



Low Latency Interest Rate Markets Theory, Pricing & Practice



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PART ONE: Theory

IR Markets, Products & Models

- Introduction to IR Markets
- Interest Rate Swaps
- IR Products & CDS
- Yield Curves
- IR Risk
- Credit Models

Quant Research Papers

<https://ssrn.com/author=1728976>

Support Materials: Quant Research, C++ and Excel Examples

<https://github.com/nburgessx/SwapsBook>

PART TWO: Pricing & Practice

Case Studies

- IRS Pricing Formulae
- IRS Pricing Case Study
- Asset Swap Structuring
- Asset Swap Pricing Case Study
- Pricing Tricks & Rules of Thumb

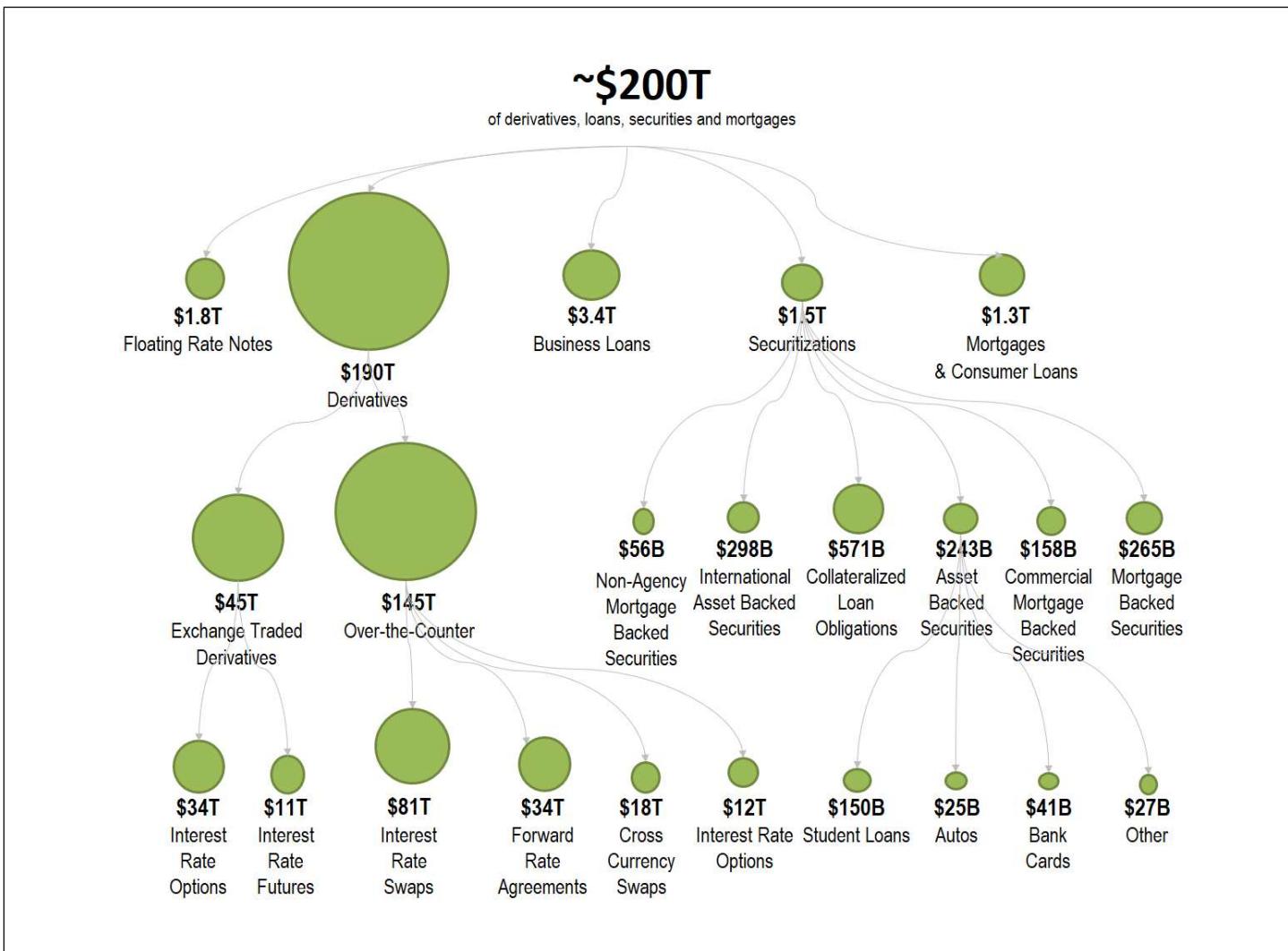


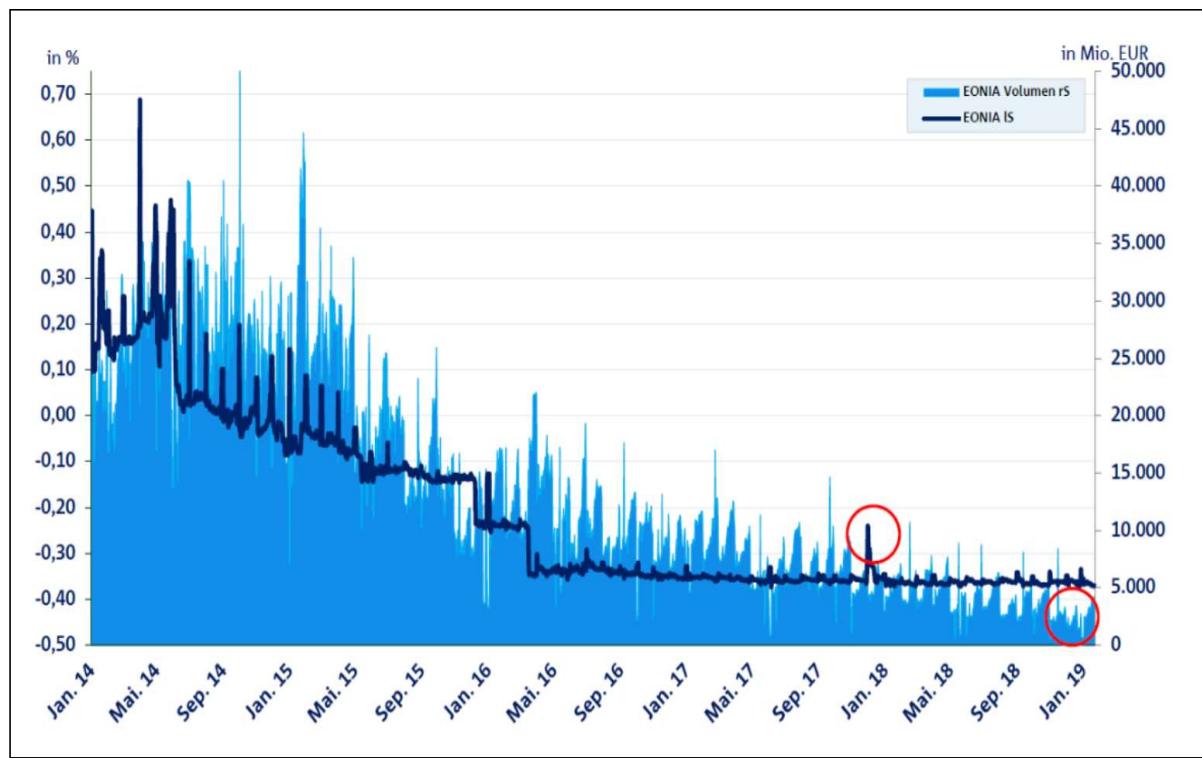
PART ONE - THEORY

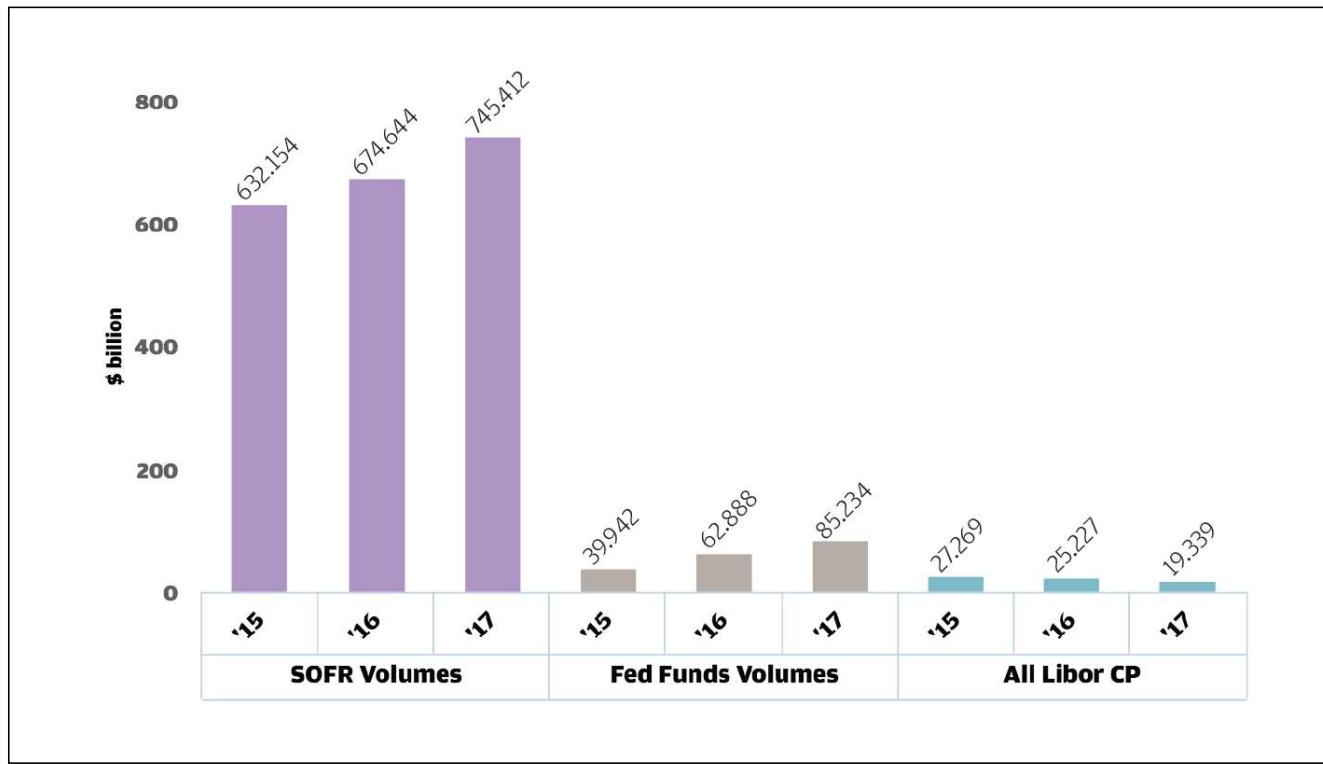


IR Markets, Products & Models

Chapter 1 – Introduction to Interest Rate Markets







Overview of identified alternative RFRs in selected currency areas

	United States	United Kingdom	Euro area	Japan
Alternative rate	SOFR (secured overnight financing rate)	SONIA (sterling overnight index average)	ESTER (euro short-term rate)	TONA (Tokyo overnight average rate)
Administrator	Federal Reserve Bank of New York	Bank of England	ECB	Bank of Japan
Data source	Triparty repo, FICC GCF, FICC bilateral	Form SMMD (BoE data collection)	MMSR	Money market brokers
Wholesale non-bank counterparties	Yes	Yes	Yes	Yes
Secured	Yes	No	No	No
Overnight rate	Yes	Yes	Yes	Yes
Available now?	Yes	Yes	Oct 2019	Yes

FICC = Fixed Income Clearing Corporation; GCF = general collateral financing; MMSR = money market statistical reporting; SMMD = sterling money market data collection reporting.

Sources: ECB; Bank of Japan; Bank of England; Federal Reserve Bank of New York; Financial Stability Board; Bank of America Merrill Lynch; International Swaps and Derivatives Association.

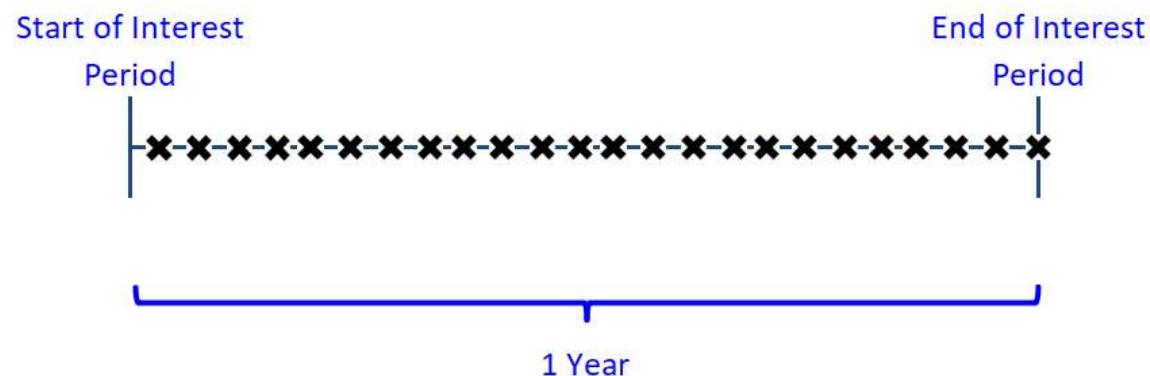
LIBOR

1. Unsecured rate
2. Various maturities
3. Built-in credit component
4. Partially transaction based
5. \$500 million underlying transactions

SOFR

1. Secured rate
2. Overnight
3. Minimal credit risk
4. Wholly transaction-based
5. \$750 billion underlying transactions

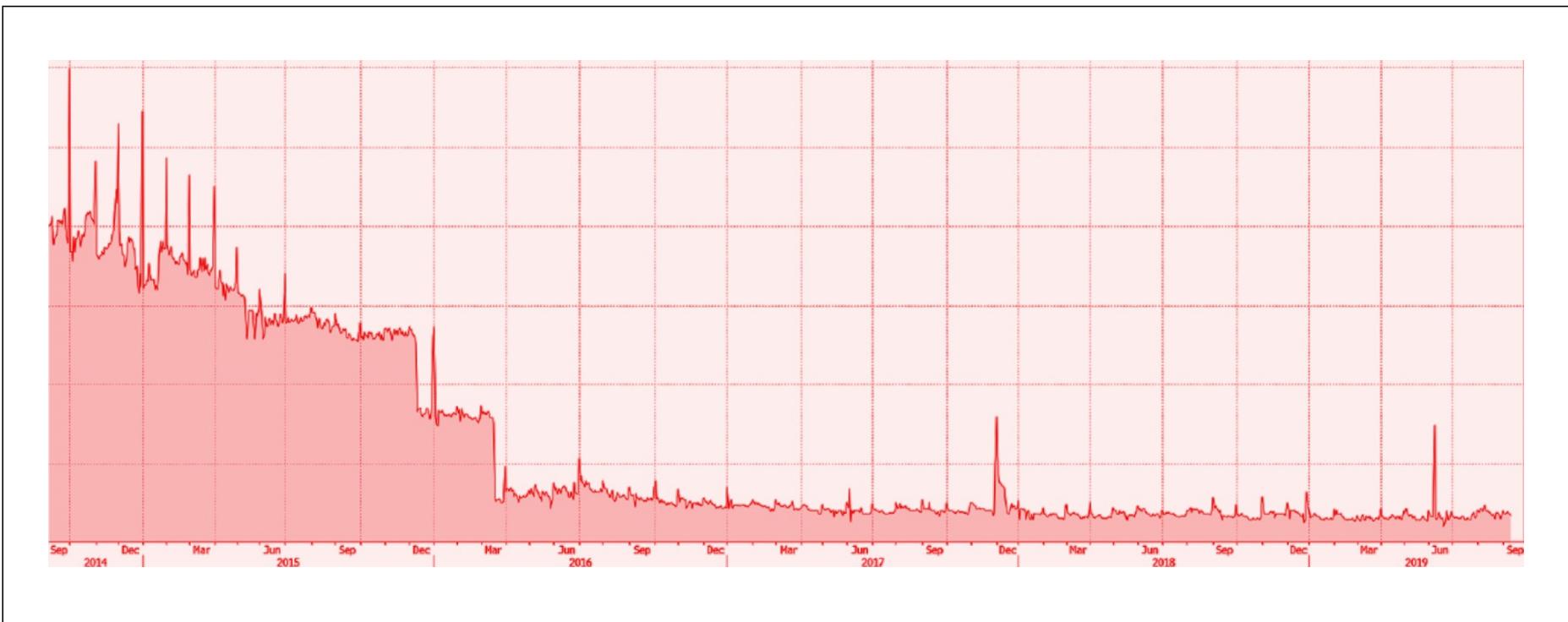




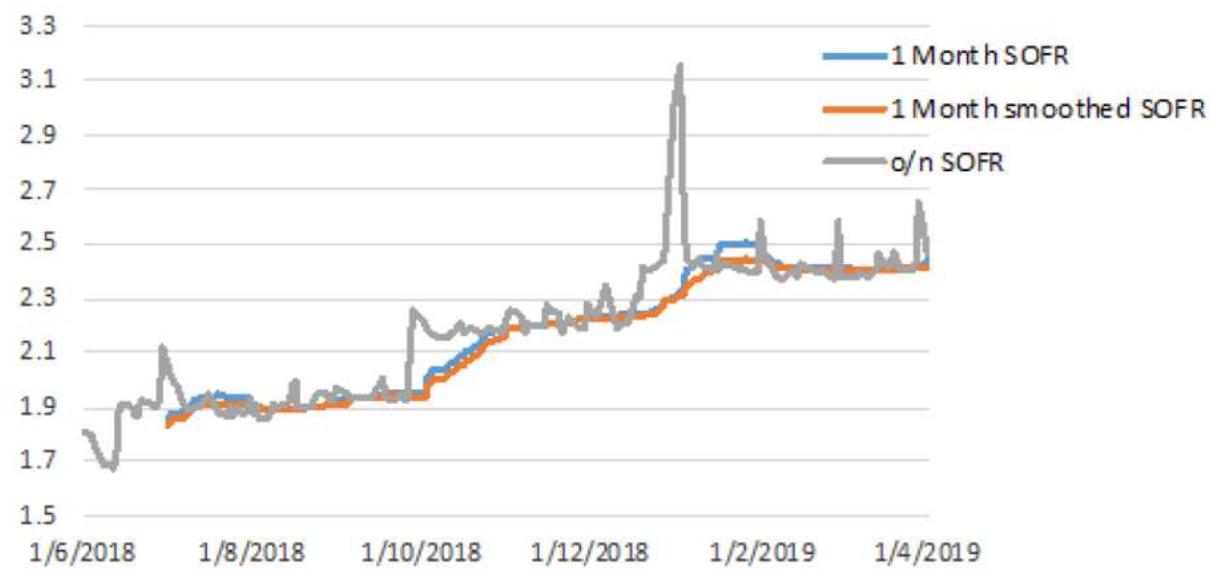
Rate: Daily Interest Rate Fixings leading to an Averaged Effective Rate

Coupon: Determined in Arrears

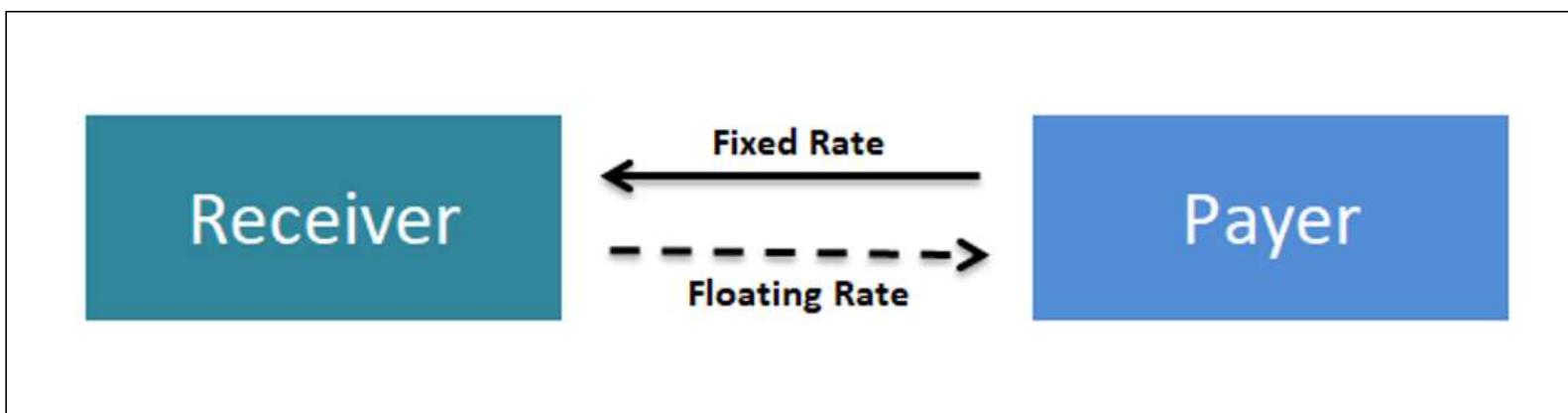


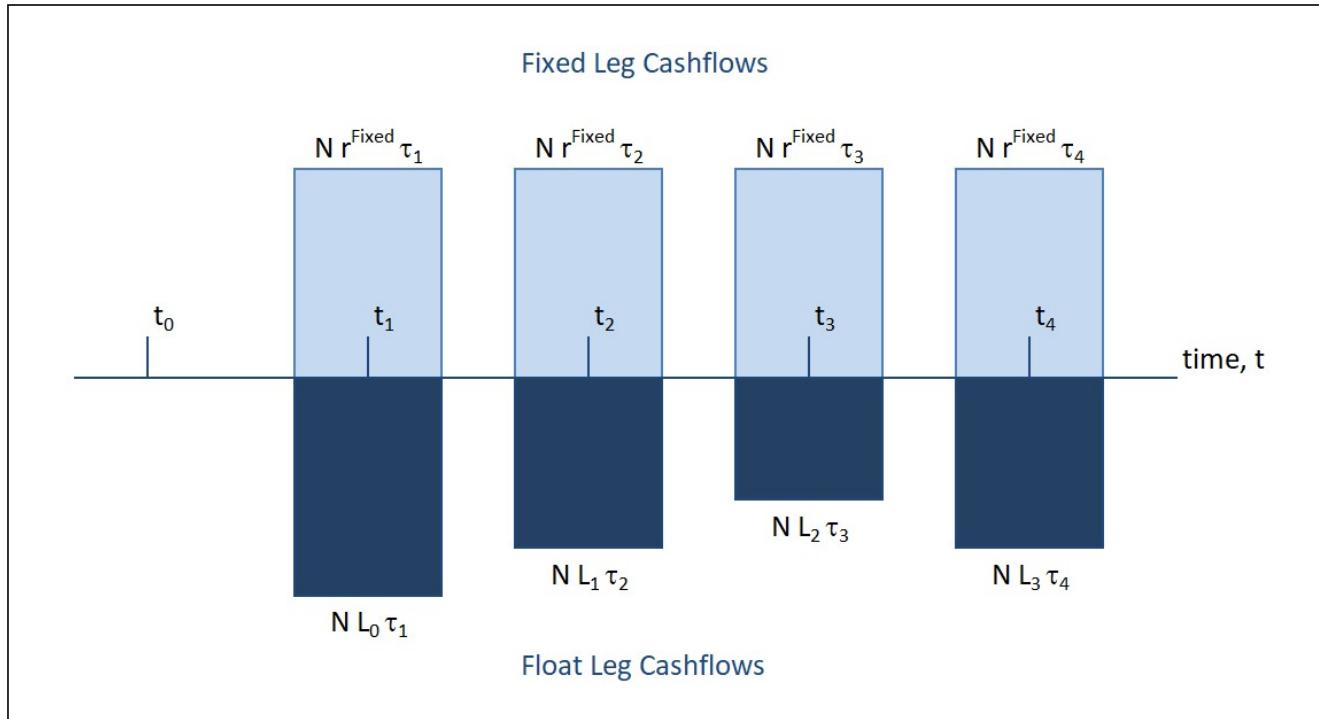


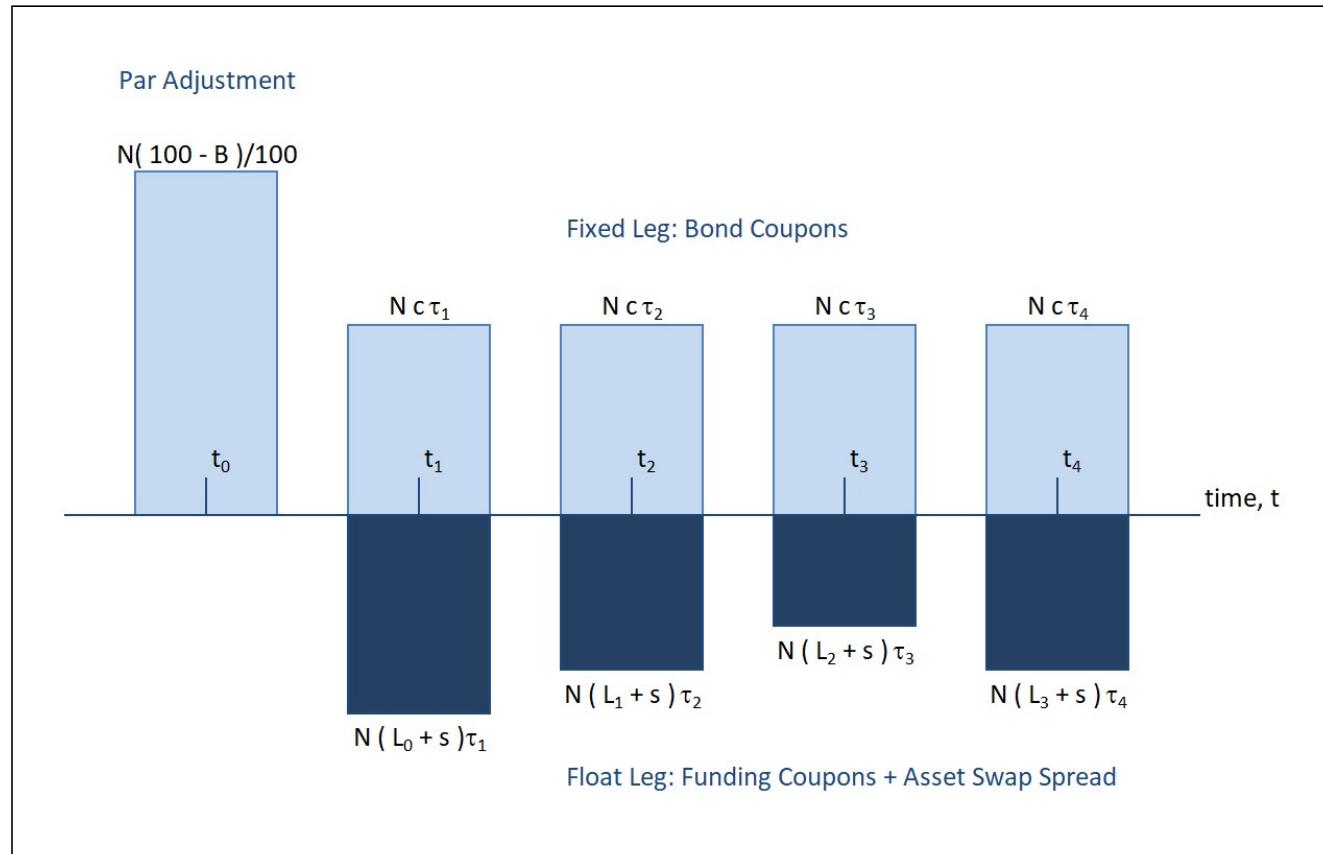
SOFR 1 month actual and smoothed



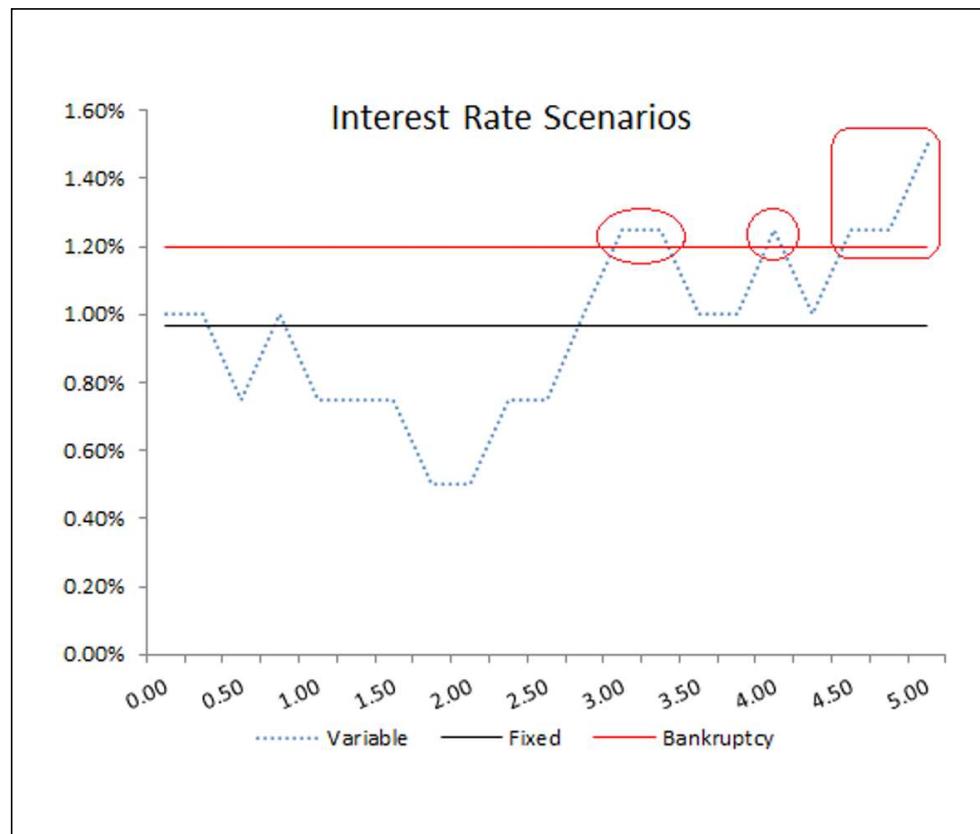
Chapter 2 – Introduction to Interest Rate Swaps







Chapter 3 – Interest Rate Products & Pricing

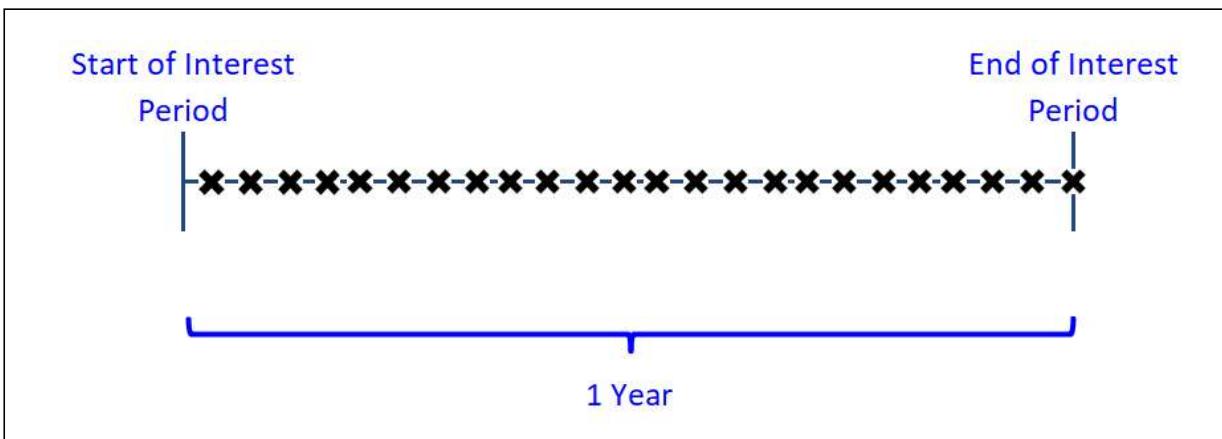


Swap PV		\$0		Float Leg		\$75,000		Fixed Leg		\$75,000	
time, t	Notional, N	Float Rate, I_i	Accrual Period, τ_i	Discount Factor, P	PV	time, t	Notional, N	Fixed Rate, R	Accrual Period, τ_i	Discount Factor, P	PV
1	\$1,000,000	1.00%	1.00	1.0000	\$10,000	1	\$1,000,000	1.50%	1.00	1.0000	\$15,000
2	\$1,000,000	1.25%	1.00	1.0000	\$12,500	2	\$1,000,000	1.50%	1.00	1.0000	\$15,000
3	\$1,000,000	1.50%	1.00	1.0000	\$15,000	3	\$1,000,000	1.50%	1.00	1.0000	\$15,000
4	\$1,000,000	1.75%	1.00	1.0000	\$17,500	4	\$1,000,000	1.50%	1.00	1.0000	\$15,000
5	\$1,000,000	2.00%	1.00	1.0000	\$20,000	5	\$1,000,000	1.50%	1.00	1.0000	\$15,000



Swap PV \$25,000			Float Leg \$100,000			Fixed Leg \$75,000					
time, t	Notional, N	Float Rate, I_j	Accrual Period, τ_j	Discount Factor, P	PV	time, t	Notional, N	Fixed Rate, R	Accrual Period, τ_j	Discount Factor, P	PV
1	\$1,000,000	1.50%	1.00	1.0000	\$15,000	1	\$1,000,000	1.50%	1.00	1.0000	\$15,000
2	\$1,000,000	1.75%	1.00	1.0000	\$17,500	2	\$1,000,000	1.50%	1.00	1.0000	\$15,000
3	\$1,000,000	2.00%	1.00	1.0000	\$20,000	3	\$1,000,000	1.50%	1.00	1.0000	\$15,000
4	\$1,000,000	2.25%	1.00	1.0000	\$22,500	4	\$1,000,000	1.50%	1.00	1.0000	\$15,000
5	\$1,000,000	2.50%	1.00	1.0000	\$25,000	5	\$1,000,000	1.50%	1.00	1.0000	\$15,000





Swap Generator	Pay/Rec Fixed	Notional	Fixed (%)	Spread (bps)	Maturity	Trade Handle
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	1Y	USD_SB3_1Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	2Y	USD_SB3_2Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	3Y	USD_SB3_3Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	4Y	USD_SB3_4Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	5Y	USD_SB3_5Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	6Y	USD_SB3_6Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	7Y	USD_SB3_7Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	8Y	USD_SB3_8Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	9Y	USD_SB3_9Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	10Y	USD_SB3_10Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	11Y	USD_SB3_11Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	12Y	USD_SB3_12Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	13Y	USD_SB3_13Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	14Y	USD_SB3_14Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	15Y	USD_SB3_15Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	20Y	USD_SB3_20Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	25Y	USD_SB3_25Y:0
USD_SWAP_3M	PAY	1,000,000	1.00%	0.00	30Y	USD_SB3_30Y:0



No. Coupon	Term Days	Cpn	YearFrac, τ_c	Total GF	Total DF	
30		0.0822		1.002192	0.997813	
Start	End	nDays	DailyRate, r_i	DailyYearFrac, τ_i	GrowthFactor, GF	DiscountFactor, DF
Wed, 9-Dec-20	Thu, 10-Dec-20	1	4.89%	0.0027	1.000134	0.999866
Thu, 10-Dec-20	Fri, 11-Dec-20	1	4.18%	0.0027	1.000249	0.999751
Fri, 11-Dec-20	Mon, 14-Dec-20	3	1.81%	0.0082	1.000398	0.999603
Mon, 14-Dec-20	Tue, 15-Dec-20	1	3.11%	0.0027	1.000483	0.999517
Tue, 15-Dec-20	Wed, 16-Dec-20	1	1.46%	0.0027	1.000523	0.999477
Wed, 16-Dec-20	Thu, 17-Dec-20	1	0.85%	0.0027	1.000546	0.999454
Thu, 17-Dec-20	Fri, 18-Dec-20	1	1.48%	0.0027	1.000587	0.999414
Fri, 18-Dec-20	Mon, 21-Dec-20	3	0.41%	0.0082	1.000620	0.999380
Mon, 21-Dec-20	Tue, 22-Dec-20	1	4.51%	0.0027	1.000744	0.999257
Tue, 22-Dec-20	Wed, 23-Dec-20	1	1.25%	0.0027	1.000778	0.999222
Wed, 23-Dec-20	Thu, 24-Dec-20	1	4.30%	0.0027	1.000896	0.999105
Thu, 24-Dec-20	Fri, 25-Dec-20	1	2.57%	0.0027	1.000966	0.999034
Fri, 25-Dec-20	Mon, 28-Dec-20	3	3.70%	0.0082	1.001271	0.998730
Mon, 28-Dec-20	Tue, 29-Dec-20	1	2.09%	0.0027	1.001329	0.998673
Tue, 29-Dec-20	Wed, 30-Dec-20	1	3.10%	0.0027	1.001413	0.998589
Wed, 30-Dec-20	Thu, 31-Dec-20	1	4.24%	0.0027	1.001530	0.998473
Thu, 31-Dec-20	Fri, 1-Jan-21	1	2.62%	0.0027	1.001602	0.998401
Fri, 1-Jan-21	Mon, 4-Jan-21	3	4.73%	0.0082	1.001991	0.998013
Mon, 4-Jan-21	Tue, 5-Jan-21	1	3.99%	0.0027	1.002101	0.997903
Tue, 5-Jan-21	Wed, 6-Jan-21	1	0.82%	0.0027	1.002124	0.997881
Wed, 6-Jan-21	Thu, 7-Jan-21	1	1.35%	0.0027	1.002161	0.997844
Thu, 7-Jan-21	Fri, 8-Jan-21	1	1.16%	0.0027	1.002192	0.997813

Arithmetic Rate	Geometric Rate	Fast Geometric Rate
2.6646%	2.6673%	2.6673%

$$r_A = \left(\sum_{i=1}^n r_i \tau_i \right) / \tau_c \qquad r_G = \left(\prod_{i=1}^n (1 + r_i \tau_i) - 1 \right) / \tau_c \qquad r_{FG} = \left(\left(\frac{1}{DF_n} \right) - 1 \right) / \tau_c$$



Swap Generator Template			
USD_SWAP_3M			
Dynamic Trade Info	LEG TYPE PAY / RECEIVE NOTIONAL FIXED RATE (%) FLOAT SPREAD (BPS) EFFECTIVE DATE / LAG MATURITY DATE / TENOR	LEG1:FIXED PAY 1,000,000 1.00% - 2D 2Y	LEG2:FLOAT RECEIVE 1,000,000 - 0.00 2D 2Y
	LEG CURRENCY NOTIONAL EXCHANGE LEVERAGE FRONT STUB INDEX BACK STUB INDEX VALUATION CURRENCY FORECAST INDEX DISCOUNT INDEX INDEX COMPOUND METHOD SPREAD COMPOUND METHOD ROLL DAY STUB TYPE FIXING BUS DAY ADJUSTMENT FIXING CALENDAR FIXING LAG + FIXING IN-ADVANCE / IN-ARREARS ACCURIAL FREQUENCY ACCURIAL BUS DAY ADJUSTMENT ACCURIAL CALENDAR ACCURIAL DAYCOUNT PAYMENT FREQUENCY PAYMENT BUS DAY ADJUSTMENT PAYMENT CALENDAR PAYMENT LAG	USD NONE 1.00 - - USD - USDOIS - - END SHORT START - - - - - SEMI-ANNUAL MODIFIED_FOLLOWING NY 30/360 SEMI-ANNUAL MODIFIED_FOLLOWING NY 2D	USD NONE 1.00 NATURAL NATURAL USD USD3M USDOIS NONE NONE END SHORT START MODIFIED_FOLLOWING NY-LDN 2D IN-ADVANCE QUARTERLY MODIFIED_FOLLOWING NY ACT/360 QUARTERLY MODIFIED_FOLLOWING NY 2D





FLOAT LEG - FIXED CONVENTIONS

BUS DAY ADJ	MODIFIED_FOLLOWING
CALENDAR	NY+LDN
FIXING LAG	2D

FLOAT LEG - ACCRUAL CONVENTIONS

FREQUENCY	QUARTERLY
BUS DAY ADJ	MODIFIED_FOLLOWING
CALENDAR	NY
DAY COUNT	ACT/360

FIXED LEG - ACCRUAL CONVENTIONS

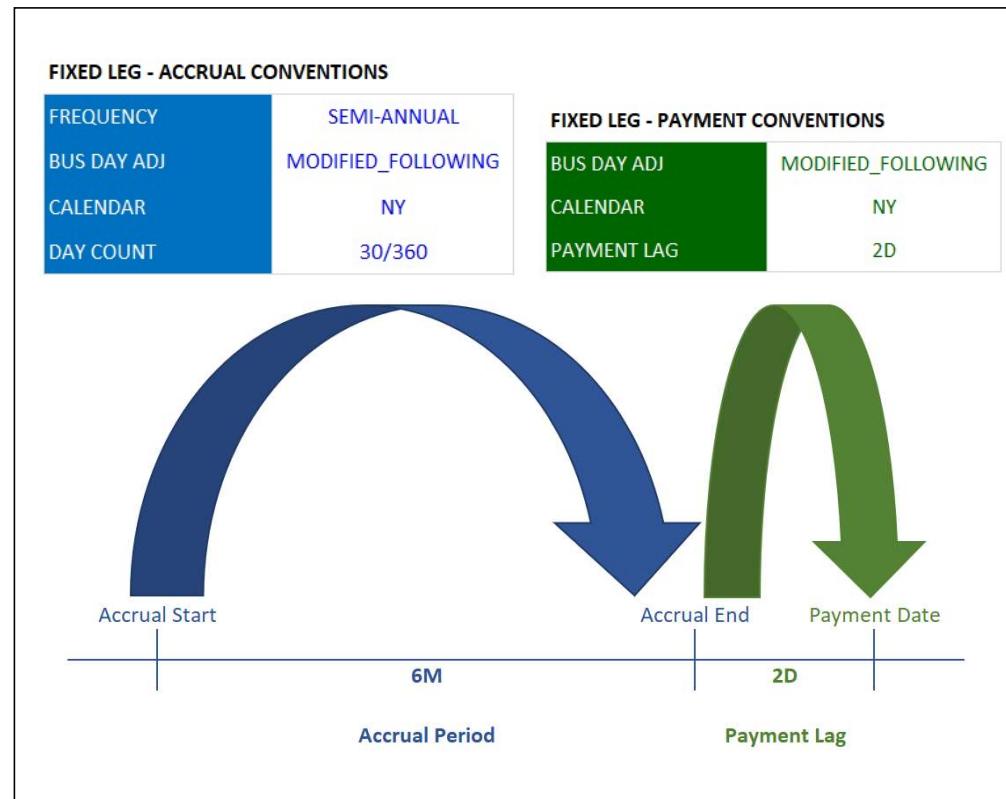
FREQUENCY	SEMI-ANNUAL
BUS DAY ADJ	MODIFIED_FOLLOWING
CALENDAR	NY
DAY COUNT	30/360

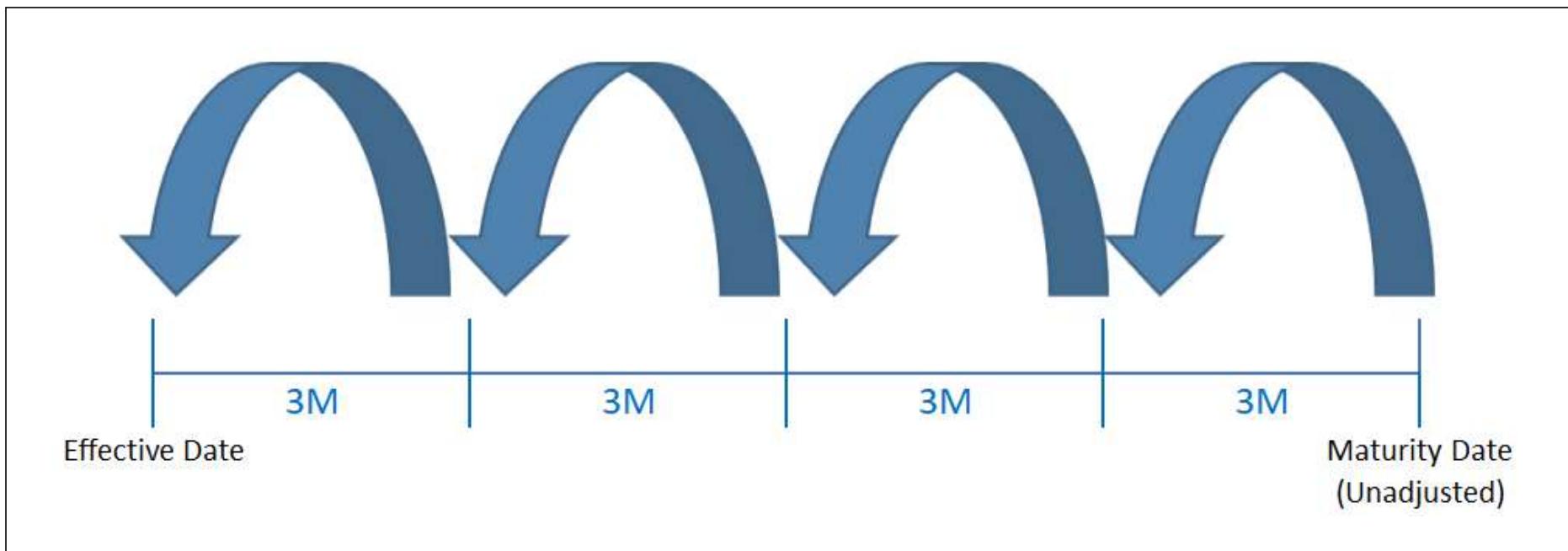
FLOAT LEG - PAYMENT CONVENTIONS

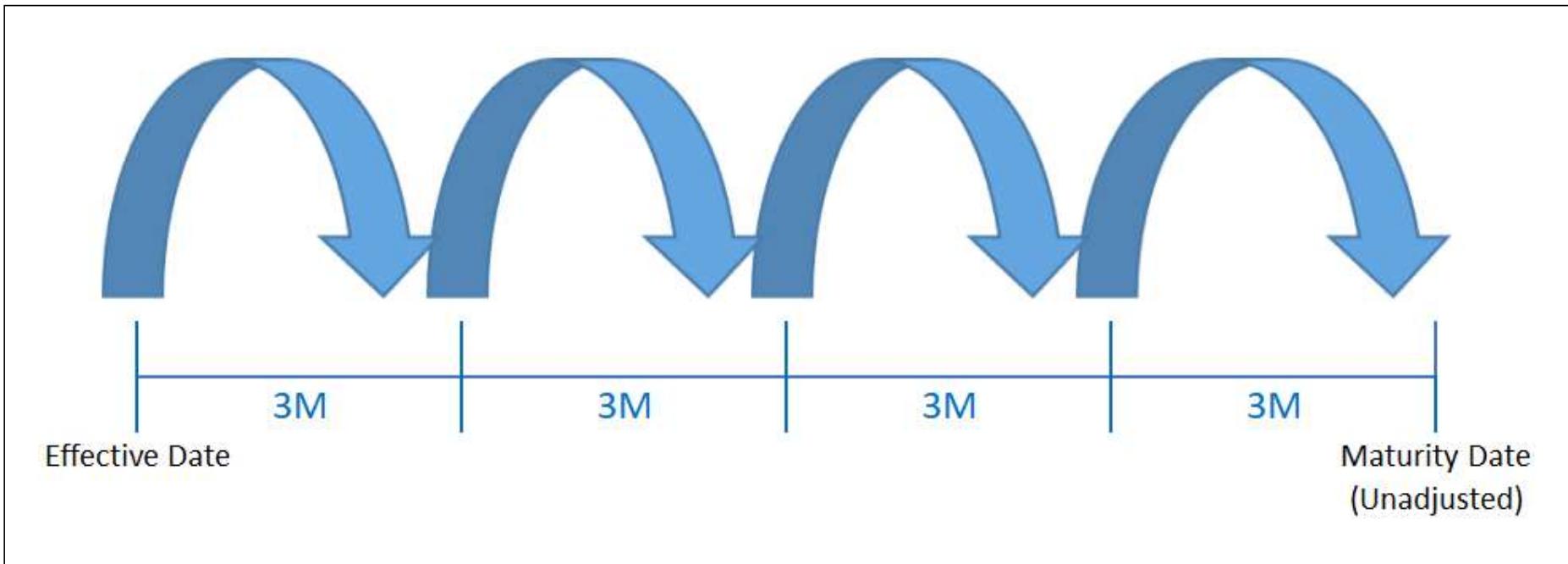
BUS DAY ADJ	MODIFIED_FOLLOWING
CALENDAR	NY
PAYMENT LAG	2D

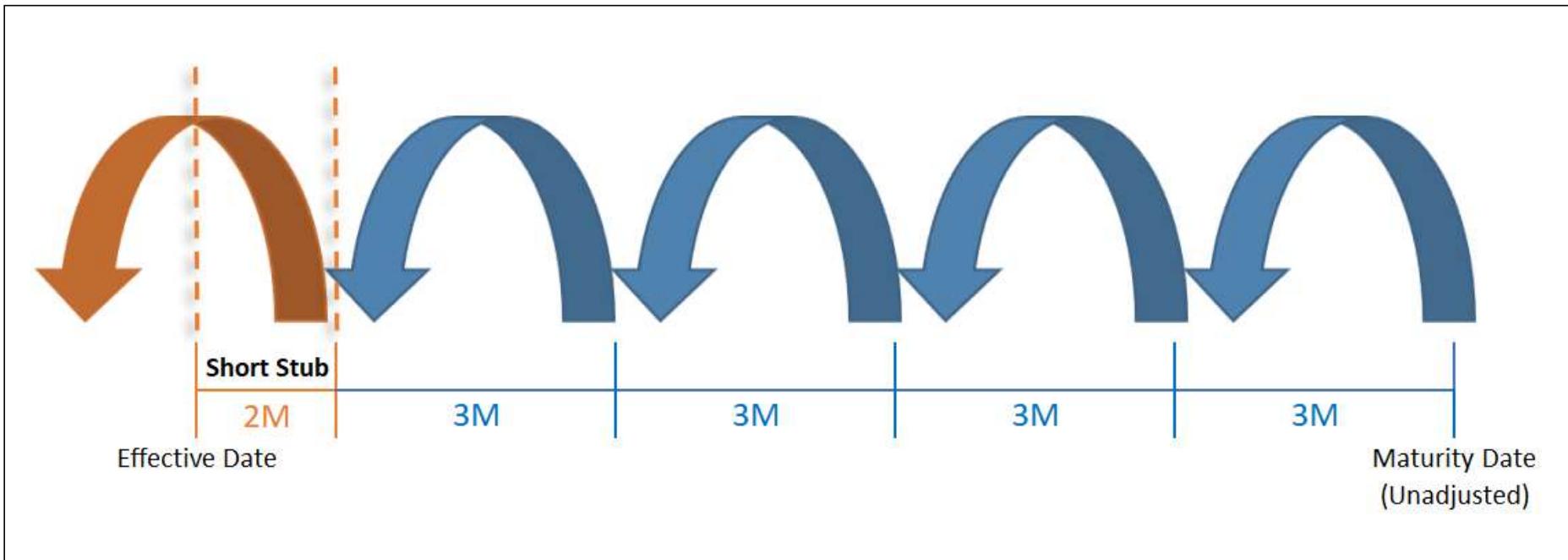
FIXED LEG - PAYMENT CONVENTIONS

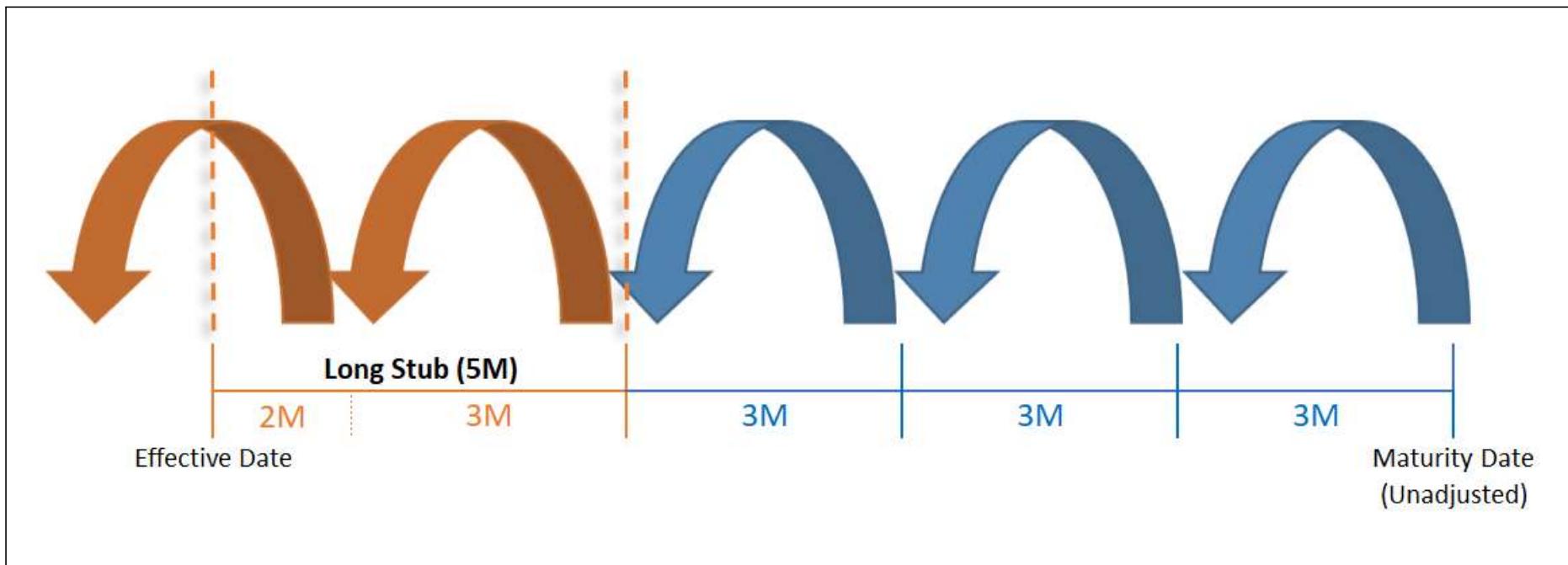
BUS DAY ADJ	MODIFIED_FOLLOWING
CALENDAR	NY
PAYMENT LAG	2D

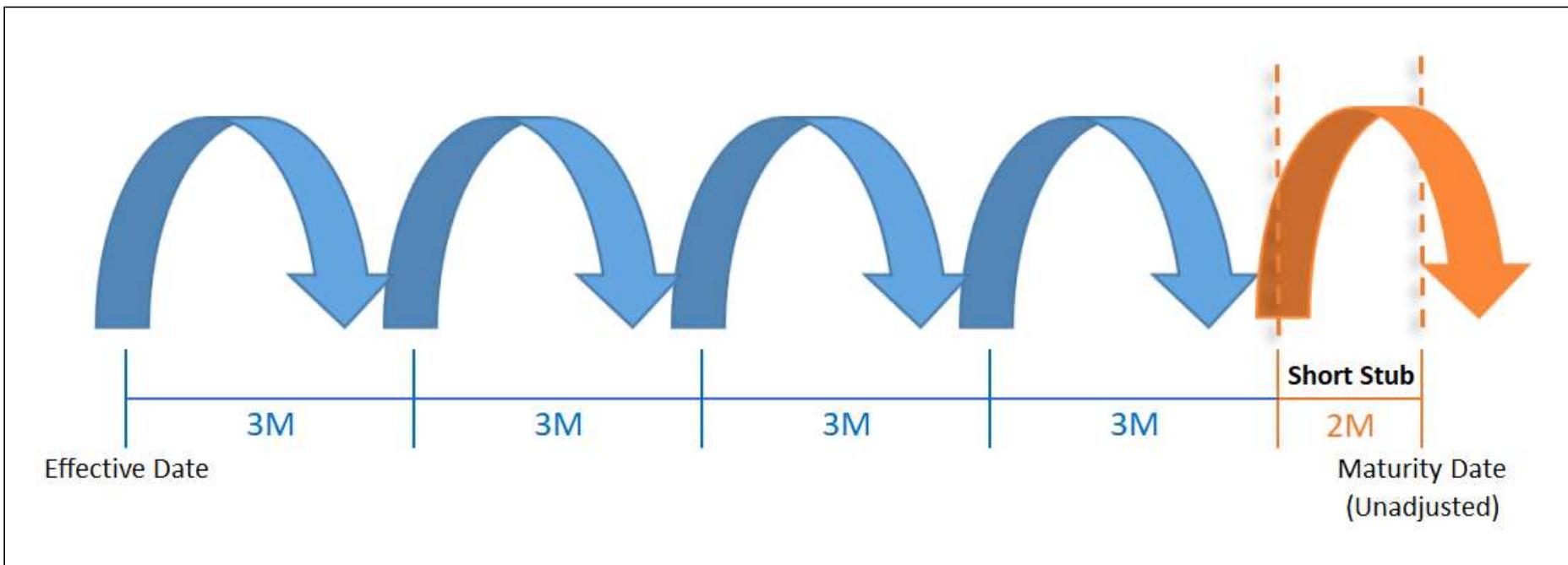


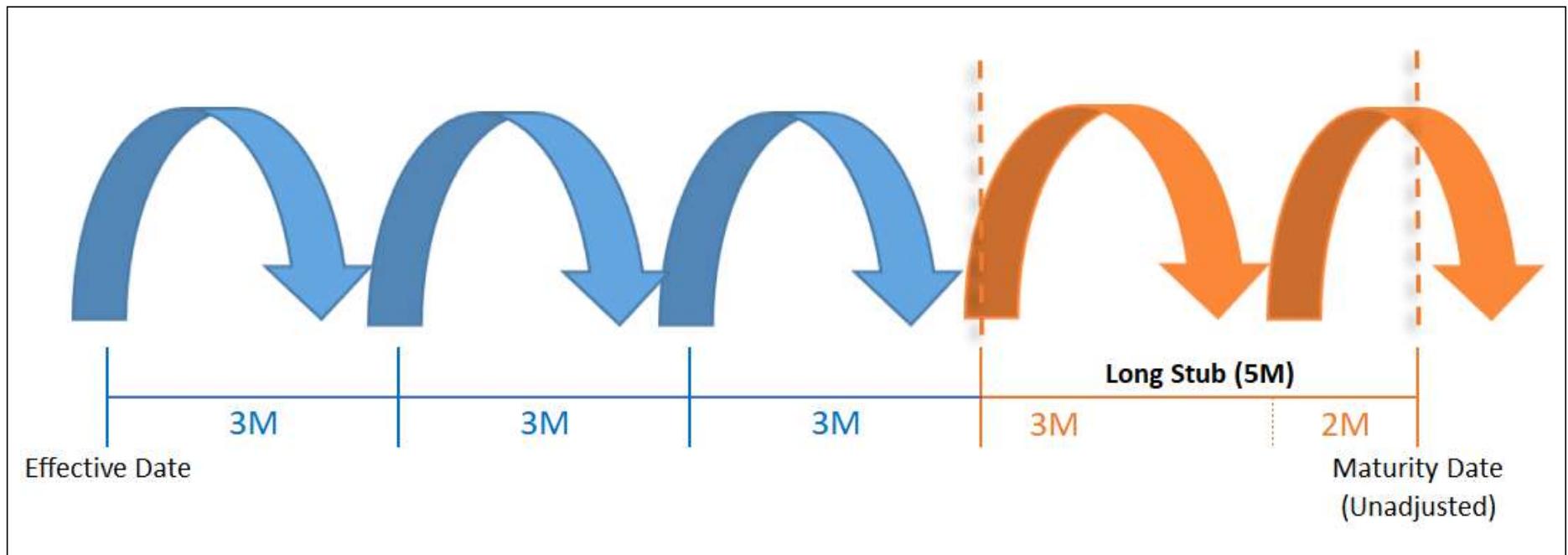












Year Fraction		Discount Factor	
Accrual Start	Accrual End	Pay Date	
21-May-22	19-Nov-22	19-Nov-22	
19-Nov-22	21-May-23	21-May-23	
21-May-23	19-Nov-23	19-Nov-23	
19-Nov-23	20-May-24	20-May-24	

τ

$P(t_0, t_i)$

Fixed Leg

N	r^{Fixed}	τ_i	$P(t_E, t_i)$	NPV^{Fixed}
1,000,000	1.0000%	0.50	0.997824	4,989
1,000,000	1.0000%	0.50	0.994549	4,973
1,000,000	1.0000%	0.50	0.991815	4,959
1,000,000	1.0000%	0.50	0.987801	4,939

$$PV^{\text{Fixed Leg}} = r \sum_{i=1}^n N_i \tau_i P(t_0, t_i)$$

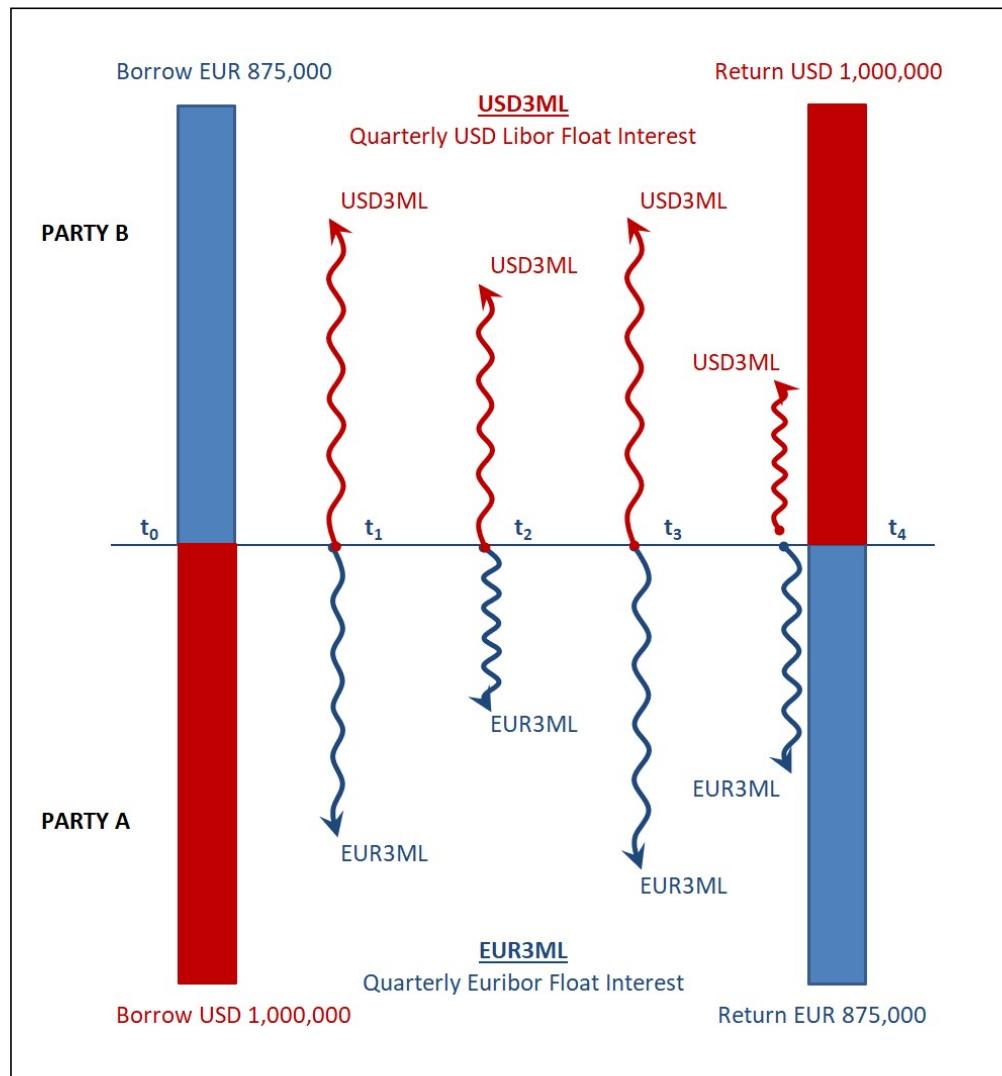


Forward Rate		Year Fraction		Discount Factor	
Fixing Date		Accrual Start	Accrual End	Pay Date	
19-May-22		21-May-22	20-Aug-22	20-Aug-22	
18-Aug-22		20-Aug-22	19-Nov-22	19-Nov-22	
17-Nov-22		19-Nov-22	18-Feb-23	18-Feb-23	
16-Feb-23		18-Feb-23	21-May-23	21-May-23	
19-May-23		21-May-23	20-Aug-23	20-Aug-23	
18-Aug-23		20-Aug-23	19-Nov-23	19-Nov-23	
17-Nov-23		19-Nov-23	19-Feb-24	19-Feb-24	
17-Feb-24		19-Feb-24	20-May-24	20-May-24	

Float Leg					
N	l_{j-1}	s	τ_j	$P(t_E, t_j)$	NPV^{float}
1,000,000	0.2800%	0.00	0.25	0.999302	700
1,000,000	0.2995%	0.00	0.25	0.997824	747
1,000,000	0.3385%	0.00	0.25	0.996240	843
1,000,000	0.3775%	0.00	0.25	0.994549	939
1,000,000	0.4165%	0.00	0.25	0.992752	1,034
1,000,000	0.4555%	0.00	0.25	0.991815	1,129
1,000,000	0.4750%	0.00	0.25	0.989860	1,175
1,000,000	0.5140%	0.00	0.25	0.987801	1,269

$$PV^{\text{float leg}} = \sum_{j=1}^m N_j (l_{j-1} + s) \tau_j P(t_0, t_j)$$





	TRADE PARAMETERS	LEG1	LEG2
TRADE ECONOMICS	LegType	FLOAT	FLOAT
	Currency	EUR	USD
	Notional	8,769,622	10,000,000
	NotionalExchange	ALL	ALL
	PayReceive	PAY	RECEIVE
	EffectiveDate	Fri, 26-Oct-18	Fri, 26-Oct-18
	MaturityDateOrTenor	1Y	1Y
	FixedRate (%)	-	-
	FloatSpread (Bps)	0.00	0.00
	IndexCompoundMethod	NONE	NONE
	SpreadCompoundMethod	NONE	NONE
	Leverage	1.00	1.00
	ForecastCurve	EUR3M	USD3M
	DiscountCurve	EURDF_USDCSA	USDDF
MTM SWAPS	isMTMResetLeg	FALSE	TRUE
	ResetBaseFX	1.00000	1.14030
	ValuationCurrency	USD	USD
COUPON & STUB CONVENTIONS	CouponRollDay	NATURAL	NATURAL
	isEndOfDayMonth	TRUE	TRUE
	StubType	SHORT_START	SHORT_START
	FrontStubCurveIndex	NATURAL	NATURAL
	BackStubCurveIndex	NATURAL	NATURAL
	FrontStubDate	-	-
SCHEDULE INFORMATION	BackStubDate	-	-
	AccrualFrequency	QUARTERLY	QUARTERLY
	AccrualCalendar	TGT+NY+LON	TGT+NY+LON
	AccrualBusDayConv	MOD_FOLLOWING	MOD_FOLLOWING
	AccrualDaycount	ACT/360	ACT/360
	IRFixingBusDayConv	MOD_FOLLOWING	MOD_FOLLOWING
	IRFixingCalendar	TGT+NY+LON	TGT+NY+LON
	IRFixingLag	2D	2D
	IRFirstFixingLag	-	-
	PaymentFrequency	QUARTERLY	QUARTERLY
NON-DELIVERABLES	PaymentBusDayConv	MOD_FOLLOWING	MOD_FOLLOWING
	PaymentCalendar	TGT+NY+LON	TGT+NY+LON
	PaymentLag	2D	2D
	IsNonDeliverable	FALSE	FALSE
NON-DELIVERABLES	SettlementCurrency	-	-
	FXFixingLag	-	-
	FXFixingBusDayConv	-	-
	FXFixingCalendar	-	-

		Leg1	Leg2
	Currency	BRL	USD
NON- DELIVERABLES	IsNonDeliverable	TRUE	-
	SettlementCurrency	USD	-
	FXFixingLag	2D	-
	FXFixingBusDayConv	MOD_FOLLOWING	-
	FXFixingCalendar	SAO+NY	-

TradeDate	Fri, 26-Oct-18	-
Maturity (Years)	Sat, 26-Oct-19	1Y
Trade Notional	1,000,000	-
Trade Currency	USD	-
MtM	YES	-
NotionalExchanges	YES	-
Reset Currency	USD	USD
CSA Currency	USD	-
Valuation Currency	USD	-
SpotFX	1.14030	USD/EUR
LegCurrency	EUR	USD
LegNotional	876,962	1,000,000
PayOrReceive	PAY	RECEIVE
LegType	FLOATING	FLOATING
RateOrSpread (%)	0.00000%	0.00000%
FloatIndex	EUR EURIBOR 3M	USD LIBOR 3M
Frequency	QUARTERLY	QUARTERLY
LegResetsRequired	NO	YES
LegSpotFX	0.87696	1.14030
ValuationFXAdj	1.14030	1.00000
DaycountBasis	ACT/360	ACT/360
UseMarketSchedule	NO	NO



LEG 1 - EUR CASH FLOWS

Notional	FXFixingDate	ForwardFX	NotionalExchange	Spread	FloatRate	Coupon	DiscountFactor	CouponPV	SpotFX	ValuationPV
			876,962			876,962	1.000000	876,962	1.14030	1,000,000
-876,962	Fri, 26-Oct-18	1.00000	0	0.00%	-0.31695%	703	1.002365	704	1.14030	803
-876,962	Fri, 25-Jan-19	1.00000	0	0.00%	-0.31644%	701	1.004182	704	1.14030	803
-876,962	Fri, 26-Apr-19	1.00000	0	0.00%	-0.28931%	641	1.005926	645	1.14030	736
-876,962	Fri, 26-Jul-19	1.00000	-876,962	0.00%	-0.22709%	-876,459	1.007807	-883,301	1.14030	-1,007,229

LEG 2 - USD CASH FLOWS

Notional	FXFixingDate	ForwardFX	NotionalExchange	Spread	FloatRate	Coupon	DiscountFactor	CouponPV	SpotFX	ValuationPV
			-1,000,000			-1,000,000	1.000000	-1,000,000	1.00000	-1,000,000
1,000,000	Fri, 26-Oct-18	1.14030	-8,233	0.00%	2.47475%	-1,977	0.994180	-1,966	1.00000	-1,966
1,008,233	Fri, 25-Jan-19	1.14969	-8,104	0.00%	2.79581%	-979	0.988041	-967	1.00000	-967
1,016,337	Fri, 26-Apr-19	1.15893	-8,635	0.00%	2.93764%	-1,088	0.981419	-1,067	1.00000	-1,067
1,024,972	Fri, 26-Jul-19	1.16878	1,024,972	0.00%	3.05383%	1,032,884	0.974803	1,006,858	1.00000	1,006,858



Trade Template		USDEUR MTMXCCY USD3ML EUR3ML 1Y	
Swap		LEG1:FLOAT	LEG2:FLOAT
Pay / Receive		RECEIVE	PAY
Notional		1,000,000	884,799.15
Currency		USD	EUR
Effective Date	2D	Tue, 26-Mar-2019	2D Tue, 26-Mar-2019
Maturity Date	1Y	Thu, 26-Mar-2020	1Y Thu, 26-Mar-2020
Fixed Rate (%)			
Float Index	3M	USD3ML	3M EUR3ML
Float Spread (bps)		0.000	-12.625
Reset Frequency		QUARTERLY	QUARTERLY
Pay Frequency		QUARTERLY	QUARTERLY
Day Count		ACT/360	ACT/360
Market			
Curve Date		Fri, 22-Mar-2019	Fri, 22-Mar-2019
Leg NPV		1,002,566.12	-1,002,566.12
Forecast Curve		USD3ML	EUR3ML
Discount Curve		USDOIS	EUROIS_USDCSA
Valuation Results			
Valuation Date		Fri, 22-Mar-2019	
Valuation Ccy		USD	
Par Spread (bps)		-12.625	
NPV		0.00	
BR01		-102.10	
DV01		0.00	

FX Forward: GBP/EUR (Replication)

5) Deposit Funds: Receive 1 GBP
Receive Deposit and Interest from (4)

1) Borrow EUR to Fund Spot FX

$$s(t)^{\text{GBP/EUR}} \cdot P(t, T)^{\text{GBP}}$$



3) Spot FX: Receive GBP

$$P(t, T)^{\text{GBP}}$$

Receive Cash Flows

Pay Cash Flows

2) Spot FX: Pay EUR for GBP

$$s(t)^{\text{GBP/EUR}} \cdot P(t, T)^{\text{EUR}}$$



4) Deposit GBP

$$P(t, T)^{\text{GBP}}$$



Note: All boxed transactions are at time t (today), cancel out and net to zero

6) Borrowed EUR: Pay Spot EUR + Interest

Return EUR with interest from (1)

$$f(t, T)^{\text{GBP/EUR}} = s(t)^{\text{GBP/EUR}} \cdot (P(t, T)^{\text{GBP}} / P(t, T)^{\text{EUR}})$$

FXFixingDate	$s^{\text{EUR/USD}}$	$P(t_0, t_i)^{\text{EUR_USDCSA}}$	$P(t_0, t_i)^{\text{USD_USDCSA}}$	$f(t_i)^{\text{USD/EUR}}$
Fri, 26-Oct-18	1.14030	1.000000	1.000000	1.14030
Fri, 25-Jan-19	1.14030	1.002365	0.994180	1.14969
Fri, 26-Apr-19	1.14030	1.004182	0.988041	1.15893
Fri, 26-Jul-19	1.14030	1.005926	0.981419	1.16878



Notional ^{EUR}	FFixingDate	ForwardFX	Notional ^{USD}	NotionalReset ^{USD}
876,962	Fri, 26-Oct-18	1.14030	1,000,000	-8,233
876,962	Fri, 25-Jan-19	1.14969	1,008,233	-8,104
876,962	Fri, 26-Apr-19	1.15893	1,016,337	-8,635
876,962	Fri, 26-Jul-19	1.16878	1,024,972	1,024,972



Notional Scaling Factor, $\psi(t, \text{EUR})$

Notional	$s^{\text{USD} / \text{EUR}}$	$f(t)^{\text{USD} / \text{EUR}}$	$\alpha(t, \text{EUR})$	$\beta(t, \text{EUR})$	$\psi(t, \text{EUR})$	NotionalAdj
876,962						
876,962	1.1403	1.1403	1.1403	1.0000	1.1403	1,000,000
876,962	1.1403	1.1403	1.1403	1.0000	1.1403	1,000,000
876,962	1.1403	1.1403	1.1403	1.0000	1.1403	1,000,000
876,962	1.1403	1.1403	1.1403	1.0000	1.1403	1,000,000

Notional Scaling Factor, $\psi(t, \text{USD})$

Notional	$s^{\text{USD} / \text{EUR}}$	$f(t)^{\text{USD} / \text{EUR}}$	$\alpha(t, \text{USD})$	$\beta(t, \text{USD})$	$\psi(t, \text{USD})$	NotionalAdj
1,000,000						
1,000,000	1.1403	1.1403	1.0000	1.0000	1.0000	1,000,000
1,000,000	1.1403	1.1497	1.0000	1.0082	1.0082	1,008,233
1,000,000	1.1403	1.1589	1.0000	1.0163	1.0163	1,016,337
1,000,000	1.1403	1.1688	1.0000	1.0250	1.0250	1,024,972



Leg1 - EUR Cashflows

USD -4,887

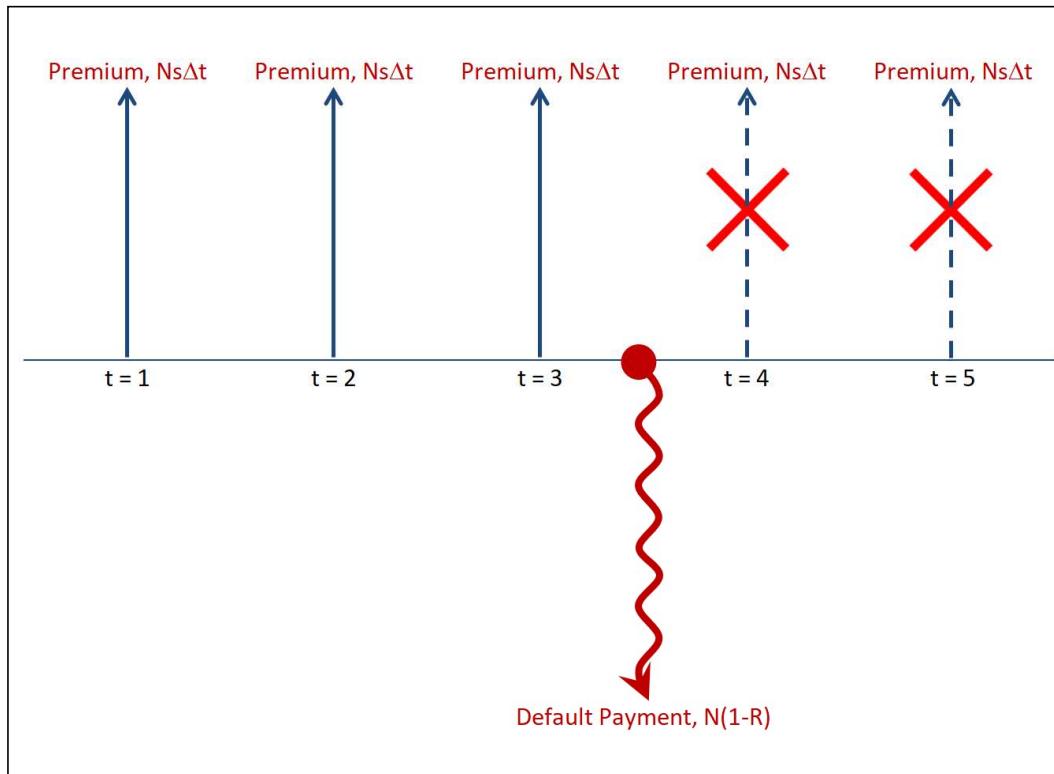
Notional	FX Fixing Date	Fwd FX	Notional Exch	Spread	Float Rate	Coupon	Disc Factor	Coupon PV	Spot FX	Valuation PV
			876,962			876,962	1.0000	876,962	1.1403	1,000,000
-876,962	Fri, 26-Oct-18	0.8770	0	0.00%	-0.31695%	703	1.0024	704	1.1403	803
-876,962	Fri, 25-Jan-19	0.8698	0	0.00%	-0.31644%	701	1.0042	704	1.1403	803
-876,962	Fri, 26-Apr-19	0.8629	0	0.00%	-0.28931%	641	1.0059	645	1.1403	736
-876,962	Fri, 26-Jul-19	0.8556	-876,962	0.00%	-0.22709%	-876,459	1.0078	-883,301	1.1403	-1,007,229

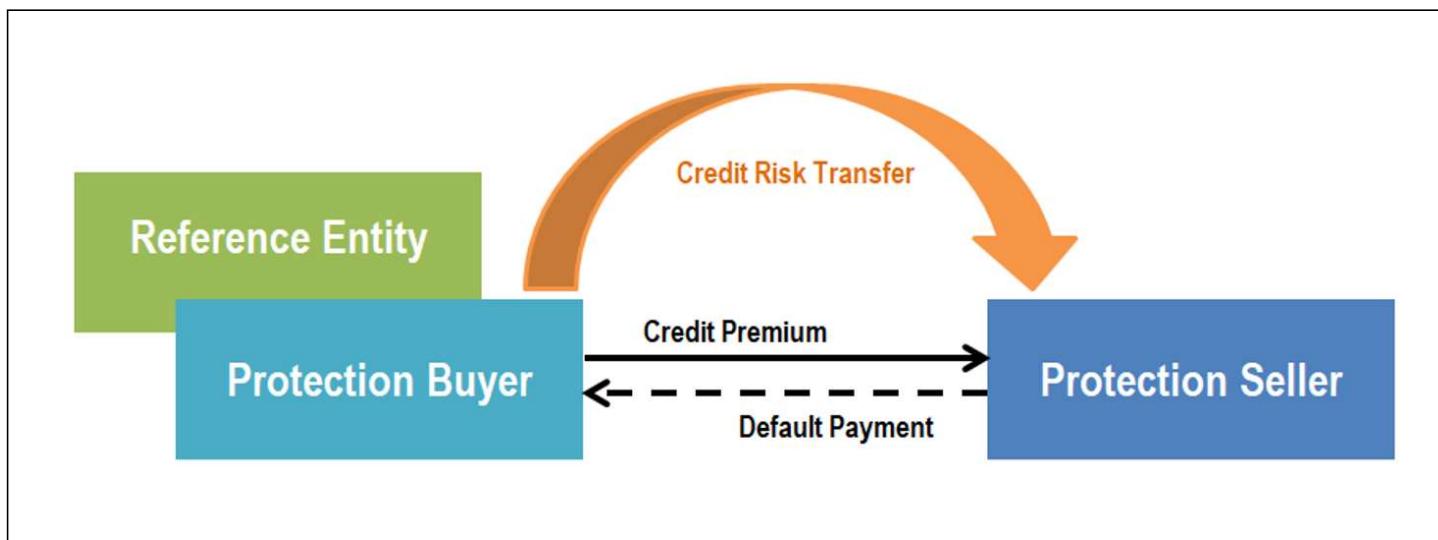
Leg2 - USD Cashflows

USD 2,858

Notional	FX Fixing Date	Fwd FX	Notional Exch	Spread	Float Rate	Coupon	Disc Factor	Coupon PV	Spot FX	Valuation PV
			-1,000,000			-1,000,000	1.0000	-1,000,000	1.0000	-1,000,000
1,000,000	Fri, 26-Oct-18	1.1403	-8,233	0.00%	2.47475%	-1,977	0.9942	-1,966	1.0000	-1,966
1,008,233	Fri, 25-Jan-19	1.1497	-8,104	0.00%	2.79581%	-979	0.9880	-967	1.0000	-967
1,016,337	Fri, 26-Apr-19	1.1589	-8,635	0.00%	2.93764%	-1,088	0.9814	-1,067	1.0000	-1,067
1,024,972	Fri, 26-Jul-19	1.1688	1,024,972	0.00%	3.05383%	1,032,884	0.9748	1,006,858	1.0000	1,006,858







Premium Leg							Total PV	-4,943.10
Time, T	Notional, N	Credit Spread, s	Year Fraction, δ_t	Coupon	P(Survive), Q(T)	Disc Fact, P(t,T)	PV	
0.25	-1,000,000	0.5000%	0.2500	-1,250	0.997919	0.997503	-1,244.28	
0.50	-1,000,000	0.5000%	0.2500	-1,250	0.995842	0.995012	-1,238.59	
0.75	-1,000,000	0.5000%	0.2500	-1,250	0.993770	0.992528	-1,232.93	
1.00	-1,000,000	0.5000%	0.2500	-1,250	0.991702	0.990050	-1,227.29	



Accrued Interest

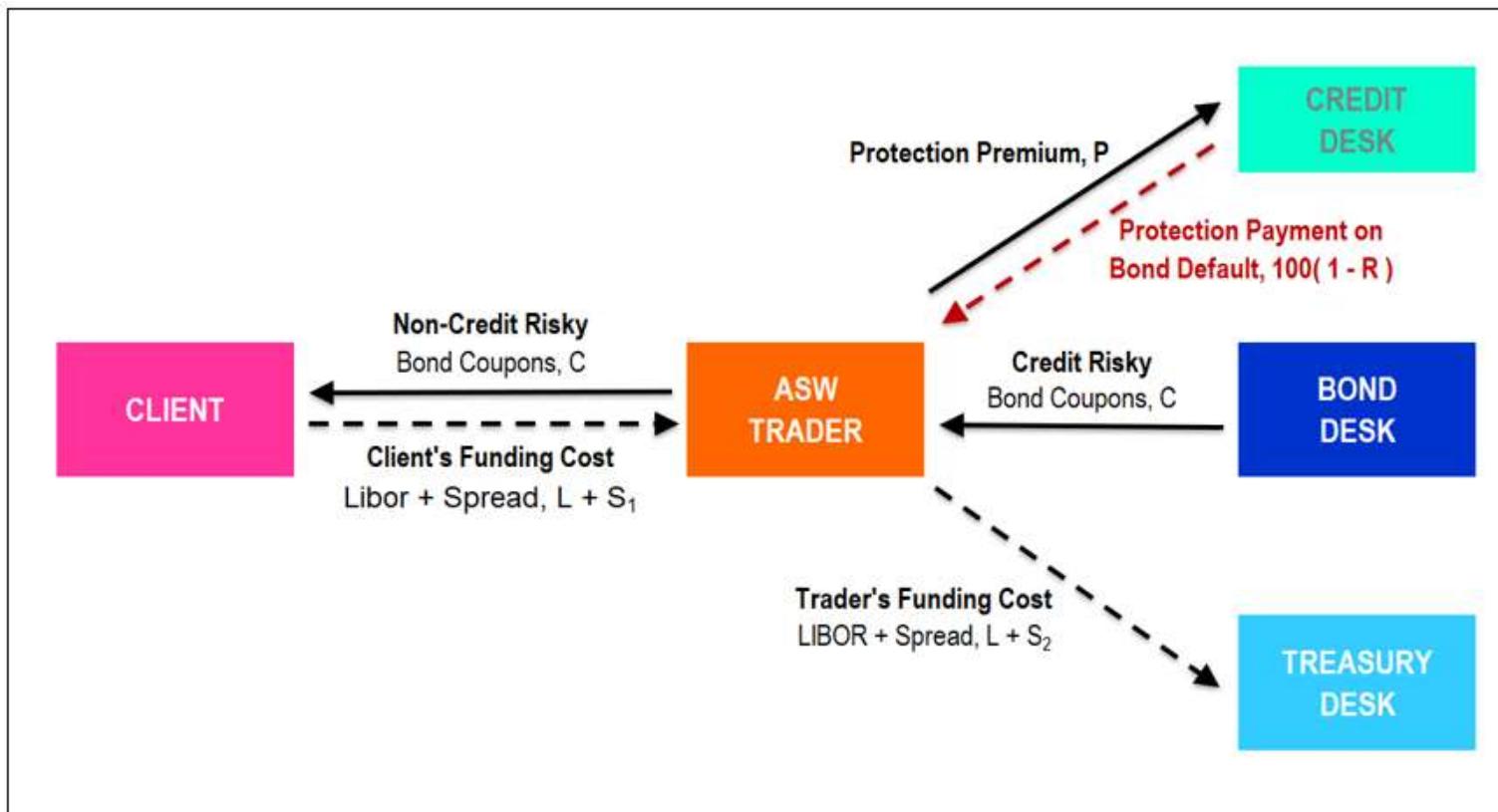
Time, T	Notional, N	Credit Spread, s	Year Fraction, δt	Coupon	P(Survive), Q(T)	Disc Fact, P(t,T)	Total PV	-5.15
0.25	-1,000,000	0.5000%	0.1250	-625	0.002081	0.997503	-1.30	
0.50	-1,000,000	0.5000%	0.1250	-625	0.002077	0.995012	-1.29	
0.75	-1,000,000	0.5000%	0.1250	-625	0.002072	0.992528	-1.29	
1.00	-1,000,000	0.5000%	0.1250	-625	0.002068	0.990050	-1.28	

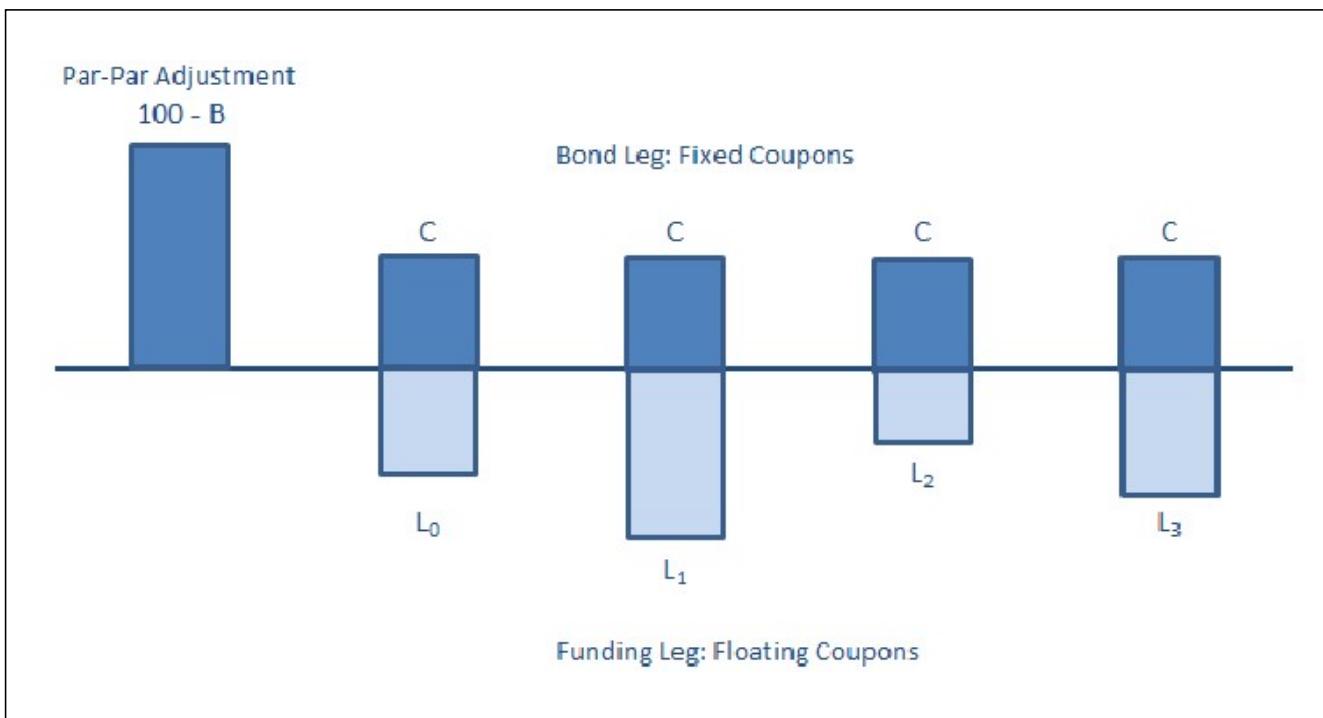


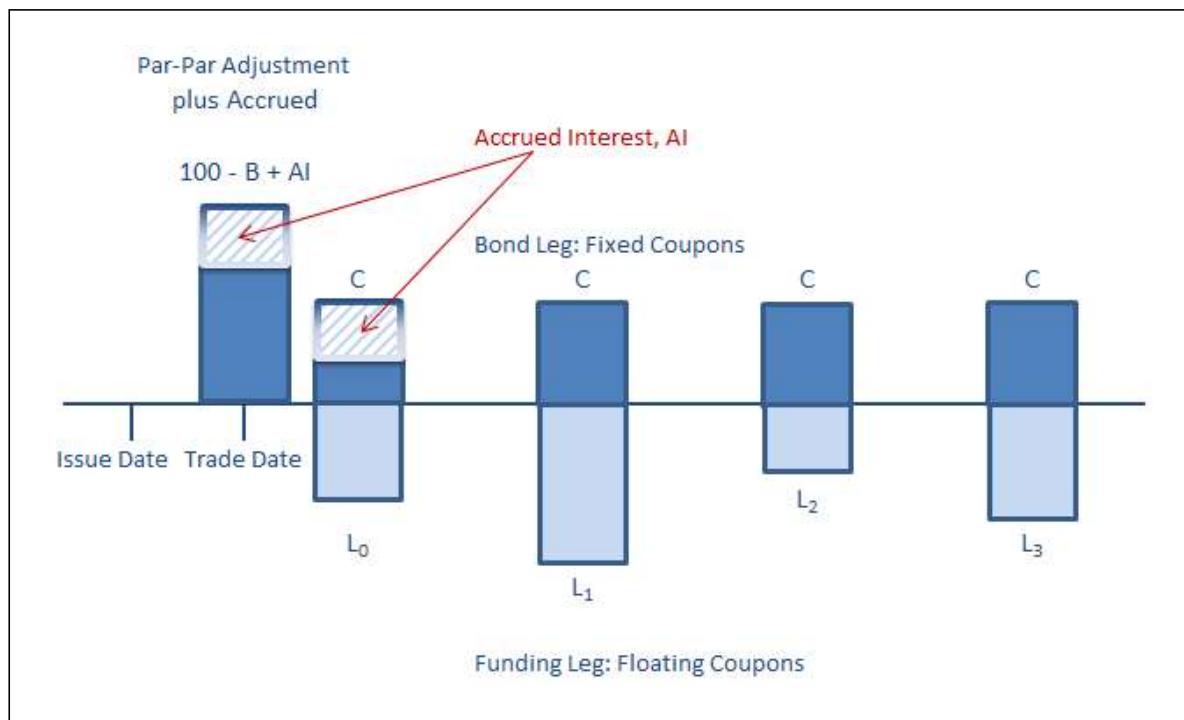
Protection Leg					Total PV	4,947.86
Time, T	Notional, N	Loss Given Default, LGD	P(Default), Q(t) $\lambda(t)$	Disc Fact, P(t,T)	PV	
0.25	1,000,000	600,000	0.002081	0.997503	1,245.48	
0.50	1,000,000	600,000	0.002077	0.995012	1,239.79	
0.75	1,000,000	600,000	0.002072	0.992528	1,234.12	
1.00	1,000,000	600,000	0.002068	0.990050	1,228.47	



Trade Template		USD CDS 5% FORD MOTOR 5Y			
Swap	LEG1:PREMIUM		LEG2:PROTECTION		
	PAY	RECEIVE			
	10,000,000	10,000,000			
	USD	USD			
	US35370BX76	Ford Motor Company			
	IMM Wed, 16-Mar-2016				
	5D Mon, 23-May-2016	5D Mon, 23-May-2016			
	5Y Tue, 16-Mar-2021	5Y Tue, 16-Mar-2021			
	500.000	40.000%			
	QUARTERLY				
Market					
Curve Date	Mon, 16-May-2016	Mon, 16-May-2016			
Credit Curve		USD_FORD_MOTOR_CO			
Discount Curve	USDOIS	USDOIS			
Valuation Results					
Valuation Date	Mon, 16-May-2016				
Par Spread (bps)	139.173800				
Clean PV	-1,669,036				
Accrued	-87,500				
Dirty PV	-1,786,536				
DV01	4,357.30				
CS01	4,951.24				







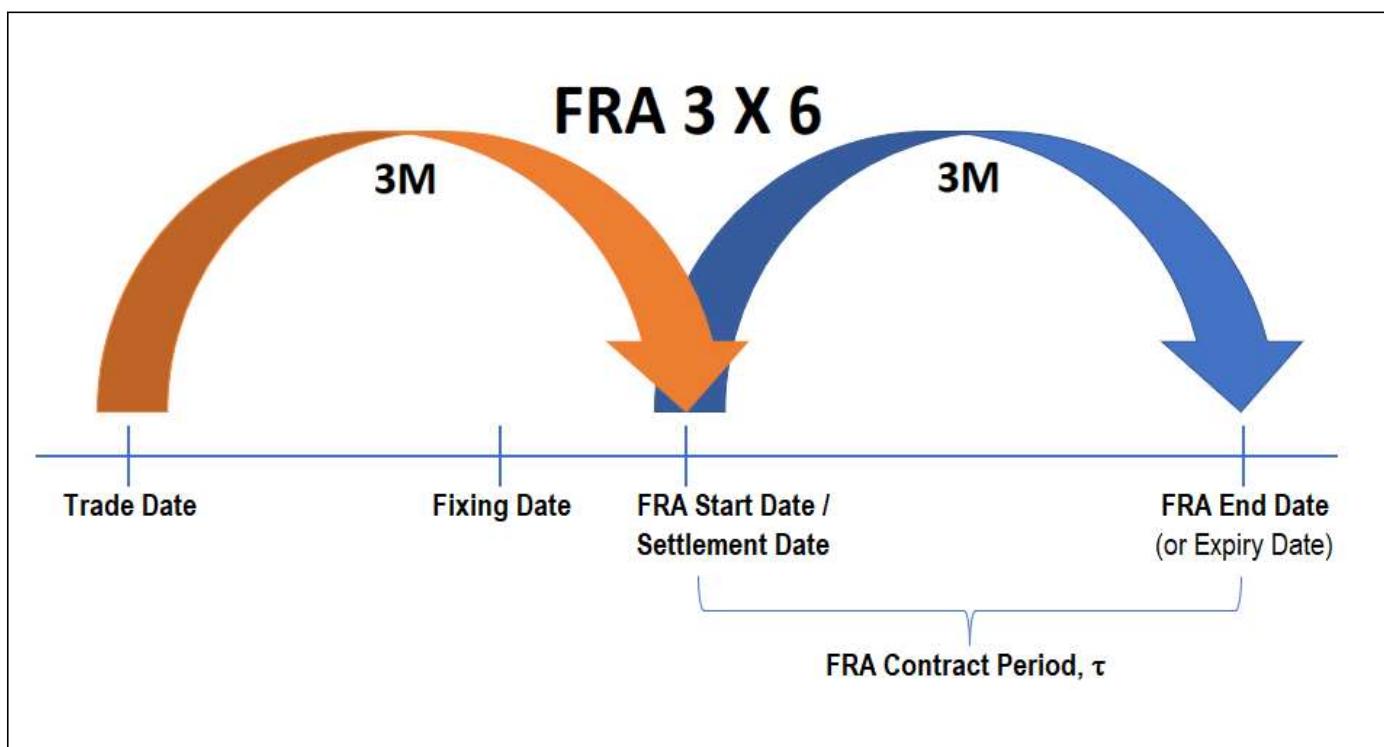
Clean Price	106.680
Dirty Price	106.919
Accrued (175 Days)	2,391.87
Ticker	DE0001102390 Govt
Security Name	DBR 0 1/2 02/15/2026
Issue Date	Fri, 15-Jan-16
First Coupon Date	Wed, 15-Feb-17
Maturity Date	Sun, 15-Feb-26
Coupon	0.50%
Price	106.680
Is Clean Price	TRUE
Day Count	ACT/ACT
Frequency	Annual

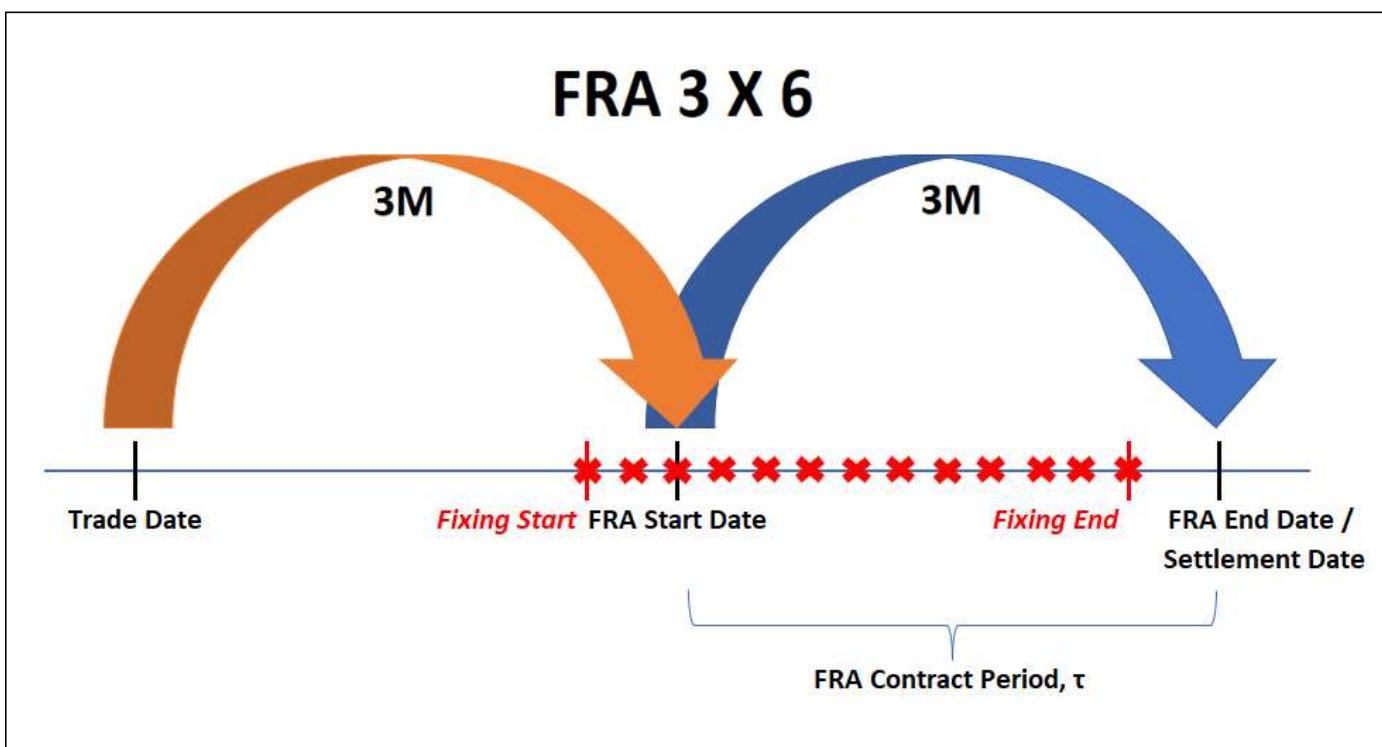
Swap Leg Breakdown

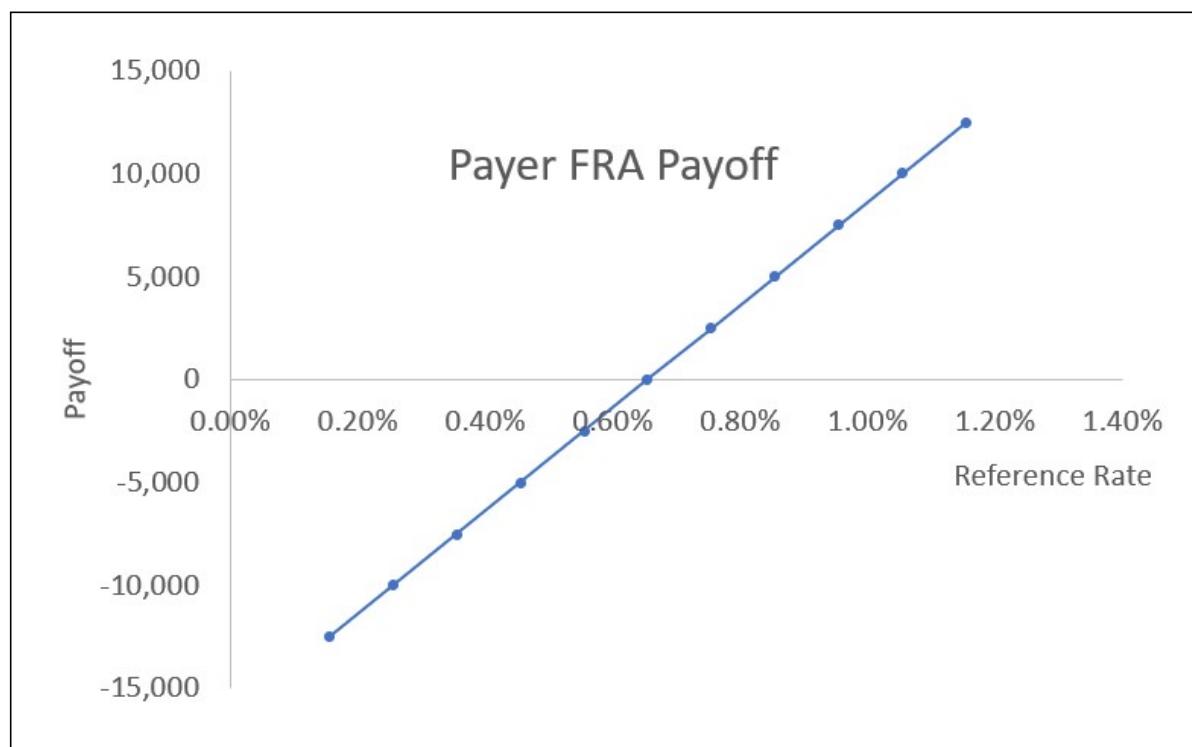
Fixed PV	51,219
Accrued Interest	2,392
Fixed PV Less Accrued	48,828
Float PV	22,805

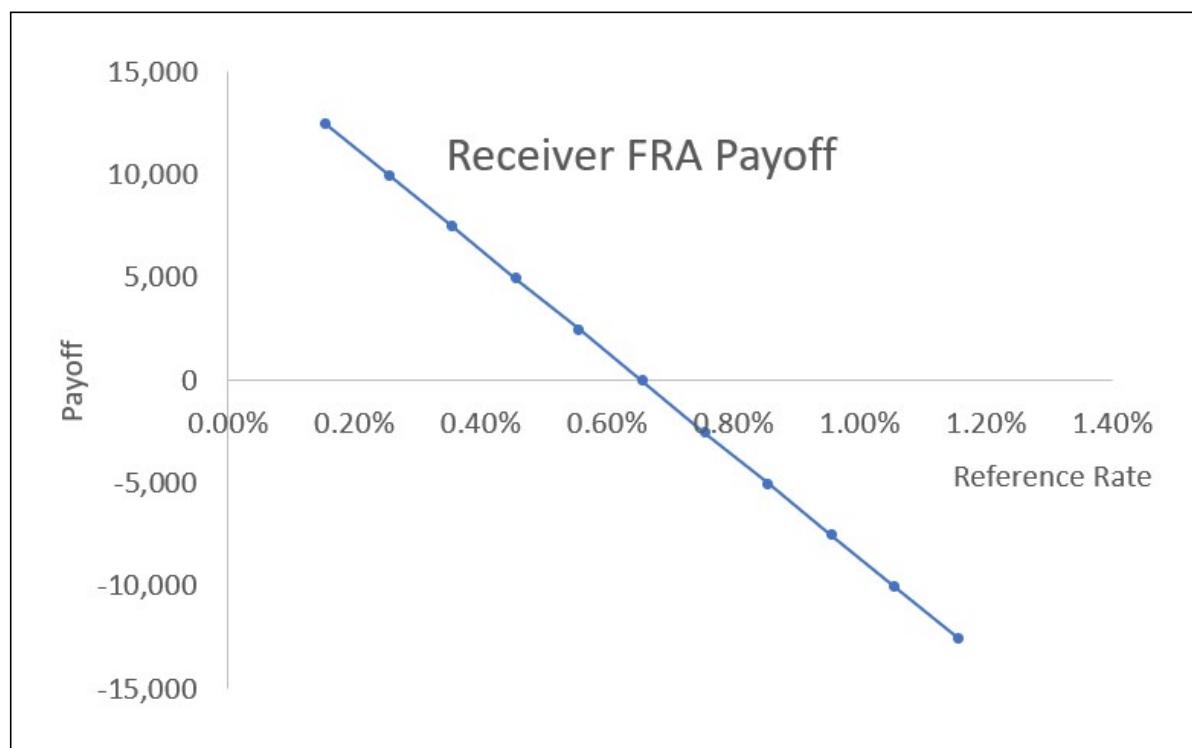
Asset Swap Calculation

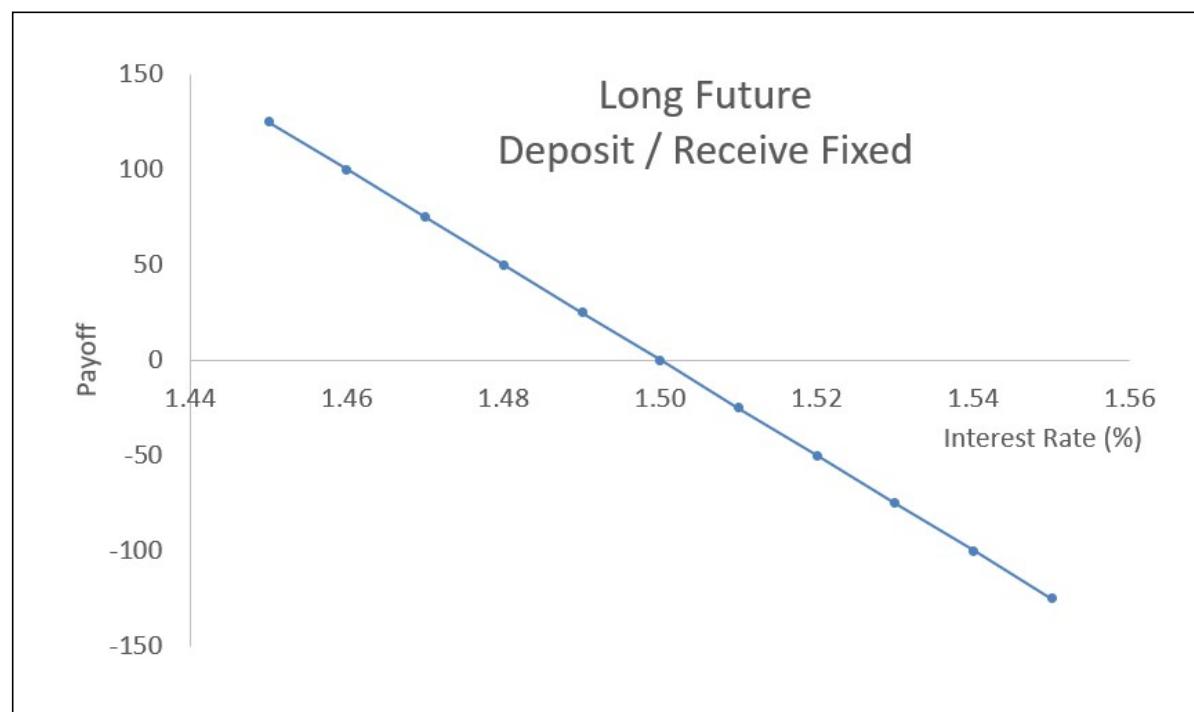
Swap PV	26,022
Par Adjustment	-66,800
Discounting Difference	6
Float Annuity	9,907,204
ASW Spread	-41.166

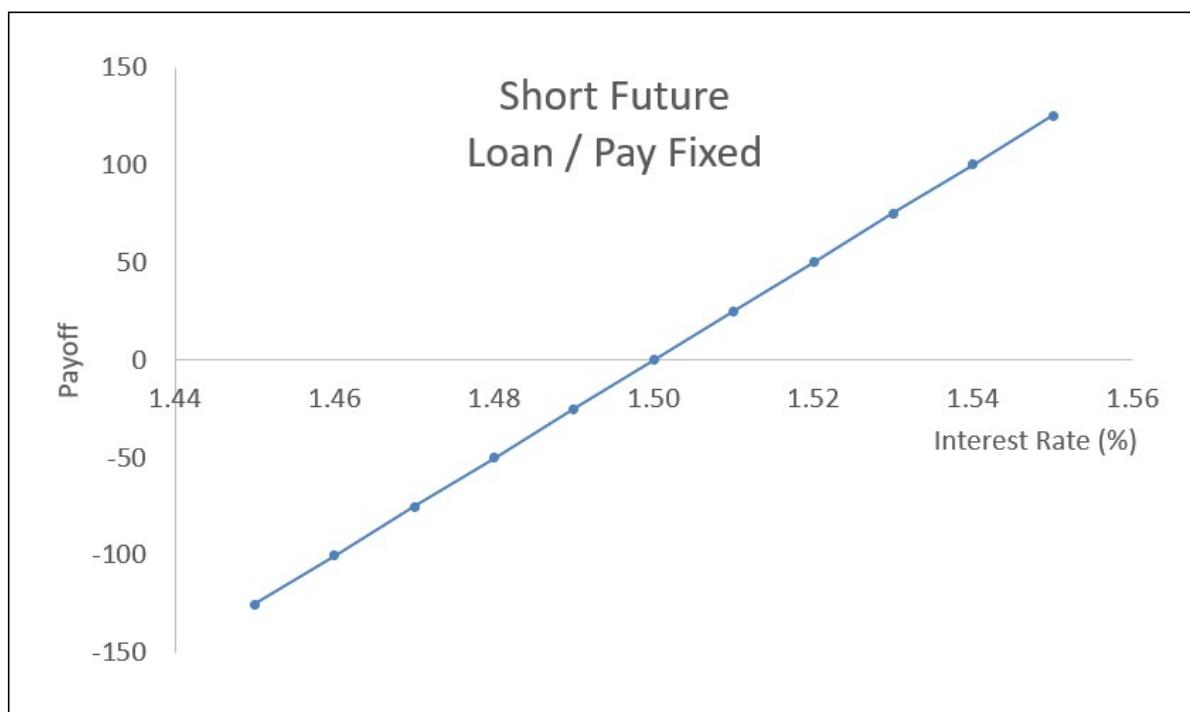












Month	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Symbol	F	G	H	J	K	M	N	Q	U	V	X	Z

YEAR	COLOUR
1st	White
2nd	Red
3rd	Green
4th	Blue
5th	Gold
6th	Purple
7th	Orange
8th	Pink
9th	Silver
10th	Copper

TICKER	MONTH	LAST PRICE	CHANGE	PRIOR PRICE	OPEN	HIGH	LOW	VOLUME
SR3M2	JUN-22	98.1175	-0.005 (-0.01%)	98.1225	98.1225	98.1475	98.11	45,593
SR3U2	SEP-22	97.06	+0.015 (+0.02%)	97.045	97.035	97.18	97.03	236,774
SR3Z2	DEC-22	96.71	+0.04 (+0.04%)	96.67	96.63	96.87	96.605	339,455
SR3H3	MAR-23	96.735	+0.105 (+0.11%)	96.63	96.58	96.88	96.54	305,759
SR3M3	JUN-23	96.97	+0.145 (+0.15%)	96.825	96.77	97.1	96.735	255,183
SR3U3	SEP-23	97.195	+0.18 (+0.19%)	97.015	96.965	97.315	96.935	199,337
SR3Z3	DEC-23	97.365	+0.20 (+0.21%)	97.165	97.13	97.475	97.095	185,140
SR3H4	MAR-24	97.49	+0.21 (+0.22%)	97.28	97.24	97.595	97.22	152,166
SR3M4	JUN-24	97.595	+0.225 (+0.23%)	97.37	97.34	97.68	97.315	112,246
SR3U4	SEP-24	97.625	+0.21 (+0.22%)	97.415	97.375	97.715	97.37	72,282
SR3Z4	DEC-24	97.62	+0.195 (+0.20%)	97.425	97.39	97.71	97.38	68,370
SR3H5	MAR-25	97.615	+0.175 (+0.18%)	97.44	97.405	97.705	97.395	52,353
SR3M5	JUN-25	97.58	+0.155 (+0.16%)	97.425	97.39	97.675	97.38	49,777
SR3U5	SEP-25	97.535	+0.14 (+0.14%)	97.395	97.355	97.62	97.345	19,103
SR3Z5	DEC-25	97.47	+0.12 (+0.12%)	97.35	97.31	97.56	97.305	15,861
SR3H6	MAR-26	97.41	+0.10 (+0.10%)	97.31	97.265	97.505	97.26	12,703
SR3M6	JUN-26	97.355	+0.085 (+0.09%)	97.27	97.225	97.455	97.22	10,425
SR3U6	SEP-26	97.32	+0.08 (+0.08%)	97.24	97.19	97.42	97.185	2,435
SR3Z6	DEC-26	97.27	+0.07 (+0.07%)	97.2	97.15	97.37	97.15	3,040
SR3H7	MAR-27	97.225	+0.06 (+0.06%)	97.165	97.115	97.33	97.11	1,867

TICKER	MONTH	LAST PRICE	CHANGE	PRIOR PRICE	OPEN	HIGH	LOW	VOLUME
SR3M7	JUN-27	97.18	+0.05 (+0.05%)	97.13	97.09	97.29	97.075	1,810
SR3U7	SEP-27	97.135	+0.04 (+0.04%)	97.095	97.05	97.18	97.05	158
SR3Z7	DEC-27	97.135	+0.08 (+0.08%)	97.055	97.19	97.19	97.135	34
SR3H8	MAR-28	-	-	97.03	-	-	-	0
SR3M8	JUN-28	-	-	96.995	-	-	-	0
SR3U8	SEP-28	-	-	96.96	-	-	-	0
SR3Z8	DEC-28	-	-	96.92	-	-	-	19
SR3H9	MAR-29	-	-	96.89	-	-	-	0
SR3M9	JUN-29	-	-	96.85	-	-	-	0
SR3U9	SEP-29	-	-	96.82	-	-	-	0
SR3Z9	DEC-29	-	-	96.79	-	-	-	0
SR3H0	MAR-30	-	-	96.765	-	-	-	0
SR3M0	JUN-30	-	-	96.725	-	-	-	0
SR3U0	SEP-30	-	-	96.685	-	-	-	0
SR3Z0	DEC-30	-	-	96.67	-	-	-	0
SR3H1	MAR-31	-	-	96.645	-	-	-	0
SR3M1	JUN-31	-	-	96.62	-	-	-	0
SR3U1	SEP-31	-	-	96.6	-	-	-	0
SR3Z1	DEC-31	-	-	96.59	-	-	-	0

Date	Position	Profit / Loss	Cash Flow	Margin Account Balance
Day One	Buy 10 Futures @ 9910		Initial Margin: 10 x 2,500 = (25,000) Pay	25,000 CR
	Settlement Price @ 9942	(9942 - 9910) x 25 x 10 = 8,000 Profit		33,000 CR
			Variation Margin: 8,000 Receive	25,000 CR
Day Two	Settlement Price @ 9932	(9932 - 9942) x 25 x 10 = (2,500) Loss		22,500 CR
			Variation Margin: (2,500) Pay	25,000 CR
Day Three	Sell 6 Futures @ 9927	(9927 - 9932) x 25 x 6 = (750) Loss		24,250 CR
	Settlement Price @ 9925	(9925 - 9932) x 25 x 4 = (700) Loss		23,550 CR
			Variation Margin: = -750 - 700 = (1,450) Pay	25,000 CR
			Initial Margin: 6 x 2,500 = 15,000 Receive	10,000 CR
Day Four	Sell 4 Futures @ 9938	(9938 - 9925) x 25 x 4 = 1,300 Profit		11,300 CR
			Closing of Position Return of Margin Balance 11,300 Receive	0

Net Position	Net P&L	Net Cash Flows	Margin Account Balance
0 Futures	5,350	5,350	0

Date	Profit / Loss	Cash Flow	Cash Flow Description	Margin Account
Day One		(25,000)	Open Position Pay Initial Margin	25,000
	8,000			33,000
		8,000	Profit Receive Margin	25,000
Day Two	(2,500)			22,500
		(2,500)	Loss Margin Call	25,000
Day Three	(750)			24,250
	(700)			23,550
		(1,450)	Loss Margin Call	25,000
		15,000	Partial Close Position Receive Initial Margin	10,000
Day Four	1,300			11,300
		11,300	Fully Close Position Receive Margin Balance	0

Net P&L	Net Cash Flows	Margin Balance
5,350	5,350	0

Cash Rates

Term	Bid	Ask
3M	2.42300%	2.42300%

Curve Template



USD3ML

Contiguous Futures

1	6
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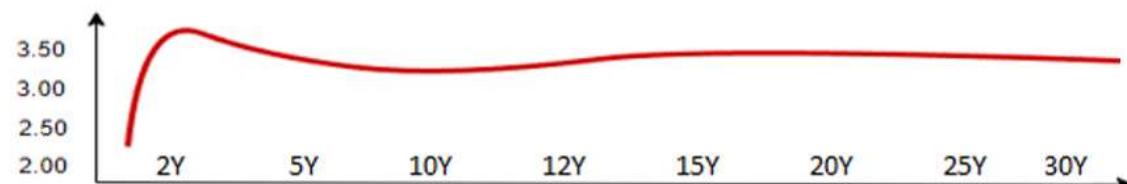
Futures

	Contract	Price	Cvx Adj	Rate
1	SEP-22 + 3	96.6750	-0.00110	3.32390%
2	DEC-22 + 3	96.1450	-0.00326	3.85174%
3	MAR-23 + 3	96.1850	-0.00659	3.80841%
4	JUN-23 + 3	96.3550	-0.01087	3.63413%
5	SEP-23 + 3	96.5650	-0.01600	3.41900%
6	DEC-23 + 3	96.7600	-0.02203	3.21797%
7	MAR-24 + 3	96.8950	-0.02893	3.07607%
8	JUN-24 + 3	96.9950	-0.03670	2.96830%

Swaps

Term	Bid	Ask
1Y	3.41532%	3.42668%
2Y	3.38246%	3.39164%
3Y	3.23062%	3.24638%
4Y	3.17325%	3.18184%
5Y	3.15423%	3.16357%
6Y	3.14866%	3.15714%
7Y	3.14521%	3.15179%
8Y	3.14509%	3.15131%

Forward Rate (%)



Chapter 4 – Yield Curves, Forecasting & Discounting Cash Flows

Cash Rates

Term	Bid	Ask
3M	2.42300%	2.42300%

Curve Template



USD3ML

Serial Futures

1	6
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Futures

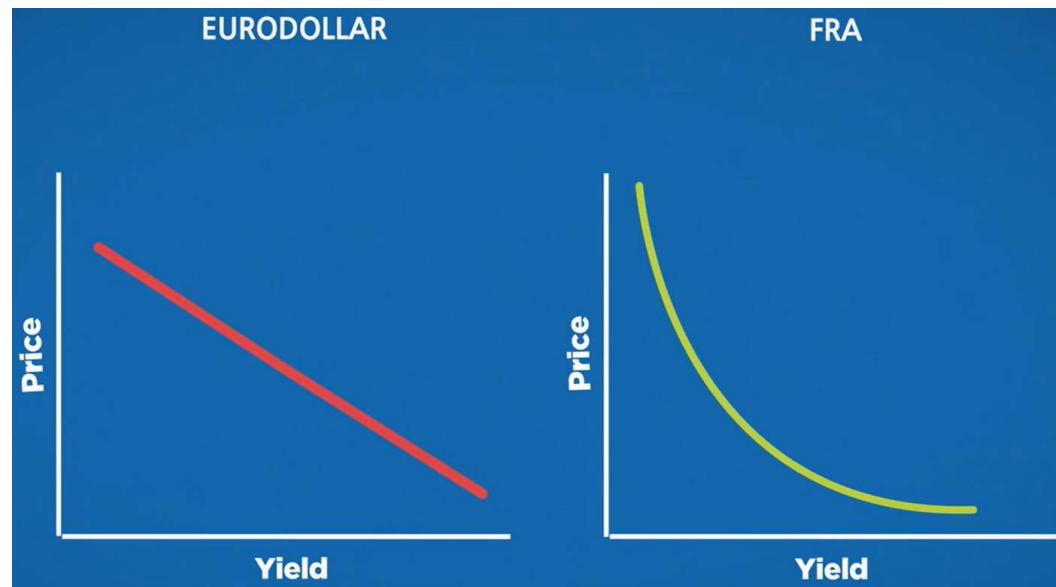
	Contract	Price	Cvx Adj	Rate
1	JUL-22 + 3	97.4475	-0.00009	2.55241%
2	AUG-22 + 3	97.1100	-0.00045	2.88955%
3	SEP-22 + 3	96.6750	-0.00103	3.32397%
4	OCT-22 + 3	96.4950	-0.00159	3.50341%
5	NOV-22 + 3	96.3250	-0.00224	3.67276%
6	DEC-22 + 3	96.1450	-0.00305	3.85195%
7	JAN-23 + 3	96.1850	-0.00616	3.80884%
8	FEB-23 + 3	96.3550	-0.01016	3.63484%

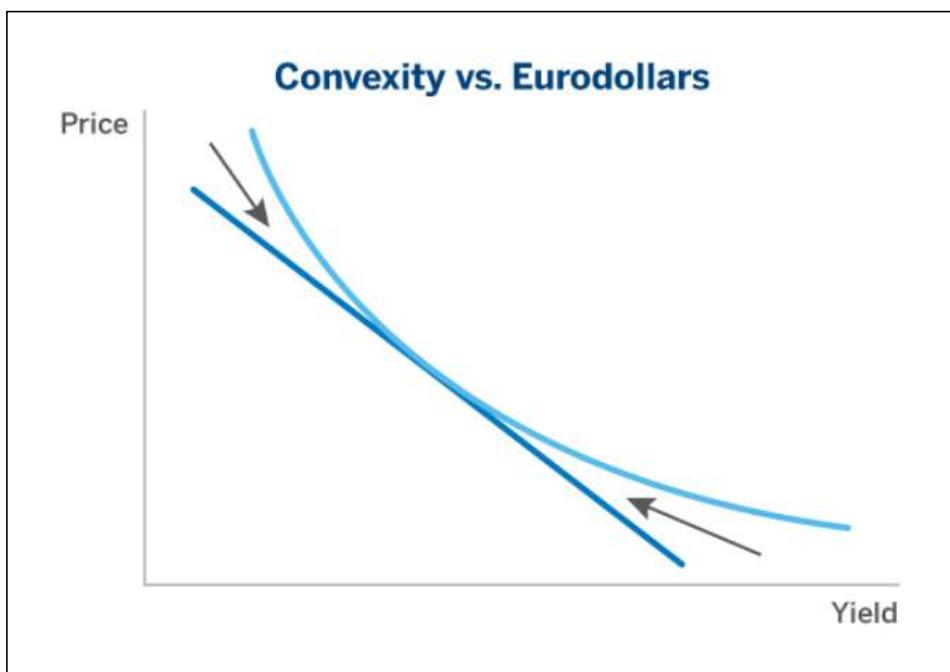
Swaps

Term	Bid	Ask
1Y	3.41532%	3.42668%
2Y	3.38246%	3.39164%
3Y	3.23062%	3.24638%
4Y	3.17325%	3.18184%
5Y	3.15423%	3.16357%
6Y	3.14866%	3.15714%
7Y	3.14521%	3.15179%
8Y	3.14509%	3.15131%

Forward Rate (%)







Cash Rates

Term	Bid	Ask
1D	1.54000%	1.54000%

Curve Template



USDSOFR

SOFR Futures

1M	0	0
3M	0	0

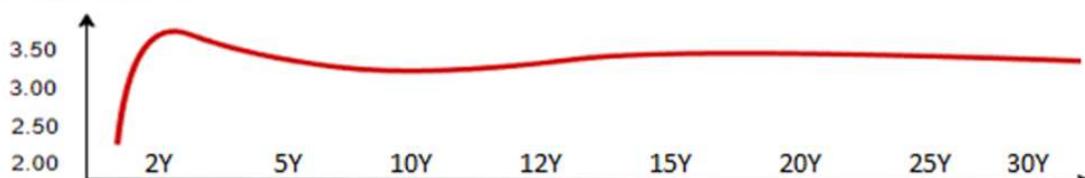
Futures

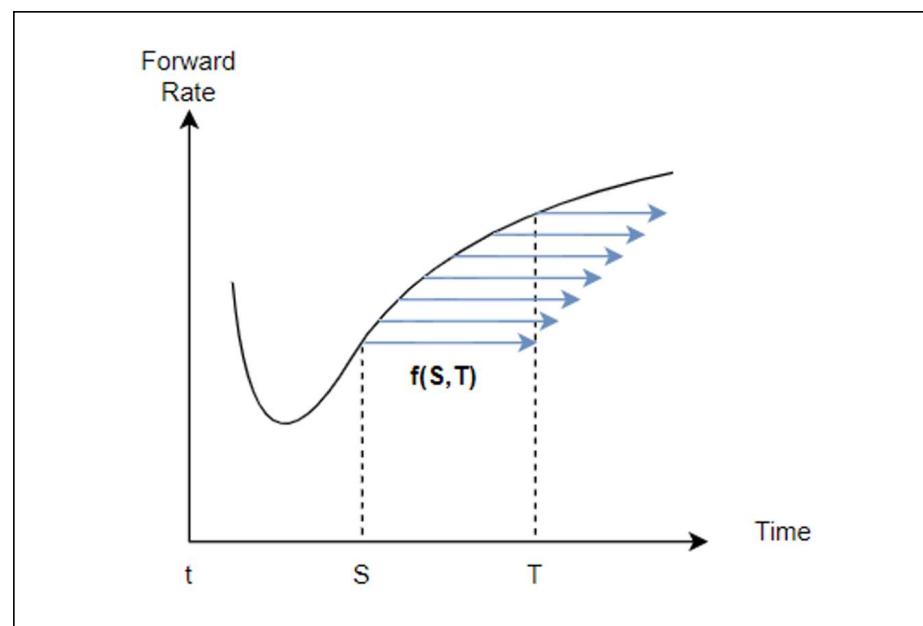
	Contract	Price	Cvx Adj	Rate
1	JUN-22 +3	98.0625	-0.01599	1.93734%
2	JUL-22 +1	98.3800	0.10408	1.62104%
3	AUG-22 +1	97.7350	0.19972	2.26700%
4	SEP-22 +3	96.9250	-0.13725	3.07363%
5	SEP-22 +1	97.5650	0.21840	2.43718%
6	OCT-22 +1	97.1550	-0.98714	2.83513%
7	NOV-22 +1	96.7800	0.30844	3.22308%
8	DEC-22 +3	96.4275	0.09714	3.57347%

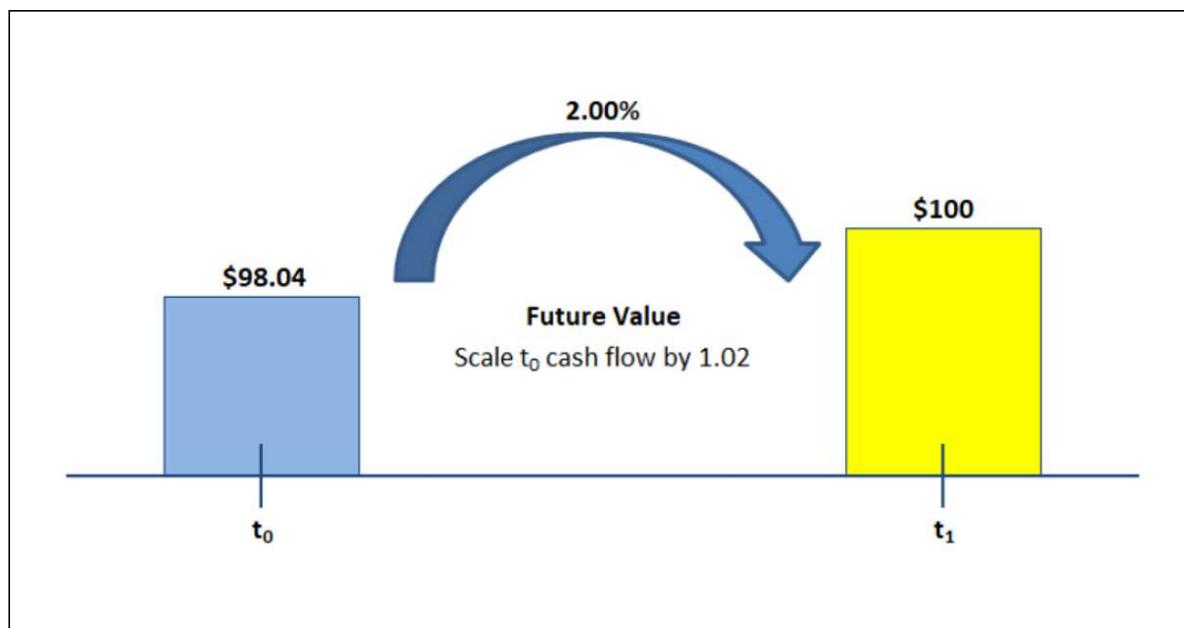
Swaps

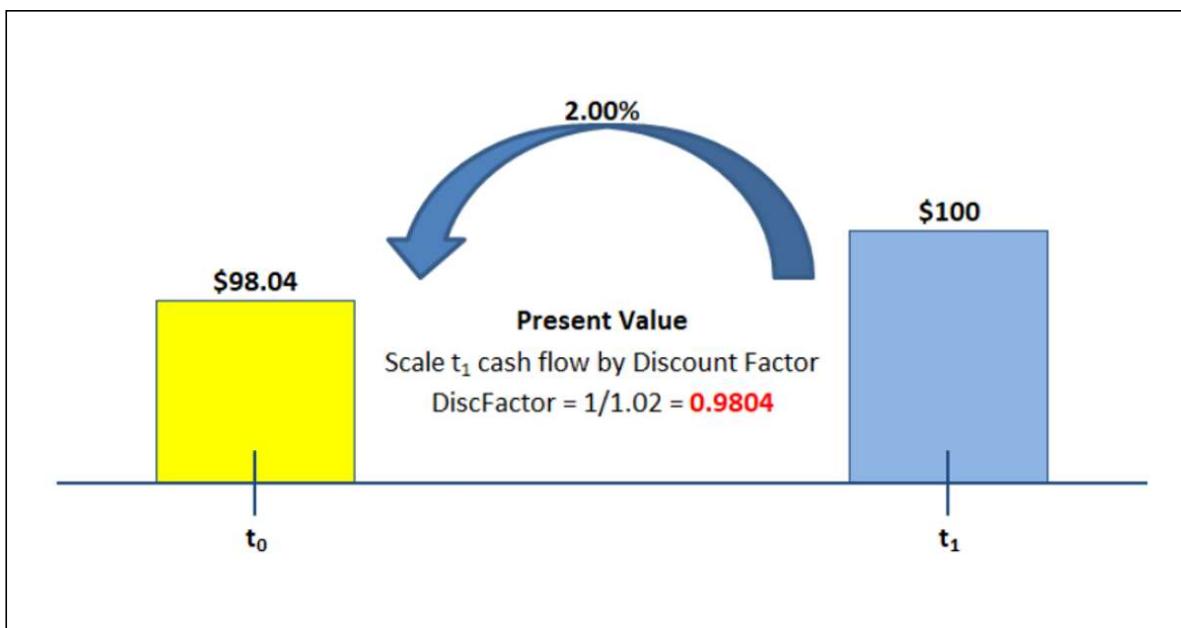
Term	Bid	Ask
1Y	3.41532%	3.42668%
2Y	3.38246%	3.39164%
3Y	3.23062%	3.24638%
4Y	3.17325%	3.18184%
5Y	3.15423%	3.16357%
6Y	3.14866%	3.15714%
7Y	3.14521%	3.15179%
8Y	3.14509%	3.15131%

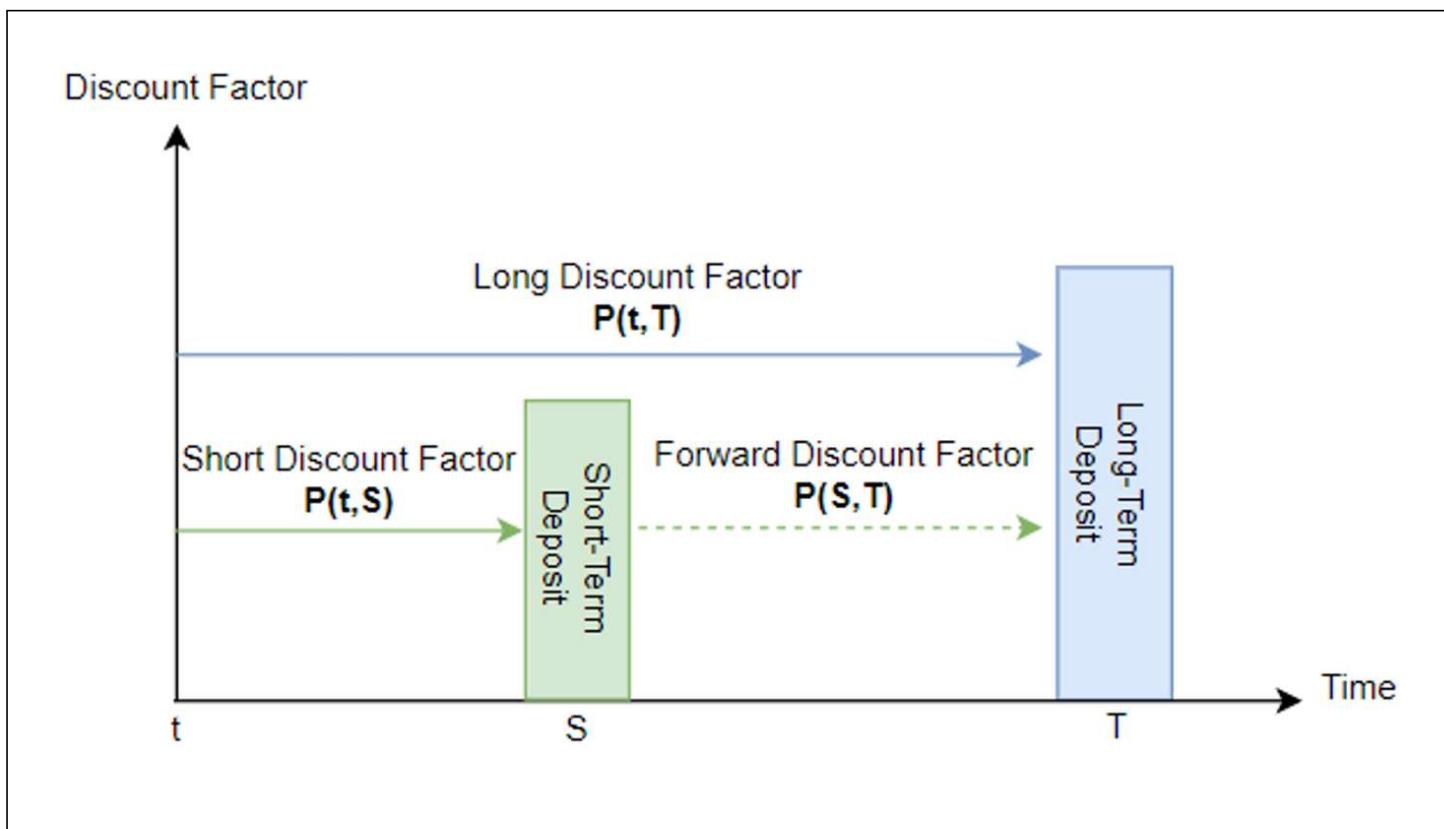
Forward Rate (%)

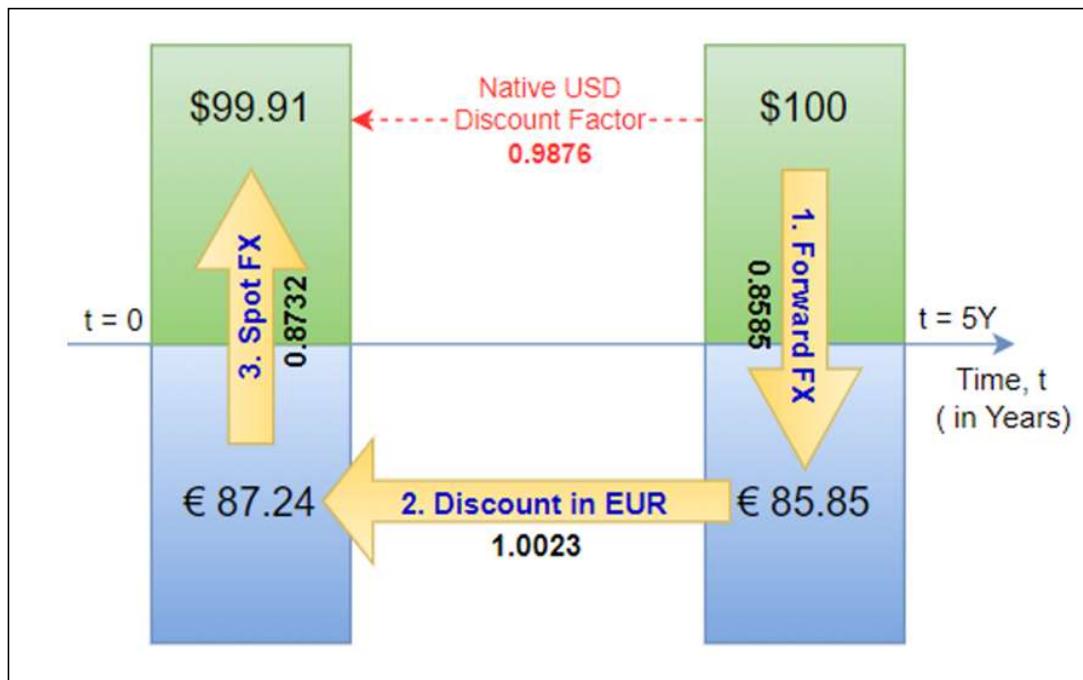


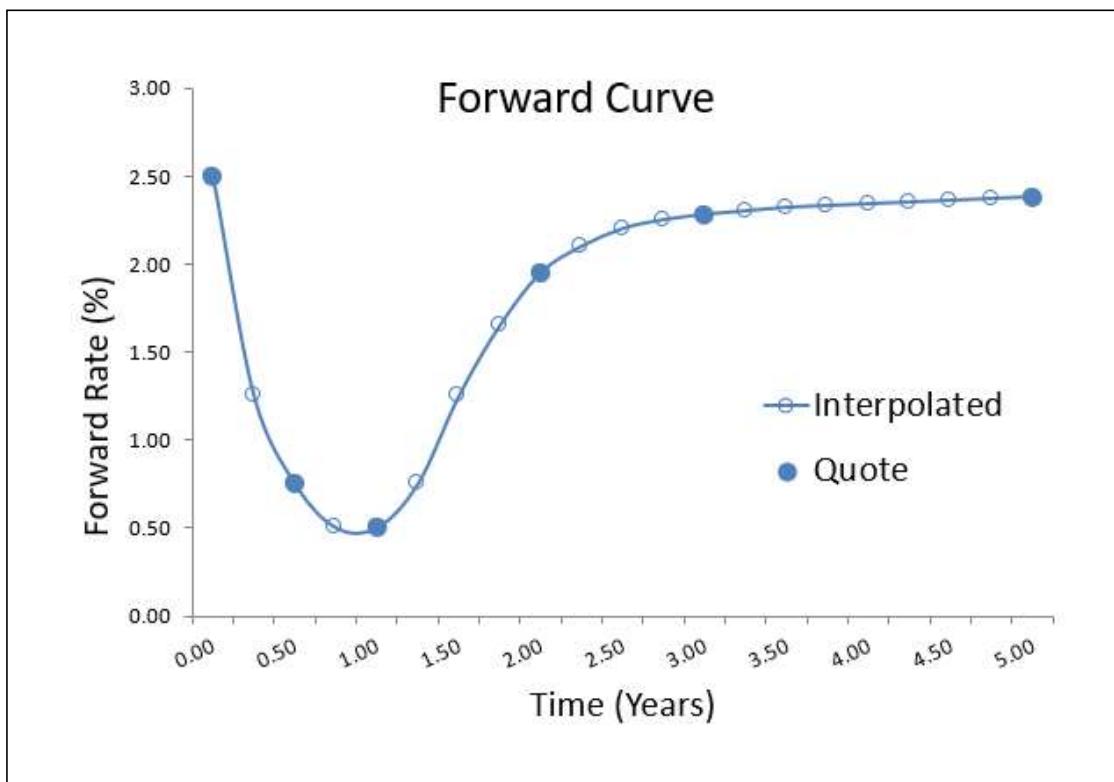


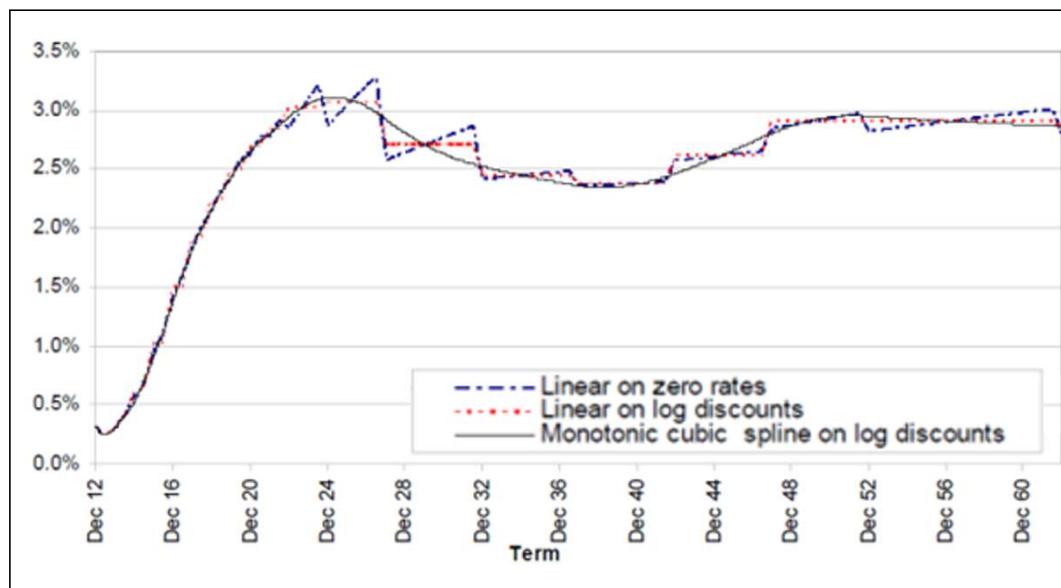












OIS Curve (1D)

Instrument	Tenor	Quote	Interpolation Style
Cash Deposit	1D	2.02480	Linear
OIS Swap	6M	7.73450	Spline
OIS Swap	1Y	1.59890	Spline
OIS Swap	18M	1.52050	Spline
OIS Swap	2Y	1.46050	Spline
OIS Swap	5Y	1.36900	Spline
LIBOR-OIS Basis Swap	7Y	0.26563	Spline
LIBOR-OIS Basis Swap	10Y	0.26063	Spline
LIBOR-OIS Basis Swap	15Y	0.25500	Spline
LIBOR-OIS Basis Swap	20Y	0.25375	Spline
LIBOR-OIS Basis Swap	30Y	0.25375	Spline
LIBOR-OIS Basis Swap	40Y	0.25375	Spline
LIBOR-OIS Basis Swap	50Y	0.25375	Spline

Swap Curve (USD3ML)

Instrument	Tenor	Quote	Interpolation Style
Cash Deposit	3M	2.13940	Linear
Future1	SEP-19	97.85500	Linear
Future2	DEC-19	97.97500	Linear
Future3	MAR-20	98.23500	Linear
Future4	JUN-20	98.33500	Linear
Future5	SEP-20	98.39500	Linear
Future6	DEC-20	98.38000	Linear
LIBOR Swap	3Y	1.69450	Spline
LIBOR Swap	5Y	1.65880	Spline
LIBOR Swap	7Y	1.67880	Spline
LIBOR Swap	10Y	1.74720	Spline
LIBOR Swap	15Y	1.84090	Spline
LIBOR Swap	20Y	1.89680	Spline
LIBOR Swap	30Y	1.92460	Spline
LIBOR Swap	40Y	1.92460	Spline
LIBOR Swap	50Y	1.92460	Spline

Tenor-Basis Curve (USD6ML)

Instrument	Term (Years)	Quote	Interpolation Style
Cash Deposit	6M	2.70300	Linear
LIBOR Basis Swap (3X6)	1Y	0.01750	Spline
LIBOR Basis Swap (3X6)	2Y	0.04125	Spline
LIBOR Basis Swap (3X6)	3Y	0.05125	Spline
LIBOR Basis Swap (3X6)	4Y	0.05625	Spline
LIBOR Basis Swap (3X6)	5Y	0.06125	Spline
LIBOR Basis Swap (3X6)	7Y	0.07375	Spline
LIBOR Basis Swap (3X6)	10Y	0.08500	Spline
LIBOR Basis Swap (3X6)	15Y	0.09625	Spline
LIBOR Basis Swap (3X6)	20Y	0.10375	Spline
LIBOR Basis Swap (3X6)	30Y	0.11000	Spline
LIBOR Basis Swap (3X6)	40Y	0.11000	Spline
LIBOR Basis Swap (3X6)	50Y	0.11000	Spline

Cash Rates

Term	Bid	Ask
3M	2.42300%	2.42300%

Curve Template



USD3ML

Contiguous Futures

1	6
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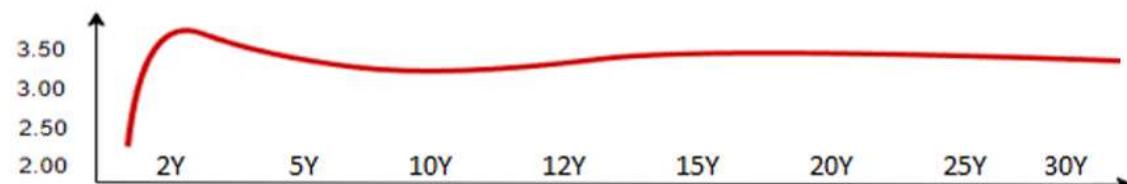
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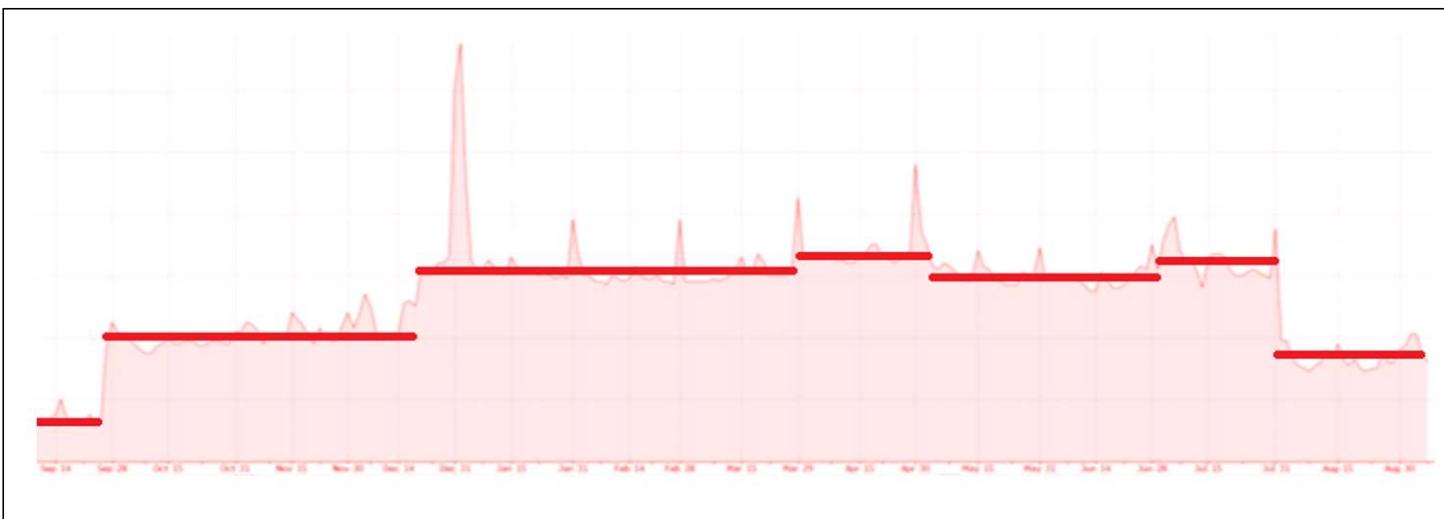
	Contract	Price	Cvx Adj	Rate
1	SEP-22 + 3	96.6750	-0.00110	3.32390%
2	DEC-22 + 3	96.1450	-0.00326	3.85174%
3	MAR-23 + 3	96.1850	-0.00659	3.80841%
4	JUN-23 + 3	96.3550	-0.01087	3.63413%
5	SEP-23 + 3	96.5650	-0.01600	3.41900%
6	DEC-23 + 3	96.7600	-0.02203	3.21797%
7	MAR-24 + 3	96.8950	-0.02893	3.07607%
8	JUN-24 + 3	96.9950	-0.03670	2.96830%

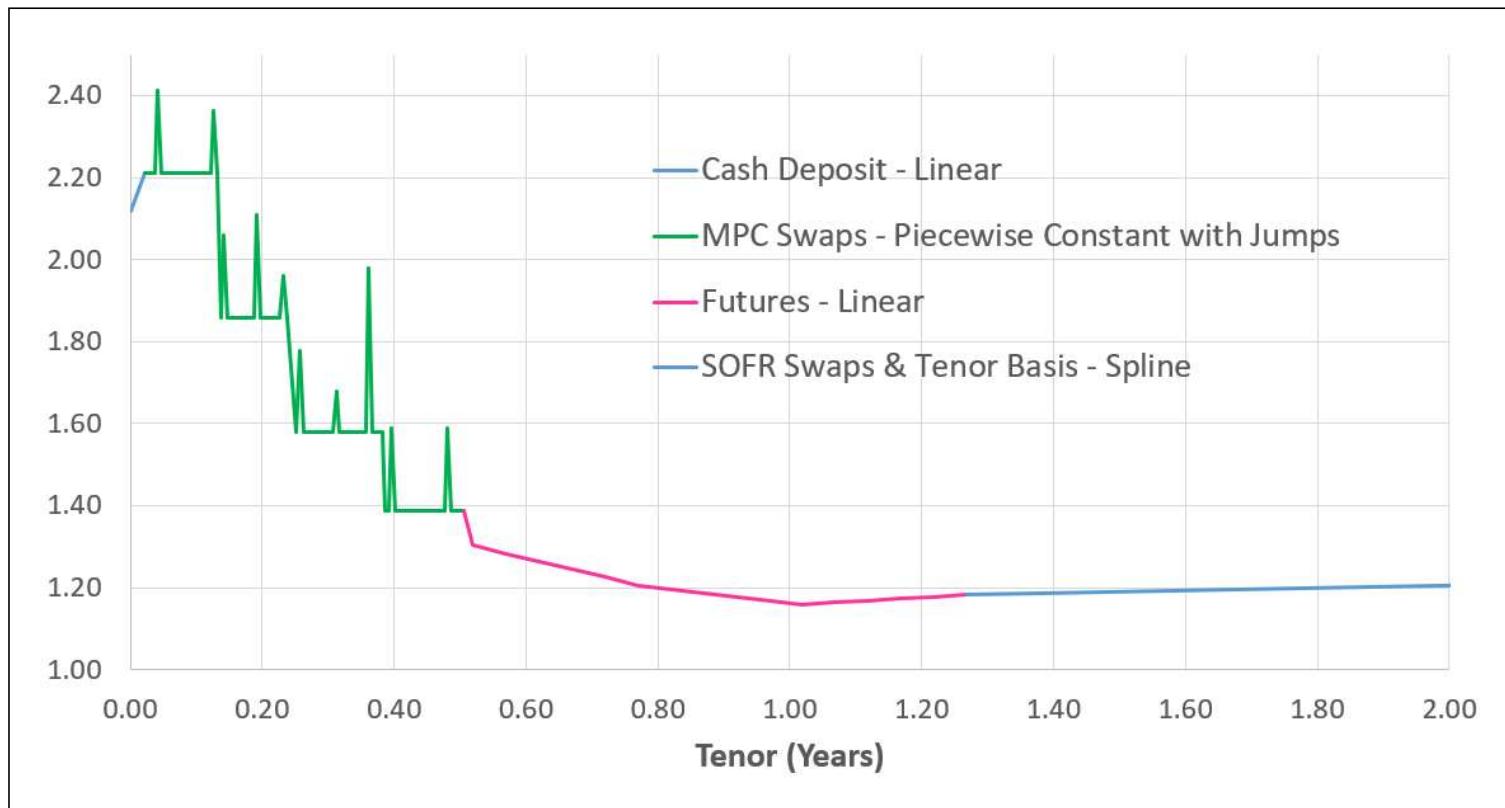
Swaps

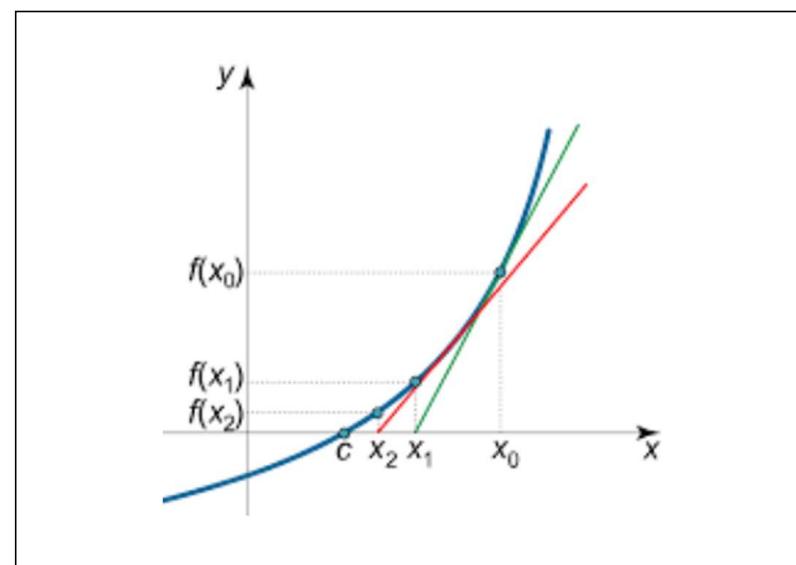
Term	Bid	Ask
1Y	3.41532%	3.42668%
2Y	3.38246%	3.39164%
3Y	3.23062%	3.24638%
4Y	3.17325%	3.18184%
5Y	3.15423%	3.16357%
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7Y	3.14521%	3.15179%
8Y	3.14509%	3.15131%

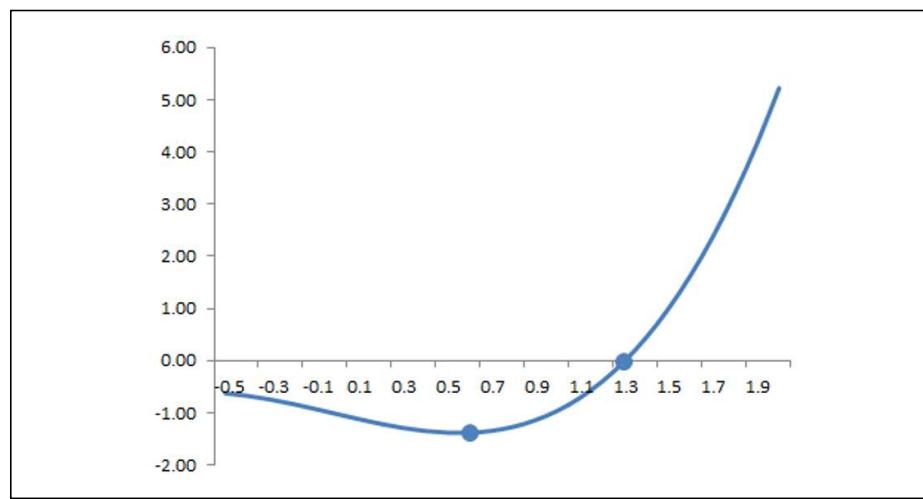
Forward Rate (%)







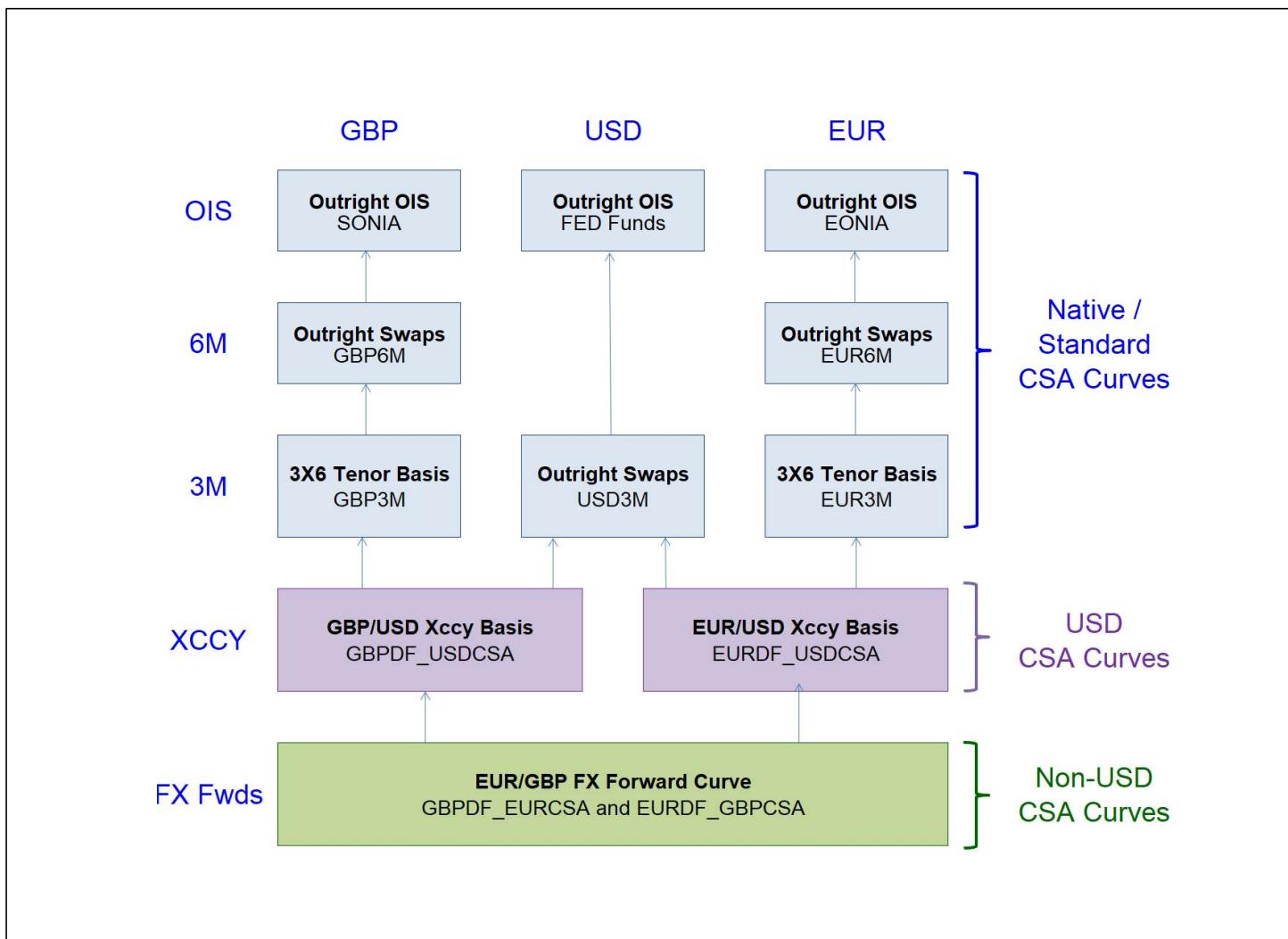


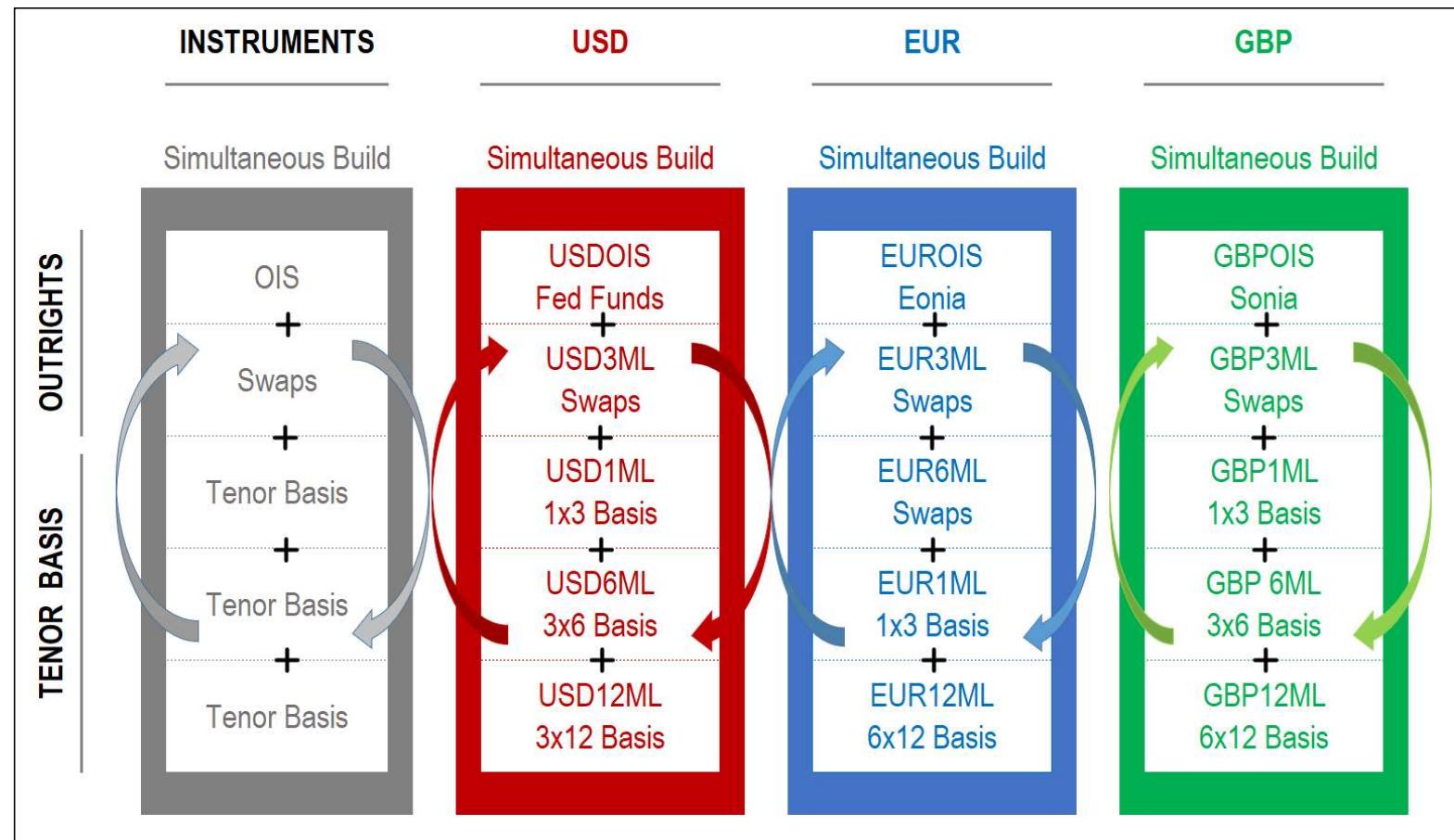


n	x_{n+1}	x_n	$f(x_n)$	$f'(x_n)$	ϵ
1	3.39	5.00	119.00	74.00	1.608
2	2.36	3.39	34.63	33.51	1.033
3	1.74	2.36	9.76	15.69	0.622
4	1.43	1.74	2.50	8.04	0.311
5	1.33	1.43	0.47	5.10	0.093
6	1.32	1.33	0.04	4.33	0.008

n	x_{n+1}	x_n	$f(x_n)$	$f'(x_n)$	ϵ
1	2.53	5.00	74.00	30.00	2.467
2	1.33	2.53	18.25	15.20	1.201
3	0.79	1.33	4.33	7.99	0.541
4	0.61	0.79	0.88	4.75	0.185
5	0.58	0.61	0.10	3.64	0.028
6	0.58	0.58	0.00	3.47	0.001

	Instrument	USD
Tenor Basis	Outrights	
1st	OIS	USDOIS Fed Funds
2nd	Swaps	USD3ML Swaps
3rd	Tenor Basis	USD1ML 1x3 Basis
4th	Tenor Basis	USD6ML 3x6 Basis
5th	Tenor Basis	USD12ML 3x12 Basis



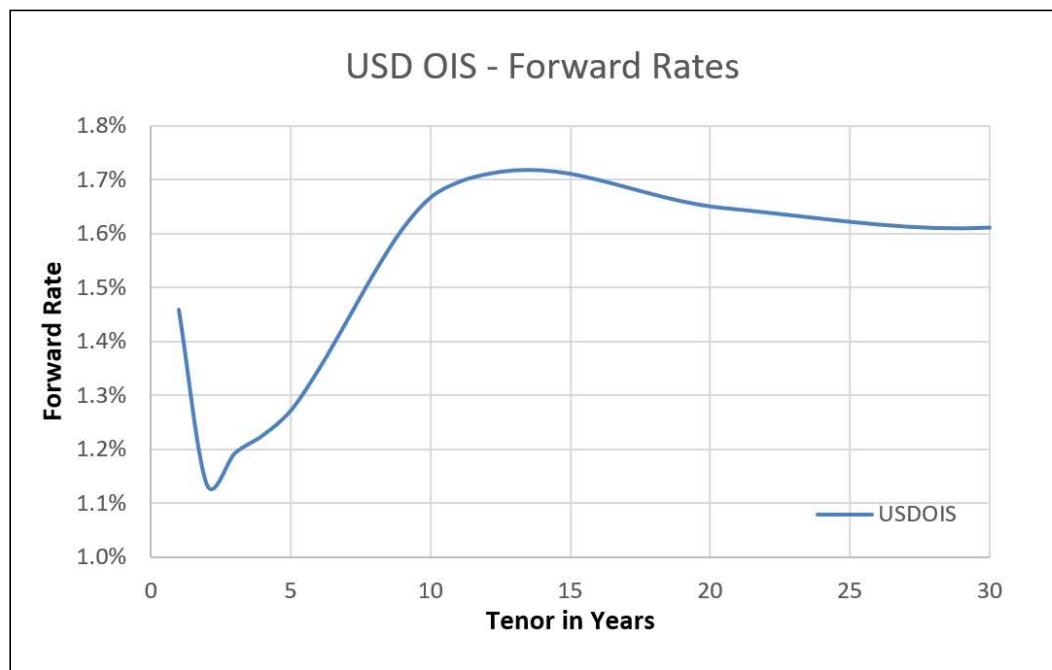


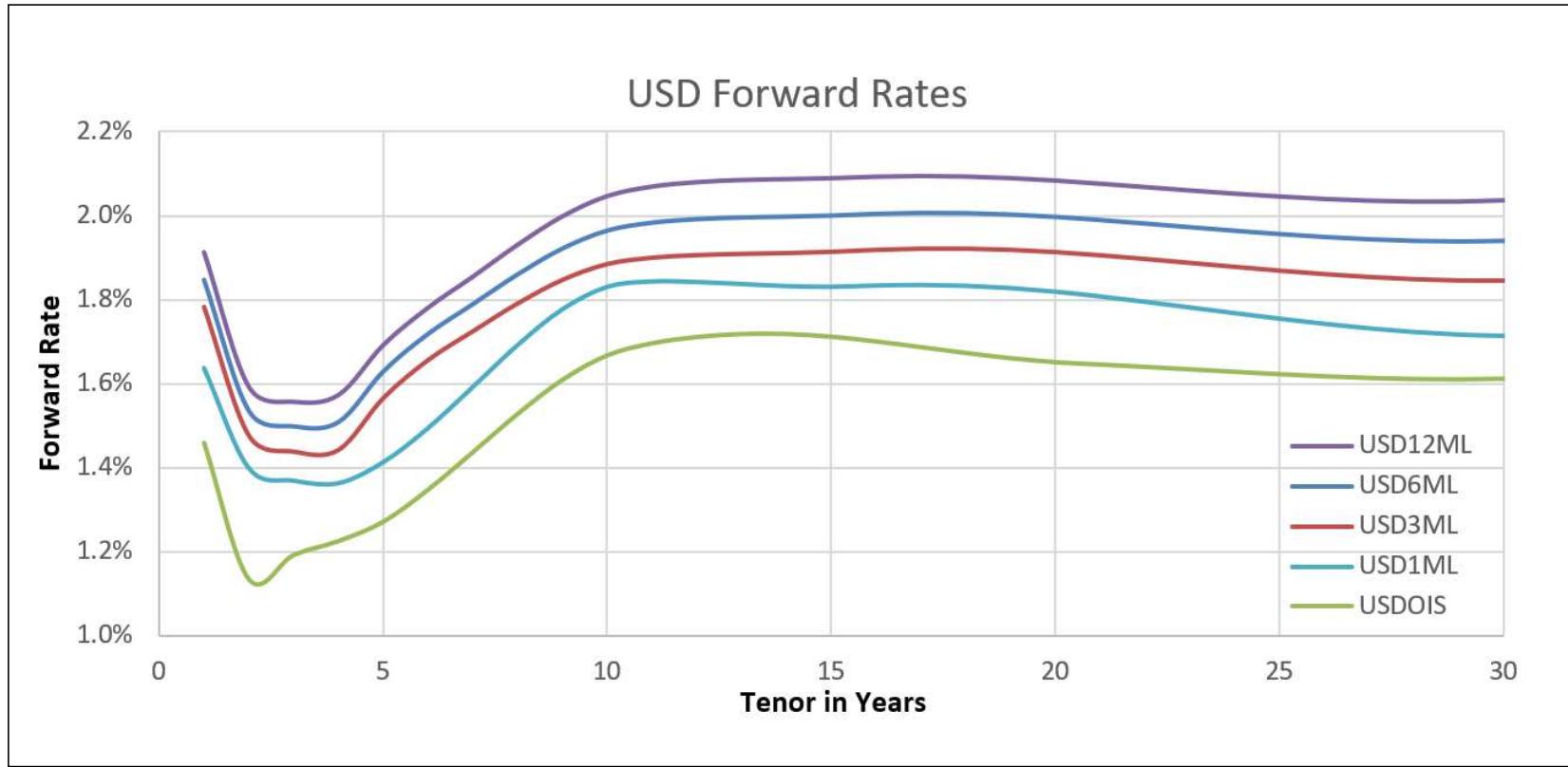
OIS Curve (1D)

Instrument	Tenor	Quote	Interpolation Style
Cash Deposit	1D	2.02480	Linear
OIS Swap	6M	7.73450	Spline
OIS Swap	1Y	1.59890	Spline
OIS Swap	18M	1.52050	Spline
OIS Swap	2Y	1.46050	Spline
LIBOR-OIS Basis Swap	3Y	0.27500	Spline
LIBOR-OIS Basis Swap	5Y	0.26625	Spline
LIBOR-OIS Basis Swap	7Y	0.26563	Spline
LIBOR-OIS Basis Swap	10Y	0.26063	Spline
LIBOR-OIS Basis Swap	15Y	0.25500	Spline
LIBOR-OIS Basis Swap	20Y	0.25375	Spline
LIBOR-OIS Basis Swap	30Y	0.25375	Spline
LIBOR-OIS Basis Swap	40Y	0.25375	Spline
LIBOR-OIS Basis Swap	50Y	0.25375	Spline

Swap Curve (USD3ML)

Instrument	Tenor	Quote	Interpolation Style
Cash Deposit	3M	2.13940	Linear
Future1	SEP-19	97.85500	Linear
Future2	DEC-19	97.97500	Linear
Future3	MAR-20	98.23500	Linear
Future4	JUN-20	98.33500	Linear
Future5	SEP-20	98.39500	Linear
Future6	DEC-20	98.38000	Linear
Future7	MAR-21	98.37500	Linear
Future8	JUN-21	98.37000	Linear
LIBOR Swap	5Y	1.65880	Spline
LIBOR Swap	7Y	1.67880	Spline
LIBOR Swap	10Y	1.74720	Spline
LIBOR Swap	15Y	1.84090	Spline
LIBOR Swap	20Y	1.89680	Spline
LIBOR Swap	30Y	1.92460	Spline
LIBOR Swap	40Y	1.92460	Spline
LIBOR Swap	50Y	1.92460	Spline





Multi-Dimensional Newton-Raphson Algorithm

$$X_{n+1} = X_n - J^{-1} f(X_n)$$

1.00E-08

RMSE

8.72E-12

USDOIS Discount Factors

Integrate USDOIS Forward Polynomial

Iteration: 4**Initial Guess**

Curve	Term	Time, t	X_{n+1}	X_n	X_0	$f(X_n)$	Epsilon
USDOIS	1Y	1.00	1.4359%	1.4359%	2.0000%	0.0000%	0.00E+00
USDOIS	2Y	2.00	1.2332%	1.2332%	2.0000%	0.0000%	2.69E-12
USDOIS	3Y	3.00	1.2511%	1.2511%	2.0000%	0.0000%	3.86E-12
USDOIS	4Y	4.00	1.2913%	1.2913%	2.0000%	0.0000%	1.00E-12
USDOIS	5Y	5.00	1.3978%	1.3978%	2.0000%	0.0000%	-3.89E-12
USD3ML	1Y	1.00	1.7090%	1.7090%	2.0000%	0.0000%	0.00E+00
USD3ML	2Y	2.00	1.4736%	1.4736%	2.0000%	0.0000%	3.13E-12
USD3ML	3Y	3.00	1.4953%	1.4953%	2.0000%	0.0000%	4.44E-12
USD3ML	4Y	4.00	1.5593%	1.5593%	2.0000%	0.0000%	5.28E-14
USD3ML	5Y	5.00	1.6300%	1.6300%	2.0000%	0.0000%	-2.89E-12

Time, t	DiscFactor	Integrand
1.00	0.98228	1.7878%
2.00	0.96958	3.0894%
3.00	0.95767	4.3251%
4.00	0.94557	5.5963%
5.00	0.93307	6.9271%

Update Solver



Iteration Results

Term	X ₀	X ₁	X ₂	X ₃	X ₄	X ₅	X ₆	X ₇	X ₈	X ₉	X ₁₀
1Y	2.0000%	1.4359%	1.4359%	1.4359%	1.4359%						
2Y	2.0000%	1.2325%	1.2332%	1.2332%	1.2332%						
3Y	2.0000%	1.2504%	1.2511%	1.2511%	1.2511%						
4Y	2.0000%	1.2911%	1.2913%	1.2913%	1.2913%						
5Y	2.0000%	1.3992%	1.3978%	1.3978%	1.3978%						
1Y	2.0000%	1.7090%	1.7090%	1.7090%	1.7090%						
2Y	2.0000%	1.4728%	1.4736%	1.4736%	1.4736%						
3Y	2.0000%	1.4946%	1.4953%	1.4953%	1.4953%						
4Y	2.0000%	1.5593%	1.5593%	1.5593%	1.5593%						
5Y	2.0000%	1.6310%	1.6300%	1.6300%	1.6300%						



Jacobian, dP/dL

	L_{1Y}^{OIS}	L_{2Y}^{OIS}	L_{3Y}^{OIS}	L_{4Y}^{OIS}	L_{5Y}^{OIS}	L_{1Y}^{IRS}	L_{2Y}^{IRS}	L_{3Y}^{IRS}	L_{4Y}^{IRS}	L_{5Y}^{IRS}
OIS_{1Y}	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OIS_{2Y}	0.50	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OIS_{3Y}	0.34	0.33	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OIS_{4Y}	0.25	0.25	0.25	0.25	0.00	0.00	0.00	0.00	0.00	0.00
OIS_{5Y}	0.21	0.20	0.20	0.20	0.19	0.00	0.00	0.00	0.00	0.00
IRS_{1Y}	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
IRS_{2Y}	0.00	0.00	0.00	0.00	0.00	0.50	0.50	0.00	0.00	0.00
IRS_{3Y}	0.00	0.00	0.00	0.00	0.00	0.34	0.33	0.33	0.00	0.00
IRS_{4Y}	0.00	0.00	0.00	0.00	0.00	0.25	0.25	0.25	0.25	0.00
IRS_{5Y}	0.00	0.00	0.00	0.00	0.00	0.21	0.20	0.20	0.20	0.19



Ultra-Fast Yield Curves using Inverse Jacobian

$$L_{\text{NEW}} = L_{\text{OLD}} + dL$$

New Fwds Chg in Mkt Data Inverse Jacobian, J^{-1} (or dL/dP)

L_{NEW}	$dP (\%)$	L_{NEW}	OIS_{1Y}	OIS_{2Y}	OIS_{3Y}	OIS_{4Y}	OIS_{5Y}	IRS_{1Y}	IRS_{2Y}	IRS_{3Y}	IRS_{4Y}	IRS_{5Y}
L_{1Y}^{OIS} 1.44591%	OIS_{1Y} 0.0100%	L_{1Y}^{OIS}	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L_{2Y}^{OIS} 1.24323%	OIS_{2Y} 0.0100%	L_{2Y}^{OIS}	-1.01	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L_{3Y}^{OIS} 1.26107%	OIS_{3Y} 0.0100%	L_{3Y}^{OIS}	0.00	-2.04	3.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L_{4Y}^{OIS} 1.30130%	OIS_{4Y} 0.0100%	L_{4Y}^{OIS}	0.00	0.00	-3.08	4.08	0.00	0.00	0.00	0.00	0.00	0.00
L_{5Y}^{OIS} 1.40782%	OIS_{5Y} 0.0100%	L_{5Y}^{OIS}	0.00	0.00	0.00	-4.13	5.13	0.00	0.00	0.00	0.00	0.00
L_{1Y}^{IRS} 1.71896%	IRS_{1Y} 0.0100%	L_{1Y}^{IRS}	0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
L_{2Y}^{IRS} 1.48359%	IRS_{2Y} 0.0100%	L_{2Y}^{IRS}	0.00	0.00	0.00	0.00	0.00	-1.01	2.01	0.00	0.00	0.00
L_{3Y}^{IRS} 1.50531%	IRS_{3Y} 0.0100%	L_{3Y}^{IRS}	0.00	0.00	0.00	0.00	0.00	0.00	-2.04	3.04	0.00	0.00
L_{4Y}^{IRS} 1.56934%	IRS_{4Y} 0.0100%	L_{4Y}^{IRS}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3.08	4.08	0.00
L_{5Y}^{IRS} 1.63999%	IRS_{5Y} 0.0100%	L_{5Y}^{IRS}	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.13	5.13

Use Jacobian to Imply Change in Forward Rates

$$\text{Change in Forwards} = J^{-1} \cdot dP = (dL/dP) \cdot dP = dL$$



New Fwds From Calibration			New Fwds From Jacobian			Inverse Jacobian, J^{-1} (or dL/dP)									
	L_{NEW}	$+/-$		L_{NEW}		OIS_{1Y}	OIS_{2Y}	OIS_{3Y}	OIS_{4Y}	OIS_{5Y}	IRS_{1Y}	IRS_{2Y}	IRS_{3Y}	IRS_{4Y}	IRS_{5Y}
L_{1Y}^{OIS}	1.44591%	0.0000%	L_{1Y}^{OIS}	1.4459%		1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L_{2Y}^{OIS}	1.24322%	0.0000%	L_{2Y}^{OIS}	1.2432%		-1.01	2.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L_{3Y}^{OIS}	1.26107%	0.0000%	L_{3Y}^{OIS}	1.2611%		0.00	-2.04	3.04	0.00	0.00	0.00	0.00	0.00	0.00	0.00
L_{4Y}^{OIS}	1.30130%	0.0000%	L_{4Y}^{OIS}	1.3013%		0.00	0.00	-3.08	4.08	0.00	0.00	0.00	0.00	0.00	0.00
L_{5Y}^{OIS}	1.40784%	0.0000%	L_{5Y}^{OIS}	1.4078%		0.00	0.00	0.00	-4.13	5.13	0.00	0.00	0.00	0.00	0.00
L_{1Y}^{IRS}	1.71896%	0.0000%	L_{1Y}^{IRS}	1.7190%		0.00	0.00	0.00	0.00	0.00	1.00	0.00	0.00	0.00	0.00
L_{2Y}^{IRS}	1.48358%	0.0000%	L_{2Y}^{IRS}	1.4836%		0.00	0.00	0.00	0.00	0.00	-1.01	2.01	0.00	0.00	0.00
L_{3Y}^{IRS}	1.50530%	0.0000%	L_{3Y}^{IRS}	1.5053%		0.00	0.00	0.00	0.00	0.00	0.00	-2.04	3.04	0.00	0.00
L_{4Y}^{IRS}	1.56934%	0.0000%	L_{4Y}^{IRS}	1.5693%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	-3.08	4.08	0.00
L_{5Y}^{IRS}	1.64000%	0.0000%	L_{5Y}^{IRS}	1.6400%		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-4.13	5.13



Inverse Curve Jacobian, $J = dL/dP$

Change in Libor rate per unit change in market par rates

	dP_{1Y}^{IRS}	dP_{2Y}^{IRS}	dP_{3Y}^{IRS}	dP_{4Y}^{IRS}	dP_{5Y}^{IRS}
dL_{1Y}^{IRS}	1.00	0.00	0.00	0.00	0.00
dL_{2Y}^{IRS}	-1.01	2.01	0.00	0.00	0.00
dL_{3Y}^{IRS}	0.00	-2.04	3.04	0.00	0.00
dL_{4Y}^{IRS}	0.00	0.00	-3.08	4.08	0.00
dL_{5Y}^{IRS}	0.00	0.00	0.00	-4.13	5.13

Shift Size, dP

Change in market par rates

	Shift, Bp	Shift, %
dP_{1Y}^{IRS}	1.00	0.01%
dP_{2Y}^{IRS}	1.00	0.01%
dP_{3Y}^{IRS}	1.00	0.01%
dP_{4Y}^{IRS}	1.00	0.01%
dP_{5Y}^{IRS}	1.00	0.01%

Swap Jacobian, dS/dL

Change in swap value per unit change in Libor Rate

	dL_{1Y}	dL_{2Y}	dL_{3Y}	dL_{4Y}	dL_{5Y}
dS_{1Y}^{IRS}	98	0	0	0	0
dS_{2Y}^{IRS}	98	97	0	0	0
dS_{3Y}^{IRS}	98	97	96	0	0
dS_{4Y}^{IRS}	98	97	96	95	0
dS_{5Y}^{IRS}	98	97	96	95	93
$dS_{4Y,5Y}^{IRS}$	0	0	0	0	93
$dS_{4.5Y}^{IRS}$	98	97	96	95	47

Risk, $dS/dP = dS/dL \times dL/dP$

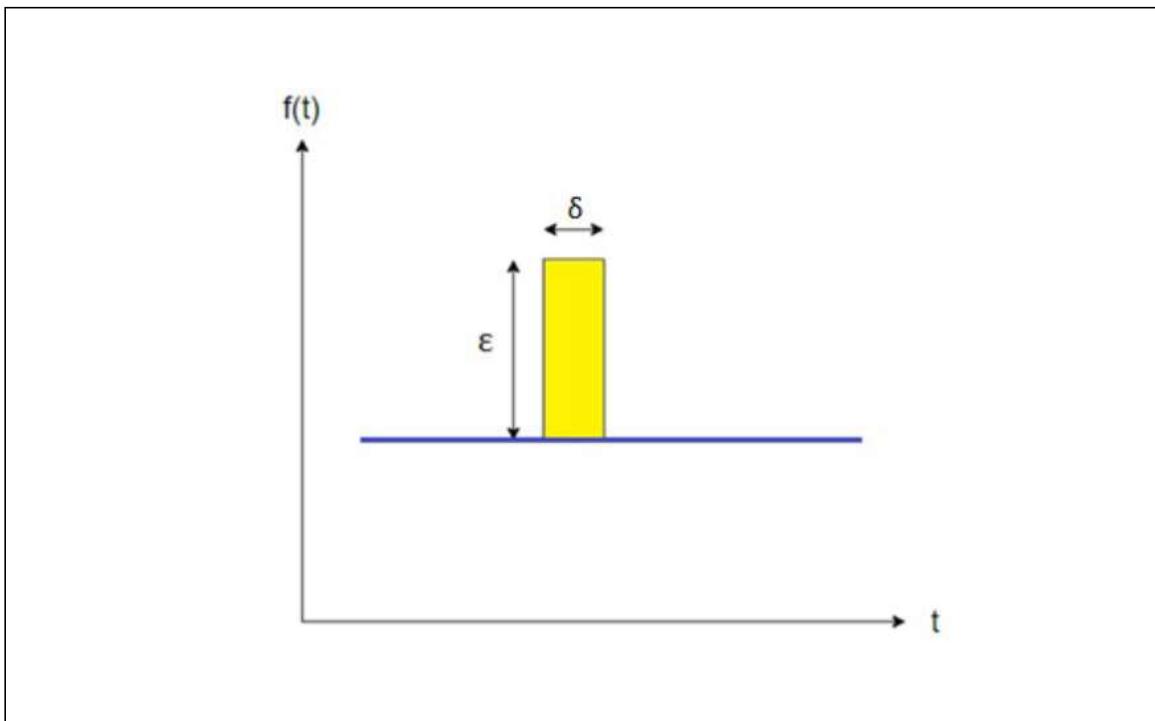
Change in swap value per unit change in market par rates

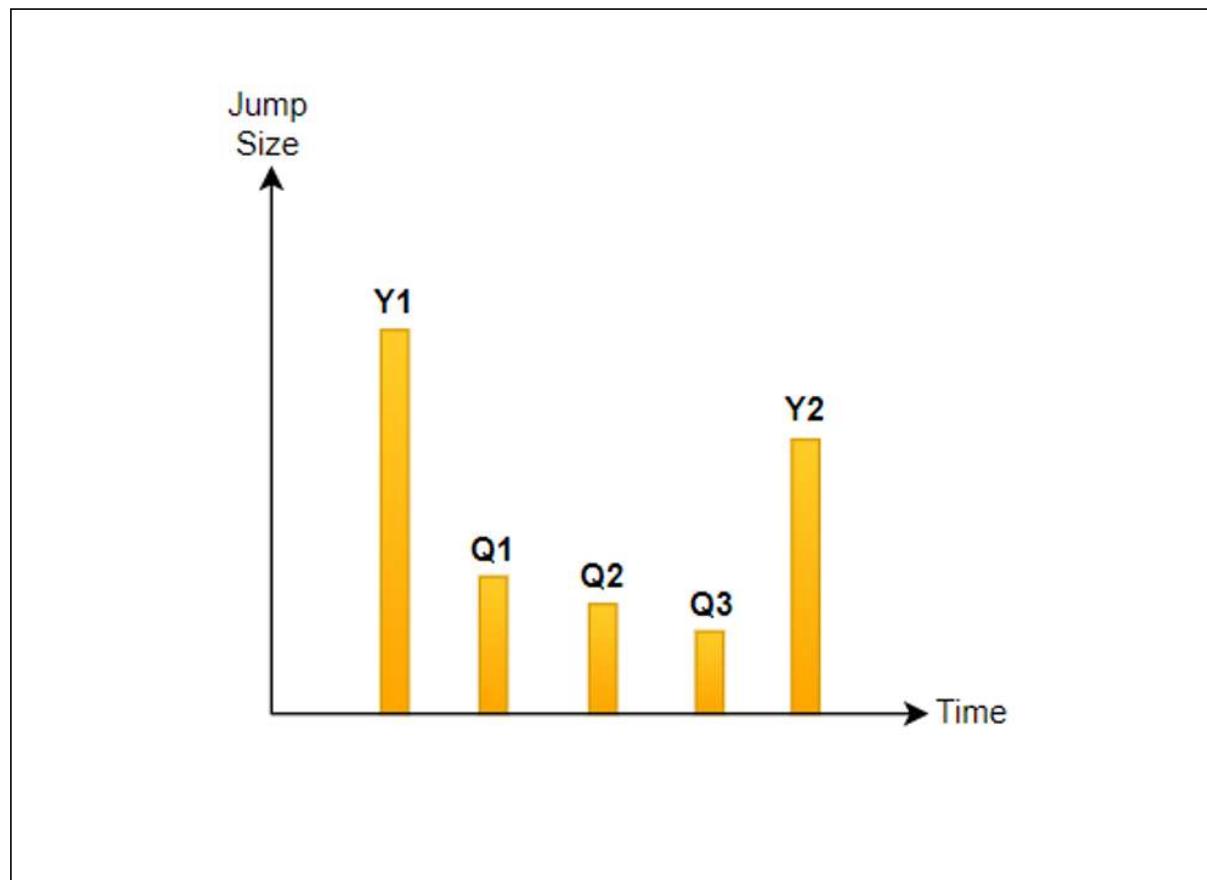
	dP_{1Y}^{IRS}	dP_{2Y}^{IRS}	dP_{3Y}^{IRS}	dP_{4Y}^{IRS}	dP_{5Y}^{IRS}	Total
dS_{1Y}^{IRS}	98	0	0	0	0	98 IRS(1Y)
dS_{2Y}^{IRS}	0	195	0	0	0	195 IRS(2Y)
dS_{3Y}^{IRS}	0	0	291	0	0	291 IRS(3Y)
dS_{4Y}^{IRS}	0	0	0	386	0	386 IRS(4Y)
dS_{5Y}^{IRS}	0	0	0	0	479	479 IRS(5Y)
$dS_{4Y,5Y}^{IRS}$	0	0	0	-386	479	93 Forward IRS(4Y,5Y)
$dS_{4.5Y}^{IRS}$	0	0	0	193	239	432 IRS(4.5Y)

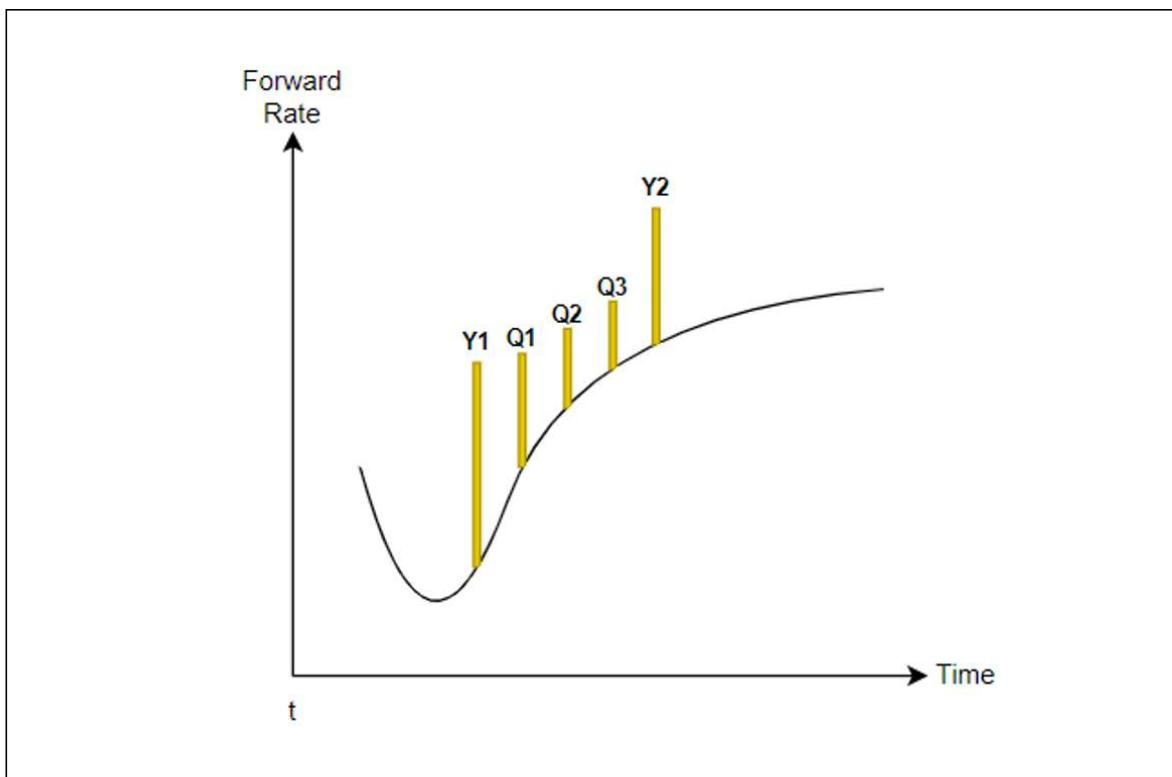
$$\text{Swap Delta} = \frac{dS}{dP} = \frac{dS}{dL} \cdot \frac{dL}{dP} \times \text{Shift Size}$$

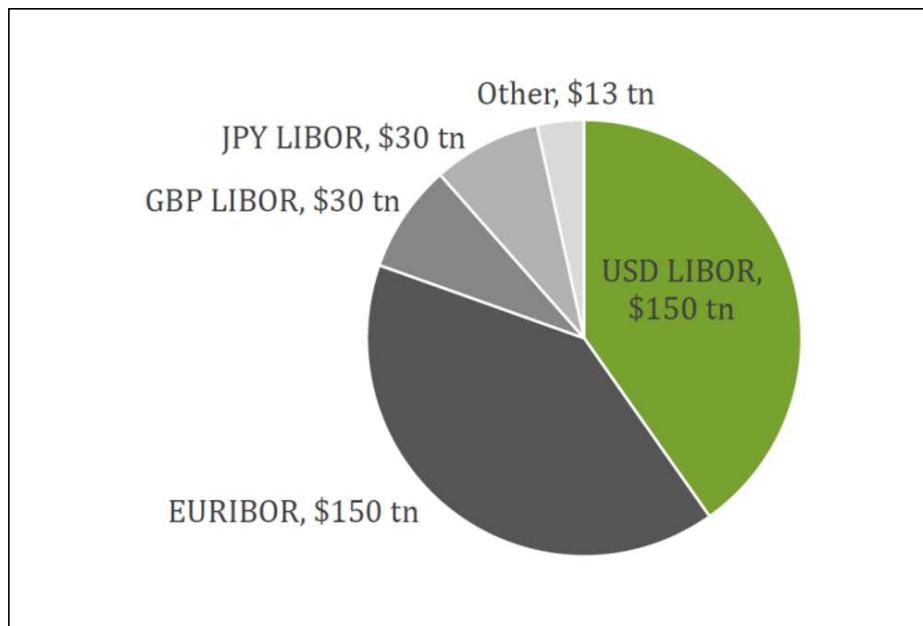


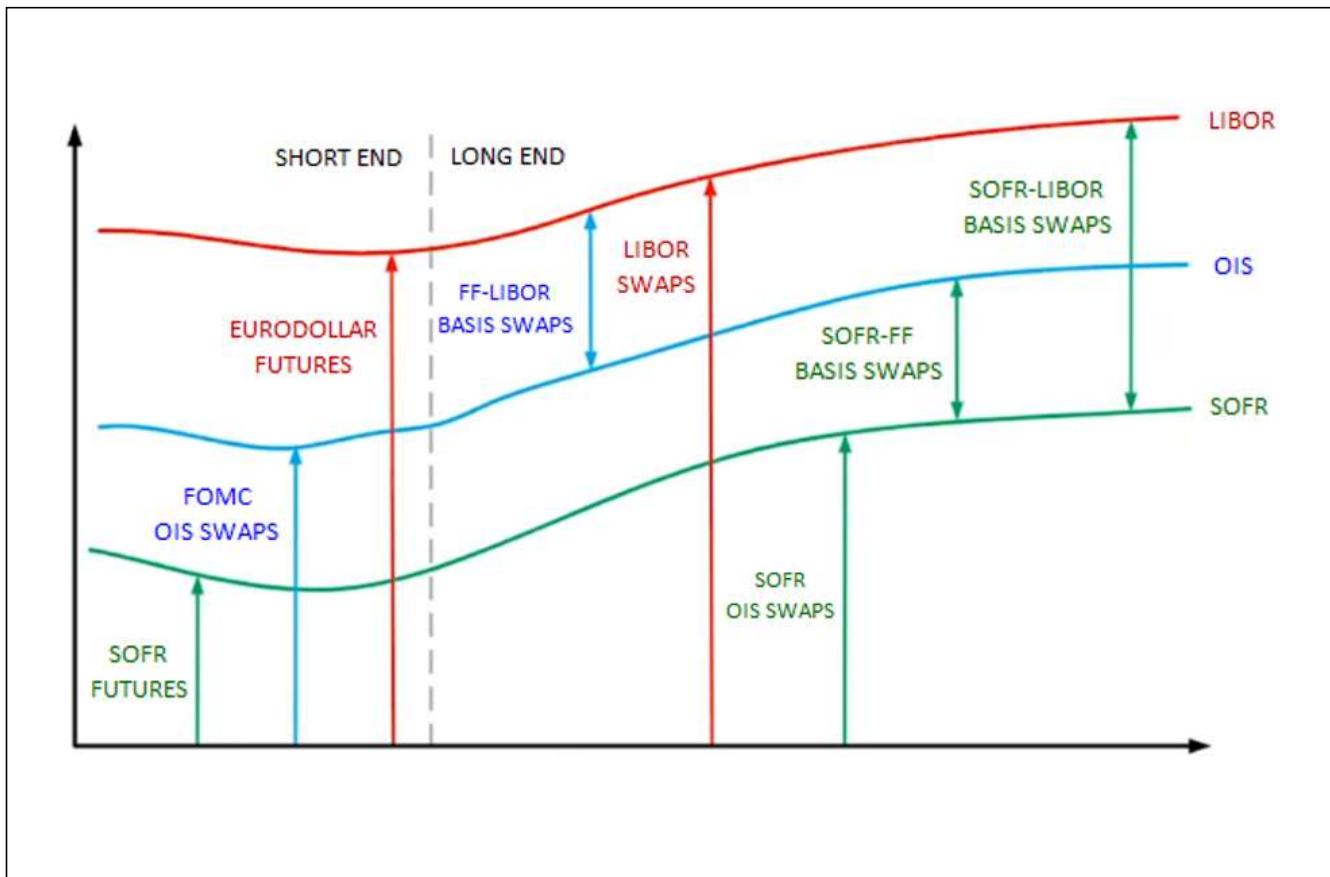
Instrument	Maturity	Quote	Interpolation Style
Cash Deposit	1D	2.12000	Linear
Future 1M	1M	97.78734	Linear
Future 1M	2M	98.14013	Linear
Future 1M	3M	98.42061	Linear
Future 1M	4M	98.61140	Linear
Future 3M	6M	98.69700	Linear
Future 3M	9M	98.79400	Linear
Future 3M	12M	98.84100	Linear
Future 3M	15M	98.81700	Linear
Future 3M	18M	98.02500	Linear
SOFR Swap	3Y	1.22559	Spline
SOFR Swap	5Y	1.20502	Spline
SOFR Swap	7Y	1.23028	Spline
SOFR Swap	10Y	1.29071	Spline
SOFR Swap	15Y	1.36849	Spline
SOFR Swap	20Y	1.41102	Spline
SOFR Swap	30Y	1.42135	Spline
SOFR Swap	40Y	1.40063	Spline
SOFR Swap	50Y	1.36656	Spline



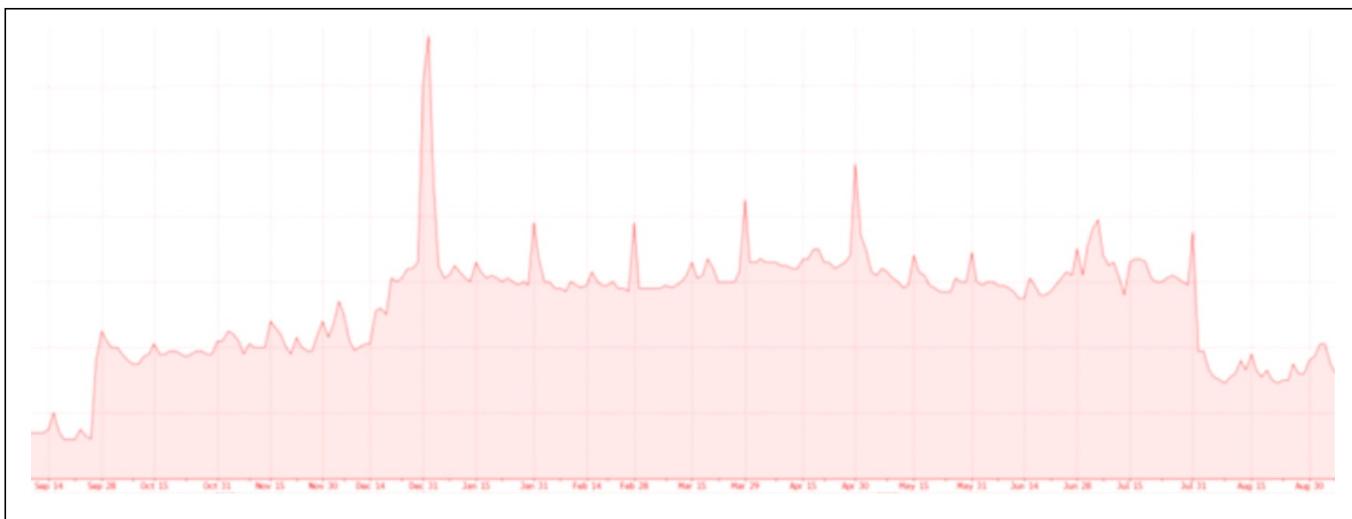




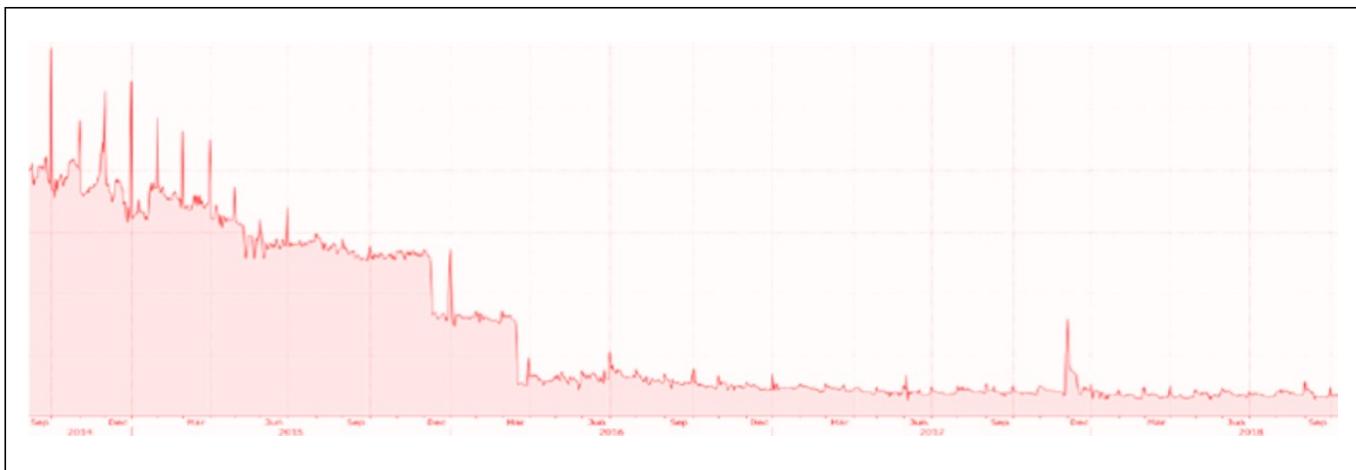




Instrument	Maturity	Quote	Interpolation Style
Cash Deposit	0.00	2.12000	Linear
Monetary Policy SOFR Swap	1M	2.21266	Piecewise-Constant with Jumps
Monetary Policy SOFR Swap	2M	1.85987	Piecewise-Constant with Jumps
Monetary Policy SOFR Swap	3M	1.57939	Piecewise-Constant with Jumps
Monetary Policy SOFR Swap	4M	1.38860	Piecewise-Constant with Jumps
Future 3M	6M	98.69700	Linear
Future 3M	9M	98.79400	Linear
Future 3M	12M	98.84100	Linear
Future 3M	15M	98.81700	Linear
Future 3M	18M	98.02500	Linear
SOFR Swap	3Y	1.22559	Spline
SOFR Swap	5Y	1.20502	Spline
SOFR Swap	7Y	1.23028	Spline
SOFR-OIS Basis Swap	10Y	0.01000	Spline
SOFR-OIS Basis Swap	15Y	0.02500	Spline
SOFR-OIS Basis Swap	20Y	0.05000	Spline
SOFR-LIBOR Basis Swap	30Y	0.07500	Spline
SOFR-LIBOR Basis Swap	40Y	0.08000	Spline
SOFR-LIBOR Basis Swap	50Y	0.10000	Spline







Chapter 5 – Interest Rate Risk

Trade Template			USD IRS 5% USD3ML 5Y	
Swap	LEG1:FIXED		LEG2:FLOAT	
	Pay / Receive	RECEIVE	PAY	
	Notional	1,000,000	1,000,000	
	Currency	USD	USD	
	Effective Date	2D Tue, 25-Aug-2015	2D Tue, 25-Aug-2015	
	Maturity Date	5Y Tue, 25-Aug-2020	5Y Tue, 25-Aug-2020	
	Fixed Rate (%)	5.000000%		
	Float Index		3M USD3ML	
	Float Spread (bps)		0.000	
	Reset Frequency		QUARTERLY	
Pay Frequency	SEMI-ANNUAL		QUARTERLY	
Day Count	30/360		ACT/360	
Market				
Curve Date	Fri, 21-Aug-2015		Fri, 21-Aug-2015	
Forecast Curve			USD3ML	
Discount Curve	USDOIS		USDOIS	
Valuation Results				
Valuation Date	Fri, 21-Aug-2015			
Par Rate	1.548250%			
NPV	167,892.11			
PV01	486.40			
DV01	532.42			

EffectiveLag	Maturity	SwapTemplate	FixedLeg	Notional	FixedRate	FloatSpread
2D	1Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.89350%	0.00
2D	2Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.68360%	0.00
2D	3Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.62600%	0.00
2D	4Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.61700%	0.00
2D	5Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.64200%	0.00
2D	6Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.67900%	0.00
2D	7Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.71600%	0.00
2D	8Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.75700%	0.00
2D	9Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.79800%	0.00
2D	10Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.83200%	0.00
2D	15Y	USD_SOFR_SWAP:0	PAY	1,000,000	1.96800%	0.00
2D	20Y	USD_SOFR_SWAP:0	PAY	1,000,000	2.03300%	0.00
2D	25Y	USD_SOFR_SWAP:0	PAY	1,000,000	2.04100%	0.00
2D	30Y	USD_SOFR_SWAP:0	PAY	1,000,000	2.04900%	0.00

Swap	YieldCurve	PV	ParRate	PV01	DV01
USD_SOFR_SWAP_1Y:0	USDYC_SOFR	0.00	1.8935%	99	99
USD_SOFR_SWAP_2Y:0	USDYC_SOFR	0.00	1.6836%	198	198
USD_SOFR_SWAP_3Y:0	USDYC_SOFR	0.00	1.6260%	294	294
USD_SOFR_SWAP_4Y:0	USDYC_SOFR	0.00	1.6170%	389	389
USD_SOFR_SWAP_5Y:0	USDYC_SOFR	0.00	1.6420%	482	482
USD_SOFR_SWAP_6Y:0	USDYC_SOFR	0.00	1.6790%	574	574
USD_SOFR_SWAP_7Y:0	USDYC_SOFR	0.00	1.7160%	665	665
USD_SOFR_SWAP_8Y:0	USDYC_SOFR	0.00	1.7570%	752	752
USD_SOFR_SWAP_9Y:0	USDYC_SOFR	0.00	1.7980%	838	838
USD_SOFR_SWAP_10Y:0	USDYC_SOFR	0.00	1.8320%	922	922
USD_SOFR_SWAP_15Y:0	USDYC_SOFR	0.00	1.9680%	1,315	1,315
USD_SOFR_SWAP_20Y:0	USDYC_SOFR	0.00	2.0330%	1,664	1,664
USD_SOFR_SWAP_25Y:0	USDYC_SOFR	0.00	2.0410%	1,977	1,977
USD_SOFR_SWAP_30Y:0	USDYC_SOFR	0.00	2.0490%	2,259	2,259
			Total Risk	12,428	12,428

USD SOFR YIELD CURVE - CALIBRATION INSTRUMENTS

Instrument	Term	Rate
USD SOFR Swap	ON	2.37000%
USD SOFR Swap	1W	2.36510%
USD SOFR Swap	2W	2.34960%
USD SOFR Swap	3W	2.35200%
USD SOFR Swap	1M	2.34550%
USD SOFR Swap	2M	2.30320%
USD SOFR Swap	3M	2.25590%
USD SOFR Swap	4M	2.19610%
USD SOFR Swap	5M	2.14750%
USD SOFR Swap	6M	2.10350%
USD SOFR Swap	1Y	1.89350%
USD SOFR Swap	2Y	1.68360%
USD SOFR Swap	3Y	1.62600%
USD SOFR Swap	4Y	1.61700%
USD SOFR Swap	5Y	1.64200%
USD SOFR Swap	6Y	1.67900%
USD SOFR Swap	7Y	1.71600%
USD SOFR Swap	8Y	1.75700%
USD SOFR Swap	9Y	1.79800%
USD SOFR Swap	10Y	1.83200%
USD SOFR Swap	15Y	1.96800%
USD SOFR Swap	20Y	2.03300%
USD SOFR Swap	25Y	2.04100%
USD SOFR Swap	30Y	2.04900%

Bucketed DV01, USD

Instrument	Tenor	DV01
USD SOFR Swap	ON	8
USD SOFR Swap	1W	0
USD SOFR Swap	2W	0
USD SOFR Swap	3W	0
USD SOFR Swap	1M	0
USD SOFR Swap	2M	0
USD SOFR Swap	3M	0
USD SOFR Swap	4M	0
USD SOFR Swap	5M	-1
USD SOFR Swap	6M	1
USD SOFR Swap	1Y	92
USD SOFR Swap	2Y	213
USD SOFR Swap	3Y	294
USD SOFR Swap	4Y	409
USD SOFR Swap	5Y	453
USD SOFR Swap	6Y	541
USD SOFR Swap	7Y	723
USD SOFR Swap	8Y	736
USD SOFR Swap	9Y	852
USD SOFR Swap	10Y	892
USD SOFR Swap	15Y	1,320
USD SOFR Swap	20Y	1,662
USD SOFR Swap	25Y	1,979
USD SOFR Swap	30Y	2,252
Total Risk		12,428

Pricing Jacobian - Single Trade

Trade	OIS Rates (Discount Risk)					LIBOR Rates (Forward Risk)				
	dO _{1Y}	dO _{2Y}	dO _{3Y}	dO _{4Y}	dO _{5Y}	dL _{1Y}	dL _{2Y}	dL _{3Y}	dL _{4Y}	dL _{5Y}
dS _{3Y} ^{IRS}	0	0	0	0	0	98	97	96	0	0

Pricing Jacobian - Trade Portfolio

Trade	OIS Rates (Discount Risk)					LIBOR Rates (Forward Risk)				
	dO _{1Y}	dO _{2Y}	dO _{3Y}	dO _{4Y}	dO _{5Y}	dL _{1Y}	dL _{2Y}	dL _{3Y}	dL _{4Y}	dL _{5Y}
dS _{1Y} ^{IRS}	0	0	0	0	0	98	0	0	0	0
dS _{2Y} ^{IRS}	0	0	0	0	0	98	97	0	0	0
dS _{3Y} ^{IRS}	0	0	0	0	0	98	97	96	0	0
dS _{4Y} ^{IRS}	0	0	0	0	0	98	97	96	95	0
dS _{5Y} ^{IRS}	0	0	0	0	0	98	97	96	95	93
dS _{4Y,5Y} ^{IRS}	0	0	0	0	0	0	0	0	0	93
dS _{4.5Y} ^{IRS}	0	0	0	0	0	98	97	96	95	47



		Curve Jacobian									
		OIS Curve Instruments					Swap Curve Instruments				
		dP_{1Y}^{OIS}	dP_{2Y}^{OIS}	dP_{3Y}^{OIS}	dP_{4Y}^{OIS}	dP_{5Y}^{OIS}	dP_{1Y}^{IRS}	dP_{2Y}^{IRS}	dP_{3Y}^{IRS}	dP_{4Y}^{IRS}	dP_{5Y}^{IRS}
OIS and LIBOR Forward Rates	dO_{1Y}	1.00	0	0	0	0	0	0	0	0	0
	dO_{2Y}	-1.01	2.01	0	0	0	0	0	0	0	0
	dO_{3Y}	0.00	-2.04	3.04	0	0	0	0	0	0	0
	dO_{4Y}	0.00	0.00	-3.08	4.08	0	0	0	0	0	0
	dO_{5Y}	0.00	0.00	0.00	-4.13	5.13	0	0	0	0	0
	dL_{1Y}	0	0	0	0	0	1.00	0	0	0	0
	dL_{2Y}	0	0	0	0	0	-1.01	2.01	0	0	0
	dL_{3Y}	0	0	0	0	0	0.00	-2.04	3.04	0	0
	dL_{4Y}	0	0	0	0	0	0.00	0.00	-3.08	4.08	0
	dL_{5Y}	0	0	0	0	0	0.00	0.00	0.00	-4.13	5.13



Trade DV01

Risk Bucket	IRS 1Y	IRS 2Y	IRS 3Y	IRS 4Y	IRS 5Y	IRS(4Y, 5Y)	IRS(4.5Y)
OIS 1Y	0	0	0	0	0	0	0
OIS 2Y	0	0	0	0	0	0	0
OIS 3Y	0	0	0	0	0	0	0
OIS 4Y	0	-1	-1	-1	0	0	0
OIS 5Y	0	1	1	1	0	0	0
IRS 1Y	98	0	0	0	0	0	0
IRS 2Y	0	195	0	0	0	0	0
IRS 3Y	0	0	291	0	0	0	0
IRS 4Y	0	0	0	386	0	-386	193
IRS 5Y	0	0	0	0	479	479	239

Total Trade DV01

IRS 1Y	IRS 2Y	IRS 3Y	IRS 4Y	IRS 5Y	IRS(4Y, 5Y)	IRS(4.5Y)
98	195	291	386	479	93	432



Risk Bucket	Total Risk	Hedge	Qty
OIS 1Y	0	OIS 1Y	-
OIS 2Y	0	OIS 2Y	-
OIS 3Y	0	OIS 3Y	-
OIS 4Y	-2	OIS 4Y	-
OIS 5Y	2	OIS 5Y	-
IRS 1Y	98	IRS 1Y	-1.00
IRS 2Y	195	IRS 2Y	-1.00
IRS 3Y	291	IRS 3Y	-1.00
IRS 4Y	193	IRS 4Y	-0.50
IRS 5Y	1,197	IRS 5Y	-2.50

Portfolio DV01
1,975



Forwards	Calibration Instruments							
	dP_{1Y}^{OIS}	dP_{2Y}^{OIS}	dP_{4Y}^{OIS}	dP_{5Y}^{OIS}	dP_{1Y}^{IRS}	dP_{2Y}^{IRS}	dP_{4Y}^{IRS}	dP_{5Y}^{IRS}
dO_{1Y}	1.00	0	0	0	0	0	0	0
dO_{2Y}	-1.01	2.01	0	0	0	0	0	0
dO_{4Y}	0.34	-2.05	2.71	0	0	0	0	0
dO_{5Y}	0.00	0.00	-4.13	5.13	0	0	0	0
dL_{1Y}	0	0	0	0	1.00	0	0	0
dL_{2Y}	0	0	0	0	-1.01	2.01	0	0
dL_{4Y}	0	0	0	0	0.34	-2.05	2.71	0
dL_{5Y}	0	0	0	0	0.00	0.00	-4.13	5.13



Pricing Jacobian								
	OIS Rates (Discount Risk)				LIBOR Rates (Forward Risk)			
	dO_{1Y}	dO_{2Y}	dO_{4Y}	dO_{5Y}	dL_{1Y}	dL_{2Y}	dL_{4Y}	dL_{5Y}
dS_{1Y}^{IRS}	0	0	0	0	98	0	0	0
dS_{2Y}^{IRS}	0	0	0	0	98	97	0	0
dS_{3Y}^{IRS}	0	0	0	0	98	145	48	0
dS_{4Y}^{IRS}	0	0	0	0	98	145	142	0
dS_{5Y}^{IRS}	0	0	0	0	98	145	142	93
$dS_{4Y,5Y}^{IRS}$	0	0	0	0	0	0	0	93
$dS_{4,5Y}^{IRS}$	0	0	0	0	98	145	142	47



Bucketed Trade DV01 Risk

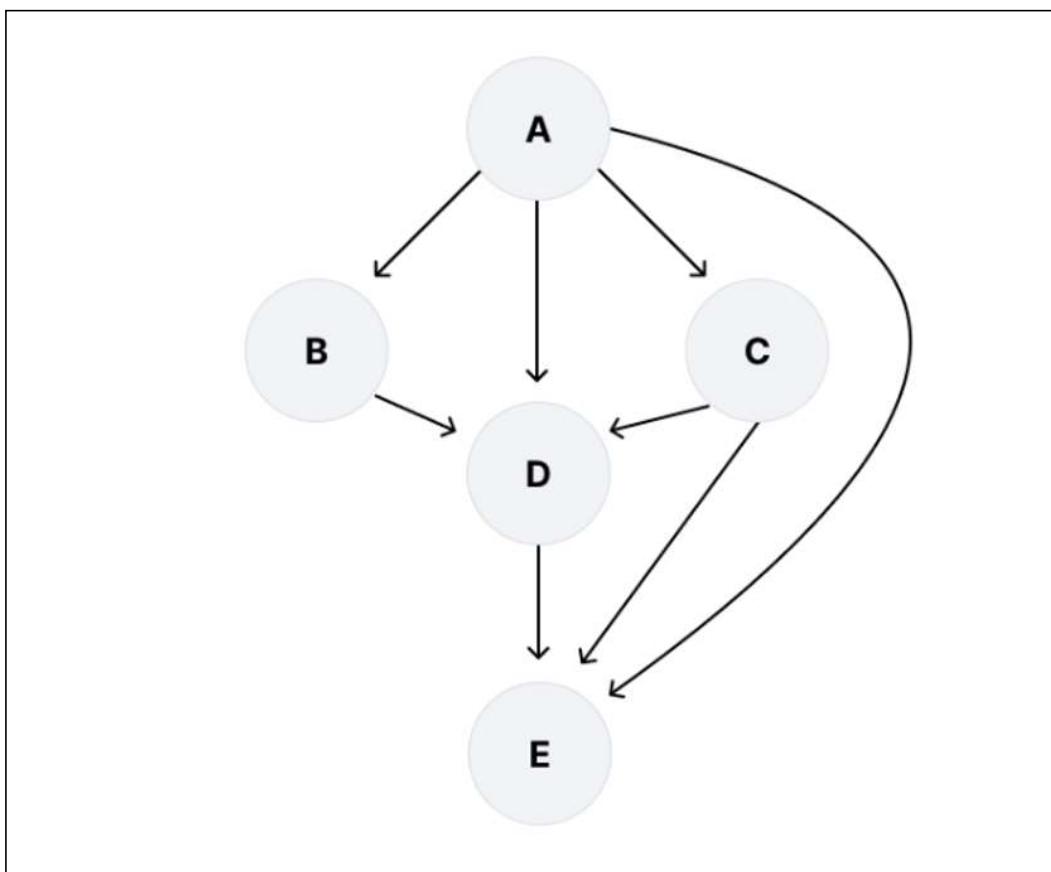
Risk Bucket	IRS 1Y #	IRS 2Y #	IRS 3Y	IRS 4Y #	IRS 5Y #	IRS(4Y, 5Y)	IRS(4.5Y)
OIS 1Y	0	0	0	0	0	0	0
OIS 2Y	0	0	0	0	0	0	0
OIS 4Y	0	-1	-1	-1	0	0	0
OIS 5Y	0	1	1	1	0	0	0
IRS 1Y	98	0	-32	0	0	0	0
IRS 2Y	0	195	194	0	0	0	0
IRS 4Y	0	0	130	386	0	-386	193
IRS 5Y	0	0	0	0	479	479	239

Total Trade DV01

IRS 1Y #	IRS 2Y #	IRS 3Y	IRS 4Y #	IRS 5Y #	IRS(4Y, 5Y)	IRS(4.5Y)
98	195	291	386	479	93	432



Risk Bucket	Risk Total	Hedge	Qty
OIS 1Y	0	OIS 1Y	-
OIS 2Y	0	OIS 2Y	-
OIS 4Y	-2	OIS 4Y	-
OIS 5Y	2	OIS 5Y	-
IRS 1Y	66	IRS 1Y	-0.7
IRS 2Y	389	IRS 2Y	-2.0
IRS 4Y	322	IRS 4Y	-0.8
IRS 5Y	1,197	IRS 5Y	-2.5
Total DV01			
1,975			



```
01 double function( double x1, double x2 )
02 {
03     double a = x1*x1;           // Step 1:     $a = x_1^2$ 
04     double b = 2*a;            // Step 2:     $b = 2x_1^2$ 
05     double c = x2;             // Step 3:     $c = x_2$ 
06     double d = 3*c;            // Step 4:     $d = 3x_2$ 
07     double f = b + d;          // Step 5:     $f = 2x_1^2 + 3x_2$ 
08     return f;
09 }
```



```

01 double tangent( double x1, double x2, double x1_dot, double x2_dot )
02 {
03     double a = x1*x1;           // Step 1:    $a = x_1^2$ 
04     double a_dot = 2*x1*x1_dot; // Tangent:   $\dot{a} = 2x_1 \cdot \dot{x}_1$        $\dot{a} = 2x_1$ 
05     double b = 2*a;           // Step 2:    $b = a$ 
06     double b_dot = 2*a_dot;   // Tangent:   $\dot{b} = 2 \cdot \dot{a}$          $\dot{b} = 4x_1$ 
07     double c = x2;           // Step 3:    $c = x_2$ 
08     double c_dot = x2_dot;   // Tangent:   $\dot{c} = \dot{x}_2$            $\dot{c} = 1$ 
09     double d = 3*c;           // Step 4:    $d = 3c$ 
10     double d_dot = 3*c_dot;  // Tangent:   $\dot{d} = 3 \cdot \dot{c}$         $\dot{d} = 3$ 
11     double f = b + d;         // Step 5:    $f = 2x_1^2 + 3x_2$ 
12     double f_dot = b_dot + d_dot; // Tangent:  $\dot{f} = \dot{b} + \dot{d}$ 
13     return f_dot;            // Result:    $\dot{f} = 4x_1 + 3$ 
14 }
```



```
01  tangent(2.0, 3.0, 1.0, 0.0);      // Input: x1 = 2, x2 = 3, x1_d = 1, x2_d = 0      Output: 8
02  tangent(2.0, 3.0, 0.0, 1.0);      // Input: x1 = 2, x2 = 3, x1_d = 0, x2_d = 1      Output: 3
```



```

01 void adjoint( double x1, double x2, double f_bar )
02 {
03     // Forward Sweep
04     double a = x1*x1;           // Step 1:    $a = x_1^2$ 
05     double b = 2*a;            // Step 2:    $b = 2x_1^2$ 
06     double c = x2;             // Step 3:    $c = x_2$ 
07     double d = 3*c;            // Step 4:    $d = 3x_2$ 
08     double f = b + d;          // Step 5:    $f = 2x_1^2 + 3x_2$ 
09
10    // Back Propagation
11    double b_bar = f_bar;       // Step 5:    $b_{\bar{}} = 1$       from input variable
12    double d_bar = f_bar;       // Step 5:    $d_{\bar{}} = 1$       from input variable
13    double c_bar = 3*d_bar;     // Step 4:    $c_{\bar{}} = 3$ 
14    double x2_bar = c_bar;      // Step 3:    $x2_{\bar{}} = 3$        $df/dx_2 = 3$ 
15    double a_bar = 2*b_bar;     // Step 2:    $a_{\bar{}} = 2$ 
16    double x1_bar = 2*x1*a_bar; // Step 1:    $x1_{\bar{}} = 4x_1$      $df/dx_1 = 4x_1$ 
17
18    std::cout << "df/dx1: " << x1_bar << std::endl;           //  $\bar{x}_1 = df/dx_1 = 4x_1$ 
19    std::cout << "df/dx2: " << x2_bar << std::endl;           //  $\bar{x}_2 = df/dx_2 = 3$ 
20 }

```



```
01     adjoint(2.0, 3.0, 1.0); // Input: x1 = 3, x2 = 2, f_bar  Output: df/dx1=8 and df/dx2 = 3
```



```

01 // Swap Inputs
02 // phi      Pay or Receive Fixed: Pay = 1, Receive = -1
03 // n       Swap Notional
04 // r       Fixed rate
05 // tau     Accrual year fraction
06 // t       Coupon Payment Time
07 // f       Floating Forward Rate
08 // s       Floating Spread
09 // z       Discounting Zero Rate for Discount Factor, where df = exp(-z*t)
10
11 double swap_pv(double phi, double n, double r, double tau, double t, double f, double s,
12                  double z)
13 {
14     double df          = exp(-z*t);           // Step 1. Discount Factor using zero rate, z
15     double pv_fixed = phi*n*r*tau*df;        // Step 2. Fixed PV =  $\varphi N r \tau_1 P(0, t_1)$ 
16     double pv_float  = -phi*n*(f+s)*tau*df; // Step 3. Float PV =  $\varphi N(l_1 + s) \tau_1 P(0, t_1)$ 
17     double pv_swap   = pv_fixed+pv_float;    // Step 4. Swap PV = Fixed PV + Float PV
18     return pv_swap;

```



```
01 double tangent(double phi, double n, double r, double tau, double t, double f, double s,
02                 double z, double f_dot, double z_dot)
03 {
04     double df          = exp(-z*t);           // Step 1.
05     double df_dot      = -t*exp(-z*t)*z_dot;
06     double pv_fixed    = phi*n*r*tau*df;       // Step 2.
07     double pv_fixed_dot = phi*n*r*tau*df_dot;
08     double pv_float    = -phi*n*(f+s)*tau*df;   // Step 3.
09     double pv_float_dot = -phi*n*tau*df*f_dot
09          - phi*n*f*tau*df_dot;
10     double pv_swap     = pv_fixed+pv_float;      // Step 4.
11     double pv_swap_dot = pv_fixed_dot + pv_float_dot;
12 }
```



```
01 // inputs( phi, n, r, tau, t, f, s, z, f_dot, z_dot )
02 tangent( 1, 1000000, 0.02, 1, 1, 0.01, 0, 0.02, 0.0001, 0.0001 ); // Output DV01 Risk
```



```

01 double adjoint(double phi, double n, double r, double tau, double t, double f, double s, double z,
02 double pv_bar)
03 {
04     // Forward Sweep
05     double df = exp(-z*t); // Step 1. Discount Factor using zero rate, z
06     double pv_fixed = phi*n*r*tau*df; // Step 2. Fixed PV = φ N r τ_1 P(0,t_1 )
07     double pv_float = -phi*n*(f+s)*tau*df; // Step 3. Float PV = φ N(l_1+s) τ_1 P(0,t_1 )
08     double pv_swap = pv_fixed+pv_float; // Step 4. Swap PV = Fixed PV + Float PV
09
10    // Backward Propagation
11    double pv_fixed_bar = pv_bar; // Step 4.
12    double pv_float_bar = pv_bar; // Step 4.
13    double f_bar = -phi*n*tau*df*pv_float_bar*shift_size_f; // Step 3. *
14    double df_bar = -phi*n*f*tau*pv_float_bar*shift_size_df; // Step 3. *
15    df_bar += phi*n*r*tau*pv_fixed_bar*shift_size_df; // Step 2. *
16    double z_bar = -t*exp(-z*t)*df_bar; // Step 1.
17
18    // DV01 Result
19    return f_bar + df_bar; // Sensitivity to 1 bps change in forwards and discount factors
}

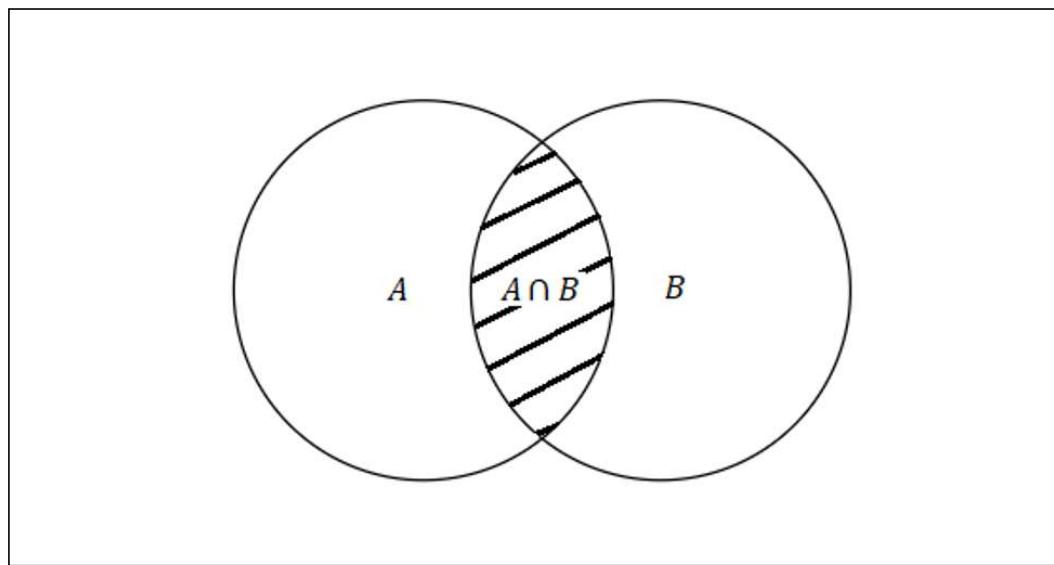
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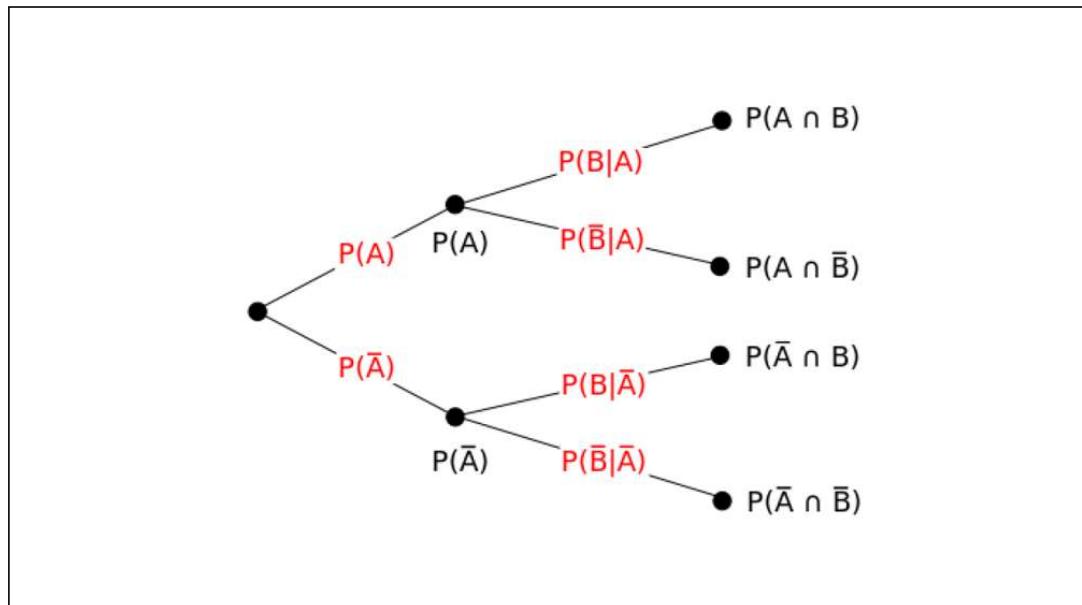


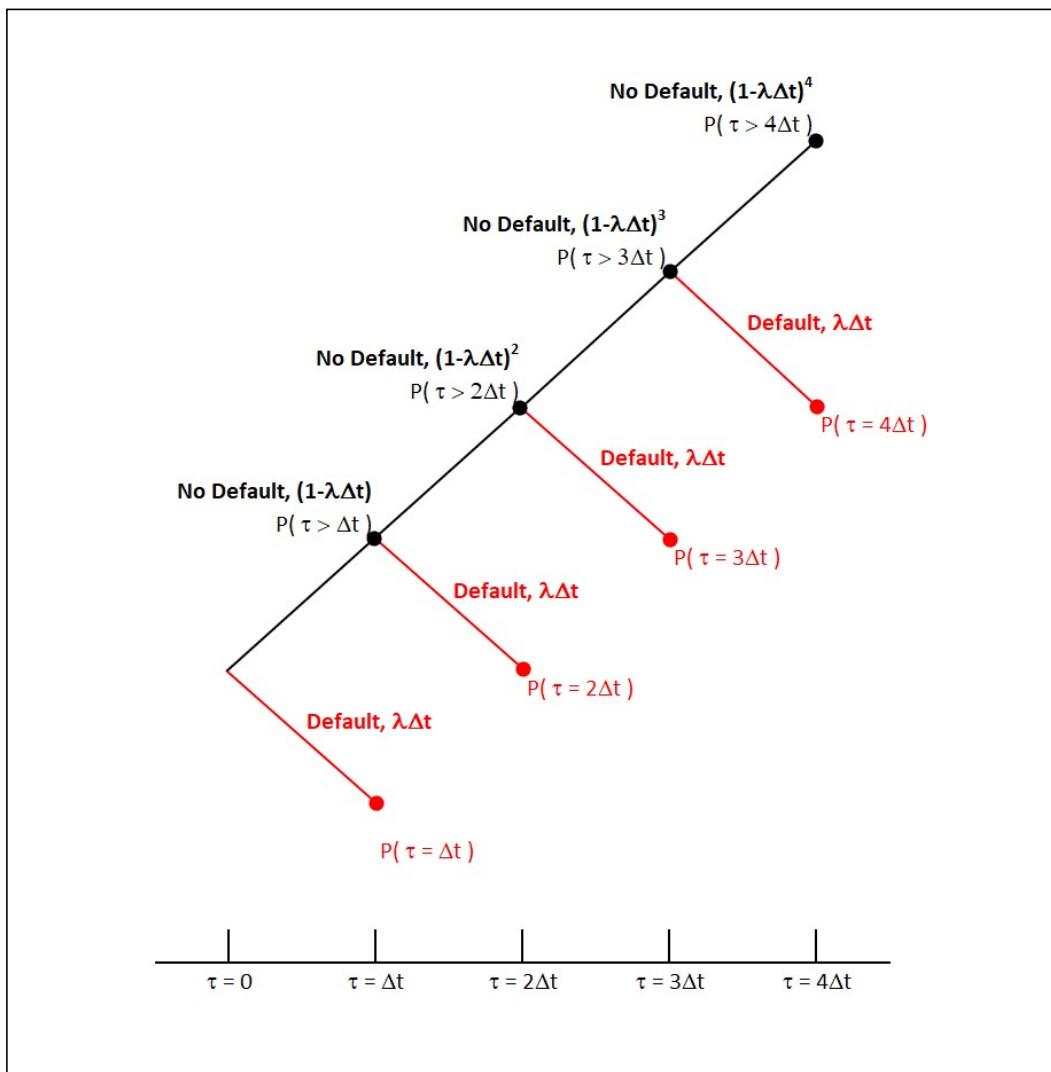
```
01 // inputs( phi, n, r, tau, t, f, s, z, pv_bar )
02 adjoint( 1, 1000000, 0.02, 1, 1, 0.01, 0, 0.02, 1 ); // Output DV01 Risk
```

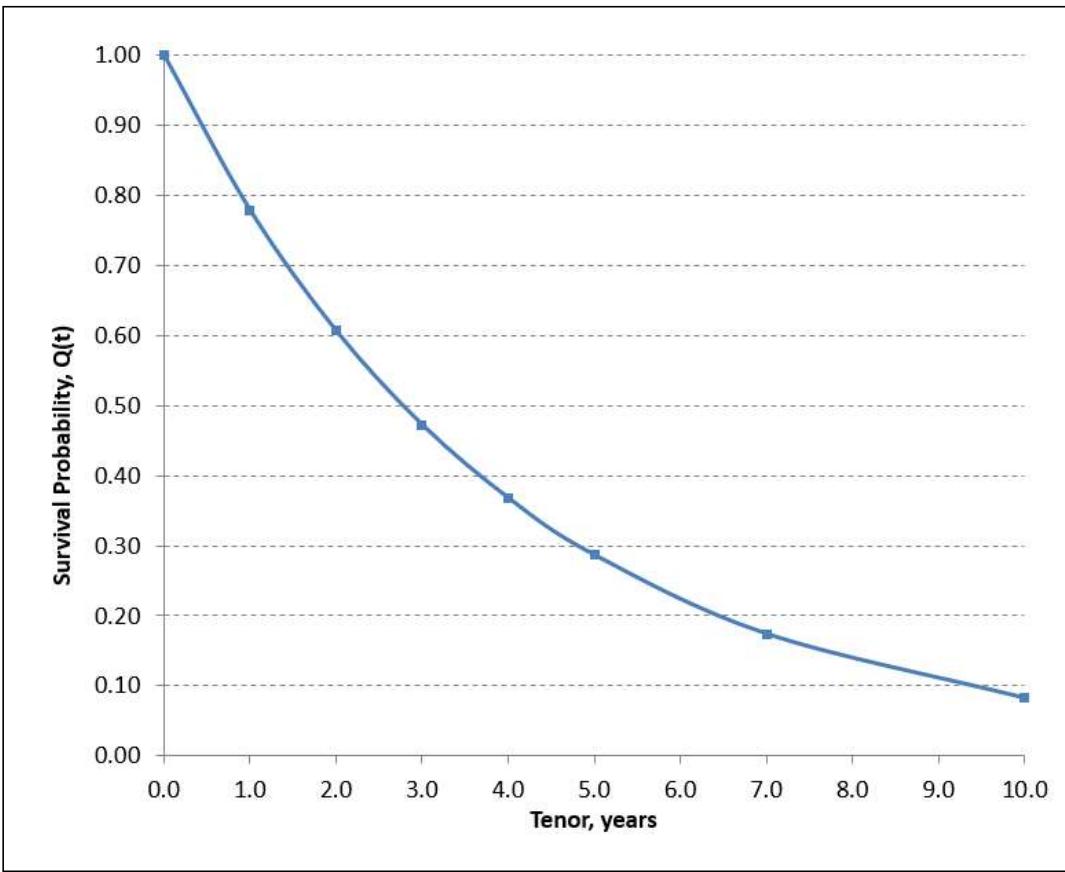


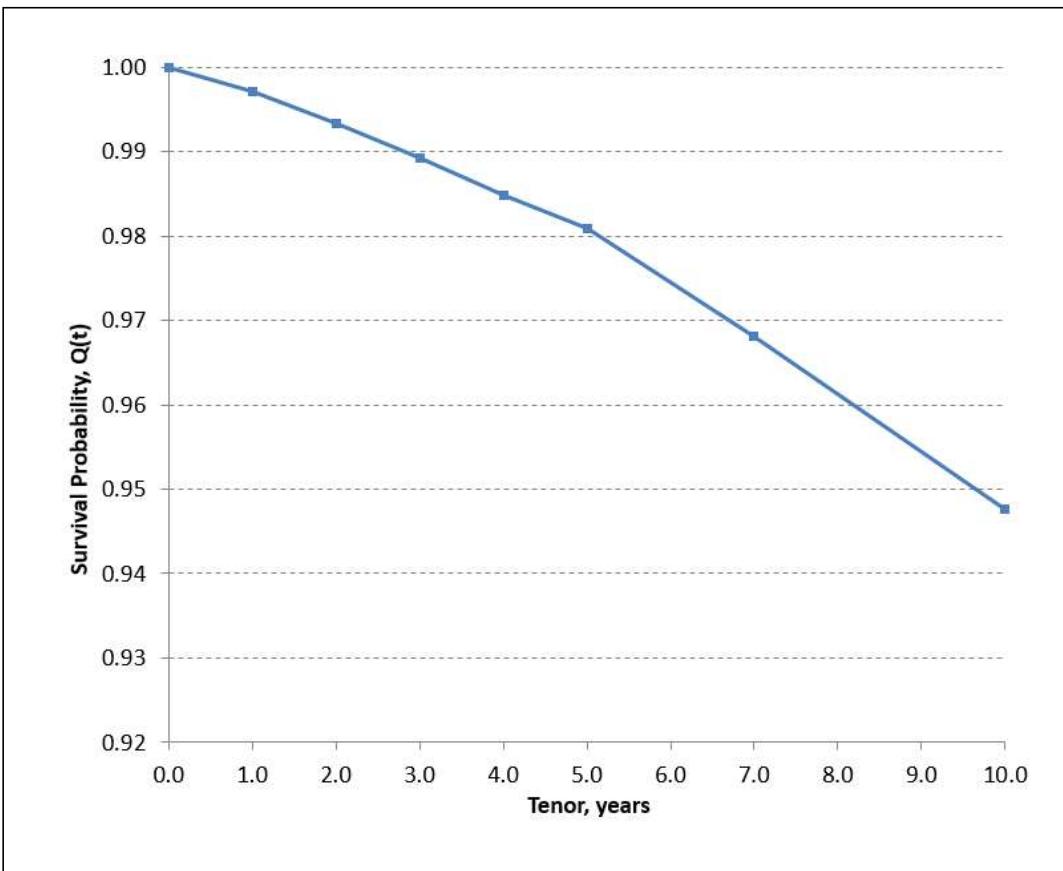
Chapter 6 – Credit Models

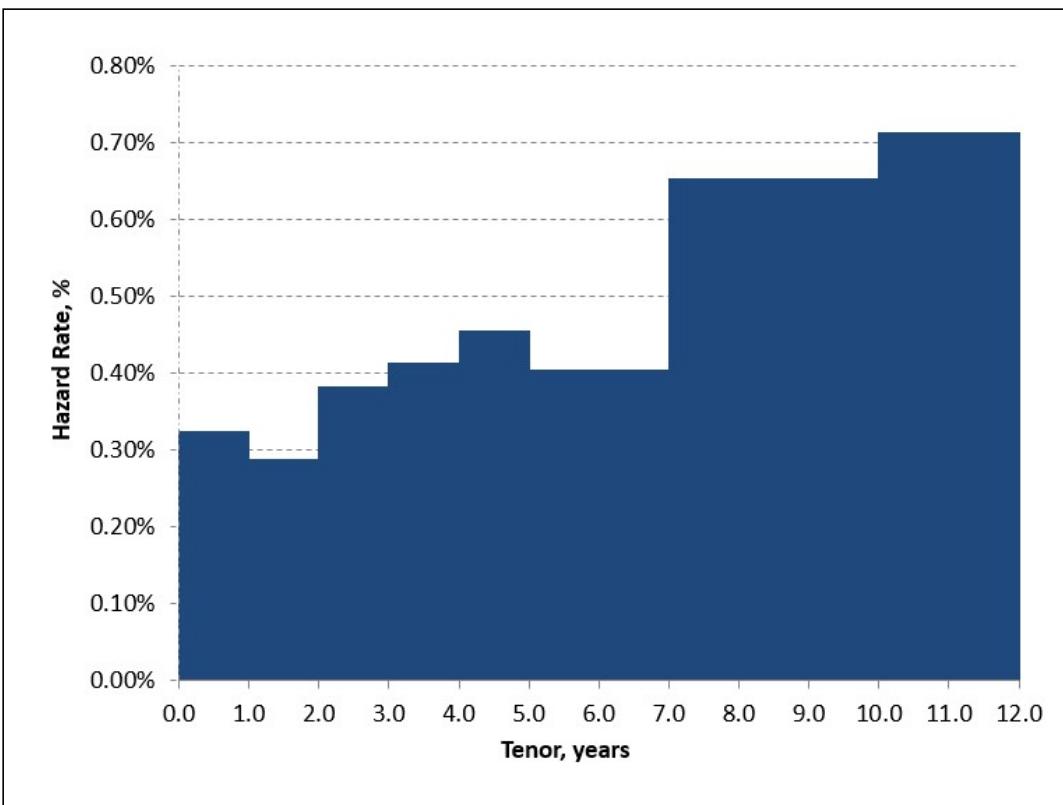


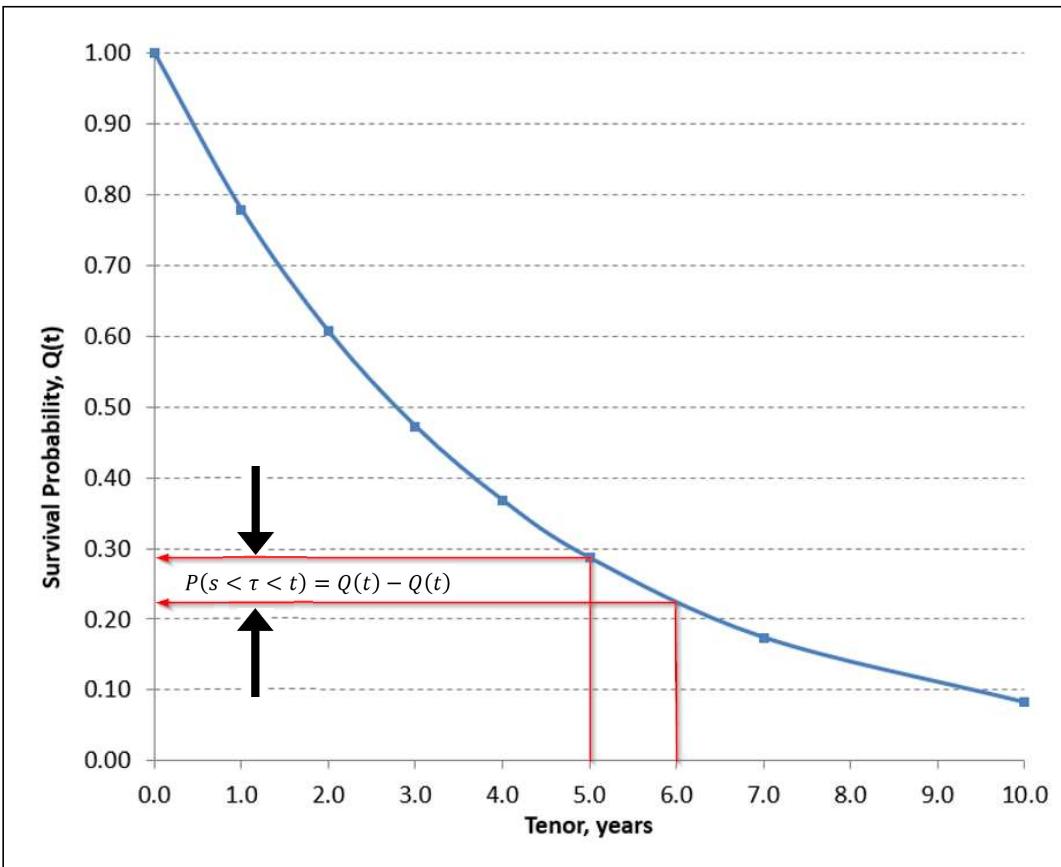












SWAP LEG	CONVENTION	EUR	USD	GBP	JPY
FLOAT LEG	FREQUENCY DAYCOUNT	SEMI-ANNUAL ACT/360	QUARTERLY ACT/360	SEMI-ANNUAL ACT/365	SEMI-ANNUAL ACT/360
FIXED LEG	FREQUENCY DAYCOUNT	ANNUAL 30E/360	SEMI-ANNUAL 30/360	SEMI-ANNUAL ACT/365	SEMI-ANNUAL ACT/365F

SWAP LEG	CONVENTION	EUR	USD	GBP	JPY
FLOAT LEG	FREQUENCY DAYCOUNT	SEMI-ANNUAL ACT/360	QUARTERLY ACT/360	SEMI-ANNUAL ACT/365	SEMI-ANNUAL ACT/360
FIXED LEG	FREQUENCY DAYCOUNT	ANNUAL 30E/360	SEMI-ANNUAL 30/360	SEMI-ANNUAL ACT/365	SEMI-ANNUAL ACT/365F

Trade Template			USD IRS 5% USD3ML 5Y	
Swap	LEG1:FIXED		LEG2:FLOAT	
	Pay / Receive	RECEIVE	PAY	
	Notional	1,000,000	1,000,000	
	Currency	USD	USD	
	Effective Date	2D Tue, 25-Aug-2015	2D Tue, 25-Aug-2015	
	Maturity Date	5Y Tue, 25-Aug-2020	5Y Tue, 25-Aug-2020	
	Fixed Rate (%)	5.000000%		
	Float Index		3M USD3ML	
	Float Spread (bps)		0.000	
	Reset Frequency		QUARTERLY	
Pay Frequency	SEMI-ANNUAL		QUARTERLY	
Day Count	30/360		ACT/360	
Market				
Curve Date	Fri, 21-Aug-2015		Fri, 21-Aug-2015	
Forecast Curve			USD3ML	
Discount Curve	USDOIS		USDOIS	
Valuation Results				
Valuation Date	Fri, 21-Aug-2015			
Par Rate	1.548250%			
NPV	167,892.11			
PV01	486.40			
DV01	532.42			

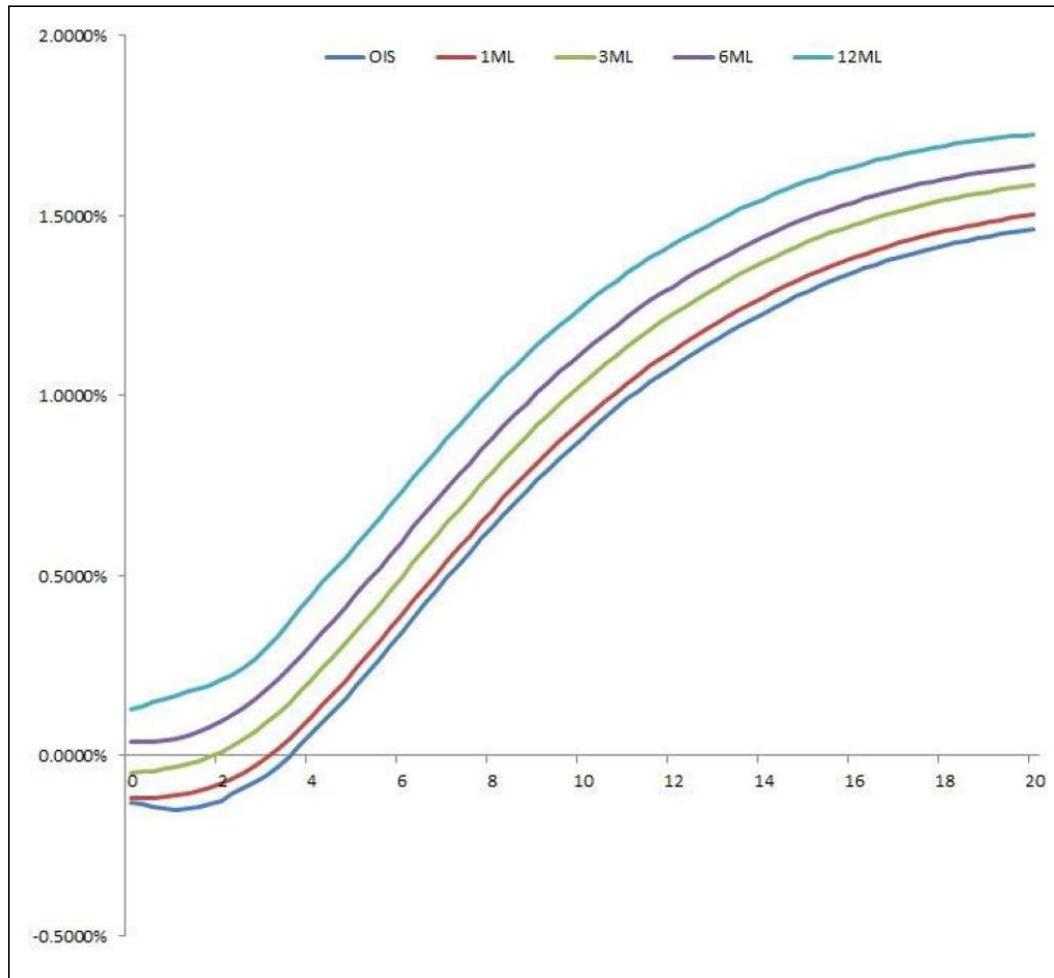
Trade Template		
EUR IRS 5% EUR6ML 5Y		
Swap	LEG1:FIXED	LEG2:FLOAT
Pay / Receive	RECEIVE	PAY
Notional	1,000,000	1,000,000
Currency	EUR	EUR
Effective Date	2D Tue, 25-Aug-2015	2D Tue, 25-Aug-2015
Maturity Date	5Y Tue, 25-Aug-2020	5Y Tue, 25-Aug-2020
Fixed Rate (%)	5.000000%	
Float Index		6M EUR6ML
Float Spread (bps)		0.000
Reset Frequency		SEMI-ANNUAL
Pay Frequency	ANNUAL	SEMI-ANNUAL
Day Count	30/360	ACT/360
Market		
Curve Date	Fri, 21-Aug-2015	Fri, 21-Aug-2015
Forecast Curve		EUR6ML
Discount Curve	EUROIS	EUROIS
Valuation Results		
Valuation Date	Fri, 21-Aug-2015	
Par Rate	0.349000%	
NPV	232,643.20	
PV01	500.20	
DV01	571.01	

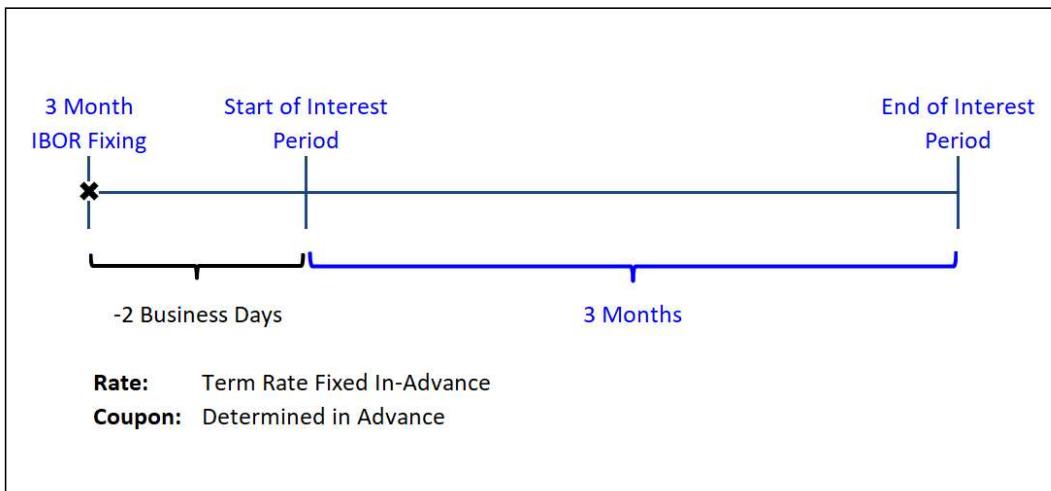
Trade Template		USD IRS USDSOFR 1Y	
Swap	LEG1:FIXED		LEG2:FLOAT
	RECEIVE		PAY
	10,000,000		10,000,000
	USD		USD
	0D	Mon, 13-Jun-2022	0D
	1Y	Tue, 13-Jun-2023	Tue, 13-Jun-2023
	3.315906%		
			1D USD SOFR
			0.000
			DAILY
Pay Frequency	SEMI-ANNUAL	QUARTERLY	
Day Count	30/360	ACT/360	
Market			
Curve Date	Mon, 13-Jun-2022		Mon, 13-Jun-2022
Forecast Curve	USDSOFR		
Discount Curve	USDSOFR		USDSOFR
Valuation Results			
Valuation Date	Mon, 13-Jun-2022		
Par Rate	3.158335%		
NPV	15,416.96		
PV01	978.41		
DV01	973.45		

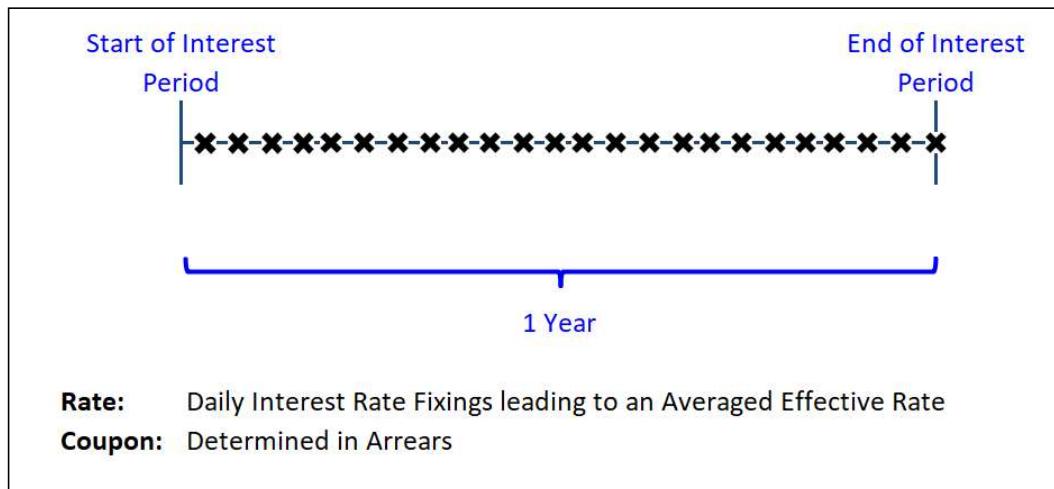
Trade Template		EUR IRS EURESTR 1Y	
Swap		LEG1:FIXED	
Pay / Receive	RECEIVE	PAY	
Notional	10,000,000	10,000,000	
Currency	EUR	EUR	
Effective Date	0D Mon, 13-Jun-2022	0D Mon, 13-Jun-2022	
Maturity Date	1Y Tue, 13-Jun-2023	1Y Tue, 13-Jun-2023	
Fixed Rate (%)	0.964683%		
Float Index		1D EURESTR	
Float Spread (bps)		0.000	
Reset Frequency		DAILY	
Pay Frequency	ANNUAL	SEMI-ANNUAL	
Day Count	30/360	ACT/360	
Market			
Curve Date	Mon, 13-Jun-2022	Mon, 13-Jun-2022	
Forecast Curve		EURESTR	
Discount Curve	EURESTR	EURESTR	
Valuation Results			
Valuation Date	Mon, 13-Jun-2022		
Par Rate	0.797643%		
NPV	16,570.96		
PV01	992.03		
DV01	1,004.73		

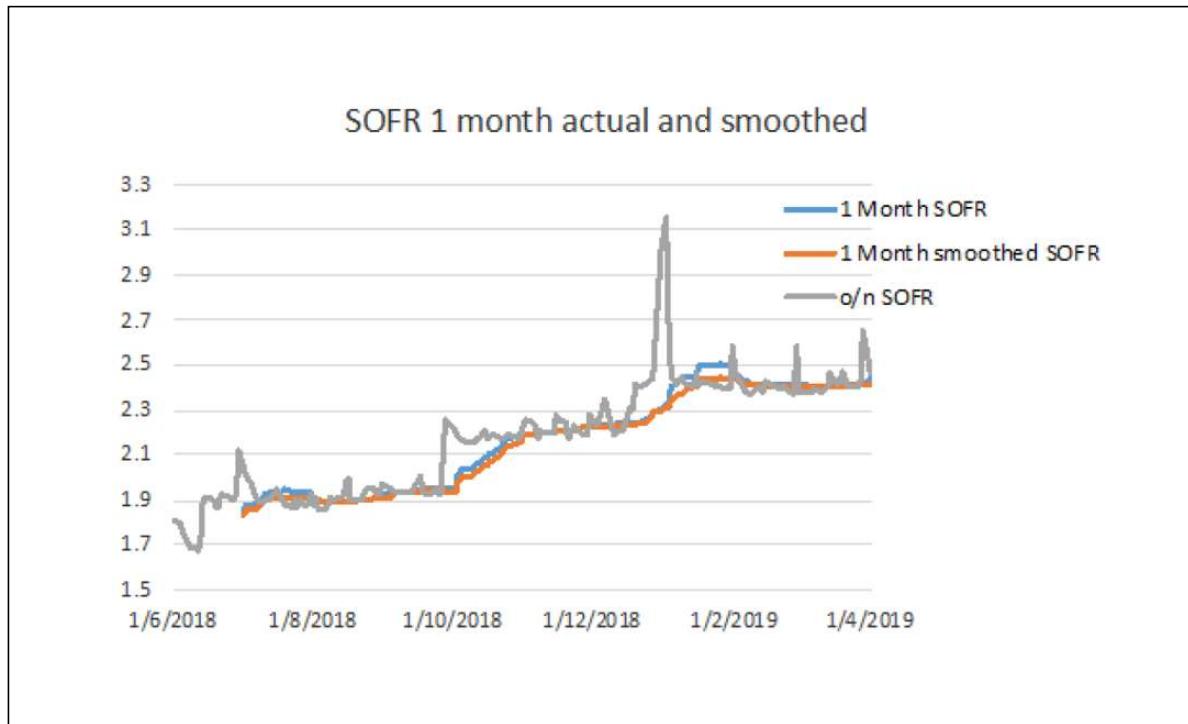
Trade Template		GBP IRS GBPSONIA 1Y	
Swap	LEG1:FIXED		LEG2:FLOAT
Pay / Receive	RECEIVE	PAY	
Notional	10,000,000	10,000,000	
Currency	GBP	GBP	
Effective Date	0D Mon, 13-Jun-2022	0D Mon, 13-Jun-2022	
Maturity Date	1Y Tue, 13-Jun-2023	1Y Tue, 13-Jun-2023	
Fixed Rate (%)	2.750713%		
Float Index		1D GBPSONIA	
Float Spread (bps)		0.000	
Reset Frequency		DAILY	
Pay Frequency	SEMI-ANNUAL	SEMI-ANNUAL	
Day Count	ACT/365	ACT/365	
Market			
Curve Date	Mon, 13-Jun-2022	Mon, 13-Jun-2022	
Forecast Curve		GBPSONIA	
Discount Curve	GBPSONIA	GBPSONIA	
Valuation Results			
Valuation Date	Mon, 13-Jun-2022		
Par Rate	2.501760%		
NPV	24,474.58		
PV01	983.10		
DV01	968.51		

Trade Template		JPY IRS JPYTONAR 1Y	
Swap	LEG1:FIXED		LEG2:FLOAT
	RECEIVE		PAY
	10,000,000		10,000,000
	JPY		JPY
	0D	Mon, 13-Jun-2022	0D
	1Y	Tue, 13-Jun-2023	Mon, 13-Jun-2022
	0.072396%		1Y
	Float Index		JPYTONAR
	Float Spread (bps)		0.000
	Reset Frequency		DAILY
Pay Frequency		SEMI-ANNUAL	SEMI-ANNUAL
Day Count		ACT/365F	ACT/360
Market			
Curve Date		Mon, 13-Jun-2022	Mon, 13-Jun-2022
Forecast Curve		JPYTONAR	
Discount Curve		JPYTONAR	JPYTONAR
Valuation Results			
Valuation Date		Mon, 13-Jun-2022	
Par Rate		0.015548%	
NPV		5,684.00	
PV01		999.00	
DV01		1,011.00	









PART TWO – PRICING & PRACTICE

Case Studies
Interest Rate Swaps & Asset Swaps

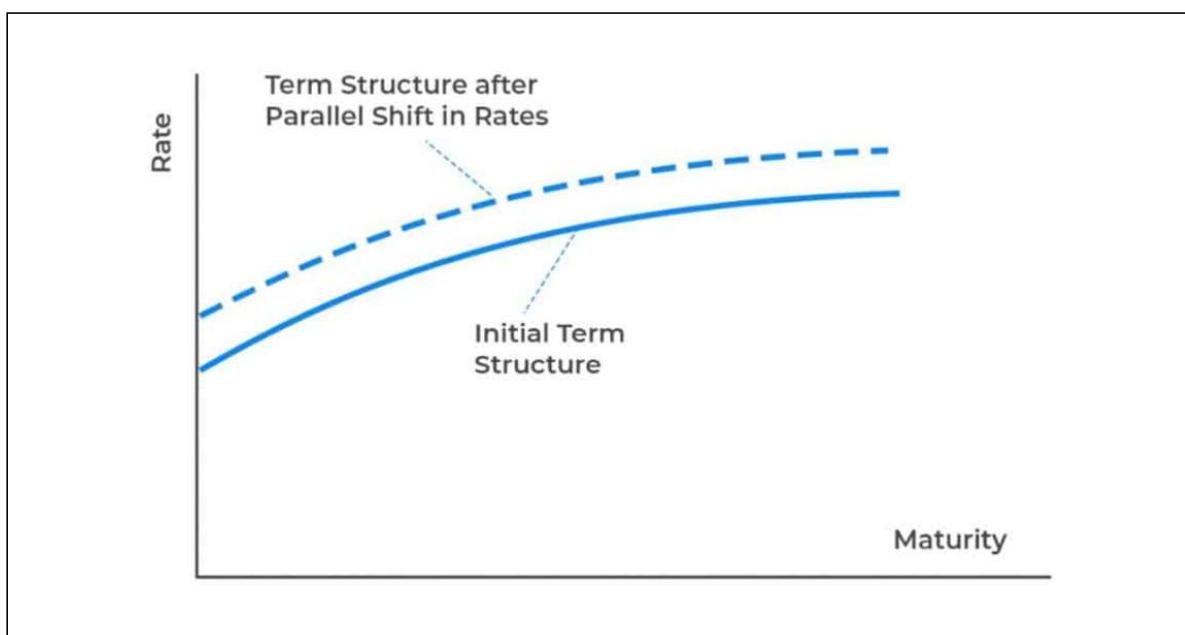
Chapter 7 – Interest Rate Swap Pricing & Risk

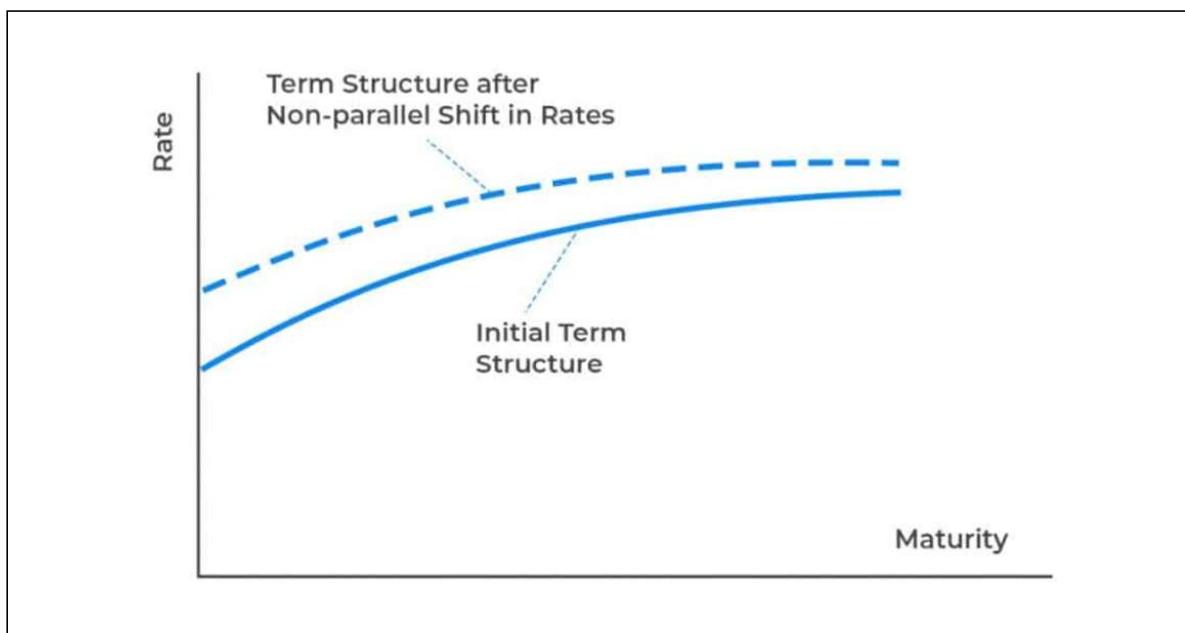
Trade Template		EUR IRS 1% EUR6ML 5Y	
Swap	LEG1:FIXED		LEG2:FLOAT
Pay / Receive	RECEIVE	PAY	
Notional	1,000,000	1,000,000	
Currency	EUR	EUR	
Effective Date	2D Tue, 25-Aug-2015	2D	Tue, 25-Aug-2015
Maturity Date	5Y Tue, 25-Aug-2020	5Y	Tue, 25-Aug-2020
Fixed Rate (%)	1.00000%		
Float Index		6M	EUR6ML
Float Spread (bps)		0.000	
Reset Frequency		SEMI-ANNUAL	
Pay Frequency	ANNUAL	SEMI-ANNUAL	
Day Count	30/360	ACT/360	
Market			
Curve Date	Fri, 21-Aug-2015	Fri, 21-Aug-2015	
Forecast Curve		EUR6ML	
Discount Curve	EUROIS	EUROIS	
Valuation Results			
Valuation Date	Fri, 21-Aug-2015		
Par Rate	0.34900%		
NPV	32,563.05		
PV01	500.20		
DV01	510.11		

USD Semi Fixed vs 3M Libor					Spreads vs Treasuries				
Tenor	Bid		Ask	Change	Tenor	Bid		Ask	Change
1Y	0.750	/	0.754	+0.014	1Y	14.627	/	15.614	-0.794
2Y	1.045	/	1.049	+0.017	2Y	9.991	/	10.374	+0.068
3Y	1.284	/	1.287	+0.018	3Y	8.082	/	8.432	-0.262
4Y	1.467	/	1.471	+0.015	4Y	5.250	/	5.535	-0.385
5Y	1.617	/	1.621	+0.014	5Y	5.053	/	5.446	-0.360
6Y	1.750	/	1.754	+0.012	6Y	2.500	/	2.875	-0.253
7Y	1.866	/	1.870	+0.011	7Y	0.356	/	0.671	-0.308
8Y	1.966	/	1.970	+0.011	8Y	0.503	/	0.809	-0.877
9Y	2.052	/	2.056	+0.011	9Y	-0.125	/	0.500	-0.377
10Y	2.126	/	2.129	+0.011	10Y	0.072	/	0.441	-0.471
12Y	2.250	/	2.254	+0.007	12Y	6.113	/	6.424	-1.038
15Y	2.376	/	2.380	+0.006	15Y	1.123	/	1.375	-0.563
20Y	2.497	/	2.501	+0.003	20Y	-4.875	/	-4.500	-0.565
25Y	2.558	/	2.563	+0.003	25Y	-13.500	/	-13.000	-1.125
30Y	2.592	/	2.597	+0.003	30Y	-24.171	/	-23.786	-0.715

EUR 6M EURIBOR			
Tenor	Bid	Ask	Change
1Y	0.041	/ 0.046	-0.002
18M	0.052	/ 0.058	-0.002
2Y	0.075	/ 0.080	-0.001
3Y	0.146	/ 0.151	-0.001
4Y	0.241	/ 0.246	-0.004
5Y	0.351	/ 0.356	-0.004
6Y	0.470	/ 0.475	-0.007
7Y	0.592	/ 0.597	-0.009
8Y	0.711	/ 0.716	-0.011
9Y	0.820	/ 0.825	-0.014
10Y	0.917	/ 0.922	-0.015
15Y	1.243	/ 1.251	-0.024
20Y	1.377	/ 1.385	-0.030
25Y	1.407	/ 1.416	-0.035
30Y	1.413	/ 1.423	-0.038

EUR Bund Trading								
Tenor	Security	Bid Px	Ask Px	Bid Yield	Ask Yield	Px Change		
3M	BUBILL 0% 10/02/16	100.081	/	100.099	-0.347%	/	-0.424%	-0.001
6M	BUBILL 0% 18/05/16	100.174	/	100.208	-0.343%	/	-0.411%	-0.008
1Y	BUBILL 0% 27/07/16	100.262	/	100.298	-0.373%	/	-0.424%	-0.004
2Y	BKO 0% 15/09/17	100.680	/	100.695	-0.371%	/	-0.379%	+0.005
3Y	OBL 1% 11/10/19	103.900	/	103.905	-0.336%	/	-0.338%	+0.020
4Y	OBL 0.25% 11/10/19	101.975	/	101.985	-0.254%	/	-0.256%	+0.040
5Y	OBL 0.25% 16/10/20	101.830	/	101.845	-0.121%	/	-0.124%	+0.075
6Y	DBR 2.25% 04/09/21	113.310	/	113.325	-0.043%	/	-0.046%	+0.100
7Y	DBR 1.5% 04/09/22	109.685	/	109.705	0.072%	/	0.068%	+0.145
8Y	DBR 2% 15/08/23	113.685	/	113.695	0.215%	/	0.214%	+0.195
9Y	DBR 1% 15/08/24	105.365	/	105.375	0.375%	/	0.374%	+0.240
10Y	DBR 1% 15/08/25	104.455	/	104.465	0.529%	/	0.528%	+0.275
15Y	DBR 6.25% 04/01/30	172.160	/	172.240	0.820%	/	0.816%	+0.535
20Y	DBR 4.75% 04/07/34	160.820	/	160.925	1.115%	/	1.111%	+0.695
30Y	DBR 2.5% 15/08/46	127.850	/	127.950	1.382%	/	1.378%	+0.920





Chapter 8 – Interest Rate Swap Case Study Examples

Fixed Leg

	Accrual Start	Accrual End	Pay Date	t_i	N	r^{Fixed}	τ_i	Cash Flow	$P(t_0, t_i)$	PV^{Fixed}
1	23-Apr-22	22-Oct-22	22-Oct-22	0.50	1,000,000	1.0000%	0.50	5,000	0.997824	4,989
2	22-Oct-22	23-Apr-23	23-Apr-23	1.00	1,000,000	1.0000%	0.50	5,000	0.994549	4,973
3	23-Apr-23	22-Oct-23	22-Oct-23	1.50	1,000,000	1.0000%	0.50	5,000	0.991815	4,959
4	22-Oct-23	22-Apr-24	22-Apr-24	2.00	1,000,000	1.0000%	0.50	5,000	0.987801	4,939
5	22-Apr-24	22-Oct-24	22-Oct-24	2.50	1,000,000	1.0000%	0.50	5,000	0.983373	4,917
6	22-Oct-24	22-Apr-25	22-Apr-25	3.00	1,000,000	1.0000%	0.50	5,000	0.979783	4,899
7	22-Apr-25	22-Oct-25	22-Oct-25	3.50	1,000,000	1.0000%	0.50	5,000	0.974642	4,873
8	22-Oct-25	23-Apr-26	23-Apr-26	4.00	1,000,000	1.0000%	0.50	5,000	0.969104	4,846
9	23-Apr-26	22-Oct-26	22-Oct-26	4.50	1,000,000	1.0000%	0.50	5,000	0.964693	4,823
10	22-Oct-26	23-Apr-27	23-Apr-27	5.00	1,000,000	1.0000%	0.50	5,000	0.958476	4,792



Float Leg

	Fixing Date	Accrual Start	Accrual End	Pay Date	t_j	N	$I_{j-1} + s$	τ_j	Cash Flow	$P(t_0, t_j)$	PV^{float}
1	21-Apr-22	23-Apr-22	23-Jul-22	23-Jul-22	0.25	1,000,000	0.2800%	0.25	700	0.999302	700
2	21-Jul-22	23-Jul-22	22-Oct-22	22-Oct-22	0.50	1,000,000	0.2995%	0.25	749	0.997824	747
3	20-Oct-22	22-Oct-22	21-Jan-23	21-Jan-23	0.75	1,000,000	0.3385%	0.25	846	0.996240	843
4	19-Jan-23	21-Jan-23	23-Apr-23	23-Apr-23	1.00	1,000,000	0.3775%	0.25	944	0.994549	939
5	21-Apr-23	23-Apr-23	23-Jul-23	23-Jul-23	1.25	1,000,000	0.4165%	0.25	1,041	0.992752	1,034
6	21-Jul-23	23-Jul-23	22-Oct-23	22-Oct-23	1.50	1,000,000	0.4555%	0.25	1,139	0.991815	1,129
7	20-Oct-23	22-Oct-23	22-Jan-24	22-Jan-24	1.75	1,000,000	0.4750%	0.25	1,188	0.989860	1,175
8	20-Jan-24	22-Jan-24	22-Apr-24	22-Apr-24	2.00	1,000,000	0.5140%	0.25	1,285	0.987801	1,269
9	20-Apr-24	22-Apr-24	22-Jul-24	22-Jul-24	2.25	1,000,000	0.5530%	0.25	1,383	0.985638	1,363
10	20-Jul-24	22-Jul-24	22-Oct-24	22-Oct-24	2.50	1,000,000	0.5920%	0.25	1,480	0.983373	1,455
11	20-Oct-24	22-Oct-24	21-Jan-25	21-Jan-25	2.75	1,000,000	0.6310%	0.25	1,578	0.981005	1,548
12	19-Jan-25	21-Jan-25	22-Apr-25	22-Apr-25	3.00	1,000,000	0.6700%	0.25	1,675	0.979783	1,641
13	20-Apr-25	22-Apr-25	23-Jul-25	23-Jul-25	3.25	1,000,000	0.6895%	0.25	1,724	0.977262	1,685
14	21-Jul-25	23-Jul-25	22-Oct-25	22-Oct-25	3.50	1,000,000	0.7285%	0.25	1,821	0.974642	1,775
15	20-Oct-25	22-Oct-25	21-Jan-26	21-Jan-26	3.75	1,000,000	0.7675%	0.25	1,919	0.971922	1,865
16	19-Jan-26	21-Jan-26	23-Apr-26	23-Apr-26	4.00	1,000,000	0.8065%	0.25	2,016	0.969104	1,954
17	21-Apr-26	23-Apr-26	23-Jul-26	23-Jul-26	4.25	1,000,000	0.8455%	0.25	2,114	0.966188	2,042
18	21-Jul-26	23-Jul-26	22-Oct-26	22-Oct-26	4.50	1,000,000	0.8845%	0.25	2,211	0.964693	2,133
19	20-Oct-26	22-Oct-26	21-Jan-27	21-Jan-27	4.75	1,000,000	0.9040%	0.25	2,260	0.961632	2,173
20	19-Jan-27	21-Jan-27	23-Apr-27	23-Apr-27	5.00	1,000,000	0.9430%	0.25	2,358	0.958476	2,260



Fixed Leg

	Accrual Start	Accrual End	Pay Date	t_i	N	r^{Fixed}	τ_i	Cash Flow	$P(t_0, t_i)$	PV^{Fixed}
1	01-Aug-22	01-Aug-23	03-Aug-23	1.00	1,000,000	1.0000%	1.00	10,000	0.9900	9,900
2	01-Aug-23	01-Aug-24	03-Aug-24	2.00	1,000,000	1.0000%	1.00	10,000	0.9804	9,804
3	01-Aug-24	01-Aug-25	03-Aug-25	3.00	1,000,000	1.0000%	1.00	10,000	0.9708	9,708
4	01-Aug-25	01-Aug-26	03-Aug-26	4.00	1,000,000	1.0000%	1.00	10,000	0.9612	9,612
5	01-Aug-26	01-Aug-27	03-Aug-27	5.00	1,000,000	1.0000%	1.00	10,000	0.9516	9,516

Total NPV 48,540.00



Float Leg

	Fixing Date	Accrual Start	Accrual End	Pay Date	t_j	N	$I_{j-1} + s$	τ_j	Cash Flow	$P(t_0, t_j)$	PV^{float}
1	30-Jul-22	01-Aug-22	01-Aug-23	03-Aug-23	1.00	1,000,000	0.2800%	1.00	2,800	0.9900	2,772
2	30-Jul-23	01-Aug-23	01-Aug-24	03-Aug-24	2.00	1,000,000	0.5140%	1.00	5,140	0.9804	5,039
3	30-Jul-24	01-Aug-24	01-Aug-25	03-Aug-25	3.00	1,000,000	0.7480%	1.00	7,480	0.9708	7,262
4	30-Jul-25	01-Aug-25	01-Aug-26	03-Aug-26	4.00	1,000,000	0.9820%	1.00	9,820	0.9612	9,439
5	30-Jul-26	01-Aug-26	01-Aug-27	03-Aug-27	5.00	1,000,000	1.2160%	1.00	12,160	0.9516	11,571

Total NPV 36,083.28



Fixed Leg

	Accrual Start	Accrual End	Pay Date	t_i	N	r^{Fixed}	τ_i	Cash Flow	$P(t_0, t_i)$	PV^{Fixed}
1	01-Aug-22	01-Aug-23	03-Aug-23	1.00	5,000,000	0.5000%	1.00	25,000	1.0380	25,950
2	01-Aug-23	01-Aug-24	03-Aug-24	2.00	5,000,000	0.5000%	1.00	25,000	1.0260	25,650

Total NPV 51,600.00



Float Leg

	Fixing Date	Accrual Start	Accrual End	Pay Date	t_j	N	$I_{j-1} + s$	τ_j	Cash Flow	P(t_0, t_j)	PV ^{Float}
1	30-Jul-22	01-Aug-22	01-Aug-23	03-Aug-23	1.00	10,000,000	0.2800%	1.00	28,000	0.9900	27,720
2	30-Jul-23	01-Aug-23	01-Aug-24	03-Aug-24	2.00	10,000,000	0.5140%	1.00	51,400	0.9804	50,393

Total NPV 78,112.56



Float Leg

	Fixing Date	Accrual Start	Accrual End	Pay Date	t_j	N	$I_{j-1} + s$	τ_j	Cash Flow	$P(t_0, t_j)$	PV^{float}
1	30-Jul-22	01-Aug-22	01-Aug-23	03-Aug-23	0.50	5,000,000	0.0487%	0.50	1,218	1.0440	1,271
2	30-Jul-23	01-Aug-23	01-Aug-24	03-Aug-24	1.00	5,000,000	0.1687%	0.50	4,218	1.0380	4,378
3	30-Jul-24	01-Aug-24	01-Aug-25	03-Aug-25	1.50	5,000,000	0.2887%	0.50	7,218	1.0320	7,448
4	30-Jul-25	01-Aug-25	01-Aug-26	03-Aug-26	2.00	5,000,000	0.4087%	0.50	10,218	1.0260	10,483

Total NPV 23,580.45



Annuity - Fixed Leg

N	τ_i	$P(t_0, t_i)$	A_N^{Fixed}
10,000,000	1.00	0.9900	9,900,000
10,000,000	1.00	0.9804	9,804,000

Total A_N^{Fixed} 19,704,000**Annuity - Float Leg**

N	τ_i	$P(t_0, t_i)$	A_N^{Float}
10,000,000	1.00	0.9900	9,900,000
10,000,000	1.00	0.9804	9,804,000

Total A_N^{Float} 19,704,000

Par Rate

PV ^{Float}	A _N ^{Fixed}	p ^{Trade}
78,112.56	19,704,000	0.396430%

**Fixed Leg**

	Accrual Start	Accrual End	Pay Date	t_i	N	r ^{Fixed}	τ_i	Cash Flow	P(t ₀ , t _i)	PV ^{Fixed}
1	01-Aug-22	01-Aug-23	03-Aug-23	1.00	10,000,000	1.5000%	1.00	150,000	0.9900	148,500
2	01-Aug-23	01-Aug-24	03-Aug-24	2.00	10,000,000	1.5000%	1.00	150,000	0.9804	147,060

Total NPV 295,560.00

**Swap PV**

Pay/Rec, ϕ	r ^{Fixed}	p ^{Trade}	A _N ^{Fixed}	PV ^{Swap}
1	1.5000%	0.396430%	19,704,000	217,447.44



Duration - Fixed Leg

t_i	N	τ_i	$P(t_0, t_i)$	A_N^{Fixed}	$D_{\text{MAC}}^{\text{Fixed}}$
1.00	10,000,000	1.00	0.9900	19,704,000	0.5024
2.00	10,000,000	1.00	0.9804	19,704,000	0.9951

Total $D_{\text{MAC}}^{\text{Fixed}}$ 1.4976**Duration - Float Leg**

t_j	N	τ_j	$ j_1 + s $	$P(t_0, t_j)$	PV^{Float}	$D_{\text{MAC}}^{\text{Float}}$
1.00	10,000,000	1.00	0.2800%	0.9900	27,720	0.3549
2.00	10,000,000	1.00	0.5140%	0.9804	50,393	1.2903

Total $D_{\text{MAC}}^{\text{Float}}$ 1.6451

Modified Duration - Fixed Leg

D _{MAC} ^{Fixed}	p ^{Trade}	D _{MOD} ^{Fixed}
1.4976	0.396430%	1.4917

**Modified Duration - Float Leg**

D _{MAC} ^{Float}	p ^{Trade}	D _{MOD} ^{Float}
1.6451	0.396430%	1.6386



Swap PV01

Pay/Rec, ϕ	A_N^{Fixed}	PV01
1	19,704,000	1,970.40



Analytical Swap DV01

Pay/Rec, ϕ	PV01	PV^{Swap}	$D_{\text{MOD}}^{\text{Fixed}}$	DV01
1	1,970.40	217,447.44	1.4917	2,002.84

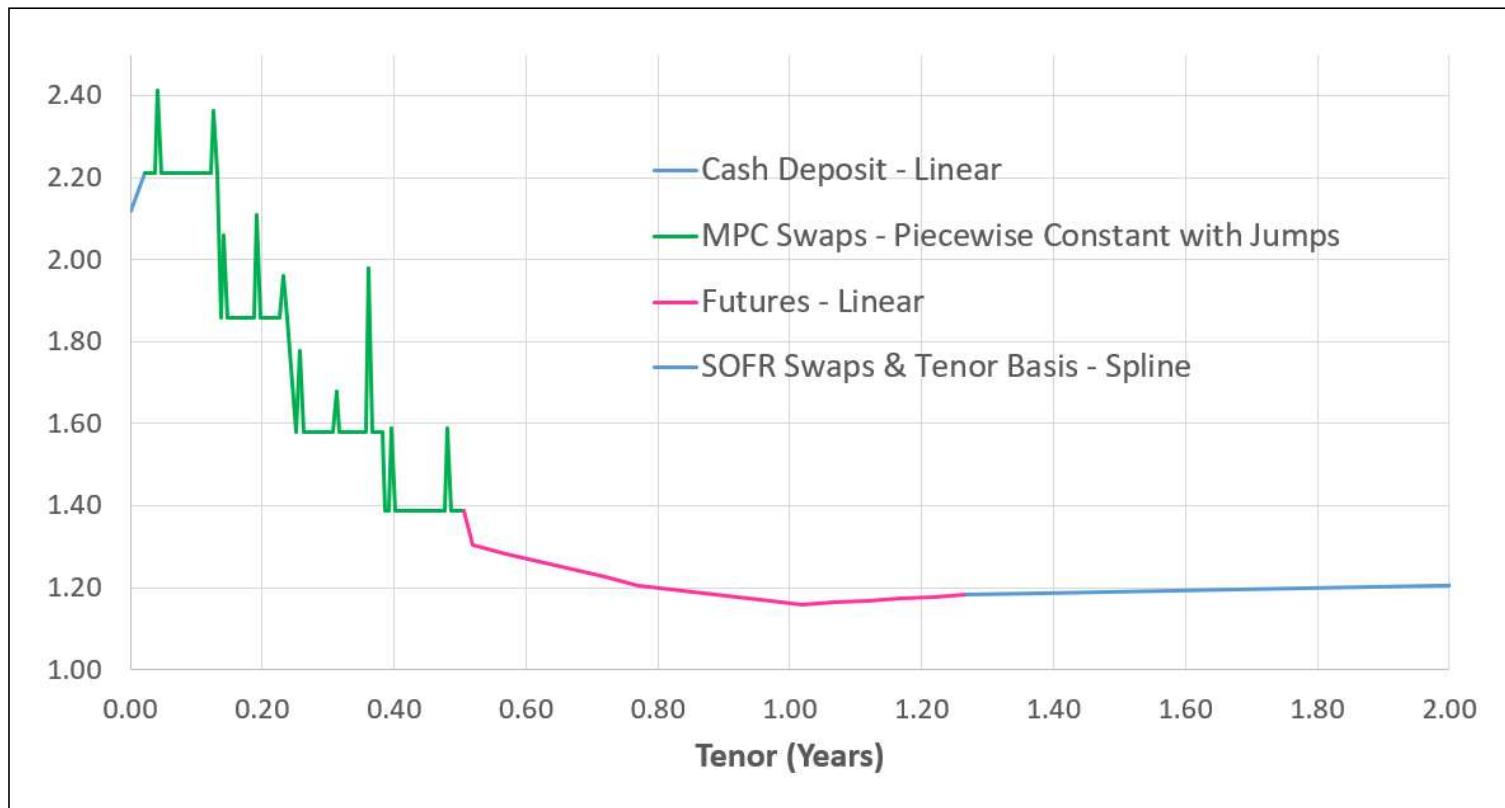


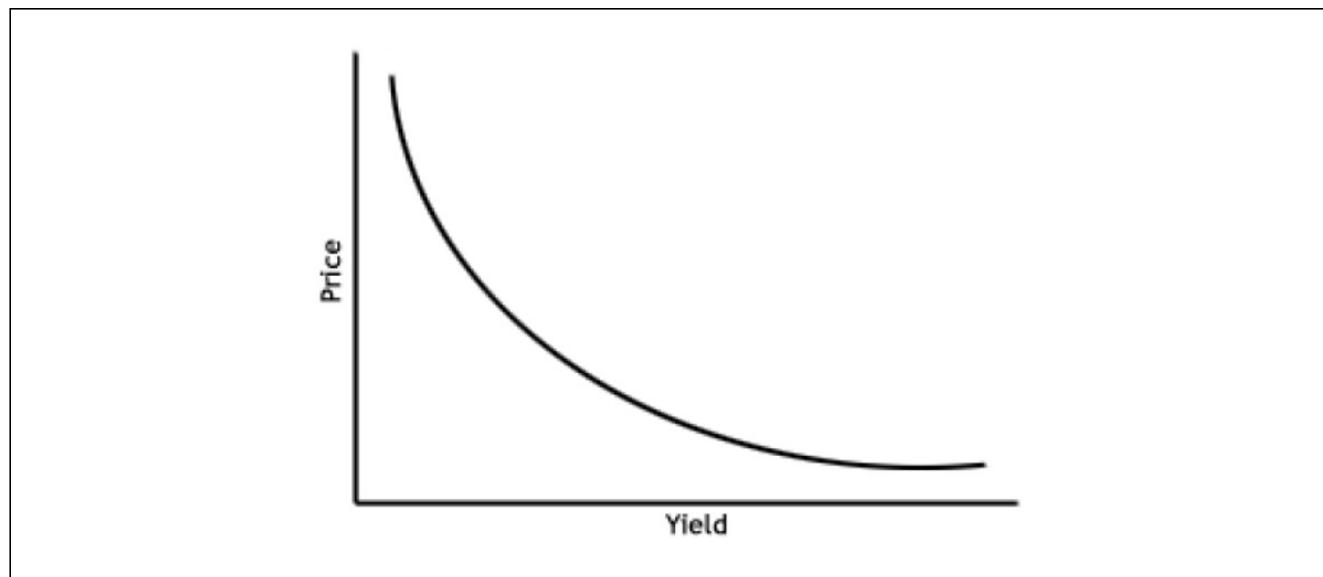
DV01 Decomposition

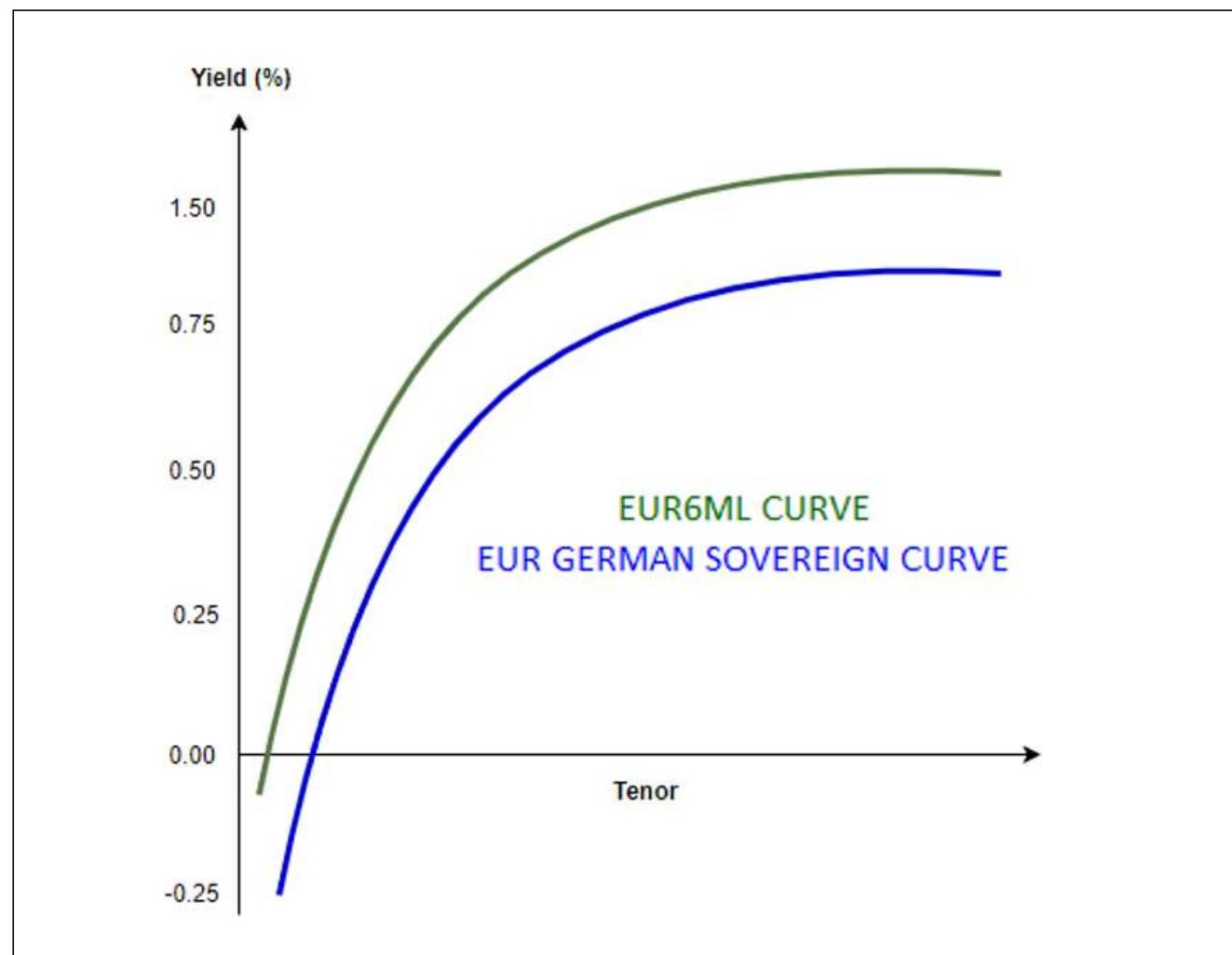
PV01	1,970.40	Forward Risk
DF01	32.44	Discount Risk
DV01	2,002.84	Total Risk

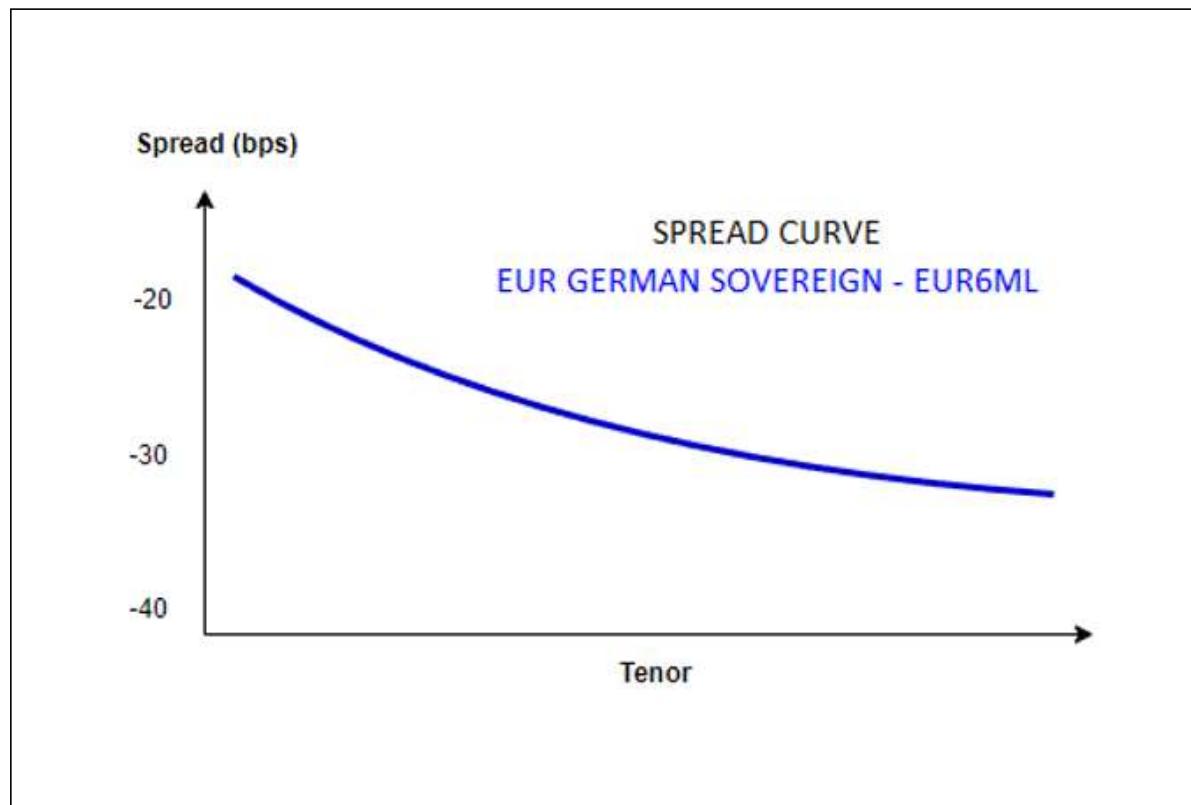


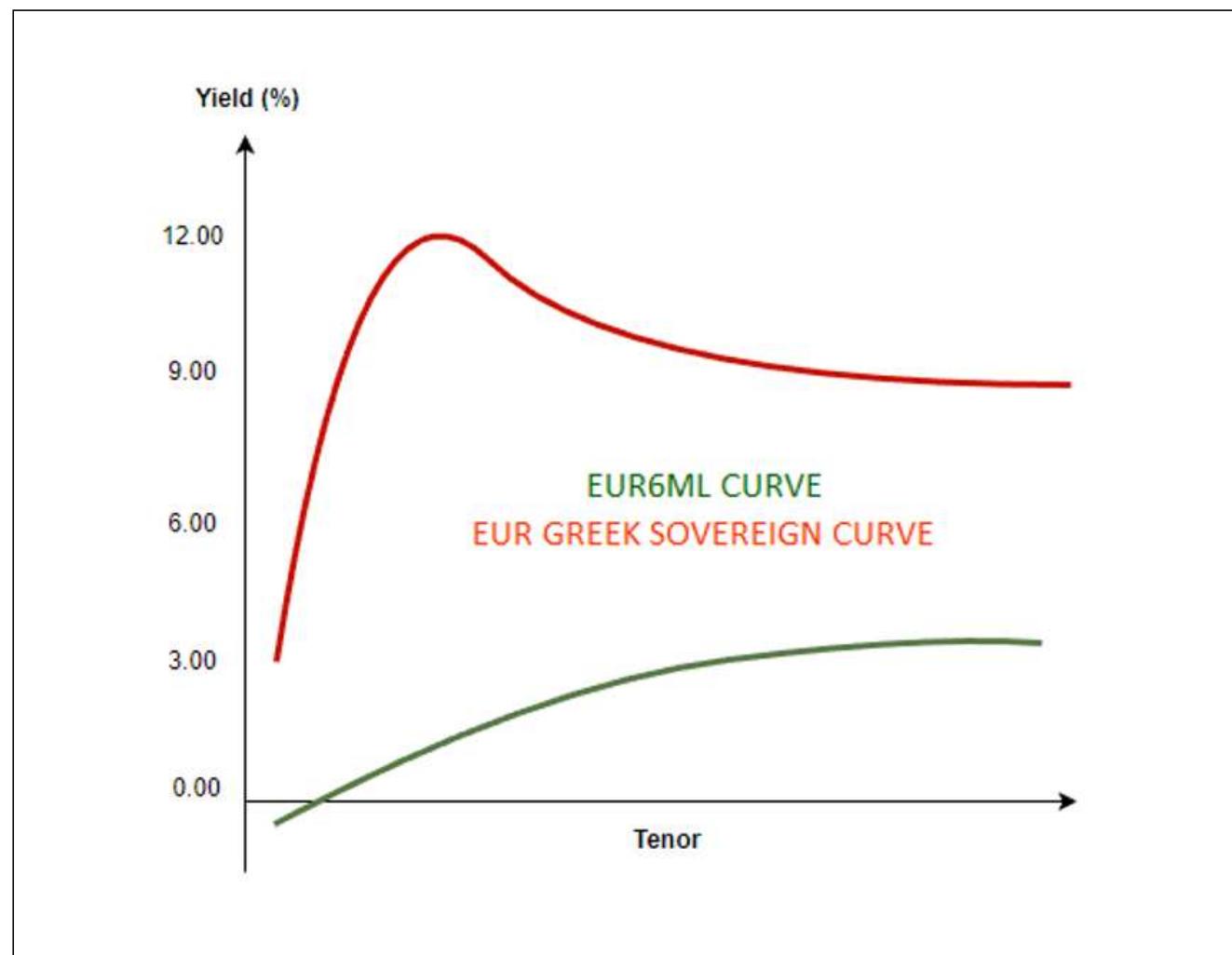
Chapter 9 – Asset Swap Structuring

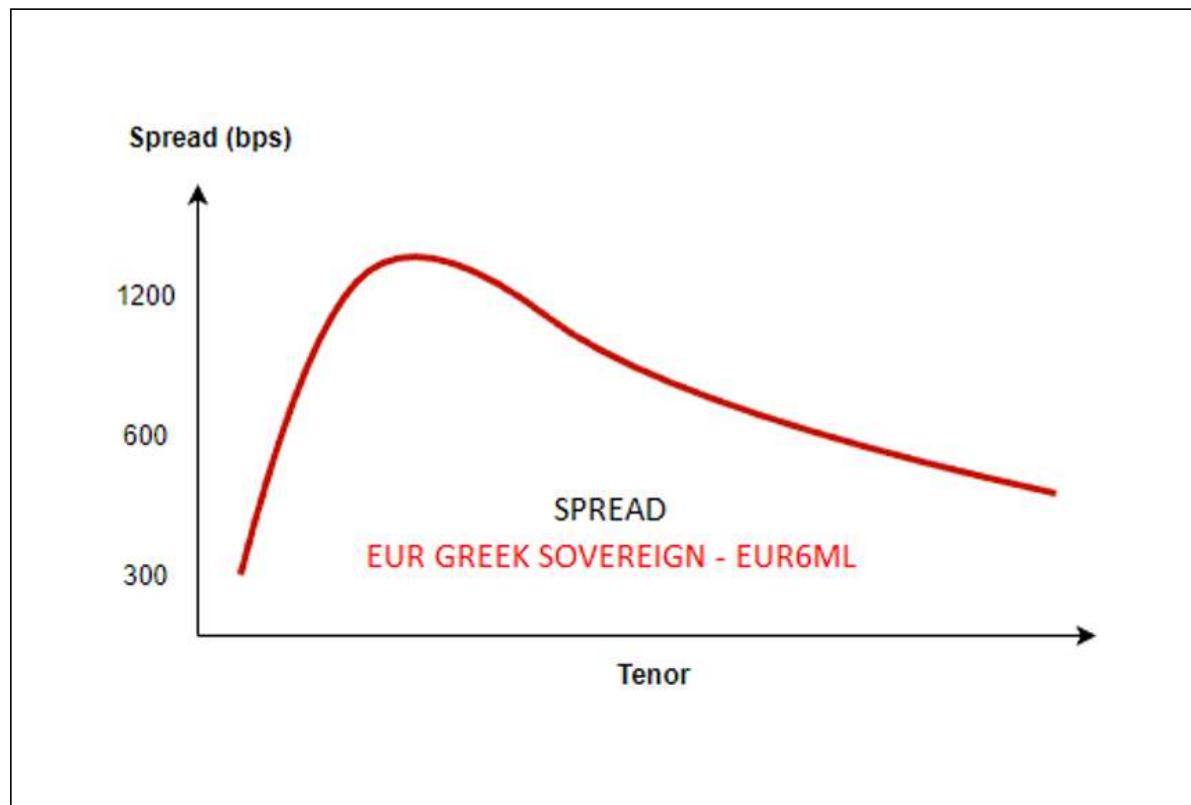


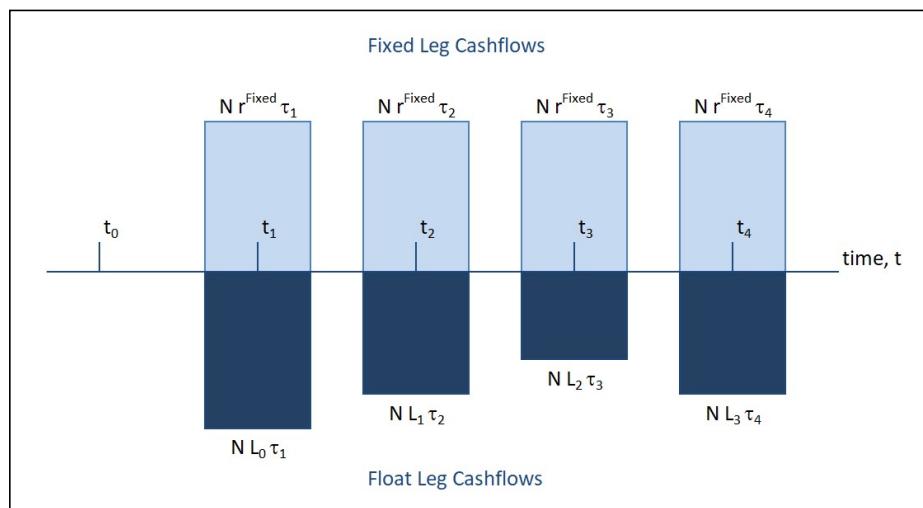








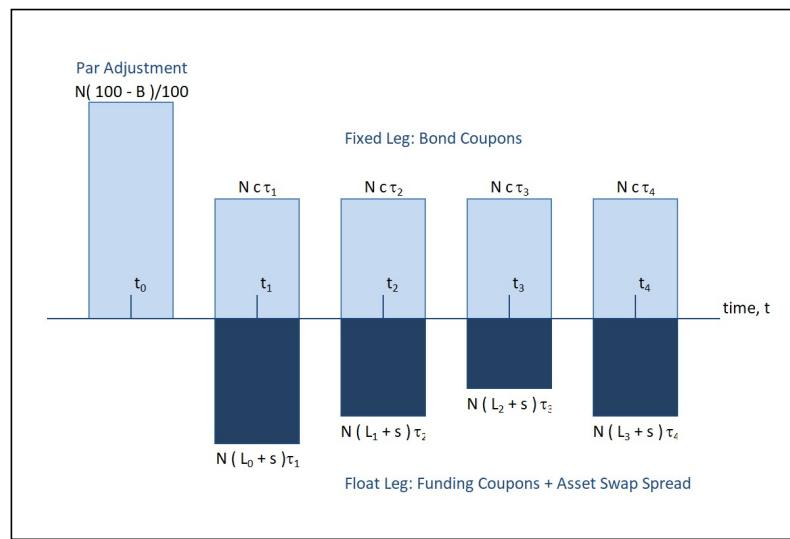


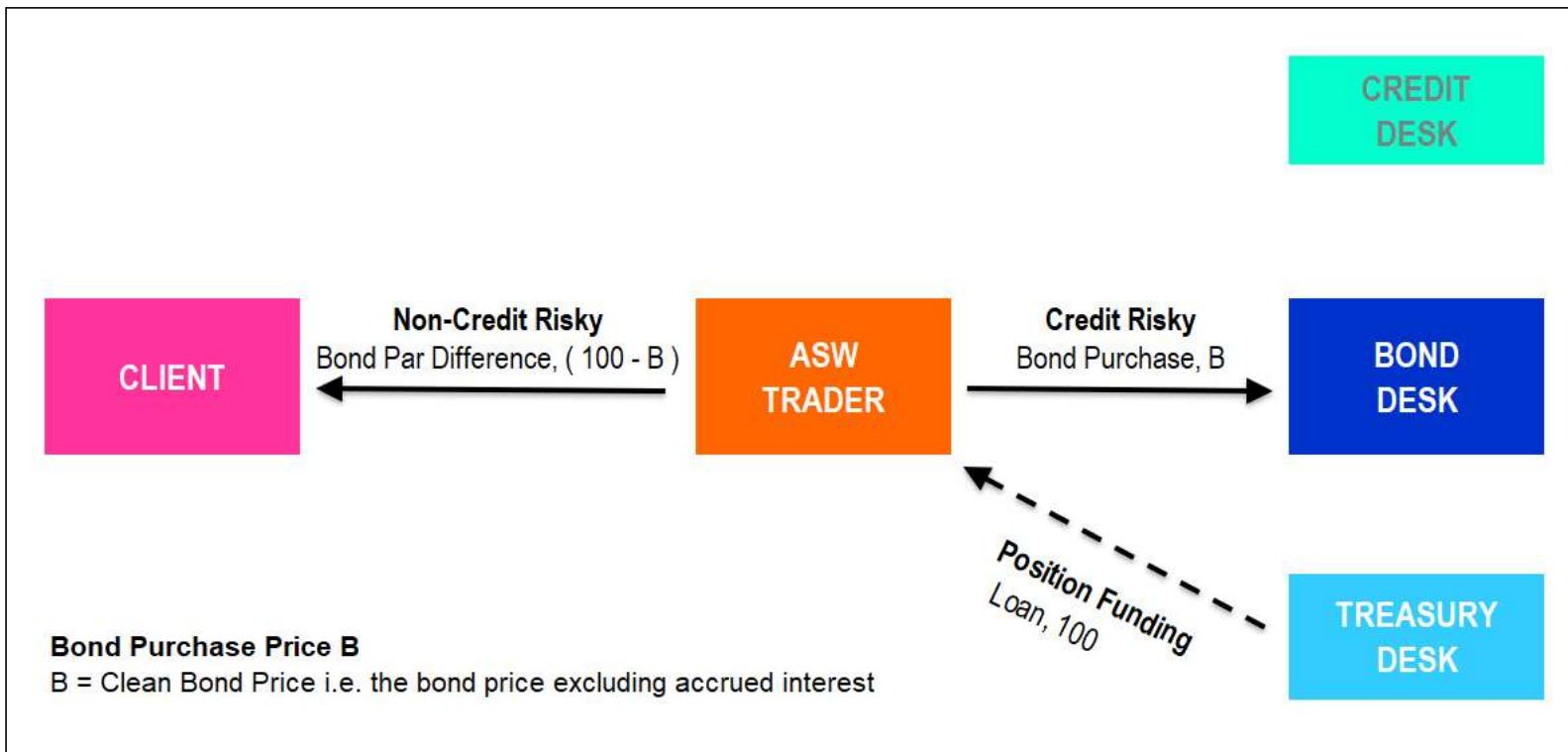


Year	UST Yield	Spread	Swap Rate
1Y	0.062%	0.105%	0.167%
2Y	0.225%	0.091%	0.316%
3Y	0.444%	0.099%	0.543%
5Y	0.786%	0.079%	0.865%
7Y	1.057%	0.012%	1.069%
10Y	1.261%	0.006%	1.267%
30Y	1.874%	-0.281%	1.593%

Spreads vs Treasuries				
Tenor	Bid	Ask	Change	
1Y	14.627	/	15.614	-0.794
2Y	9.991	/	10.374	+0.068
3Y	8.082	/	8.432	-0.262
4Y	5.250	/	5.535	-0.385
5Y	5.053	/	5.446	-0.360
6Y	2.500	/	2.875	-0.253
7Y	0.356	/	0.671	-0.308
8Y	0.503	/	0.809	-0.877
9Y	-0.125	/	0.500	-0.377
10Y	0.072	/	0.441	-0.471
12Y	6.113	/	6.424	-1.038
15Y	1.123	/	1.375	-0.563
20Y	-4.875	/	-4.500	-0.565
25Y	-13.500	/	-13.000	-1.125
30Y	-24.171	/	-23.786	-0.715

EUR 6M EURIBOR				
Tenor	Bid	/	Ask	Change
1Y	0.041	/	0.046	-0.002
18M	0.052	/	0.058	-0.002
2Y	0.075	/	0.080	-0.001
3Y	0.146	/	0.151	-0.001
4Y	0.241	/	0.246	-0.004
5Y	0.351	/	0.356	-0.004
6Y	0.470	/	0.475	-0.007
7Y	0.592	/	0.597	-0.009
8Y	0.711	/	0.716	-0.011
9Y	0.820	/	0.825	-0.014
10Y	0.917	/	0.922	-0.015
15Y	1.243	/	1.251	-0.024
20Y	1.377	/	1.385	-0.030
25Y	1.407	/	1.416	-0.035
30Y	1.413	/	1.423	-0.038



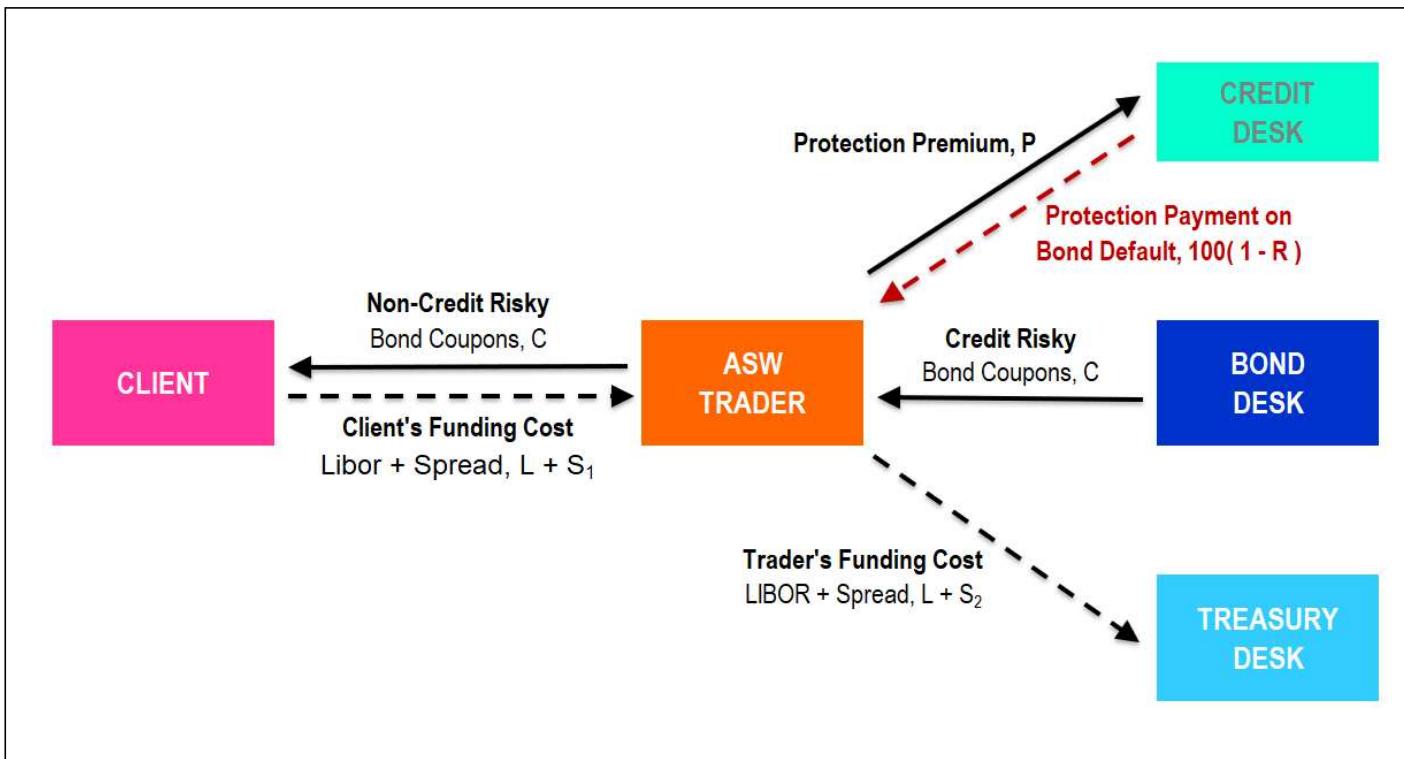


ASW Trader - Initial Cash Flows

Counterparty	Cash Flow	Description
Treasury Desk	+100	Loan Funds to purchase Bond
Bond Desk	- B	Bond Purchase (B = Clean Price)
Client	- (100 - B)	Difference
Net Cashflow	0	

Client - Initial Cash Flows

Counterparty	Cash Flow	Description
ASW Trader	(100 - B)	Credit / Debit difference arising from Position Funding and the Bond Purchase.
Net Cashflow	(100 - B)	



ASW Trader - Interim Cash Flows

Counterparty	Cash Flow	Description
Bond Desk	+ C	Bond Coupons
Treasury Desk	- (L+S ₂)	Funding Cost: Libor + Spread S ₂
Credit Desk	- P	Credit Protection Premium
Client	- C	Bond Coupons
Client	+ (L+S ₁)	Funding Cost: Libor + Spread S ₁
Net Cashflow	S ₁ - S ₂ - P	Difference between spreads [†]
	= F	This equals trader commission / fee (F)

Asset Swap Spread Details:

[†]Spreads $S_1 = S_2 + P + F$
 $S_1 > S_2$

ASW Trader - Cash Flows in the Event of a Bond Default

Counterparty	Cash Flow	Description
Credit Desk	+ 100 (1 - R)	Credit Protection in Event of Bond Default Where R = Recovery Rate % from Bond Default

Client - Interim Cash Flows

Counterparty	Cash Flow	Description
ASW Trader	+ C	Bond Coupons
ASW Trader	- (L+S ₁)	Funding Cost: Libor + Spread S ₁
Net Cashflow	C - (L + S ₁) Bond Coupons less Funding	

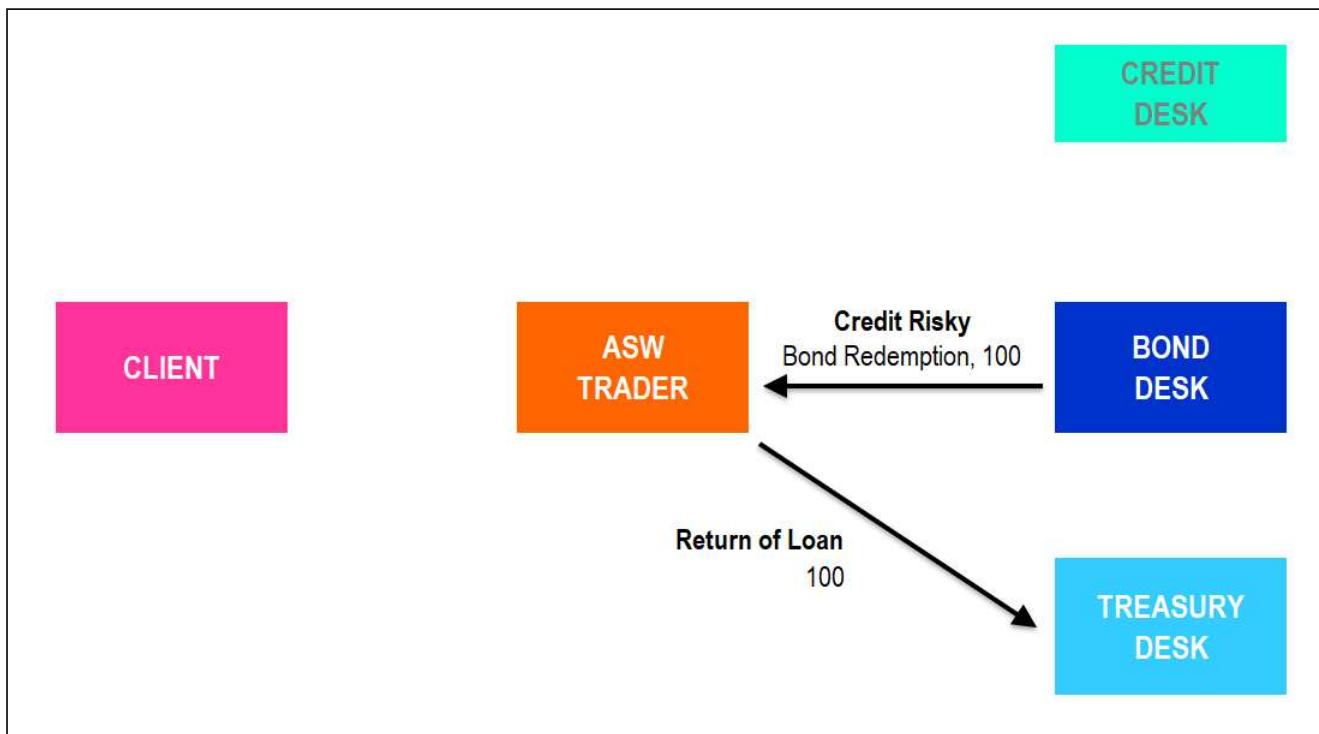
Asset Swap Spread Details:

Libor Spreads S₁ and S₂

$$S_1 > S_2$$

Spread S₁ includes funding spread (S₂), credit risk premium (P) and
trader commission / fee (F)

$$S_1 = S_2 + P + F$$



ASW Trader - Final Cash Flows at Maturity

Counterparty	Cash Flow	Description
Bond Desk	+100	Bond Redemption
Treasury Desk	-100	Return of Loan
Net Cashflow	0	

Client - Final Cash Flows at Maturity

Counterparty	Cash Flow	Description
None		
Net Cashflow	0	

Trade Template			USD IRS 5% USD3ML 5Y	
Swap	LEG1:FIXED		LEG2:FLOAT	
	Pay / Receive	RECEIVE	PAY	
	Notional	1,000,000	1,000,000	
	Currency	USD	USD	
	Effective Date	2D Tue, 25-Aug-2015	2D Tue, 25-Aug-2015	
	Maturity Date	5Y Tue, 25-Aug-2020	5Y Tue, 25-Aug-2020	
	Fixed Rate (%)	5.000000%		
	Float Index		3M USD3ML	
	Float Spread (bps)		0.000	
	Reset Frequency		QUARTERLY	
Pay Frequency	SEMI-ANNUAL		QUARTERLY	
Day Count	30/360		ACT/360	
Market				
Curve Date	Fri, 21-Aug-2015		Fri, 21-Aug-2015	
Forecast Curve			USD3ML	
Discount Curve	USDOIS		USDOIS	
Valuation Results				
Valuation Date	Fri, 21-Aug-2015			
Par Rate	1.548250%			
NPV	167,892.11			
PV01	486.40			
DV01	532.42			

Chapter 10 – Asset Swap Pricing Examples

Trade Template																																						
EUR ASW DBR 0.5% 15/02/26																																						
Bond																																						
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Valuation Results																																						
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Trade Template		EUR ASW GGB 3.0% 24/02/26																																				
Bond																																						
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EUR 6M EURIBOR				
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2Y	0.075	/	0.080	-0.001
3Y	0.146	/	0.151	-0.001
4Y	0.241	/	0.246	-0.004
5Y	0.351	/	0.356	-0.004
6Y	0.470	/	0.475	-0.007
7Y	0.592	/	0.597	-0.009
8Y	0.711	/	0.716	-0.011
9Y	0.820	/	0.825	-0.014
10Y	0.917	/	0.922	-0.015
15Y	1.243	/	1.251	-0.024
20Y	1.377	/	1.385	-0.030
25Y	1.407	/	1.416	-0.035
30Y	1.413	/	1.423	-0.038

Chapter 11 – Multiples Pricing, Trader Tricks & Rules of Thumb

Trade Template		EUR ASW DBR 0.5% 15/02/26	
Bond			
Bond		JW503423	
Description		DBR 0.5% 15/02/26	
Coupon (%)		0.500000%	
Cpn Frequency		ANNUAL	
Day Count		ACT/ACT	
Accrual Start Date		Thu, 15-Jan-2026	
Maturity Date		Sun, 15-Feb-2026	
Maturity Price		100.0000	
Price Type		CLEAN	
Price		104.5800	
Swap		LEG1:FIXED	
Pay / Receive	PAY	RECEIVE	
Notional	1,000,000	1,000,000	
Currency	EUR	EUR	
Effective Date	Fri, 15-Jan-2016	Fri, 15-Jan-2016	
Maturity Date	Sun, 15-Feb-2026	Tue, 25-Aug-2020	
Fixed Rate (%)	0.500000%		
Float Index	6M	EUR6ML	
Float Spread (bps)	0.000		
Reset Frequency		SEMI-ANNUAL	
Pay Frequency	ANNUAL	SEMI-ANNUAL	
Day Count	ACT/ACT	ACT/360	
Market			
Curve Date	Thu, 9-Jun-2016	Thu, 9-Jun-2016	
Forecast Curve		EUR6ML	
Discount Curve	EUROIS	EUROIS	
Valuation Results			
Settle Date	Mon, 13-Jun-2016		
Par Rate (%)	0.441040%		
Par-Par Spread (bps)	-40.6		
Yield-Yield Spread	-41.2		

Trade Template		EUR ASW GGB 3.0% 24/02/26			
Bond					
Bond					
Bond	EJ044543	LEG1:FIXED	LEG2:FLOAT		
Description	GGB 3% 24/02/26	PAY	RECEIVE		
Coupon (%)	3.000000%	1,000,000	1,000,000		
Cpn Frequency	ANNUAL	EUR	EUR		
Day Count	ACT/ACT	Wed, 24-Feb-2016	Wed, 24-Feb-2016		
Accrual Start Date		Tue, 24-Feb-2026	Tue, 24-Feb-2026		
Maturity Date		100.0000			
Maturity Price	CLEAN				
Price Type		75.2800			
Price					
Swap					
Pay / Receive					
Notional	1,000,000	LEG1:FIXED	LEG2:FLOAT		
Currency	EUR	PAY	RECEIVE		
Effective Date	Wed, 24-Feb-2016	1,000,000	1,000,000		
Maturity Date	Tue, 24-Feb-2026	EUR	EUR		
Fixed Rate (%)	3.000000%	Wed, 24-Feb-2016	Wed, 24-Feb-2016		
Float Index		5M	EUR6ML		
Float Spread (bps)		0.000			
Reset Frequency		SEMI-ANNUAL			
Pay Frequency	ANNUAL	SEMI-ANNUAL			
Day Count	ACT/ACT	ACT/360			
Market					
Curve Date		Thu, 9-Jun-2016	Thu, 9-Jun-2016		
Forecast Curve			EUR6ML		
Discount Curve		EUROIS	EUROIS		
Valuation Results					
Settle Date		Mon, 13-Jun-2016			
Par Rate (%)		0.444180%			
Par-Par Spread (bps)		573.8			
Yield-Yield Spread		682.4			

Trade Template		USD IRS 5% USD3ML 5Y	
Swap	LEG1:FIXED		LEG2:FLOAT
Pay / Receive	RECEIVE	PAY	
Notional	1,000,000	1,000,000	
Currency	USD	USD	
Effective Date	2D Tue, 25-Aug-2015	2D Tue, 25-Aug-2015	
Maturity Date	5Y Tue, 25-Aug-2020	5Y Tue, 25-Aug-2020	
Fixed Rate (%)	5.000000%		
Float Index		3M USD3ML	
Float Spread (bps)		0.000	
Reset Frequency		QUARTERLY	
Pay Frequency	SEMI-ANNUAL	QUARTERLY	
Day Count	30/360	ACT/360	
Market			
Curve Date	Fri, 21-Aug-2015	Fri, 21-Aug-2015	
Forecast Curve		USD3ML	
Discount Curve	USDOIS	USDOIS	
Valuation Results			
Valuation Date	Fri, 21-Aug-2015		
Par Rate	1.548250%		
NPV	167,892.11		
PV01	486.40		
DV01	532.42		

Trade Template			USD CDS 5% FORD MOTOR 5Y	
Swap	LEG1:PREMIUM		LEG2:PROTECTION	
	PAY		RECEIVE	
	10,000,000		10,000,000	
	USD		USD	
	US35370BX76		Ford Motor Company	
	IMM	Wed, 16-Mar-2016		
	5D	Mon, 23-May-2016	5D	Mon, 23-May-2016
	5Y	Tue, 16-Mar-2021	5Y	Tue, 16-Mar-2021
	500.000			
	QUARTERLY		40.000%	
Market				
Curve Date		Mon, 16-May-2016	Mon, 16-May-2016	
Credit Curve			USD_FORD_MOTOR_CO	
Discount Curve	USDOIS		USDOIS	
Valuation Results				
Valuation Date		Mon, 16-May-2016		
Par Spread (bps)		139.173800		
Clean PV		-1,669,036		
Accrued		-87,500		
Dirty PV		-1,786,536		
DV01		4,357.30		
CS01		4,951.24		

Trade Template

EUR ASW DBR 0.5% 15/02/26

Bond

Bond	JW503423
Description	DBR 0.5% 15/02/26
Coupon (%)	0.500000%
Cpn Frequency	ANNUAL
Day Count	ACT/ACT
Accrual Start Date	Thu, 15-Jan-2026
Maturity Date	Sun, 15-Feb-2026
Maturity Price	100.0000
Price Type	CLEAN
Price	104.5800

Swap

	LEG1:FIXED	LEG2:FLOAT
Pay / Receive	PAY	RECEIVE
Notional	1,000,000	1,000,000
Currency	EUR	EUR
Effective Date	Fri, 15-Jan-2016	Fri, 15-Jan-2016
Maturity Date	Sun, 15-Feb-2026	Tue, 25-Aug-2020
Fixed Rate (%)	0.500000%	
Float Index		6M EUR6ML
Float Spread (bps)		0.000
Reset Frequency		SEMI-ANNUAL
Pay Frequency	ANNUAL	SEMI-ANNUAL
Day Count	ACT/ACT	ACT/360

Market

Curve Date	Thu, 9-Jun-2016	Thu, 9-Jun-2016
Forecast Curve		EUR6ML
Discount Curve	EUROIS	EUROIS

Valuation Results

Settle Date	Mon, 13-Jun-2016
Par Rate (%)	0.441040%
Par-Par Spread (bps)	-40.6
Yield-Yield Spread	-41.2

Notional, N'	$Net Rate, r^{Net Bps}$	Maturity, T	Base Multiple	PV (USD)
1,000,000	1 bps	1.0	1	100
2,000,000	25 bps	2.0	100	10,000
5,000,000	50 bps	2.0	500	50,000
5,000,000	75 bps	2.0	750	75,000
10,000,000	100 bps	5.0	5000	500,000

Notional, N'	Maturity, T	Base Multiple	PV01 (USD)	DV01 (USD)
1,000,000	1.0	1	100	100
2,000,000	1.0	2	200	200
5,000,000	1.0	5	500	500
5,000,000	2.0	10	1,000	1,000
10,000,000	5.0	50	5,000	5,000

Actual Risk**Hedge Trade Risk****Hedge Trades**

Risk Bucket	IRS 1Y	IRS 2Y	IRS 3Y	IRS 4Y	IRS 5Y
OIS 1Y	0	0	0	0	0
OIS 2Y	0	0	0	0	0
OIS 3Y	0	0	0	0	0
OIS 4Y	0	0	0	0	0
OIS 5Y	0	0	0	0	0
IRS 1Y	98	0	0	0	0
IRS 2Y	0	195	0	0	0
IRS 3Y	0	0	291	0	0
IRS 4Y	0	0	0	386	0
IRS 5Y	0	0	0	0	479

Total Trade DV01

IRS 1Y	IRS 2Y	IRS 3Y	IRS 4Y	IRS 5Y
98	195	291	386	479



Actual Risk**Portfolio Risk - Trade Level**

Risk Bucket	IRS 1Y	IRS(4Y, 5Y)	IRS(4.5Y)
OIS 1Y	0	0	0
OIS 2Y	0	0	0
OIS 3Y	0	0	0
OIS 4Y	0	0	0
OIS 5Y	0	0	0
IRS 1Y	98	0	0
IRS 2Y	0	0	0
IRS 3Y	0	0	0
IRS 4Y	0	-386	193
IRS 5Y	0	479	239

Actual Risk**Portfolio Risk - Total**

Risk Bucket	Risk Total
OIS 1Y	0
OIS 2Y	0
OIS 3Y	0
OIS 4Y	0
OIS 5Y	0
IRS 1Y	98
IRS 2Y	0
IRS 3Y	0
IRS 4Y	-193
IRS 5Y	718

Actual Risk**Portfolio Hedges**

Hedge	Qty
OIS 1Y	0
OIS 2Y	0
OIS 3Y	0
OIS 4Y	0
OIS 5Y	0
IRS 1Y	-1
IRS 2Y	0
IRS 3Y	0
IRS 4Y	0.50
IRS 5Y	-1.50

Total Trade DV01

IRS 1Y	IRS(4Y, 5Y)	IRS(4.5Y)
98	93	432

Total DV01

624



Quick Risk**Hedge Trade Risk****Hedge Trades**

Risk Bucket	IRS 1Y	IRS 2Y	IRS 3Y	IRS 4Y	IRS 5Y
OIS 1Y	0	0	0	0	0
OIS 2Y	0	0	0	0	0
OIS 3Y	0	0	0	0	0
OIS 4Y	0	0	0	0	0
OIS 5Y	0	0	0	0	0
IRS 1Y	100	0	0	0	0
IRS 2Y	0	200	0	0	0
IRS 3Y	0	0	300	0	0
IRS 4Y	0	0	0	400	0
IRS 5Y	0	0	0	0	500

Total Trade DV01

IRS 1Y	IRS 2Y	IRS 3Y	IRS 4Y	IRS 5Y
100	200	300	400	500



Quick Risk**Portfolio Risk - Trade Level**

Risk Bucket	IRS 1Y	IRS(4Y, 5Y)	IRS(4.5Y)
OIS 1Y	0	0	0
OIS 2Y	0	0	0
OIS 3Y	0	0	0
OIS 4Y	0	0	0
OIS 5Y	0	0	0
IRS 1Y	100	0	0
IRS 2Y	0	0	0
IRS 3Y	0	0	0
IRS 4Y	0	-400	200
IRS 5Y	0	500	250

Quick Risk**Portfolio Risk - Total**

Risk Bucket	Risk Total
OIS 1Y	0
OIS 2Y	0
OIS 3Y	0
OIS 4Y	0
OIS 5Y	0
IRS 1Y	100
IRS 2Y	0
IRS 3Y	0
IRS 4Y	-200
IRS 5Y	750

Quick Risk**Portfolio Hedges**

Hedge	Qty
OIS 1Y	0
OIS 2Y	0
OIS 3Y	0
OIS 4Y	0
OIS 5Y	0
IRS 1Y	-1
IRS 2Y	0
IRS 3Y	0
IRS 4Y	0.50
IRS 5Y	-1.50

Total Trade DV01

IRS 1Y	IRS(4Y, 5Y)	IRS(4.5Y)
100	100	450

Total DV01

650



EUR 6M EURIBOR				
Tenor	Bid	/	Ask	Change
1Y	0.041	/	0.046	-0.002
18M	0.052	/	0.058	-0.002
2Y	0.075	/	0.080	-0.001
3Y	0.146	/	0.151	-0.001
4Y	0.241	/	0.246	-0.004
5Y	0.351	/	0.356	-0.004
6Y	0.470	/	0.475	-0.007
7Y	0.592	/	0.597	-0.009
8Y	0.711	/	0.716	-0.011
9Y	0.820	/	0.825	-0.014
10Y	0.917	/	0.922	-0.015
15Y	1.243	/	1.251	-0.024
20Y	1.377	/	1.385	-0.030
25Y	1.407	/	1.416	-0.035
30Y	1.413	/	1.423	-0.038

References

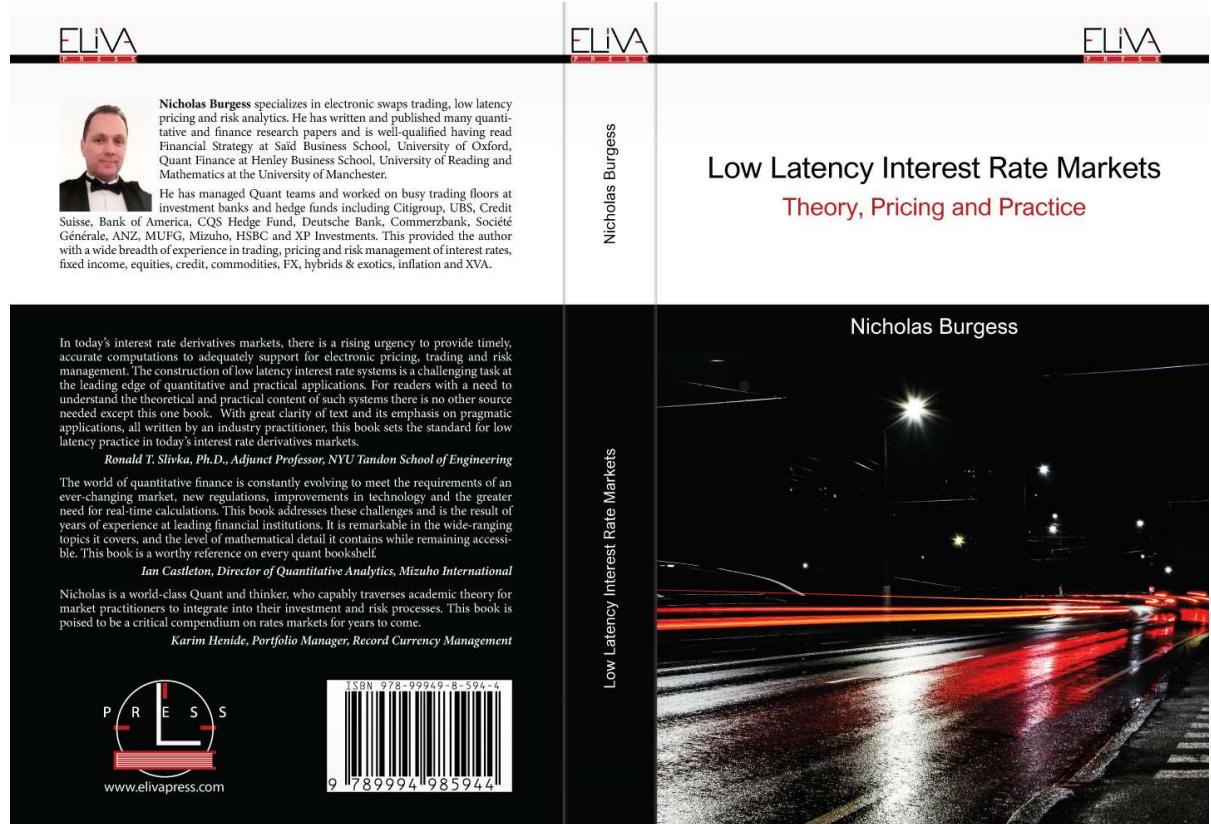


Quant Research Papers

<https://ssrn.com/author=1728976>

Support Materials, C++ & Excel Examples

<https://github.com/nburgessx/SwapsBook>



The image shows the front cover of the book "Low Latency Interest Rate Markets: Theory, Pricing and Practice" by Nicholas Burgess. The cover is white with black text. At the top right is the ELiVA PRESS logo. Below it is the title "Low Latency Interest Rate Markets" in bold, followed by "Theory, Pricing and Practice" in a smaller font. In the center is a portrait photo of the author, Nicholas Burgess, wearing a tuxedo and bow tie. To the left of the photo is a short bio: "Nicholas Burgess specializes in electronic swaps trading, low latency pricing and risk analytics. He has written and published many quantitative and finance research papers and is well-qualified having read Financial Strategy at Said Business School, University of Oxford, Quant Finance at Henley Business School, University of Reading and Mathematics at the University of Manchester." Below the bio is a paragraph about his professional experience: "He has managed Quant teams and worked on busy trading floors at investment banks and hedge funds including Citigroup, UBS, Credit Suisse, Bank of America, COS Hedge Fund, Deutsche Bank, Commerzbank, Société Générale, ANZ, MUFG, Mizuho, HSBC and XP Investments. This provided the author with a wide breadth of experience in trading, pricing and risk management of interest rates, fixed income, equities, credit, commodities, FX, hybrids & exotics, inflation and XVA." At the bottom left is a quote from Ronald T. Slivka: "In today's interest rate derivatives markets, there is a rising urgency to provide timely, accurate computations to adequately support for electronic pricing, trading and risk management. The construction of low latency interest rate systems is a challenging task at the leading edge of quantitative and practical applications. For readers with a need to understand the theoretical and practical content of such systems there is no other source needed except this one book. With great clarity of text and its emphasis on pragmatic applications, all written by an industry practitioner, this book sets the standard for low latency practice in today's interest rate derivatives markets." Below that is another quote from Ian Castleton: "The world of quantitative finance is constantly evolving to meet the requirements of an ever-changing market, new regulations, improvements in technology and the greater need for real-time calculations. This book addresses these challenges and is the result of years of experience at leading financial institutions. It is remarkable in the wide-ranging topics it covers, and the level of mathematical detail it contains while remaining accessible. This book is a worthy reference on every quant bookshelf." At the very bottom left is a quote from Karim Henide: "Nicholas is a world-class Quant and thinker, who capably traverses academic theory for market practitioners to integrate into their investment and risk processes. This book is poised to be a critical compendium on rates markets for years to come." On the right side of the cover, the author's name "Nicholas Burgess" is printed vertically. The bottom right corner features a photograph of a city street at night with blurred lights from moving vehicles.

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<https://www.amazon.co.uk/dp/9994985949>