Capstone Project :
FRTB Instruction and Implementation

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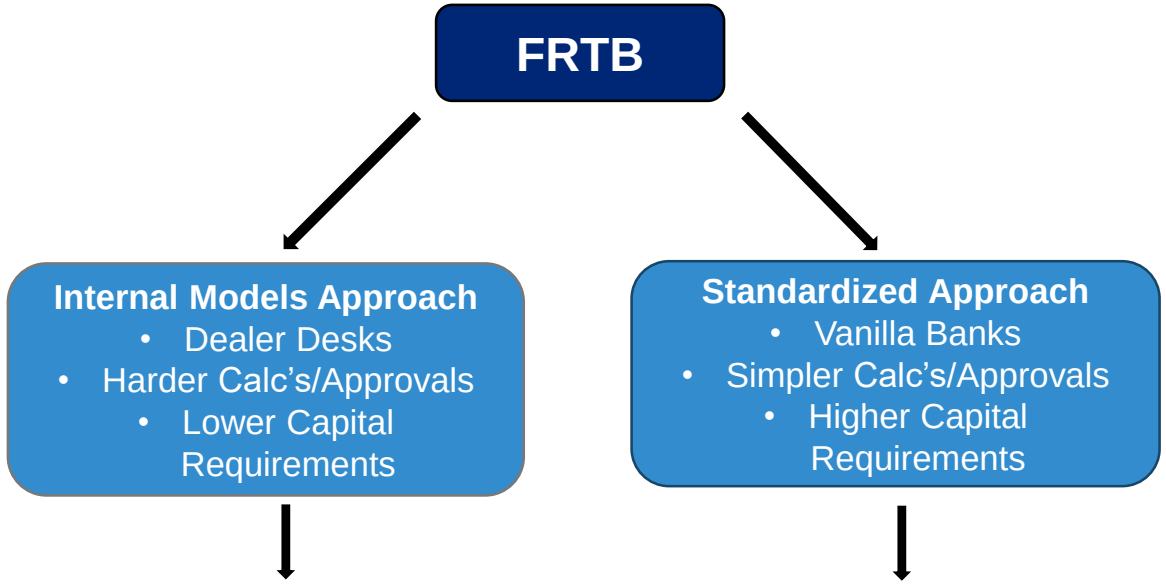
Financial and Risk Engineering | xx.xx.2017

NYU TANDON SCHOOL OF ENGINEERING

CONTENT

FRTB FRAMEWORK



Market Risk	Full historical stress ES + stressed scenarios for Illiquid factors	Approx ES with sensitivities + Residual Risk Add-On
Default Risk	VaR over random default vectors and LGDs	Approx VaR with weights and fixed LGDs

FRTB – MAJOR ASPECTS

- FRTB is a game changing regulation for capital markets trading businesses
- Significantly more granular and prescriptive standards
  - Limit jurisdictional and institutional interpretations
  - Consistency across regulatory and geographic jurisdictions
- Revised trading/banking book boundary with explicit requirements and limitations
- Flexibility to select model approach for calculating capital charge at trading desk level
- Use of Expected Shortfall (ES) as the principal risk parameter
- Revised Standardized Approach (SA) – more risk-sensitive with Default Risk Charge (DRC) and Residual Risk Add On (RRAO)
- Redefined Internal Models Approach (IMA)
  - Focuses on tail risk with varying liquidity horizons, risk factor based, with constrained diversification
  - Stringent model approval process – desk-level P&L attribution tests

HIGH LEVEL CALIBRATION OF FRTB IMPACT

Capital cliff will be significant and dependent upon many factors

- FRTB **will likely worsen** both standard and internal capital charge requirement for banks
- The calibration of the floor to IMA capital as a percentage of the SA capital, along with the treatment of the sovereign risk, may further modify the impact on the market risk capital requirements
- IMA and SA computation at desk level will be a significant challenge to supervisors as well as supervised
  - Capital planning will be a more difficult process using the internal model, given the "cliff effect"
  - An industry study by ISDA/gfma/IIF[1] shows NMRF remains 30% of IMA capital
  - Balancing PLA against NMRF through risk factor calibration will add complexity for banks and supervisors
- The study[1] also shows a high ratio of SA/IMA capital (a/k/a "capital cliff"), even after adjusting for excluded RRAO (SA) and NMRF (IMA)[1,2]

Risk Factor Classes	SA/IMA Cliff[1]	SA/IMA Cliff Adjusted[2]
Interest Rate Risk	3.0x	2.4x
Credit Spread Risk	2.0x	1.6x
Equity Risk	4.1x	3.3x
Commodity Risk	2.9x	2.4x
FX Risk	6.2x	5.1x

[1] Results based on 21 banks, refreshing earlier QIS4 analysis based on final QIS rules. RRAO and NMRF are excluded from SA and IMA, respectively.

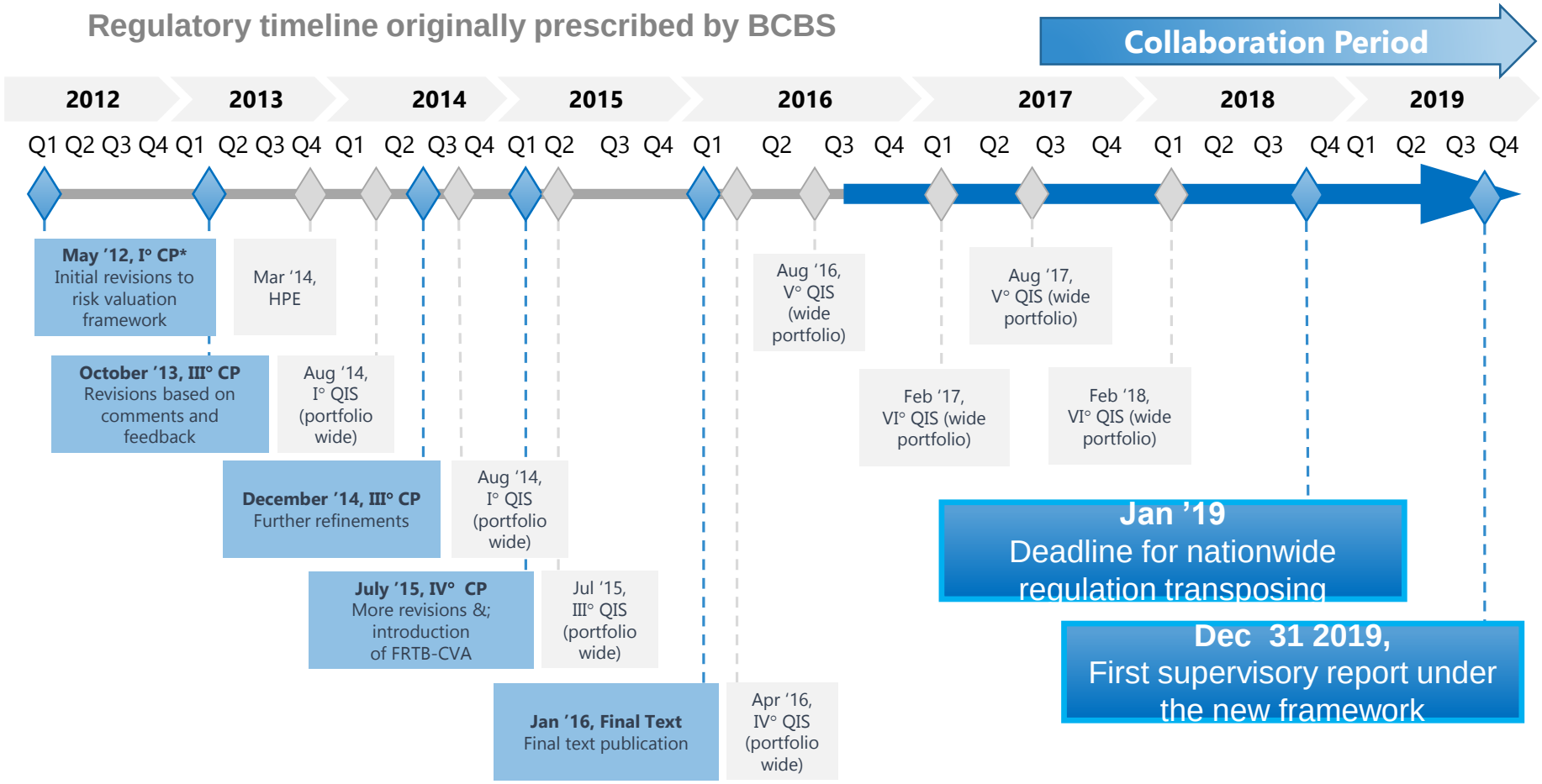
[2] Adjusted for 6% avg RRAO and 30% avg NMRF

PRACTICAL CHALLENGES OF FRTB IMPLEMENTATION

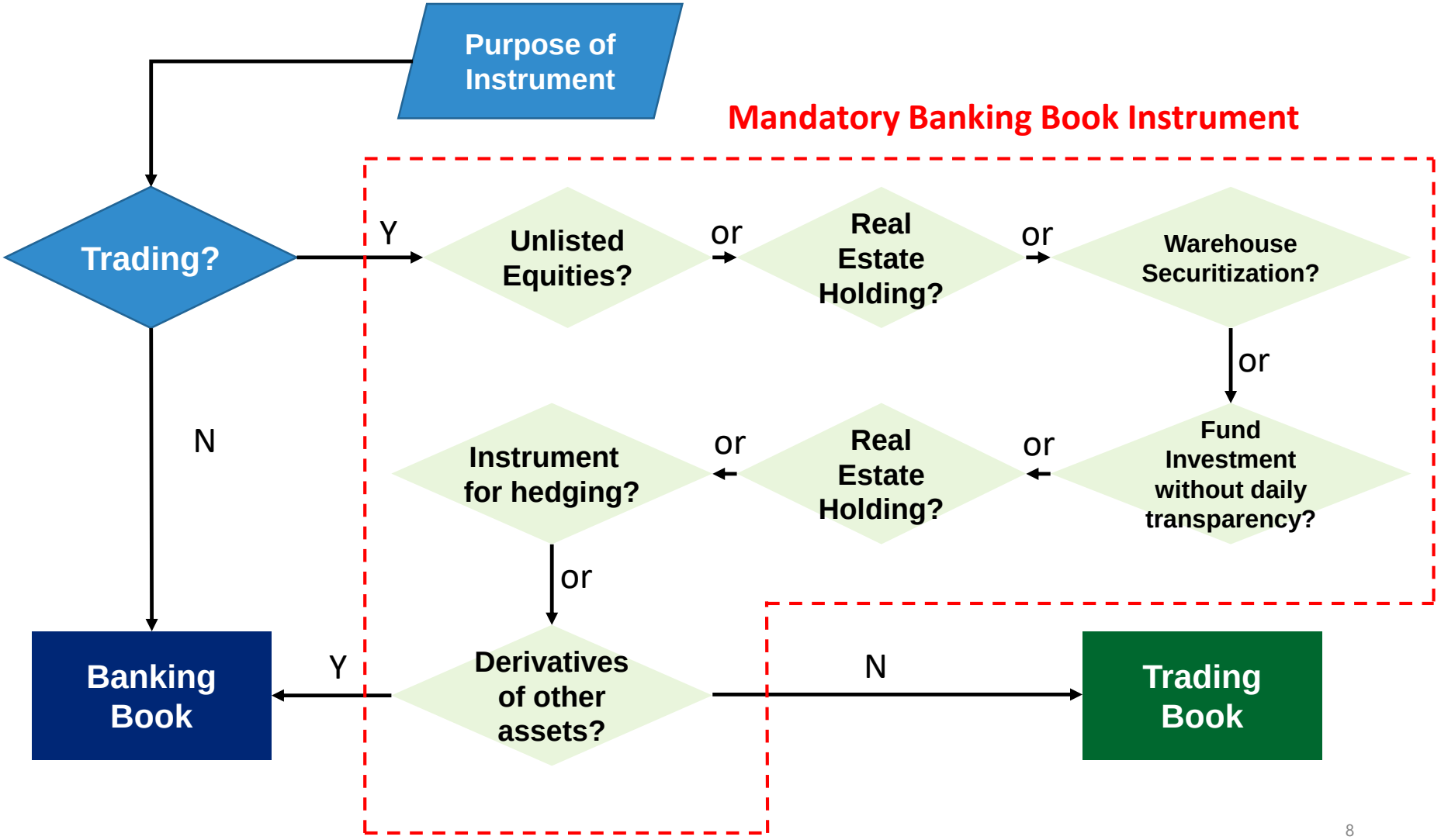
- P&L Attribution Test
  - Hard to pass
  - Creates adverse incentives
- NMRF - How do you model the unmodelable?
- Data – Sources, gaps, consistency, interpolations, proxies
- High implementation costs, particularly for small banks
- Impossible to calibrate real impact
  - QIS to date are flawed….

FRTB IMPLEMENTATION TIMELINE

Regulatory timeline originally prescribed by BCBS

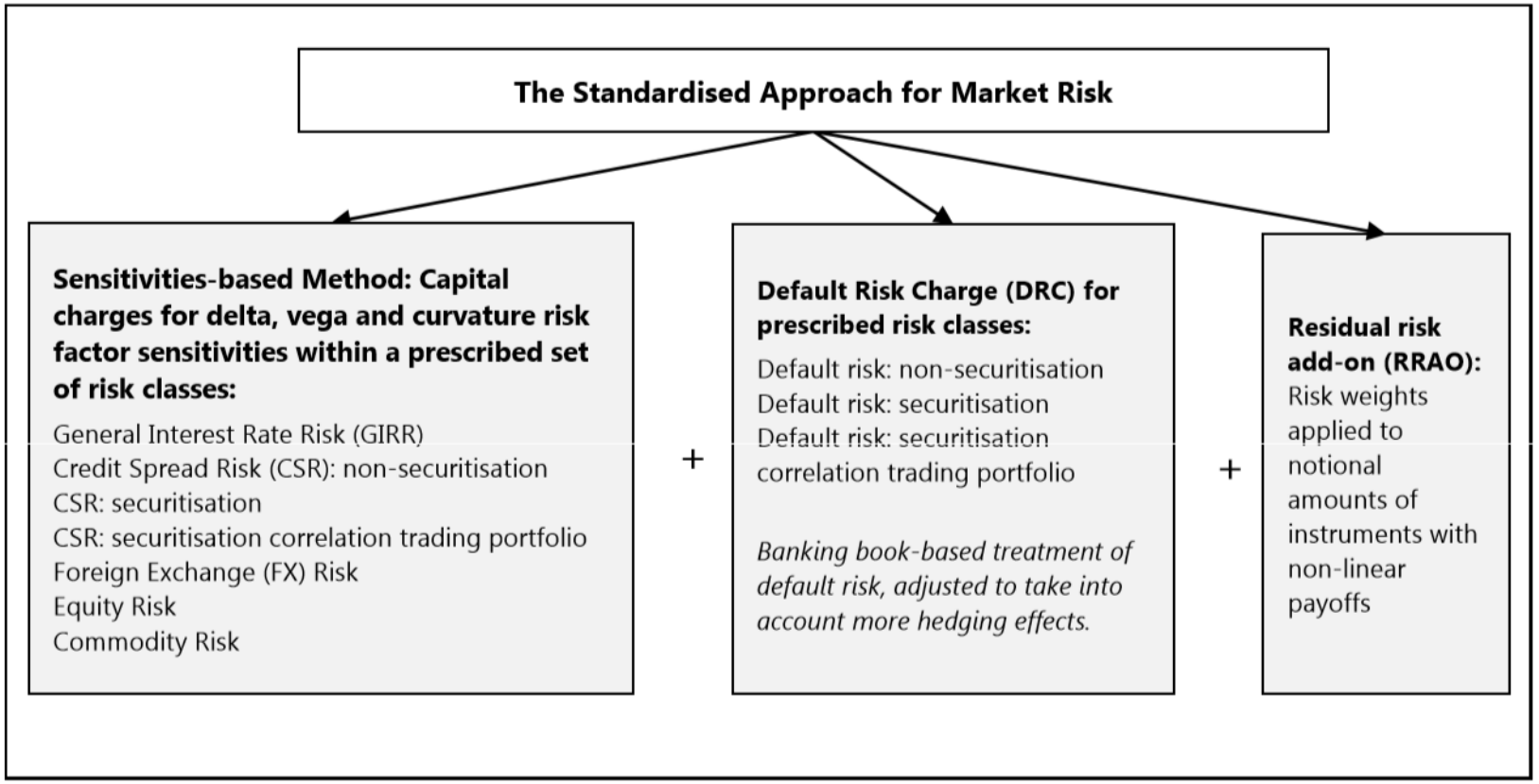


SA AND IMA BOUNDARY: AN EFFECTIVE WAY TO DISTINGUISH TRADE ALLOCATION



STANDARDIZED APPROACH FRAMEWORK

The new FRTB has a new guideline for Standardized Approach(SA). The framework states 3 separated parts to calculate regulated capital under SA approach



WESTERN AUSTRALIAN TREASURY CORPORATE BOND

Trade Description and Result Summary

- Calculation Date:
  - 3/31/2016
- Trade Description

Description	Western Australian Treasury Corporate Bond
Notional	10 mm AUD
Coupon Payment	8% Semiannual
Coupon Payment Date	07-15-2016, 01-16-2017, 07-15-2017
Current MTM (USD)	8,341,196

- Result Summary (USD)

SBA	DRC	RRAO	Total SA
2,026,191	192,838	0	2,219,030

SBA: Sensitivities-based Method
DRC: Default Risk Charge
RRAO: Residual Risk add-on

AUD CORPORATE BOND - CURVE ASSUMPTIONS

Curve Description	Curve Key	Term(days)	Rate
Currency Price	FX Price AUD/USD Spot Exchange Rate	2	0.77(x)
Bond Zero	Zero Bond Term Rate	106	234 bps
		291	201 bps
		471	192 bps
Bond Spread	Credit Spread for Western Australian Treasury Corporate	106	25 bps
		291	25 bps
		471	25 bps

Source: Numerix

AUD CORP BOND - SA CALCULATION STEP 1

SA

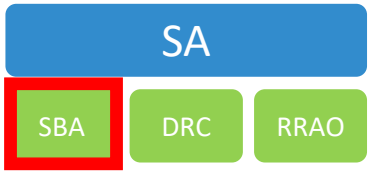
SBA | DRC | RRAO

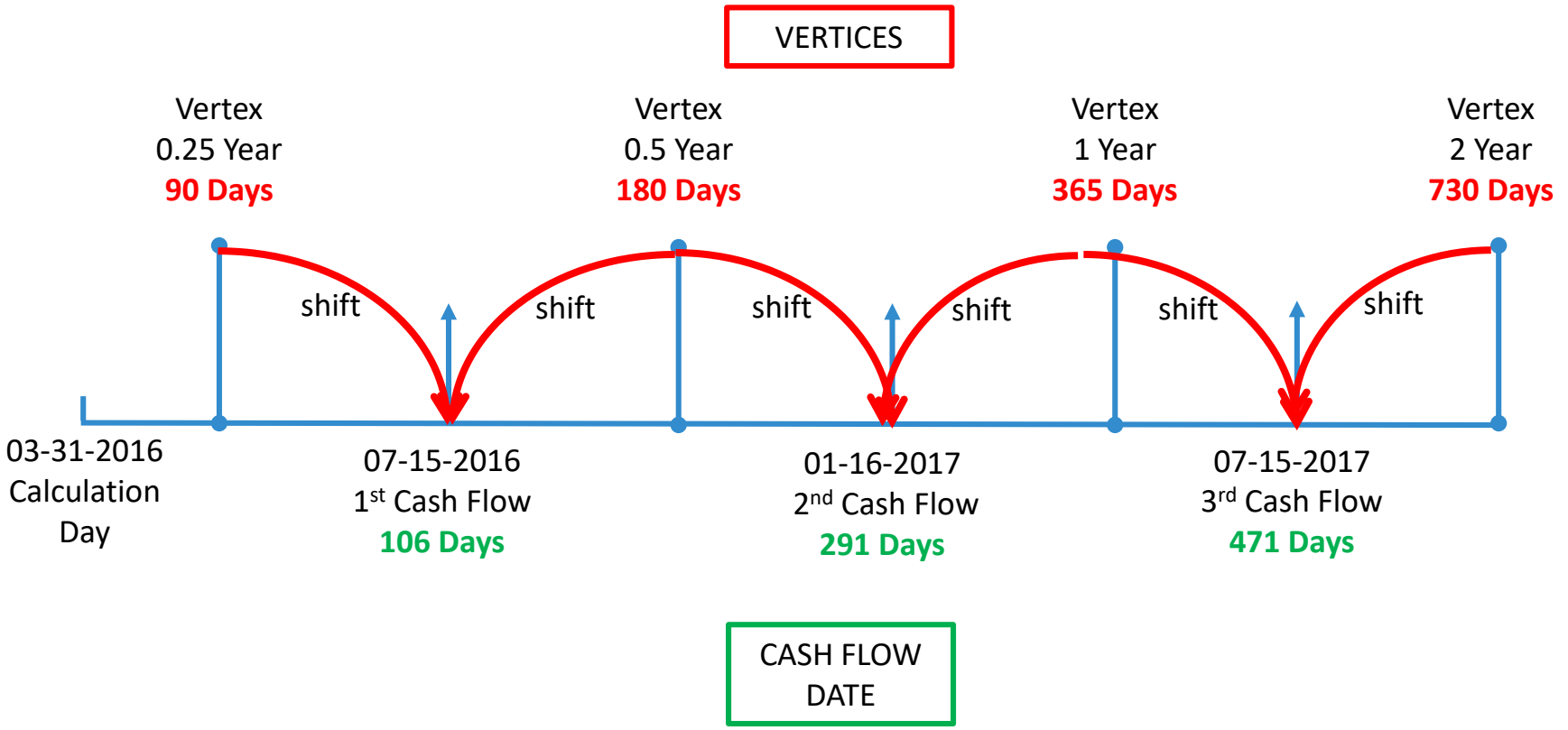
Identify risk classes, risk factors and risk buckets

GIRR	Delta Vega Curvature	Vertex (year): 0.25, 0.5, 1, 2
CSR (Non-Securitization)	Delta Vega Curvature	Vertex (year):0.5, 1, 3
CSR (Securitization-CTP)		
CSR (Securitization-Non CTP)		
FX Risk	Delta Vega Curvature	
Equity Risk		
Commodity Risk		

AUD CORPORATE BOND - SA CALCULATION STEP 2

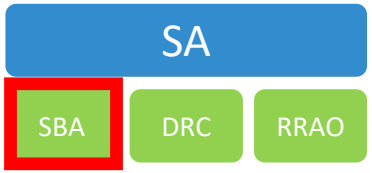
GIRR: Calculate Net Sensitivities



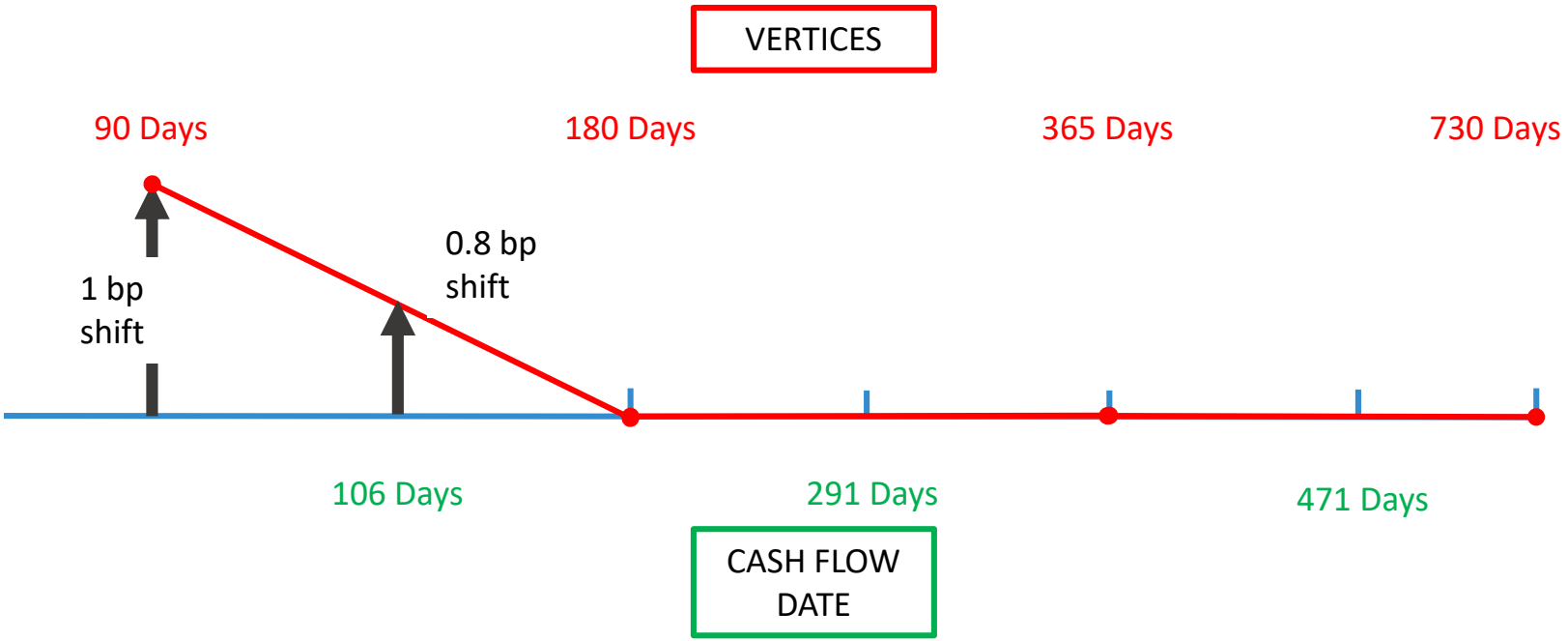


AUD CORPORATE BOND – GIRR INTERPOLATION

Vertex (days) : 90

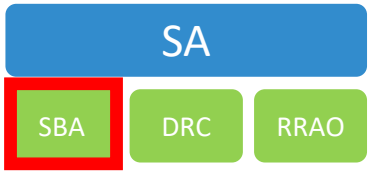


- FRTB ask to assign 1 bp shift to each vertex
- Use linear interpolation to calculation shift assigned to the interest rate for different cash flow date.
- Calculate PV01 Change with respect to the new interest rate.



AUD CORPORATE BOND – GIRR INTERPOLATION 90 DAYS

Graphical Interpretation



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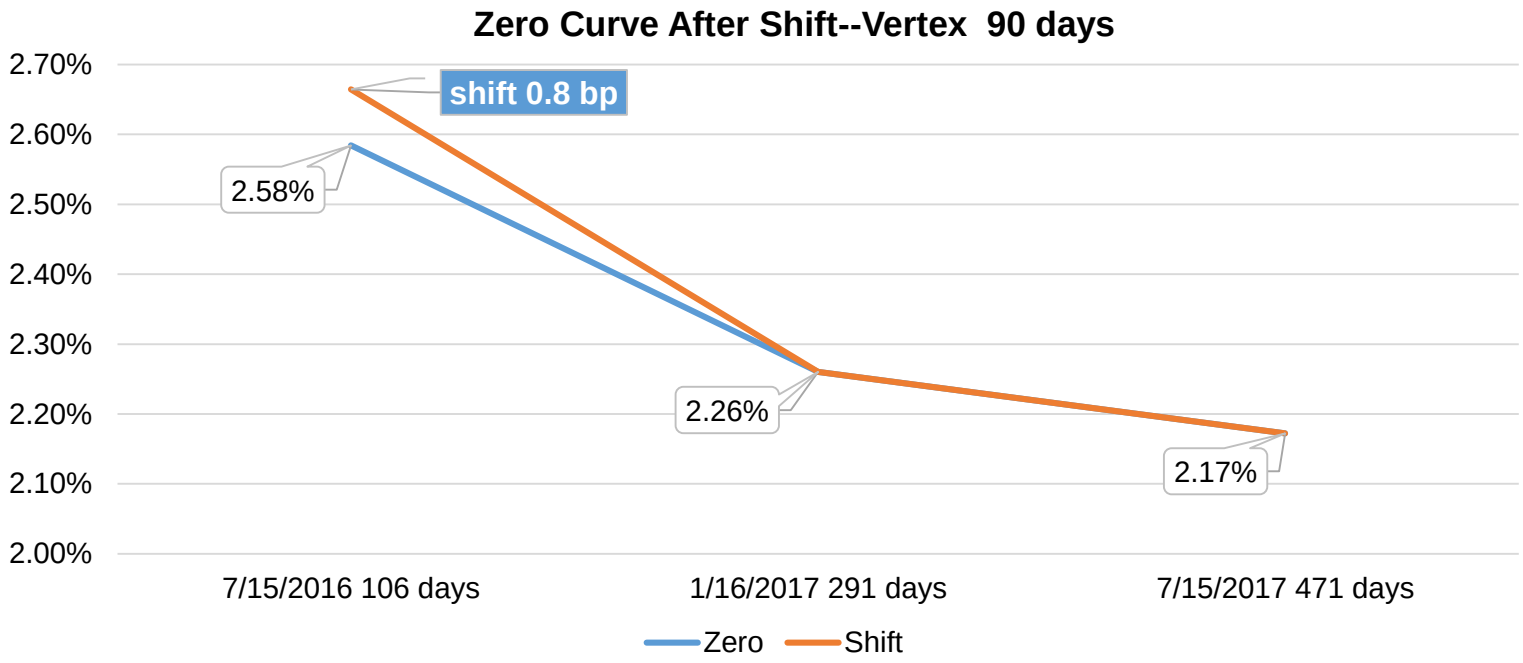
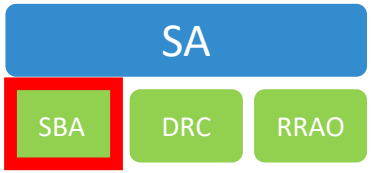


GIRR NET SENSITIVITIES CALCULATION DETAIL 90 DAYS

Present Value Per 1 Basis Point Change Calculation

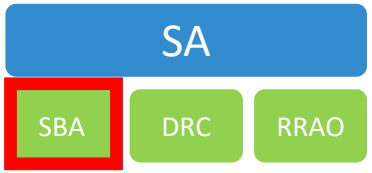


- FRTB ask to assign 1 bp shift to each vertex
- Use linear interpolation to calculation shift assigned to the interest rate for different cash flow date.
- Calculate PV01 Change with respect to the new interest rate.

Dates	Days (A)	Shift	AUD Cash flow (B)	Zero Term Rate (C)	AUD NPV=(B)× $e^{-\frac{(C)*(A)}{365}}$	Zero Term Rate After shift (E)	AUD NPV After shift =(B)× $e^{-\frac{(E)*(A)}{365}}$
3/31/2016							
7/15/2016	106	0.8 bp	397,814	2.58%	394,840	2.59%	394,830
1/16/2017	291	0	404,461	2.26%	397,239	2.26%	397,239
7/15/2017	471	0	10,394,521	2.17%	10,107,171	2.17%	10,107,171
PV01 Change 8,341,188 - 8,341,196 = -7.22				Sum of NPV	10,899,250	Sum of NPV	10,899,240
				USD	8,341,196	USD	8,341,188

AUD CORPORATE BOND – GIRR CALCULATION STEP 2

GIRR : Calculate Net Sensitivities(s_k)

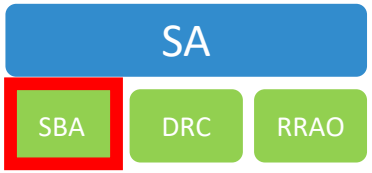


Vertex (day): 90, 180, 365, 730

GIRR NET SENSITIVITIES (s_K)		
Vertex	PV01 Change	Sensitivity(s_K)
90	-5.85	**-58,502**
180	-8.69	**-86,896**
365	-710.30	**-7,102,993**
730	-306.27	**-3,062,710**
	Total	**-10,311,102**

AUD CORPORATE BOND – GIRR CALCULATION STEP 3

GIRR : Calculate Weighted Sensitivities(WS_k)



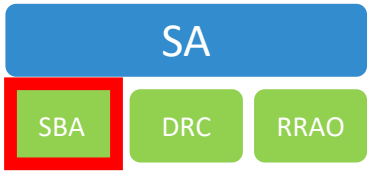
Vertex (day): 90, 180, 365, 730

GIRR WEIGHTED SENSITIVITIES (WS_K)			
Vertex	Sensitivity(s_K)	Risk Weight (RW_K)	Weighted Sensitivities (WS_K)
90	-58,502	1.70%	**-993**
180	-86,896	1.70%	**-1,475**
365	-7,102,993	1.59%	**-113,008**
730	-3,062,710	1.33%	**-40,714**

Source: Basel Committee D352 - Fundamental Review and Trading Book,

AUD CORPORATE BOND – GIRR CALCULATION STEP 4

GIRR : Aggregate Intra-Bucket (K_b)



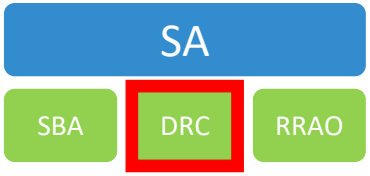
GIRR DELTA BUCKET b (K_b)						
Correlation Assumption = 1.25						
			Weighted Sensitivity (WS_L)			
Vertex (year)		Correlation Matrix (ρ_{kl})	-993	-1,475	-113,008	-40,714
0.25	Weighted Sensitivity (WS_K)	-993	1	1	1	1
0.5		-1,475	1	1	1	1
1		-113,008	1	1	1	1
2		-40,714	1	1	1	1
K_b=156,190						

$$K_b = \sqrt{\sum_k WS_k^2 + \sum_k \sum_{k \neq l} \rho_{kl} WS_k WS_l}$$

$$\rho_{kl} = \max\left[e^{\left(-\theta \cdot \frac{|T_k - T_l|}{\min\{T_k; T_l\}}\right)}; 40\%\right]$$

SA CALCULATION STEP 5

DRC Calculation

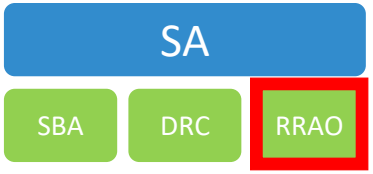


STANDARDIZED APPROACH - DEFAULT RISK CHARGE (SA-DRC)

Step 1	Step 2	Step 3	Step 4
Gross Jump-To-Default (JTD) Risk • Calculate all longs and shorts separately, even when referencing the same obligor • Intended to capture tail risk shocks which may not be captured in CSR • Borrows the concept of Loss Given Default (LGD) from Banking Book • Calculation: – Long JTD = Max (LGD × national + P&L, 0) – Short JTD = Min (LGD × national + P&L, 0) where P&L = market value – notional • LGD Prescribed – Equity 100% – Non-Senior Debt 100% – Covered Bonds 25% – Senior Debt 75%	**Net JTD Risk** • Long & shorts to same obligor can be netted if: – short seniority position is the same or less than long – varying maturities are scaled to a 1 year horizon – net longs and shots are aggregated separately	**Hedge Benefit Recognition** • Hedge Benefit Ratio is calculated within each bucket • No hedge benefit given across buckets • HBR is also called the "weighted to short" (WtS) ratio • Steps for HBR calculation – Sum all net long and short JTD's (not risk weighted) by the 9 risk bonds – Divide net long by the Sum of net long + the absolute value of net shorts – Mathematically, $HBR = \frac{\sum \text{net JTD}_{Long}}{(\sum \text{net JTD}_{long} + \sum \lvert \text{net JTD}_{Short} \rvert)}$	**DRC Risk Weight** • Net JTD's assigned Risk Weights base on 9 bands of credit ratings (AAA to CCC, plus unrated & default) • Weighted net JTD's then bucketed as follows: – corporates – sovereigns – governments/muni

Calculate Capital Charge for Each Bucket, Then Add the Buckets

RESIDUAL RISK ADD-ON CAPTURES RISK OUT OF SCOPE IN SENSITIVITY-BASED APPROACH



Instruments with an exotic underlying are trading book instruments with an underlying exposure that is **not within** the scope of delta, vega or curvature risk treatment in any risk class under the Sensitivities-based Method or Default Risk Charge in the Standardised Approach

-- Minimium Capital Requirements for Market Risk, BCBS

1 Exotic Underlying Exposure

Longevity Risk

- Insurance-type derivatives

Natural Disasters

- Weather derivatives

Future Realized Volatility

- Underlying exposure in Swap

…

2 Other Residual Risks

Gap Risk

- Barrier Options
- Asian Options
- Digital Options

Correlation Risk

- Basket Options
- Bermudian Options
- Spread Options

Behavioral Risk

- Callable Bond
- Bond affected by prepayment

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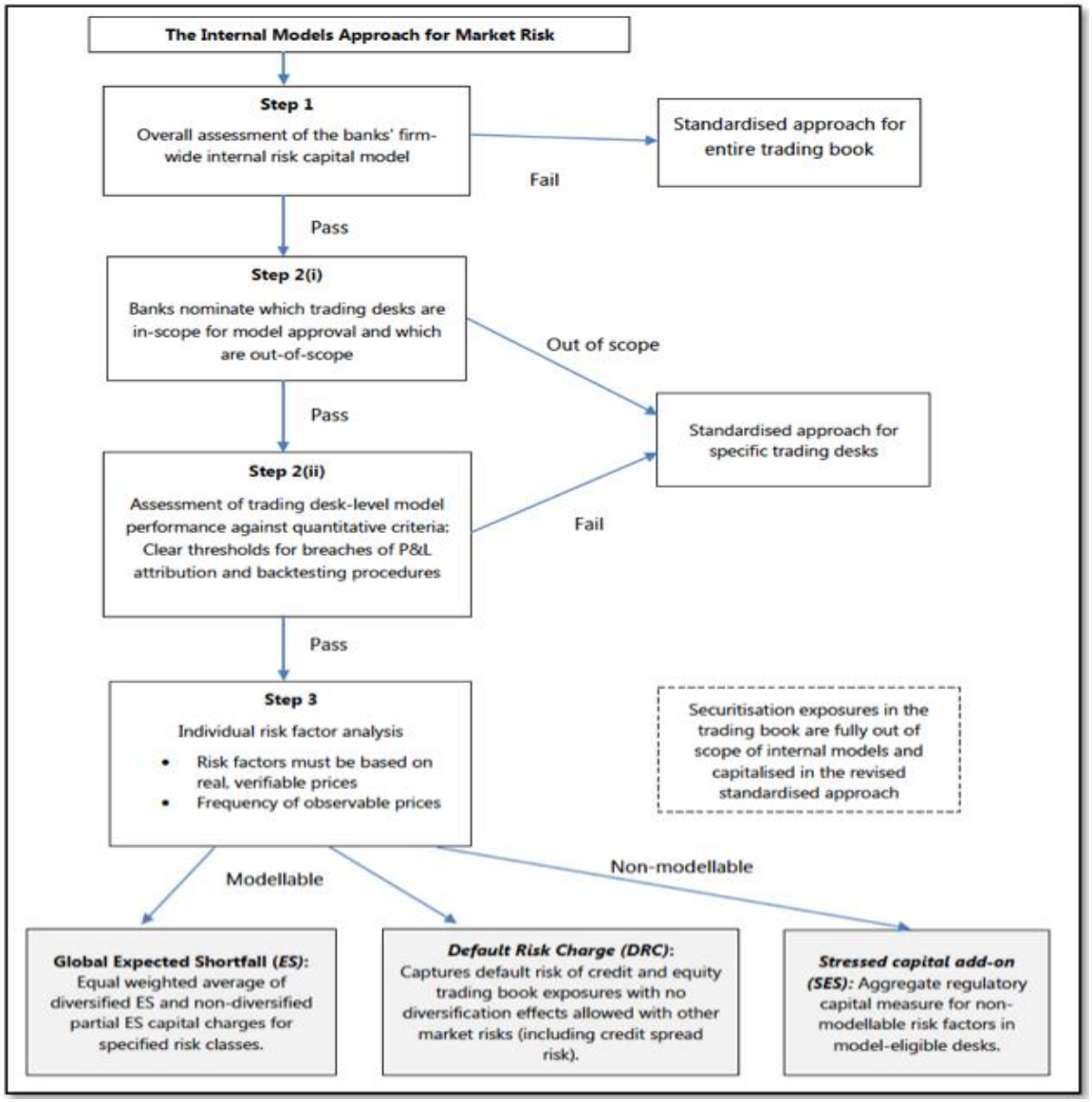
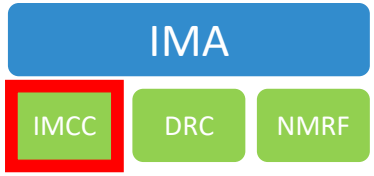
Note： RW_i is the risk weight: 1% for instruments with an exotic underlying, and 0.1% for instruments bearing other residual risks

INTERNAL MODELS APPROACH FRAMEWORK

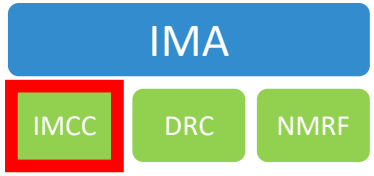




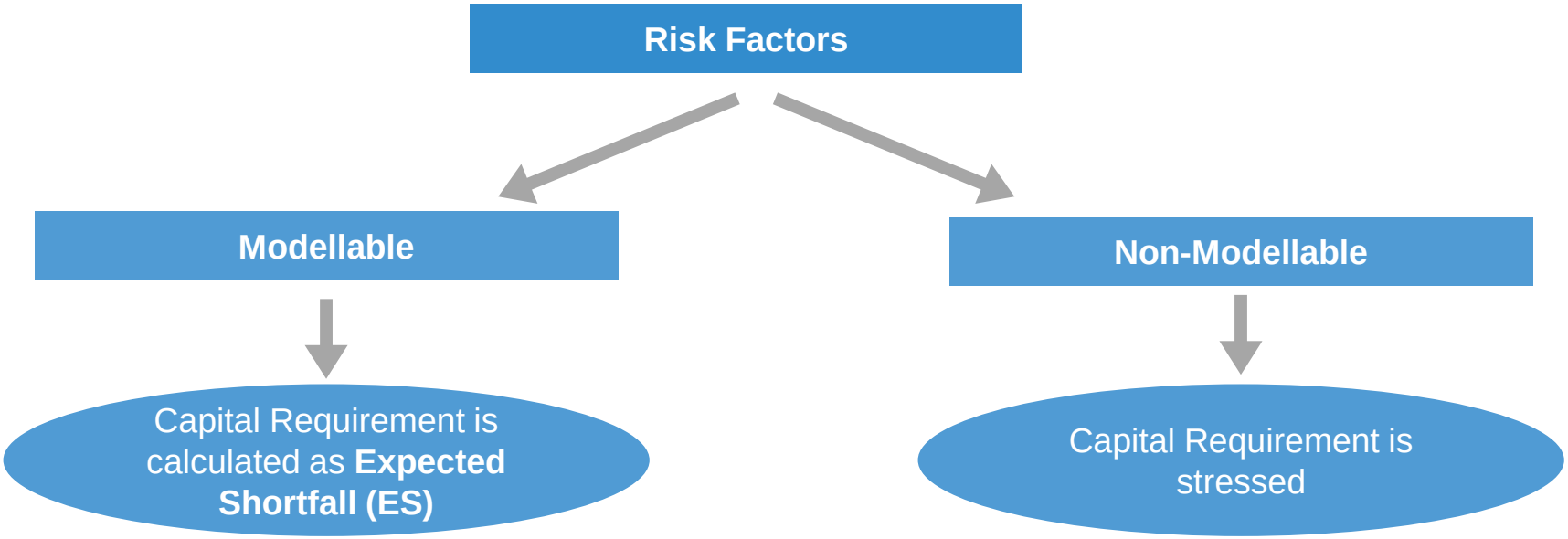
The total IMA capital requirement would be an aggregation of ES, the default risk charge (DRC) and stressed capital add-on (SES) for non-modellable risks.

CLASSIFICATION OF MARKET RISK FACTORS

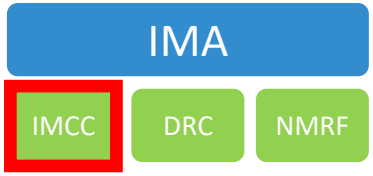
'MODELLABLE'&'NON-MODELLABLE'



Under IMA, risk factors could be classified into two different kinds: modellable and non-modellable risk factors based on the liquidity, verifiability and observability of the historical data.



WHAT IS MODELLABLE RISK FACTORS



Definition

To be modellable, risk factors need to meet 2 criteria under FRTB

- ‘’Real’’ Price
  - The institution has conducted a transaction; **OR**
  - Verifiable price for an actual transaction between other arms-length parties; **OR**
  - A committed quote; **OR**
  - Obtained from a third-party vendor
    - ✓ The transaction has been processed through the vendor
    - ✓ Provide evidence of the transaction to supervisors upon request
    - ✓ the price meets the three criteria immediately listed above
- Continuous observable ‘‘real’’ price data
  - At least 24 observable “real” prices per year **AND**
  - Maximum period of one month between two consecutive observations; **AND**
  - The above criteria have to be assessed on a monthly basis.

All other risk factors would be considered as **non-modellable** risk factors.

TRADE DESCRIPTION AND RESULTS SUMMARY

TRADE 1

- **Calculation Date:** 3/31/2016
- **Trade Description**

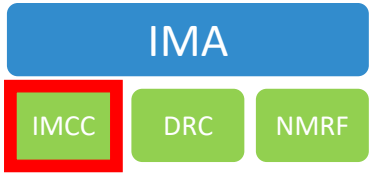
Description	Western Australian Treasury Corporate Bond
Notional &Coupon Payment	10 mm AUD 8% Semiannual
Cash flow Date	07-15-2016, 01-16-2017, 07-15-2017
Current MTM	8,341,196

- **Trade Summary**

Factor Set	ESRS	ESRC	ESFC	IMCC (C)
Total	1,410,655	395,244	395,244	1,410,655
Credit	56,491	8,375	8,375	56,491
FX	1,453,147	400,581	400,581	1,453,147
Interest	15,895	24,125	24,125	15,895
IMCC	**1,468,094**			

IMCC: **I**nternally **M**odeled **C**apital **C**harge

LIST RISK CLASSES AND LIQUIDITY HORIZONS

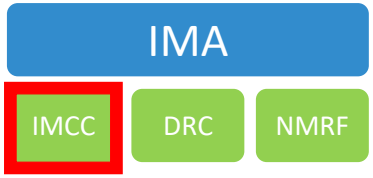


We have 5 risk classes and 5 liquidity horizons as listed below

Risk Class	Liquidity Horizon				
Interest Rate	**10**	20	60		
Foreign Exchange	**10**	20	40		
Equity	10	20	60		
Commodity	10	20	60	120	
Credit Spread	**10**	**20**	40	60	120

Liquidity Horizon: It is designed to scale the Expected Shortfall. The more illiquild the asset is, the longer liquidity horizon would be, and the more capital charge consequently.

CLARIFY EXPECTED SHORTFALL (ES)



Expected Shortfall (ES) takes place of VaR

Under FRTB, the expected shortfall is decomposed into 3 parts as follows, all use 97.5% percentile, one-tailed confidence level:

ESRS

- The most severe **12-month** stress over the previous **10** years
- The reduced set of risk factors ES≥ 75% full ES model

ESFC

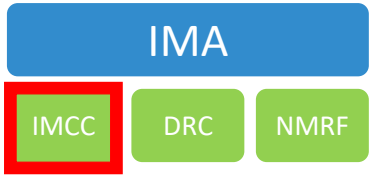
- current (most recent) 12-month observation period with a full set of risk factors

ESRC

- current (most recent) 12-month observation period with a reduced set of risk factors

ESRS: RS is Reduced Stress for short.
ESFC: FC is Full Current for short.
ESRC: RC is Reduced Current for short. ESRC acts like the bridge that connects ESRS and ESFC when data is unavailable. Sometimes we don't have adequate data for stressed period back in 10 years ago.

CALCULATE EXPECTED SHORTFALLS (ESRS)



ESRS is the ES with Reduced risk factors under Stressed scenario

- 260 trading days a year, back in 10 years with reduced RFs (FX with LH:10, Credit with LH:20)
- ES is the average of most severe 6 losses during the observation period

Liquidity Horizon:10 days	Risk Factor: FX	Liquidity Horizon:20 days	Risk Factor: Credit
Historic Shift Date	Change in MTM	Historic Shift Date	Change in MTM
2008/10/10	-1,604,257	2008/12/15	-49,862
2008/10/13	-1,585,830	2008/12/12	-47,314
2008/10/8	-1,497,792	2008/12/16	-42,471
2008/10/9	-1,398,655	2008/12/11	-37,362
2008/10/16	-1,266,520	2008/12/17	-32,120
2008/10/28	-1,107,481	2008/12/10	-30,544
Total Change in MTM	**-1,410,089**	Total Change in MTM	**-39,945**

CALCULATE EXPECTED SHORTFALL (ES) & IMCC

IMA

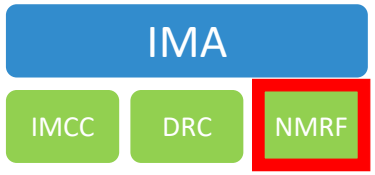
IMCC | DRC | NMRF

- ESRS, ESRC, ESFC all have 2 liquidity horizons
- We need to net them together, consider the weight of LH into calculation of IMCC

Factor Set	ESRS	ESRC	ESFC
Total	1,410,655	395,244	395,244
Commodity	0	0	0
Credit	56,491	8,375	8,375
Equity	0	0	0
FX	1,453,147	400,581	400,581
Interest	15,895	24,125	24,125
IMCC:	**1,468,094**		

- $ES = ES_{R,S} \cdot \frac{ES_{F,C}}{ES_{R,C}}$ The ratio of ESFC over ESRC is floored at 1.
- $ES = \sqrt{(ES_T(P))^2 + \sum_{j \geq 2}(ES_T(P,j)\sqrt{\frac{(LH_j - LH_{j-1})}{T}})^2}$ ES is calculated with scaling liquidity horizon, T is the length of base horizon, ie 10 days
- $IMCC = \rho\big(IMCC(C)\big) + (1-\rho)\big(\sum_{i=1}^{R} IMCC(C_i)\big)$. The value of ρ is 0.5.

HOW TO SPECIFY THE IMA RISK FACTOR SET IN THE CONTEXT OF NMRF AND P&L ATTRIBUTION?



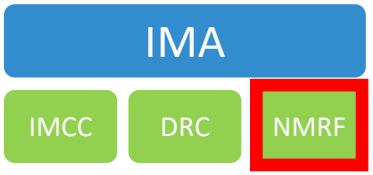
Higher granularity prerequisite for internal model usage

- **P&L Attribution Test (PLA)**
  - Newly introduced in FRTB
  - PLA is part of eligibility test and prerequisite for internal model usage Obtained from a third-party vendor
  - Test is designed to ensure appropriate risk factor coverage within the risk model

Lower granularity will mitigate punitive NMRD capital impact

- **Non-modellable risk factors (NMRF)**
  - Newly introduced in FRTB
  - All risk factors in the internal model need to be classified according to “modellability”
  - Only “modellable” risk factors can be capitalized in ES model
  - All others will be capitalized individually using stress scenarios

P&L ATTRIBUTION TEST QUANTIFIES THE ACCURACY OF THE RISK MODELS



The purpose of the P&L Attribution Eligibility Test is to:

1. Verify the risk factor completeness of the risk model
2. Verify the accuracy of valuation functions used for Risk measures

P&L Attribution Desk-level

- Comparison between Risk Theoretical P&L and Hypothetical P&L
- Mean and variance-based ratios to quantify P&L differences
- IMA eligibility when ratios exceed respective thresholds fewer than 4 times over rolling 12-month period

Hypothetical P&L

- "The P&L produced by revaluing the positions held at the end of the previous day using the market data at the end of the current day". pg. 87

Risk-Theoretical P&L

- "The daily desk-level P&L that is predicted by the risk management model conditional on a realization of all relevant risk factors that enter the model". pg. 87

Source: Minimum Capital Requirement for Market Risk, BCBS

P&L ATTRIBUTION TEST REQUIRES GRANULAR RISK FACTOR DEFINITION IN LINE WITH DEFINITION USED FOR P&L CALCULATION

IMA

IMCC | DRC | NMRF

Risk-theoretical P&L - Hypothetical P&L = Unexplained P&L

P&L using Risk's Expected Shortfall engine pricing functions and internal model risk factor set

One-day P&L using Front Office pricing functions and full risk factor sets used for P&L calculation

IF

(P&L th-P&L hy)/STD(P&L hy)

Test 1: MS P&L test (or "mean ratio") Mean of daily unexplained P&Ls - divided by - Standard deviation of hypothetical P&Ls

Is resulting |Ratio| >10% = breach

Passing variance ratio test is critical

OR

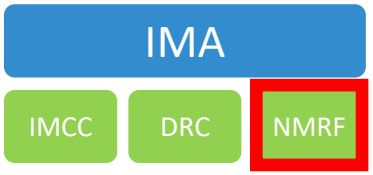
VAR(P&L th-P&L hy)/VAR(P&L hy)

Test 2: VV P&L test (or "variance ratio") Variance of unexplained P&Ls - divided by - Variance of daily hypothetical P&Ls

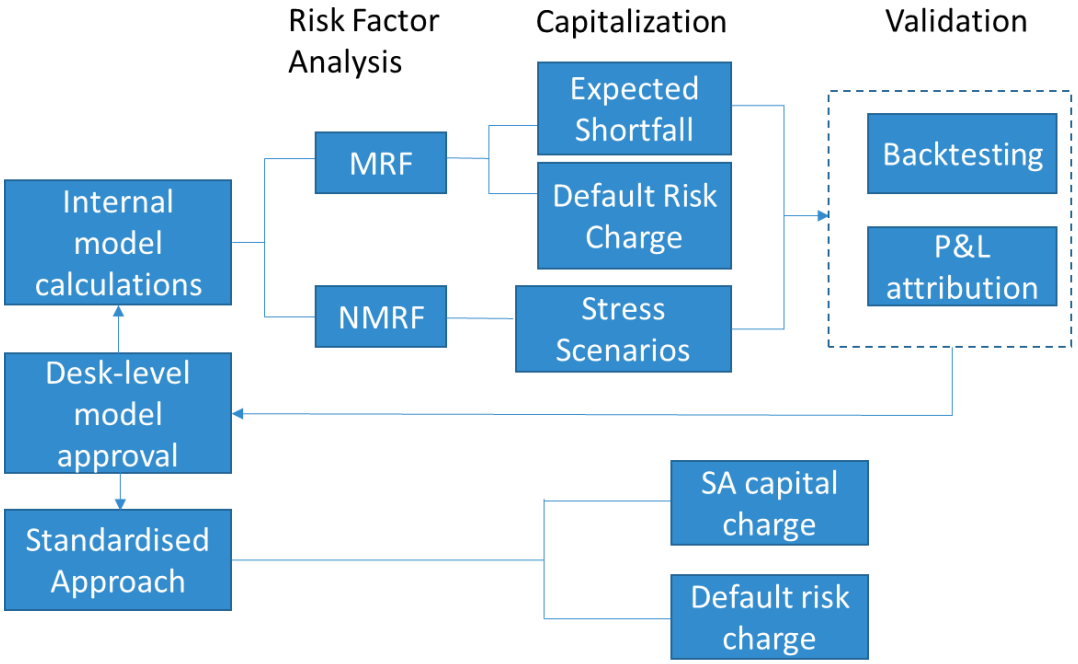
Is resulting Ratio > 20% = breach

4 Breaches = Fail: desk no longer eligible for internal model usage

THE TREATMENT OF NON-MODELLABLE RISK FACTORS IS ONE OF NEW CONCEPTS INTRODUCED IN THE FRTB FRAMEWORK



NMRF as part of the FRTB model landscape

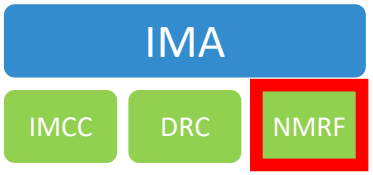


Motivation for introducing the NMRF concept

- The most sophisticated risk model could give incorrect results if the market data input is not robust
- Banks need to evidence historical risk factor values before they can be included in the internal model
- NMRFs are market risk factors whose values cannot be objectively validated in the market using actual transactions

Source: Interplay Between NMRF and Eligibility Test, Deutsche Bank, 07/2017

HIGH RISK FACTOR GRANULARITY LEADS TO MORE NMRFS AND INCREASES IMPACT OF CONSERVATIVE AGGREGATION SCHEME



Classification of Non-modellable Risk Factors

"For a risk factor to be classified as modellable by a bank, there must be continuously available **'real' prices** for a sufficient set of representative transactions.

1 Real Price of Representative Transactions

Real prices are prices from

- **transactions** of arms-length parties
- or taken from a "committed" quote

"Clear and apparent relationship between the value of the risk factor and each verifiable price" (CRR)

2 Continuously Available

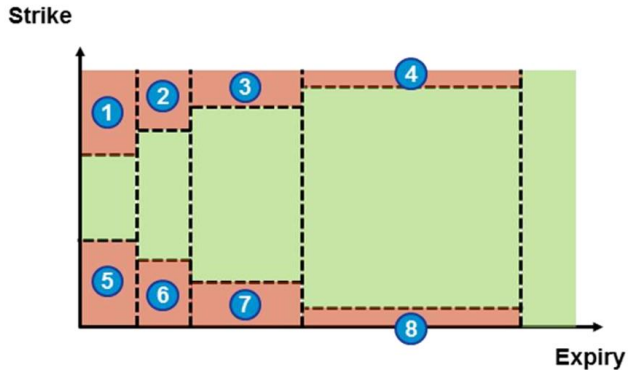
- At least **24 observations per year**
- **Max. one month between two observations**

Capital Charge Calculation

"Each non-modellable risk factor is to be capitalized using a stress scenario"

"No correlation or diversification effect between other non-modellable risk factors is permitted."

Example: Equity volatility surface



Each NMRF is **shocked individually** and **aggregated conservatively using simple sum**

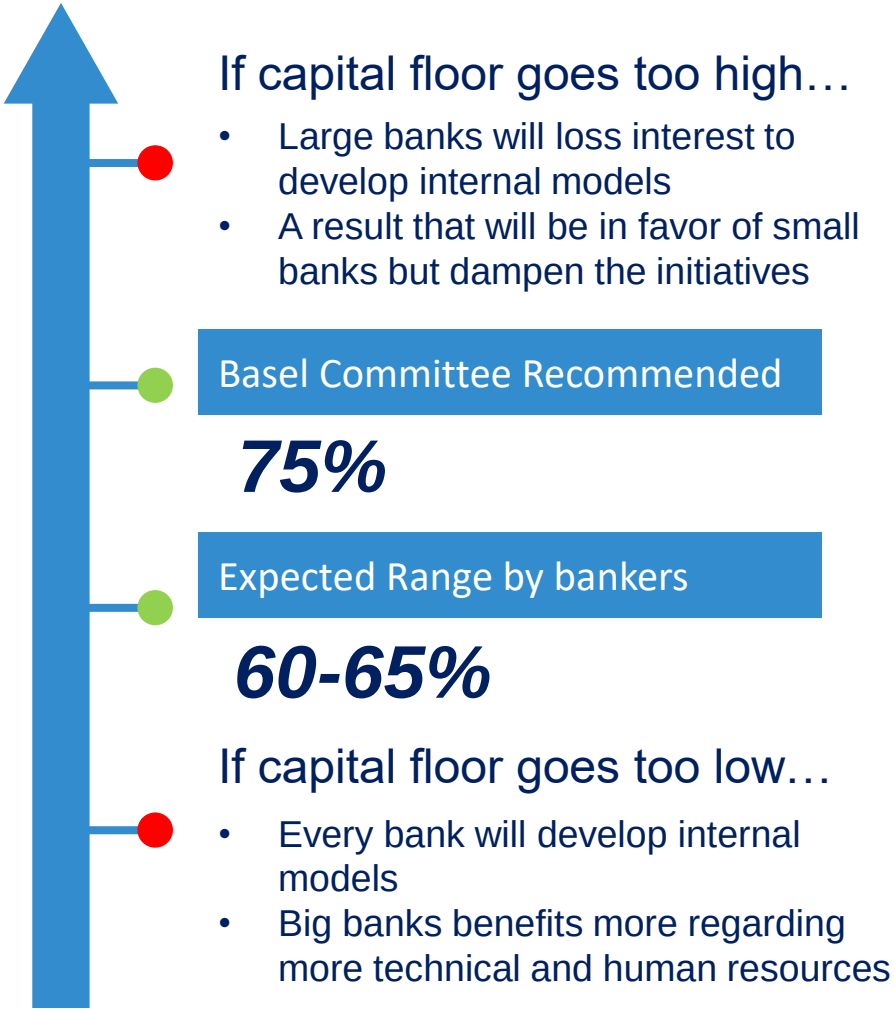
Source: Interplay Between NMRF and Eligibility Test, Deutsche Bank, 07/2017

CONTENT

CAPITAL FLOOR IS INTRODUCED TO LEVERAGE OVERLY OPTIMISTIC INTERNAL MODELS

Capital Floor in FRTB is …

- The level of capital that each IMA desk must maintain compared with SA capital
- To prevent over-optimized internal models from calculating underestimated risk capital
- the **watershed between choosing SA and IMA**, affecting decisions of each trading desk



Source: Fundamental Review of the Trading Book in Industry Update, KPMG, 05/2017

TRADE SUMMARY

Trade description and fair value on 03/31/2016

Book	Source ID	Product	Description	Fair Value of Trade($USD)
Trade5	EQHolding1	EquityHolding	MSFT	23,954,719
Trade1	Bond1	BondCorporate	Western Australian Treasury Corporate Bond	8,341,196
Trade2	CCS1	CCSwap	Fixed USD, Float JPY Currency Swap	996,854
Trade3	CDS1	CreditDefaultSwap	Credit Default Swap on JP Morgan	279,993
Trade4	EQAM1	EquityAmerican	American Call Option	128,111
Trade7	FXF2	FXForward	USD/EUR FX Forward	535
Trade9	FXV1	FXVanilla	FX European Call Option	188
Trade10	CF1	IRCapFloor	Interest Rate Cap	1
Trade8	FXF3	FXForward	EUR/SGD FX Forward	-654
Trade6	FXF1	FXForward	USD/JPY FX Forward	-801
Trade12	IRS2	IRSwap	Interest Rate Swap	-1,300,214
Trade11	IRS1	IRSwap	Interest Rate Swap	-1,534,985
Trade13	IRS3	IRSwap	Interest Rate Swap	-1,773,429

DESK DESCRIPTION AND SUMMARY

Assignment of 13 trades to 5 desks based on similar product type

Regulatory Trading Desk(RTD)	Trade Allocation	IMA Capital	SA Capital	SA/IMA
RTD1 - Options	Trade4, Trade9, Trade10	93,467	509,066	5.45x
RTD2 - FX Derivatives	Trade6, Trade7, Trade8	804	4,247	5.28x
RTD3 - Swap	Trade2, Trade3, Trade11, Trade12, Trade13	828,967	5,156,897	6.22x
RTD4 - Equity	Trade5	4,103,974	7,306,189	1.78x
RTD5 - Bond	Trade1	1,402,858	2,219,030	1.58x

Total IMA Capital = 5,692,812 Total SA Capital = 14,187,659

Note: the incremental capital required by the floor $C_F = \max\left|SA_{RTD} \times floor(\%) - IMA_{RTD}, 0\right|$

WHEN WE SWITCH ASSUMING FLOOR TO 60%, COST SAVING CAN BE MORE APPLICABLE

Assuming capital floor percentage under **75% / 60% / 50%,** the cost saving is shown as below. Meanwhile, RTD1 and RTD2 is too small to afford IMA operation cost so they are excluded

Regulatory Trading Desk	75%	60%	50%
RTD3	319,004	346,440	364,731
RTD4	-	90,250	180,802
RTD5	-	-	1,051

- **The result indicates that the lower capital floor percentage will allow more RTDs to save cost and eventually save more capital**
- The benefit of lower capital floor percentage shares by banks using IMA instead of SA, **which is in favor of very largest banks in the market**
- The lower capital floor percentage will also encourage banks to run IMA for calculating Equity and FX risk as both of them are very expensive in SA approach

AS THE CONSEQUENCE OF FRTB, REGULATORY TRADING DESKS(RTD) WILL NEED TO REORGANIZED

Some Key Drivers of RTD Optimization

Trading/Banking Book Boundary	Risk Factors	Operational Cost	New Required Tests	…
• **Reduced flexibility** likely leads to higher costs, which eventually affect optimization • More documentation and maintenance work	• Different risk factors such as default risk, credit spread risk **react differently** in SA or IMA • Desks might be easier to restore hedges	• Bigger desks can **lower resource cost** for management • Smaller desks can be more robust to control risk	• Some desks might need to set to **quarantine trades that test badly**	

UNCERTAINTY STILL HAUNTS WHEN TRADES ARE ALLOCATED BY RISK FACTORS

According to the distribution of risk factors, we assign 13 trades into different RTDs by 6 different allocations, **Port1** is under the instruction that classifying trades with similar risk factors into one RTD.

Top 3 IMA saving allocation

Total	IMA(from smallest to largest)	SA
PLAN 1	6,332,359	15,218,617
PLAN 3	6,484,014	15,358,067
PLAN 4	6,504,252	15,448,341

Top 3 SA saving allocation

Total	IMA	SA(from smallest to largest)
PLAN 5	6,534,920	15,215,848
PLAN 1	6,332,359	15,218,617
PLAN 3	6,484,014	15,358,067

Furthermore, we walk through every single combination of trades under **Monte Carlo Simulation** and eventually conclude that the optimization is not significant under product type allocation or risk factor allocation.

TRADE 3 - DESCRIPTION AND RESULTS SUMMARY

Long, $10 million 5-year CDS referencing JP Morgan

Start Date: 01/05/2016 **End Date:** 01/05/2021

- Notional Amount: **10,000,000**
- Currency: USD
- Premium Spread: 0.2%
- Frequency: Quarterly
- Premium Day Count: ACT360

Standardized Approach Summary (USD)	
Sensitivity	2,192,744
Default Risk Charge	0
Residual Risk Add-on	0
Total	**2,192,744**

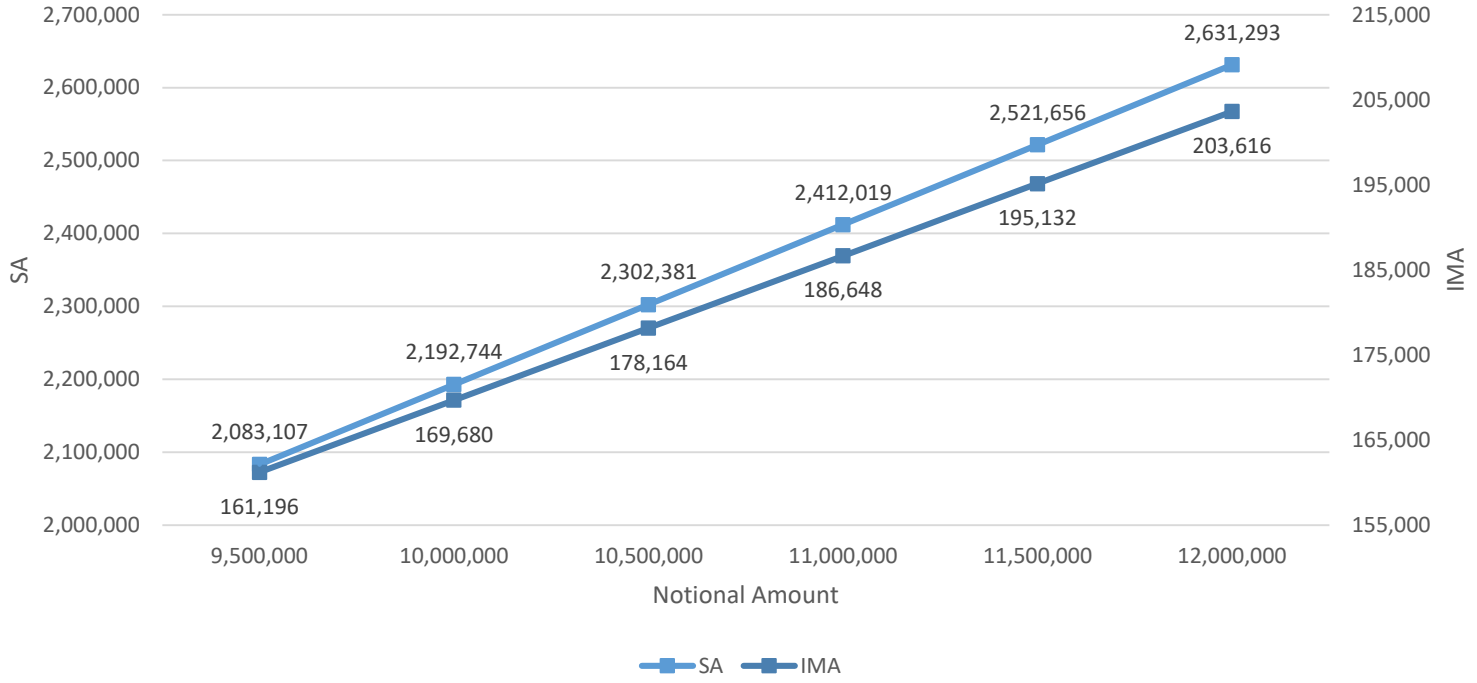
Internal Model Approach Summary (USD)	
Internal Model Capital Charge(IMCC)	169,680
Default Risk Charge	0
Stress Capital Add-on	0
Total	**169,680**

**Note: Source by Numerix*

TRADE 3 - LONG CDS - SENSITIVITY ON NOTIONAL

Notional Amount: SA Capital increases at a higher rate than IMA Capital

- We step-wisely increase notional amount.

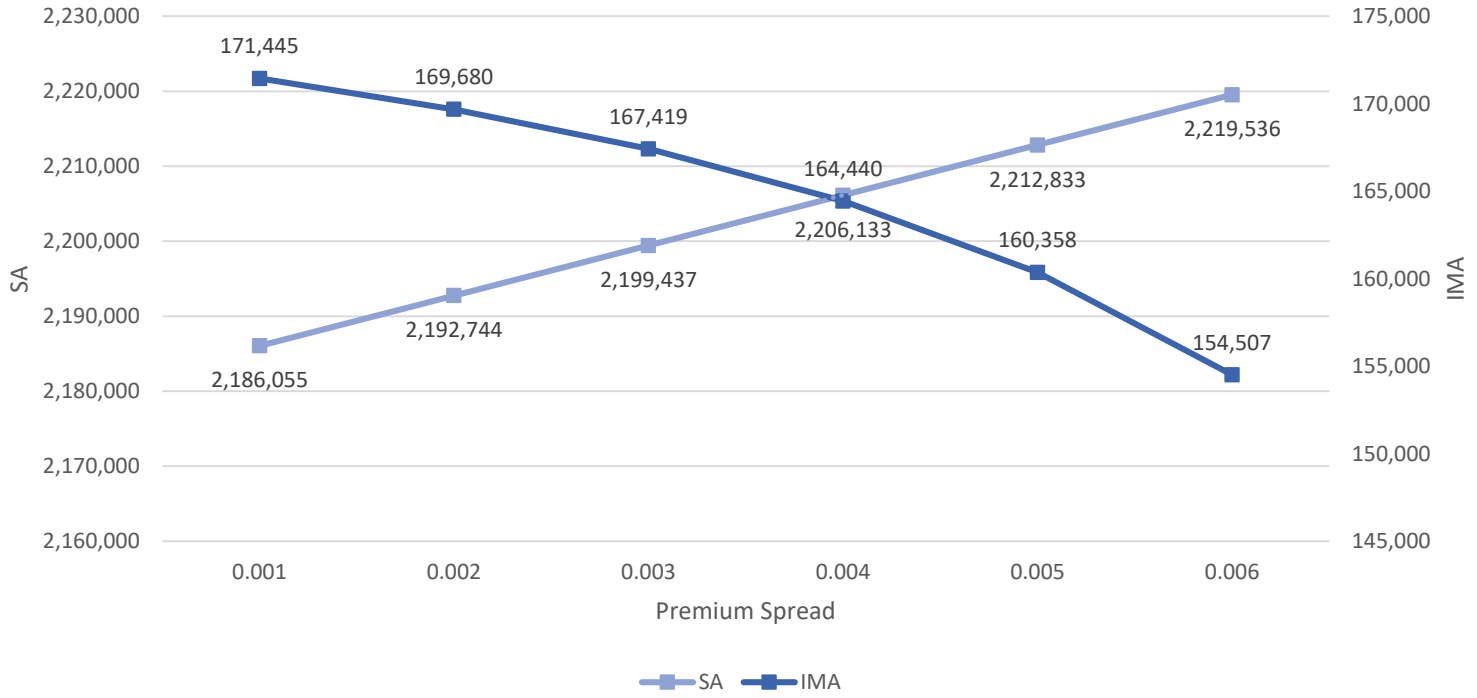


- The capital charge increases linearly with change in notional amount.
- SA capital charge increases with a higher rate.

TRADE 3 - LONG CDS - SENSITIVITY ON PREMIUM SPREAD

Premium Spread: SA Capital increases linearly; IMA Capital decreases nonlinearly

- We step-wisely increase premium spread.

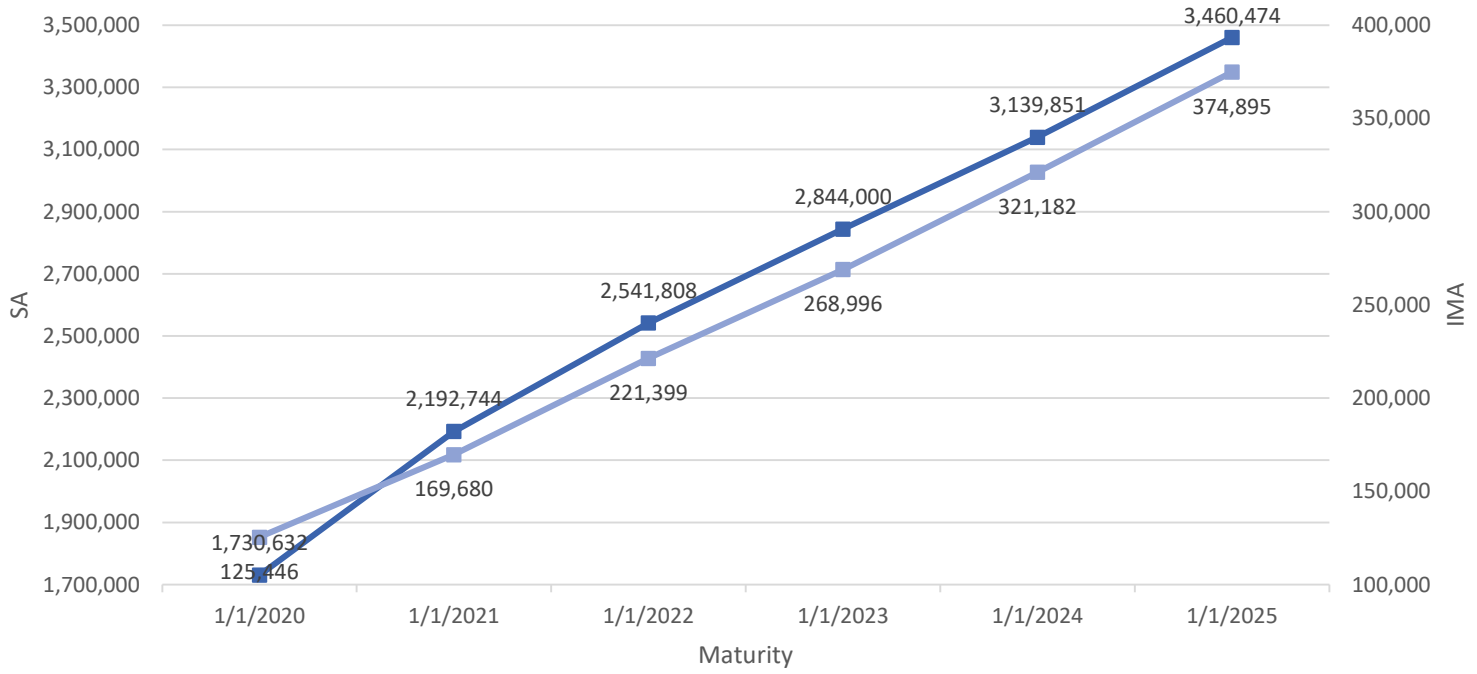


- The SA capital charge increases linearly with change in premium spread.
- The IMA capital charge decreases nonlinearly with change in premium spread.

TRADE 3 - LONG CDS - SENSITIVITY ON MATURITY

Maturity: both SA & IMA increase nonlinearly

- We step-wisely increase maturity.



- The SA&IMA capital charge increases nonlinearly with change in maturity.
- SA increases with a higher rate.

TRADE 9 - DESCRIPTION AND RESULTS SUMMARY

Long, 10,000 Notional USD/JPY FX Vanilla

Start Date: 03/31/2016 **End Date:** 10/25/2017

- USD Amount: 10,000
- JPY Amount:1,000,000
- MtM: 653,198 USD

Standardized Approach Summary (USD)	
Sensitivity	1,002
Default Risk Charge	0
Residual Risk Add-on	0
Total	**1,002**

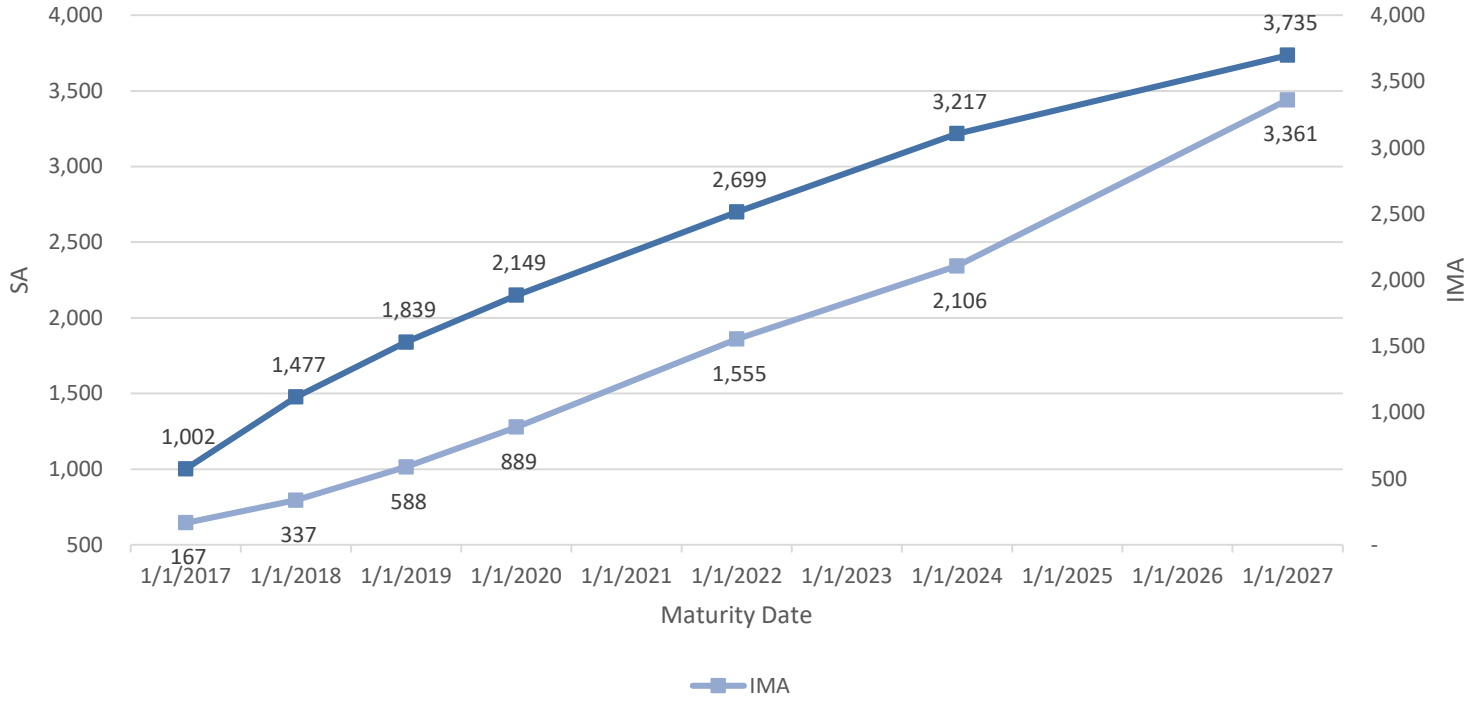
Internal Model Approach Summary (USD)	
Internal Model Capital Charge(IMCC)	167
Default Risk Charge	0
Stress Capital Add-on	0
Total	**167**

**Note: Source by Numerix*

TRADE 9 - LONG FX VANILLA - SENSITIVITY ON MATURITY

Maturity: both SA & IMA increase nonlinearly

- We step-wisely increase maturity.



- SA&IMA capital charge increases nonlinearly with change in maturity.
- IMA increases with a higher rate.

WHAT CAN BE CONCLUDED IN SENSITIVITY ANALYSIS

We can derive several conclusions from sensitivity analysis:

- The SA capital charge and IMA capital charge always **increase linearly with notional amount**, except for FX vanilla.

- Both SA capital charge and IMA capital charge **increase non-linearly with maturity**. When IMA increases at a higher rate, it is possible for IMA capital charge to exceed SA capital charge at some point in the future.

- The SA capital charge **increases linearly** with change in premium spread, the IMA capital charge **decreases nonlinearly** with change in premium spread.

- SA&IMA capital charge decrease nonlinearly with change in strike price, and **SA capital charge has a higher decreasing rate than IMA capital charge**.

PORTFOLIO SELECTION – METHODOLOGY(1/3)
SELECT 100 TRADES FROM DIFFERENT PRODUCT TYPE

- In system there are 3000 pre-selected trades based on real trading activity from an investment bank. We choose 50 trades for a single trading desk then hedge risk by selecting trades from the database.

Government Bond	142	8
Corporate Bond	142	4
Equity Holding	331	15
FX Forward	673	20
FX Single Barrier	146	8
FX Vanilla	331	5
Interest Rate Swap	379	12
Interest Rate Cap/Floor	142	8
CCSwap	316	2
Commodity Futures	142	7
Equity American Options	248	8
Credit Default Swap	30	4
Total	**3022**	**100**

PORTFOLIO SELECTION – METHODOLOGY(2/3)
HEDGED RISK BY REVERSE TRADE AND HEDGED PAIR

Criteria

1. Select same product type based on the Mark-to-Market(MtM) Value with different positions(e.g. long/short, currency pair, call/put)

TradeID	Product	Currency	ReferenceEntity	Notional	PremiumSpread	Bought/ Sold
749	CreditDefaultSwap	USD	US_MSFT	6000000	0.004335666	B
745	CreditDefaultSwap	USD	US_MSFT	6000000	0.003362677	S

2. Besides same product type, select hedged pair to align with scenarios when different types are applied

EquityHolding	AmeOption
FX Forward	FX Vanilla Op
FX Forward	FX Barrier Op
Corp. Bond	CDS
Gov. Bond	IRS
Gov. Bond	IR Cap/Floor

PORTFOLIO SELECTION – METHODOLOGY(3/3)
TRADE SELECTION MUST MATCHES MATURITY, NOTIONAL, CURRENCY TO MINIMIZED VAR

Criteria

3. Be aware of maturity, notional amount, currency pair when hedging risk. Minimal difference can be elastic when calculating required capital under FRTB

TradeID	IRSwap	Source Currency	StartDate	EndDate	Notional	Currency	Direction	LegA Fixed Rate	LegB Floating Forward Reference
3048	IRSwap	**USD**	10/4/2015	**10/4/2031**	**23,400,000**	**HKD**	ReceiveA PayB	**0.01**	HKD-HIBOR-HKAB-6M
3060	IRSwap	**USD**	6/14/2015	**6/14/2030**	**23,400,000**	**HKD**	PayA ReceiveB	**0.01**	HKD-HIBOR-HKAB-6M
...									
3109	IRSwap	**USD**	6/10/2016	**6/10/2026**	**20,915,000**	**AUD**	ReceiveA PayB	**0.03**	AUD-BBR-BBSW-6M
3244	IRSwap	**USD**	6/5/2015	**6/5/2024**	**19,607,000**	**AUD**	PayA ReceiveB	**0.03**	AUD-BBR-BBSW-6M

PORTFOLIO SUMMARY(1/2) – BEFORE RISK HEDGING

Reporting Date: 12/30/2016

99% VaR: 18,057,336.38

Internal Model Capital Charge(IMCC): 22,254,094.62

Total MtM Value: -10,984,836

SA Capital: 30,732,328.70

Product Type	Risk MtM Value($ USD)
BondCorporate	32,505,834
FXVanilla	4,822,566
CCSwap	2,961,683
CommodityFutures	61,905
CreditDefaultSwap	11,279
EquityHolding	5,939
EquityAmerican	(748)
FXForward	(946,513)
IRCapFloor	(1,421,129)
FXSingleBarrier	(4,800,828)
IRSwap	(11,896,174)
Total	**(10,984,936)**

PORTFOLIO SUMMARY(2/2) – AFTER RISK HEDGING

Reporting Date: 12/30/2016

99% VaR: 720,867.95

Internal Model Capital Charge(IMCC): 19,136,902.77

Total MtM Value: 30,820,821.86

SA Capital: 16,414,240.66

Product Type	Risk MtM Value($ USD)
BondCorporate	71,031,265.88
BondGovernment	(39,822,789.32)
IRSwap	(3,607,469.25)
FXVanilla	3,316,901.24
FXForward	(1,828,588.94)
FXSingleBarrier	980,615.68
CCSwap	500,012.68
IRCapFloor	156,095.10
CreditDefaultSwap	76,918.85
EquityHolding	14,547.55
EquityAmerican	3,312.38
CommodityFutures	-
Total	**30,820,821.86**

WHY IMA > SA? DRILLDOWN INTO SYSTEM AND CHECK IMA CONFIGURATION HELPS US IDENTIFY THE PROBLEM

Step1
We look at the ESRC and ESFC, the FX risk is disturbingly high

Main Results

Factor Set	ESRS	ESRC	ESFC	IMCC (C)
Commodity	0.00	0.00	0.00	0.00
Equity	321.08	119.85	119.85	321.08
Credit	4,451,179.84	173,773.73	173,773.73	4,451,179.84
Interest	15,794,958.05	5,926,732.90	5,926,732.90	15,794,958.05
FX	1,088,547.04	64,717,420.03	64,717,420.03	1,088,547.04
Total	16,854,153.87	134,336,782.45	134,336,782.45	16,854,153.87

Step2
Then we drill down into historical shift and check day by day. Somehow there is a dodgy change which probably comes from wrong data

Portfolio MTM by Path

Path ID	Historic Shift Date	Change in MTM
10	15/01/2016	-773,018,548.18
106	30/05/2016	-11,696,352.50
86	02/05/2016	-7,479,399.08
62	29/03/2016	-6,697,627.58
120	17/06/2016	-4,180,792.07
57	22/03/2016	-2,943,660.14

PORTFOLIO SUMMARY(2/2) – AFTER RISK HEDGING

Reporting Date: 12/30/2016

99% VaR: 720,867.95

Internal Model Capital Charge(IMCC): 6,357,793.88

Total MtM Value: 30,820,821.86

SA Capital: 16,414,240.66

Product Type	Risk MtM Value($ USD)
BondCorporate	71,031,265.88
BondGovernment	(39,822,789.32)
IRSwap	(3,607,469.25)
…	…

- We have discovered several curves in FX and interest risk classes that are quite dodgy, most of which are resulted from wrong configuration and data sources
- The IMA has significantly descended which turns to be much superior than SA now
- Drilldown into configuration is part of daily responsibility for risk manager to ensure data is well prepared for capital calculation