_0}^{\mathrm{CC}}$ denominated in relative / percent-change, shock units. The following spread shock unit conversion is then made, dividing each given absolute shock by its associated t_0 spread level:

Equation B-37 – absolute to relative spread shock conversion

$$\mathrm{r}\Delta s_{R_0,R}^{c}(t) = \frac{\Delta s_{R_0,R}^{c}(t)}{s_{R_0}^{c}(0)}$$

Where:

- $\mathrm{r}\Delta s_{R_0,R}^{c}(t)$ is the relative spread shock corresponding to the absolute spread shock $\Delta s_{R_0,R}^{c}(t)$;
- when $c \notin \text{CDS}$, $s_{R_0}^{c}(0)$ is the t_0 value of the generic corporate spread projection for rating R_0, previously defined for whole loan exposures above (see Equation B-10);
- when $c \in \text{CDS Indices}$, $s_{R_0}^{c}(0)$ is the t_0 spread level for index R_0; and
- when $c \in \text{CDS Single Name}$, $s_{R_0}^{c}(0)$ is determined, by rating, from the proxy indices tabulated in Figure B-13.

[97] Firm-reported grids are sourced from FR Y-14Q, Schedule F (Trading).

Figure B-13 – calibration indices, for determining t_0 single name CDS spread levels by rating, used in relative to absolute credit spread shock unit conversion (Equation B-37).

Rating	*Index*
AAA	CDX NA IG
AA	CDX NA IG
A	CDX NA IG
BBB	CDX NA IG BBB
BB	CDX NA HY BB
B	CDX NA HY B
CCC	CDX NA HY Ex-BB

e. *Assumptions and Limitations*

Beyond the general constant portfolio assumption maintained across all sub-models, the Loan Hedge Model component embeds certain key assumptions and limitations, itemized as follows:

- The P&L grids provided by firms are assumed to be accurate.
- Foreign currency yield curves are assumed to shift in parallel to U.S. risk-free rates.
- Foreign stock markets are assumed have returns mirroring those of the U.S. stock market.
- Securitized product hedge values are assumed to respond to ABS spread widening via generic credit spread durations, matched by broad ABS product types.
- FX hedges are not credited by the Loan Hedge Model, since FX risk is not shocked by the Wholesale Model or Retail Model components.

vi. Question

Question B1: The Board seeks comment on using a dynamic wholesale loan LGD model, as compared to the Board's current approach of a static fifty percent assumption in the FVO / HFS

Wholesale Model. What would be the advantages and disadvantages of using a dynamic LGD model?

C. Yield Curve Model

i. Statement of Purpose

A yield curve depicts or graphs the relationship between interest rates (yields) on bonds and their corresponding maturities, for a given security or category (e.g., government bonds or corporate bonds). This relationship is sometimes described as the term structure of interest rates. A yield curve is specific to a point in time and thus is expected to change from one period to the next. Modeling the term structure of interest rates is a necessary step in assessing the impact of interest rate shocks on bonds, loans and other interest rate-sensitive assets with different maturities or durations. To this end, the Yield Curve Model is used to augment the set of key interest rates published as part of the macroeconomic scenario, which pertain to a limited number of maturities and categories.[98] It does so by expanding this set into a more comprehensive collection of yield curve projections (as tabulated in Figure ***C-1***) and covering all relevant maturities up to thirty years, thus enabling the impact of interest rate movements depicted in the macroeconomic scenario to be estimated for a variety of assets held by firms. Such impacts are determined within the Securities Model, FVO Model, and PPNR Model, which consume the Yield Curve Model projections as inputs.

ii. Model Overview

The Yield Curve Model produces estimates, consistent with a given macroeconomic scenario, of U.S. Treasury, Secured Overnight Financing Rate (SOFR), and corporate yields by maturity, as tabulated in Figure ***C-1***.

[98] Projections of the three-month, five-year, and ten-year U.S. Treasury yields and ten-year U.S. BBB corporate yield are part of the stress test's core macroeconomic scenario data.

Figure C-1 – Yield Curve Model, methodological approach by projected curve

Model Component	Description	Approach
Treasury	Treasury Zero-Coupon	Interpolation using Nelson-Siegel term structure
	Treasury Par-Coupon	
SOFR	SOFR Swap	t_0 spread to Treasuries at each maturity held constant over the projection horizon
	Term SOFR	
Corporate	Corporate AAA	Flat spread (s_i) to Treasuries, projected dynamically for each rating, i, via a linear sensitivity, β_i, to a macroeconomic scenario spread e.g. $\Delta s_i(t) = \beta_i \Delta s_{\text{BBB}}(t)$
	Corporate AA	
	Corporate A	
	Corporate BBB	
	Corporate BB	
	Corporate B	
	Corporate CCC-C	

Treasury, SOFR, and corporate curves are produced by three component sub-models (the Treasury Model, the SOFR Model, and the Corporate Model, respectively). The Treasury Model utilizes a Nelson-Siegel level, slope, curvature formulation to interpolate / extrapolate scenario-provided Treasury yields by maturity and derive full par-coupon and zero-coupon yield curves. The Corporate Model constructs curves by credit rating using a flat spread over the Treasury curve, and with the spread for a given rating bucket varying over the projection horizon in fixed proportion to BBB or high yield corporate spread changes depicted in a given macroeconomic scenario. Finally, the SOFR Model projects SOFR curves simply by using static spreads to the Treasury curve—fixing the spreads observed by maturity at the jump-off point of the stress test and holding them constant over the projection horizon.

Additional summary information for each model is provided immediately below, with full specification detail for all three components following in dedicated sections.

iii. Treasury Model

The Treasury Model takes the three U.S. Treasury yield projections (for three-month, five-year, and ten-year maturities) provided in the macroeconomic scenario and models the remaining yields for each quarter in the projection horizon, for maturities from three months to thirty years. The resulting Treasury yield curves are the basis for modeling corporate and SOFR yield curves (as described in dedicated sections below). Once constructed, these yield curves become inputs to the Securities, FVO, and PPNR models—used respectively to project the impact of the macroeconomic scenario's interest rate shocks on the fair value of securities, the fair value of loans, and on various interest income and expense items.

a. *Model Specification*

A simplified version of the Nelson-Siegel term structure model (see **Equation *C-1***) is used to achieve a reasonable interpolation of Treasury yields provided in the macroeconomic scenario. The Nelson-Siegel model is widely used for depicting the term structure of interest rates, due in part to its simple but effective design—wherein a small number of interpretable parameters that can be efficiently estimated are able to capture a wide range of yield curve shapes, as discussed in further detail immediately below.

Under the simplified Nelson-Siegel formulation utilized by the Treasury Model, a yield curve $y_\tau(t)$, comprising market yields by maturity τ, and observed at time $t,$ is expressed as the sum of the three standard Nelson-Siegel factors (the level, slope, and curvature factors described below), but with a time-invariant shape parameter $\lambda(t) \equiv \lambda$, according to:

Equation C-1 – Nelson-Siegel, spot yield curve

$$y_\tau(t) = \beta_l(t) + \beta_s(t)\left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau}\right) + \beta_c(t)\left(\frac{1 - e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right),$$

where $\beta_l(t)$, $\beta_s(t)$, and $\beta_c(t)$ are dynamic coefficients[99] against the Nelson-Siegel level, slope, and curvature factors, respectively—factors capturing different aspects of yield curve shape (as defined immediately below), and that depend on maturity τ, and a time-invariant shape parameter λ—and where, for a fixed time t (suppressed in what follows for notational clarity):

- β_l is the "level" coefficient, defining the long-term level of yields (with modeled yields eventually converging towards this level as maturity increases). β_l is multiplied against the "level" factor $L_\tau \equiv 1$, which is a constant that doesn't depend on maturity (and that is not explicitly notated in **Equation *C-1***);
- β_s is the "slope" coefficient, which fixes the short-term level of yields at $\beta_l + \beta_s$ (with modeled yields converging to this level, at the shortest maturities) and thus defines a slope between short-term and long-term yield levels. β_s is multiplied against the "slope" factor $S_\tau = \left(\frac{1-e^{-\lambda\tau}}{\lambda\tau}\right)$, which declines towards zero with increasing maturity τ;
- β_c is the "curvature" coefficient, which controls the shape of the curve at medium-term maturities and loosely how "humped" the curve is, as it transitions between the short- and long-term yield levels set by $\beta_l + \beta_s$ and β_l, respectively. β_c is multiplied against the curvature factor $C_\tau = \left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right)$, which initially rises with increasing maturity τ, before reaching a peak at a certain maturity and then declining back towards zero thereafter, as maturities increase further; and

[99] Dynamic coefficients change over time.

- λ is a shape parameter that determines the rate at which yields converge towards the long-term level β_l with increasing maturity by causing the contributions made by the slope and curvature factors to reduce towards zero more or less rapidly, as the maturity rises.

Note that for a given λ, the curvature factor reaches its maximum at $\tau = 1.792/\lambda$,[100] loosely corresponding to the maturity at which the "hump" in the intermediate section of the curve reaches its peak. For example, given a curve with $\beta_l = 5\%$ and $\beta_s = 0$ (such that short-term and long-term yields are both anchored at five percent, without any slope between them) and where $\lambda = 0.5$, then a positive curvature coefficient, $\beta_c > 0$, would produce a curve with yields beginning at 5 percent for the shortest maturities, then rise with increasing maturity to reach a maximum at 3.6 years ($= 1.792/0.5$)—the peak of the "hump"—before falling gradually back towards five percent as maturities increase further. A higher value of λ shifts this peak to a shorter maturity.

The following three equations (Equation C-2, Equation C-3 and Equation C-4) and accompanying descriptions specify how the Nielsen-Siegel model in **Equation *C-1*** is "fit" to Treasury yield paths given in the macroeconomic scenario (which are only provided for three maturity points) to provide an interpolation between (and extrapolation beyond) these points and hence determine yields over a comprehensive set of maturities for each projection quarter.

With λ fixed,[101] the yield curve determined by **Equation *C-1*** is a linear combination of factors L_τ, S_τ, and C_τ, with each depending only on maturity τ (and not on time). This linear

[100] $\tau = 1.792/\lambda$ is a calculus result, specifically the solution to $\frac{\delta}{\delta\tau}\left(\frac{1-e^{-\lambda\tau}}{\lambda\tau} - e^{-\lambda\tau}\right) = 0$, which defines inflection points (e.g., a peak or maximum) along the curvature factor, where the slope is zero as τ varies, while holding λ constant.

[101] The use of a time-invariant lambda is a standard modelling approach in both industry and the academic literature, due in part to the ease of model fitting it confers.

combination can be expressed in matrix form as follows (focusing on a specific point in time, and omitting its index t for notational clarity):

Equation C-2 – Nelson-Siegel, spot yield curve, matrix form

$$y_\tau = \begin{bmatrix} \beta_l \\ \beta_s \\ \beta_c \end{bmatrix}' \begin{bmatrix} 1 \\ (1 - e^{-\lambda\tau})/\lambda\tau \\ (1 - e^{-\lambda\tau})/\lambda\tau - e^{-\lambda\tau} \end{bmatrix} = \begin{bmatrix} \beta_l \\ \beta_s \\ \beta_c \end{bmatrix}' \begin{bmatrix} L_\tau \\ S_\tau \\ C_\tau \end{bmatrix}$$

Then for a specific horizon t, given the three U.S. Treasury yield points (corresponding to the three-month, five-year, and ten-year maturities, respectively, $\tau = 0.25, 5, 10$) as projected in a given macroeconomic scenario, the model solves for the level, slope and curvature coefficients β_l, β_s, and β_c that define a complete curve passing through these three points. Specifically, given yield projections $y_{.25}, y_5$ and y_{10}, the coefficients β_l, β_s, and β_c that produce a curve containing these yields satisfy the following equation:

Equation C-3 – interpolation equation

$$\begin{bmatrix} y_{.25} \\ y_5 \\ y_{10} \end{bmatrix}' = \begin{bmatrix} \beta_l \\ \beta_s \\ \beta_c \end{bmatrix}' \begin{bmatrix} L_{.25} & L_5 & L_{10} \\ S_{.25} & S_5 & S_{10} \\ C_{.25} & C_5 & C_{10} \end{bmatrix}$$

which has solution:

Equation C-4 – interpolation equation, solution

$$\begin{bmatrix} \beta_l \\ \beta_s \\ \beta_c \end{bmatrix}' = \begin{bmatrix} y_{.25} \\ y_5 \\ y_{10} \end{bmatrix}' \begin{bmatrix} L_{.25} & L_5 & L_{10} \\ S_{.25} & S_5 & S_{10} \\ C_{.25} & C_5 & C_{10} \end{bmatrix}^{-1}$$

A fixed λ of 0.36 is used so that the curvature factor reaches its peak at the five-year maturity,[102] ensuring that the shape of the intermediate part of the curve is anchored to the five-year Treasury yield explicitly provided in the macroeconomic scenario.

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[102] As noted above, the peak of the curvature component occurs at $\tau = 1.792/\lambda$, which corresponds to a maturity of five years when lambda is 0.36.

A zero-coupon yield curve $y_\tau^z(t)$ is derived from the par yield curve $y_\tau(t)$.[103] using standard methods (based on semi-annual coupon bearing, par-priced bonds).[104] The par yield curve is based on the closing market bid prices on the most recently auctioned Treasury securities in the over-the-counter market.[105] All projected Treasury yields are floored at zero.[106]

b. *Specification Rationale and Calibration*

The Treasury Model is designed to be robust, simple, and transparent, consistent with the principles in the Board's Policy Statement. It employs a standard Nelson-Siegel parametric form,[107] with time invariant[108] λ (the shape parameter) to achieve a reasonable interpolation / extrapolation of the macroeconomic scenario's core U.S. Treasury yield projections (given for three-month, five-year and ten-year maturities), with a minimum of assumptions and in a manner that is easily replicable. The Nelson-Siegel model was chosen as a well-established tool for depicting the term structure of interest rates, widely used in practice due to its simple but effective design and ability to capture a wide range of yield curve shapes with a small number of intuitive and interpretable parameters—parameters that can be efficiently estimated. The

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[103] A par yield is the yield-to-maturity (YTM) of a coupon-bearing bond trading at par (when its coupon rate and YTM coincide). That is, the discount rate that equates the present value of the bond's interest payments and maturity payment with its market price. A zero-coupon yield, meanwhile, is the YTM of a bond that pays no coupon—i.e., the discount rate that equates the present value of the bond's maturity payment with its market price. Zero-coupon yields are a critical input for pricing fixed-income securities, by discounting their individual cashflows, and are used as such in the stress test, for example by the Securities Model, to project the fair value of AFS Treasury securities.

[104] *See, e.g.*, Mishkin, F. and Eakins, S., 2018. Financial Markets and Institutions (Pearson).

[105] For information on how the Treasury's yield curve is derived, visit [Treasury Yield Curve Methodology | U.S. Department of the Treasury].

[106] Historically, negative yields have been rare and only temporary in the U.S. (corresponding with an anomalous situation where borrowers are paid to borrow money and lenders paid to lend). The Board determined that negative yields are not a feature the Yield Curve Model should introduce in the course of augmenting and adding detail to the macroeconomic scenario's core yield projections.

[107] *See* Nelson, C. and Siegel, A., 1987. Parsimonious Modeling of Yield Curves (Journal of Business 60/4).

[108] Use of a time-invariant lambda is a standard modelling approach in both industry and the academic literature, due in part to the ease of model fitting this confers.

calibration of λ to 0.36 was chosen so that, for any derived curve, the curvature factor reaches its peak at the five-year maturity,[109] ensuring that the shape of the intermediate part of the curve is robustly anchored to the five-year Treasury yield explicitly provided in the macroeconomic scenario—thereby avoiding curve interpolations that might otherwise introduce features not directly implied by the scenario (for example, kinks or humps in the region of the curve covering maturities up to five years). Previous studies using the Nelson-Siegel model with a fixed shape parameter have adopted calibrations for λ that similarly maximize the curvature factor at intermediate maturities.[110]

c. *Data Adjustments*

Not applicable

d. *Assumptions and Limitations*

The Treasury Model embeds certain assumptions and limitations, as itemized below.

(1) Fixed Shape Parameter

(2) The model assumes a fixed shape parameter of λ = 0.36, constraining the level, slope, and curvature factor functions (L_τ, S_τ, C_τ) to depend only on maturity τ, and thus leaving only three dynamic coefficients ($\beta_l(t)$, $\beta_s(t)$, and $\beta_c(t)$) that can easily be determined, at each horizon point t, from the three Treasury yields provided in the macroeconomic scenario.
Arbitrage Constraints

The model utilizes the standard Nelson-Siegel formulation, with the known limitation that the curves produced by the model do not strictly preclude implicit violations of the no-arbitrage principle, which may minimally occur. Such small, implicit arbitrage opportunities

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[109] *See* footnote 100 regarding the maturity at which the curvature factor peaks and how this relates to λ.

[110] *See, e.g.*, Fabozzi, F., Martellini, L., and Priaulet, P., 2005. Predictability in the Shape of the Term Structure of Interest Rates (Journal of Fixed Income, 15/1).; and Diebold, F. and Li, C. 2006. Forecasting the Term Structure of Government Bond Yields (Journal of Econometrics, 130/2).

(caused, for example, by the mispricing of forward rates) are not implausible in a severely adverse macroeconomic scenario when market illiquidity and rate uncertainty could make these types of arbitrage opportunities difficult to exploit. In any case, minimal violations of the no-arbitrage principle are tolerated in view of their immaterial impact on results and the benefits otherwise derived from the simplicity of the standard Nelson-Siegel model.

(3) Coefficient Dynamics

The model assumes that the level, slope and curvature coefficients $\beta_l(t)$, $\beta_s(t)$, and $\beta_c(t)$ can be independently determined for each projection period t without placing constraints on the patterns that these parameters vary over the projection horizon. In essence, the model assumes the macroeconomic scenario will depict "realistic" yield curve behavior and that the interpolations carried out by the model in each projection quarter will reflect this realism without the need for additional constraints.

iv. SOFR Model

The Secured Overnight Financing Rate (SOFR) is a benchmark interest rate, determined and published daily by the Federal Reserve Bank of New York, that reflects the cost of borrowing cash overnight in a loan collateralized by U.S. Treasury securities. SOFR is a floating rate referenced by a variety of fixed income securities and derivatives, including those held by firms subject to the supervisory stress test. To assess the impact of the macroeconomic scenario on such positions, the SOFR Model projects two SOFR-related curves, corresponding respectively to the following key products that reference SOFR:

- SOFR swaps—interest rate swaps that use SOFR as a reference rate. The swap curve projected by the SOFR Model depicts swap rates by maturity for standard fixed versus floating SOFR swaps, wherein one party pays a fixed rate of interest (the swap rate) annually while the other party pays a floating rate based on SOFR.

- Term SOFR—a set of forward-looking interest rates, published daily by the Chicago Mercantile Exchange, that reflect market expectations for the average level of SOFR, anticipated over specific look-ahead periods (i.e., one-month, three-month, six-month, twelve-month). The model projects Term SOFR rates for maturities up to twelve months.

a. *Model Specification*

While the macroeconomic scenario does not include an explicit projection of SOFR, the movements it depicts in Treasury rates are viewed as a reasonable proxy for changes in SOFR rates, given the similar risk-free character of both curves. Following this rationale, SOFR swap and Term SOFR curves are projected to each horizon time t using a static spread to the Treasury curve δ_τ. This spread is fixed for each maturity τ as observed in PQ0 (the fourth quarter of the year containing the jump-off point for a given stress test) and held constant over the projection horizon, so that changes projected in Treasury rates are accompanied by identical changes in SOFR rates at corresponding maturities.

Equation C-5 – SOFR swap and Term SOFR curve projection

$$\mathrm{SWAP}_\tau(t) = y_\tau(t) + \delta_\tau^{\mathrm{SWAP}}(0)$$

$$\mathrm{TSOFR}_\tau(t) = y_\tau(t) + \delta_\tau^{\mathrm{TSOFR}}(0)$$

Where:

- $y_\tau(t)$ is the Treasury curve (specified in **Equation *C-1***);
- $\delta_\tau^{\mathrm{SWAP}}(0)$ is the spread at maturity τ between the SOFR swap rate and Treasury yield (SOFR minus Treasury), as observed on average over PQ0; and

- $\delta_\tau^{\mathrm{TSOFR}}(0)$ is the spread at maturity τ between the Term SOFR rate and Treasury yield, as observed on average over PQ0.

All projected SOFR swap and Term SOFR rates $\mathrm{SWAP}_\tau(t)$ and $\mathrm{TSOFR}_\tau(t)$ are floored at zero, for historical realism, as discussed above.[111]

b. *Specification Rationale and Calibration*

The assumption that Treasury and SOFR curves shift in parallel is motivated by the similar risk-free character of both curves and their strong historical correlation.[112] In the absence of an explicit divergence between Treasury and SOFR rates in the macroeconomic scenario, the parallel shift assumption is preferred, in line with the Board's principles:[113] for simplicity and because it avoids the introduction of idiosyncratic scenario features[114] by the Yield Curve Model, whose purpose is to add details that tie predictably to the macroeconomic scenario's core interest rate projections, without altering their character.

c. *Assumptions and Limitations*

Assumptions and limitations of the SOFR Model are itemized below:

(1) SOFR Spread Risks Not Captured

SOFR is a collateralized rate, distinct from Treasury rates, determined in the repo market. Accordingly, the SOFR spread over Treasuries is sensitive to factors that may differentially

[111] *See* footnote 106.

[112] *See* Federal Reserve Bank of New York, 2021. An Updated User's Guide to SOFR.

[113] *See* 12 CFR part 252, Appendix B.

[114] Relative movements between SOFR and Treasuries are difficult to predict (partly because of the limited historical record owing to the recent adoption of SOFR as a reference rate) and could be influenced by multiple factors specific to a given scenario, including illiquidity, frictions or dysfunction specific to the repo or treasury markets, as well as potential monetary policy interventions in either.

impact the Treasury versus repo market[115] and thereby cause the SOFR spread to change. The potential for such changes is not captured in the model. Relatedly, fixing the SOFR swap and Term SOFR spreads at their PQ0 levels precludes the capture of higher-order curve dynamics in projections, such as the propensity of shorter maturities to exhibit more volatility.

v. Corporate Model

The risk-free curves produced by the Treasury and SOFR Models are utilized in the stress test for the projection and valuation of assets, such as Treasuries or Agency MBS, that are assumed to bear no credit risk; meanwhile, to model corporate bonds or loans and other credit-sensitive assets, corporate yields incorporating a credit component are required. The Corporate Model projects such yields for specific credit rating levels over the nine-quarter stress test horizon. These yields are inputs to value credit-sensitive assets in the FVO and Securities Models or in the projection of related interest income / expense items in the PPNR Model.

a. *Model Specification*

Corporate yields $\mathrm{corp}_{i,\tau}(t)$ observed at time t by maturity τ and credit rating bucket $i \in \{\mathrm{AAA}, \mathrm{AA}, \mathrm{A}, \mathrm{BBB}, \mathrm{BB}, \mathrm{B}, \text{CCC-C}\}$ are projected by adding a flat spread (one that does not vary by maturity) $s_i(t)$ to the Treasury yield curve $y_\tau(t)$:

[115] For example, flight to safety effects in the Treasury market or repo market funding pressure due to balance sheet constraints of the dealers that intermediate in the repo market.

Equation C-6 – corporate curve, flat spread construction

$$\mathrm{corp}_{i,\tau}(t) = y_\tau(t) + s_i(t)$$

where $s_i(t)$ varies by projection period t in proportion to (i) variation in the macroeconomic scenario's BBB spread projection,[116] when i is an investment grade rating, or (ii) variation in the macroeconomic scenario's high yield corporate spread (an Auxiliary Scenario Variable described further in Section I), when i is a speculative grade rating:[117]

Equation C-7 – corporate spread projection

$$s_i(t) = \begin{cases} s_i(0) + \beta_i \cdot [s_{\mathrm{BBB}}(t) - s_{\mathrm{BBB}}(0)] & \text{when } i \in \{\mathrm{AAA}, \mathrm{AA}, \mathrm{A}, \mathrm{BBB}\} \\ s_i(0) + \beta_i \cdot [s_{\mathrm{HY}}(t) - s_{\mathrm{HY}}(0)] & \text{when } i \in \{\mathrm{BB}, \mathrm{B}, \text{CCC-C}\} \end{cases}$$

Where:

- $s_i(0)$ is initial spread level for rating bucket i, as observed on average over PQ0 (the fourth quarter of the year containing the jump-off point for a given stress test). Example values of $s_i(0)$ are provided in Figure C-2, and their calibration is detailed in Section C(v)(b);
- β_i is the sensitivity to changes in BBB-spread s_{BBB} or high yield spread s_{HY} of rating bucket i's spread, estimated annually from historical data using a simple linear regression (e.g., example values of β_i are provided in Figure C-2, and their calibration is detailed in Section C(v)(b));
- $s_{\mathrm{BBB}}(t) = y_{\mathrm{BBB}}(t) - y_{10}(t)$ is the macroeconomic scenario projection of U.S. BBB corporate spread, determined as the difference between the U.S. BBB corporate yield projection $y_{\mathrm{BBB}}(t)$ minus the U.S. ten-year Treasury yield projection $y_{10}(t)$; and

[116] This spread is derived from the macroeconomic scenario's BBB and Treasury yield projections.

[117] Dividing projections into investment and speculative grades allows the model to capture the different characteristics of these two categories, such as yield, spread, liquidity and volatility.

- $s_{\text{HY}}(t)$ is an Auxiliary Scenario Variable, projecting OAS for high yield corporate bonds (see Section I for further details on Auxiliary Scenario Variables).

Example calibrated values for the initial spread levels by rating $s_i(0)$, and corresponding β_i sensitivities used in Equation C-7, are given in Figure C-2.

Figure C-2 – initial spread levels and sensitivities by rating bucket, to BBB and HY spread changes, as calibrated for the stress test jump-off quarter (fourth quarter of 2024), using available historically monthly spread changes spanning 1997–2023, via regression Equation C-8.

Rating i	$S_i(0)$	β_i	Auxiliary Scenario Variable
AAA	0.45%	0.26	U.S. BBB corporate spread $s_{\text{BBB}}(t)$
AA	0.57%	0.47	
A	0.84%	0.63	
BBB	1.16%	1.00	
BB	2.07%	0.72	HY Corporate Bonds spread $s_{\text{HY}}(t)$
B	3.09%	1.04	
CCC-C	8.33%	1.93	

b. *Specification Rationale and Calibration*

The Corporate Model is designed to project corporate yields that are consistent with a given macroeconomic scenario using a minimum of additional assumptions and in a manner that is stable, interpretable, and replicable.[118] The following sections provide rationale for specific components of the model: (1) flat spread term structure; (2) calibration of spread beta; and (3) calibration of the PQ0 spread level.

[118] Stress Testing Policy Statement, Principles of Supervisory Stress Testing: The system of models used in the supervisory stress test is designed to result in projections that are (i) from an independent supervisory perspective; (ii) forward-looking; (iii) consistent and comparable across covered companies; (iv) generated from simpler and more transparent approaches, where appropriate; (v) robust and stable; (vi) conservative; and (vii) able to capture the impact of economic stress. 12 CFR 252, Appendix B.

(1) Flat Spread Term Structure

The macroeconomic scenario depicts (i) a single investment grade corporate spread, regarding BBB-rated credits that are indicative of average spread levels, for medium term bonds within each projection quarter, and (ii) a single high yield corporate spread,[119] indicative of average spread levels within each projection quarter for bonds rated less than BBB. These two scenario variables are used as anchor spreads from which to estimate spreads for all investment-grade and high-yield credit ratings. The assumption of a flat spread applied to all maturities for a given rating and quarter captures the primary spread dynamics depicted in the macroeconomic scenario, makes the model simple to maintain and replicate, and does not represent a material simplification in the context of estimated firm losses.

(2) Calibration of Spread Beta

Spread betas β_i for each rating i are determined via the following linear regression:

Equation C-8 – spread beta estimation regression

$$\Delta \mathrm{OAS}_i(t) = \begin{cases} \beta_i \cdot \Delta \mathrm{OAS}_{\mathrm{BBB}}(t) + \varepsilon_i(t) \\ \beta_i \cdot \Delta \mathrm{OAS}_{\mathrm{HY}}(t) \;\; + \varepsilon_i(t) \end{cases}$$

Where:

- $\Delta \mathrm{OAS}_i(t)$ is the historical monthly change,[120] to month-end t, in the level of an Option-Adjusted Spread (OAS) calibration index for rating i as specified in Figure C-3;
- $\Delta \mathrm{OAS}_{\mathrm{BBB}}(t)$ is the corresponding historical change in the level of the 7-10 year BBB U.S. Corporate Index projected in the macroeconomic scenario as a core variable;

[119] High yield corporate spreads are captured by an Auxiliary Scenario Variable. *See* Section I.

[120] Historical data used in calibration are from 1997 to present.

- $\Delta\text{OAS}_{\text{HY}}(t)$ is the historical change in the level of the high yield corporate bond OAS projected in the macroeconomic scenario as an Auxiliary Scenario Variable (see Section I); and
- monthly data starting in 1997[121] and continuing until the end of the year preceding a given stress test effective date[122] are used in the regression estimates.

Figure C-3 – calibration indices obtained from a third-party data vendor for initial spread levels and betas by rating

Rating	Corporate Option-Adjusted Spread (OAS) Calibration Index
AAA	7-10 Year AAA U.S. Corporate
AA	7-10 Year AA U.S. Corporate
A	7-10 Year Single-A U.S. Corporate
BBB	7-10 Year BBB U.S. Corporate
BB	BB Global High Yield
B	Single-B Global High Yield
CCC-C	CCC & Lower Global High Yield

An expanding calibration window (with a fixed starting point in 1997 and new data added each year as they become available) is chosen to support stability in estimates while ensuring the inclusion of relevant historical stress periods (the 2008 financial crisis as well as the COVID period) within the calibration data over time.

Monthly estimation data are chosen to achieve estimate stability (associated with higher frequency data and increasing numbers of observations) while utilizing a time interval relevant to the stress test horizon and the macroeconomic shocks depicted. By using monthly data, the model aims to not only (i) avoid the confounding effects of transient / short-term market

[121] Data before 1997 are not consistently available for all credit ratings.

[122] For example, a stress test with 2030:Q4 as the jump-off point would utilize monthly OAS covering 1997–2029 (inclusive) for beta calibration.

microstructure noise, which is more prevalent in higher frequency observations and less relevant to the forecast horizon of the stress test (where losses are projected on a quarterly basis), but also (ii) maintain a sufficient volume of data points to support a stable estimate and ensure sufficient resolution to capture the peaks and troughs of relevant stress events occurring in the calibration window. Monthly time series data achieve a reasonable balance between these two objectives.

(3) Calibration of PQ0 Spread Level

Initial spread levels by rating i for a given stress test Q4 jump-off point are determined as the average spread levels over that Q4, using the calibration indices specified in Figure C-3. This is consistent with how the BBB yield included in the macroeconomic scenario is determined. By using consistent units for all credit ratings (i.e., Q4 quarter average spreads, as opposed to, for example, spread levels observed on the last trading day of Q4) a coherent set of projections across credit ratings is achieved, and potential instability associated with starting spreads calibrated to a single date is avoided.

c. *Data Adjustments*

The OAS indices used in model calibration are constructed from a changing sample of bonds, as determined by market conditions. When the sample is small, the index value may be driven by outliers within the sample (bonds that do not adequately represent the demographic the sample is intended to capture), and this could potentially make the initial spread level and beta sensitivity estimates unreliable; for example, they may contain violations in monotonicity, where the spread for AAA-rated bonds is higher than that for the AA rating bucket. In such rare cases, maturity-agnostic fallback calibration indices may be utilized as specified in Figure C-4. The chosen fallback indices are an exact match in credit quality and differ only in the range of maturities they represent—a difference that is not significant when used to estimate firm losses.

The fallback indices, therefore, are considered similarly representative of bonds within a given credit rating category (and the larger the sample size is, the more accurate and representative the estimation results would be). The use of fallback indices is, in general, expected to be limited to the AAA rating bucket only, due to the smaller number of eligible securities used to construct that index.

Figure C-4 – primary and fallback calibration indices for determination of PQ0 spread levels or beta sensitivities by rating

	U.S. Corporate OAS Calibration Index	
Rating	Primary Index	Fallback Index
AAA	7-10 Year AAA	All maturities AAA
AA	7-10 Year AA	All maturities AA
A	7-10 Year A	All maturities A

d. *Assumptions and Limitations*

(1) Flat Spread Term Structure

The Corporate Model projects yields with a flat spread to Treasuries, ignoring maturity variation in spread dynamics or levels; for example, as credit conditions depicted in the macroeconomic scenario deteriorate and the BBB spread widens, the model determines a corresponding spread widening for bonds rated AA, but this spread widening is applied identically to all AA maturities. In practice, bonds with shorter maturities may exhibit higher spread variation than those with longer maturities.[123] By ignoring such variation by maturity, the model's projections may mildly overstate spread shocks and levels pertaining to long-term maturities while understating those for short-term maturities; however, in the context of the

[123] *See* Longstaff, F. and Schwartz, E., 1993. Interest Rate Volatility and Bond Prices (Financial Analysts Journal, 49/4).

limited magnitude and diversified nature of credit-sensitive bond exposure subject to the stress test, this simplification is immaterial.

vi. Alternative Approaches

a. *Arbitrage-Free Nelson-Siegel Model*

The Board previously utilized an arbitrage-free Nelson-Siegel model variant[124] before arriving at the current Yield Curve Model specification. In this alternative approach, risk-free and corporate yields follow an integrated overarching stochastic process[125] against which projected curve realizations can be estimated conditional on both (i) historically observed yield dynamics and (ii) the yield trajectories for a given macroeconomic scenario. Many parameters are needed to estimate this model, and without a closed-form solution,[126] a complex and computationally intensive numerical routine is required to produce parameter estimates. The resulting estimates are subject to estimation uncertainty and may be driven in part by parameter estimates determined in prior stress tests, resulting in low replicability; consequently, an external party would be significantly challenged to reproduce model estimates given their dependence on extensive implementation and execution detail in respect of the parameter estimation process. This model, while capturing richer yield curve dynamics and more detailed scenario

124 *See* Christensen, J. and Lopez, J., 2012. Common Risk Factors in the US Treasury and Corporate Bond Markets: An Arbitrage-Free Dynamic Nelson-Siegel Modeling Approach (Federal Reserve Bank of San Francisco).

125 A stochastic process is a set of random variables that describe how a system changes over time, where outcomes are governed by probabilities.

126 No "closed-form solution" means that the model parameters cannot be determined exactly via a mathematical expression involving a finite number of standard functions. Parameter estimates are instead determined numerically and iteratively. This process adds an additional layer of complexity to the model.

conditioning, was not chosen due to its relatively high complexity, low replicability, and the computational intensity of its estimation routines.[127]

b. *Inclusion of Yield Curve Projections as part of the Macroeconomic Scenario*

The Yield Curve Model is used to augment and expand upon a limited set of key yield variables depicted in the macroeconomic scenario. This avoids the practical challenges of incorporating granular yield projections within the core macroeconomic scenario design process itself. In general, macroeconomic scenario design is focused on a range of economic variables relating to diverse aspects of the economy and on projecting their interrelated co-movement over the forecast horizon to form a broad and coherent picture of economic stress. The particular variables included in the macroeconomic scenario design process individually represent important aspects of the economy (for example, the national rate of unemployment or the level of the stock market). Inclusion of extensive sub-variables and detail beneath these primary factors (for example, individual stock price projections or granular regional measures of unemployment) is generally avoided. This is to prevent the scenario design process from becoming intractably detailed and extensive in its scope. Hence, the generation of Treasury, SOFR, and Corporate yield curves in an expansion step to supplement the key yields provided in the macroeconomic scenario is preferred.

[127] Adopting a less complicated model specification without material loss impacts is consistent with the Board's Stress Testing Policy Statement's simplicity principle. *See* 12 CFR 252, Appendix B, Section 1.4

D. Private Equity Model

i. Statement of Purpose

The Private Equity Model estimates losses on private equity investments in the hypothetical severely adverse macroeconomic scenario with losses entering projected net income as unrealized changes in fair value. The Private Equity Model is important for accurately assessing whether firms would be sufficiently capitalized to absorb the material stress to their private equity holdings that could manifest in a severe recession. The Private Equity Model is applied to private equity carry values reported in FR Y-14Q, Schedule F.24 (Private Equity), which, as of 2025, total approximately $50 billion.

ii. Model Overview

The Private Equity Model projects changes in the fair value of private equity assets over the stress test horizon based on the macroeconomic scenario.[128] These changes in fair value are recognized as unrealized losses (or gains, as investments may recover in the later quarters of the projection horizon) through net income for all positions,[129] regardless of the individual accounting elections made in determining their carry values.[130] Private equity losses are

[128] Fair value, on a given measurement date, is the price that would be received upon the orderly sale of a private equity investment. The Board considers changes in fair value to be a reasonable measure of an investment's impact on the capital position of a firm when viewed as a going concern (thus assuming the investment will not be subject to forced liquidation in a distressed sale).

[129] "Positions" and "exposures" are used interchangeably in the text to refer to a firm's own private equity interests. Third-party assets under management are not in scope.

[130] The carry value (or book value) of a private equity investment may be measured under either a fair value or non-fair-value accounting paradigm depending on the investment specifics and, in certain cases, discretion of the reporting entity. Under U.S. GAAP, the method used to determine the carry value of a private equity investment depends primarily on the degree of influence the investor has over its investee. Fair value is generally applied to passive investments where influence is limited (i.e., an equity interest of less than twenty percent of an investee's voting stock). For investors with significant influence over their investee (i.e., an investment exceeding twenty percent of an investee's voting stock), the "equity method," a non-fair value paradigm, is typically applied. The equity method initially records an investment at cost and then incrementally updates it in line with an investor's pro-

calculated based on investment carry values reported in Schedule F.24,[131] where they are segmented by industry, geography and accounting treatment. These exposures capture various types of private equity investments, including direct investments in private companies, limited partnership (LP) interests in private equity funds that are managed by third-party fund managers, and general partnership (GP) interests in private equity funds where the fund is managed by the banking organization itself. Private equity positions may qualify as Public Welfare Investments (PWI),[132] and they can also take the form of equity investments in debt funds, including but not limited to Small Business Investment Company (SBIC) funds.[133] Many of these investments are similar to traditional leveraged buyouts, although they also include venture capital and growth equity investments.

iii. Model Specification

The Private Equity Model depicts the relationship between private and public equity markets to project the magnitude of private equity losses that would result when public markets decline by a certain percentage (as specified in the macroeconomic scenario). This relationship

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rata share of its investee's earnings. Reporting entities may elect, in certain circumstances—for example, via "fair value option" or "measurement alternative" elections—to record what would ordinarily be a non-fair value exposure at fair value or vice versa. Note that when an investor is deemed to have a controlling financial interest in an investee (e.g., an ownership stake over fifty percent of the investee's voting stock), the investment would be consolidated onto the investor's balance sheet, where it would be reflected in terms of the constituent assets and liabilities of the investee rather than as a private equity security. These constituent assets and liabilities would then be individually subject to FR Y-14Q reporting requirements and associated stress testing treatment.

[131] Schedule F.24 reporting, up to and including the 2025 stress test, is currently required of firms subject to Category I, II, or III standards that have aggregate trading assets and liabilities of $50 billion or more (a four-quarter average) or aggregate trading assets and liabilities equal to ten percent or more of total consolidated assets. However, the Board proposes that Schedule F.24 be reported by firms that have four-quarter average private equity carry values greater than $5 billion or five (ten) percent of Tier 1 capital for Category I-III (IV) firms, following the thresholds generally applied in the FR Y-14Q to determine "material portfolios."

[132] PWI are investments that promote community welfare, such as the economic rehabilitation and development of low-income areas, as specified under 12 CFR 225.28(b)(12) and 12 CFR 225.127.

[133] An SBIC is a privately owned investment company, licensed and regulated by the U.S. Small Business Administration (SBA), that invests in small businesses in the form of debt and equity, pursuant to 13 CFR 107.

is captured via a "beta" parameter,[134] representing the sensitivity of private equity fair values to movements in the public stock market, with the public stock market represented by the Dow Jones Total Stock Market Index.

The Private Equity Model projects the value (PE_t) of funded[135] private equity investments for a given quarter t based on the path of public stocks included in the macroeconomic scenario, as follows:

Equation D-1 – private equity asset value projection

$$\mathrm{PE}_t = \mathrm{PE}_0 \cdot \exp[\beta \cdot \mathrm{rDJ}_t]$$

Where:

- PE_0 is the initial investment carry value, as recorded at the start of the stress test horizon and reported in Schedule F;[136]
- $\mathrm{rDJ}_t = \ln(\mathrm{DJ}_t/\mathrm{DJ}_0)$ is the cumulative log-return of public equity through projection quarter t, which is derived from the Dow Jones Total Stock Market Index path (DJ_t) specified in the macroeconomic scenario; and
- β represents the sensitivity of private equity exposures to changes in the Dow Jones Total Stock Market Index and is set to 0.75 for all exposures, except for investments in Small Business Investment Companies (SBICs), which are subject to a lower beta of 0.50 based on the distinct risk profile of SBIC investments, as further described below.

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134 The Private Equity Model's beta assumptions are estimated from historical public and private equity returns observed since 2007, as further described in Section D(iv), Specification Rationale and Calibration.

135 Funded investments, which account for the large majority (approximately ninety percent) of private equity balances subject to the model, are those for which capital has been dispersed to the end investee. Firms also have a limited amount of private equity exposure in the form of unfunded commitments or capital that is contractually committed to private equity investments, but which has not yet been deployed.

136 The value is adjusted, when applicable, to remove embedded goodwill or equity capital in unconsolidated financial institutions to the extent these amounts are not included in CET1 capital.

PWI related to affordable housing are not subject to a macroeconomic scenario-based projection; instead these investments are assigned an unrealized loss of $\mathrm{PE}_0 \times \mathrm{Shock}_{\mathrm{Sec42}}$ in the first projection quarter without subsequent recovery, where PE_0 is initial investment carry value and $\mathrm{Shock}_{\mathrm{Sec42}}$ is the fair value shock applicable to Section 42 Housing tax credit investments, as specified in the GMS, within its Other Fair Value Assets category. Affordable housing investments are distinguished in this way, in view of their structure and risk profile, as further discussed under Section D(iv), Specification Rationale and Calibration.

To capture risk associated with unfunded commitments to private equity, the model assumes that one third of any unfunded commitment is drawn into investments at the start of the stress test horizon; these investments are then treated identically to funded positions of the same type.[137]

The following example demonstrates how private equity losses are calculated in Equation D-1 under an illustrative severely adverse scenario. The illustrative severely adverse scenario assumes a fifty percent decline in the Dow Jones Total Stock Market Index from the jump-off point of the stress test (December 31) through the fourth projection quarter (such that $\mathrm{DJ}_4/\mathrm{DJ}_0 = 0.5$) and a GMS Section 42 tax credit shock of 4.9 percent. Figure D-1 shows the cumulative unrealized[138] loss to the fourth projection quarter ($\mathrm{PE}_0 - \mathrm{PE}_4$), that would result per $\$100.00$ of initial funded exposure (PE_0) or unfunded commitment, for each of the model's three risk segments:

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[137] The one third draw rate assumption applied to unfunded commitments was chosen based on the typical rate at which capital committed to private equity funds is deployed, as further described in Section D(iv), Specification Rationale and Calibration.

[138] The unrealized loss reflects the simplifying assumption that positions are held constant, without exits, over the stress test projection horizon.

Figure *D-1* – *Illustrative cumulative unrealized loss to the fourth projection quarter per $100 of initial exposure by model segment, assuming a severely adverse scenario depicting a fifty percent decline in the Dow Jones Total Stock Market Index level from the jump-off point of the stress test (December 31) through the fourth projection quarter (*$\mathrm{DJ}_4/\mathrm{DJ}_0 = 0.5$*) and a Section 42 tax credit shock of 4.9 percent.*

Segment	Loss to PQ4 per $100 of funded investments	Loss to PQ4 per $100 of unfunded commitments
Core Private Equity	$40.54	$13.51
SBICs	$29.29	$9.76
Affordable Housing PWIs	$4.90	$1.63

iv. Specification Rationale and Calibration

The motivating logic and rationale for key decisions impacting the model specification are provided below.

a. *Losses Based on Changes in Fair Value*

While U.S. GAAP allows for private equity to be carried under a variety of accounting measures, the Private Equity Model does not differentiate projected loss rates by accounting paradigm but rather equates capital impact with change in fair value for all investments. This choice is motivated by the following considerations:

- Fair value is typically realized upon the orderly sale of a given private equity investment, irrespective of its accounting treatment during the holding period.
- Unlike fixed income instruments, private equity investments generally cannot be redeemed by holding to maturity and are therefore fundamentally exposed to market risk at exit.
- Variation in accounting measurement for private equity is principally driven by the degree to which an investor can influence its investee, or by elections made at an

investor's discretion (such as the fair value option), and is generally not reflective of differences in investment risk.

- A model that assigned different losses based on accounting elections could produce inconsistent stress capital requirements between firms holding substantially similar investments that present similar economic risks.

b. *Macroeconomic Variable Selection*

The model uses public stock performance as the macroeconomic variable upon which to base projected private equity losses. This choice is motivated by the following considerations: (1) private and public equities are structurally similar instruments, both representing claims on residual company earnings, and can therefore be expected to react similarly to changing macroeconomic conditions; (2) historically, private equity fair values have exhibited a robust statistical relationship to public stocks,[139] with measurement of private equity risk via reference to public stocks being a common practice.[140]

c. *Calibration of Core Beta to 0.75*

To estimate the response of private equity fair values to public stock prices (and particularly large declines in those prices under stress), a regression analysis was performed using quarterly returns observed over the period 2007 through 2023. Importantly, return variation during this observation period incorporates the 2008 financial crisis, a severe recession accompanied by a large and protracted decline in public stocks, broadly consistent with public stock paths that may be depicted in the macroeconomic scenario. In this regression analysis,

[139] *See* Stafford, E., 2022. Replicating Private Equity with Value Investing, Homemade Leverage, and Hold-to-Maturity Accounting (The Review of Financial Studies 35/1).

[140] *See* Korteweg, A., 2019. Risk Adjustment in Private Equity Returns (Annual Review of Financial Economics 11/1).

historical public stock returns were measured from the Dow Jones U.S. Total Stock Index (consistent with the domestic stock market variable included in the macroeconomic scenario). Private equity returns were constructed from a third-party data vendor index tracking the fair value performance of a large sample of private equity funds,[141] with investments in a diverse set of geographies and industries, broadly consistent with the profile of firm private equity exposures reported in FR Y-14Q, Schedule F. The analysis utilized the below lagged-regression specification, which captures the sensitivity of private equity returns to both (i) concurrent public market returns as well as (ii) prior or "lagged" public market returns. The regression's lagged specification was chosen to capture the timing with which private equity fair values react to, or follow, changes in public markets—a dynamic observed to unfold with some delay, over multiple quarters, rather than occurring immediately.[142]

Equation D-2 – lagged beta regression specification

$$\mathrm{rPE}_t^* = \alpha + \sum_{l=0}^{n} \beta_l \cdot \mathrm{rDJ}_{t-l}^* + \varepsilon_t$$

Where:

- rPE_t^* is the private equity return observation associated with quarter t, equal to the change in the natural logarithm ("log-return") of the private equity performance index, between the end of quarter $t-1$ through to the end of quarter t, in excess of the

[141] Specifically, the third-party data vendor's index tracks returns constructed from a large and diversified sample of funds (including buyout, growth equity and venture capital activity) and the quarterly net asset value reported for those funds (wherein fund investment assets, net of fund liabilities, are measured at fair value under U.S. GAAP).

[142] Private Equity Fund NAVs generally rely on holistic analysis of a fund's constituent investments, analysis that is not strictly tied to observable transaction prices but may give weight to assessments of fundamental value based on projections of an investee's operations or cashflow. The resulting valuations tend to be less anticipatory and react more conservatively to changing economic conditions or shocks relative to public markets, filtering out and smoothing some of the sentiment-driven volatility inherent in exchange prices.

corresponding risk-free return for that period (defined by the three-month U.S. Treasury rate);

- rDJ^*_{t-l} is the public equity return observation lagged by l quarters from quarter t, equal to the change in the natural logarithm of the Dow Jones U.S. Total Stock Index between the end of quarter $t-l-1$ through to the end of quarter $t-l$, in excess of the corresponding risk-free return for that period (defined by the three-month U.S. Treasury rate);
- β_l is the regression coefficient against each lagged public equity return for $l = 0, 1, \dots, n$ with n equal to the maximum lag considered in the model, set to three or four quarters as further described, below;
- ε_i is residual variation[143] in the ith private equity return, which is assumed to follow a normal distribution, $\varepsilon_i \sim N(0, \sigma^2)$; and
- α is the regression intercept, representing a return component that is uncorrelated with the public stock market.

The lagged form of the regression specified in Equation D-2 above, can be attributed to Dimson,[144] with the β_l regression coefficients sometimes referred to as "Dimson betas." Summing these coefficients produces a total beta estimate, $\beta = \sum_{l=0}^{n} \beta_l$, capturing the full reaction, unfolding over n-quarters, of private equity fair value, to a given public market movement. As an example, given estimated betas covering $n = 3$ lags of $(\beta_0, \beta_1, \beta_2, \beta_3) =$

[143] Residual variation refers to variation in private equity returns that is not explained by the public stock returns considered in the regression model—i.e., the difference between the observed private equity return values and the fitted values predicted by the regression equation.

[144] *See* Dimson, E., 1979. Risk Measurement when Shares are Subject to Infrequent Trading (Journal of Financial Economics 7/2).

$(0.40, 0.15, 0.10, 0.10)$, then under Equation D-2 a public market return of 10 percent in a given quarter t would translate into resulting private equity returns of:

- $4.0\% = \beta_0 \times 10\%$, in that projection quarter t
- followed by $1.5\% = \beta_1 \times 10\%$, in quarter $t + 1$
- followed by 1.0% in each of quarters $t + 2$ and $t + 3$

making a total return of 7.5 percent, elapsing over four quarters (7.5 percent being the 10 percent public market return, multiplied by the total beta of $0.75 = \sum_{l=0}^{3} \beta_l$). Several authors have applied this paradigm to measure the total beta of private equity fund returns to public market returns, typically using between three and five lags. Figure D-2 summarizes total beta estimates of this type for a selection of private equity buyout funds (the predominant private equity fund type) over various sample periods, based on performance data sourced from different vendors.

Figure D-2 – summary of studies that include measures of the total beta of private equity to public markets, made by regressing buyout fund net asset value (NAV) returns against current and lagged public market returns (per regression Equation D-2), and then summing up the estimated beta coefficients across all lags. Data tabulated for the first three studies is presented as summarized by Korteweg.[145] The fourth and final study listed, Stafford (2022), does not focus on or advocate for the Dimson beta paradigm, but rather includes the estimates summarized in the table as descriptive statistics (in prelude to constructing alternative measures of private equity risk).

Study	Buyout Fund Performance Data Source	Sample Period	Number of Lags Used	Total Beta
Anson (2007)[146]	Venture Economics	1985–2005	3	0.7
Woodward (2009)[147]	Cambridge Associates	1996–2008	5	1.0

[145] *See* Korteweg, A., 2019. Risk Adjustment in Private Equity Returns (Annual Review of Financial Economics 11/1).

[146] *See* Anson, M., 2007. Performance Measurement in Private Equity: Another Look (The Journal of Private Equity).

[147] *See* Woodward, S., 2009. Measuring Risk for Venture Capital and Private Equity Portfolios (SSRN 1458050).

Study	Buyout Fund Performance Data Source	Sample Period	Number of Lags Used	Total Beta
Ewens, Jones & Rhodes-Kropf (2013)[148]	Preqin	1980–2007	4	0.7
Stafford (2022)[149]	Preqin	1996–2014	3	0.7
	Cambridge Associates			0.8
	Burgis			0.9

The Board's own regression analysis (under regression Equation D-2), which as noted above used the sample period 2007–2023 and covered a broad private equity fund population (inclusive of venture capital and growth equity funds in addition to buyout funds), produced similar results.[150] This analysis found a total beta of 0.75 was robustly supported and fell reliably in the body of the regression confidence interval, under a range of minor variations in the application of Equation D-2, created by utilizing:

- Gross or net returns (in excess of prevailing risk-free rates);
- $n = 3$, 4 or 5 lags (though lags beyond the fourth were not statistically significant in the Board's analysis); and
- alternate performance indices for private equity (e.g., restricting to buyout funds or using performance indices from alternate vendors).

[148] *See* Ewens, M., Jones, C., and Rhodes-Kropf, M., 2013. The Price of Diversifiable Risk in Venture Capital and Private Equity (The Review of Financial Studies 26/8).

[149] *See* Stafford, E., 2022. Replicating Private Equity with Value Investing, Homemade Leverage, and Hold-to-Maturity Accounting (The Review of Financial Studies 35/1).

[150] The Board's analysis utilized log-returns (for consistency with projection ***Equation D-1***), whereas simple returns (i.e., percent change) are more commonly used in the literature. A beta of 0.75 in log-returns is equivalent to a marginally higher beta defined in simple returns. This is why the example in **Figure *D-1*** shows an approximate forty percent loss on private equity resulting from a fifty percent decline in public stocks, consistent with a beta between these simple returns of approximately 0.80, five percentage points higher than the 0.75 beta parameter used to produce these figures via ***Equation D-1***.

The Board examined differences in the sectoral composition of firms' private equity investments, relative to industry-level exposure held by private equity funds (to whose historical performance the model is calibrated). This examination revealed that bank private equity investments are not substantially different from overall industry trends, supporting a simple model without industry segmentation, calibrated to broad private equity return data.

The beta calibration utilized in the Private Equity Model is designed to depict the dynamics of private equity fair value in a severely adverse scenario, as measured under U.S. GAAP (which the Board considers to be a reasonable basis for determining capital impacts, assuming, as noted above, a firm's private equity investments will not be subject to forced liquidation into a dislocated market). Loss projections under the chosen beta calibration—for example, a forty percent decline in private equity accompanying a fifty percent drop in public stocks, per Figure D-1 —compare conservatively to fair value outcomes during the 2008 financial crisis (where, for example. buyout funds produced an approximately negative thirty percent NAV-based return, between 2007:Q4 and 2009:Q1 quarter ends, while public stocks fell by approximately fifty percent over the same period). The Board does not consider its 0.75 beta assumption to be in in conflict with studies that, in aiming to compare public and private equity through-the-cycle under a common price measure, disregard the distinct fair value accounting practices applicable to private equity (distinct from the mark-to-market, real time transaction-price-based accounting applicable to public stocks) and estimate private equity betas above one or inferior risk-adjusted returns relative to public stocks.[151] In past stress tests, when private equity was subject to the GMS and treated on a mark-to-market basis, equivalent to public

[151] *See, e.g.*, Ang, A., Chen, B., Goetzmann, W. and Phalippou, L., 2018. Estimating Private Equity Returns from Limited Partner Cash Flows (The Journal of Finance 73/4).; and Stafford, E., 2022. Replicating Private Equity with Value Investing, Homemade Leverage, and Hold-to-Maturity Accounting (The Review of Financial Studies 11/1).

stocks, the Board similarly applied shocks to private equity that exceeded the accompanying shocks depicted for public markets, thus embedding a beta above one.

d. *Calibration of SBIC Beta to 0.50*

Small Business Investment Companies (SBICs) are licensed and regulated by the Small Business Administration (an independent agency of the U.S. government) to provide financing to small businesses. SBICs are funded by a mix of private capital and low-cost, SBA-guaranteed debt,[152] with total fund leverage limited by regulation. SBICs can make both equity and debt investments in small companies, serving as a source of financing for investees that may not be able to access traditional bank loans. Small Business Administration data show that, in practice, loan assets predominate among SBIC holdings,[153] which, together with the subsidized debt funding utilized by SBICs and related oversight by the SBA, suggest a lower risk profile relative to the average private equity investment.[154] In the absence of historical fair value return data for SBICs through a severe recession, the Board was not able to directly measure past SBIC fair value outcomes in recessionary periods; however, analysis using a performance index pertaining to U.S. private debt funds from a third-party data vendor (viewed as a reasonable proxy for SBICs given their typical asset composition), and the same form of lagged regression above (Equation D-2), suggests a 0.50 beta assumption as reasonable for SBICs. In light of this analysis, and in the spirit of other areas of the banking rules that consider the unique

[152] The SBA generally pools its debt interests in SBICs and sells them to investors in the form of government-guaranteed securities.

[153] *See* Brown, G., Hu, W., Robinson, D., and Volckmann, W., 2024. The Performance of Small Business Investment Companies (IPC). Available at "SBIA_Paper_June-19-2024.pdf."

[154] Loans are generally associated with lower risk relative to equity investments. They offer both a more predictable return (in the form of contractual interest and principal payments, which are less sensitive to company performance than the earnings-driven return offered by equity investments) and higher priority for repayment in the event of company default relative to equities.

characteristics of SBICs, the Board applies this lower beta to all eligible SBIC investments, which are otherwise still modeled via the simple projection in Equation D-1. While SBICs constitute a narrow and well-defined fund population, supported by subsidized funding, and with guardrails on their leverage and risk profile (by virtue of their licensing and regulation), debt funds, in general, take a variety of forms with varying degrees of leverage,[155] asset quality, and risk. As such, the Board does not extend a similar treatment to equity interests in debt-focused funds, more broadly (i.e., uniformly lowering the applicable beta applied through projection Equation D-1 to 0.50, without adding risk segmentation specific to debt-focused funds). In the absence of a dedicated model component for debt funds, not currently viewed as warranted given that debt funds currently account for only a small fraction of the positions subject to the model (less than five percent), the Board subjects them to the same treatment as other forms of private equity exposure for simplicity.

e. *Shock Treatment for Affordable Housing PWI*

PWI target "corporations or projects designed primarily to promote community welfare, such as the economic rehabilitation and development of low-income areas by providing housing, services, or jobs for residents."[156] PWI are a permissible type of equity investment[157] for bank holding companies and receive preferential treatment under the capital adequacy rules.[158] A

[155] Private debt funds tend to rely more on bank credit lines or the bond market to obtain leverage, which comes at a substantially higher cost than the SBA-guaranteed debt used by SBICs. *See* Chernenko, S., Ialenti, R., and Scharfstein, D., 2025. Bank Capital and the Growth of Private Credit (SSRN 5097437).

[156] *See* 12 CFR 225.28(b)(12) and 12 CFR 225.127.

[157] The Bank Holding Company Act authorizes firms to engage in nonbanking activities, including investing in community development companies or projects. *See* 12 U.S.C.1843(c)(8); 12 CFR 225.28(b)(12). Depository institution subsidiaries may also hold equity positions in PWIs. *See, e.g.*, 12 CFR 208.22.

[158] *See, e.g.*, 12 CFR 217.51, which articulates the standardized risk-weighted asset calculation applicable to equity exposures.

substantial portion of firms' PWI arise from participation in the Low-Income Housing Tax Credit (LIHTC) program,[159] where firms provide capital to affordable housing projects in exchange for tax credits, which reduce tax liabilities over a ten-year period. These tax credit assets are not subject to the Private Equity Model, but rather, when carried at fair value, are subject to the Trading P&L Model and GMS, which includes a dedicated shock for "Section 42 Housing Credits" within its Other Fair Value Assets component. Alongside tax credit investments, firms also hold related PWI in affordable housing, which are subject to the Private Equity Model. (These include equity investments in properties previously financed with LIHTCs but that have exited their tax recapture period, properties with other public subsidies but not with active LIHTC financing, as well as naturally occurring affordable housing.) In view of the low risk profile generally presented by affordable housing projects—where robust demand for below market-rate housing and government subsidies can drive stable income and low foreclosure risk—and in the spirit of other elements of the banking rules,[160] the Board determined, beginning with the 2020 stress test, to subject private equity PWI in affordable housing to the same treatment as LIHTC tax credit investments carried at fair value. This reduced the loss rate applicable to private equity affordable housing PWI (which had previously been shocked more punitively in the GMS, as general real estate exposures) and achieved a consistent rate of stress loss across related forms of affordable housing investment. The Private Equity Model continues this treatment of PWI in affordable housing. While affordable housing is a significant component of PWI, presenting relatively low risk, PWI in general encompasses a

[159] LIHTC is a federal program that awards tax credits to developers of affordable housing projects, which can be sold to investors, including banks, as a means of raising private capital to fund development activities in service of expanding and improving the affordable housing stock.

[160] For example, PWI are subject to distinct risk-weighted asset treatment and designated as permissible equity investments, as referenced in footnotes 158 and 157, respectively

variety of investment models, risks and activities, some of which may be more speculative in nature. As such, a similar carveout or reduction in stress losses is not extended broadly to all PWI.

f. *Draw Rate of One Third for Unfunded Commitments*

Unfunded commitments account for a small fraction of private equity exposures covered by the model but nevertheless may give rise to losses, to the extent they are invested during the projection horizon into private equity securities that subsequently decline in value. To account for the risk presented by unfunded commitments, the model assumes that a third will be channeled into investments at the start of the projection horizon. This assumption was chosen to broadly align with the rate at which remaining commitments are drawn, in the context of private equity fund activity—where investment of committed capital is typically concentrated into a three-to-five-year period.[161]

g. *Projection Specification*

The loss projection specification utilized by the Private Equity Model (Equation D-1) is simplified relative to the lagged regression specification used by the Board in calibrating the private equity beta coefficient (Equation D-2). In projection Equation D-1, the intercept term (alpha) is set to zero, and the total beta response to public market movements is applied immediately in each quarter, rather than being phased in under the lagged dynamics captured in the regression Equation D-2. Although regression analyses with Equation D-2 indicate a positive intercept (alpha) of around three percent per annum on average over the sample period, this result is sensitive to the time range of the sample period and not robustly significant across

[161] *See* Li, Y. 2024. Liquidity Shocks and Private Equity Investments (SSRN 4618348).

variations in the application of Equation D-2 employed by the Board (where different numbers of lags, return units or private equity performance data sources were utilized as described above). As such, the model follows a simpler and more conservative projection specification with alpha set at zero, thereby avoiding crediting private equity with an uncorrelated return enhancement relative to public equity, the applicability of which, in a severe recession, was not confidently established. The total beta response without lags is similarly used for simplicity and conservatism. In the event of a large decline in public stocks and severe recession, the fully phased-in reaction of private equity represents a more prudent estimate of fair value relative to the dynamics projected by the lagged model, which may capture temporary bias or delay driven mechanically by valuation and reporting protocols while economic conditions are deteriorating.

h. *Limited Segmentation Scheme*

The model does not differentiate between the region or industry segments captured in FR Y-14Q, Schedule F.[162] The model's limited segmentation scheme was chosen, in light of the relatively low materiality of private equity, for simplicity and to avoid loss projections that unduly prejudice one sector or region over another, given that the macroeconomic scenario does not provide equity market projections by region or sector. Although the model does not currently depict systematic risk differences across the particular industry and geography segments employed in Schedule F, the Board will continue to investigate the appropriateness of the model's limited segmentation scheme, including the possibility of capturing alternative

[162] Private equity balances reported in FR Y-14Q, Schedule F.24 are principally organized by industry sector (e.g., financials, information technology, health care) and region (e.g., United States, Western Europe, other developed markets, emerging markets). This segmentation does not fully align with the taxonomies typically utilized in private equity performance measurement, which tend to include investment strategy (e.g., buyout, venture capital, growth equity) as a principal dimension of segmentation.

dimensions of segmentation in Schedule F, such as investee size or stage, leverage at the company or fund level, and fund strategy (i.e., venture capital, buyout, debt, or infrastructure).

i. *Exclusion of CET1 Deductions from Carry Values*

Private equity carry values may embed amounts of goodwill, or stock in unconsolidated financial institutions, that are not counted in common equity tier 1 (CET1) capital. The Private Equity Model excludes these amounts from the initial carry values (PE_0 in projection Equation D-1) used as the basis for loss projections. This exclusion is a simple approach to preventing the model from punitively assigning losses against balances that are not included in capital (a double-count that is mitigated in practice when losses to the carry value of a deduction item are mechanically offset by a reduced capital deduction in respect of that item).

v. Alternative Approaches

a. *Mark-to-Market Approach:*

Historically, losses on private equity investments were calculated within the GMS. Private equity positions were subject to carry value shocks specified in the GMS, which embedded the assumption that mark-to-market dynamics,[163] as exhibited by public stocks during stress periods, should similarly apply to private equity securities;[164] however, given the propensity for dislocation or a disconnect between public transaction prices and a fundamental assessment of fair value under severely stressed conditions, and the distinct manner and markets

[163] Mark-to-market dynamics are driven, in part, by sentiment, liquidity, and market structure as investors react to changing economic conditions and execute transactions (which may include forced or panic selling in the context of economic stress and uncertainty) that impact exchange prices regardless of whether they are driven by an assessment of long-term fundamental value.

[164] The GMS shocks were calibrated to the stressed price behavior of proxy public stocks with comparable characteristics to private equity investments.

in which private and public stocks are transacted and valued,[165] the Board views direct calibration to historically observable private equity fair values to be a reasonable basis for stress loss estimation, better aligned with valuation in the context of an orderly private equity transaction.[166]

b. *Treatment of Private Equity Hedges:*

Private equity hedges have historically been included with the trading book population reportable throughout FR Y-14Q, Schedule F and subject to the GMS alongside the private equity investments they pertain to. Now that private equity investments are subject to the macroeconomic scenario, the Board is proposing revisions to Schedule F that would require private equity hedges (which are currently not identifiable within the schedule) to be separately reported. This would allow private equity hedges to be treated analogously to Accrual Loan Hedges and FVO Hedges (as described within the FVO Model Section B(v)). The Board seeks comment on this potential model change.

c. *Exposure Basis for Projections:*

Initial carry values are assumed to be a reasonable basis for projecting losses. While the carry value of individual positions may differ from fair value to some degree, the accounting rules should limit the extent of such divergence in aggregate, and the Board relies on audited balance sheet carry value data (as currently reported in Schedule F.24) as the exposure basis

[165] Public equities can be transacted in real time by a broad collection of retail and institutional investors based on transparent market-based pricing, whereas private equity securities are typically transacted among a more restricted class of institutional investors following a process of valuation and bilateral negotiation. Moreover, private equities are most often purchased with the intent to hold over a long horizon—whereas the holding intent in public equity transactions varies widely among investors.

[166] The supervisory stress test assumes that firms will continue as going concerns, which precludes distressed liquidations of long-term investment holdings.

against which loss rates are applied for private equity investments—producing losses in proportion to their t_0 contributions to CET1 capital (analogous to the risk-weighted asset treatment of equity exposures[167]).

- An alternative approach could utilize t_0 investment fair value, in place of carry value, as the basis for loss projections. This would imply new reporting requirements, with fair value line items added in FR Y-14Q, Schedule F.24, alongside the carry value items already collected. Since the model equates capital impact with fair value change, the use of t_0 fair value instead of carry value as the exposure basis would, in the absence of any additional change in projection methodology, result in higher losses for exposure segments where initial fair value exceeds initial carry value and lower losses in the opposite case. This would not necessarily be desirable since, with fair value above carry value, losses would be generated on exposure amounts not counted in starting CET1 capital (or conversely, with fair value below carry value, no loss would be generated on amounts that are counted in CET1 capital).
- Under another alternative, the model could additionally adopt differential treatment of exposures, based on the extent to which initial fair value differs from carry value, by equating capital impact with, for example, change in the minimum of projected fair value and initial carry value instead of change in fair value. Such an approach, in attempting effectively to alter the t_0 capital contribution of investments, could produce outcomes where the fair value of exposures are projected to decline without any associated capital impact, or where stress losses are assigned in the absence of any projected fair value

[167] *See, e.g.*,12 CFR 217.51, which similarly uses carry value as the basis for capitalization of equity exposures.

change (also not necessarily desirable since the capital buffer implied by the model would no longer be in proportion to changes in the projected fair value of assets held, when in practice such changes would impact a firm's economic capital position).

The chosen approach, where audited carry values are used as the basis of projections, in addition to being simple and consistent, also has the merit of falling between the two alternatives outlined above in terms of severity.

vi. Data Adjustments

The Private Equity Model utilizes balances reported in FR Y-14Q, Schedule F.24 to determine initial carry values, PE_0 in Equation D-1, subject to the following two narrow data adjustments:[168]

- **CET1 deductions**: As discussed above, private equity carry values as reported in the current version of Schedule F may incorporate amounts of goodwill or stock in unconsolidated financial institutions that are not counted in regulatory capital. The Private Equity Model adjusts reported carry values to exclude these amounts where applicable. These adjustments have, to date, been facilitated by special data collections conducted outside of the FR Y-14Q reporting process. However, the Board is now proposing revisions in FR Y-14Q, Schedule F that would require private equity carry values to be reported net of embedded amounts not included in regulatory capital; once adopted, these revisions would obviate the need for the CET1 deduction item adjustments described in this paragraph.

[168] These adjustments will only remain necessary pending adoption of proposed FR Y-14Q revisions.

- **SBIC exposures**: SBIC exposures are not separately identifiable within the current version of FR Y-14Q, Schedule F. Data on SBIC investments are reported in aggregate with other non-SBIC forms of private equity. The Board currently separates SBIC exposures from the rest of reported private equity investments by relying on data submitted via special data collections outside of the FR Y-14Q reporting process, pending proposed updates to the FR Y-14Q that would distinguish SBIC investments within Schedule F.

vii. Assumptions and Limitations

Key assumptions and limitations associated with the Private Equity Model are noted as follows:

- **Fair value loss metric:** Projected losses and recoveries are based on unrealized changes in fair value for all positions, regardless of their accounting treatment.
- **Constant positions:** Consistent with the Credit Supply Maintenance policy found in the Stress Testing Policy Statement, positions are assumed to be held constant without exits over the stress test horizon.
- **Bank vs. industry exposure:** Vendor-performance indices depicting historical performance in a broadly diversified population of private equity funds are assumed to be a reasonable proxy for bank private equity exposure.
- **Carry value exposure basis:** Initial carry values are assumed to be a reasonable basis for projecting losses. As noted and further discussed above under Alternative Approaches Section D(v), the Board relies, for simplicity and consistency, on audited balance sheet carry value data (as currently reported in FR Y-14Q, Schedule F.24) as the exposure basis

against which loss rates are applied for private equity investments, thereby producing losses in proportion their t_0 contribution to CET1 capital.

- **Limited segmentation:** The model does not differentiate loss projections by characteristics within private equity such as geography, sector, investee company stage, leverage, or exposure type (i.e., general partner interest, limited partner interest, or direct investment).

viii. Question

Question D1: The Board seeks comment on subjecting private equity hedges (PE Hedges) to a treatment analogous to that currently followed for FVO Hedges and Accrual Loan Hedges (as further discussed in the FVO Model Section B(v)), as compared to the Board's prior approach of calculating losses on private equity investments via the Trading P&L Model under the GMS.

E. Trading Profit and Loss Model

i. Statement of Purpose

The Trading Profit and Loss Model (Trading P&L Model) estimates GMS mark-to-market impacts on trading book positions, which enter as realized losses into projected pre-tax net income in the first quarter of the stress test horizon.[169]

The Trading P&L Model is applied to firms subject to the GMS, which generally includes firms with substantial trading operations.[170] These firms collectively hold over $400 billion in standardized market risk-weighted assets. The Trading P&L Model is important for assessing whether such firms are sufficiently capitalized to withstand a financial market stress event that coincides with a severe recession.

ii. Model Overview

The Trading P&L Model is applied to the subset of firms subject to the GMS. The model estimates mark-to-market P&L for trading positions and Other Fair Value Assets (OFVA)[171] resulting from the sudden risk factor shocks specified in the GMS.[172] Estimated P&L impacts are recognized in the first quarter of the projection horizon. The Trading P&L Model utilizes exposures and sensitivities[173] reported by firms in FR Y-14Q, Schedule F (Trading), to generate

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[169] *See* Section B (Overview of Scenario Design Process) in the Global Market Shock (GMS) Description.

[170] The GMS applies to a firm that is: subject to the stress test; has aggregate trading assets and liabilities of $50 billion or more, or aggregate trading assets and liabilities equal to ten percent or more of total consolidated assets; and is not a Category IV firm under the Board's tailoring framework. *See* 12 CFR 238.143(b)(2)(i); 12 CFR 252.54(b)(2)(i).

[171] Other Fair Value Assets are defined in the instructions to the FR Y-14Q, Schedule F as all non-derivative assets held under FVO accounting except wholesale and retail loans.

[172] The abrupt nature of the GMS scenario means that shocks are applied as though the entire set of shocks occurred at once (i.e., on a specified trading day and affecting firms' positions as of that date) rather than unfolding over an extended period.

[173] A sensitivity, for purposes of this model description, is defined as the mark-to-market change in a portfolio of trading positions in response to a specific unit move in a specific risk factor (e.g., a shock to that risk factor's level or volatility).

its P&L estimates. Schedule F sensitivities are submitted separately for two distinct trading populations, distinguished (according to FR Y-14Q instructions and nomenclature) by "submission type" designations of "Trading" and "CVA Hedges," respectively, with CVA Hedges capturing the subset of trading book positions used specifically for the purpose of hedging credit risk associated with derivatives counterparties (as further described in the CVA Model Section G). The Trading P&L Model, as now described, is applied to "Trading" positions and separately to "CVA Hedges" to estimate associated P&L in each case. The model has two components depending on the trading book asset being modeled:

(i) A Market Value Component, which stresses market values for certain trading positions reported in Schedule F (namely Securitized Products, Loans, Loan CDS, defaulted Munis and defaulted Corporate Credit, and OFVA) by applying haircuts as prescribed in the GMS; and

(ii) A Sensitivity-Based Component, which produces stress loss estimates for the remainder of the trading positions reported in Schedule F, using a sensitivity-based approximation of portfolio risk. Linear risks[174] are captured via local sensitivities[175] collected in Schedule F. In areas where there may be significant nonlinearity, Schedule F requests

[174] Linear risk denotes exposure to a risk factor such that P&L responds in a linear fashion, i.e., for each additional unit move in the risk factor a consistent amount of additional profit or loss is realized. This contrasts with non-linear risks or exposures, where each additional unit of risk factor shock produces a varying rather than constant P&L impact.

[175] A local sensitivity to a given risk factor is measured in respect of small perturbations of the risk factor from its initial level. A local sensitivity can be used to reasonably approximate mark-to-market impacts resulting from movements, by a given risk factor, in the vicinity of its initial level, even if the true impacts are not strictly linear under larger shocks.

expanded sensitivity data in the form of univariate[176] "P&L grids."[177] In these cases, the Trading P&L Model uses linear interpolation, given a prescribed GMS shock, to calculate a P&L result from the associated P&L grid provided.[178] There are also limited cases in which Schedule F collects two-dimensional "Spot-Vol grids,"[179] (e.g., for equities and commodities exposures). The Sensitivity-Based Component uses the information in these grids to calculate additional P&L, reflecting higher-order impacts from simultaneous price and volatility shocks.[180]

The total P&L for a given firm and portfolio is the sum of the market value haircut and sensitivity-based P&L estimates $\text{P\&L}_{\text{MV}}$ and $\text{P\&L}_{\text{SE}}$, respectively, produced by the two model components:

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[176] Univariate means involving only one variable (risk factor).

[177] A "P&L grid" is a connected series of P&L estimates, generated in response to a set of incrementally increasing shocks to a given risk factor. For example, the series $\{\text{P\&L}_{50}, \text{P\&L}_{100}, \text{P\&L}_{150}, \ldots\}$ of mark-to-market impacts resulting from yield curve shocks $\Delta y_i \in \{50bps, 100bps, 150bps, \ldots\}$ is referred to as a P&L grid. Because the P&L grid can effectively capture mark-to-market impacts over a range of grid points, it can capture non-linear risks, at a resolution determined by the density of the grid points.

[178] Linear interpolation calculates P&L impacts for risk factor shocks falling between points provided in a P&L grid by assuming the P&L varies linearly between those reported values using the standard definition and method of linear interpolation. P&L grids must be reported with fixed grid points or some minimal criteria regarding grid point quantity and spacing, as described in the FR Y-14Q instructions. For example, Equity by Geography grids must be reported with a minimum of five points spanning shocks between zero percent and negative fifty percent. The GMS generally specifies a shock between reported grid points; thus linear interpolation is used to estimate P&L at the GMS-specified shock. For example, if a firm reported an equity P&L grid over shocks of $0, -10, -20, -35, -40, -50$ percents and the relevant GMS scenario for equity exposure was -23 percent, linear interpolation would be used between the -20 and -35 percent grid points to estimate P&L associated with the -23 percent shock. In rare cases the GMS may specify a shock falling outside the corresponding P&L grid, in which case linear extrapolation is utilized. Linear extrapolation assumes that, at the lower or upper limits of the grid, the linear relationship between the last two points continues beyond the end of the reported grid. Instances of linear extrapolation are minimal in the model, both in terms of frequency and overall contribution to P&L outputs.

[179] Spot-Vol grids collect P&L sensitivities to simultaneous spot price and volatility shocks to a given risk factor, organized in a two-dimensional grid.

[180] Higher-order impacts or risks, for the purposes of this model description, refer to P&L effects that deviate from the first-order or linear response of P&L to risk factor shocks. For example, Vega (the sensitivity of a portfolio to changes in the volatility of the price of an instrument) would be a first-order sensitivity, whereas Volgamma (the sensitivity of Vega itself to changes in volatility) would be considered a higher-order sensitivity. The Trading P&L Model is not designed to capture P&L from all higher-order risks—higher-order risks are included selectively based on materiality.

Equation E-1 – total P&L is the sum of market value haircut and sensitivity-based P&L estimates

$$\text{P\&L}_{\text{Total}} = \text{P\&L}_{\text{MV}} + \text{P\&L}_{\text{SE}}$$

Different assets in the trading book are subject to different model components (either the Market Value Component or the Sensitivity-Based Component). The model components applicable to each of the asset classes in the GMS shock template are summarized below in Figure E-1 and further defined in the Market Value Component Section E(iii) and Sensitivity-Based Component Section E(iv).

Figure E-1 – Model components by asset class: model components applicable to the various asset classes, as shocked under the GMS.[181]

Asset Class	*Model Component*
Equity	Sensitivity-Based
FX	Sensitivity-Based
Interest Rates	Sensitivity-Based
Commodities	Sensitivity-Based
Securitized Products	Market Value
Agencies	Sensitivity-Based
Munis	Sensitivity-Based, Market Value
Corporate Credit: Advanced Economies	Sensitivity-Based, Market Value
Corporate Credit: Emerging Market	Sensitivity-Based, Market Value
Sovereign Credit	Sensitivity-Based
Other Fair Value Assets	Market Value

[181] Note that although corporate credit assets are predominantly subject to the Sensitivity-Based Component, a subset of corporate positions (defaulted exposures and traded loans) are instead subject to the Market Value Component.

The Sensitivity-Based Component is generally applied to actively traded asset classes, with well-established and observable market risk factors, readily available sensitivity measurements, and shocks that can be readily calibrated and translated into mark-to-market impacts. The simpler Market Value Component is applied to less liquid asset classes for which the components necessary to support a robust sensitivity-based calculation are less readily available.

In general, the Trading P&L Model takes as inputs both (i) GMS shocks and (ii) firm-provided FR Y-14Q sensitivities and market values, functioning as a simple calculator to determine associated P&L results. Since the modeling and analytics utilized in generating sensitivity and shock inputs falls outside and upstream of the Trading P&L Model itself, a fundamental assumption is that these data are accurate (i.e., firms' pricing models accurately calculate market values, P&L sensitivities, and grids reported in the FR Y-14) and complete (all trading positions are accounted for), and that the scope of risk factors covered by the GMS is sufficiently comprehensive to capture risk effectively.

iii. Market Value Component

a. *Model Specification*

The Market Value Component of the Trading P&L Model uses a straightforward market value (MV) haircut calculation of the following form:

Equation E-2 – P&L calculation, Market Value Component

$$\text{P\&L}_{\text{MV}} = \sum_{R} \sum_{e \in R} \text{MV}_{R,e} \cdot \text{haircut}_{R,e}$$

summing estimated losses over each exposure segment[182] e within each risk category R as defined in the GMS and FR Y-14Q, Schedule F and summarized in Figure E-2, which tabulates the specific positions covered by the Market Value Component.

Figure E-2 – Exposure Scope for the Market Value Component: "Data Sources and Quantities" columns identify, for each risk category, (i) the worksheet within the GMS template[183] specifying market value shocks by exposure segment within the risk category and (ii) the corresponding section of the Schedule F form[184] in which market value exposures are reported.[185] The risk categorization, nomenclature, and exposure units reflected in the table are used as defined in the instructions to the FR Y-14Q and as used in the Schedule F form and GMS template. Note that only a subset of municipal bonds and corporate credit assets fall under the Market Value Component—the GMS shock template specifies market value haircuts for this subset only. By contrast, the GMS shock template specifies spread widening shocks for all remaining municipal bonds and corporate credit assets, which are accordingly treated via the Sensitivity-Based Component of the Trading P&L Model as addressed in the Sensitivity-Based Component Section E(iv).

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[182] Exposure segments are the individual product groupings for which market value shocks are specified within the GMS and for which corresponding market value exposures are reported in the Schedule F. Consult the GMS template for a full list of exposure segments and shocks pertaining to a given risk category. (For example, the 2025 GMS template can be accessed at https://www.federalreserve.gov/supervisionreg/files/ccar-2025-stress-test-severely-adverse-market-shocks.xlsx).

[183] For example, see the 2025 GMS shock template at: https://www.federalreserve.gov/supervisionreg/files/ccar-2025-stress-test-severely-adverse-market-shocks.xlsx

[184] FR Y-14Q form and instructions are available at: https://www.federalreserve.gov/apps/reportingforms/Report/Index/FR_Y-14Q

[185] The abbreviation "MV" in the table represents market value.

Market Value Component - Details by Asset Class					
Asset Class	Risk Category	Data Sources and Quantities			Notes
		Data Type	GMS Shock Template worksheet or FR Y-14Q section	Quantity Specified	
Credit	Securitized Products	Shocks	Securitized Products	Relative MV shock	
		Exposures	Securitized Products	Market value	
	Munis	Shocks	Munis	Relative MV shock	Only for exposures to defaulted bonds rated <B
		Exposures	Munis	Market value	
	Corporate Credit: Advanced Economies	Shocks	Corporate Credit - Advanced	Relative MV shock	Only for exposures to defaulted bonds rated <B, and to loans
		Exposures	Corporate Credit - Advanced	Market value	
	Corporate Credit: Emerging Market	Shocks	Corporate Credit - EM	Relative MV shock	Only for exposures to defaulted bonds rated <B, and to loans
		Exposures	Corporate Credit - EM	Market value	
Other Fair Value Assets	All	Shocks	Other Fair Value Assets	Relative fair value shocks	
		Exposures	Other Fair Value Assets	Carry values	

b. *Specification Rationale and Calibration*

The specification of the Market Value Component is dictated by the GMS shock units applicable to the asset classes it covers—where the GMS specifies market value haircut shocks, the model applies them via simple multiplication against their associated market value exposures to determine P&L, as in Equation E-2. The asset classes subject to market value haircuts in the GMS are generally more illiquid, where sensitivities and associated risk factor observations may be unavailable, inaccurate, or irrelevant (as in the case of defaulted bonds rated lower than “B”).

In general, the Market Value Component is a recipient of GMS shock factor values as specified, hence the simple calculation for this component.

c. *Alternative Approaches*

Because the specification of GMS shocks relevant to the Market Value Component requires that they be applied as haircuts to the appropriate exposure quantities via multiplication, alternative approaches are not applicable for the Market Value Component.

d. *Data Adjustments*

Data inputs for the Market Value Component of the Trading P&L Model are taken directly from the GMS shock template and firms' Schedule F submissions without adjustment.

e. *Assumptions and Limitations*

As noted in the Model Overview Section E(ii), the Market Value Component of the Trading P&L Model relies on the assumption that the data reported by firms in Schedule F are both accurate (i.e., the firms' pricing models accurately calculate market values) and complete (i.e., all trading positions are accounted for). The Trading P&L Model as designed is limited to exposure data reported in Schedule F—any exposures not reported will not be captured by the model.

In addition, the Trading P&L Model assumes that all positions within the individual exposure segments for which the GMS specifies shocks experience the same loss rates under stress. Variation in risk due to factors that are not captured by the GMS risk factor segmentation scheme are not reflected in Trading P&L Model results (e.g., individual stocks within a country receive the same shock in the GMS). Finally, the Market Value Component also inherits the GMS assumption that shocks occur suddenly, such that firms are unable to dynamically hedge risks to mitigate losses.

iv. Sensitivity-Based Component

a. *Model Specification*

The Sensitivity-Based Component estimates P&L for each given GMS shock and associated exposure sensitivity pair it covers via either:

(i) dot product calculation,[186] where risk factor sensitivities $\Delta_{R,r}$ for the risk factors r, within the risk categories $R \in \text{DOT}$, are multiplied against corresponding GMS shocks, denoted by $\text{Shock}_{R,r}$, as specified in the GMS (with DOT denoting the set of risk categories subject to dot product calculation, as tabulated in Figure E-3); or

(ii) P&L grid-based interpolation, where P&L grids $\text{GRD}_{R,r}$ for risk factors r, within the risk categories $R \in \text{GRID}$, are used to determine P&L responses to corresponding shocks, denoted by $\text{Shock}_{R,r}$, as specified in the GMS (with GRID denoting the set of risk categories subject to P&L grid-based interpolation, as tabulated below),

resulting in a total sensitivity-based P&L estimate $\text{P\&L}_{\text{SE}}$ of:

Equation E-3 – P&L calculation, Sensitivity-Based Component

$$\text{P\&L}_{\text{SE}} = \sum_{R \in \text{DOT}} \sum_{r \in R} \Delta_{R,r} \cdot \text{Shock}_{R,r} + \sum_{R \in \text{GRID}} \sum_{r \in R} \text{GRD}_{R,r}\left[\text{Shock}_{R,r}\right] + \text{HRA}$$

Where:

- $\Delta_{R,r} \cdot \text{Shock}_{R,r}$ is a linear approximation of P&L resulting from $\text{Shock}_{R,r}$ (the GMS shock to risk factor r, within risk category R), based on the associated firm-reported sensitivity $\Delta_{R,r}$;

[186] The dot product calculation is the sum of the products of each risk factor shock and corresponding exposure sensitivity pair, within a risk category. Each product represents the profit or loss resulting from the given shock.

- $\mathrm{GRD}_{R,r}\left[\mathrm{Shock}_{R,r}\right]$ denotes the linear interpolation or extrapolation of P&L in respect of $\mathrm{Shock}_{R,r}$, using the firm-reported P&L grid $\mathrm{GRD}_{R,r}$; and
- HRA is a Higher-Order Risk Add-On, further detailed in Section E(iv)(a)(1).

Whether dot product calculation or P&L grid-based interpolation is applied to a given risk category R depends on the type of sensitivity data collected in FR Y-14Q, Schedule F. P&L grids are generally collected selectively for risks for which non-linear P&L effects may be material given the typical range of shock magnitudes depicted in the GMS.[187]

Note that in addition to the P&L grid interpolation explicitly denoted in Equation E-3 by $\mathrm{GRD}_{R,r}\left[\mathrm{Shock}_{R,r}\right]$, linear interpolation is also used in instances where a firm has reported a sensitivity $\Delta_{R,r}$ at a tenor point falling between the standard tenor points[188] specified in the GMS.[189] In this case, the value of $\mathrm{Shock}_{R,r}$ would also be interpolated linearly from these standard tenor points.[190]

The individual sensitivities noted in this section (e.g., Delta, Gamma, Vega, etc.) follow the definitions given in the instructions to Schedule F.[191]

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[187] *See* footnote 177 for illustration of how P&L grids are used to capture non-linear risks.

[188] Tenor generally refers to the time remaining until a relevant event (maturity, expiry, delivery, settlement, etc.) occurs in the product exposures associated with a given risk factor. So, for example, yield shocks by maturity or volatility shocks by option expiry, may generically be referred to as shocks provided by tenor.

[189] FR Y-14Q, Schedule F instructions give firms discretion, in certain cases, to report risk factor sensitivities along a given term structure using tenor points that are readily available in their risk measurement systems. Since the GMS only provides shocks for a finite set of standardized tenor points, linear interpolation is used to obtain shocks corresponding to any non-standard tenor points included in firm sensitivity reporting.

[190] Linear interpolation may thus happen for both P&L grids and for "grids" of shocks (i.e., a set of shocks at multiple tenors).

[191] The precise sensitivities and associated units collected in Schedule F vary by asset class and risk category, as defined in Schedule F instructions. They are largely comprised of Delta, Gamma and Vega metrics, which are widely used in derivatives risk management alongside other similar sensitivity metrics (i.e., "Greeks") to measure the sensitivity of a derivative's theoretical price to changes in a specific risk factor (such as the price or volatility of

Figure E-3 – Sensitivity-Based Component Calculation Methodologies: parts (a) through (e) of this figure, starting with (a), below, tabulate the GMS shocks and corresponding exposures subject to the Sensitivity-Based Component, indicating which are treated via dot product (of local sensitivities against GMS shocks) and which are treated via P&L grid interpolation. The risk categorization, nomenclature, and exposure units reflected in the table are as defined in the Schedule F instructions and as used in the Schedule F form and GMS template.

Figure E-3(a) – Equity details for the Sensitivity-Based Component: This table identifies the calculation methodologies used for equity risk categories in the Sensitivity-Based Component.

Asset Class	Risk Category	Data Sources and Quantities			Calculation Methodology	Notes
		Data Type	GMS Shock Template worksheet or FR Y-14Q section	Quantity Specified		
Equity	Delta / Gamma	Shocks	Equity by Geography	% spot shock	P&L grid	
		Exposures	Equity by Geography	P/L from % Change in Country Equity Prices		
	Vega	Shocks	Equity by Geography	Vol Point shocks	Dot product	Shocks and exposures matched by country/index and tenor
		Exposures	Equity by Geography	Vega		
	Dividends	Shocks	Dividends	% dividend shock	Dot product	
		Exposures	Other Equity	P/L from -1% change in dividends		

In Figure E-3(a), equity shocks are specified in either relative (percent) or absolute (e.g., points of volatility, in the case of equity Vega) terms, depending on the equity risk category. A P&L grid is specified for equity Delta / Gamma exposures to help approximate potential non-linearity or curvature in the P&L response to equity price moves driven, for example, by

an underlying security) salient to the derivative's valuation. Delta and Vega measure a derivative's price sensitivity to the price and volatility, respectively, of a derivative's underlying asset. Gamma measures the sensitivity of Delta to changes in the price of a derivative's underlying asset. Delta can be interpreted as the rate or speed at which a derivative's P&L accrues (as the price of an underlying asset moves) and Gamma as the acceleration.

derivative exposures.[192] Exposures for equity Vega and Dividends are modeled linearly using the sensitivity quantities specified in the table, and thus a dot product is used to calculate P&L for those risk categories.

Figure E-3(b) – Foreign Exchange details for the Sensitivity-Based Component: This table shows calculation methodologies for foreign exchange risk categories in the Sensitivity-Based Component.

Asset Class	Risk Category	Data Sources and Quantities			Calculation Methodology	Notes
		Data Type	GMS Shock Template worksheet or FR Y-14Q section	Quantity Specified		
FX	Delta / Gamma	Shocks	FX Spot	% spot shock	P&L grid	
		Exposures	% Change in Spot Price in Currency1 / Currency2	P/L from % Change in Spot Price		
	Vega	Shocks	FX Vega	Absolute vega shock	Dot product	Shocks and exposures matched by currency pair and tenor
		Exposures	FX Vega	FX lognormal vega		

In Figure E-3(b), FX shocks are specified in either relative (percent) or absolute terms depending on the FX risk category. A P&L grid is specified for FX Delta / Gamma to help approximate potential curvature in the P&L response to increasing FX spot price shocks driven, for example, by FX option exposures. FX Vega exposure is modeled linearly and thus uses the dot product calculation methodology.

[192] Curvature refers to the shape of P&L responses when graphed against equity price shocks, which may be curved (rather than linear) and reflect variation in the slope (or Delta) of P&L as the size of price shocks change. Gamma is a measure of variation in Delta as equity prices change, so curvature is associated with a non-zero Gamma. A “P&L grid” provides P&L estimates at various points on a grid, reflective of both Delta and Gamma as applicable, hence the Schedule F nomenclature “Delta / Gamma” used to identify this risk category.

Figure E-3(c) – Interest Rate details for the Sensitivity-Based Component: This table shows calculation methodologies for interest rate risk categories in the Sensitivity-Based Component.

Asset Class	Risk Category	Data Sources and Quantities			Calculation Methodology	Notes
		Data Type	GMS Shock Template worksheet or FR Y-14Q section	Quantity Specified		
Interest Rates	Rates DV01	Shocks	Rates DV01	Absolute basis shock (bps)	Dot product	Shocks and exposures matched by currency, maturity, and tenor
		Exposures	Rates DV01	Interest rate basis DV01		
	Vega	Shocks	Rates Vega: Normal & Relative -OR- Absolute	Vega shock (rel. or abs.)	Dot product	Firms choose how to calculate (relative or absolute)
		Exposures	Rates Vega	Vega		
	Cross Currency Basis	Shocks	Other Rates	Absolute basis shock	Dot product	Shocks and exposures matched by currency and tenor
		Exposures	Other Rates	Basis sensitivities		
	Inflation	Shocks	Other Rates	Absolute inflation shock	Dot product	
		Exposures	Other Rates	Inflation delta		

In Figure E-3(c), interest rate shocks are generally specified in absolute terms, except for interest rate Vega shocks. Firms may choose to report their Vega exposures in either relative or absolute units per Schedule F instructions (to prevent firms with risk systems that support only one of these Vega measurement conventions from being unduly burdened with the production of alternative Vega metrics not otherwise used by a firm during business-as-usual risk management). Consequently, shocks are specified for both possibilities. Only the shocks corresponding to the units in which interest rate Vega exposures are reported by a given firm are used in the Vega P&L calculations. Regardless of whether shocks are relative or absolute, all the exposures in the table are modeled linearly and thus use the dot product calculation methodology.

Figure E-3(d) – Commodities details for the Sensitivity-Based Component: This table shows calculation methodologies for commodities risk categories in the Sensitivity-Based Component. Note that for each of the commodity product groups included in the table (Energy, Metals, Ags & Softs, Commodity Indices), Delta risk is captured through price shocks by tenor along the forward curves[193] of products falling within those groups (e.g., Month 3 Brent Crude Oil or Year 5 Lumber).

<table>
<tr><th rowspan="2">Asset Class</th><th rowspan="2">Risk Category</th><th colspan="3">Data Sources and Quantities</th><th rowspan="2">Calculation Methodology</th><th rowspan="2">Notes</th></tr>
<tr><th>Data Type</th><th>GMS Shock Template worksheet or FR Y-14Q section</th><th>Quantity Specified</th></tr>
<tr><td rowspan="4">Commodities</td><td rowspan="2">Delta</td><td>Shocks</td><td>Energy, Metals, Ags & Softs, Commodity Indices</td><td>% price shocks</td><td rowspan="2">Dot product</td><td rowspan="2">Shocks and exposures matched by product and tenor</td></tr>
<tr><td>Exposures</td><td>Energy, Metals, Ags & Softs, Commodity Indices</td><td>Delta</td></tr>
<tr><td rowspan="2">Vega</td><td>Shocks</td><td>Energy, Metals, Ags & Softs, Commodity Indices</td><td>Vega shock (rel. or abs.)</td><td rowspan="2">Dot product</td><td rowspan="2">Firms choose how to calculate (relative or absolute)</td></tr>
<tr><td>Exposures</td><td>Energy, Metals, Ags & Softs, Commodity Indices</td><td>Vega (rel. or abs.)</td></tr>
</table>

In Figure E-3(d), commodities Delta shocks are specified in relative (percent) terms, while commodities Vega shocks are specified in both relative and absolute terms; as with Vega shocks for Interest Rates in Figure E-3(c), alternative units are supported for commodities' Vega to mitigate reporting burden on firms when filing Schedule F. All exposures in the table are modeled linearly and thus use the dot product calculation methodology.

193 The forward curve plots variation in current market prices against increasing contractual future delivery dates or "tenors."

Figure E-3(e) – Credit details for the Sensitivity-Based Component: This table shows calculation methodologies for credit risk categories in the Sensitivity-Based Component. For Municipal bonds and Corporate Credit (both Advanced Economies and Emerging Markets), the information in this table is applicable to any exposures not specifically noted in Figure E-2 (which itemizes the small subset of Credit exposures addressed by the model's Market Value Component).

Asset Class	Risk Category	Data Sources and Quantities			Calculation Methodology	Notes
		Data Type	GMS Shock Template worksheet or FR Y-14Q section	Quantity Specified		
Credit	Agencies	Shocks	Agencies	Absolute shock (bps)	P&L grid	
		Exposures	Agencies	P/L from Absolute Widening in OAS (bps)		
	Munis	Shocks	Munis	Absolute shock (bps)	P&L grid	
		Exposures	Munis	P/L from Widening in Spreads (rel. AND abs.)		
	Corporate Credit: Advanced Economies	Shocks	Corporate Credit - Advanced	Spread Widening (rel. or abs.)	P&L grid	Firms choose how to calculate (relative or absolute)
		Exposures	Corporate Credit - Advanced	P/L from Widening in Spreads		
	Corporate Credit: Emerging Market	Shocks	Corporate Credit - EM	Spread Widening (rel. or abs.)	P&L grid	Firms choose how to calculate (relative or absolute)
		Exposures	Corporate Credit - EM	P/L from Widening in Spreads		
	Sovereign Credit	Shocks	Sovereign Credit	Spread Widening (rel. or abs.)	P&L grid	Firms choose how to calculate (relative or absolute)
		Exposures	Sovereign Credit	P/L from Widening in Spreads (rel. or abs.)		

In Figure E-3(e), credit shocks may be specified in either relative or absolute terms depending on credit risk category. For all credit spread shocks, P&L grids are used to capture potential nonlinearity in the P&L response to widening credit spreads. For Credit Correlation, P&L is modeled linearly using the dot product methodology, with correlation shocks multiplied against Corr01 sensitivities, which measure P&L with respect to one percent absolute shifts in base correlations.[194]

(1) Higher-Order Risk Add-On (HRA)

The Sensitivity-Based Component, per Equation E-3 above, includes an HRA term to account for the following higher-order P&L risks (each described further below):[195]

- non-linear P&L exposure to large directional interest rate shocks;
- non-linear P&L exposure to simultaneous price-level and volatility shocks within equities; and
- non-linear P&L exposure to simultaneous price-level and volatility shocks within commodities.

These risks are captured by the components $\mathrm{HRA}_{\mathrm{Rates}}$, $\mathrm{HRA}_{\mathrm{Equity}}$ and $\mathrm{HRA}_{\mathrm{Comm}}$, respectively, which are summed to determine the total HRA:

Equation E-4 – HRA, Sensitivity-Based Component

$$\mathrm{HRA} = \mathrm{HRA}_{\mathrm{Rates}} + \mathrm{HRA}_{\mathrm{Equity}} + \mathrm{HRA}_{\mathrm{Comm}}$$

$\mathrm{HRA}_{\mathrm{Rates}}$, $\mathrm{HRA}_{\mathrm{Equity}}$, and $\mathrm{HRA}_{\mathrm{Comm}}$ are each calculated using relevant P&L sensitivities reported in Schedule F, principally:

194 Base correlation is an implied correlation measure derived from the market price of a tranched credit product referencing a group of underlying issuers. It broadly represents market perceptions regarding the propensity of these issuers to default in unison, driven by shared sensitivity to common economic risk factors.

195 For general discussion of higher-order risks, *see* footnote 180.

- a set of interest rate-related P&L grids each measuring the impact of a range of parallel[196] interest rate shocks to a specific interest rate curve;
- a single equity P&L grid measuring the impact of simultaneous movements in equity prices and equity volatility, globally; and
- a set of commodity P&L grids each measuring the impact of simultaneous movements in prices and volatility levels within a broad category of commodities (e.g., oil products or precious metals).

These sensitivity data, as reported in Schedule F, are less granular than the corresponding shocks specified in the GMS;[197] for example, the GMS specifies interest rate shocks by interest rate curve and maturity, whereas the interest-rate-related P&L grids used to determine the $\text{HRA}_{\text{rates}}$ add-on depict the impact of parallel rate shocks without variation by maturity. This difference in granularity motivates the inclusion of associated GMS P&L as an add-on to the Sensitivity-Based Component, rather than as part of its core formulation, which (per Equation E-3) requires sensitivities and shocks of equal granularity. The add-on calculations, for each of the three higher-order P&L risks itemized above, are described in detail below.

(a) Interest Rate HRA

FR Y-14Q, Schedule F.6 collects directional P&L grids by interest rate curve, measuring, for each curve, P&L over a range of parallel interest rate shocks.[198] These P&L grids are used to

[196] A "parallel" shock is one applied uniformly across maturities, impacting all interest rates equally, regardless of maturity.

[197] The lower granularity of sensitivity data, relative to certain GMS shocks, results from the thousands of risk factors depicted in the GMS coupled with the practical need to limit the extent of sensitivity data collected in Schedule F to minimize associated reporting burden.

[198] *See* Section III.A(2) for a description of DV01s.

determine an add-on to the Sensitivity-Based Component, $\text{HRA}_{\text{Rates}}$, for P&L convexity risk[199] that may manifest under larger interest rate movements.

$\text{HRA}_{\text{Rates}}$, as defined in Equation E-5, is a component of the total HRA, as per Equation E-4.

Equation E-5 – rates, higher-order risk add-on

$$\text{HRA}_{\text{Rates}} = \sum_{c,t} ConvGRD^{c,t}(\Delta r_{c,t})$$

Where:

- c indexes the individual interest rate curves tabulated by currency in Schedule F.6, while t indexes tenor points along each curve;
- $\Delta r_{c,t}$ is the GMS interest rate shock for the interest rate curve c and tenor t; and
- $ConvGRD^{c,t}$ is the convexity grid used for linear approximations of $\text{HRA}_{\text{Rates}}$ and calculated in advance for each of the grid points specified in Schedule F.6 as:

$$ConvGRD^{c,t}(\Delta_r) \; = (P/L_c(\Delta_r) \; + \; \Delta_r \cdot Total\ DV01_c)/n$$

Where:

- Δ_r is the interest rate shock per grid point specified in Schedule F.6;
- $P/L_c(\Delta_r)$ is the change in P&L for a given interest rate curve and shock grid point Δ_r;
- n is the number of points along the curve reported in Schedule F.6; and
- $Total\ DV01_c$ is the total DV01 for curve c reported in Schedule F.6.

[199] The risk associated with certain interest rate-sensitive instruments, for which P&L responds non-linearly to changes in interest rates.

The add-on calculation is constructed in this way to capture the incremental P&L impact driven by convexity effects (over and above linear P&L risk with respect to interest rates, which is already captured in the sensitivity component, per Equation E-3, via a dot product calculation incorporating tenor-specific shocks). This add-on is intended to capture non-negligible P&L that could be missed otherwise.

(b) Equity HRA

FR Y-14Q, Schedule F.2 (Equity Spot-Vol Grid) collects two-way[200] sensitivities measuring equity P&L globally in response to simultaneous movements in equity prices and equity volatility, over a range of levels in each dimension, in a Spot-Vol grid. The equity Spot-Vol grid is used to construct an add-on, $\mathrm{HRA}_{\mathrm{Equity}}$, capturing the incremental P&L over and above the simple summation of P&L impacts from these two risk factors when considered independently. This simple sum is otherwise captured in the sensitivity component, per Equation E-3, outside of the $\mathrm{HRA}_{\mathrm{Equity}}$ add-on, which is defined as follows:

Equation E-6 – equities, higher-order risk add-on

$$\mathrm{HRA}_{\mathrm{Equity}} = \sum_{c=1}^{n} \frac{Net\ Vega\ P/L_c^{Post\ Shock}}{n} - Total\ Pre\ Shock\ Vega\ P/L$$

Where:

- n is the number of countries / indices with non-zero Vega exposure, indexed by c;
- $Total\ Pre\ Shock\ Vega\ P/L$ captures the change in P&L from equity volatility shocks and is calculated as a sum of products of GMS volatility shocks for each country / index and tenor, and corresponding Vega sensitivities, reported in Schedule F.1; and

200 A two-way sensitivity measures the combined P&L impact from simultaneous movements in two risk factors.

- $Net\ Vega\ P/L_c^{Post\ Shock}$ is the net Vega P&L from post spot shocks calculated as follows:

Equation E-7 - net Vega post spot shock P&L for a given country / index

$$Net\ Vega\ P/L_c^{Post\ Shock} = S_c^{vol} \cdot Net\ Vega_c^{Post\ Shock}$$

Where:

- $Net\ Vega_c^{Post\ Shock}$ is the post spot shock net Vega that is interpolated from the Vega post spot shock table (at zero vol shock) in Schedule F.2 using the corresponding spot shock for each reported country / index c; and
- S_c^{vol} is the tenor-weighted volatility shock calculated for each country / index c listed in Schedule F.1 using the Vega by tenor and the corresponding GMS volatility shocks, as follows:

Equation E-8 – tenor-weighted volatility shock for a given country / index

$$S_c^{vol} = \sum_{t=1}^{n} w_{c,t} \cdot Vega\ Shock_{c,t}$$

Where:

- $Vega\ Shock_{c,t}$ is the GMS Vega shock for country / index c and tenor point t; and
- $w_{c,t}$ is the weight for country / index c and tenor t computed as:

$$w_{c,t} = \frac{|Vega_{c,t}|}{\sum_{t=1}^{n} |Vega_{c,t}|}$$

Where:

- $Vega_{c,t}$ is the value of Vega for country / index c and tenor t reported in Schedule F.1.

The add-on calculation is constructed to isolate incremental P&L driven by the specific convexity and price-volatility interaction effects not otherwise captured by the Sensitivity-Based Component. $\text{HRA}_{\text{Equity}}$ is a component of the total HRA, as per Equation E-4.

(c) Commodities HRA

FR Y-14Q, Schedule F.13 (Commodity Spot-Vol Grids) collects two-way commodity P&L sensitivities from simultaneous movements in both commodity price and volatility levels, organized in Spot-Vol grids. Like the Equity HRA calculation, independent commodity price and volatility impacts are captured by the Delta and Vega calculations in the Sensitivity-Based Component of the Trading P&L Model; however, their interaction is not directly captured and is thus included via the HRA_{Comm} term.[201] The aggregated Commodity HRA is the sum of each HRA calculation for the eleven commodity product categories:[202] Oil, Natural Gas, Power, Emissions, Coal, Freight, Other Structured / Energy, Base Metals, Precious Metals, Ags & Softs, and Diversified Indices. See Equation E-9.

Equation E-9 – commodities, higher-order risk add-on

$$\text{HRA}_{\text{Comm}} = \sum_{p=1}^{m} \text{HRA}_{Comm}^{p}$$

Where m is the total number of commodity product categories indexed by p.

[201] The Sensitivity-Based Component's commodities Delta calculations measure the sensitivity of P&L to underlying commodity prices, assuming volatility is constant. Its commodities Vega calculations measure the sensitivity of P&L to the volatility level of commodity prices, assuming the price itself is constant. HRA_{Comm} is designed to capture sensitivity to simultaneous movements in underlying price and the general level of price volatility.

[202] These categories follow the product taxonomy used in the GMS and Schedule F, where shocks and sensitivities for similar commodities (e.g., gold, silver and platinum or different varieties of crude oil) are organized into broad categories (e.g., Precious Metals or Oil Products).

The commodities Spot-Vol grids are used to calculate HRA_{Comm} for a particular commodity product category p according to:

Equation E-10 – higher-order risk add-on for commodity product category p

$$\text{HRA}_{Comm}^{p} = \sum_{pr=1}^{n} ConvGRD^{pr}(\Delta_{pr})$$

Where:

- pr indexes over n specific products within commodity product category p;
- Δ_{pr} is the GMS spot shock for commodity product pr; and
- $ConvGRD^{pr}(.)$ is an adjusted product convexity grid calculated in advance for all shock grid points from the Spot-Vol grid table at zero volatility in Schedule F.13—weighted by the product's share within the broader product category p—defined as follows:

Equation E-11 – commodity adjusted product convexity grid

$$ConvGRD^{pr}\left(\Delta_{grid}\right) = w_{pr}\left[GRD\left(\Delta_{grid}, 0\right) - Delta^{p} \cdot \Delta_{grid}\right]$$

Where:

- Δ_{grid} are grid point shock values reported in the commodity Spot-Vol grid;
- $GRD\left(\Delta_{grid}, 0\right)$ is the Spot-Vol grid P&L at zero volatility for a given product category p and spot shock Δ_{grid};
- $Delta^{p} \cdot \Delta_{grid}$ is the total Delta P&L for a product category p calculated using grid point shock values Δ_{grid} and spot Deltas $Delta^{p}$ reported in Schedule F.13 for product category p; and

- w_{pr} is the weight for the specific product pr, within a product category p, calculated as a fraction of the total absolute Gamma exposure for a given product γ_{pr} in the total absolute Gamma exposure for the given product category p, defined as follows:

Equation E-12 – specific commodity product weights

$$w_{pr} = \frac{|\gamma_{pr}|}{\sum_p |\gamma_{pr}|}$$

The convexity grid points should be calculated in advance for all grid point shock values in the commodity Spot-Vol grid in section F.13. As the final step, the convexity add-on for each spot shock is calculated from the convexity grid using linear interpolation and aggregated, as described in Equation E-10.

The add-on calculation is constructed in this way to isolate incremental P&L driven by the specific convexity and price-volatility interaction effects not otherwise captured by the Sensitivity-Component.

$\mathrm{HRA}_{\mathrm{Comm}}$ is a component of the total higher-order-risk add-on amount, HRA, as per Equation E-4.

b. *Specification Rationale and Calibration*

As with the Market Value Component of the Trading P&L Model, the Sensitivity-Based Component specification was selected as a relatively straightforward translation of GMS shocks into P&L impacts using trading book risk factor sensitivities reported in FR Y-14Q, Schedule F. The use of local sensitivities supplemented by targeted univariate and bivariate P&L grids improves risk capture compared with an approach based purely on local risk sensitivities (which would not inherently capture higher-order effects) while remaining operationally feasible and limiting the reporting burden for firms that must report exposures in Schedule F.

P&L grids are generally collected selectively for risks where non-linear P&L effects may be material, given the typical range of shock magnitudes depicted in the GMS. Linear interpolation of P&L grids (and shocks as applicable) was selected as a simple method of approximating P&L (and shocks) between grid points—with Schedule F instructions specifying the minimum density of grid points to limit error introduced by this approximation.

The HRA is used to capture certain higher-order P&L risks for which P&L grids are collected in Schedule F at a lower granularity than the corresponding shocks specified in the GMS. This lower granularity precludes the associated GMS P&L from being determined within the core formulation of the Sensitivity-Component (which requires sensitivities and shocks of equal granularity).

For additional commentary on the specification, see the Alternative Approaches and Assumptions and Limitations Sections E(iv)(c) and E(iv)(e).

c. *Alternative Approaches*

The following are alternative frameworks considered for the Sensitivity-Based Component of the Trading P&L Model:

(1) Local Sensitivities Only Approach, Using Taylor Series Approximation:

While certain local sensitivities (e.g., Delta, Gamma, and Vega) are currently collected in FR Y-14Q, Schedule F, this approach could be expanded to replace the use of P&L grids. Taylor series expansions[203] using local sensitivities can approximate the shape of P&L response to given risk factor shocks and can be calculated relatively efficiently. While local sensitivities may support reasonable P&L estimates for relatively small risk factor shocks, the approximations are liable to become less accurate for larger shock sizes, particularly if the true P&L response function exhibits significant nonlinearity with respect to the shocked quantity.[204] As a result, this approach was not selected.

(2) Full Revaluation

Losses could be estimated using a full revaluation approach. Full revaluation in this context refers to repricing the trading positions held by firms using the parameters of the relevant valuation model for each instrument type, rather than approximating via portfolio-level sensitivities to a smaller set of risk factors. One advantage of full revaluation is greater accuracy in P&L estimates due to valuation models that are more tailored to each firm's business and exposures; however, this approach would require the collection and storage of position-level data for all firms to facilitate the position-level re-pricing calculations required for full revaluation, as well as either development or procurement of third-party pricing models for the full range of positions held by all firms subject to the stress test (including exotic and bespoke over-the-counter derivatives in firm trading portfolios, which would require extensive data and specific

[203] A Taylor series expansion is a mathematical technique that can be used to approximate a more complex function by means of a simple sum of terms constructed from the function's derivatives. Mathematically, Delta, Gamma, Vega, and "the Greeks" more generally, are all derivatives (e.g., Delta is the first derivative of the P&L response function with respect to a given price shock; Gamma is the second derivative of the P&L response function with respect to the given price shock) and can be used in a Taylor series approximation of a P&L response function under a given shock.

[204] Non-linearity with respect to a given shock means that Delta will vary as the price shock increases. Delta is unlikely to vary significantly at points sufficiently close to the unshocked price (if the function does not have sharp discontinuities) but may change significantly under larger changes in price. Because the Taylor series approximation relies on sensitivity values measured at a particular level of a given risk factor, the approximation may become less accurate under large changes in the risk factor (which might be depicted in the GMS).

models to reprice). These requirements imply prohibitive operational and resource implications, and, as a result, this approach was not selected.

(3) Firm Calculations

In addition, the Board considered an approach that would utilize firm estimates of trading P&L as reported in FR Y-14A, conditional on a given GMS. Under this approach, the Board would rely on each firm's final comprehensive estimate of total GMS P&L (rather than constructing P&L estimates from component P&L sensitivities submitted in FR Y-14Q). These final GMS P&L estimates could be direct inputs into the capital projections used to calibrate firm SCB requirements, in place of the sensitivity-based loss estimates produced by the Trading P&L Model. The benefits of this approach would be a more accurate and complete capture of higher-order effects (including, in particular, interactions between risk factors, which are only accounted for in limited cases within the Trading P&L Model), along with potential reporting and operational simplifications; however, the Board preferred the Trading P&L Model because its reliance on intermediate calculations (i) is more transparent regarding the key risks driving loss outcomes across the portfolio of GMS firms, (ii) allows the Board to independently determine P&L results over a wide range of potential market shock scenarios, consistent with the Policy Statement principles,[205] and (iii) is more robust to firm specific assumptions or reporting fidelity issues, as P&L is determined from standardized sensitivity metrics that can be individually tracked over time, compared across firms, and checked for reasonability.

[205] *See* 12 CFR 252, Appendix B. The principle of independence supports the use of firm-invariant data sources and models.

d. *Data Adjustments*

In general, data inputs for the Sensitivity-Based Component of the Trading P&L Model are taken directly from the GMS shock template and the FR Y-14Q submissions. There are two cases in which shocks are adjusted or calculated from provided data:

- **Term Structure Shocks:** Term structure shocks may be linearly interpolated to match the tenor points at which firm sensitivities are provided when these points differ from those used in the GMS. As described in the Model Specification section, Section E(iv)(a), FR Y-14Q, Schedule F instructions permit firms, in certain cases, discretion to report risk factor sensitivities along a given term structure using tenor points that are readily available in their risk measurement systems. Since the GMS only provides shocks for a finite set of standardized tenor points, linear interpolation is used to obtain shocks that correspond to any non-standard tenor points included in firm sensitivity reporting. The principal areas in which term structure interpolation may be applied (generally, equity, FX, and interest rate volatility shocks by maturity; commodity price shocks by tenor along the forward curve; and interest rate shocks by maturity) receive GMS shocks covering a wide range of tenors with sufficiently dense spacing such that the P&L effects resulting from term structure shock interpolation are expected to be minimal.
- **FX Spot Shocks:** If a firm reports exposure to a foreign exchange rate $\mathrm{CCY}_1/\mathrm{CCY}_2$[206] within the sensitivities submitted in FR Y-14Q, Schedule F.4 (FX Spot Sensitivities) for which a shock is not explicitly tabulated in the GMS template, a common currency CCY_c

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[206] Exchange rate $\mathrm{CCY}_1/\mathrm{CCY}_2$ gives the market price for a unit of currency CCY_1 quoted in terms of currency CCY_2. For example, a EUR/USD exchange rate of 1.20 implies that one euro (€1.00) can be purchased for one dollar and twenty cents ($1.20).

is used to infer the shock $S_{\mathrm{CCY}_1/\mathrm{CCY}_2}$ to this exchange rate,[207] as implied by the shocks explicitly provided in the GMS for the exchange rates $\mathrm{CCY}_1/\mathrm{CCY}_c$ and $\mathrm{CCY}_2/\mathrm{CCY}_c$, as follows:

$$S_{\mathrm{CCY}_1/\mathrm{CCY}_2} = \frac{1 + S_{\mathrm{CCY}_1/\mathrm{CCY}_c}}{1 + \mathrm{S}_{\mathrm{CCY}_2/\mathrm{CCY}_c}} - 1$$

This formula assumes exchange rates under the GMS remain globally consistent (i.e., they do not allow for risk-free profits via circular FX transactions). In addition, shocks to offshore currencies are mapped to their onshore counterparts, and where an exposure has no shock specified in the GMS, the shock for “Other / USD” is used.

e. *Assumptions and Limitations*

The following are the main assumptions and limitations of the Sensitivity-Based Component of the Trading P&L Model:

- **Firm-provided estimates:** As with the Market Value Component of the Trading P&L Model, the data reported by firms in Schedule F are assumed to be both accurate (i.e., the firms’ pricing models accurately calculate the P&L grids and sensitivities) and complete (i.e., all requested information for all trading positions is included in Schedule F).
- **Linear interpolation and extrapolation:** When linear interpolation or extrapolation are used by the Sensitivity-Based Component of the Trading P&L Model, the model assumes linearity between any two consecutive points in firm-provided P&L grids. In addition,

[207] The currency pairs for which FX shocks may be inferred from the explicit shocks included in the GMS number in the tens of thousands. Since many of them give rise to immaterial or zero P&L exposure, they are not explicitly included in the GMS template.

the model makes the simplifying assumption that points outside the provided P&L grids can be linearly extrapolated from the nearest points in the P&L grid vectors. To the extent that points within the P&L grid vectors are sparse and shock values exceed the outer limits of the data provided, the estimated stress loss figures will lose precision. Schedule F instructions specify the minimum density and range of reported P&L grid points to limit the degree of interpolation and / or extrapolation required. Instances of extrapolation in P&L calculations are subject to monitoring, and generally the P&L attributable to cases in which the model performed extrapolation is minimal as fraction of overall projected P&L (less than one percent). Linear interpolation / extrapolation is chosen as the simplest method of utilizing available grid points to produce required estimates consistent with the information in a given P&L grid without introducing additional assumptions or complexity.

- **Higher-order risks:** Despite the use of P&L grids and Spot-Vol grids, the Trading P&L Model does not fully capture profit or loss from higher-order risks (e.g., Cross-Gamma, which measures cross-asset price sensitivities, or Volgamma, which measures asset Vega sensitivities to volatility). Such higher-order risks could result in additional profit or loss depending on the scenario and asset classes involved, a known limitation of the model. For a discussion of alternative methodologies that could potentially ameliorate this risk, see the Alternative Approaches section, Section E(iv)(c).
- **Sudden shocks:** As with the Market Value Component, the Sensitivity-Based Component inherits the GMS assumption of abrupt shocks such that reported sensitivities remain static over the shock horizon and firms are unable to dynamically hedge risks to

mitigate losses. The effects of the passage of time on sensitivities that are ignored by this assumption can be material.

v. Question

Question E1: The Board seeks comment on the imposition of a floor on losses calculated by the Trading P&L Model, as compared to the Board's current approach where Trading P&L Model results are included in pre-tax net income without adjustment, whether positive or negative. Given that trading book exposures are comprised of both long and short positions across various risks, they may in general give rise to net losses or net gains under a given single GMS scenario. Implementing a loss floor could prevent cases (which are atypical but possible) of positive GMS trading P&L detracting from the capitalization of risks beyond the scope of the Trading P&L Model.

F. Trading Issuer Default Loss Model

i. Statement of Purpose

The Trading Issuer Default Loss Model (Trading IDL Model) estimates losses, which are a component of projected pre-tax net income, resulting from defaults of trading book credit positions.[208] The Trading IDL Model only applies to firms subject to the GMS, which generally includes firms with substantial trading operations.

The Trading IDL Model is important for accurately assessing whether firms are sufficiently capitalized to absorb trading losses resulting from issuer jump-to-default events, which occur when a given credit instrument (e.g., bond, loan, or credit default swap) suddenly declines in market value, precipitated by the unexpected default of the instrument's issuer or

[208] Trading book credit positions include bonds, loans, and credit default swaps.

reference entity. These events may occur throughout the projection horizon of the stress test and pose risks not otherwise captured by the general (non-issuer specific) credit spread widening depicted in the GMS.[209] These events may be particularly material for firms with trading portfolios that include large, concentrated exposures to individual issuers.

ii. Model Overview

The Trading IDL Model captures jump-to-default losses on trading book credit positions arising over the full nine-quarter projection horizon. For a given credit instrument (e.g., bond, loan, or credit default swap), jump-to-default loss refers to a sudden decline in market value, precipitated by the unexpected default of the instrument's issuer or reference entity. Jump-to-default events, while rare over short-term trading horizons, can nevertheless be expected to occur in a portfolio of exposures over an extended period.[210]

To assign losses to a given portfolio, the model simulates a large collection of default scenarios that could transpire over the nine-quarter stress horizon; scenarios in which each issuer within the portfolio defaults or survives, according to a credit rating-based probability of default (PD).[211] Loss impacts are determined for each scenario, creating a distribution of potential default loss outcomes in the portfolio. A final loss amount is then selected from a point in the upper tail of this distribution.

[209] *See* footnote 15.

[210] Defaults will tend to materialize beyond the horizon of the GMS, which demonstrates the more immediate forward-looking reaction of market sentiment and traded asset prices to deteriorating conditions.

[211] Default probabilities in the model are calibrated to a third-party vendor's dataset of historical default events, defined to include: (1) a missed or delayed disbursement of an interest or principal payment; (2) a bankruptcy filing or legal receivership by the debt issuer; (3) a distressed exchange whereby an issuer offers creditors a new or restructured debt or a new package of securities; or (4) a change in the payment terms of a credit agreement or indenture imposed by a third party that results in a diminished financial obligation.

The Trading IDL Model is applied to the subset of firms with significant trading operations, which are subject to the GMS component of the stress test and therefore required to file FR Y-14Q, Schedule F (Trading).[212]

Throughout this Trading IDL Model description, t_0 is used to denote the as-of-date for exposures reported in FR-Y14Q, Schedule F for a given stress test exercise.

iii. Model Specification

a. *Total IDL*

The Trading IDL Model divides a firm's trading book credit exposures into three portfolio segments $P \in \{\mathrm{SOV}, \mathrm{MA}, \mathrm{CORP}\}$ composed respectively of sovereign ("SOV"), municipal or agency[213] ("MA"), and corporate ("CORP") credit instruments. The model treats each segment P in isolation and determines a stressed cumulative loss IDL_P in respect of issuer defaults within that segment, projected over the full nine-quarter stress test horizon. The IDL_P are then combined via summation (without any diversification benefit[214]) to arrive at a firm's total projected default loss $\mathrm{IDL}_{\mathrm{TOTAL}}$:

Equation F-1 – total IDL as the sum of portfolio segment IDL

$$\mathrm{IDL}_{\mathrm{TOTAL}} = \mathrm{IDL}_{\mathrm{SOV}} + \mathrm{IDL}_{\mathrm{MA}} + \mathrm{IDL}_{\mathrm{CORP}}$$

[212] *See* footnote 170.

[213] Agency MBS are assumed to carry negligible credit risk and are excluded from the model. Foreign agency exposures, however, are included.

[214] Determining portfolio segment-specific stressed losses in isolation and then adding them is more sensitive to default risks within each segment and more conservative relative to an alternative approach that would simulate the segments collectively, in a single portfolio, to produce a single stressed loss amount. This reflects imperfect correlation between the segment-specific loss outcomes' "diversification benefit"—the tendency for severe outcomes in one segment to not necessarily coincide rigidly with severe outcomes in other segments. There is additional discussion of this topic, including why the Trading IDL Model takes the more conservative approach, in Section F(vi)(b) (Alternative Approaches).

$\mathrm{IDL}_{\mathrm{TOTAL}}$ is then divided equally over the nine-quarter stress test horizon, resulting in a pre-tax loss contribution of $\mathrm{IDL}_{\mathrm{TOTAL}}/9$ in each projection quarter PQ_t for $t = 1, \ldots, 9$.

The three portfolio segment losses IDL_P, which together comprise $\mathrm{IDL}_{\mathrm{TOTAL}}$, are each determined in a simulation (detailed immediately below), which broadly involves the use of random number generation in conjunction with issuer default probabilities, to simulate scenarios in which each issuer within the given portfolio segment defaults or survives during the nine-quarter stress test horizon—effecting a loss realization for the portfolio segment, more or less severe, depending on the extent of defaults and the sizes of the particular obligors that defaulted in the scenario. By repeating this process, a range of many possible scenarios are generated, which in turn define a corresponding range of potential portfolio segment loss realizations. Ultimately a loss from the severe end of this range (specifically from the 93rd percentile) is taken as the final stressed loss amount for the portfolio segment.

$\mathrm{IDL}_{\mathrm{TOTAL}}$ thus captures the total loss to a firm that would result cumulatively over nine quarters if relatively severe default loss outcomes were realized in each of the three portfolio segments. The total loss is divided equally into the nine quarters of the stress test horizon to reflect defaults accruing both incrementally over the horizon and with constant intensity in each projection quarter.

b. *Portfolio IDL*

IDL_P is defined, for each portfolio segment $P \in \{\mathrm{SOV}, \mathrm{MA}, \mathrm{CORP}\}$, as the maximum of (i) the 93rd percentile of the random jump-to-default loss variable $\boldsymbol{L_P}$ (defined below) and (ii) zero:

Equation F-2 – portfolio IDL

$$\mathrm{IDL}_P = \max(q_{0.93}[\boldsymbol{L_P}], 0)$$

$\boldsymbol{L_P}$ is a random variable[215] (and so denoted in bold text, a convention used to distinguish random variables throughout the Trading IDL Model description) capturing the distribution of potential default loss outcomes, in portfolio segment P. This distribution is determined by repeated simulation of issuer default scenarios, as detailed below, in which "default indicators" $\boldsymbol{I_i}$, specific to each issuer i, record the default ($\boldsymbol{I_i} = 1$) or survival ($\boldsymbol{I_i} = 0$) of that issuer, based on the outcome of a random number draw (in a process broadly analogous to flipping a coin to determine the default or survival of each issuer). The 93rd percentile of the distribution, denoted by $q_{0.93}[\boldsymbol{L_P}]$ in Equation F-2, represents a stressed default loss outcome corresponding to a level of loss that is attained or exceeded by only seven percent of the possible scenarios simulated by the model, and is therefore commensurate with the general severity of outcomes depicted in the stress test—the stress test being predicated on severe recessions, which have historically occurred at a similarly rare frequency.[216] The use of a distribution of outcomes to characterize jump-to-default risk, generated independently and without conditioning on scenario variables, is chosen in view of the unreliable relationship between jump-to-default losses and the broader economic environment—a relationship that can be significantly influenced by portfolio composition artifacts, where idiosyncratic events pertaining to specific large exposures may be as or more important in determining loss severity than general economic conditions, and where even the direction of the relationship could be positive or negative, depending on the balance of long and short credit exposures held at a given point in time.

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[215] A variable that, rather than having a fixed numerical value, may take any value in a range, according to a probability distribution.

[216] The motivation for selecting this particular point (93rd percentile) in the upper tail of the loss distribution (further discussed in Section F(v)(f)) is the same as followed in the Operational Risk Model, which similarly uses the 93rd percentile of an unconditional modelled loss distribution, to capitalize a risk that may be substantially idiosyncratic in nature.

IDL_p is floored at zero (i.e., equal to the maximum of $q_{0.93}[\boldsymbol{L_P}]$ or zero, per Equation F-2), so that for a portfolio segment dominated by credit positions that would produce gains upon the default of their issuer,[217] and for which in consequence the large majority of simulated default scenario losses, including the 93rd percentile, are negative,[218] IDL_P will be zero. Preventing negative amounts for such portfolios avoids subtracting from projected losses and risk capture with regard to the other portfolio segments addressed by the model.

c. *Portfolio Jump-to-Default Loss Distribution*

For a given portfolio P, exposed to issuers indexed by $i = 1, \dots, n$, the total jump-to-default loss amount for the portfolio is represented by the random variable $\boldsymbol{L_P}$, which captures the cumulative jump-to-default loss amount at horizon $T = 2.25$ years (i.e., the end of the nine-quarter planning horizon), resulting from issuer defaults indicated[219] by $\boldsymbol{I_1}, \boldsymbol{I_2}, \dots, \boldsymbol{I_n}$:

Equation F-3 – portfolio jump-to-default loss, as a function of default indicators (for n constituent issuers)

$$\boldsymbol{L_P} = f_P\left(\begin{bmatrix}\boldsymbol{I_1}\\ \vdots \\ \boldsymbol{I_n}\end{bmatrix}\right)$$

Where:

- utilizing the Vasicek approach,[220] $\boldsymbol{I_i} = \boldsymbol{I}_{\boldsymbol{V_i} \leq \boldsymbol{\tau_i}}$ where the $\boldsymbol{V_i}$ [221] capture correlated changes in issuer financial condition over the stress test horizon, as further specified in Equation

[217] For example, credit default swaps entered as the protection buyer.

[218] A negative loss is equivalent to a gain.

[219] These indicators are random variables that take the value one for default by horizon T, and zero otherwise.

[220] Vasicek's single-factor Gaussian copula model, due to Vasicek, is a foundational credit risk model for modelling portfolio default losses and incorporating correlation between issuers. *See e.g.*, Vasicek, O. 1987. Probability of Loss on Loan Portfolio (KMV). The framework remains widely used, for example, as a market convention for quoting implied correlation on CDS tranches and in structured credit markets more generally.

[221] $\boldsymbol{V_i}$ refers to the set of variables $\{\boldsymbol{V_1}, \boldsymbol{V_2}, .., \boldsymbol{V_n}\}$ indexed by i.

F-5, and the τ_i represent credit rating-based default thresholds, below which a fall in financial condition results in a default, per Equation F-4;

- f_P is a function representing the calculation of jump-to-default losses, resulting from the indicated defaults, using FR Y-14Q, Schedule F (Trading) exposure inputs specific to each portfolio segment P (further detailed below), where an individual issuer's default may produce a gain or loss depending on the direction of exposure to that issuer, which in general may be "long" or "short;"[222] and
- a uniform recovery rate, $RR = 25\%$, is assumed for each default (as explained below).

The distribution of $\boldsymbol{L_P}$ is numerically generated by simulating realizations of the correlated set of financial condition variables, $\boldsymbol{V_1}, \boldsymbol{V_2}, \dots, \boldsymbol{V_n}$, which determine resulting realizations of the default indicators $\boldsymbol{I_1}, \boldsymbol{I_2}, \dots, \boldsymbol{I_n}$, specific to each issuer (through comparison of each issuer's $\boldsymbol{V_i}$ realization with its associated default threshold τ_i). Each set of default indicator realizations constitutes a "scenario" in which each issuer has been determined to default or survive over the projection horizon, and in which a corresponding realization of the cumulative portfolio jump-to-default loss $\boldsymbol{L_p}$ can be calculated (per Equation F-3). Repeated simulations produce a large sample of $\boldsymbol{L_p}$ outcomes from whose distribution a tail loss percentile (the 93rd) is ultimately taken, per Equation F-2.

This approach to modeling portfolio jump-to-default loss is an effective method of characterizing the risk posed collectively by a group of issuers, accounting for the size of

[222] A long (short) position in a given credit asset is defined as one that would experience a loss (gain) upon default of the asset's issuer or reference entity.

exposure and credit quality associated with each issuer, as well as the correlation between issuers and their propensity to default in unison, in response to economic stress.

d. *Base Probability of Default*

The model assumes, for each issuer i, a base PD over the stress test horizon, denoted by $p_{R[i]}$, that depends only on issuer credit rating $R[i]$ and is related to the financial condition variable $\boldsymbol{V_i}$ via:

Equation F-4 – PD for issuer i

$$p_{R[i]} = p(\boldsymbol{V_i} \leq \tau_i) = N(\tau_i)$$

Where:

- $\boldsymbol{V_i}$ is a standard normal random variable,[223] broadly representing uncertainty regarding how issuer i's financial condition may evolve over horizon T;
- $N(\cdot)$ represents the standard normal cumulative distribution function (CDF);[224] and
- τ_i represents a critical threshold whereby financial condition deterioration below this threshold will manifest as a default event, with $\tau_i = N^{-1}\left(p_{R[i]}\right)$, where $N^{-1}(\cdot)$ is the standard normal inverse CDF.[225]

[223] A random variable that obeys the standard normal (Gaussian) distribution—a foundational distribution in the field of probability and statistics—which has a mean of zero and a standard deviation of one. The use of normal random variables to capture the uncertain and correlated evolution of issuer financial conditions is consistent with the Vasicek approach (*see* footnote 219) and remains a widespread industry practice. In this case, the choice of a normal distribution is not a significant driver of model results relative to other distributional choices because the model is calibrated to historical default outcomes in a manner that would tend to preserve its projected loss severity, even if a different distribution were utilized.

[224] The standard normal CDF quantifies, for a given threshold τ, the probability that a standard normal random variable will fall at or below that threshold. Mathematically, $N(\tau) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{\tau} e^{-x^2/2} dx$.

[225] The standard normal inverse CDF maps a given probability p to the threshold τ for which $N(\tau) = p$, i.e., the threshold that a standard normal random variable would fall at or below with probability p.

Variable $p_{R[i]}$ is a “base” PD in the sense that it is consistent with average default rates exhibited historically over a long observation period, inclusive of a variety of economic conditions, rather than being a PD specific to stressed conditions. Stress is incorporated into the model by selecting a high percentile from a range of simulated default scenarios, scenarios that themselves depict various economic conditions (captured by the “systemic factor” variable $\mathbf{X}_{\mathrm{P}}$, introduced in Equation F-5 and associated variation in issuer PDs, above or below the model’s base PD assumptions.

The default thresholds τ_i are calibrated from a set of base default probabilities p_R, which only depend upon credit rating $R \in \{\text{AAA, AA,A, BBB, BB, B, CCC-C, NR}\}$ and that reflect long-run historical averages of cumulative default rates over the horizon $T = 2.25$ years. Default probabilities determined for the 2024:Q4 stress test effective date are provided in Figure F-1 for illustration, though the p_R are updated annually, as described below. Issuer credit ratings themselves are sourced from FR Y-14Q submission data (where firm reporting of issuer exposures include credit ratings), with the following exceptions: (i) sovereign issuer ratings and (ii) ratings of the constituent issuers included in credit indices[226] are independently sourced from credit rating agencies.

[226] A credit index (or CDS index) tracks the credit risk of a representative basket of debt issuers (for example North American investment grade corporate issuers) and typically includes roughly 100 reference entities. Firms trade derivatives that reference credit indices, giving rise to jump-to-default exposure in respect of their constituents.

Figure F-1 – Base nine-quarter default probabilities by rating, corresponding to the 2024:Q4 stress test effective date.[227]

Rating R	Base 9Q default probability p_R
AAA	0.01%
AA	0.19%
A	0.26%
BBB	0.74%
BB	3.11%
B	8.23%
CCC-C	18.07%
Not Rated	3.11%

The calibration of base default probabilities to average default rates recorded over a long historical observation period (of just over 100 years in length) anchors the distribution of default outcomes projected by the model around a stable level of severity that is not tied to any particular point in the economic cycle; rather, it represents rates of default under average economic conditions and so may reasonably be used each year as the baseline around which possible deviations in default severity over a given nine-quarter projection horizon are simulated.

e. *Issuer Correlation*

Following the Vasicek approach, correlation between issuers, within each portfolio segment P, is created by expressing the financial condition variable $\boldsymbol{V_i}$ for any issuer, as the sum of two independent random components $\boldsymbol{X_P}$ and $\boldsymbol{\varepsilon_i}$ (defined below):

[227] Calibration for each rating grade is based on the historical two-year cumulative default rate, observed on average over 1920–2023, among all corporate issuers with the relevant third-party data vendor's rating, then scaled to a 2.25-year cumulative default rate, as further described in Section F(v)(d).

Equation F-5 – single factor Gaussian default copula

$$\boldsymbol{V_i} = \sqrt{\rho} \cdot \boldsymbol{X}_P + \sqrt{1-\rho} \cdot \boldsymbol{\varepsilon_i}$$

Where:

- $\boldsymbol{X_P}$ is a systemic factor[228] representing general economic conditions pertinent to the performance of all issuers, where, by appearing in the expression for every issuer's financial condition, $\boldsymbol{X_P}$ acts as a common driver of performance across all issuers, inducing correlation between them, and thus capturing systemic risk;
- $\boldsymbol{\varepsilon_i}$ is an idiosyncratic factor**,** representing risks particular to issuer i only—each $\boldsymbol{\varepsilon_i}$ is independent of the systemic factor, and is unique to and only impacts issuer i, without influences on any other issuer, and hence captures issuer-specific risks;
- $\boldsymbol{X_P}$ and $\boldsymbol{\varepsilon_i}$ both follow standard normal distributions and when summed give rise to $\boldsymbol{V_i}$, which also follows a standard normal distribution;[229] and
- ρ is the correlation $\rho(\boldsymbol{V_i}, \boldsymbol{V_j})$ between outcomes for any pair of issuers i and j, within a given portfolio segment P, indicating their shared sensitivity to the systemic factor $\boldsymbol{X_P}$. In the Trading IDL Model, ρ is set to twenty-five percent for the corporate, sovereign, and municipal / agency portfolio segments.[230]

[228] In the context of the Vasicek approach, the systemic factor is a latent (unobservable) variable representing the broad market or macroeconomic conditions that simultaneously affect all the individual entities (issuers) within a portfolio. *See* Vasicek, O., 2022. Loan Portfolio Value (Risk 15/12). The systemic factor captures the broad mechanism by which correlation between issuers arises; it is intended to be representative and does not correspond to an explicit measurable economic quantity.

[229] The sum of two independent, normally distributed, random variables is also normally distributed, with mean and variance given by the sum of the two means or variances—this is a foundational result in the field of probability and statistics and a convenience of using the normal distribution. For additional information on the standard normal distribution and its use in this model, see footnote 219.

[230] *See* Section F(v)(e) (Specification Rationale and Calibration) for more details.

The issuer correlation assumption is a key driver of loss severity in the model, with higher correlation reflecting issuers that are more systemically sensitive to the common economic environment they are operating in (captured by $\boldsymbol{X_P}$), and hence more liable to face concurrent solvency issues as that environment deteriorates (reflected in the model' simulations by $\boldsymbol{X_P}$ realizations that are more negative). Parameter ρ is hence calibrated, given the set of base default probabilities by rating specified above, to ensure the model produces a reasonable distribution of default rates around this base level—one that is consistent with historically observed default rate variability, including the elevated default rate outcomes seen in past periods of stress (and the degree of systemic risk or issuer correlation these outcomes are indicative of).

iv. Technical Specification by Portfolio Segment

The general form of the portfolio jump-to-default loss calculation (provided in Equation F-3) is applied as noted and motivated above, to each of three portfolio segments $P \in \{\mathrm{SOV}, \mathrm{MA}, \mathrm{CORP}\}$, or sovereign ("SOV"), municipal or agency ("MA"), and corporate ("CORP") credit instruments. In this section, further technical detail is provided covering the particular FR Y-14Q exposure inputs utilized for each portfolio segment, in the application of Equation F-3, to determine each respective portfolio jump-to-default loss variable $\boldsymbol{L_P}$.

Note that in general, the Trading IDL Model projects default risk against exposures reported in Schedule F under the submission types "Trading" and "CVA Hedges" (per the FR Y-14Q instructions and nomenclature). Together they partition[231] the trading book population, where CVA Hedges capture the subset of the trading book used specifically for the purpose of

[231] The two sub-populations, "Trading" and "CVA Hedges" submissions, respectively, together cover the trading book in full and do not overlap.

hedging credit risk associated with derivatives transactions (as further described in the CVA Model in Section G). Since the distinction between CVA Hedges and other trading book positions is not relevant for the Trading IDL Model (which views these positions as presenting equivalent jump-to-default risk, regardless of their particular purpose within the trading book), the "Trading" and "CVA Hedges" submissions are combined by the model when projecting portfolio jump-to-default losses, as specified below.

a. *Sovereign Portfolio Jump-to-Default Loss*

Sovereign portfolio jump-to-default loss[232] $\boldsymbol{L}_{\mathbf{SOV}}$ is determined based on the notional N_i and (bond-equivalent)[233] market value MV_i of exposure, reported as of a given FR Y-14Q, Schedule F (Trading) effective date t_0, for the sovereign issuer line items i, tabulated in FR Y-14Q, Schedule F.20 (Sovereign Credit) and noted by specific field codes below, as follows:

Equation F-6 – sovereign portfolio jump-to-default loss

$$\boldsymbol{L}_{\mathbf{SOV}} = \begin{bmatrix} J_1 \\ \vdots \\ J_n \end{bmatrix}' \cdot \begin{bmatrix} \boldsymbol{I_1} \\ \vdots \\ \boldsymbol{I_n} \end{bmatrix}$$

where defaults are indicated by $\boldsymbol{I_i} = \boldsymbol{I}_{\boldsymbol{V_i} \leq \boldsymbol{\tau_i}}$ for each specific sovereign issuer $i = 1, \ldots, n$ tabulated individually on Schedule F.20 (which includes explicit line items for seventy individual sovereign issuers), with:

- $\boldsymbol{V_i} = \sqrt{\rho} \cdot \boldsymbol{X}_{\mathrm{SOV}} + \sqrt{1-\rho} \cdot \boldsymbol{\varepsilon_i}$ (per Equation F-5), and with $\rho = 25\%$;
- $\tau_i = N^{-1}\left(p_{R[i]}\right)$ with $p_{R[i]}$ being the base default probability (per Equation F-4) corresponding to each sovereign's long-term foreign currency rating $R[i]$, as of t_0,

[232] Sovereign portfolio jump-to-default loss is the random variable reflecting cumulative default impacts, over the nine-quarter projection horizon, with respect to all sovereign credit instruments.

[233] Per FR Y-14Q instructions, bond equivalent market value of a credit position represents the loss or gain when all issuers referenced by the position default without recovery.

mapped onto the whole-notch rating scale {AAA, AA, A, BBB, BB, B, CCC-C, NR} utilized in the model and described in Figure F-1; and

- each jump-to-default loss J_i, is calculated as:[234]

Equation F-7 – sovereign issuer jump-to-default loss

$$J_i = s_i \cdot \text{median}(0, |\text{MV}_i - N_i \cdot \text{RR}|, |\text{MV}_i|)$$

with MV_i and N_i being the sum of all local currency (CTRDH123, CTRDH124) and foreign currency (CTRDH125, CTRDH126) market value and notional amounts, respectively, reported for t_0 with respect to sovereign issuer i, under submission types (CTRDH346) "Trading" or "CVA Hedges," with $s_i = \text{sgn}(\text{MV}_i)$ equal to positive of negative one for net long and short positions, respectively, and $\text{RR} = 25\%$ (the uniform recovery rate assumption applied to all defaults); and where exposure to sovereigns in default at t_0 is excluded.

b. *Municipal / Agency Jump-to-Default Loss*

Municipal/agency jump-to-default loss $\boldsymbol{L}_{\mathbf{MA}}$ is determined based on net market values, aggregated by rating R, over foreign-agency, municipal, and auction rate securities reported for t_0 respectively in FR Y-14Q, Schedules F.15, F.16, and F.17, and further subdivided, using the same calculation methodology as in a previous section and $\rho = 25\%$.

Equation F-8 – municipal / agency portfolio, jump-to-default loss

$$\boldsymbol{L}_{\mathbf{MA}} = \begin{bmatrix} J_1 \\ \vdots \\ J_n \end{bmatrix}' \cdot \begin{bmatrix} \boldsymbol{I_1} \\ \vdots \\ \boldsymbol{I_n} \end{bmatrix}$$

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234 Note that the median expression can be read as $\text{median}(floor, |\text{MV} - N \cdot RR|, cap)$, meaning that jump-to-default loss is generally the difference between the pre-default market value MV and post default recovery value $N \cdot$ RR, but floored at zero (to prevent positions from gaining in value upon default) and capped at MV (to prevent positions from losing more than their market value, which could otherwise occur in rare cases when MV and N have different signs, due to the mechanics of netting and aggregating different instruments referencing the same issuer).

c. *Corporate Portfolio Jump-to-Default Loss*

Corporate portfolio jump-to-default loss $\boldsymbol{L}_{\mathbf{CORP}}$ is calculated as the sum of three correlated components, capturing losses on different types of credit instruments in three corporate portfolio segments (Single-Name Products, Index Products, and Other instruments):

Equation F-9 – corporate portfolio jump-to-default loss

$$\boldsymbol{L}_{\mathbf{CORP}} = \boldsymbol{L}_{\mathbf{SN}} + \boldsymbol{L}_{\mathbf{INDEX}} + \boldsymbol{L}_{\mathbf{OTH}}$$

Where:

- $\boldsymbol{L}_{\mathbf{SN}}$ is default loss on Single-Name Product[235] exposures, reported in FR Y-14Q, Schedule F.22 (IDR-Corporate Credit), Tables D & E;
- $\boldsymbol{L}_{\mathbf{INDEX}}$ is default loss on Index Product[236] exposures reported in FR Y-14Q, Schedule F.22, Table F and FR Y-14Q, Schedule F.21 (Credit Correlation); and
- $\boldsymbol{L}_{\mathbf{OTH}}$ captures default losses on Other remaining corporate exposures (neither non-single name nor index CDS positions) by rating, reported in FR Y-14Q, Schedule F.22 Table C.[237]

The Vasicek approach is used to model underlying issuer defaults for all three of these segments. Assuming a correlated set of default indicators, $\boldsymbol{I}_{\boldsymbol{i}} = \boldsymbol{I}_{\boldsymbol{V}_{\boldsymbol{i}} \leq \boldsymbol{\tau}_{\boldsymbol{i}}}$, influenced by the same common systemic factor $\boldsymbol{X}_{\mathbf{CORP}}$ through the set of random variables $\boldsymbol{V}_{\boldsymbol{i}} = \sqrt{\rho} \cdot \boldsymbol{X}_{\mathrm{CORP}} + \sqrt{1-\rho} \cdot \boldsymbol{\varepsilon}_{\boldsymbol{i}}$, corresponding, per Equation F-5, to the financial condition of each corporate issuer

[235] A Single-Name Product is a credit instrument whose value is sensitive to the creditworthiness of a single issuer (e.g., a bond issued by a single corporate or a credit default swap referencing a single entity).

[236] Index Products are credit default swaps referencing an index of issuers (*see* footnote 225) rather than a single entity.

[237] Table C collects residual "Other" credit exposures, which represent a small minority of positions that do not meet the definition of a single name product or index CDS exposure. For example, exposure to an exchange traded debt fund that could not be decomposed into constituent credits could be included in "Other."

(with corporate issuers indexed by i), with $\rho = 25\%$,[238] only the translation from defaults into losses differs between the segments. For Single Name Products, jump-to-default loss amounts are determined for each issuer and summed across those defaulting for a given scenario, analogous to the treatment of sovereigns, above. For Index Products, the same methodology is similarly used to project loss rates on underlying credit indices based on the credit rating profile of their constituent reference entities, but an additional step is required to translate the loss rate simulated on a given index into a corresponding Index Product impact, incorporating key contractual features (i.e., strike level for option exposures or seniority for tranche positions) of the Index Products referencing the credit index in question. Specifics on the form of loss projection adopted for each type of corporate exposure (Single Name Products, Other and Index Product) follow below.

(1) Single Name Products

The portfolio loss $\boldsymbol{L_{\mathrm{SN}}}$ from defaults by corporate issuers to which a firm is exposed through single-name products (as reported in Schedule F.22, Tables D & E), is determined as follows in Equation F-10, where the calculation distinguishes between "Large Issuers"[239] and "Small Issuers."[240] For Large Issuers the Vasicek approach is applied directly, using issuer-level exposure information reported in Schedule F.22 to determine individual jump-to-default loss

[238] The financial condition variable for each issuer is constructed as a linear combination of a systemic and an idiosyncratic factor, as described in ***Equation F-5***. The calibration of the correlation parameter is discussed in Section F(v)(e).

[239] Large Issuers are those for which exposure market value exceeds $50 million, and that are required to be reported individually on Table D. The threshold of $50 million is used in Schedule F.22 to capture the subset of issuers that are big enough to drive idiosyncratic risk and hence warrant reporting individually; it was chosen based on an analysis suggesting that the approximate treatment of issuers smaller than $50 million specified in ***Equation F-10*** does not materially impact losses projected by the model.

[240] Small Issuers are those with market value of less than $50 million, reported in aggregate by rating and long or short direction on Table E.

amounts, while for Small Issuers the Vasicek approach is also applied only after a disaggregation step where the aggregate exposure amounts reported for groups of Small Issuers, organized by direction d, long or short, and rating R in Schedule F.22, are first decomposed into uniformly sized individual issuers[241] (to which the Vasicek approach is then equivalently applied).

Equation F-10 – corporate single name portfolio jump-to-default loss

$$\boldsymbol{L}_{\mathbf{SN}} = \begin{bmatrix} J_1^{\mathrm{LG}} \\ \vdots \\ J_n^{\mathrm{LG}} \end{bmatrix}' \cdot \begin{bmatrix} \boldsymbol{I}_{\mathbf{1}}^{\mathbf{LG}} \\ \vdots \\ \boldsymbol{I}_{\boldsymbol{n}}^{\mathbf{LG}} \end{bmatrix} + \sum_d \sum_R \left(J_{d,R}^{\mathrm{SM}} \cdot \sum_{k=1}^{C_{d,R}} \boldsymbol{I}_{\boldsymbol{d,R,k}}^{\mathbf{SM}} \right) + \boldsymbol{L}_{\mathbf{OTH}}$$

Where:

- $\boldsymbol{I}_{\boldsymbol{j}}^{\mathbf{LG}}$ indicates defaults for each Large Issuer $j = 1, \dots, n$, reported in Schedule F.22, Table D, as of t_0, under submission types "Trading" or "CVA Hedges"; and
- $\boldsymbol{I}_{\boldsymbol{d,R,k}}^{\mathbf{SM}}$ indicates defaults for each Small Issuer reported in FR Y-14Q, Schedule F.22, Table E, under submission types "Trading" or "CVA Hedges," as of t_0, excluding only those already in default[242] at t_0 (CTRDH150 = "< B: Defaulted"), where:
  - $d \in$ {long, short} is direction[243];
  - $R \in$ {AAA, AA, A, BBB, BB, B, CCC-C, NR} is rating (determined from CTRDH150); and
  - $k \in \{1, \dots, C_{d,R}\}$ indexes the individual issuers counted under CTRDLF71 & CTRDLF91, for direction d and rating R;

and where all indicators $\{\boldsymbol{I}_{\boldsymbol{j}}^{\mathbf{LG}}, \boldsymbol{I}_{\boldsymbol{d,R,k}}^{\mathbf{SM}}\}$ are determined, via Equation F-5, as $\boldsymbol{I}_{\boldsymbol{V_i \leq \tau_i}}$, with i universally indexing the individual issuers represented, i.e., with

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[241] This disaggregation step uses the firm-reported count of Small Issuers within each group.

[242] Positions already in default are assumed not to present any further default risk.

[243] *See* footnote 219.

- $\boldsymbol{V_i} = \sqrt{\rho} \cdot \boldsymbol{X}_{\text{CORP}} + \sqrt{1-\rho} \cdot \boldsymbol{\varepsilon_i}$ and $\sqrt{\rho} = 0.25$;
- $\tau_i = N^{-1}\big(p_{R[i]}\big)$ with $p_{R[i]}$ being the base default probability (per Equation F-4) corresponding to each issuer rating, as reported in FR Y-14Q, Schedule F.22 Table B, under CTRDLF86 for Large Issuers and as in FR Y-14Q, Schedule F.22, Table E under CTRDH150 for Small Issuers;

and where:

- for each Large Issuer j[244], jump-to-default loss amount J_j^{LG}, is calculated as:

Equation F-11 – corporate large issuer jump-to-default loss

$$J_j^{\text{LG}} = s_i \cdot \text{median}\big(0, \big|\text{MV}_j^{\text{LG}} - N_j^{\text{LG}} \cdot RR\big|, |\text{MV}_j^{\text{LG}}|\big)$$

with market value MV_j^{LG} and notional value N_j^{LG}, as reported in Schedule F.22, Table D, for t_0, under CTRDLF74 and CTRDLF75, respectively, aggregated by unique large issuer j over submission types (CTRDH346) "Trading" and "CVA Hedges", with $s_j = \text{sgn}(\text{MV}_j^{\text{LG}})$ so that s_j is positive or negative one for long and short credit positions, respectively, and $\text{RR} = 25\%$; and

- each small Issuer jump-to-default loss amount $J_{d,R}^{\text{SM}}$ is calculated as:

Equation F-12 – corporate small issuer jump-to-default loss

$$J_{d,R}^{\text{SM}} = s_d \cdot \frac{1}{C_{d,R}} \cdot \text{median}\big(0, \big|\text{MV}_{d,R}^{\text{SM}} - N_{d,R}^{\text{SM}} \cdot \text{RR}\big|, |\text{MV}_{d,R}^{\text{SM}}|\big)$$

with long and short market value $\text{MV}_{d,R}$ (CTRDH151 and CTRDH152), notional $N_{d,R}^{\text{SM}}$ (CTRDH154 and CTRDH155), and issuer count $C_{d,R}$ (CTRDLF91) as reported for t_0, in Schedule F.22, Table E, aggregated over submission types (CTRDH346) "Trading" and "CVA

[244] For Large Issuers that may present significant concentration risk, losses are calculated based on individually reported issuer sizes. For Small Issuers, losses are estimated based on the aggregate characteristics of groups of issuers, organized by rating and exposure direction.

Hedges" by direction d (long or short) and rating R (CTRDH150), and with s_d taking the value of positive or negative one when d is long or short, respectively.

(2) Other Products

The portfolio jump-to-default loss $\boldsymbol{L}_{\mathbf{OTH}}$ from defaults by corporate issuers to which a firm is exposed through products other than single-name products or index CDS products, is determined based on market values and notional amounts by direction d and rating R reported in FR Y-14Q, Schedule F.22, Table C according to:

Equation F-13 – other corporate exposure portfolio jump-to-default loss

$$\boldsymbol{L}_{\mathbf{OTH}} = \sum_{d} \sum_{R} J_{d,R} \cdot \boldsymbol{I}_{\boldsymbol{d,R}}^{\mathbf{OTH}}$$

Where:

$$J_{d,R} = s_d \cdot \text{median}\left(0, \left|\text{MV}_{d,R} - N_{d,R} \cdot \text{RR}\right|, \left|\text{MV}_{d,R}\right|\right);$$

and where the data for long and short market value and notional are sourced from Schedule F.22, Table C, reported by geographies (CTRDH149) "Advanced Economies" and "Emerging Markets" and submission types (CTRDH346) "Trading" and "CVA Hedges", and by direction d (long or short) and rating R (CTRDH150), and with s_d taking value positive or negative one when d is long or short, respectively, and further subdivided and allocated as $\text{MV}_{d,R}$ and $N_{d,R}$, and $\boldsymbol{I}_{\boldsymbol{d,R}}^{\mathbf{OTH}}$ is indicating defaults for each issuer in the Other / Unspecified segment.

(3) Index CDS Products

The loss $\boldsymbol{L_{INDEX}}$ resulting from defaults by CDS index constituents[245] to which a firm is exposed via linear index, payer index option, and index tranche CDS products,[246] is calculated per Equation F-14. The calculation simulates loss rates $\boldsymbol{L_i}$ on a common representative set of six underlying credit indices (indexed by i) following the approach outlined in Equation F-14, based on a calibrated credit rating profile (depicting the distribution of constituents across credit rating buckets Figure F-2) for each index. The calculation distinguishes between option positions from linear index exposures to broadly capture the non-linear market value impacts expected for option products, as defaults accrue. The default response function f_{opt} in Equation F-14 approximates this non-linearity and principally serves to prevent option exposures with remote strikes from unduly contributing to projected jump-to-default losses. Default response procedure f_{trn} provides a simulation for the loss in market value of a CDS tranche position.

Equation F-14 – corporate CDS index exposures jump-to-default loss

$$\boldsymbol{L}_{\mathbf{INDEX}} = \sum_{i}\left(\mathrm{MV}_{i}^{\mathrm{lin}} \cdot \boldsymbol{L_i} + \sum_{M}\left[\mathrm{MV}_{i,M}^{\mathrm{opt}} \cdot f_{\mathrm{opt}}(\boldsymbol{L_i}, M)\right] + \sum_{T \in \mathrm{T}_i}\left[\mathrm{MV}_{i,T}^{\mathrm{trn}} \cdot f_{\mathrm{trn}}(\boldsymbol{L_i}, T)\right]\right)$$

Where:

- i is an index for CDS index families;

[245] A CDS index references a collection of constituent issuers per note 225.

[246] A linear index CDS is a standard index CDS product without option or tranche features (broadly equivalent to a collection of single-name CDS). A payer index option is an option to enter an index CDS product as the protection buyer. A tranche CDS is a structured credit derivative created by slicing an index CDS into tranches of varying seniority, whereby index constituent defaults are first absorbed by the most junior tranche (which is the most expensive to buy protection against) until it is exhausted, before sequentially impacting the remaining tranches in order of increasing seniority.

$i \in \{\text{CDX IG}, \text{CDX HY}, \text{CDX Other}, \text{ITX Main}, \text{ITX XO}, \text{ITX Other}\}$;[247]

- $\boldsymbol{L_i}$ is the CDS index category loss rate for the index categories above;

Figure F-2 – Assumed credit rating distribution weights, by index category and rating R, with respect to 2024:Q4 stress test effective date for CDX IG, CDX HY, iTraxx Main, iTraxx XO.[248]

Rating	CDX IG	CDX HY	ITRX Main	ITRX XO
AAA	0.9%	0.0%	0.0%	0.0%
AA	2.9%	0.0%	9.9%	0.0%
A	23.0%	1.2%	34.2%	0.0%
BBB	72.4%	9.1%	55.5%	13.6%
BB	0.8%	49.5%	0.4%	50.8%
B	0.0%	31.2%	0.0%	27.6%
CCC-C	0.0%	8.9%	0.0%	8.0%

- $\mathrm{MV}_i^{\mathrm{lin}}$ is the linear index CDS exposure to index category i, as reported at t_0 in FR Y-14Q, Schedule F.22, Table B (under CTRDH153), and aggregated over submission types (CTRDH346) "Trading" and "CVA Hedges";

[247] The index categories follow the segmentation of standard CDS indices around which FR Y-14Q, Schedule F reporting of index exposures is organized.

[248] Weights $w_{i,R}$ for a given effective date t_0 are determined via a weighted average of rating profiles over the on-the-run (OTR) series $l = 0$ as-of t_0 and the ten prior series $l = 1, \dots, 10$ (where l is a lag index in the series number relative to OTR) using series weights F_l that decline with increasing series lag l as follows: $\{F_0, F_1, F_2\} = \{25\%, 25\%, 10\%\}$ and $F_l = 5\%$ for $l = 3, \dots, 10$.

- M indexes the CDS payer option moneyness bucket (receiver options are excluded) with:[249,250]

$$M \in \{< \text{-}400, [\text{-}400,\text{-}200), [\text{-}200,\text{-}100), [\text{-}100,\text{-}0), >= 0\};$$

- $\mathrm{MV}_{i,M}^{\mathrm{opt}}$ is the net payer option exposure to index category i and moneyness bucket[251] M as reported in FR Y-14Q, Schedule F.22, Table F for t_0 (under CTRDLF81), aggregated over series (CTRDLF90) and submission types (CTRDH346) "Trading" and "CVA Hedges";
- T indexes the set of all tranches T_i applicable to each index category i, as tabulated in FR Y-14Q, Schedule F.21, inclusive of both (i) the standard tranches itemized by detachment points[252] as well as, but separately, (ii) the generic bespoke tranches, itemized by "Equity," "Mezzanine," and "Super Senior"[253] designations;

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[249] "Moneyness" measures the distance between the strike of an option (in this case a specified "strike spread" on the credit index referenced by the option) and the corresponding market level currently observed for the options underlying (i.e., the current level of the index spread). Schedule F.22 captures moneyness expressed in percentage points, defined as $(1 - strike\ spread/index\ spread) \cdot 100$, using the bucketing scheme listed in basis points.

[250] Receiver options are options to enter an index CDS as the protection seller. These options become valuable as credit conditions improve and present minimal credit default risk (default losses being limited to a loss of option premium only).

[251] As specified in Trading FR Y-14Q instructions, "Payer Index Options should be bucketed by moneyness based on $(1 - strike\ spread/index\ spread)$ in percentage points."

[252] The attachment and detachment points of a CDS tranche define the loss rates on the underlying credit index at which the tranche itself begins to incur losses (attachment point) and at which the tranche is ultimately exhausted (detachment point). These points set the thresholds for when a CDS protection seller for the tranche initially starts to bear losses from defaults on the underlying credit index and when, as losses further increase, a full payout of the protection notional is ultimately required.

[253] Bespoke tranches are tailored (relative to the standard tranches with established market liquidity pertaining to a given credit index), to meet specific client preferences—e.g., by adding or subtracting index constituents or using alternative attachment / detachment points. Following FR Y-14Q nomenclature and definitions: "Equity" tranches are those with a zero percent attachment point; "Super Senior" tranches are those with a detachment point of 100 percent; and "Mezzanine" tranches are those that are not Equity or Super Senior tranches (so with a non-zero attachment point and a detachment point less than 100 percent).

- $\mathrm{MV}_{i,T}^{\mathrm{trn}}$ is the net exposure to index category i and tranche $T \in \mathrm{T}_i$ as reported in FR Y-14Q, Schedule F.21 for t_0 (under CTRDH140, CTRDH141, CTRDH144, and CTRDH145), aggregated over submission types (CTRDH346) "Trading" and "CVA Hedges";
- $f_{\mathrm{opt}}(\boldsymbol{L_i}, M)$ is, for each non-other index category $i \in \{\text{CDX IG}, \text{CDX HY}, \text{ITX Main}, \text{ITX XO}\}$, the loss in market value of a sold payer option (per dollar of long bond-equivalent MV exposure at t_0), in response to index loss rate $\boldsymbol{L_i}$**,** determined with respect to a generic payer option to enter a five-year maturity Index CDS contract,[254] valued at t_0 based on a third-party data vendor's index option pricing model,[255] assuming
    - option expiry at t_0 plus three months;
    - option strike at moneyness s_M, for positions allocated to bucket M, as tabulated below:

Figure F-3 – proxy spread-moneyness points s_M by moneyness bucket M.[256]

M	< -400	[-400, -200)	[-200, -100)	[-100, -0)	>= 0
s_M	-450	-300	-150	-50	50

- the t_0 index spread of the prevailing on-the-run series of index category i;
- a flat volatility of fifty percent; and

[254] This generic contract is used to proxy a typical payer option jump-to-default exposure, with three-month option expiry and fifty percent implied volatility. It is considered broadly representative based on index option market and transaction data. These expiry and volatility assumptions have a small impact on the shape of f_{opt}, which is primarily driven by option moneyness, and are associated with immaterial sensitivity.

[255] This is an industry standard CDS index option model, available from a third-party data vendor.

[256] Proxy spread-moneyness points are placed at the middle of the three closed strike buckets $M \in$ {[-400, -200), [-200, -100), [-100, -0)}, so as to be broadly reflective of average positions allocated to each of these buckets and near the thresholds of the two terminal buckets, $M \in$ {< -400, >= 0}. This reflects an approximately linear default response f_{opt} for positions with $M >= 0$ and immaterial default response for the most remote options reported with M<-400.

- $f_{\text{trn}}(\boldsymbol{L_i}, T)$ is, for each core (i.e., non-other) index category i, the loss in market value of a CDS tranche position (per dollar of exposure at t_0), in response to index loss rate $\boldsymbol{L_i}$ assuming:
    - Attachment or detachment points indicated by tranche in FR Y-14Q, Schedule F.21, where, to avoid doubt, the detachment points are listed in Figure F-4:

Figure F-4 – detachment points for generic bespoke tranches for indices CDX IG, CDX HY, iTraxx Main, iTraxx XO, as tabulated in FR Y-14Q, Schedule F.21[257]

Tranche	Detachment Point			
	CDX IG	CDX HY	ITX Main	ITX XO
Equity	3%	10%	3%	10%
Mezzanine	30%	35%	22%	35%
Super Senior	100%	100%	100%	100%

- the t_0 index spread of the prevailing on-the-run series of index category i.

v. Specification Rationale and Calibration

a. *Vasicek Default Copula*

The Vasicek approach, where the financial condition variable for each issuer is constructed as a linear combination of a systemic and an idiosyncratic risk factor, as described in Equation F-5, is an effective and widely used method of characterizing the risk posed collectively by a group of issuers. It accounts for both the size of exposure and credit quality

[257] These tranche reporting buckets were created based on common tranche values to accommodate a variety of bespoke tranches and broadly distinguish the risks they present based on their seniority.

associated with each issuer, as well as the correlation between issuers and their propensity to default in unison, in response to economic stress.

b. *Position Scope*

Position Scope refers to the specific trading book positions that are subject to the Trading IDL Model. The Trading IDL Model is designed to capture default risk over the full stress test horizon in trading book credit positions based on unstressed market values reported at t_0.[258] The scope of the Trading IDL Model includes credit-sensitive instruments referencing corporate, sovereign, and municipal/agency issuers.

Securitized products, as reported in FR Y-14Q, Schedule F.14 (Securitized Products), and equity securities (both public and private), as included in FR Y-14Q, Schedule F.23 (IDR-Jump to Default), are excluded from the scope of the model to avoid double-counting against their GMS treatment; historically the market value haircuts applied by the GMS to these exposures were judged to account adequately for overall price risk over an extended horizon and obviated the need for a separate credit default component. However, the Board is now considering adding trading book public equity securities to the scope of the Trading IDL Model to enhance risk capture—see Alternative Approaches Section F(vi).

c. *Exposure Projection*

Exposure projection refers to assumptions made by the model about how the population of positions reported at t_0 evolves over the projection horizon. Unstressed positions reported at t_0 are held constant and subject to cumulative default rates over the full nine-quarter projection

[258] Time t_0 denotes the Schedule F effective as-of date pertaining to a given stress test exercise.

horizon, without aging or replacement in the event of default. An alternative and more complicated methodology could, for example,

(i) divide the projection horizon into n contiguous segments of equal length (commensurate with the characteristic holding period of the trading assets covered by the model), and reset exposures to their t_0 values at the end of each $2.25/n$ year period; and

(ii) utilize GMS-stressed measures of jump-to-default for the initial segments of the projection horizon (e.g., those falling within the calibration horizon of applicable GMS shocks (less than or equal to three months)).[259]

The use of unstressed exposures over the full projection horizon, without any GMS adjustment, was chosen over more complicated approaches, such as the one outlined above, in accordance with the principle of simplicity described in the Stress Testing Policy Statement, and in view of the following considerations: (i) GMS calibration horizons account for no more than one ninth of the horizon that defaults are projected, which, coupled with the frequency at which trading assets turn over as well as the long and short nature of the positions within the model's scope, makes the net influence of the GMS on jump-to-default exposures and losses a secondary effect of low materiality; and (ii) additional Y-14 reporting burden would be required to obtain reliable estimates of issuer-level stressed and unstressed jump-to-default exposures systematically across the assets covered by the model.

[259] Since GMS shocks are calibrated to a time horizon no greater than three months, the GMS adjustment to jump-to-default exposures would apply to the first projection period only.

The projection of cumulative default risk, against positions held at t_0 over a single nine-quarter period without replacement in the event of a default, was chosen following comparisons of loss rates per dollar of initial market value under this approach and an alternative multi-period approach with replacement. These comparisons suggested that the simpler approach results in similar loss severity but with fewer assumptions and is hence preferred. This adheres to the Stress Testing Policy Statement's principle of simplicity.

d. *Base Probability of Default & Recovery Rate*

Base probability of default refers to the average cumulative nine-quarter default rates assumed in the model. Base probabilities of default p_R depend only on credit rating $R \in$ {AAA, AA, A, BBB, BB, B, CCC-C, NR} for all issuers. The p_R are calibrated annually to average long-run cumulative default rates, reported by rating, from a third-party data vendor.

For a stress test conducted in year t (with jump-off-point in year $t - 1$), the p_R are derived from the third-party data vendor's reported average cumulative issuer-weighted global default rates by letter rating $p_R^{2\mathrm{Y}}$ for a two-year default horizon consistent with the nine-quarter projection horizon, averaged over the period beginning with the year 1920, through and inclusive of the year $t - 2$, via:

Equation F-15 – nine quarter base PD calibration, calculated via simple scaling of a third-party data vendor's two-year long run average PDs by rating since 1920

$$p_r = 1 - (1 - p_R^{2\mathrm{Y}})^{\frac{9}{8}}$$

The model's global recovery rate assumption of $\mathrm{RR} = 25\%$ was inferred from tail outcomes in the time-series of average corporate bond recovery rates by year since 1983, included in a third-party data vendor's annual global corporate default study. The recovery rate distribution is relatively stable; hence, this value is, in general, not recalibrated annually while it remains consistent with the fifth percentile of this annual bond recovery time series.

The decision to utilize a common set of base probabilities of default by rating and a common stressed recovery rate for all issuers (be they corporate or government entities) calibrated to historical corporate default and recovery data was due to: (i) data sparsity concerns with respect to historical non-corporate defaults; and (ii) because the limited and idiosyncratic data on average historical sovereign defaults and recoveries do not suggest significant differences relative to the corporate default and recovery data.

e. *Issuer correlation*

The issuer correlation assumption, as noted above, is an important driver of loss severity in the model, with higher correlation reflecting issuers that are more systemically sensitive to the common economic environment they are operating in (captured in Equation F-5 by $\boldsymbol{X_P}$) and hence more liable to face concurrent solvency issues as that environment deteriorates (resulting in model simulations, by $\boldsymbol{X_P}$, in realizations that are more negative). The issuer correlation assumption is hence calibrated to ensure the model produces a reasonable distribution of default rates—one that is consistent with historically observed default rate variability, including the elevated default rate outcomes seen in past periods of stress (as well as the degree of systemic risk or issuer correlation these outcomes are indicative of).

The Board calibrated the issuer correlation $\rho = 25\%$ to the same historical default data as used to determine base probabilities of default by rating—specifically the record of defaults by a third-party data vendor's rated corporate entities since 1920. Fixing the base probabilities by rating to their average levels (as tabulated for example in Figure F-1), the likelihood of different degrees of correlation giving rise to this historical default data, under the default copula specification of Equation F-5, is calculated. The relative strength of the likelihoods associated with different correlation levels is used to select a correlation level that appropriately comports with the data. While the historical record of sovereign defaults is much less abundant, a similar analysis is used, based on a third-party data vendor's rated sovereign defaults since 1983, to determine if the same correlation assumption is valid for sovereigns. The analysis found that it is not, and in view of comparable correlation in the credit default swap spreads of different sovereigns compared to corporates, the Board determined to harmonize the correlation assumption to twenty-five percent for all issuers.

Similarly, for the miscellaneous domestic and foreign exposures included in the Municipal / Agency segment, which collectively account for only a small fraction (approximately ten percent) of modeled losses, the Board prefers not to maintain a separate issuer correlation calibration, consistent with the Stress Testing Policy Statement's principle of simplicity.

Issuer correlation assumptions are in general not updated annually, absent significant new information pertinent to tail default rate outcomes.

f. *Tail Loss Percentile*

The model determines a distribution of potential nine-quarter jump-to-default loss realizations for each firm and portfolio segment. The Board uses the 93rd percentile from the modeled distributions to represent a stressed outcome, with the degree of stress commensurate with the general severity of outcomes depicted in the stress test. The 93rd percentile is chosen based on the frequency of severe recessions.[260] More specifically, in the sixty years from 1956

[260] The 93rd percentile is also used in the Operational Risk Model, following the same rationale. *See* Section A(iv) (Model Specification) in the Operational Risk Model Documentation.

to 2015 (with 2015 corresponding to the year when this practice was first adopted), nine recessions occurred, four of which were severe.[261] Thus, the calculated frequency of severe recessions is four in sixty years or roughly an event that happens once every fifteen years. This frequency suggests a draw from the 93rd percentile of the jump-to-default distribution.[262]

vi. Alternative Approaches

a. *Inclusion of Public Equity Jump-to-Default Risk*

The Trading IDL Model currently excludes equity securities from its calculation of corporate portfolio jump-to-default loss. Historically the market value haircuts applied by the GMS to equity exposures were judged to account adequately for overall price risk over an extended horizon, obviating the need for a separate credit default component. However, due to the transition of private equity positions out of the scope of the GMS (they are now stressed via the macroeconomic scenario instead) and adjustments to the calibration of GMS shocks for public equity (reducing their severity), the Board is considering adding trading book public equity issuer exposure to the scope of the Trading IDL Model to enhance risk capture. This could be achieved, along with general simplification in the Corporate portfolio jump-to-default loss calculation, by utilizing issuer exposures reported in FR Y-14Q, Schedule F.23 to project default losses on all corporate products (both debt and equity positions). Non-linearity in loss response as defaults accrue against index option positions would no longer be explicitly modeled. Instead, the marginal impact of each corporate issuer default in isolation, as reported

[261] The timeframe and recession classification are consistent with the Policy Statement on the Scenario Design Framework for Stress Testing. *See* 12 CFR 252, Appendix A.

[262] The 93rd percentile is derived as $1 - \frac{4}{60} \approx 0.93$.

in FR Y-14Q, Schedule F.23, inclusive of all relevant corporate product impacts, would be utilized additively in the model.

The Board seeks comment on this alternative treatment of corporate exposures, which would involve revisions to FR Y-14Q, Schedule F.23 to exclude private equity positions and standardize the recovery rate assumptions used in determining issuer jump-to-default amounts.

b. *Correlation Structure*

Correlation structure refers to how the Trading IDL Model mechanically combines risks arising in different portfolio segments, as well as the resulting issuer correlation assumptions within each segment. In the model, stressed jump-to-default loss realizations are determined separately in each of three portfolio segments (corresponding to corporate, sovereign, and municipal/agency issuers) and then combined additively without diversification benefits. The Board considered an alternative approach, in which all issuer defaults are sensitive to a common systemic factor, and where default losses are projected in an integrated simulation without segmentation, producing a single tail loss result. The segmented approach was determined to be preferable, as it is: (i) more risk sensitive with respect to potential issuer concentrations within the corporate and sovereign segments; and (ii) more transparent and interpretable in its determination of explicit loss amounts for each portfolio segment, the loss amounts being comparable across firms. The Board also considered pursuing a more granular correlation structure, with additional factors to capture higher degrees of co-movement in the creditworthiness of issuers occupying the same industry group or geographic region. However, the Board determined that the additional risk capture gained by this type of refinement would be limited, and, in view of the additional assumptions, complexity, and reporting requirements it would introduce, preferred the simpler one-factor model specified, in accordance with the Stress Testing Policy Statement's principle of simplicity.

vii. Data Adjustments

The Trading IDL Model utilizes FR Y-14Q exposure inputs as described in the model specification section, without adjustment. In cases where FR Y-14Q inputs are identified as unusual or potentially erroneous, these are escalated to the reporting firm for confirmation or correction.

viii. Assumptions and Limitations

a. *Position Scope*

Position Scope refers to the specific trading book positions that are subject to the Trading IDL Model. The Trading IDL Model is designed to capture salient default risks, not otherwise accounted for in the stress test, and over the full stress test horizon in trading book credit positions based on unstressed market values reported at t_0. The model assumes that securitized products, as reported in FR Y-14Q, Schedule F.14, and equity securities (both public and private), as included in FR Y-14Q, Schedule F.23, should be excluded to avoid double counting against stress treatment outside of the Trading IDL Model. However, as noted in the Alternative Approaches section, Section F(vi), due to the transition of private equity positions out of the scope of the GMS component of the stress test (they are now stressed via the macroeconomic scenario instead) and reductions in the severity of GMS shocks for public equity, the Board is considering adding trading book public equity positions to the scope of the Trading IDL Model to enhance risk capture.

b. *Exposure Projection*

Exposure projection refers to assumptions made by the model about how the population of positions reported at time t_0 evolves over the projection horizon. The model assumes unstressed exposure reported at t_0 is frozen and subject to cumulative default rates over the full nine-quarter projection horizon, without replacement in the event of default and without consideration of contractual maturity for individual positions. The assumed form of exposure projection is chosen for the simplicity it affords, without material impact relative to more complex approaches (as discussed in the Specification Rationale and Calibration section, Section F(v)(c)).

c. *Correlation Structure*

The model assumes stressed jump-to-default loss realizations can be determined separately in each of three portfolio segments covered by the model and then combined additively without diversification benefits. Determining segment-specific stressed losses in isolation and then adding them in this manner, is preferred (relative to an alternative approach that would simulate the segments collectively, in a single portfolio, to produce a single stressed loss amount), as noted above, for being more sensitive to default risks within each portfolio segment and for producing interpretable loss projections that are can be directly attributed by portfolio segment.

d. *Not-Rated Exposure*

Issuers lacking a credit rating are assigned to BB. This choice is motivated by the following considerations:

- Not-rated exposures are negligible among sovereign issuers and typically only account for approximately five percent of the gross corporate exposures covered by the model. As such, sensitivity to the assumed PD for not-rated issuers is not material.

- Rated corporate exposures center around BBB (i.e., this is the modal credit rating bucket among the rated corporate issuers covered by the model).

- Not-rated exposures, which may correspond with smaller entities or entities overwise subject to less external scrutiny, are potentially of a lower credit quality on average than rated exposures. Thus, a mapping to one notch below the modal rating of BBB is chosen, consistent with the Stress Testing Policy Statement's principle of conservatism.

ix. Question

Question F1: Should the Board consider including public equities in the scope of the Trading IDL Model based on a revised FR Y-14Q, Schedule F.23 that excludes private equity exposure and standardizes the recovery rate assumptions used to determine jump-to-default loss amounts? This could be implemented by altering the Corporate portfolio jump-to-default loss calculation to utilize issuer exposures reported in FR Y-14Q, Schedule F.23 for projecting default losses on all corporate products (including both debt and equity positions). Non-linearity in loss response as defaults accrue against CDS tranche and index option positions would no longer be explicitly modeled. Instead, the marginal impact of each corporate issuer default in isolation, as reported in FR Y-14Q, Schedule F.23, inclusive of all relevant corporate product impacts, would be utilized additively in the model. The Board seeks comment on this simplified but broader treatment of corporate exposures. Are there other approaches the Board should consider? What are the advantages or disadvantages of these alternatives?

G. CVA Model

i. Statement of Purpose

The credit valuation adjustment model (CVA Model) is a component model of the supervisory stress test that estimates counterparty credit risk losses in the GMS for firms with substantial trading or custodial operations. These losses are a component of trading and counterparty losses within overall stressed losses. CVA is an adjustment to the mark-to-market valuation of a firm's exposures to its derivative counterparties, taking into account estimates of the probability of default and loss given default for each counterparty.

The CVA Model is important for accurately assessing whether a firm would be sufficiently capitalized to absorb material stress to counterparty credit worthiness and the resulting impact on the value of derivatives receivables. Total net current exposures from over-the-counter derivative positions, accounting for collateral exchanged but ignoring negative positions as well as central counterparty (CCP)[263] exposures, across firms subject to the GMS are nearly $170 billion in 2024:Q4 and have been as high as $280 billion since 2022.[264]

ii. Model Overview

CVA is an industry-wide, standard valuation adjustment[265] used by firms to adjust the risk-free value of a derivative position to account for the risk that the counterparty might default in the future over the lifetime of the derivative position. It is a market-based measure of counterparty credit risk that reflects the market-implied probability of the counterparty defaulting

[263] A central counterparty (CCP) is defined in the regulatory capital rules, 12 CFR 217.2, as "a counterparty (for example, a clearing house) that facilitates trades between counterparties in one or more financial markets by either guaranteeing trades or novating contracts."

[264] Data are from the FR Y-14Q, Schedule L (Counterparty), item 1e (Aggregate CVA data by ratings and collateralization).

[265] *See, e.g.,* Hull, J., 2011. Options, Futures and Other Derivatives. (Prentice Hall).; and Gregory, J., 2015. The xVA Challenge: Counterparty Credit Risk, Funding, Collateral, and Capital. (Wiley).

at a future date on the derivative transaction, as well as the probable receivable exposure to the counterparty at the time of future default. These probabilities are derived from market prices on other traded instruments, namely credit default swaps (CDS).

CVA is most often computed at the netting-set level for each counterparty and aggregated into an overall valuation adjustment reported in net income in a firm's financial statements daily.[266] Its value thus changes daily as market conditions change. The CVA Model captures the increasing risk of credit losses in the trading book over time arising from changes in both the derivative portfolio value due to market risk effects and the probability of default due to credit risk effects on counterparties from the GMS.

The model is applied to only the subset of firms subject to the GMS[267] and is driven by the following firm-provided estimates of the components of CVA in FR Y-14Q, Schedule L (Counterparty) as defined below:

1. Discount factors (DF), rates used to discount future derivative and firm exposures, reported in Schedule L.2 (Expected exposure [EE], profile by counterparty);
2. Expected exposures (EE) to counterparties, the positive expected values of future derivative positions based on simulations of market risk factors, reported in Schedule L.2;
3. Market-implied probabilities of default (PD) of counterparties, the default probability of a counterparty derived from CDS prices, reported in Schedule L.2; and
4. Market-implied loss given default (LGD) of counterparties, the proportion of a closed out derivative position that is unrecoverable, reported in Schedule L.2.

[266] A counterparty may have many trades executed with a firm whose exposures can be netted in aggregate allowing cashflows to be offset and, in the event of a default, for mark-to-market values to be summed into a single net value. The unit of aggregation for netting, typically distinguished by each contractual netting agreement, is identified as a netting set.

[267] *See* footnote 170.

The projected CVA loss for a given GMS is the difference between the stressed CVA projections under the GMS and those in the unstressed data submission. CVA losses, or the increase in CVA values in the stress scenario, are recognized in the first quarter of the projection horizon, as the GMS is assumed to occur instantaneously on a single market date.

The CVA Model takes into consideration only the default probabilities of a firm's counterparties, not a firm's own probability of default as measured by the reciprocal debit valuation adjustment (DVA).[268] There is, therefore, no consideration of DVA when estimating CVA losses, as the stress test assumes the survival of each firm as an operating entity.

CVA is computed without accounting for gains or losses from any CVA hedges.[269] The Board instead uses the Trading P&L Model (*see* Section E) to calculate and recognize gains or losses on firm CVA hedge derivative positions, since they are reported in FR Y-14Q, Schedule F alongside trading position data.[270] The calculation of gains or losses on CVA hedges follows the same methodology as the calculation of mark-to-market P&L on trading book positions (described in full in Section E).

The CVA Model employs one of two methods to determine losses based on a given firm's reported counterparty exposures:

[268] Just as the value of a firm's trading position may be positive and an asset on a firm's balance sheet or negative and a liability, CVA is analogous to a positive derivative position when a firm is theoretically owed money by a counterparty were the position to close. DVA is thus analogous to a negative trading position, when the firm would owe money to its counterparty in a close out—and thus the firm's own probability of default determines the likelihood of the counterparty receiving such a payment.

[269] In the same manner that a firm may hedge a derivative position, or any other position, firms may (and do) hedge their CVA exposure. Such positions are called CVA hedges.

[270] The Board collects information on CVA hedge positions in the same format, separately, as information on other trading positions in FR Y-14Q, Schedule F (Trading).

(i) Standard Approach: The Board uses this approach by default unless critical model inputs are missing or materially incomplete in FR Y-14Q, Schedule L—see Standard CVA Model Section G(iii).

(ii) Non-Standard Approach: The Board uses the Non-Standard Approach as a fallback when critical model inputs are missing or materially incomplete in FR Y-14Q, Schedule L—see Non-Standard CVA Model Section G(iv).

iii. Standard CVA Model

a. *Model Specification*

A firm's CVA loss ($\mathrm{CVA}_{\mathrm{loss}}$), under a given GMS, is calculated as the difference between CVA under the GMS $\left(\mathrm{CVA}(\mathrm{gms})\right)$, and unstressed data submission CVA $\left(\mathrm{CVA}(u)\right)$. See Equation G-1.

Equation G-1 – CVA Loss

$$\mathrm{CVA}_{\mathrm{loss}} = \mathrm{CVA}(\mathrm{gms}) - \mathrm{CVA}(u)$$

Each term in Equation G-1 is an aggregate CVA arrived at by first calculating CVA for the top ninety-five percent of counterparties, as ranked by CVA in each scenario, and multiplying by a factor to approximate the full 100 percent of CVA for all counterparties. Then any additional / offline reserves, $\mathrm{AOR}(s)$, which are CVA amounts not included in a firm's regular or routine CVA calculations, are added, as described in greater detail below. See Equation G-2.

Equation G-2 – calculation of CVA

$$\mathrm{CVA}(s) = \mathrm{CVA}_{95}(s) \cdot F(s) + \mathrm{AOR}(s)$$

Where:

- $\mathrm{CVA}(s)$ represents the CVA for a given scenario s;
- s denotes either the GMS (gms) or the unstressed data submission (u);

- CVA_{95} represents the CVA calculated for the reporting firm's top ninety-five percent of counterparties ranked at the consolidated parent level that cumulatively account for ninety-five percent of a firm's total CVA balance, per Equation G-3;
- F is a scaling factor used to capture CVA associated with the residual five percent of parent counterparties as specified in Equation G-4; and
- AOR represents firm-reported additional / offline CVA reserves (reserves taken for risks not fully captured in firm CVA models or calculations), as specified in Equation G-5.

b. *Top Ninety-five Percent CVA*

The top ninety-five percent CVA[271] $\left(\mathrm{CVA}_{95}(s)\right)$ for a firm is calculated as the product of the expected exposure, probability of default, loss given default, and discount factor across all forward-looking time periods of the firm's derivative exposures and across all counterparties and netting sets reported in FR Y-14Q, Schedule L.2. See Equation G-3.

Equation G-3 – CVA for Top Counterparties

$$\mathrm{CVA}_{95}(s) = \sum_{k} \sum_{t=1}^{T} \mathrm{DF}(s,t,k) \cdot \mathrm{EE}(s,t,k) \cdot \mathrm{PD}(s,t,k) \cdot \mathrm{LGD}(s,k)$$

Where:

- s represents the given scenario (GMS or unstressed data submission);
- k is an index representing counterparty reporting by the firm at its most granular level; i.e., the counterparty legal entity (required), netting set (optional) or subnetting set (optional);

[271] This percentile is a reporting requirement—one arrived at after consultation with firms—that balances risk capture with reporting burden. In general, the higher the percentile the larger the number of counterparties to report and the larger the number of immaterial exposures.

- t is an index representing forward time periods of contractual derivative exposure as reported by firms;
- T represents the maturity or final time period of the contractual derivative exposures; and
- DF, EE, PD, and LGD represent, respectively, the discount factor; expected exposure; counterparty marginal probability of default between periods t and $t + 1$; and loss given default for a specific scenario, counterparty, and time, each obtained from FR Y-14Q, Schedule L.2. See Figure G-1.

Figure G-1 – FR Y-14Q, Schedule L technical fields corresponding to the component terms used to calculate stressed and unstressed CVA_{95}. Note that stressed EE is reported assuming (i) a ten-day margin period of risk assumption for margined counterparties and (ii) that no additional margin is collected due to the downgrade of a counterparty. The PD and LGD used in the stressed CVA calculation are both market-implied and consistent with pricing observed in the CDS market.[272]

Variable	**$\mathbf{CVA_{95}}(s)$ calculation inputs** FR Y-14Q, Schedule | Line Item | MDRM	
	Stressed	Unstressed
DF	L.2 (Counterparty) | Stressed Discount Factor FR Scenario (Severely Adverse) | *CACBR523*	L.2 (Counterparty) | Discount Factor | *CACBR486*
EE	L.2 (Counterparty) | Stressed Expected Exposure - FR Scenario & FR Specification (Severely Adverse) | *CACBR487*	L.2 (Counterparty) | Expected Exposure - BHC Specification| *CACBP799*
PD	L.2 (Counterparty) | Stressed Marginal PD FR Scenario (Severely Adverse) | *CACBR492*	L.2 (Counterparty) | Marginal PD | *CACBQ451*
LGD	L.2 (Counterparty) | Stressed LGD (PD) FR Scenario (Severely Adverse) | *CACBR498*	L.2 (Counterparty) | LGD (CVA) | *CACBQ667*

[272] *See* FR Y-14Q instructions, p. 276.

c. *Scaling Factor*

FR Y-14Q, Schedule L.2 collects the component-level data (EE, DF, PD, and LGD) used in the calculation of CVA_{95} (Equation G-3) for only the subset of parent counterparties representing ninety-five percent of total CVA or the top ninety-five percent. To account for risk associated with the residual five percent of parent counterparties not reported at a counterparty level, Equation G-2 multiplies CVA_{95} by a scaling factor $F(s)$. $F(s)$ captures the ratio of (i) firm-provided total CVA, in respect of all counterparties, relative to (ii) the sum of CVAs reported for the top ninety-five percent counterparty subset. The value of $F(s)$ is typically very close to 1.05, as the denominator term should, by definition, be very close to ninety-five percent of the numerator term. See Equation G-4.

Equation G-4 – Scaling Factor

$$F(s) = \frac{\text{Total CVA}(s)}{\text{Top95 CVA}(s)}$$

Where:

- Total CVA is the sum of all aggregate CVA in scenario s reported in FR Y-14Q, Schedule L, sub-schedules L.1.e.3 (Collateralized netting sets) and L.1.e.4 (Uncollateralized netting sets); and
- Top95 CVA is the sum of all counterparty-level CVA, accounting for the top ninety-five percent of total CVA in scenario s, reported in FR Y-14Q, Schedule L, sub-schedules L.1.a. (Top consolidated / parent counterparties comprising ninety-five percent of firm unstressed Credit Valuation Adjustment (CVA), ranked by unstressed CVA) and L.1.b. (Top consolidated/parent counterparties comprising ninety-five percent of firm stressed CVA, ranked by Federal Reserve Severely Adverse Scenario stressed CVA for the CCAR quarter). FR Y-14Q, Schedule L, sub-schedule 1.b. is reported only in stressed

data submissions and often contains a marginal increase in counterparties reported to account for the top ninety-five percent of stressed CVA. See Figure G-2.

In the stressed scenario, the denominator in Equation G-4 also includes any additional top counterparties that are only reported in the stressed data in FR Y-14Q, Schedule L, sub-schedule L.1.b (Top consolidated/parent counterparties comprising ninety-five percent of firm stressed CVA, ranked by Federal Reserve Severely Adverse Scenario stressed CVA for the CCAR quarter). The scaling factor is calculated separately for both stressed and unstressed amounts.

Figure G-2 – FR Y-14Q, Schedule L technical fields corresponding to the numerator and denominator of the scaling factor $F(s)$ (Equation G-4). Schedule L, sub-schedules L.1.e.3 and L.1.e.4 both correspond to aggregate CVA data by ratings, but for collateralized (L.1.e.3) and uncollateralized (L.1.e.4) netting sets, respectively. Schedule L, sub-schedules L.1.a. and L.1.b. correspond to top counterparty CVA reporting in the unstressed (L.1.a) and stressed (L.1.b) cases, respectively.[273]

Variable	**$F(s)$ calculation inputs** FR Y-14Q, Schedule | Line Item | MDRM	
	Stressed	Unstressed
Total CVA	L.1.e.3 & L.1.e.4 | Stressed CVA (Severely Adverse) | *CACLM917*	L.1.e.3 & L.1.e.4| CVA | *CACLM916*
Top95 CVA	L.1.a & L.1.b | Stressed CVA (Severely Adverse) | *CACVM917*	L.1.a | CVA | *CACVM916*

d. *Additional / Offline CVA Reserves*

The CVA calculation in Equation G-2 incorporates firm-reported additional / offline CVA reserves via the term $\text{AOR}(s)$ for a given scenario s. Additional / offline CVA reserves are any non-standard add-ons to reserves that are not explicitly included or modeled in a firm's reported EE profiles in FR Y-14Q, Schedule L.2. or CDS curves in FR Y-14Q, Schedule L.3 (Credit Quality by Counterparty) but still present a risk that is managed by the firm. Such add-

[273] *See* FR Y-14Q instructions, p. 266.

ons may include, but are not limited to, model limitations from risks not in a firm's regular CVA model, wrong way risk (positive correlations between counterparty default and exposure), offline reserves set aside at the discretion of firm treasury or finance, or trades not captured by a firm's regular CVA model or calculations. These add-ons are reported by firms subject to the supervisory stress test as shown in Figure G-3. The $\mathrm{AOR}(s)$ term in Equation G-2 includes all categories of additional / offline CVA reserves reported in FR Y-14Q, Schedule L, sub-schedule L.1.e.2. (Additional / Offline CVA Reserves), except for funding valuation adjustment (FVA),[274] which is reported in FR Y-14Q, Schedule L, sub-schedule L.1.e.2.d. Equation G-5 specifies $\mathrm{AOR}(s)$ as the sum of all reported additional / offline CVA reserve categories, indexed by i, less reported FVA amounts.

Equation G-5 – additional / offline CVA reserves included in the CVA Model

$$\mathrm{AOR}(s) = \sum_i \mathrm{AOR}(s,i) - \mathrm{AOR}_{\mathbf{FVA}}(s)$$

Offline reserve balance inputs used to determine $\mathrm{AOR}(s)$ are obtained from FR Y-14Q, Schedule L, sub-schedule L.1.e.2. See Figure G-3.

Figure G-3 – FR Y-14Q, Schedule L technical fields for all additional / offline CVA reserve categories referenced in Equation G-5. The CVA Model calculates $AOR(s)$ by summing all categories and subtracting FVA.[275]

Additional / Offline CVA Reserve Categories	**$AOR(s)$ calculation inputs** FR Y-14Q, Schedule | AOR Category | MDRM	
	Stressed	Unstressed
Model/infrastructure limitations	L.1.e.2 | AOR (a) | *CACLM917*	L.1.e.2 | AOR (a) | *CACLM916*
Trades not captured	L.1.e.2 | AOR (b) | *CACLM917*	L.1.e.2 | AOR (b) | *CACLM916*
Fair-value SFTs	L.1.e.2 | AOR (b.1) | *CACLM917*	L.1.e.2 | AOR (b.1) | *CACLM916*

274 Funding valuation adjustment (FVA) is another valuation adjustment to risk-free derivative prices. Primarily applicable to uncollateralized derivative contracts, it represents a reserve a firm holds to fund a separate and collateralized derivative contract to hedge the risk from the initial uncollateralized trade.

275 *See* FR Y-14Q instructions, p. 272.

Offline reserves	L.1.e.2 | AOR (c) | *CACLM917*	L.1.e.2 | AOR (c) | *CACLM916*
FVA	L.1.e.2 | AOR (d) | *CACLM917*	L.1.e.2 | AOR (d) | *CACLM916*
Other	L.1.e.2 | AOR (e) | *CACLM917*	L.1.e.2 | AOR (e) | *CACLM916*

e. *Specification Rationale and Calibration*

The CVA calculation as presented in Equation G-3, follows the widely-accepted standard definition of CVA measurement where CVA is broadly estimated by multiplying the EE value (discussed further below) together with the PD of the derivative counterparty and the LGD, discounted to the present date using a DF for each point in the future over the life of the derivative transaction, and then summing across all future dates.[276] In accordance with the standard definition of CVA measurement, the PDs, EEs, LGDs, and DFs are all calculated using a so-called risk-neutral approach, also known as a market-implied approach, as opposed to an actuarial or firm-subjective approach. While this means that, in principle, firms should calculate the same CVA for the same derivative transaction and same counterparty in their FR Y-14Q reporting submissions, in practice, firms use different assumptions to estimate the values for each of the above components, even under a risk-neutral approach; therefore, to ensure a standardized approach across all firms for the CVA loss estimate in GMS, the Board has imposed specification assumptions related to stressed EE and stressed LGD, both made for reasons of transparency, standardization, and achieving consistent loss assignment across firms in alignment with the Board's stress testing principles.[277] Additional detail describing the rationale for the model specification is included below.

[276] *See* footnote 264.

[277] *See* 12 CFR 252, Appendix B.

(1) Stressed EE

Expected future positive exposure, or EE, is the expected value of all simulated positive valuation paths a derivative contract may take over its remaining lifetime subject to the simulated market risk factors determining its price. The stressed EE measure used in the model is prepared under standardizing assumptions stipulated in the instructions for the FR Y-14Q, Schedule L. Specifically, the instructions direct firms to (i) assume a ten-day margin period of risk (the time between declaring a default event and closing out or replacing the derivative position with the defaulted counterparty) for all counterparties for which collateral is collected, and (ii) exclude the collection of additional collateral from a counterparty due to a rating downgrade.[278] Firms exercise significant judgment in estimating the likely timing of closing out a derivative trade associated with a counterparty default or the degree of exposure mitigation conferred by a given counterparty rating downgrade trigger clause, both in the context of a severe market shock; therefore, standardizing both elements helps reduce subjective variation and inconsistency in CVA losses between firms as well as provide transparency in firm modeling assumptions in accordance with the Board's stress testing principles.[279]

(2) Stressed LGD

As described in the model overview section above, the stressed CVA calculation uses market-implied LGD; i.e., LGD that is consistent with a given counterparty's CDS-implied credit curve (the price of a CDS contract plotted against the length of the contract in years). In practice, firms calculating CVA for accounting purposes and financial statements may

[278] *See* FR Y-14Q Instructions, pp. 276–77 (entry for "Stressed Expected Exposure (EE) – FR scenario & FR specification (Severely Adverse – CACBR487)").

[279] *See* 12 CFR 252, Appendix B.

sometimes use tailored LGD assumptions for specific counterparties if historical recovery experience or contractual features, such as covenants associated with certain counterparty relationships, suggest a different recovery expectation relative to the CDS spreads used to establish a credit curve. While firms do report tailored LGDs under stress in the FR Y-14Q, Schedule L.2, the Board does not use those values to calculate Equation G-3 in order to avoid inconsistent assumptions between firms, which could lead to unsupportable or potentially spurious variation in loss outcomes for similar exposures, in contradiction to its stated principle of consistency and comparability across covered firms.[280]

f. *Assumptions and Limitations (Standard CVA Model)*

In general, the CVA Model takes as inputs both (i) GMS shocks and (ii) firm-provided FR Y-14Q, Schedule L derivative exposures and CVA inputs, functioning as a simple calculator to determine associated loss results. Since the modeling and analytics utilized in generating exposures and CVA inputs falls outside and upstream of the CVA Model itself, a fundamental assumption is that these data are accurate (i.e., firms' pricing models accurately calculate market values, exposures and CVA inputs reported in the FR Y-14) and complete (all derivative positions are correctly accounted for) and that the scope of risk factors covered by the GMS is sufficiently comprehensive to capture risk effectively. The Standard CVA Model additionally uses the following key assumptions, which each reflect the stress testing policy principles of conservativeness, consistency and comparability as detailed in the Specification Rationale and Calibration Section G(iii)(e).

[280] *See* 12 CFR 252, Appendix B.

- **Ten-day margin period of risk under stress:** The stressed EE measure used in the model follows a ten-day margin period of risk for margined counterparties, while the unstressed EE measure uses margin period of risk assumptions aligned with a firm's own business-as-usual accounting practice. Generally, the EE increases as the margin period of risk increases.
- **Exclusion of downgrade triggers:** The stressed EE measure used in the model excludes the possible collection of additional collateral due to a rating downgrade of a counterparty, while the unstressed EE measure treatment of rating downgrade margin triggers is aligned with a firm's own business-as-usual accounting practice. Excluding downgrade triggers is a more conservative assumption that considers the greater uncertainty of receiving additional collateral in stressed market periods.
- **Exclusion of debt valuation adjustment:** The CVA Model only takes into consideration the default probability of firm counterparties, not the default probability of the firm itself. There is, therefore, no consideration of DVA and, thus, firm default when estimating CVA losses because the Board assumes as given the survival of each firm as an ongoing entity over the course of the stress test.

g. *Alternative Approaches*

The Board considered two alternative approaches to the Standard CVA Model specification.

(1) Sensitivity-Based Calculation

The Board considered a sensitivity-based approach in which CVA losses would be calculated in a manner analogous to the profit and loss calculation used for both firm CVA hedges and a firm's trading portfolio (see Trading P&L Model Section E). Under this approach, firm-reported CVA sensitivities to generic market and credit risk factor shocks (e.g., the change in CVA from a one basis point increase in a credit spread index) would be used to translate the specific risk factor shocks in a GMS into losses or gains by multiplying the sensitivity by the shock and aggregating across all risk factors. This approach would offer the advantage of avoiding reliance on firms to provide scenario-specific data, thereby enabling the Board to independently estimate losses under a range of market conditions. However, the Board ultimately chose not to pursue this approach due to concerns about the accuracy of this method that were identified by Board analysis of this methodology in general and the Board's own prototyping using sensitivity data reported in the FR Y-14Q, Schedule L.4 (Aggregate and Top 10 CVA Sensitivities by Risk Factor). It is also the Board's understanding that firms use sensitivity-based methods as a comparison to CVA losses calculated using a full-revaluation method (whereby the derivative portfolio is stressed to precise scenario specifications and then re-valued), and that these two approaches may not reliably reconcile due to the underlying methodological differences; therefore, this approach may not align with stress testing principles of robustness and stability.

(2) Firm-Calculated Loss

In addition, the Board considered an approach that would rely on a firm's own CVA loss estimate for each scenario. These estimates would be used directly in the capital projections used to calibrate firm SCB requirements, replacing the loss measure described in Equation G-1. This would have the obvious benefit of matching firm estimates exactly. However, the Board preferred the current model because its reliance on intermediate firm calculations (i.e., EE, PD, LGD, DF) makes it more robust to reporting fidelity issues by enabling consistency checks across sub-schedules in FR Y-14Q, Schedule L. The current approach is also more transparent regarding the key factors that affect loss outcomes because it allows the Board to observe the proportion of credit and market risk factor-driven losses in each scenario. Additionally, it is more transparent by specifying modeling assumptions all firms must make in the stressed scenario. Complete reliance on firm-calculated CVA losses would compromise the first stress testing principle of independence.

h. *Data Adjustments*

Data are taken as reported in FR Y-14Q, Schedule L (Counterparty) and no adjustments are applied. A data quality assurance (DQA) process scrutinizes data submissions for technical, logical, and formatting consistency and reporting requirement compliance.

iv. <u>Non-Standard CVA Model</u>

As noted above, the Non-Standard CVA Model is used as a fallback method when critical FR Y-14Q, Schedule L.2 inputs are missing or materially incomplete. For example, materially incomplete data may omit entries in Schedule L.2 altogether or report a majority of derivative CVA exposures as offline reserves rather than through standard modeling methods. The suitability of submitted firm data is determined after completing the DQA process and corresponding with the firm if any concerns arise due to data quality, consistency, or accuracy. If data concerns cannot be assuaged or remediated, then the Non-Standard CVA Model is utilized. The Non-Standard CVA Model is constructed around derivative net current exposure (CE), which is the fair value of the position inclusive of collateral exchanged. This measure is generally reliably calculated and reported as it requires fewer resources to model and estimate than the forward-looking simulations of EE reported in Schedule L.2 and required by the Standard CVA Model.

a. *Model Specification*

The Non-Standard CVA Model relies on ratios, referred to as coverage ratios, of CVA to net CE from firms subject to the Standard CVA Model to estimate CVA for firms subject to the Non-Standard CVA Model using their reported net CE. The Non-Standard CVA Model estimates CVA losses by taking a weighted average of CVA losses from two fallback methods, each a variation on multiplying coverage ratios by net CE at varying levels of portfolio granularity.

The first fallback method is the primary non-standard approach for CVA (NAC Method), which uses four portfolio segments to differentiate exposures between collateralized and uncollateralized positions and between investment- and speculative-grade counterparties.[281] The second is the secondary non-standard approach for CVA (SNAC Method) and uses no portfolio segmentation.

Next, a weighted average of these two fallback methods is calculated. The weighting variable in the weighted-average is the proportion of total stressed net CE in a scenario reported as additional / offline CVA reserves. The weighting variable balances the estimates between the two methods. As required FR Y-14Q inputs for the NAC Method become incrementally more incomplete, the weighting variable places greater emphasis on the SNAC Method. The Non-Standard CVA Model loss estimate ($\mathrm{CVA}_{\mathrm{loss}}^{\mathrm{NS}}$) is expressed in Equation G-6.

Equation G-6 – Non-Standard CVA Model

$$\mathrm{CVA}_{\mathrm{loss}}^{\mathrm{NS}} = (1-w)\cdot \mathrm{CVA}_{\mathrm{loss}}^{\mathrm{NAC}} + w \cdot \mathrm{CVA}_{\mathrm{loss}}^{\mathrm{SNAC}}$$

[281] Any counterparty with an external rating (e.g., Moody's, Fitch, S&P) equivalent to BB or lower is considered speculative or non-investment grade.

Where:

- $\text{CVA}_{\text{loss}}^{\text{NAC}}$ is the NAC Method estimate of CVA, which uses four portfolio segments to differentiate between collateralized and uncollateralized exposures and also investment- and speculative-grade counterparties. See Equation G-8;
- $\text{CVA}_{\text{loss}}^{\text{SNAC}}$ is the SNAC Method estimate, where CVA is estimated without portfolio segmentation, via a single coverage ratio that is applied to the aggregate net CE of a firm's entire counterparty portfolio, as expressed by Equation G-12; and
- w is the weighting variable weighing estimates from $\text{CVA}_{\text{loss}}^{\text{NAC}}$ and $\text{CVA}_{\text{loss}}^{\text{SNAC}}$, defined in Equation G-7. The FR Y-14Q data used to calculated w are specified in **Figure *G-4***.

Equation G-7 – Weighting Factor for Equation G-6

$$w = \frac{\text{CE}_{\text{AOR,gms}}}{\text{CE}_{\text{online,gms}} + \text{CE}_{\text{AOR,gms}}}$$

Where:

- $\text{CE}_{\text{AOR,gms}}$ is the sum of all stressed net CE, excluding central counterparties, from additional / offline reserve categories, excluding FVA; and
- $\text{CE}_{\text{online,gms}}$ is the sum of all stressed net CE from collateralized and uncollateralized positions, excluding central counterparties. See **Figure *G-4*** for item definitions in FR Y-14Q, Schedule L (Counterparty).

Figure G-4 – FR Y-14Q, Schedule L technical fields corresponding to numerator and denominator terms used in Equation G-7. FR Y-14Q, Schedule L, sub-schedule L.1.e.2, items a-e encompass all categories of additional / offline CVA reserves, excluding FVA. Their summation follows the calculation in Equation G-5 and definitions in Figure G-3. FR Y-14Q, Schedule L, sub-schedules L.1.e.3 and L.1.e.4 both correspond to aggregate CVA data for online counterparties, grouped by collateralized (L.1.e.3) and uncollateralized (L.1.e.4) exposures, respectively.[282]

Variable	**SNAC vs NAC weighting variable (w) calculation inputs** FR Y-14Q, Schedule | Line Item | MDRM
$\mathrm{CE}_{\mathrm{AOR,gms}}$	L.1.e.2[a,b,b.1,c,e] | Stressed Net CE excluding CCPs FR Scenario (Severely Adverse) | *CACLR519*
$\mathrm{CE}_{\mathrm{online,gms}}$	L.1.e.3 & L.1.e.4 | Stressed Net CE excluding CCPs FR Scenario (Severely Adverse) | *CACLR519*

b. *Primary Non-Standard Approach to CVA (NAC Method)*

For a firm subject to the Non-Standard CVA Model, CVA losses are first calculated as the difference between stressed and unstressed CVA amounts using the NAC Method. For each scenario, the NAC Method CVA is equal to the net CE of the firm subject to the Non-Standard CVA Model f multiplied by the maximum coverage ratio, or ratio of CVA to net CE, from the population of firms subject to the Standard CVA Model. This multiplication is performed for each portfolio segment, grouping by collateralized and uncollateralized exposures and by investment- and speculative-grade counterparties, and then summed. Finally, the additional / offline CVA reserves are added, excluding any FVA amounts, to arrive at CVA for a given scenario. These calculations are expressed in Equation G-8, Equation G-9 and Equation G-10.

[282] *See* FR Y-14Q instructions, pp.270–271.

Equation G-8 – NAC Method Loss

$$\mathrm{CVA}^{\mathrm{NAC}}_{\mathrm{loss}} = \mathrm{CVA}^{\mathrm{NAC}}_{\mathrm{gms}} - \mathrm{CVA}^{\mathrm{NAC}}_{u}$$

Where:

- $\mathrm{CVA}^{\mathrm{NAC}}_{\mathrm{gms}}$ represents stressed CVA under the GMS, as provided by Equation G-9; and
- $\mathrm{CVA}^{\mathrm{NAC}}_{u}$ represents unstressed CVA, as also provided by Equation G-9, under the unstressed data submission.

Equation G-9 – NAC Method CVA

$$\mathrm{CVA}^{\mathrm{NAC}}_{s} = \sum_{n=1}^{4} \left[\mathrm{CE}_{n,s} \cdot R_{n,s}\right] + \mathrm{AOR}_{s}$$

Where:

- $\mathrm{CVA}^{\mathrm{NAC}}_{s}$ denotes CVA estimated under scenario s and is an input into Equation G-8;
- n is an index specifying the four portfolio segments to sum across: (1) collateralized investment grade (IG), (2) collateralized speculative grade (SG), (3) uncollateralized IG, and (4) uncollateralized SG;
- $\mathrm{CE}_{n,s}$ represents net CE, excluding central counterparties, for firm f in portfolio segment n under scenario s and is directly reported in sub-schedule L.1.e (Aggregate CVA Data by Ratings and Collateralization), as specified in Figure G-5;
- $R_{n,s}$ represents the maximum coverage ratio, or ratio of CVA to net CE, for portfolio segment n under scenario s, as specified in Equation G-10; and

- AOR_s is the sum of all additional / offline CVA reserves reported under scenario s, excluding only FVA, as defined under the standard CVA Model in Equation G-5 and Figure G-3.

Equation G-10 – NAC Method Coverage Ratio

$$R_{n,s} = \max_{i \in \{\text{std cva firms}\}} \left(\frac{\text{CVA}_{n,s,i}}{\text{CE}_{n,s,i}} \right)$$

Where:

- $\text{CVA}_{n,s,i}$ is the CVA balance reported by standard-CVA-modeled firm i in portfolio segment n under scenario s. Amounts are reported in sub-schedule L.1.e and items used to determine $\text{CVA}_{n,s,i}$ and $\text{CE}_{n,s,i}$ are specified in Figure G-5; and
- $\text{CE}_{n,s,i}$ is the reported net CE, excluding central counterparties, for standard CVA modeled firm i in portfolio segment n under scenario s.

Figure G-5 – FR Y-14Q, Schedule L technical fields correspond to the numerator and denominator of coverage ratios used in the calculation of CVA_s^{NAC} (Equation G-8). FR Y-14Q, sub-schedules L.1.e.3 and L.1.e.4 correspond to aggregate CVA data for online counterparties grouped by collateralized (L.1.e.3) and uncollateralized (L.1.e.4) exposures, respectively.[283]

Variable	**NAC Method calculation inputs** FR Y-14Q, Schedule | Line Item | MDRM	
	Stressed	Unstressed
$\text{CVA}_{n,s,i}$	L.1.e.3 & L.1.e.4 | Stressed CVA (Severely Adverse) | *CACLM917*	L.1.e.3. & L.1.e.4 | CVA | *CACLM916*
$\text{CE}_{n,s,i}$	L.1.e.3 & L.1.e.4 | Stressed Net CE excluding CCPs (Severely Adverse) | *CACLR519*	L.1.e.3 & L.1.e.4 | Net CE excluding CCPs | *CACLR517*
$\text{CE}_{n,s}$	L.1.e.3 & L.1.e.4 | Stressed Net CE excluding CCPs (Severely Adverse) | *CACLR519*	L.1.e.3 & L.1.e.4 | Net CE excluding CCPs | *CACLR517*
AOR_s	L.1.e.2[a,b,b.1,c,e] | Stressed CVA (Severely Adverse) | *CACLM917*	L.1.e.2[a,b,b.1,c,e] | CVA | *CACLM916*

[283] *See* FR Y-14Q instructions, pp.270–271.

c. *Secondary Non-Standard Approach to CVA (SNAC Method)*

For a firm subject to the Non-Standard CVA Model, CVA losses are also calculated under the SNAC Method, again as the difference between stressed and unstressed CVA amounts. For each scenario the SNAC Method CVA is equal to the net CE of the firm subject to the Non-Standard CVA Model f multiplied by the maximum coverage ratio, or ratio of CVA to net CE, from the population of firms subject to the Standard CVA Model. This multiplication is performed once, aggregating all exposures previously segmented by portfolio type in the NAC Method, above. The net CE is also inclusive of additional / offline CVA reserves (the weighting variable w in Equation G-7 specifically balances the proportion of stressed exposures reported as additional / offline CVA reserves). These calculations are expressed in Equation G-11, Equation G-12, and Equation G-13.

Equation G-11 – SNAC Method Loss

$$\text{CVA}_{\text{loss}}^{\text{SNAC}} = \text{CVA}_{\text{gms}}^{\text{SNAC}} - \text{CVA}_{u}^{\text{SNAC}}$$

Where:

- $\text{CVA}_{\text{gms}}^{\text{SNAC}}$ is the SNAC Method stressed CVA estimate under the GMS, as provided by Equation G-12; and
- $\text{CVA}_{u}^{\text{SNAC}}$ is the SNAC Method unstressed data submission CVA estimate, also as provided by Equation G-12.

Equation G-12 – SNAC Method CVA

$$\text{CVA}_{s}^{\text{SNAC}} = \left[\text{CE}_{\text{online},s} + \text{CE}_{\text{AOR},s}\right] \cdot R_{\text{total},s}$$

Where:

- $\text{CVA}_{s}^{\text{SNAC}}$ denotes the SNAC Method CVA estimate under scenario s (i.e., GMS or unstressed data submission) and is an input into Equation G-11;

- $\mathrm{CE}_{\mathrm{online},s}$ is the sum of all net CE from collateralized and uncollateralized positions, excluding central counterparties, for scenario s. See **Figure *G-6*** for line-item definitions in FR Y-14Q, sub-schedule L.1.e;

- $\mathrm{CE}_{\mathrm{AOR},s}$ is the sum of all net CE from additional / offline reserve categories, excluding FVA for scenario s; and

- $R_{\mathrm{total},s}$ is the maximum coverage ratio, the ratio of total CVA to net CE, under scenario s. This ratio is calculated among all firms i subject to the Standard CVA Model. See Equation G-13.

Equation G-13 – SNAC Method Coverage Ratio

$$R_{\mathrm{total},s} = \max_{i\in\{\text{std cva firms}\}}\left(\frac{\mathrm{CVA}_{\mathrm{total},s,i}}{\mathrm{CE}_{\mathrm{online},s,i} + \mathrm{CE}_{\mathrm{AOR},s,i}}\right)$$

Where:

- $\mathrm{CVA}_{\mathrm{total},s,i}$ is the total CVA balance for firm i subject to the Standard CVA Model under scenario s, including all additional / offline reserve balances but excluding FVA;
- $\mathrm{CE}_{\mathrm{online},s,i}$ is defined and calculated analogously to $\mathrm{CE}_{\mathrm{online},s}$ in Equation G-12; and
- $\mathrm{CE}_{\mathrm{AOR},s,i}$ is defined and calculated analogously to $\mathrm{CE}_{\mathrm{AOR},s}$ in Equation G-12. The FR Y-14Q, sub-schedule L.1.e line items used to determine $\mathrm{CVA}_{\mathrm{total},s,i}$, $\mathrm{CE}_{\mathrm{online},s}$ and $\mathrm{CE}_{\mathrm{AOR},s}$ are specified in **Figure *G-6***.

Figure G-6 – FR Y-14Q, Schedule L technical fields corresponding to the terms used in the calculation of CVA_s^{SNAC} (Equation G-11). FR Y-14Q, sub-schedules L.1.e.2, items a-e encompass all categories of additional / offline CVA reserves, excluding FVA. Sub-schedules L.1.e.3 and L.1.e.4 correspond to aggregate CVA data for online counterparties and are grouped by collateralized (L.1.e.3) and uncollateralized (L.1.e.4) exposures, respectively.[284]

Variable	**SNAC and SNAC Coverage Ratio calculation inputs** FR Y-14Q, Schedule | Line Item | MDRM	
	Stressed	Unstressed
$\mathrm{CVA}_{\mathrm{total},s,i}$	L.1.e.3. & L.1.e.4 & L.1.e.2[a,b,b.1,c,e] | Stressed CVA (Severely Adverse) | *CACLM917*	L.1.e.3. & L.1.e.4 & L.1.e.2[a,b,b.1,c,e] | CVA | *CACLM916*
$\mathrm{CE}_{\mathrm{online},s,i}$ & $\mathrm{CE}_{\mathrm{online},s}$	L.1.e.3. & L.1.e.4 | Stressed Net CE excluding CCPs (Severely Adverse) | *CACLR519*	L.1.e.3 & L.1.e.4 | Net CE excluding CCPs | *CACLR517*
$\mathrm{CE}_{\mathrm{AOR},s,i}$ & $\mathrm{CE}_{\mathrm{AOR},s}$	L.1.e.2[a,b,b.1,c,e] | Stressed Net CE excluding CCPs (Severely Adverse) | *CACLR519*	L.1.e.2[a,b,b.1,c,e] | Net CE excluding CCPs | *CACLR517*

d. *Specification Rationale and Calibration*

The CVA component data required by the Standard CVA Model in FR Y-14Q, Schedule L.2 involves significant computational complexity and derivative valuation infrastructure investment by supervised firms. In this context, the Non-Standard CVA Model is designed to function as a uniform fallback calculation, necessary only when appropriate model input data in Schedule L are unavailable. Because the forward-looking EE profiles necessary to calculate CVA are unavailable, the next-best available exposure measure (net CE) is used along with a loss-rate-like measure (coverage ratio) to approximate CVA. This aligns with the Board's principles of simplicity and conservativeness as well as its practice of applying conservative assumptions to a particular portfolio with missing or erroneous data.

Utilization of the Non-Standard CVA Model in limited circumstances is reasonably likely. For example, firms that have not yet fully adapted their existing business-as-usual derivative valuation and compliance infrastructure to produce EE projections appropriate for use

[284] *See* FR Y-14Q instructions, pp.270–271.

in the Standard CVA Model would be subject. Another reasonable use would be when incumbent firms are incapable of producing or reporting the necessary Schedule L.2 data. Similarly, if firms rely on proxy methods to estimate CVA rather than using risk-factor simulations to generate forward looking derivative exposure profiles over the life of the contract, or if firms report a majority of their derivative exposures as additional / offline CVA reserves, it may indicate a lack of appropriate risk modeling of counterparty credit risk in their portfolio, thereby necessitating that the non-standard CVA Model be used.

The Non-Standard CVA Model uses the net CE metric in FR Y-14Q, sub-schedule L.1.e, which, as a fair-value concept, is not as complicated or costly to model, estimate and report, relative to the forward-looking and simulated EE projection. It is, therefore, generally more reliably reported than the EE projection in FR Y-14Q, Schedule L.2.

The Board determined the use of a weighted average of two similar coverage ratio methods, which each offer different levels of derivative portfolio granularity, ensuring continuity in loss outcomes for firms that incrementally improve FR Y-14Q, Schedule L reporting by relying less on additional / offline reserve categories to report derivative exposures. It also adheres to the Board's stress testing principle of conservatism.

e. *Alternative Approaches*

The Board considered three alternative approaches to the current Non-Standard CVA Model specification.

(3) Only NAC Method

The Board considered applying only the primary NAC Method in the Non-Standard CVA Model. In considering this approach, alternatives to the maximum coverage ratio were also explored, such as a fixed conservative percentile (e.g., 90^{th}) in the distribution of coverage ratios of firms subject to the Standard CVA Model. Board analysis on all non-standard method estimates since 2019 indicated that this had an immaterial impact on loss estimates, both in dollars and basis points of firm risk-weighted assets (RWA). Overall, the Board determined this method is ill-suited when a large proportion of net CE is reported as additional / offline CVA reserves and lacks appropriate conservatism[285] when the Standard CVA Model cannot be applied due to missing or materially incomplete data.

(4) Only SNAC Method

The Board also considered applying only the SNAC Method in the Non-Standard CVA Model. It also was tested with alternatives to the maximum coverage ratio, such as a fixed percentile in the distribution of standard CVA-modeled firms' coverage ratios. It is methodologically simpler by not disaggregating portfolio exposures by collateralization and counterparty credit rating. However, this method was considered punitively conservative overall by generating significantly larger and more volatile loss estimates due to firm additional / offline reserve reporting variances. It thus did not sufficiently adhere to the Board's stress testing principle of robustness and stability.

(5) Loss Rate Method

Finally, the Board considered using a simple loss rate, the ratio of CVA losses to counterparty credit risk RWA, calculated from the firms subject to the Standard CVA Model, and multiplying it by the non-standard CVA modeled-firms' counterparty credit risk RWA measure reported in the FR Y-9C. This method was similar to the methodology used by the Board when U.S. intermediate holding companies of foreign banking organizations (IHCs) were

[285] *See* 12 CFR 252, Appendix B, at 1.6.

onboarded to the GMS in the 2018 stress test.[286] However, Board analysis found these CVA loss estimates were an order of magnitude more conservative than using only the SNAC Method, even when selecting a loss rate from only the 90th percentile. This alternative approach was, therefore, determined to be excessively conservative.

f. *Data Adjustments*

Data are taken as reported in FR Y-14Q, Schedule L, and no adjustments are applied. A DQA process scrutinizes data submissions for technical, logical and formatting consistency and reporting requirement compliance.

v. Questions

a. *Sensitivity-based Estimates*

Question G1: The Board seeks comment on using a sensitivity-based model, as compared to the Board's current approach of using firm-provided stressed counterparty-level CVA input data. What would be the advantages and disadvantages of using a sensitivity-based model to estimate CVA losses?

Question G2: Should the Board consider adding or removing any variables from the FR Y-14Q, Schedule L.4 reporting form to improve a sensitivity-based model specification? If so, which variables, i.e., risk factors and/or grid points? What would be the advantages and disadvantages of adding or removing those variables?

[286] *See* Comprehensive Capital Analysis and Review 2018 Summary Instructions (Feb. 2018), p.10, available at https://www.federalreserve.gov/newsevents/pressreleases/files/bcreg20180201a2.pdf.

Question G3: Should the Board consider expanding counterparty-level sensitivity reporting from sub-schedule L.4b to improve a sensitivity-based model estimation? If so, how should they be reported? What would be the advantages and disadvantages of using counterparty-level sensitivities?

Question G4: Should the Board consider removing stressed data submissions for FR Y-14Q, sub-schedules L.2 (EE profiles) and L.3 (CDS curves) if it were to instead adopt a sensitivity-based modeling approach? What would be the advantages and disadvantages of removing stressed data submissions of these sub-schedules?

Question G5: Should the Board consider adopting CVA sensitivity reporting requirements that align the FR Y-14Q, Schedule L.4 reporting with Fundamental Review of the Trading Book (FRTB) reporting? If so, what would be the advantages and disadvantages of alignment?

b. *Data Cleaning/Adjustments*

Question G6: The CVA Model relies on a non-standard CVA Model to estimate CVA losses for firms unable to report the FR Y-14Q, Schedule L.2 reliably and consistently. Should the Board consider the alternative only SNAC method as the Non-Standard CVA Model instead of the weighted average? What would be the advantages and disadvantages of using only the SNAC method?

Question G7: Should the Board consider moving the reporting location of firm CVA hedges from the FR Y-14Q, Schedule F (Trading) to the FR Y-14Q, Schedule L (Counterparty)? Should CVA hedges be included in the CVA loss model rather than calculated by the Board's Trading P&L Model? What would be the advantages and disadvantages of moving the reporting to the Counterparty Schedule and calculations to the Standard CVA Model?

c. *Model Exposure Population*

Question G8: Should the Board consider losses from other derivative valuation adjustments (xVAs) in the stress test? For example, should the Board include FVA losses given FVA's inclusion in net income as a common accounting practice? What would be the advantages and disadvantages of including them?

Question G9: Should the Board consider requiring firms to assume a ten-day margin period of risk in their CVA models for reporting unstressed FR Y-14Q, Schedule L (Counterparty) exposures and balances? If so, what would the advantages and disadvantages be of aligning unstressed and stressed margin periods of risk? Should the board consider a different margin period of risk to align unstressed and stressed reporting?

H. LCPD Model

i. Statement of Purpose

The Largest Counterparty Default Model (LCPD Model) is a component model of the supervisory stress test that applies to firms with substantial trading or custodial operations and captures the loss each firm would experience if its largest counterparty were to default under the hypothetical GMS component of the supervisory severely adverse stress scenario. These losses are a component of trading and counterparty losses within overall stressed losses. The model's primary objective is to assess meaningful concentrations in firms' counterparty credit risk exposures and generate scenario losses to ensure that these concentrations are capitalized against. In past supervisory stress tests, the Board has projected LCPD losses ranging from $18 billion to $24 billion, across all firms.

ii. Model Overview

During the 2008 financial crisis, financial firms came under material stress when counterparties with large exposures to these firms attempted to reduce these exposures. Given the interconnectedness of large financial firms, this stress can cause other large financial institutions to experience distress, posing risks to the stability of the financial system. Moreover, concentrations in counterparty exposure exist that are not fully captured by the CVA Model. To mitigate these risks, the LCPD component increases the resilience of firms against large counterparty exposures.

The Federal Reserve applies the LCPD scenario component to firms with substantial trading or custodial operations, as identified by the Board.[287] The LCPD scenario component captures the losses the firm would experience if its largest counterparty ranked by stressed exposure were to default after application of the GMS. Firms subject to the LCPD scenario component apply the shock to their counterparty exposures across derivative positions[288] and securities financing transactions (SFTs).[289]

For a given firm, the LCPD Model estimates the largest stressed loss that could result from a single counterparty defaulting on derivative and SFT exposures, as measured under the stressed conditions specified in the GMS component. To calculate stressed losses for a given counterparty, stressed exposures are considered net of any associated collateral and single-name CDS hedges against the counterparty. Stressed net exposure is then multiplied by a factor of 0.9, reflecting an assumption that firms will lose ninety percent of the exposure when default occurs. Any stressed CVA already attributed to the counterparty is subtracted from the loss. Consistent with the Board's modeling principles of simplicity and conservativeness, the LCPD Model assigns LCPD Loss in the first quarter of the supervisory stress test projection horizon.

[287] The Board may require a company to include one or more additional components in its severely adverse scenario in the annual stress test based on the company's financial condition, size, complexity, risk profile, scope of operations or activities, or based on risks to the U.S. financial system. See 12 CFR 252.54(b)(2)(ii); 12 CFR 238.143(b)(2)(ii).

[288] A firm's direct or indirect credit exposure to a client arising from centrally-cleared derivatives is excluded from the LCPD loss estimation. This is either the case in which the firm is acting as a financial intermediary on behalf of the client and enters an offsetting transaction with a CCP or an exchange (referred to as a back-to-back derivative) or the case in which the firm guarantees the client's performance to a CCP or an exchange (referred to as a guaranteed derivative).

[289] As per FR Y-14Q instructions, all counterparty exposures related to repurchase and reverse repurchase agreements, securities lending, and securities borrowing are defined as SFTs.

To compute the LCPD Loss for a given firm, a counterparty default loss for each of the firm's top twenty-five counterparties[290] is calculated from stressed exposure metrics reported in the FR Y-14Q, Schedule L (Counterparty). The largest default loss among all top counterparties, excluding certain entities listed below, equals the LCPD Loss.

To identify the largest default loss, the following entities are excluded:

- CCPs;
- sovereigns with a credit rating equivalent to "AA-" and above based on firms' internal ratings;
- certain Multilateral Development Banks (MDBs) and supranational entities, specifically:
    - the International Monetary Fund,
    - the Bank for International Settlements,
    - the European Commission,
    - the European Central Bank, or
    - the International Bank for Reconstruction and Development; and
- IHC affiliate counterparties.[291]

iii. <u>Model Specification</u>

The LCPD Model first calculates, for each top counterparty that is not an excluded entity, each firm's Stressed Net Default Loss to each counterparty. The LCPD Model then ranks stressed net losses from largest to smallest, and the LCPD Loss is the top-ranked counterparty-level loss for that firm.

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[290] Firms report their top twenty-five counterparties on a consolidated basis, ranked by stressed net exposure, in their GMS-as-of date quarter in the FR Y-14Q, Schedule L.

[291] IHC affiliates are defined in 12 CFR 252, subpart Q. *See also* 83 FR 38460, 38465 (Aug. 6, 2018).

The following model specifications are used in the LCPD Model.

a. *Stressed Net Default Loss by Counterparty*

For each of the firm's top counterparties reported in FR Y-14Q, Schedule L.5 (Derivatives and securities financing transactions (SFT) profile), indexed by k, Stressed Net Default Loss, $\text{SN Loss}(s, k)$, under scenario s, is calculated as:

Equation H-1 – *S*tressed Net Default Loss for counterparty k

$$\text{SN Loss}(s, k) = [\text{Total SN CE}(s, k) - \text{CDS Ntn}(k)] \cdot \text{LGD} \ - \text{CVA}(s, k),$$

Where:

- s represents a GMS component under the severely adverse scenario;
- k represents a consolidated / parent[292] top counterparty;
- $\text{Total SN CE}(s, k)$ represents the total stressed net current exposure to the consolidated / parent top counterparty k in scenario s, which is defined as:
  - the sum of FR Y-14Q, Schedule L.5.1, item "Total Stressed Net CE Severely Adverse"[293] (MDRM code CACNR536), aggregated across all Covered Netting Sets, as defined in Section H(iii)(c), attributed to consolidated / parent top counterparty k,

    less
  - the sum of FR Y-14Q, Schedule L.5.1, item "Stressed Net Current Exposure (Net CE) Derivatives Severely Adverse"[294] (MDRM code CACSR564), aggregated across all

[292] Exposures in FR Y-14Q, Schedule L.5, are reported at the Legal Entity and netting set level. The LCPD Model is based on the aggregated exposures from legal entities that are subsidiaries of the same consolidated / parent counterparty.

[293] As per FR Y-14Q instructions, this field is calculated at the netting set level as the greater of zero and the difference between the aggregate stressed mark-to-market value of securities or cash posted to the counterparty legal entity and the aggregate stressed mark-to-market value of securities or cash received from that counterparty legal entity. Values must be based on the full revaluation, under the GMS, of both derivatives and SFT exposures to the counterparty legal entity.

[294] This field refers to the portion of the stressed net CE that is related to derivatives transactions, while "Total Stressed Net CE Severely Adverse" is the aggregation of derivative and SFT stressed exposures.

Covered Netting Sets associated with consolidated / parent top counterparty k, that are Client Cleared Derivative Netting Sets, as defined in Section H(iii)(c);

- $\text{CDS Ntn}(k)$ represents the notional amount of CDS hedges on consolidated / parent top counterparty k, defined as the sum of FR Y-14Q, Schedule L.5.1, item "CDS Hedge Notional"[295] (MDRM code CACSR584), aggregated across all Covered Netting Sets attributed to consolidated / parent top counterparty k, multiplied by negative one (-1).

- LGD represents loss given default (LGD), set to ninety percent for all counterparties, motivated by the idiosyncratic nature of potential recoveries in respect of a single default, as detailed in Section H(iv); and

- $\text{CVA}(s, k)$ represents the stressed CVA associated with consolidated / parent top counterparty k in scenario s, determined as the sum of FR Y-14Q, Schedule L.5.1, item "Stressed CVA Severely Adverse"[296] (MDRM code CACSR590), aggregated across all Covered Netting Sets attributed to consolidated / parent top counterparty k.

b. *LCPD Loss*

LCPD Loss under scenario s, is defined as the largest Stressed Net Default Loss, $\text{SN Loss}(s, k)$, among all Covered Counterparties k.

Equation H-2 – LCPD loss

$$\text{LCPD Loss }(s) = \max_{k \in \text{ Covered CPs}} \{\text{SN Loss}(s, k)\}$$

[295] This field contains the net notional amount of specific CDS hedges calculated as the difference between sold and purchased amounts, where the only hedges eligible to be reported are single-name and non-tranched index credit derivatives for which one of the constituents matches directly to the reported counterparty legal entity.

[296] This field contains the CVA calculated for derivatives and SFT exposures of the corresponding netting set as evaluated under the GMS.

c. *LCPD Definitions*

Covered Counterparty: Any consolidated / parent top counterparty reported in FR Y-14Q, Schedule L.5.1 that is not an Excluded Parent Entity.

Internal Rating, as identified in FR Y-14Q, Schedule L.5.1 via field "Counterparty Legal Entity External Rating" (MDRM code CACNM07).

Excluded Parent Entity: a consolidated / parent top counterparty reported in FR Y-14Q, Schedule L.5.1 that is any of the following entity types:

- **Sovereign with zero percent risk weight**, as identified in FR Y-14Q, Schedule L.5.1 via fields "Consolidated / Parent Counterparty Name" (MDRM code CACNM900) or "Consolidated / Parent Counterparty ID" (MDRM code CACNM901);
- **CCP**, as identified in FR Y-14Q, Schedule L.5.1 via consolidated / parent top counterparty "Rank Methodology" (MDRM code CACNJD60) values of "NQCCP" or "QCCP";
- **Affiliate**, as identified in FR Y-14Q, Schedule L.5.1 via consolidated / parent top counterparty "Rank Methodology" (MDRM code CACNJD60) value of "AF"; and
- **MDBs** and **Supranational** entities:
    - International Monetary Fund,
    - Bank for International Settlements,
    - European Commission, or
    - European Central Bank

  as identified in FR Y-14Q, Schedule L.5.1 via fields "Consolidated / Parent Counterparty Name" (MDRM code CACNM900) or "Consolidated / Parent Counterparty ID" (MDRM code CACNM901).

Covered Netting Set: for a given consolidated / parent top counterparty k, a netting set reported in FR Y-14Q, Schedule L.5.1 for which:

- counterparty k is the "Consolidated/Parent Counterparty" (MDRM code CACNM900 / CACNM901); and
- the "Counterparty Legal Entity" (MDRM code CACN9017 / CACNR621) is not an Excluded Subsidiary Entity.

Excluded Subsidiary Entity: one of the following entities:

- the International Bank for Reconstruction and Development (IBRD), a subsidiary of World Bank Group,

as identified in FR Y-14Q, Schedule L.5.1 via fields "Counterparty Legal Entity Name" (MDRM code CACN9017) or "Counterparty Legal Entity Identifier (LEI)" (MDRM code CACNR621).

Client-Cleared Derivative (CCD) Netting Set: a netting set reported in FR Y-14Q, Schedule L.5.1 for which:

- "Agreement Type" (MDRM code CACNR529) is either
  - "Derivatives 1-way CSA",
  - "Derivatives 2-way SCSA",
  - "Derivatives 2-way old CSA",
  - "Derivatives Centrally Cleared", or
  - "None";

and for which

- "Agreement Role" (MDRM code CACNR530) is either
  - "Agent" (for CCDs where the firm guarantees the performance of the client to the CCP) or

- "Principal" (for back-to back CCDs, where the firm enters an offsetting transaction with the CCP).

iv. Specification Rationale and Calibration

The LCPD Model is designed to capture the systemic risk[297] associated with a large and unexpected default, specifically by an institution engaged in significant derivative or securities financing activity. LCPD Loss is based on stressed exposure, evaluated under the GMS, to reflect counterparty risks that could be precipitated or exacerbated by severe market stress. LCPD losses across firms subject to the LCPD component provide an assessment of the potential losses from defaulting concentrated exposures, as firms with a large share of their derivative and SFT exposures concentrated in one counterparty would face larger losses under this model.

For firms with substantial trading or custodial operations, the LCPD Model offers an assessment of whether they are sufficiently capitalized to absorb the losses stemming from an unexpected default of a meaningfully concentrated exposure under stressed conditions.

Key aspects of the model specification are further rationalized as follows:

a. *Exposure and Default Loss Measures*

Total stressed net current exposure is considered an appropriate measure of counterparty exposure under stressed market conditions, since it is based on full revaluation of the market value of derivative and SFT transactions under the given FR stressed market environment, net of the value of collateral posted by the counterparty to secure those trades. Full revaluation of the firm's portfolio offers an exact measure of exposure rather than, for example, approximations based on factor sensitivities. Deduction of CDS notional from total stressed exposure recognizes

[297] Risk that is specifically associated with interconnected counterparty relationships.

the firm's hedging practices, while subtracting CVA reflects the fact that any CVA associated with a counterparty would be released in the event of its default and also avoids double counting with the main CVA Model. As for LGD, the choice of ninety percent is justified by data on defaulting exposures and counterparties of the type being included in the model as well as the conservatism principle of the stress tests.

b. *Exclusion of Certain Sovereign Counterparties from the Largest Counterparty Default Component*

Though the LCPD Model does not include the probability of a counterparty defaulting as part of the loss computation, it does exclude certain counterparties considered to have very low default likelihoods. The exclusions allow the model to focus on counterparties that could plausibly default in practice by ignoring exposures that, even if large, pose negligible credit risk. In establishing these categories of excluded counterparties, the Board considered that the unique legal status and operations of these groups of entities warrant exclusion, as described below.

The following counterparties are excluded from the LCPD Model:

- Sovereigns of high credit quality: These sovereigns are regarded as high-quality counterparties that are very unlikely to default on their obligations. The list of excluded sovereigns includes the United States and those sovereigns with a rating equivalent of "AA-" and above, using the internal ratings developed by firms.[298] If there are discrepancies between these internal ratings, the Board takes the median of the internal ratings. The Board selected the threshold of "AA-" based on a review of the external

[298] For purposes of this exclusion, consistent with the U.S. capital rule, sovereigns include a central government (including the U.S. government) or an agency, department, ministry, or central bank of a central government. *See* 12 CFR 217.2 ("Sovereign"). For the avoidance of doubt, if the sovereign has a rating equivalent to "AA-" or better, any subsidiary of such sovereign would be an excluded counterparty.

ratings histories of sovereign obligors that ultimately defaulted. That review indicated that sovereign obligors that were rated "AA-" or above were unlikely to default in the nine-quarter period following such a rating. This approach is also similar to the Basel framework, which is well understood by firms and the public.

- Qualified central counterparties: Given these counterparties are designed with robust mechanisms and layers of protection such as initial margin, default fund contributions, and capital, they are very unlikely to default on their obligations.
- IHC affiliates: As U.S. subsidiaries of global foreign banking organizations (FBO), IHCs may have large exposures to their affiliates that arise from inter-company transactions with other entities within the global FBO. The exclusion is made so these firms do not limit exposures that are central to their business models, which could introduce additional risks to the IHC or reduce their operational efficiency.
- Certain multilateral development banks and supranational entities: Given their governance and stakeholders, these entities are regarded as posing very low credit risk. Their exclusion is also aligned with the single-counterparty credit limits (SCCL) capital rule. An exception is the World Bank Group, for which the LCPD Model excludes only one subsidiary of that group, the International Bank for Reconstruction and Development (IBRD), while the other entities that compose it are not excluded due to their distinct risk profiles.[299]

[299] The World Bank Group is composed of five legally separated institutions including the IBRD, International Finance Corporation (IFC), and Multilateral Investment Guarantee Agency (MIGA). IBRD's asset profile is deemed as less risky than the other World Bank Group entities as the loans in IBRD's portfolio have preferred creditor status and are granted to, and guaranteed by, governments, not to private or other investors as is the case of IFC and MIGA.

c. *Ninety Percent LGD Assumption*

The model's ninety percent LGD assumption is intended to depict the recovery risk inherent in an undiversified credit exposure under severe market conditions. It is calibrated based on the experience of the 2008 financial crisis, where recovery rates of just below ten percent[300] were observed on senior unsecured claims[301] following the collapse of Lehman Brothers—a large interconnected financial institution that defaulted under sudden market dislocations. Beyond the example of Lehman Brothers, recovery rates tend to be widely suppressed during periods of stress. For example, among rated corporate defaults occurring in 2008 and 2009, against senior unsecured claims, a median recovery rate of close to thirty percent was observed,[302] with recoveries of ten percent or less recorded in one out of every five defaults.[303]

Among the largest counterparties selected for default by the LCPD Model, financial institutions and sovereigns tend to dominate. Although crisis-era recovery data segmented by counterparty sector is limited, longer time series of senior unsecured defaults (from 2007 to the present), specific to either sovereign and financial obligors from a third-party data vendor's data, show wide idiosyncratic variation in both cases with tail recovery rates of twenty percent or lower. Based on these data and the experience of Lehman Brothers specifically, as well as corporate defaults more generally in 2008 and 2009, the Board determined that applying a

[300] Recovery rates of just below ten percent were observed in CDS auction results and the post-default traded price of Lehman Brothers debt.

[301] A senior unsecured position is typical of an over the counter (OTC) derivative and SFT position covered by the LCPD Model.

[302] The observed median recovery rate of close to thirty percent is approximately ten percentage points lower than the long run average of through-the-cycle outcomes.

[303] Excluding distressed exchanges, recoveries of ten percent or less were even more frequent.

uniform ninety percent LGD to sovereign and financial exposures in the context of a severe market shock is reasonable and, compared to a lower LGD percentage, more consistent with the supervisory stress testing principle of conservatism as defined in the Policy Statement.

d. *Margin Period of Risk*

The LCPD Model assigns losses during the first quarter of the projection horizon, based on positions and collateral on only the GMS as-of date. For all counterparties, stressed exposure and associated default loss is determined using the applicable GMS shocks, which embed calibration horizons of one to three months, that is, twenty-one to sixty-three trading days.[304] The LCPD Model does not account for actions a firm may take to close out or hedge defaulted positions.

The duration (in days) that it takes from the last exchange of collateral covering a netting set of transactions with a defaulting counterparty until that counterparty is closed out and the resulting market risk is re-hedged is known as Margin Period of Risk (MPOR). In practice, the MPOR is typically ten days. However, the LCPD Model implicitly sets the MPOR to the GMS calibration horizon because it assumes that the exposure is equal to the stressed exposure calculated under the GMS without any changes in the horizon assumed by that model.

While high-frequency margining has general risk-mitigating effects, on average, the Board believes the simplifying and conservative assumption of no differentiation in shock horizon by collateralization features[305] is appropriate to capture idiosyncratic risk inherent in the closeout of a single large counterparty, a process that may be protracted by margin disputes, ambiguity in default status, reluctance related to relationship and market impacts, or other

[304] The embedded calibration horizon varies by the asset class of underlying instruments for a given netting set.

[305] In principle, the actual shock horizon could vary based on counterparty and netting set characteristics.

operational factors. Thus, an MPOR aligned to the GMS shock horizon, typically twenty-one to sixty-three trading days, is appropriately conservative, as it is applied to an isolated default of a single large counterparty.

e. *Exclusion of CCDs*

Client-cleared derivatives are excluded from stressed exposure measurement to encourage the widely acknowledged risk-mitigating benefits of centrally clearing client transactions.[306]

v. <u>Assumptions and Limitations</u>

a. *Margined Counterparties MPOR*

A margined counterparty is a client with which the bank has an agreement to exchange collateral on a frequent basis to reduce the exposure during the life of a trade. For margined counterparties, the LCPD Model implicitly utilizes an MPOR equivalent to the GMS horizon (one to three months, or twenty-one to sixty-three trading days) for the shocks applicable to the counterparties' underlying exposures. In other words, the model assumes that the time it takes a firm to close out a defaulting exposure (measured by its MPOR) is equivalent to the relevant shock calibration horizon assumed by the GMS. Because, in practice, MPOR is typically lower

[306] For example, in a statement about the adoption of rules to facilitate central clearing for the US Treasury market in December of 2023 the SEC mentions that the range of benefits of central clearing in this market "[…] includes decreasing the overall amount of counterparty risk, […] helping to avoid disorderly counterparty defaults, and increasing multilateral netting of transactions, which should in turn reduce operational and liquidity risks." The SEC also refers to gains in transparency as ""[…] expanded central clearing should increase regulators' visibility into these markets. […] It should also increase price transparency of settlement risk to regulators and market participants. Specifically, increased transparency into settlement risk would allow a covered clearing agency […] to identify concentrated positions and crowded trades, and adjust margin requirements accordingly, which should help reduce contagion risk to both covered clearing agency and the system as a whole." *See* Crenshaw, C., 2023. Statement on Adoption of Standards for Covered Clearing Agencies for U.S. Treasury Securities and Application of the Broker-Dealer Customer Protection Rule with Respect to U.S. Treasury Securities (SEC). Available at https://www.sec.gov/newsroom/speeches-statements/crenshaw-statement-treasury-clearing-121323#_ftnref4.

than a given GMS horizon (e.g., MPOR may be ten trading days, as opposed to the typical twenty-one to sixty-three trading day GMS horizon), this results in relatively conservative treatment of margined counterparties.

b. *LGD Capturing Idiosyncratic Risk*

The LCPD Model's ninety percent LGD assumption is not intended to reflect expected aggregate recovery outcomes, but rather to capture idiosyncratic recovery rate uncertainty in the context of a single counterparty defaulting.

c. *Exclusion of Client Cleared Derivatives*

CCD trades, consisting of transactions where a firm takes direct exposure to a CCP on behalf of a client or guarantees a client's performance to a CCP, while considered to present low risk, nevertheless do expose firms to default losses in their role as guarantors of client performance to the CCP. The LCPD Model, in fully excluding CCDs from exposure measurements, assigns them a zero-loss footprint, despite the material volume of CCD activity among firms subject to the GMS, and despite CCDs bearing counterparty risk to some degree.

d. *Exclusion of certain sovereigns, CCPs, Affiliates, and MDBs*

The LCPD Model's entity exclusions, while originally based on broad risk considerations, are not expected to be strictly homogeneous in terms of credit quality over time, and may even exhibit the same credit quality as entities subject to the model.

e. *Exclusion of Prime Brokerage Margin Lending and Other Balance-sheet Exposures*

Exposure arising from margin lending to prime brokerage clients is not part of the derivative and SFT-focused trade population utilized by the LCPD Model. The model's current scope also excludes any positions beyond derivatives and SFTs, such as, for example, banking book loans or security exposures.

f. *CDS Hedge Treatment*

The default loss mitigation benefit assigned to CDS hedges is approximated by multiplying LGD by the contract notional. In practice, the jump-to-default gain associated with a given CDS hedge will additionally depend on its pre-default GMS stressed MtM value (which is implicitly set to zero in Equation H-1).

vi. Alternative Approaches

Alternative approaches considered by the Board included changing the treatment of some sovereign counterparties, changing LGDs for sovereign counterparties, a revision of MPOR assumptions for the LCPD Model, a probabilistic model specification, and a broader version of the current LCPD Model, discussed below.

a. *LCPD Model with Revised MPOR Assumptions*

The MPOR assumption in the current LCPD Model (i.e., implicitly setting it equal to the GMS horizon) may be considered overly conservative for counterparties that have margining agreements in place with firms. That is, most firms may be able to hedge or close out margined transactions in a shorter time frame, post default, compared to the relevant GMS calibration horizon. The Board considered the following adjustments that could recognize the risk-mitigating benefits of margining:

- modifying the FR Y-14Q, Schedule L, requiring stressed exposure to margined counterparties to be reported based on scaled factor shocks, with scaling following a simple stipulated rule; for example, a scaling based on the square-root of the ratio of (i) a ten-day MPOR assumption (for consistency with the CVA Model), relative to (ii) the calibration horizon for the given shock (a set of such scaled shocks could also be included in the published GMS scenario data, to avoid doubt); and

- similar scaling by the model, without any reporting change, applied directly to reported stressed exposures, again using a factor proportional to the MPOR associated with a given netting set.

The Board has not pursued either of these adjustments because they would introduce significant complexities to the submission, as in the case of modifying FR Y-14Q instructions to firms for computing stressed exposure, or to the actual model since applying a scaling factor to the reported stressed exposures would require more granularity about the asset classes of both derivative and SFT exposures (as the assumed GMS horizon depends on the underlying asset class of the exposure, e.g., equities, foreign exchange, corporate credit, commodities).

b. Sensitivity-Based Approach

Instead of relying on firm-provided stressed exposures based on full portfolio revaluations by firms, an alternative is for the model itself to estimate stressed exposures by applying factor sensitivities to unstressed exposures. This approach would provide the Board with the flexibility to independently model alternative scenarios, in addition to the GMS, in order to assess risks, produce what-if comparisons and tailor future stress tests.

The main limitation of this approach is the additional reporting burden it implies, as reported sensitivities would need to be as granular as possible to support an accurate estimate of stressed exposures. In addition, sensitivity-based estimates are always approximations while estimates from full portfolio revaluations, as in the current model, are more accurate estimates of stressed exposure.

c. Multiple Counterparty Defaults (MCPD)

As an alternative to assuming a single, deterministically selected, instantaneous and unexpected default, as in the current LCPD Model, the Board considered a probabilistic model that would project multiple defaults over a specific risk horizon, with each individual counterparty's likelihood of defaulting dependent on its credit quality. The final loss assigned to a given portfolio would be determined as a tail percentile of simulated default losses.

The Board determined that this probabilistic approach was inferior to the current LCPD Model because the current LCPD Model's single default-based approach is considered: (i) more conservative, where the estimated losses from MCPD tend to be lower despite allowing for more than one default, as losses and the likelihood of default in the model are governed by counterparty credit ratings and not on the severity of a given GMS scenario and stressed exposures; and (ii) a less assumption-driven method of capitalizing large exposure concentrations, whose individual default probabilities are difficult to systematically and confidently estimate.[307] The MCPD approach assumes that each counterparty's probability of default is dependent on the rating reported by the bank and requires further assumptions about correlations between counterparties.

d. Generalized Large Counterparty Default Scenario (Balance Sheet-Wide Exposure)

The Board also considered a broader scope for the LCPD Model: instead of targeting only derivative and SFT exposures, the model would be generalized to capture balance sheet-wide exposures for each given large counterparty, encompassing both the banking book as well as trading book exposures—a scope broadly consistent with the SCCL rule. Under this paradigm, the model's current scope of including only firms with substantial trading or custodial operations would also be relaxed and all stress test firms would be subject to the model. The

[307] Though the predictive power of market spreads and ratings for default likelihood is evident in the context of diversified credit exposures, under a probabilistic default simulation the effective exclusion of large counterparties whose defaults could present material financial stability risks, based on their individual credit ratings, was viewed as imprudent. This was based on historical experience, such as, for example, Lehman Brothers being highly rated up until its collapse.

Board evaluated whether the additional reporting and operational burden that would result from generalizing the model's firm population and exposure scope outweighed the additional concentration risk capture. The Board determined that the additional concentration risk capture was unnecessary for the underlying objective of the model, which is to capitalize systemic concentrations arising from interconnected derivatives and repo relationships, not to assess a firm's broader banking and trading book exposures.

e. Exclusion of Certain Sovereign Counterparties from the Largest Counterparty Default Component

The Board considered alternative approaches for establishing criteria for the set of excluded sovereign counterparties from the largest counterparty default component.

First, the Board considered retaining the approach that was employed in the 2025 supervisory stress test, which excluded exposures to countries of the G7 (Canada, France, Germany, Italy, Japan, the United Kingdom, and the United States). This approach was simple and transparent. However, this approach excludes sovereigns with similar credit risk as the countries of the G7.

Second, the Board considered using market-based data, such as CDS spreads, to set the group of excluded sovereign counterparties. Under this approach, the Board would analyze present and historical CDS spreads for sovereign counterparties, and set a maximum threshold based on that analysis. For example, the Board could construct a data series of CDS spreads for G7 countries over a given time period, select a percentile from among that CDS spread data, and then set a minimum CDS spread from that data to determine if other sovereign counterparties should be excluded. This approach would have the advantage of relying on public data, which would further enhance the transparency of the supervisory stress test. However, not all sovereign counterparties have actively traded CDS, which could result in volatility or unreliable data for purposes of establishing a group of excluded counterparties.

Third, the Board considered changing which entities constitute "sovereigns" for purposes of excluding counterparties. The Board considered whether to exclude only the sovereign itself, the sovereign and any subsidiaries of that sovereign, or only such sovereigns and their subsidiaries that are rated "AA-" on an entity-by-entity basis by a firm.[308] The Board is proposing to exclude the sovereign and the subsidiary of any sovereign that has a rating equivalent to "AA-" or better, because subsidiaries of sovereigns are closely linked to the credit of the sovereign.

Finally, the Board considered alternative methods of relying on internal firm ratings to set the group of excluded sovereign counterparties. The Board is proposing to rely on internal ratings to set this group because internal ratings are better tailored to the specific risks that each such counterparty would present to a given firm. As an alternative, the Board considered using external ratings published by NRSROs, instead of internal ratings, but selected internal ratings in order to tie the group of excluded sovereign counterparties to the firms' own assessment of risk, rather than to external assessments. The Board also considered alternative approaches to account for instances where firms submit conflicting internal ratings for a given sovereign counterparty. Instead of selecting the median internal rating, the Board considered selecting the lowest rating (among the firms' internal ratings) to determine whether a counterparty should be excluded. For example, if a sovereign was rated "A" by one firm and "AA-" by another firm, the Board would take the lower rating of "A" and thus the sovereign could not be excluded under the proposed standard, which would enhance the conservatism of the stress test. For transparency purposes,

[308] *See supra* note 298.

the Board also considered setting the minimum credit rating both above and below “AA-” as well as selecting the average rating, or another percentile, in order to avoid overweighting outlier ratings submitted by firms. While selecting the median firms’ internal ratings of a given sovereign counterparty should result in a reasonable determination of whether to exclude a given sovereign counterparty, alternative approaches could offer other advantages in terms of simplicity and transparency.

vii. Questions

a. *Modeling Assumptions*

Question H1: Should the LCPD Model soften its MPOR assumptions (i.e., shortening the GMS horizon) for margined counterparties? If so, what method could the Board follow to do so without adding significant complexity or reporting burden?

Question H2: Regarding the exclusion of central counterparties, international holding company affiliates, select multilateral and supranational entities, and select sovereigns based on their high credit ratings as per firms’ internal systems:

- *A) What are the advantages and disadvantages of using these exclusions to model LCPD losses in the supervisory stress test?*
- *B) Should the Board consider modifying or eliminating the set of excluded entities? If the Board were to eliminate the exclusions, how should the Board treat counterparties with little risk of default but with which banks have large exposures? What would be the advantages and disadvantages of that change?*
- *C) Does the exclusion of sovereign counterparties that have internal ratings equivalent to “AA-” and above correctly capture sovereigns of high credit quality? Is the current exclusion rule based on internal ratings appropriate to assess sovereign counterparty*

risk? What other procedures, if any, should the Board institute if the internal ratings of a given sovereign counterparty were to conflict? What other procedures, if any, should the Board institute if internal ratings are missing or only reported by one firm for a given sovereign counterparty? What are the advantages and disadvantages of such procedures?

- *D) What are the advantages and disadvantages of referencing internal ratings for sovereigns? Should the Board consider using external ratings instead? Should the Board consider an alternative approach that considers both internal and external ratings, and if so, how should the Board weight each type of rating?*
- *E) Would market-based data, such as CDS spreads, be a more suitable measure for defining the exclusion of sovereign counterparties? If market-based data, such as CDS spreads, would be a more suitable measure, what calibrations or thresholds of such data would be appropriate and how should the Board assess sovereign counterparties that typically have limited or no publicly available CDS spread information? What would be the advantages and disadvantages of the current approach, the described approach, and any alternative approaches to assess sovereign counterparty risk?*
- *F) How, if at all, should the Board treat the subsidiary entities affiliated with sovereign counterparties? For example, should the exclusion distinguish sovereign entities by their own credit ratings instead of treating all subsidiaries based on the rating of the parent sovereign? What types of sovereign subsidiaries should or should not be excluded and why? What are the advantages and disadvantages of alternative approaches to the treatment of sovereign subsidiaries?*

Question H3: Regarding the assumption of a fixed ninety percent LGD for all counterparties:

- *A) What are the advantages and disadvantages in using a fixed LGD of ninety percent to model LCPD losses in the supervisory stress test?*
- *B) Should the Board consider modifying or eliminating the assumption of a fixed ninety percent LGD? If the Board were to modify the fixed LGD assumption, how should the Board address the estimation of LGD in a manner that is both conservative and does not introduce additional complexities to the model? What would be the advantages and disadvantages of that change?*
- *C) Should the LGD instead be assigned by the firm's own methodologies? If so, what guidance should the Board provide to ensure consistency in determining LGDs across firms? What would be the advantages and disadvantages?*

Question H4: Regarding the exclusion of CCDs from the stressed exposure calculation:

- *A) Should the Board consider including CCDs? If so, how should the Board address CCD exposures in a manner that reflects their lower counterparty risk? What would be the advantages and disadvantages of that change?*
- *B) Are there other approaches that the Federal Reserve could use for the inclusion of CCD exposures, in a manner that improves overall risk capture without being unduly punitive? If so, what are these approaches and what are their advantages and disadvantages?*

b. *Alternative Approaches*

Question H5: Should the Board consider using an exposure sensitivity-based approach instead of the current model based on full portfolio revaluation? What would be the advantages and disadvantages of using the sensitivity-based approach to estimate LCPD losses?

Question H6: Should the Board consider averaging net stressed losses over multiple top counterparties? If so, should this average be risk-weighted, and how? How many top counterparties should be considered, and how would they be selected? Should the number and type of counterparties be dependent on the scenario? What would be the advantages and disadvantages of using this averaging method to estimate LCPD losses?

Question H7: Should counterparty probability of default be incorporated into the LCPD Model? If so, how? If PDs were to be assigned by firms, what guidance should the Board provide to ensure consistency in determining these default probabilities across the industry? What would be the advantages and disadvantages of introducing credit risk?

Question H8: Are there any other alternative models the Board should consider to calculate LCPD losses? If so, which ones?

Question H9: What criteria should the Board use in determining which institutions are subject to the LCPD Model?

Question H10: What are the advantages and disadvantages in incorporating balance sheet-wide counterparty exposure, beyond derivatives and securities financing transactions (for example margin lending), as per the SCCL rule? For example, should the Board consider including wholesale lending exposures to counterparties reported in FR Y-14Q, Schedule H? What would be the advantages or disadvantages of broadening the scope of counterparty exposures?

Question H11: Should the Board consider incorporating settlement risk into the LCPD Model? What would be the advantages and disadvantages of including it?

I. Auxiliary Scenario Variables

i. Statement of Purpose

The Securities Model, FVO Model and Yield Curve Model utilize nine-quarter projections of certain risk factors (Auxiliary Scenario Variables) that are supplementary to the core variables depicted in the macroeconomic scenario. The Auxiliary Scenario Variables are necessary inputs for option-adjusted spread (OAS) and yield projections described in:

(i) the Securities Model Section A—see OAS projections used in determining the fair value of Agency MBS covered in Section A(iii)(a)(b) as well as OAS and yield projections used in determining the fair values of various credit-sensitive debt securities under Section A(iii)(a)(c);

(ii) the FVO Model—see OAS projections used in determining the fair values of retail loans and securitized product loan hedges, respectively under Sections B(iv)(a)(2) and B(v)(a)(3); and

(iii) the Yield Curve Model—see the projection of speculative grade corporate yields described in Section C(v)(a).

The full set of Auxiliary Scenario Variables used by the three models noted above (and described in this Section I) include nine OAS variables (pertaining to Agency MBS, agency CMO, corporate bonds, municipal bonds and five non-agency structured product categories) as well as one yield variable (pertaining to municipal bonds)—see Figure I-1 for a detailed tabulation of the model components they feature in. All ten variables project indices provided by a third-party data vendor.

ii. Model Overview

The modeling framework used to project each given Auxiliary Scenario Variable uses historical correlations with a set of core macroeconomic variables to project nine-quarter paths that are consistent with these core variables. Each Auxiliary Scenario Variable is modeled with a vector-autoregression (VAR) model.[309] The VAR model specifies how the path of a given Auxiliary Scenario Variable is governed by its sensitivity to both its own past values and to the past values of the set of core macroeconomic variables. The VAR model is of order one[310] for all Auxiliary Scenario Variable projections—implying that the current value of any variable in the model depends on its own first lagged value and the first lags of all the other variables included in the model. Each Auxiliary Scenario Variable is projected by a separate VAR model, with estimated coefficients determined for said variable in isolation. Further, the core macroeconomic scenario variables included in the VAR models also can differ across Auxiliary Scenario Variable types, as illustrated in Figure I-1.

iii. Model Specification

The general form of first-order VAR model used for all Auxiliary Scenario Variable projections is provided in Equation I-1. This equation broadly shows how the value in quarter t of a given Auxiliary Scenario Variable s_t alongside the values of a set of core macroeconomic

[309] A VAR model is a time series model that uses linear equations to describe the evolution of a system of interrelated variables over time. VAR is a standard econometric tool, widely used in economics and finance, to analyze and forecast the behavior of macroeconomic time series.

[310] The "order" of a VAR model indicates the number of past time periods used to predict the current values of the variables being modelled.

scenario variables $\boldsymbol{c_t}$.[311] depend on their prior quarter values (s_{t-1} and $\boldsymbol{C_{t-1}}$), capturing the interrelated movement of the auxiliary and core variables together through time.

Equation I-1 – first-order VAR model for Auxiliary Scenario Variable s_t

$$\begin{bmatrix} \boldsymbol{c_t} \\ s_t \end{bmatrix} = \begin{bmatrix} \boldsymbol{\alpha_c} \\ \alpha_s \end{bmatrix} + \begin{bmatrix} \boldsymbol{\Phi_{cc}} & \boldsymbol{\Phi_{cs}} \\ \boldsymbol{\Phi_{sc}} & \Phi_{ss} \end{bmatrix} \begin{bmatrix} \boldsymbol{c_{t-1}} \\ s_{t-1} \end{bmatrix} + \begin{bmatrix} \boldsymbol{e_{c,t}} \\ e_{s,t} \end{bmatrix}$$

The terms in Equation I-1 are defined as follows:

- s_t is a single Auxiliary Scenario Variable in quarter t;
- $\begin{bmatrix} \boldsymbol{\alpha_c} \\ \alpha_s \end{bmatrix}$ is the regression intercept (a constant vector), with $\boldsymbol{\alpha_c}$ denoting intercept values pertaining to the core scenario variables and α_s denoting the auxiliary variable intercept;
- the matrices, $\boldsymbol{\Phi_{cc}}$, $\boldsymbol{\Phi_{cs}}$, $\boldsymbol{\Phi_{sc}}$, and the number Φ_{ss} are the autoregressive parameters that measure the dependence of each variable's value in quarter t on the prior quarter values of all variables in the system; and
- the vector $\boldsymbol{e_{c,t}}$ and the number $e_{s,t}$ are the error terms in the system at projection quarter t associated with the core variables and auxiliary variable, respectively.

Using the VAR model parameters (the α's and Φ's in Equation I-1), the conditional path of each Auxiliary Scenario Variable is projected over the stress test horizon following Clarida and Coyle[312] by applying the Kalman smoother[313] and conditioning on:

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[311] This Auxiliary Scenario Variable Section I adopts the convention that a symbol in **bold** denotes a vector or a matrix—in this case a matrix of core macroeconomic scenario variables at a given point in time.

[312] *See* Clarida, R.H. and Coyle, C., 1984. Conditional Projection by Means of Kalman Filtering (NBER Working Paper No. t0036).

[313] The Kalman smoother is a standard econometric tool for conditional forecasting. *See* Hamilton, J.D., 1994. Time Series Analysis (Princeton University Press).

(i) the historical values of the auxiliary variable s_t and core variables $\boldsymbol{c_t}$ as observed over $t = 1, \dots, T\text{-}\ k$ (where $t = 1$ indexes the first historical observation quarter, $t = T\text{-}\ k$ indexes the quarter preceding the jump-off quarter for the stress test and $t = T$ is the last quarter of the projection horizon); and

(ii) the path of the core variables over the projection horizon $\boldsymbol{c_{T-k+i}}$ for $i = 1, \dots, k$.

Figure I-1 – Auxiliary Scenario Variables with associated model components and core variables used in projection.

Auxiliary Scenario Variable s_t	Linkage to Core Macroeconomic Scenario Variables $\boldsymbol{C_t}$	Model Components Featured In
Agency CMO U.S. Agency Collateralized Mortgage Obligation [OAS]	U.S. Prime Rate; U.S. BBB Corporate Yield; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log House Price Index; Quarter-to-Quarter Change Log VIX Index	Securities Model – Agency CMO fair value projection
Agency MBS U.S. Agency Mortgage-Backed Securities [OAS]	U.S. BBB Corporate Yield; U.S. Prime Rate; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log House Price Index; Quarter-to-Quarter Change Log VIX Index	Securities Model – Agency MBS fair value projection
CMBS U.S. Commercial Mortgage-Backed Securities [OAS]	U.S. Real GDP growth; U.S. BBB Corporate Yield; Quarter-to-Quarter Change Log Dow Jones Stock Market Index	Securities Model – investment grade CMBS fair value projection; FVO Model – investment grade securitized product hedge fair value projection
HY Corporate Bonds Global High-Yield Corporate Bonds [OAS]	U.S. Real GDP growth; U.S. Unemployment Rate; U.S. Inflation Rate; U.S. BBB Corporate Yield; U.S. Prime Rate; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log Commercial Property Price Index; Quarter-to-Quarter Change Log VIX Index	Yield Curve Model – speculative grade yield curves by credit rating used in FVO Model for speculative grade wholesale loan fair value projection; speculative grade OAS by credit rating used in Securities Model for fair value projection for certain speculative grade credit-sensitive securities

General ABS U.S. Asset-Backed Securities [OAS]	U.S. Real GDP growth; U.S. BBB Corporate Yield; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log House Price Index	Securities Model – fair value projection for certain investment grade credit-sensitive securities; FVO Model – retail loan and investment grade securitized product hedge fair value projection
Credit Card ABS U.S. Credit Card Asset-Backed Securities [OAS]	U.S. Unemployment Rate; U.S. Inflation Rate; U.S. BBB Corporate Yield; U.S. Prime Rate; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log House Price Index; Quarter-to-Quarter Change Log VIX Index.	
Home Equity ABS U.S. Home Equity Loan Asset-Backed Securities [OAS]	U.S. Real Disposable Income Growth; U.S. BBB Corporate Yield; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log House Price Index; Quarter-to-Quarter Change Log Commercial Property Price Index	
Auto ABS U.S. Automobile Asset-Backed Securities [OAS]	U.S. Unemployment Rate; U.S. Inflation Rate; U.S. BBB Corporate Yield; U.S. Prime Rate; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log Manheim Index; Quarter-to-Quarter Change Log VIX Index	
Municipal Bonds U.S. Municipal Securities [OAS]	U.S. Real GDP growth; U.S. Unemployment Rate; U.S. Inflation Rate; U.S. BBB Corporate Yield; U.S. Prime Rate; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log House Price Index	Securities Model – Municipal bond fair value projection
10Y AAA Municipal Yield U.S. ten-year AAA Municipal Bond Yield	U.S. Real GDP growth; U.S. Unemployment Rate; U.S. Inflation Rate; U.S. BBB Corporate Yield; U.S. Prime Rate; Quarter-to-Quarter Change Log Dow Jones Stock Market Index; Quarter-to-Quarter Change Log House Price Index	

iv. Specification Rationale and Calibration

A VAR model was chosen as a standard econometric tool, with reasonably simple structure, that can capture the interdependence of multiple variables and estimate Auxiliary Scenario Variable outcomes consistent with core variable paths provided for a given macroeconomic scenario.

The parameters of the VAR model, as applied for each Auxiliary Scenario Variable (the α's and Φ's in Equation I-1) are estimated by Ordinary Least Squares (OLS) using quarterly observations of the relevant spread or yield index upon which the Auxiliary Scenario Variable is based (obtained from a third-party data vendor), starting in 1997:Q4 through to the jump-off quarter for a given stress test.

v. Data Adjustments

The Board performs manual overrides to the VAR model projections to impose a floor on each projected OAS or yield, at the minimum value observed in the historical time series.

vi. Assumptions and Limitations

The projection framework relies on historical data to estimate VAR model parameters and implicitly assumes that the underlying correlations between variables in the model have not changed over time. This assumption needs to be monitored over time, as structural changes in the securitization market could potentially alter these correlations.