



Low Latency Interest Rate Markets Theory, Pricing & Practice



Nicholas Burgess

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>

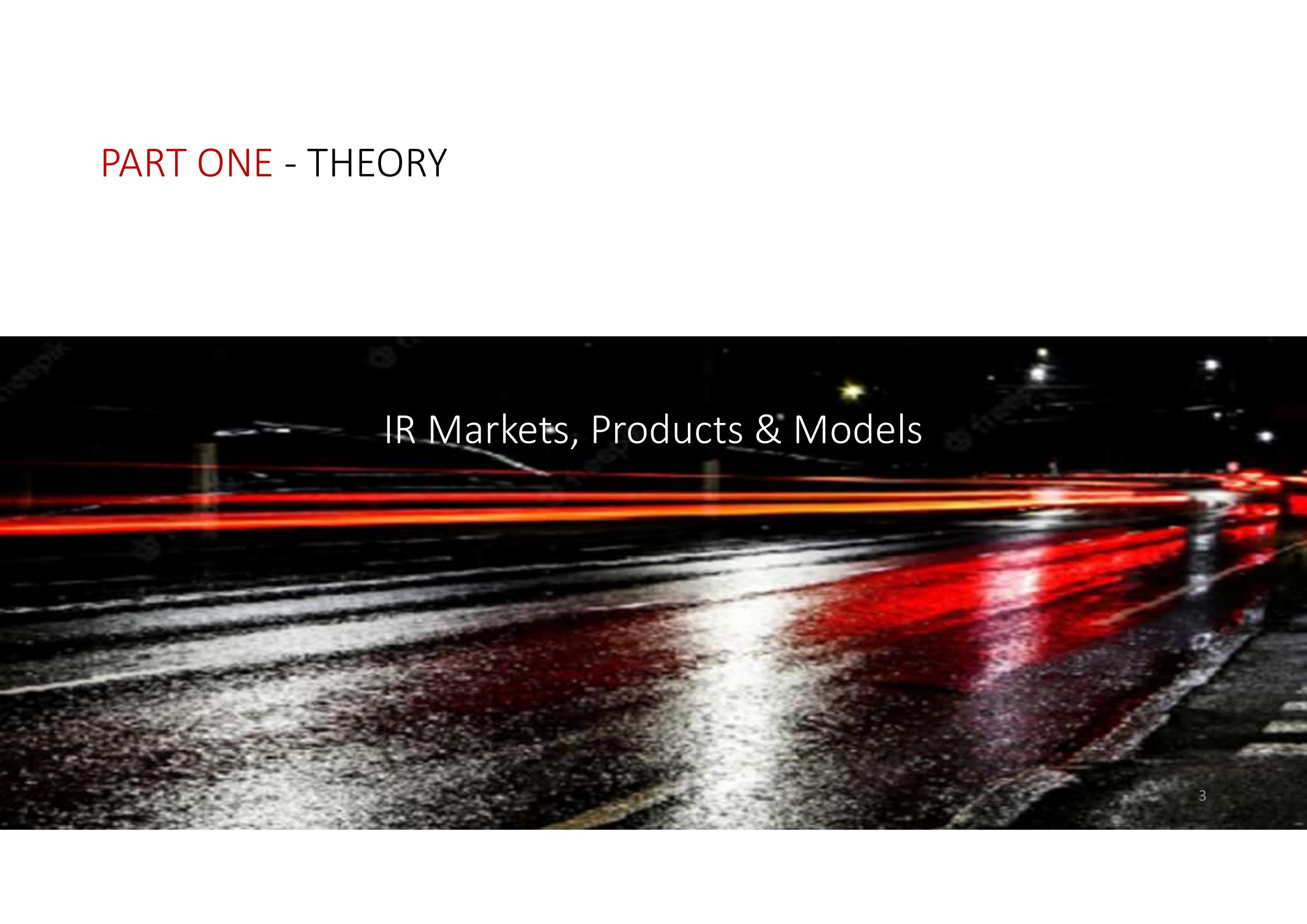
PART TWO: Pricing & Practice

Case Studies

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

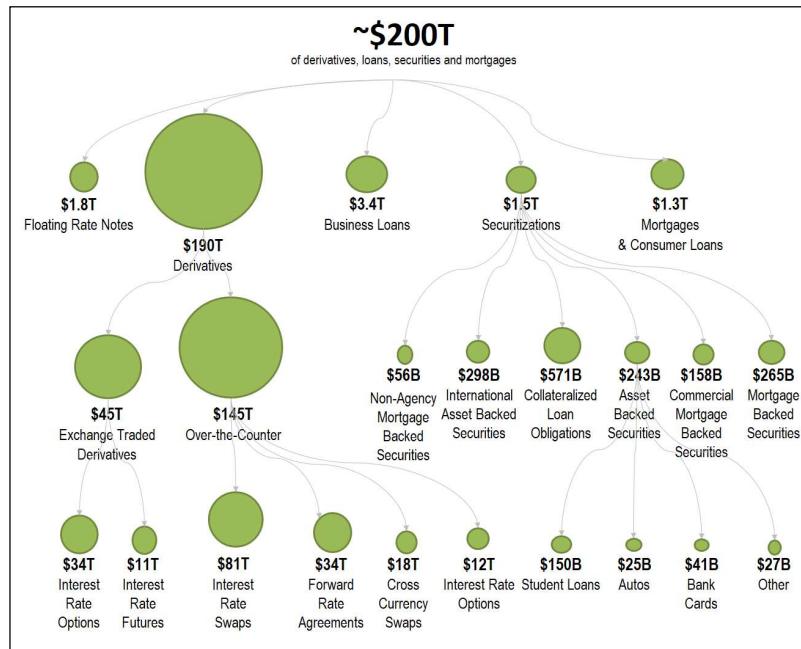


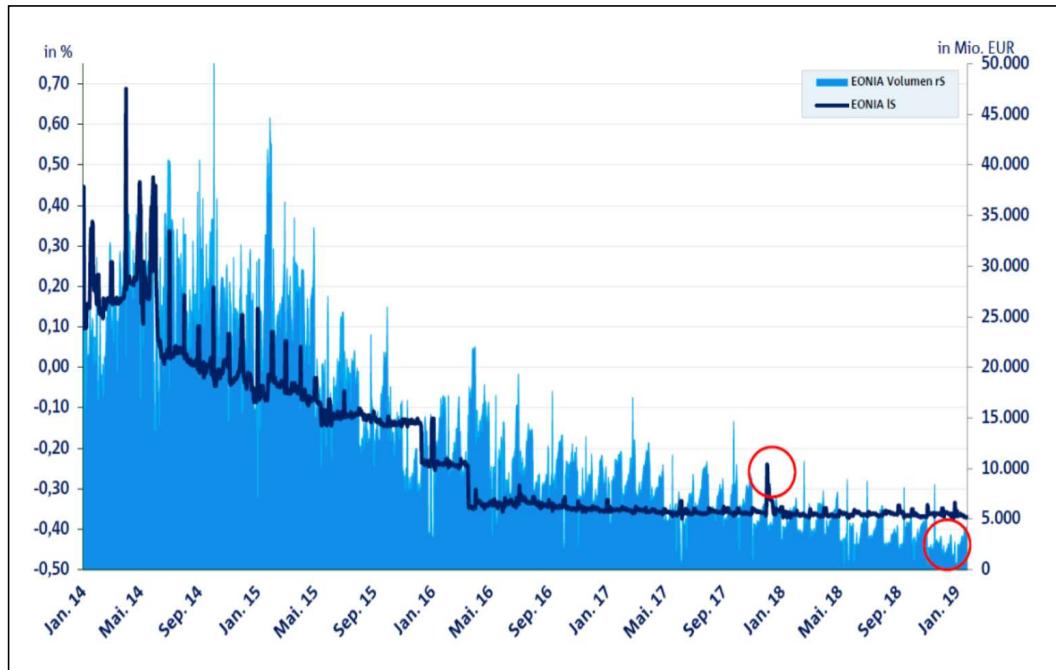
PART ONE - THEORY

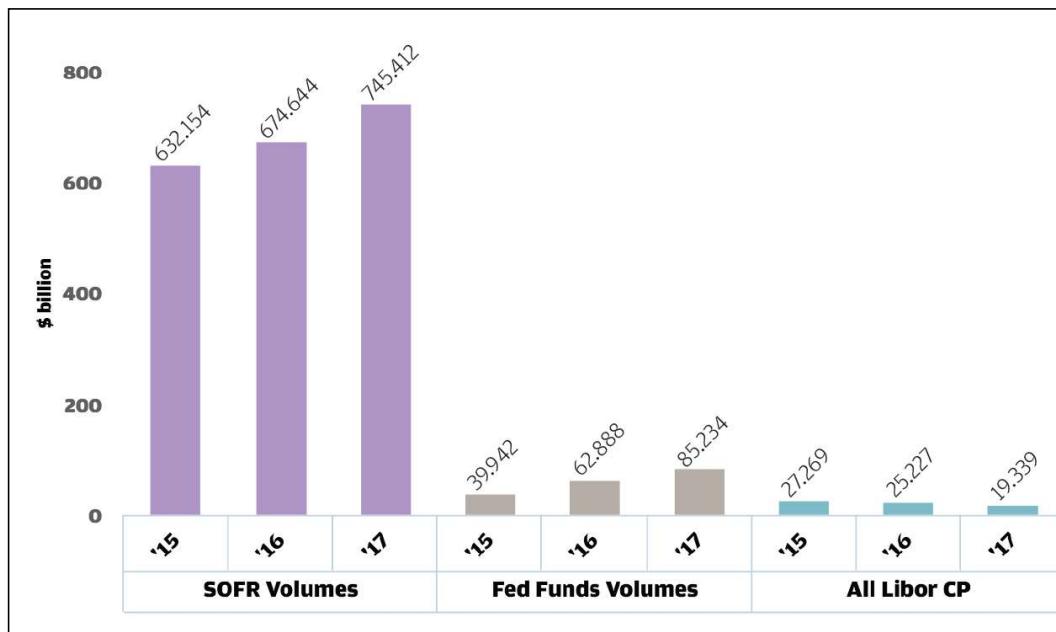
A blurred night photograph of a city street. The image shows streaks of red and orange light from moving vehicles, creating a sense of motion blur. The background is dark, and some distant lights are visible.

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.

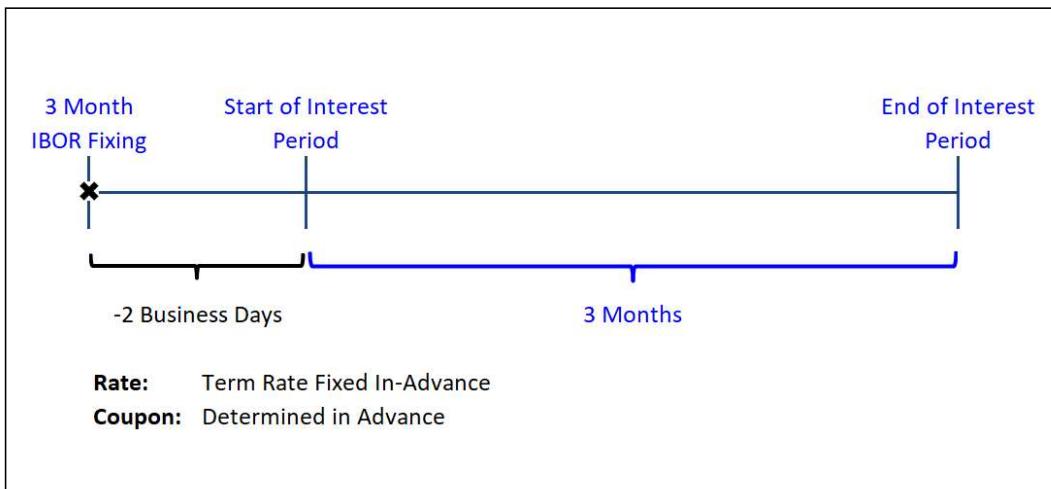
Sources: ECB; Bank of Japan; Bank of England; Federal Reserve Bank of New York; Financial Stability Board; Bank of America Merrill Lynch; International Swaps and Derivatives Association.

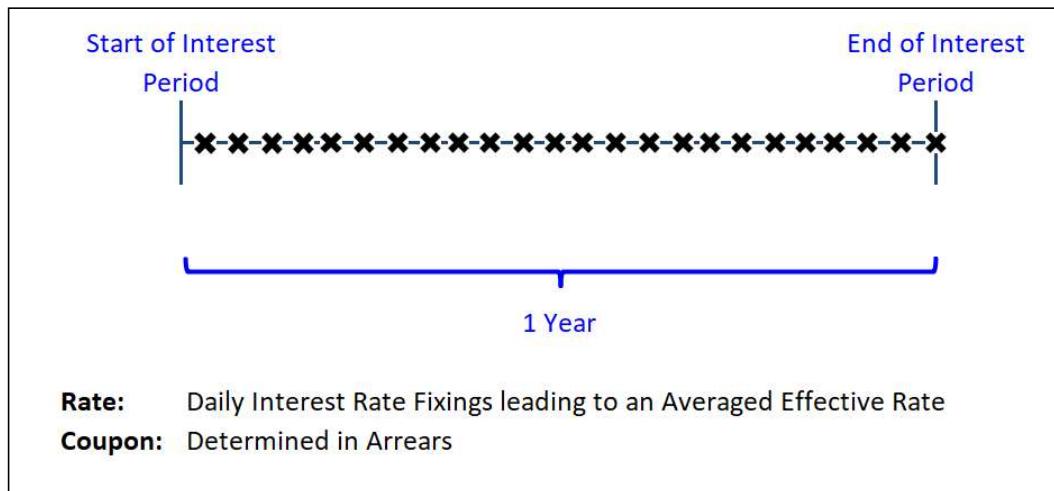
LIBOR

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

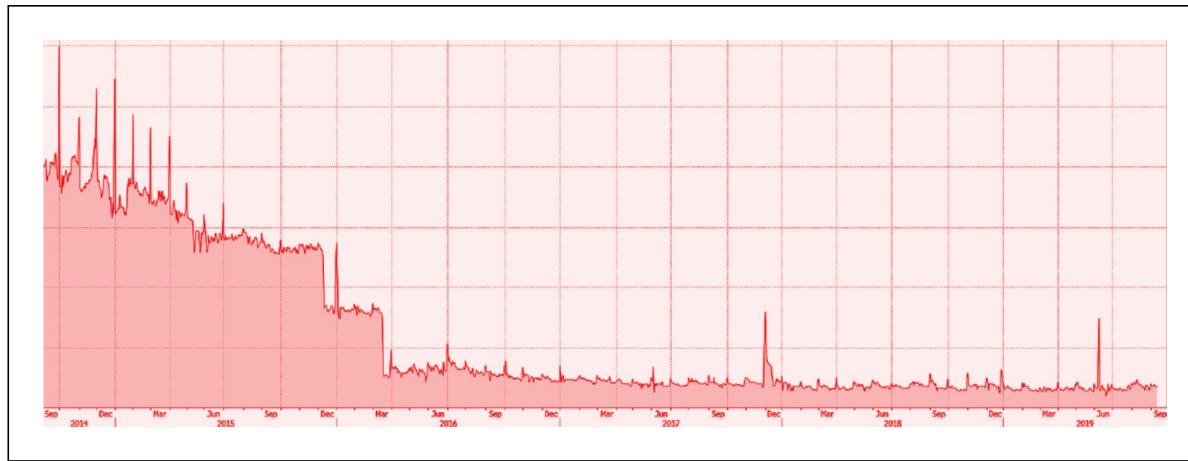
SOFR

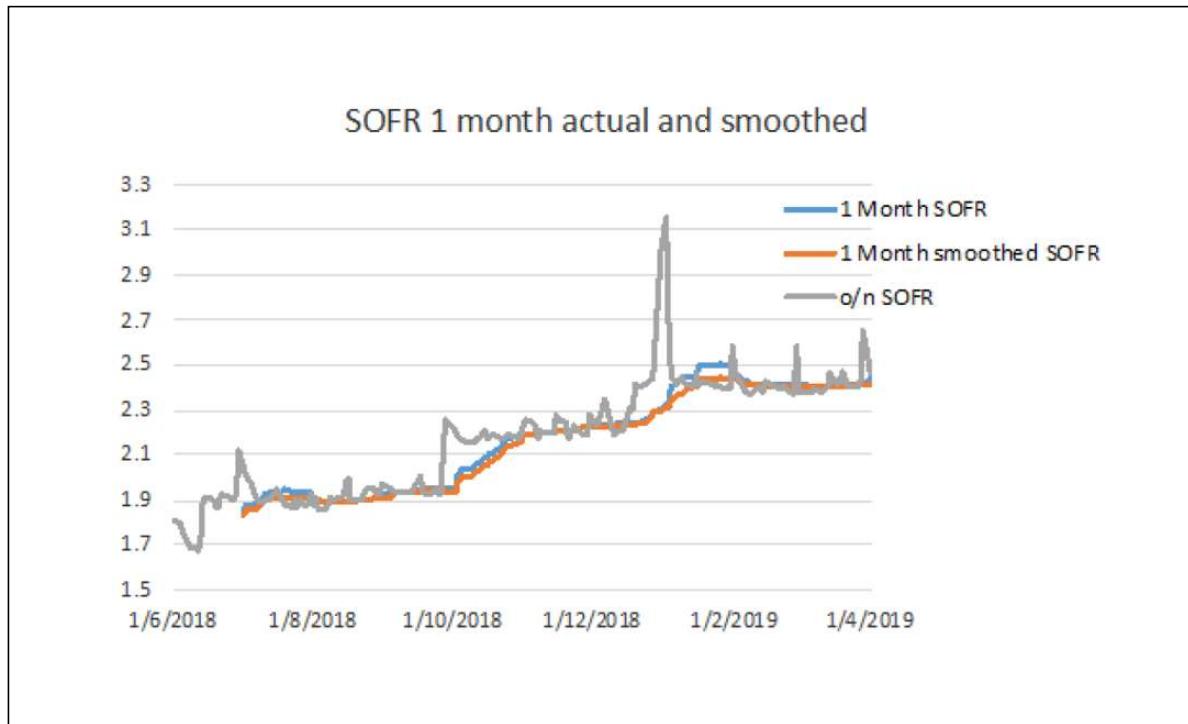
1. Secured rate
2. Overnight
3. Minimal credit risk
4. Wholly transaction-based
5. \$750 billion underlying transactions



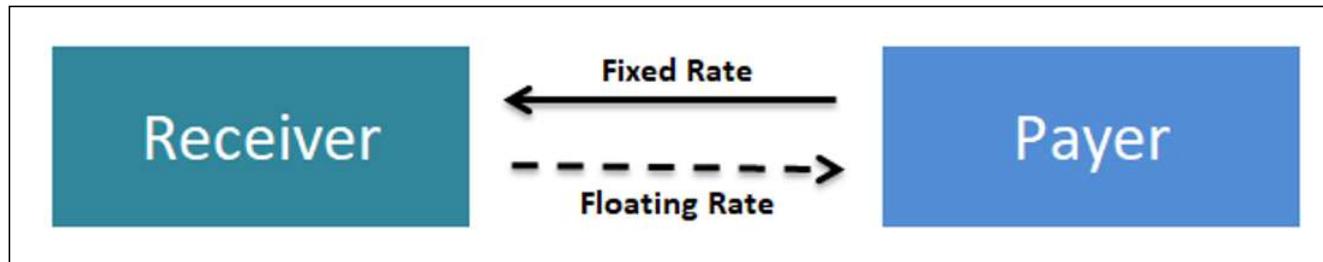


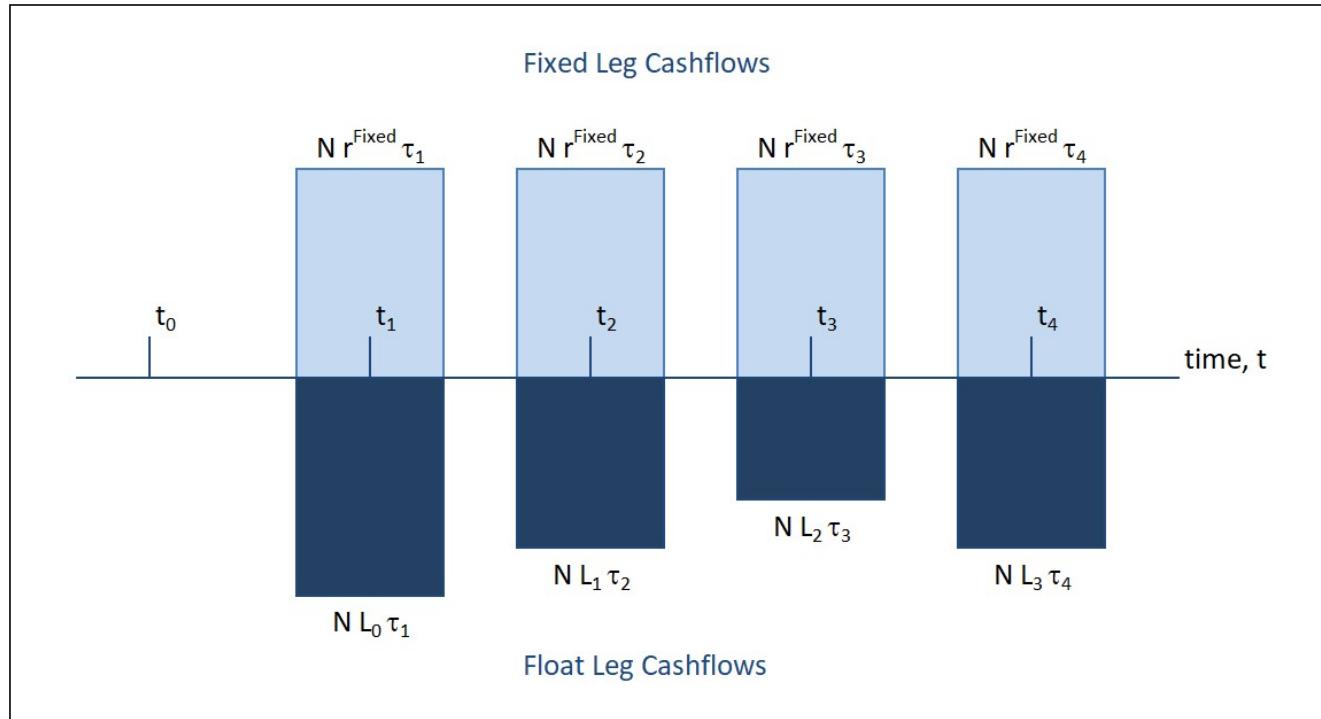


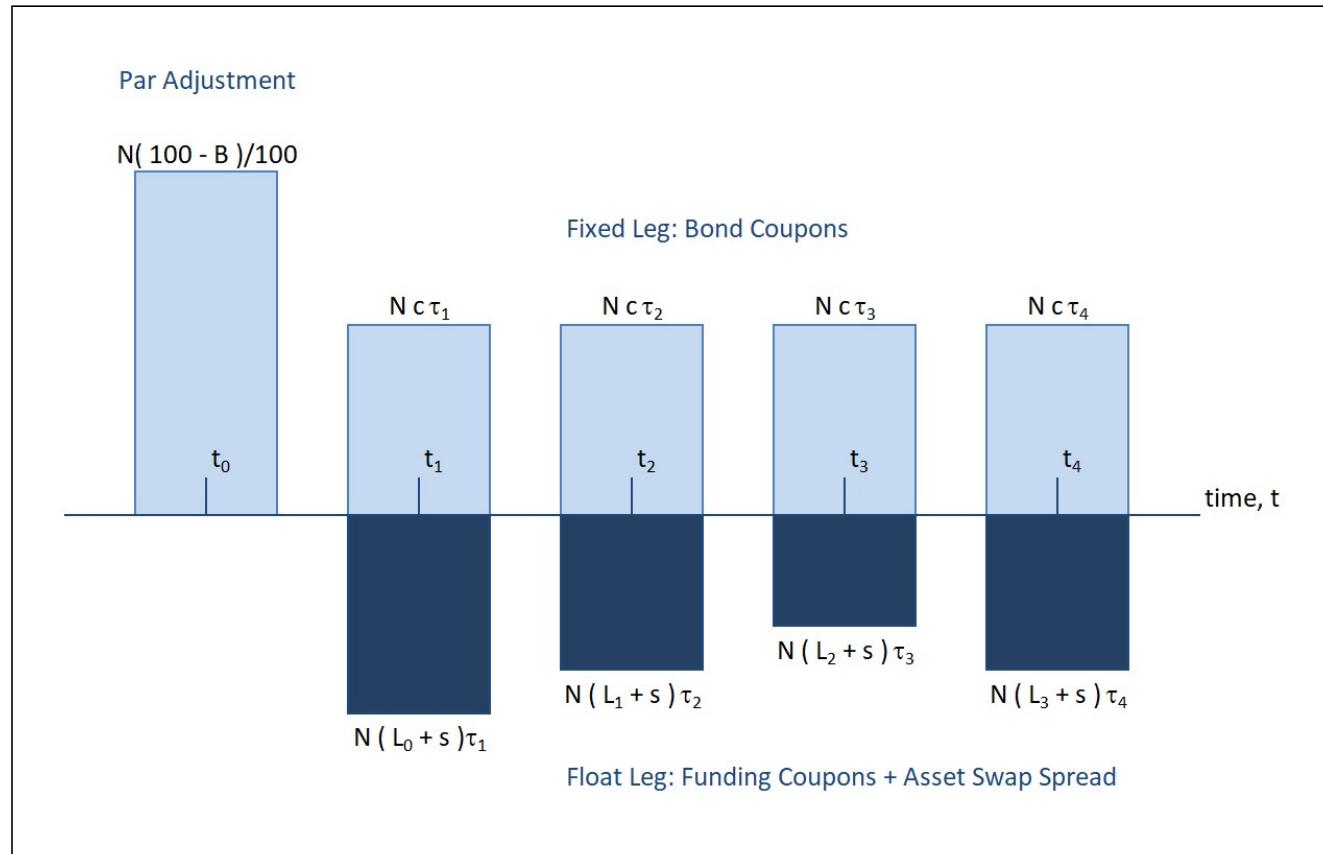




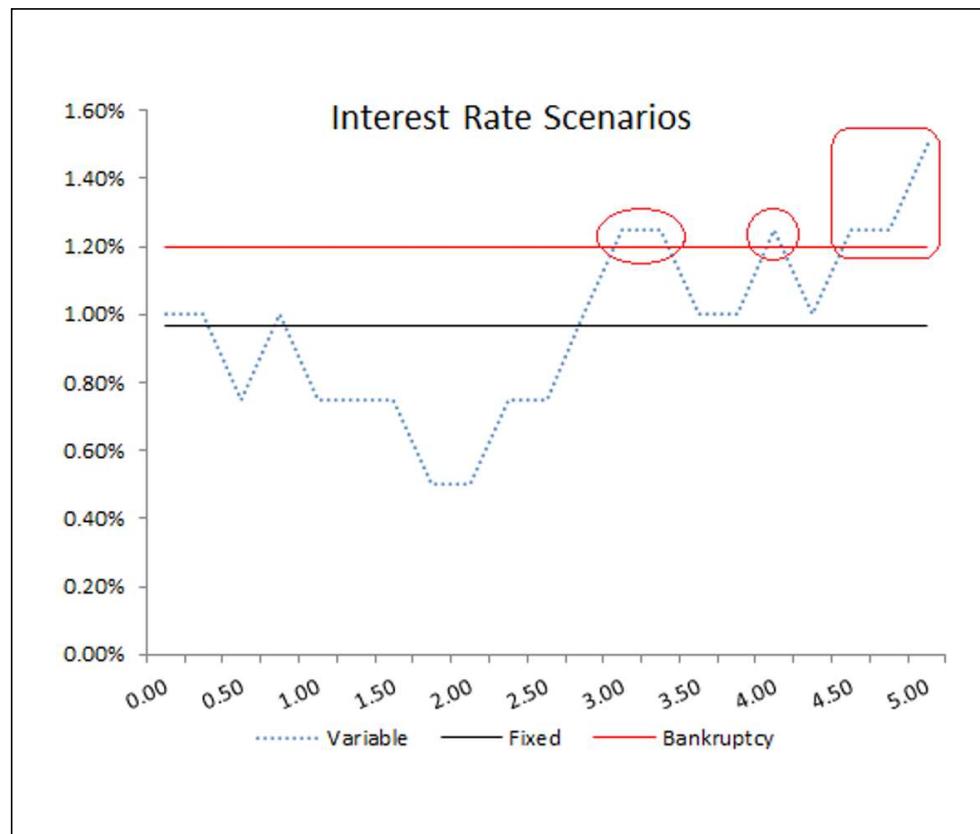
Chapter 2 – Introduction to Interest Rate Swaps







Chapter 3 – Interest Rate Products & Pricing

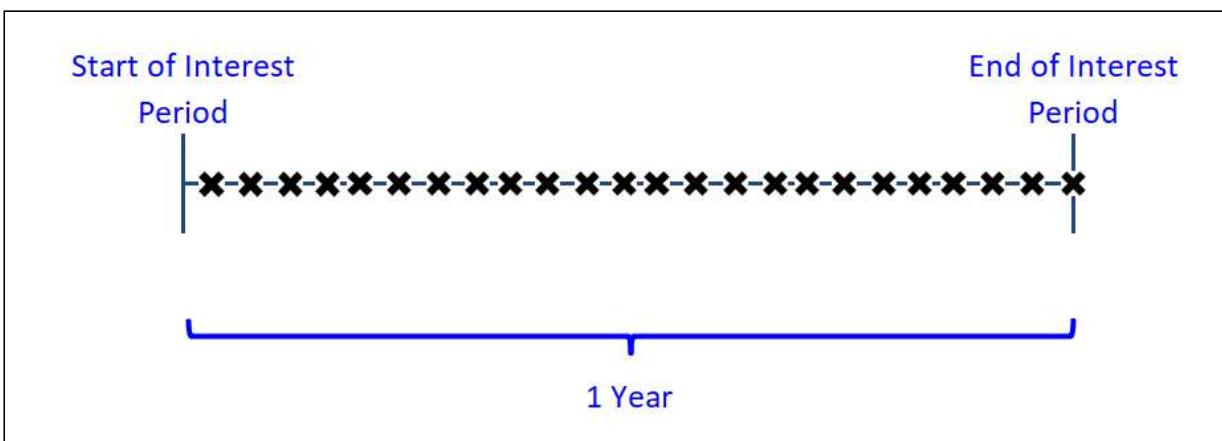


| Swap PV | | \$0 | | Float Leg | | \$75,000 | | Fixed Leg | | \$75,000 | |
|---------|-------------|-------------------|--------------------------|--------------------|----------|----------|-------------|---------------|--------------------------|--------------------|----------|
| time, t | Notional, 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 | Notional | Fixed (%) | Spread (bps) | Maturity | Trade Handle |
|----------------|---------|-----------|-----------|--------------|----------|---------------|
| | Fixed | | | | | |
| 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 |

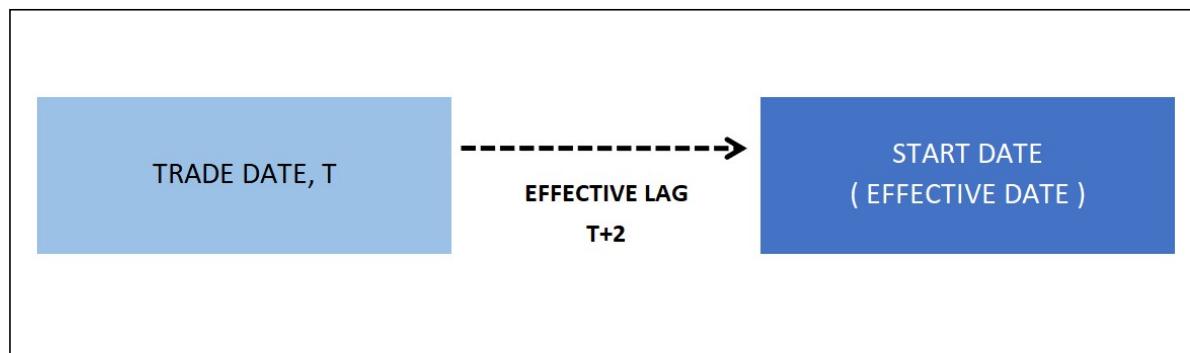
| | | |
|------------------------|-----------------------|----------------------------|
| Arithmetic Rate | Geometric Rate | Fast Geometric Rate |
| 2.6646% | 2.6673% | 2.6673% |

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



| 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

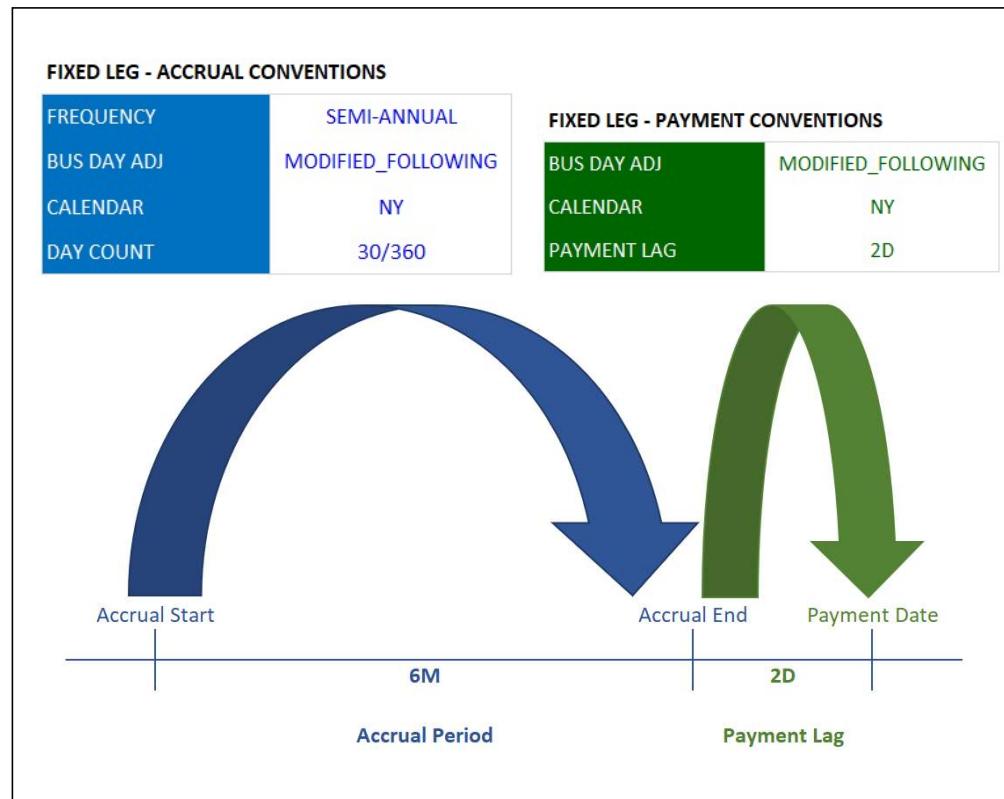
| | |
|-------------|--------------------|
| FREQUENCY | SEMI-ANNUAL |
| BUS DAY ADJ | MODIFIED_FOLLOWING |
| CALENDAR | NY |
| DAY COUNT | 30/360 |

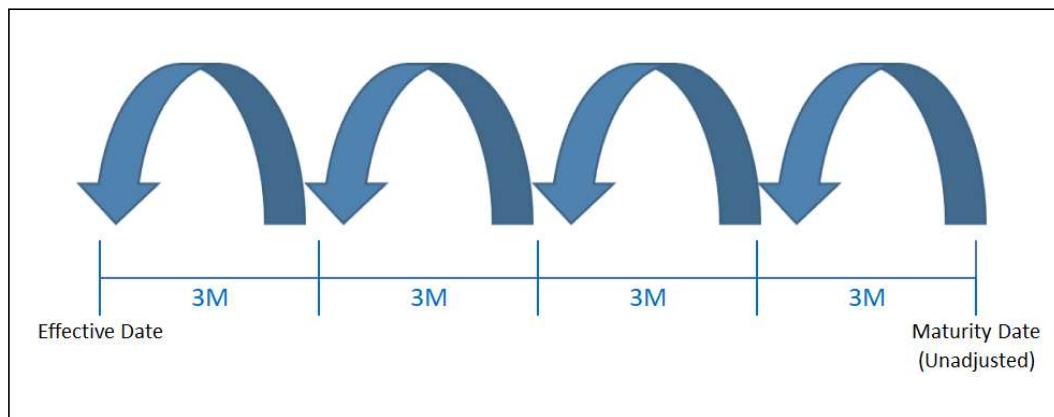
FLOAT LEG - PAYMENT CONVENTIONS

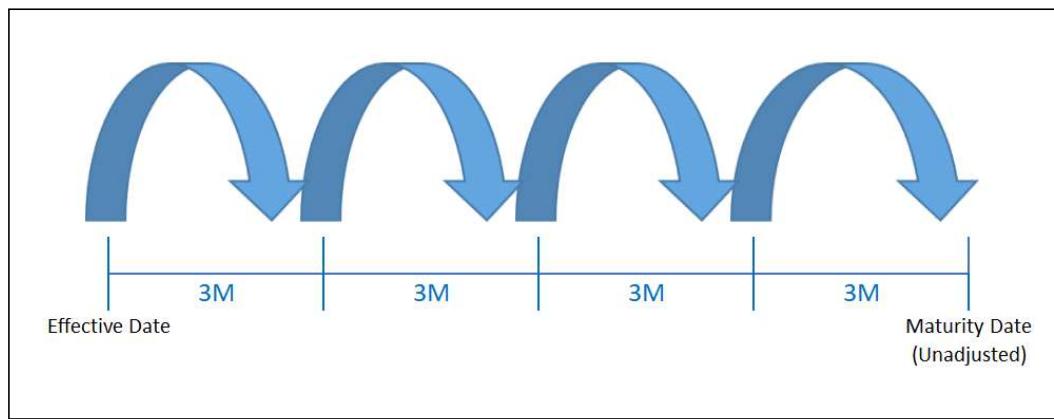
| | |
|-------------|--------------------|
| BUS DAY ADJ | MODIFIED_FOLLOWING |
| CALENDAR | NY |
| PAYMENT LAG | 2D |

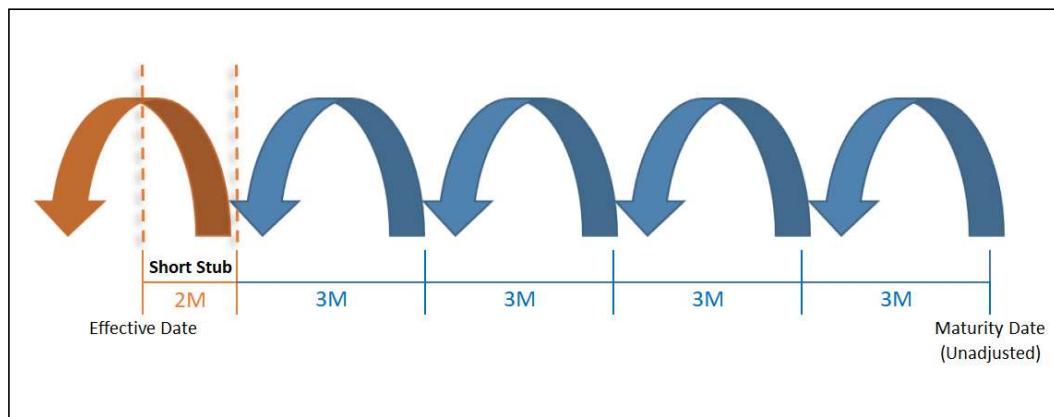
FIXED LEG - PAYMENT CONVENTIONS

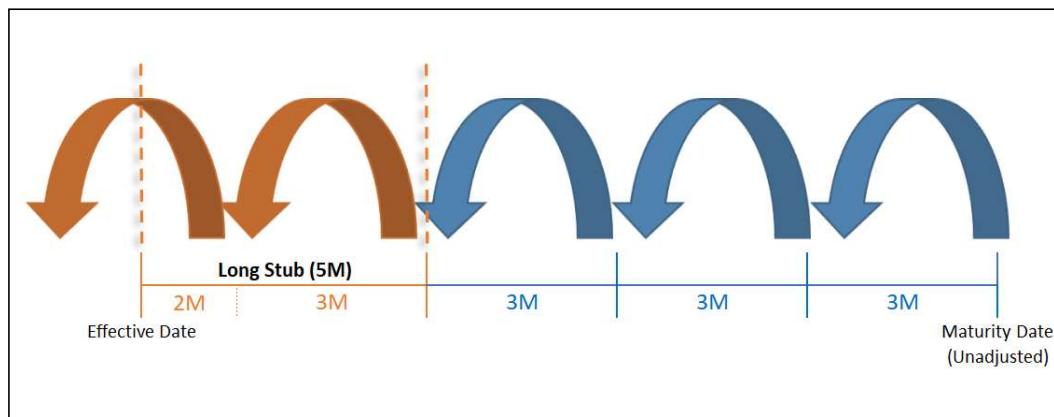
| | |
|-------------|--------------------|
| BUS DAY ADJ | MODIFIED_FOLLOWING |
| CALENDAR | NY |
| PAYMENT LAG | 2D |

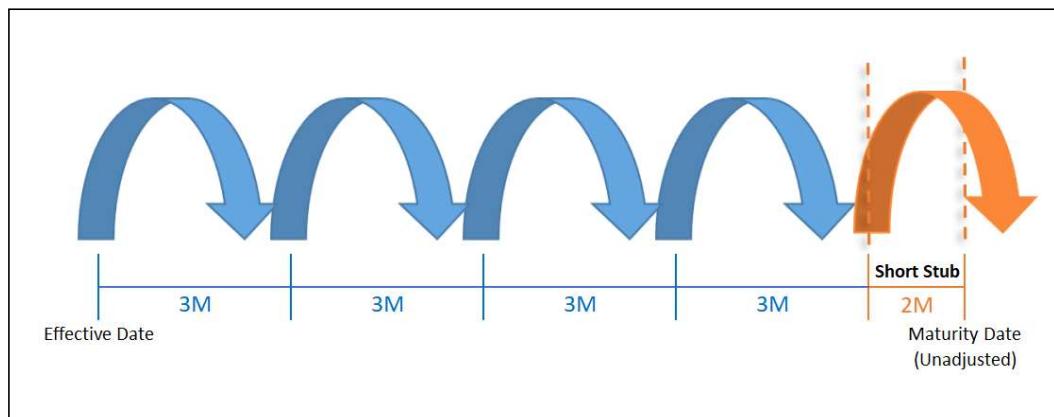


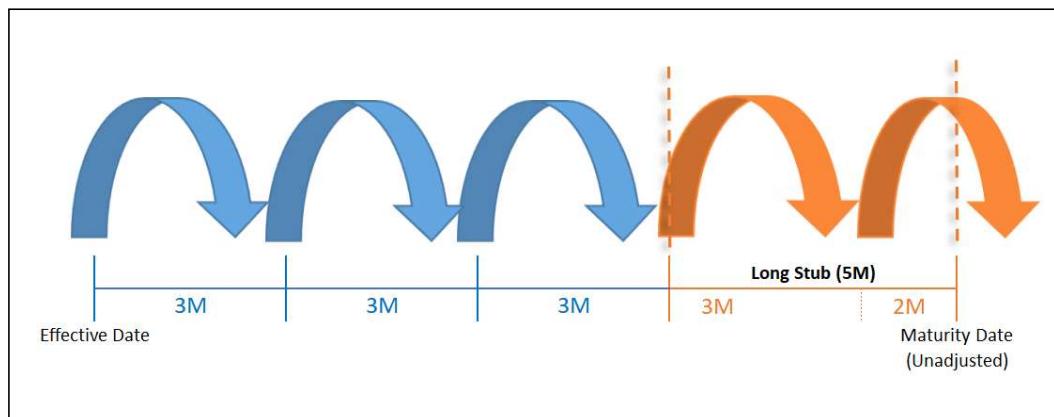












| Year Fraction | | Discount Factor | |
|---------------|-------------|-----------------|--|
| Accrual Start | Accrual End | Pay Date | |
| 21-May-22 | 19-Nov-22 | 19-Nov-22 | |
| 19-Nov-22 | 21-May-23 | 21-May-23 | |
| 21-May-23 | 19-Nov-23 | 19-Nov-23 | |
| 19-Nov-23 | 20-May-24 | 20-May-24 | |

| 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 |

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

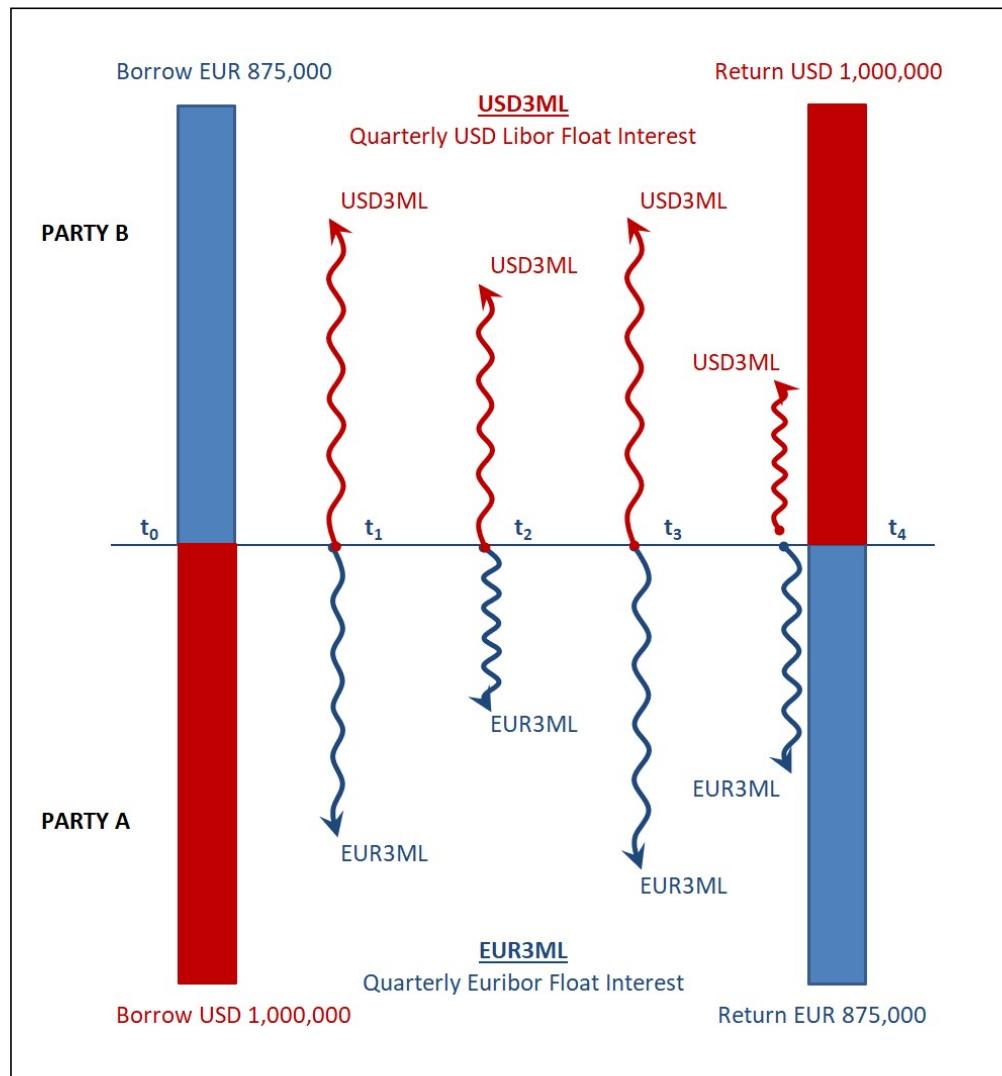


| Forward Rate | | Year Fraction | | Discount Factor | |
|--------------|--|---------------|-------------|-----------------|--|
| Fixing Date | | Accrual Start | Accrual End | Pay Date | |
| 19-May-22 | | 21-May-22 | 20-Aug-22 | 20-Aug-22 | |
| 18-Aug-22 | | 20-Aug-22 | 19-Nov-22 | 19-Nov-22 | |
| 17-Nov-22 | | 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 |
| MTM SWAPS | SpreadCompoundMethod | NONE | NONE |
| | Leverage | 1.00 | 1.00 |
| | ForecastCurve | EUR3M | USD3M |
| | DiscountCurve | EURDF_USDCSA | USDDF |
| | isMTMResetLeg | FALSE | TRUE |
| COUPON & STUB CONVENTIONS | ResetBaseFX | 1.00000 | 1.14030 |
| | ValuationCurrency | USD | USD |
| | CouponRollDay | NATURAL | NATURAL |
| | isEndOfDayMonth | TRUE | TRUE |
| | StubType | SHORT_START | SHORT_START |
| SCHEDULE INFORMATION | FrontStubCurveIndex | NATURAL | NATURAL |
| | BackStubCurveIndex | NATURAL | NATURAL |
| | FrontStubDate | - | - |
| | BackStubDate | - | - |
| | AccrualFrequency | QUARTERLY | QUARTERLY |
| NON-DELIVERABLES | 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 |
| NON-DELIVERABLES | IRFixingLag | 2D | 2D |
| | IRFirstFixingLag | - | - |
| | PaymentFrequency | QUARTERLY | QUARTERLY |
| | PaymentBusDayConv | MOD_FOLLOWING | MOD_FOLLOWING |
| | PaymentCalendar | TGT+NY+LON | TGT+NY+LON |
| NON-DELIVERABLES | PaymentLag | 2D | 2D |
| | IsNonDeliverable | FALSE | FALSE |
| | SettlementCurrency | - | - |
| | FFixingLag | - | - |
| | FFixingBusDayConv | - | - |
| NON-DELIVERABLES | FFixingCalendar | - | - |

| | | 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

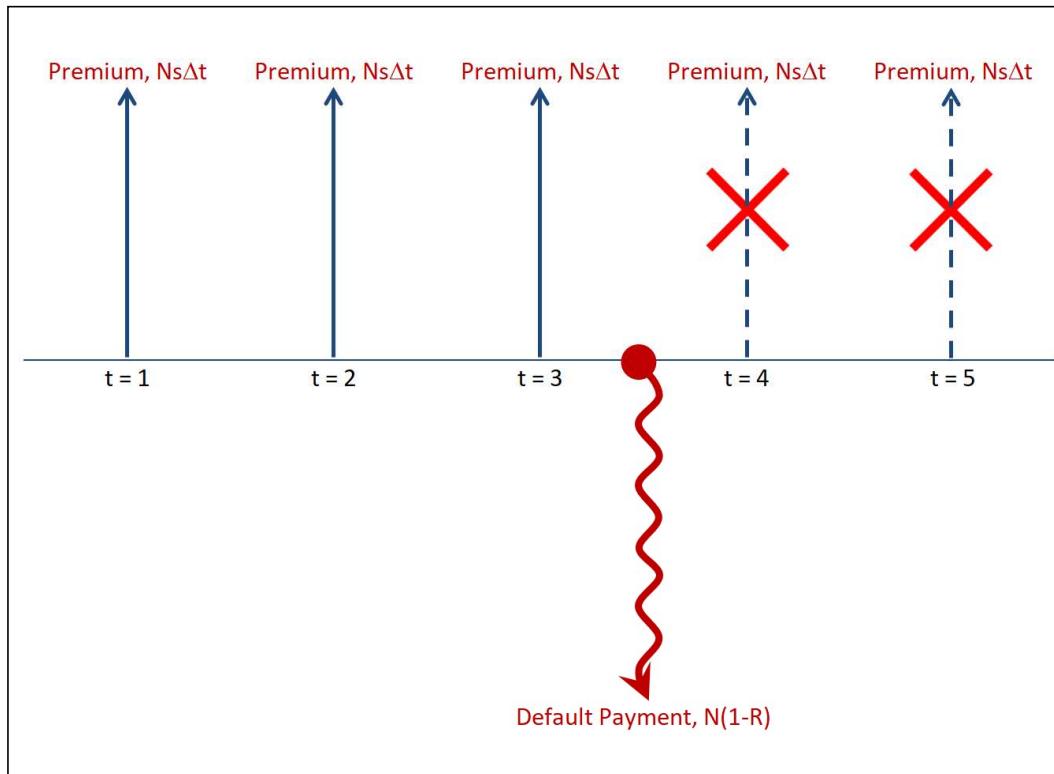
| Notional | FX Fixing Date | Fwd FX | Notional Exch | Spread | Float Rate | Coupon | Disc Factor | Coupon PV | Spot FX | Valuation PV |
|----------|----------------|--------|---------------|--------|------------|----------|-------------|-----------|---------|--------------|
| | | | 876,962 | | | 876,962 | 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 |

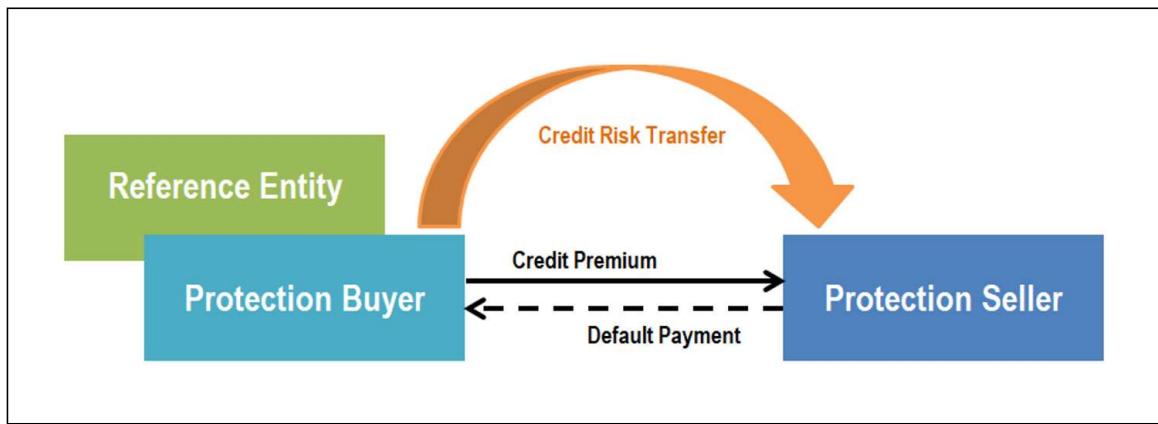
Leg2 - USD Cashflows

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

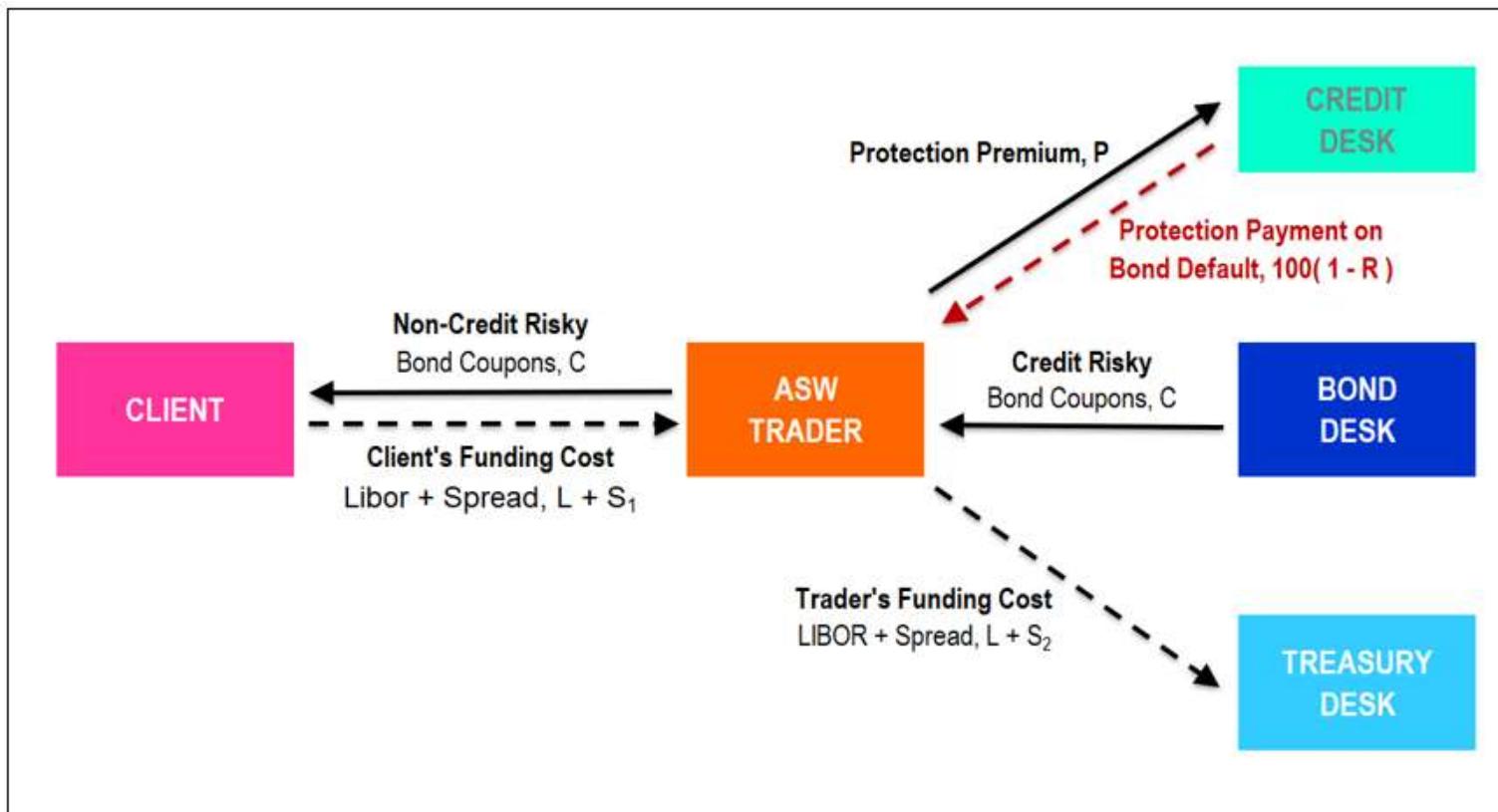
| Time, T | Notional, N | Credit Spread, s | Year Fraction, δt | Coupon | P(Survive), Q(T) | Disc Fact, P(t,T) | Total PV | -5.15 |
|---------|-------------|------------------|---------------------------|--------|------------------|-------------------|----------|-------|
| 0.25 | -1,000,000 | 0.5000% | 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 | |

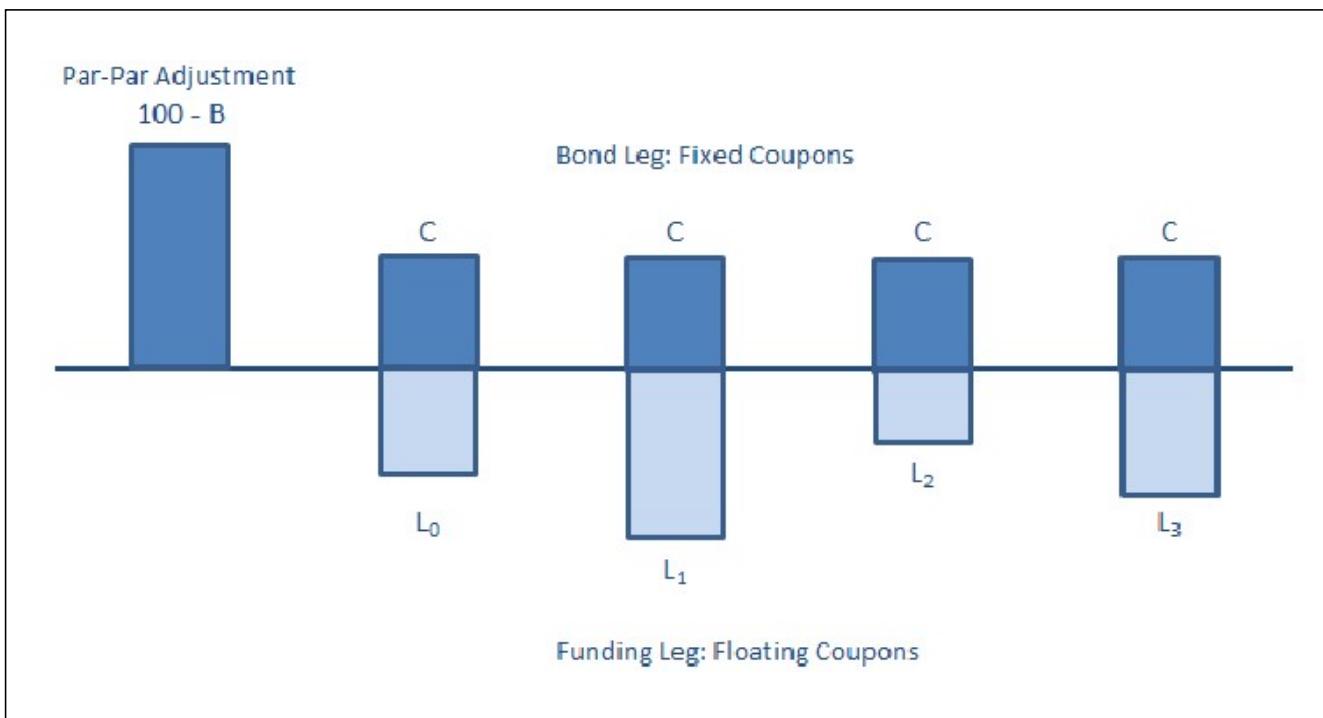


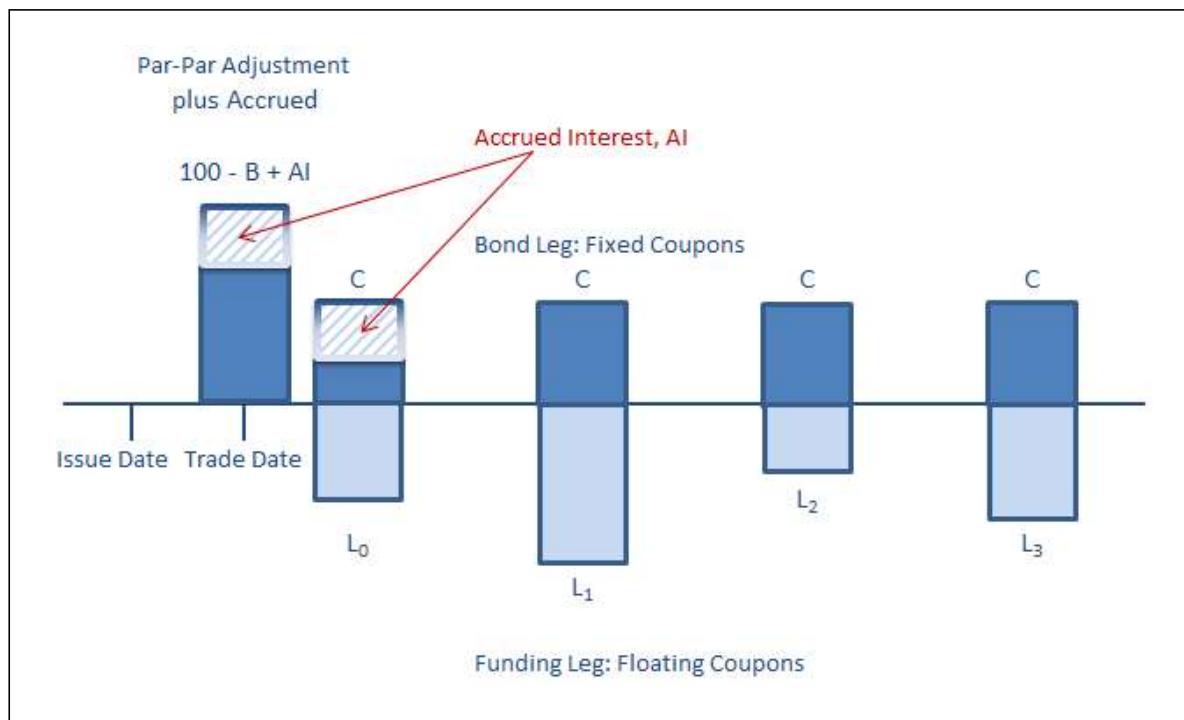
| Protection Leg | | | | | Total PV | 4,947.86 |
|----------------|-------------|-------------------------|-------------------------------|-------------------|----------|----------|
| Time, T | Notional, N | Loss Given Default, LGD | P(Default), Q(t) $\lambda(t)$ | Disc Fact, P(t,T) | PV | |
| 0.25 | 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 | | | | |

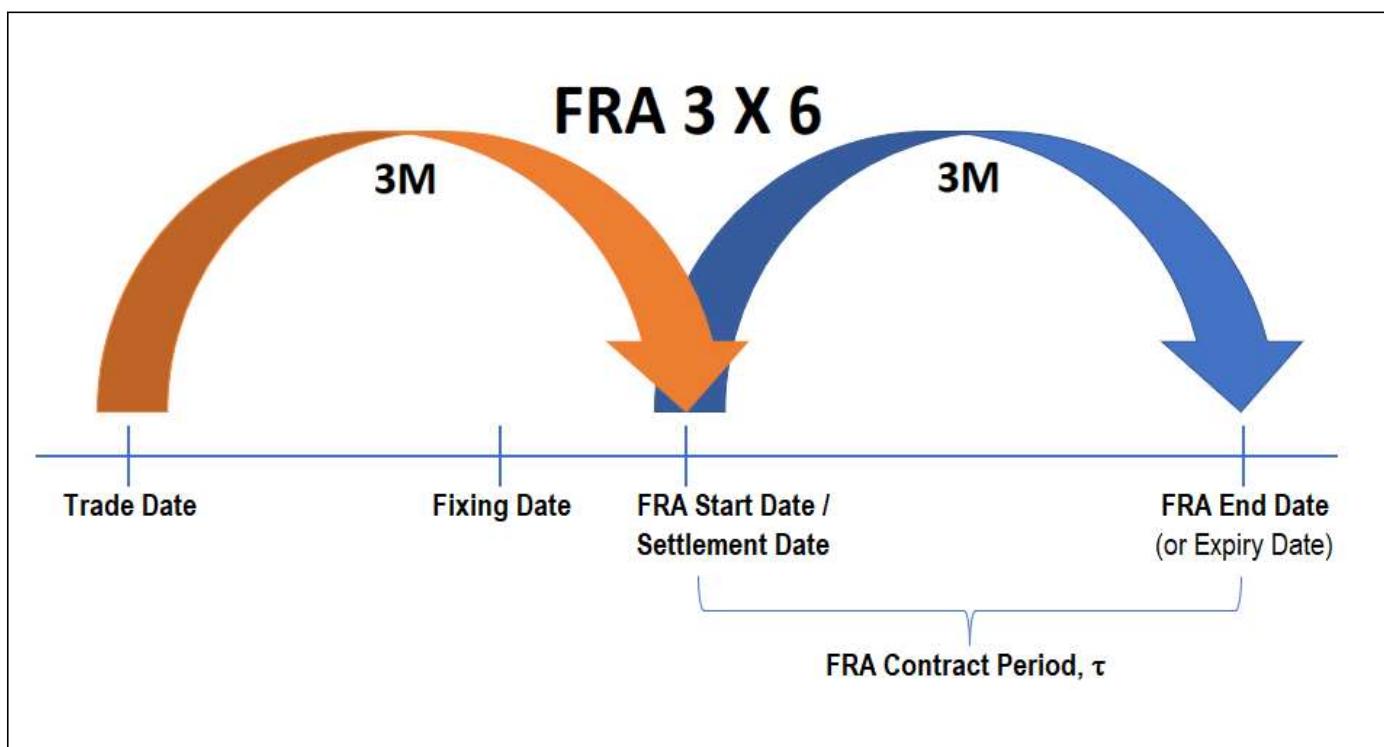


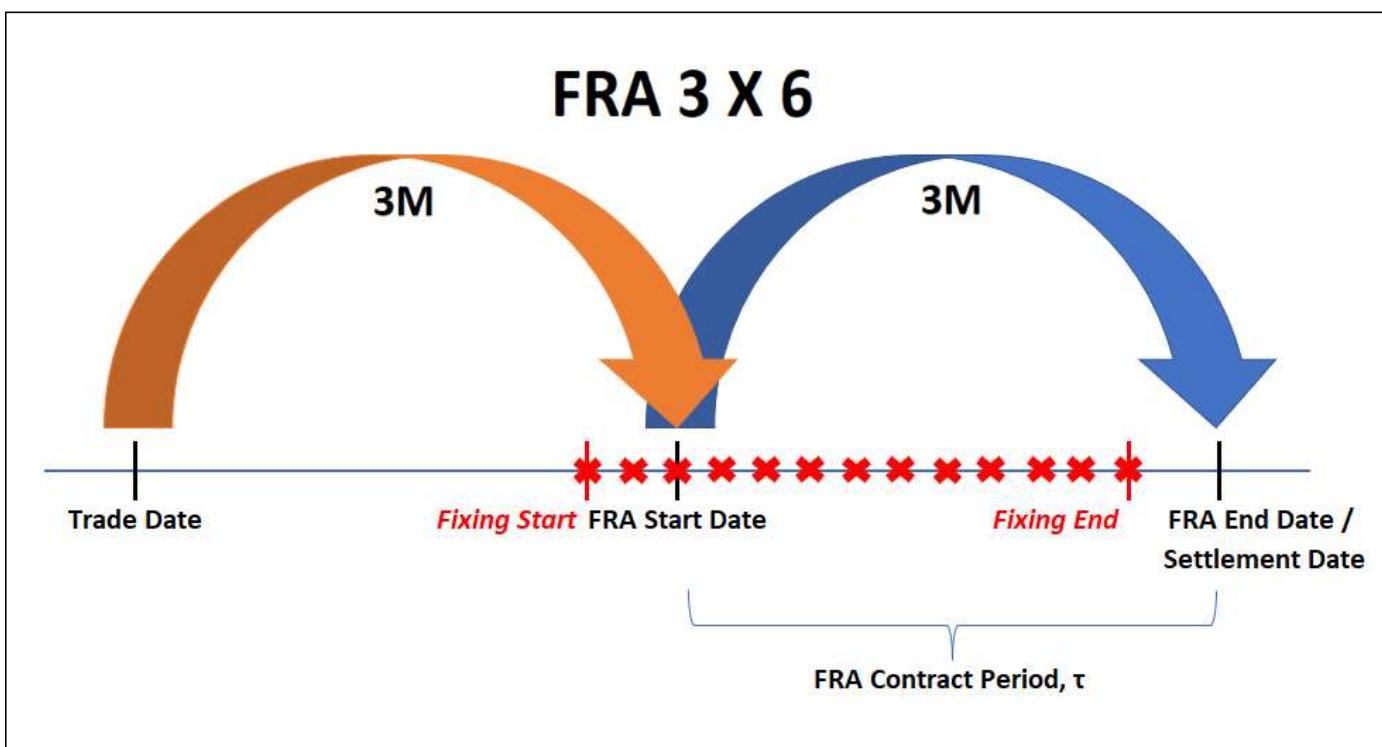


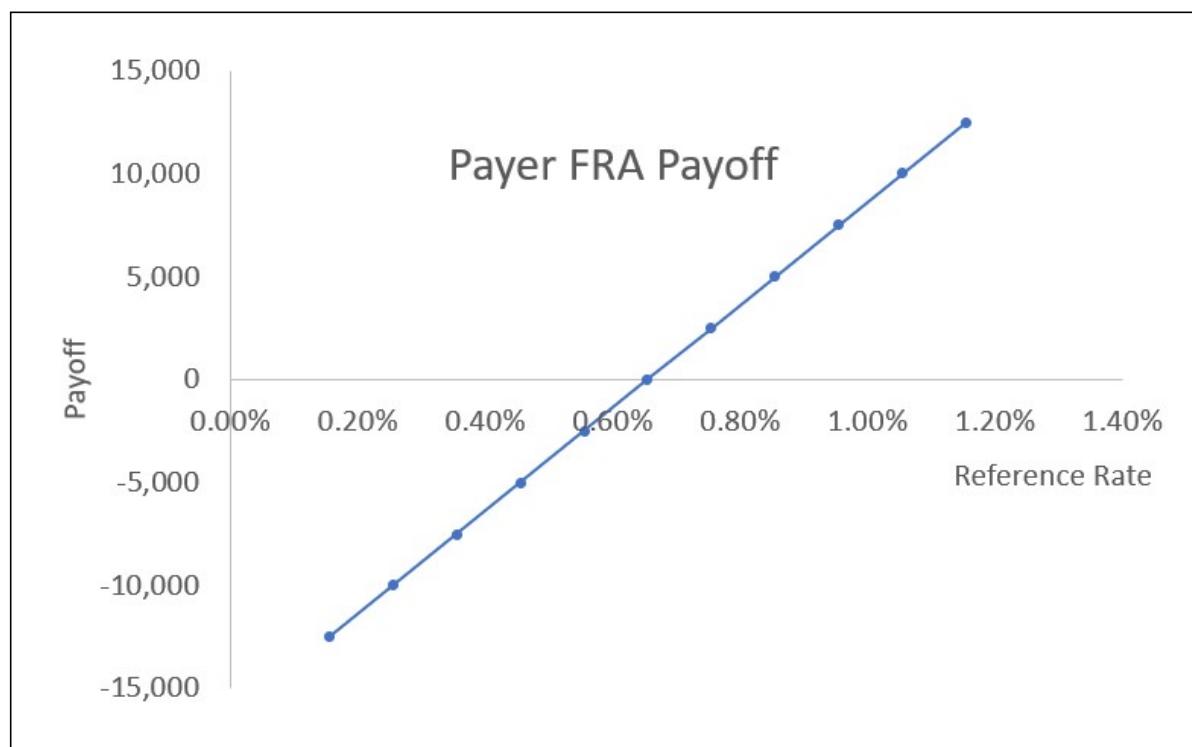


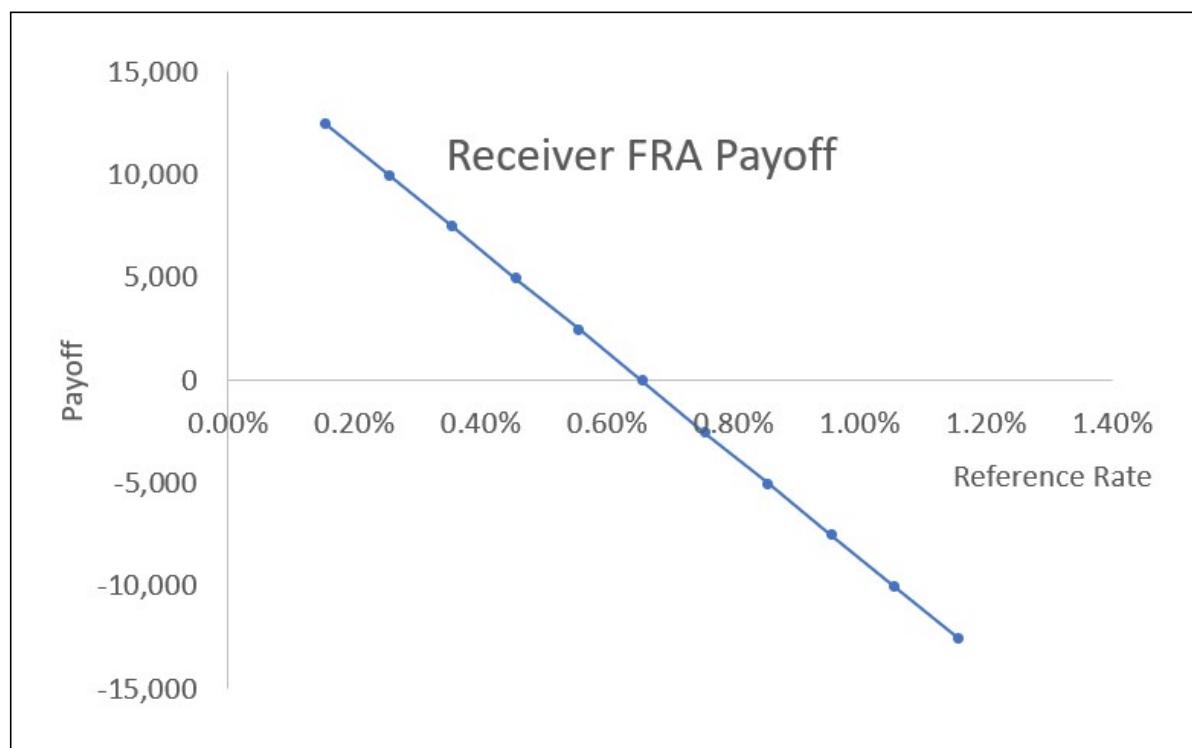
| | |
|--------------------|----------------------|
| Clean Price | 106.680 |
| Dirty Price | 106.919 |
| Accrued (175 Days) | 2,391.87 |
| Ticker | DE0001102390 Govt |
| Security Name | DBR 0 1/2 02/15/2026 |
| Issue Date | Fri, 15-Jan-16 |
| First Coupon Date | Wed, 15-Feb-17 |
| Maturity Date | Sun,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

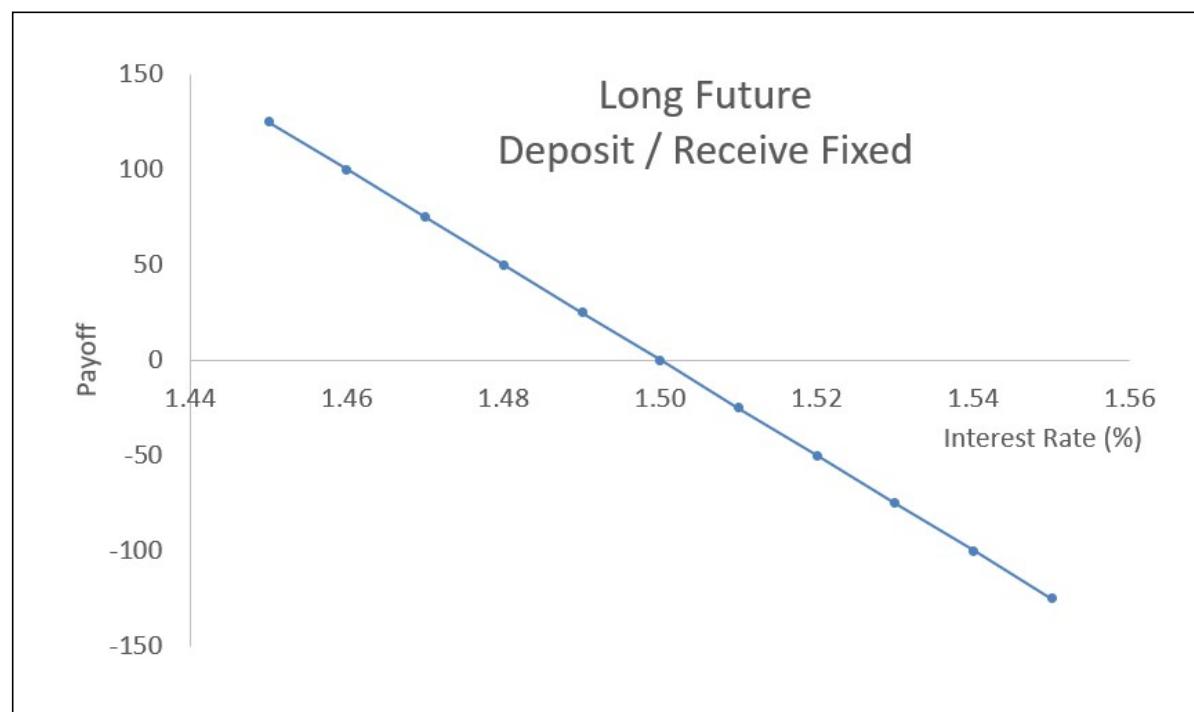
| Swap Leg Breakdown | | Asset Swap Calculation | |
|-----------------------|--------|------------------------|-----------|
| Fixed PV | 51,219 | Swap PV | 26,022 |
| Accrued Interest | 2,392 | Par Adjustment | -66,800 |
| Fixed PV Less Accrued | 48,828 | Discounting Difference | 6 |
| Float PV | 22,805 | Float Annuity | 9,907,204 |
| | | ASW Spread | -41.166 |

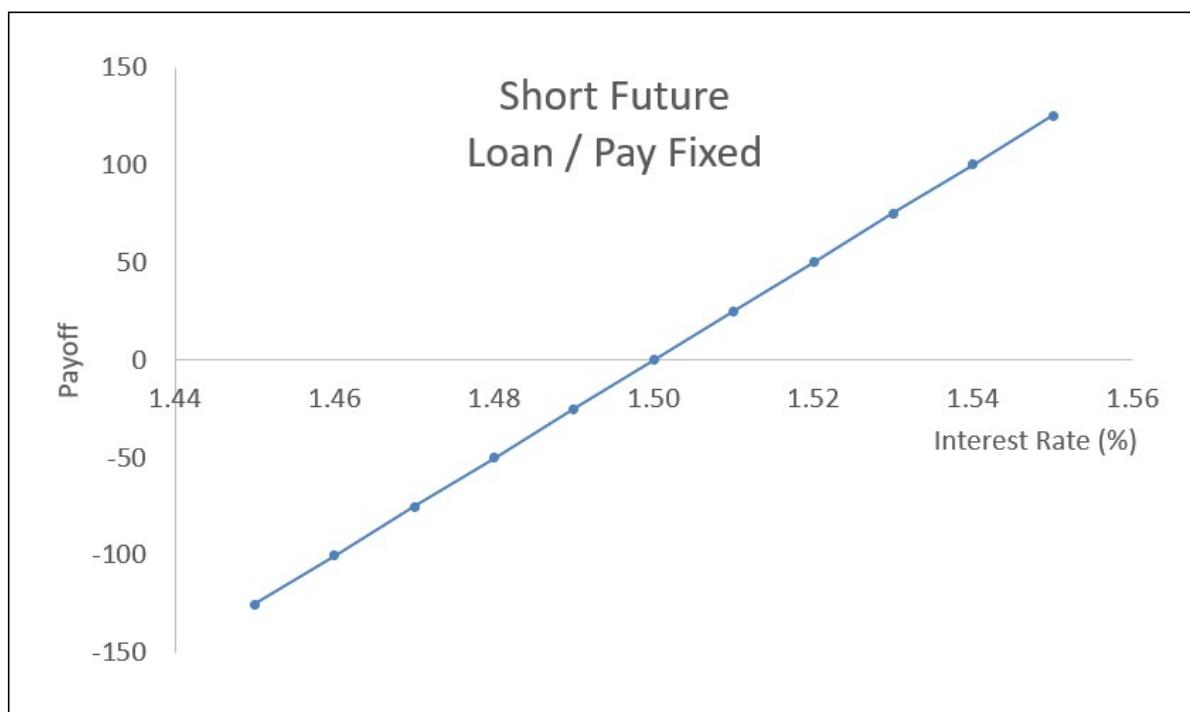












| | | | | | | | | | | | | |
|--------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| Month | JAN | FEB | MAR | APR | MAY | JUN | JUL | AUG | SEP | OCT | NOV | DEC |
| Symbol | F | G | H | J | K | M | N | Q | U | V | X | Z |

| 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 |
|---|---|

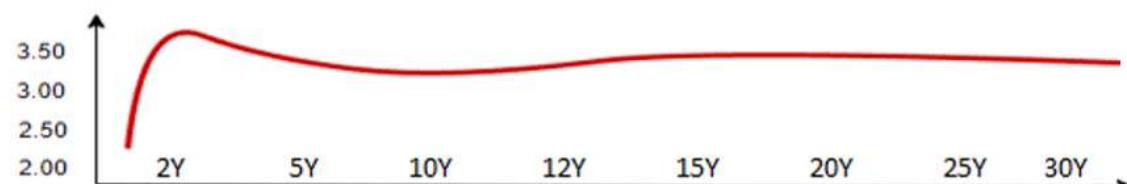
Futures

| | 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 |
|---|---|

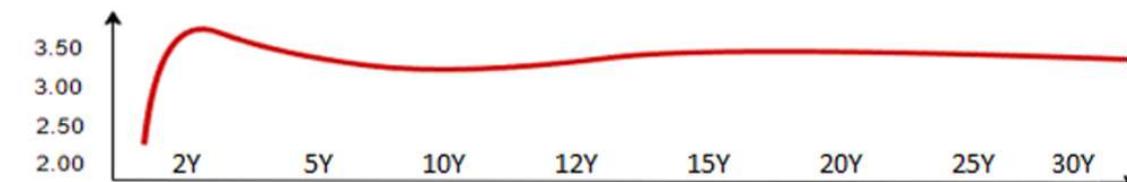
Futures

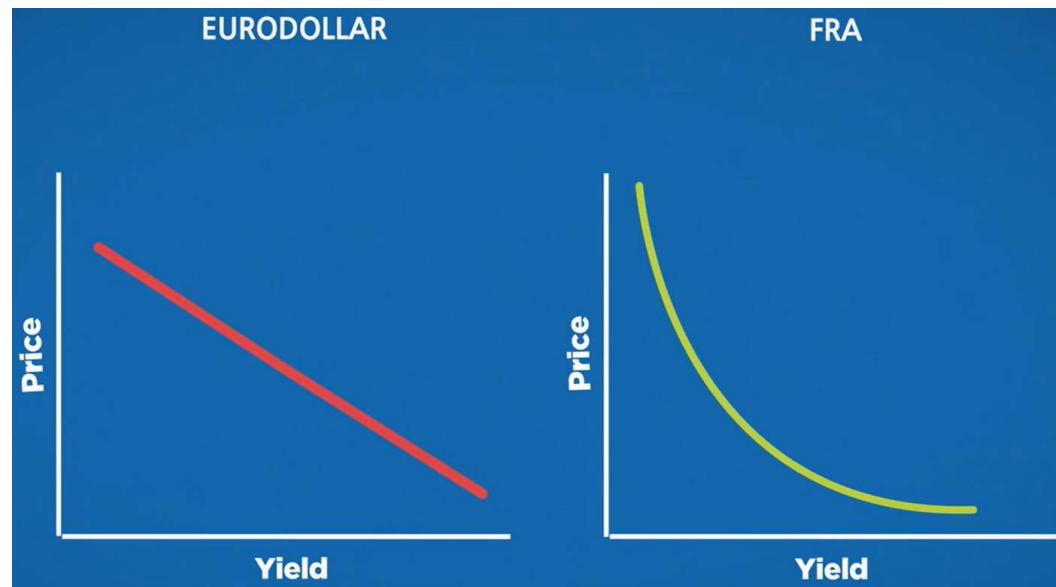
| | Contract | Price | Cvx Adj | Rate |
|---|------------|---------|----------|----------|
| 1 | JUL-22 + 3 | 97.4475 | -0.00009 | 2.55241% |
| 2 | AUG-22 + 3 | 97.1100 | -0.00045 | 2.88955% |
| 3 | SEP-22 + 3 | 96.6750 | -0.00103 | 3.32397% |
| 4 | OCT-22 + 3 | 96.4950 | -0.00159 | 3.50341% |
| 5 | 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% |

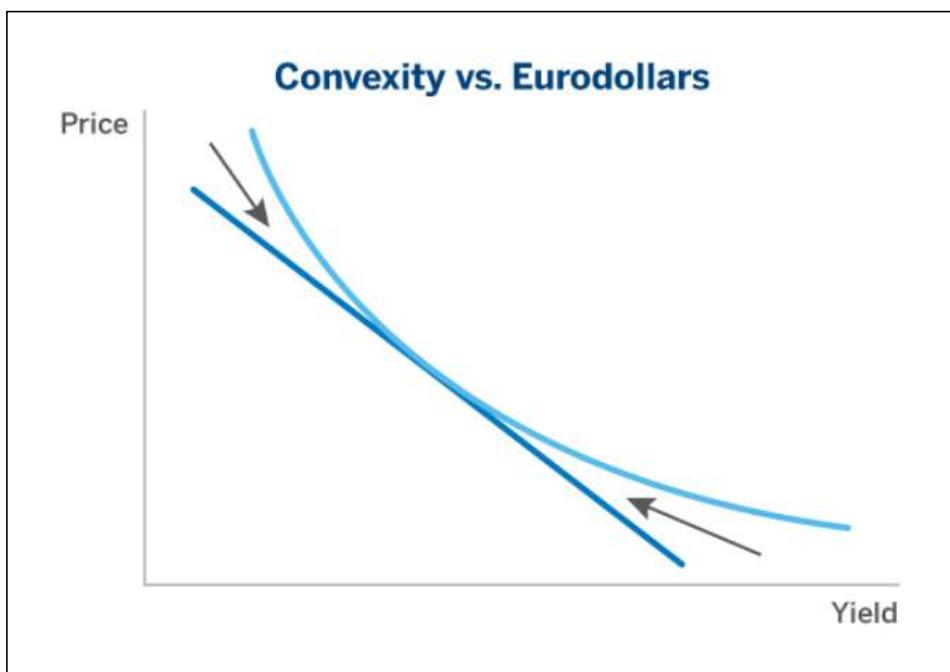
Swaps

| 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 |

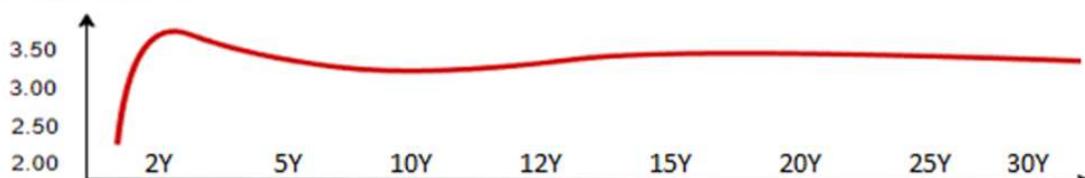
Futures

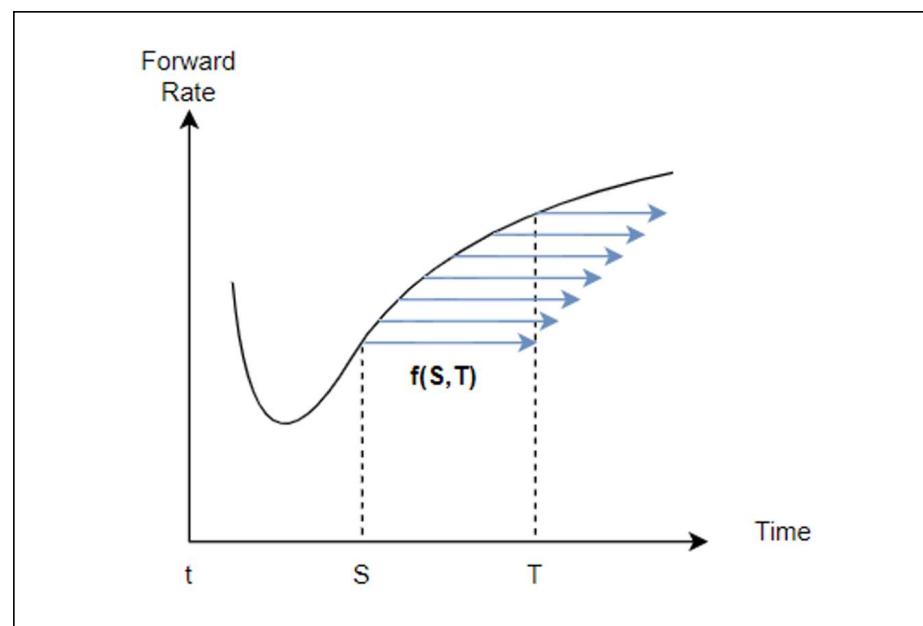
| | Contract | Price | Cvx Adj | Rate |
|---|-----------|---------|----------|----------|
| 1 | JUN-22 +3 | 98.0625 | -0.01599 | 1.93734% |
| 2 | JUL-22 +1 | 98.3800 | 0.10408 | 1.62104% |
| 3 | AUG-22 +1 | 97.7350 | 0.19972 | 2.26700% |
| 4 | SEP-22 +3 | 96.9250 | -0.13725 | 3.07363% |
| 5 | SEP-22 +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% |

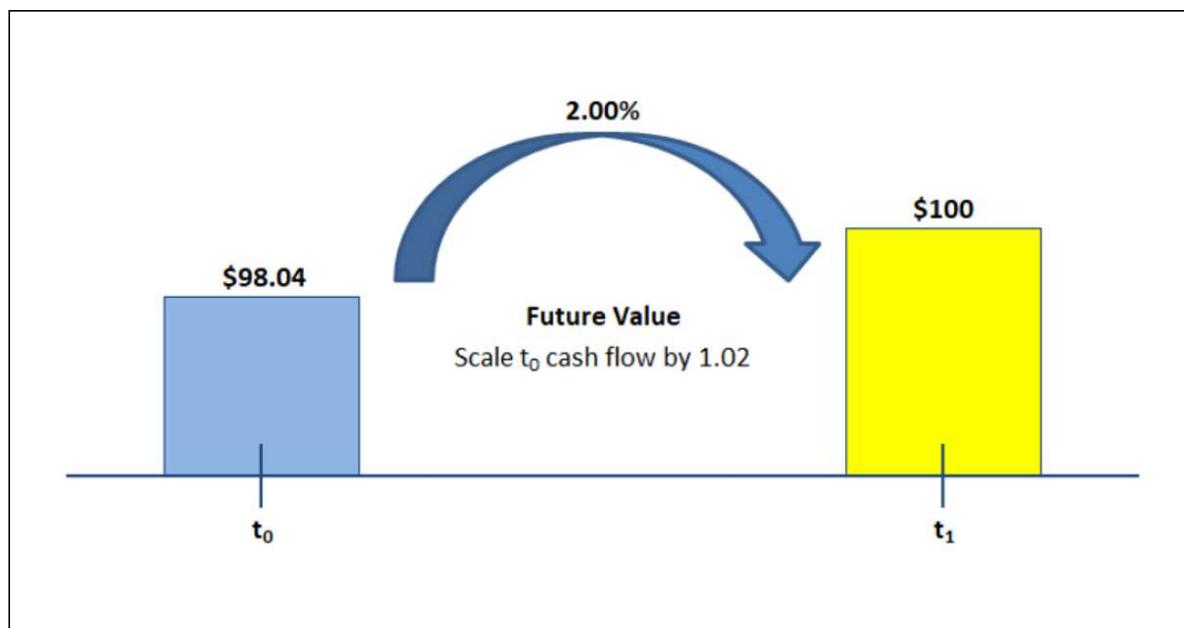
Swaps

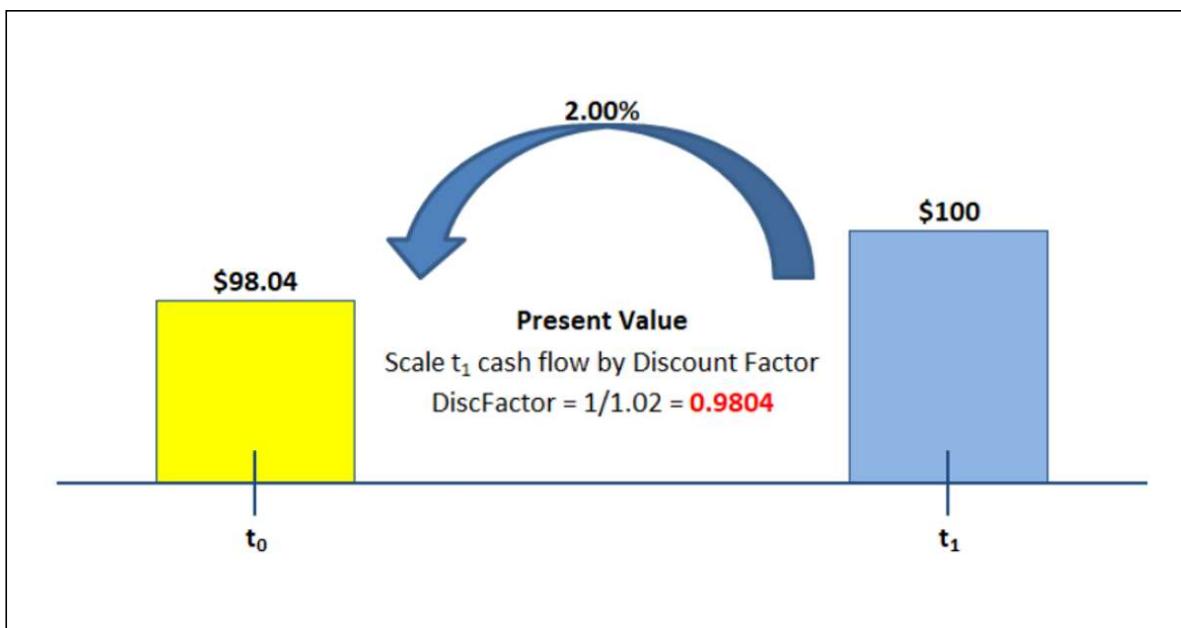
| Term | Bid | Ask |
|------|----------|----------|
| 1Y | 3.41532% | 3.42668% |
| 2Y | 3.38246% | 3.39164% |
| 3Y | 3.23062% | 3.24638% |
| 4Y | 3.17325% | 3.18184% |
| 5Y | 3.15423% | 3.16357% |
| 6Y | 3.14866% | 3.15714% |
| 7Y | 3.14521% | 3.15179% |
| 8Y | 3.14509% | 3.15131% |

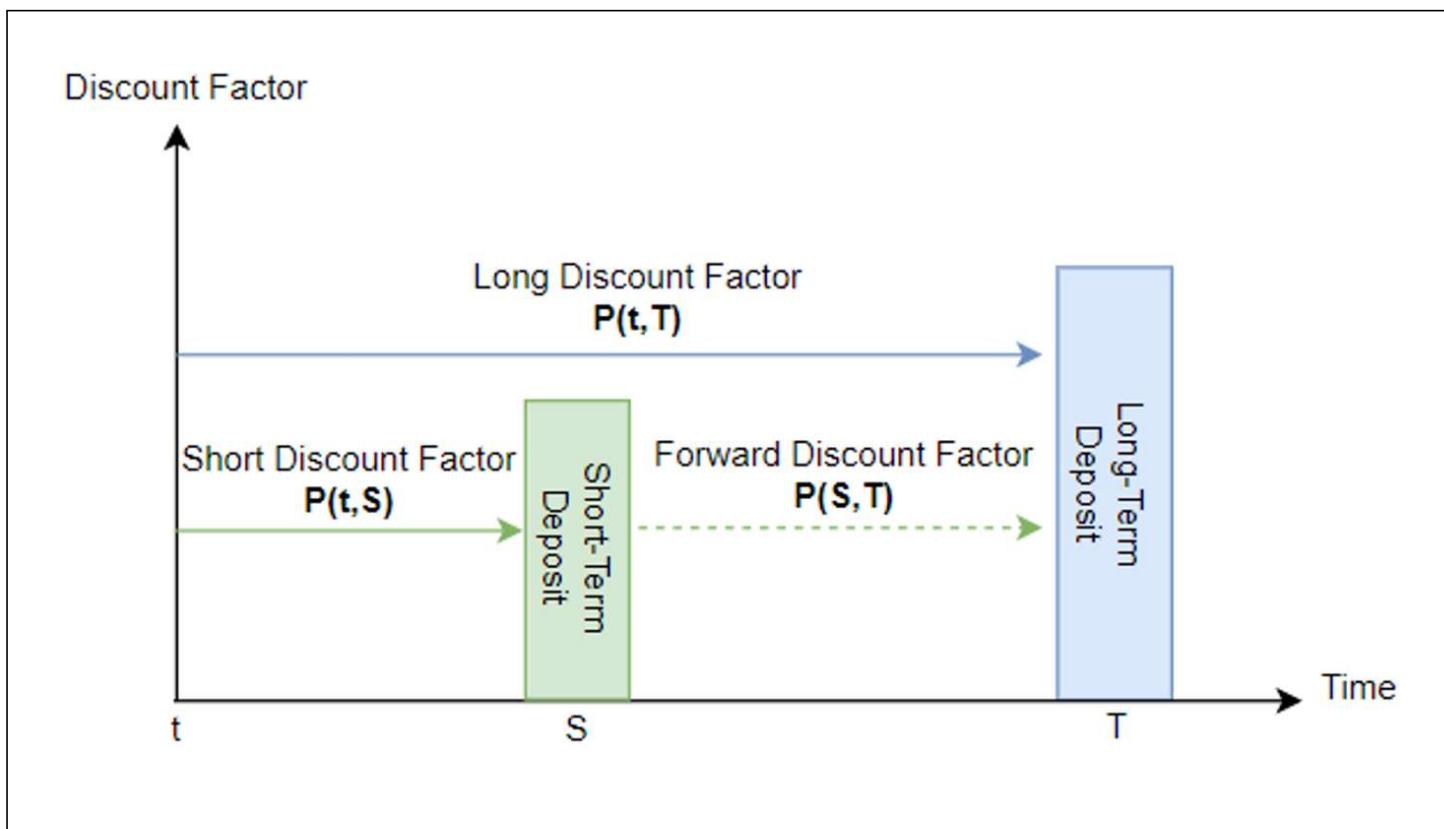
Forward Rate (%)

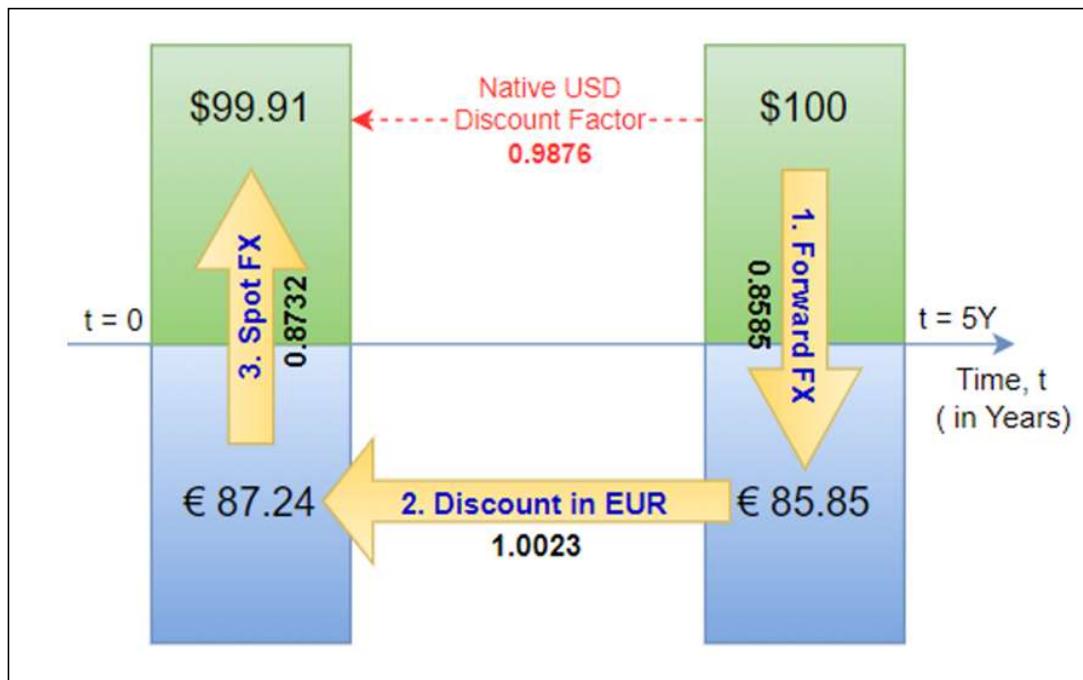


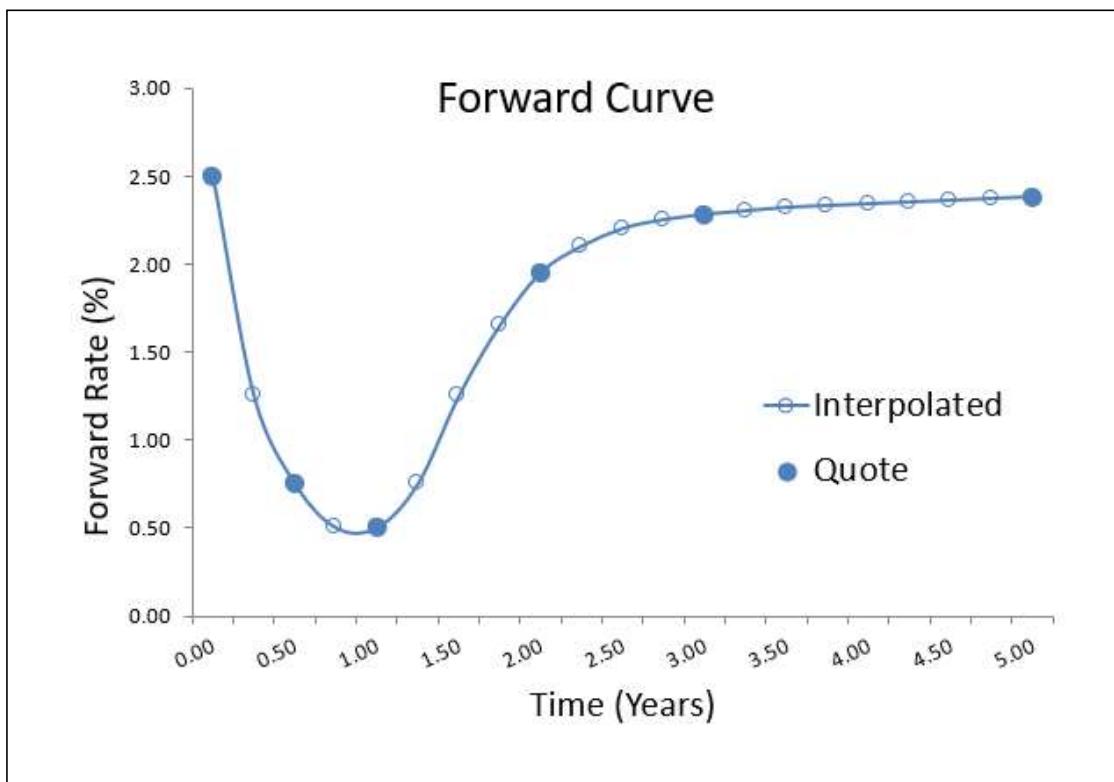


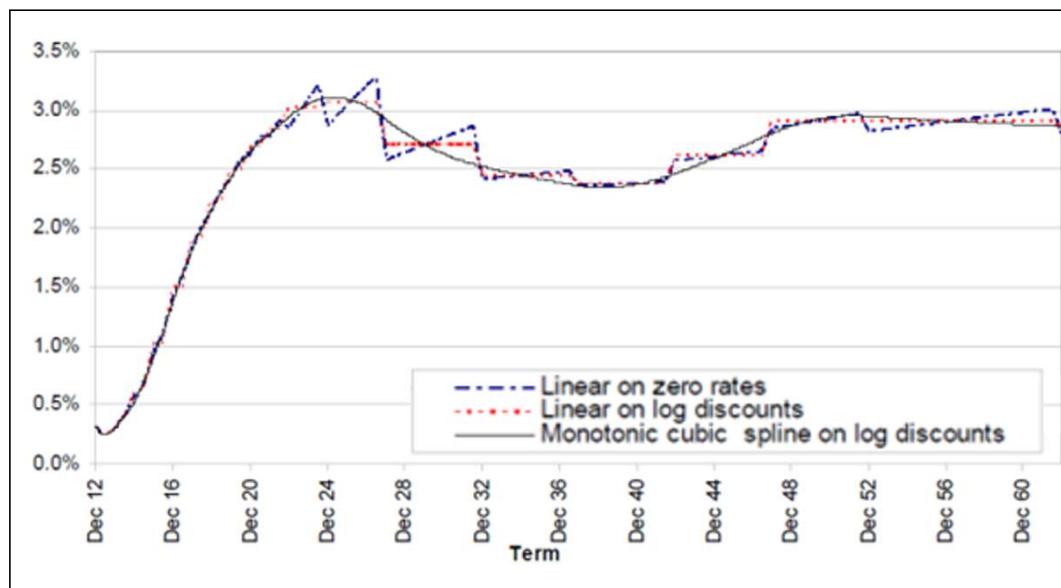












OIS Curve (1D)

| 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 |
|---|---|

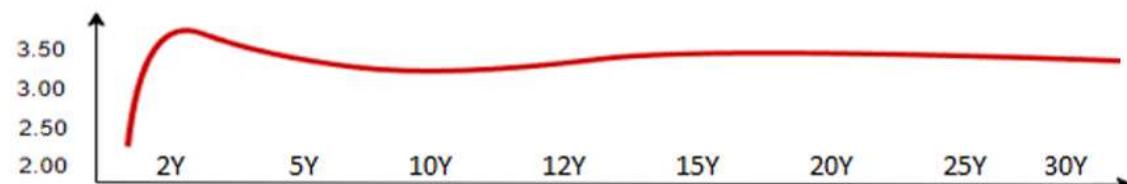
Futures

| | 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% |

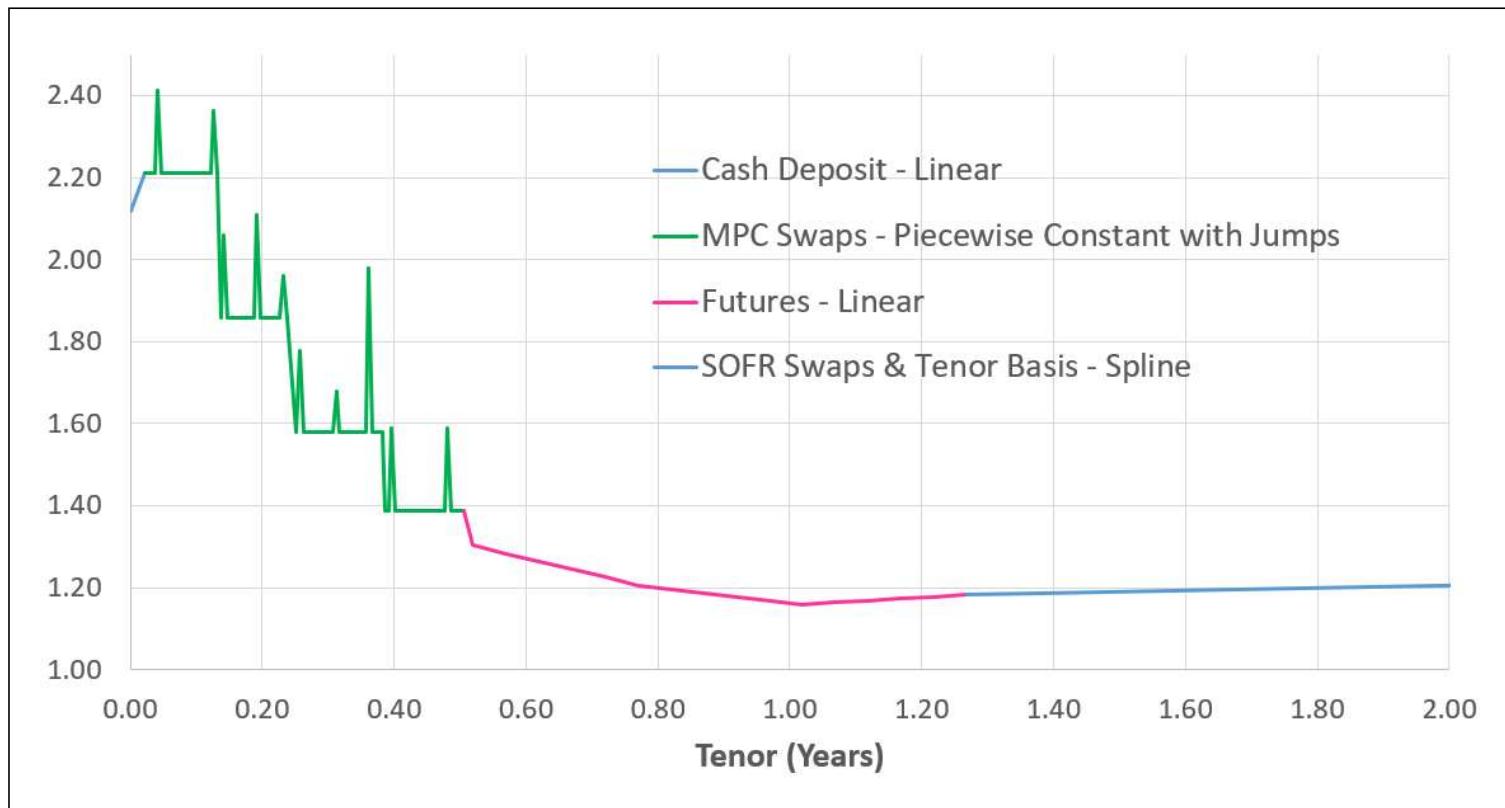
Swaps

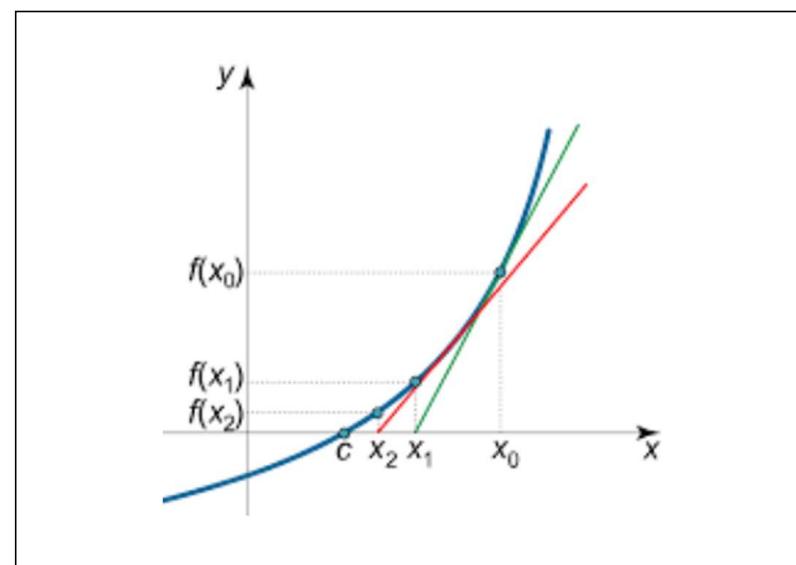
| Term | Bid | Ask |
|------|----------|----------|
| 1Y | 3.41532% | 3.42668% |
| 2Y | 3.38246% | 3.39164% |
| 3Y | 3.23062% | 3.24638% |
| 4Y | 3.17325% | 3.18184% |
| 5Y | 3.15423% | 3.16357% |
| 6Y | 3.14866% | 3.15714% |
| 7Y | 3.14521% | 3.15179% |
| 8Y | 3.14509% | 3.15131% |

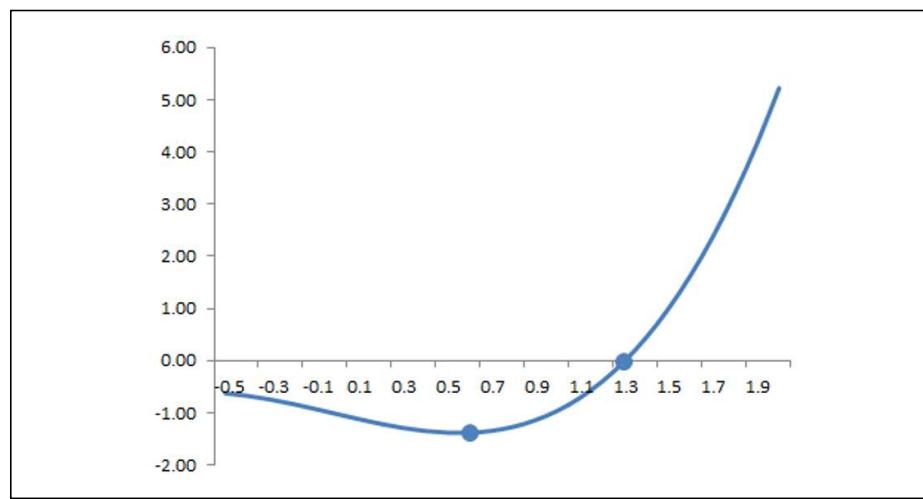
Forward Rate (%)







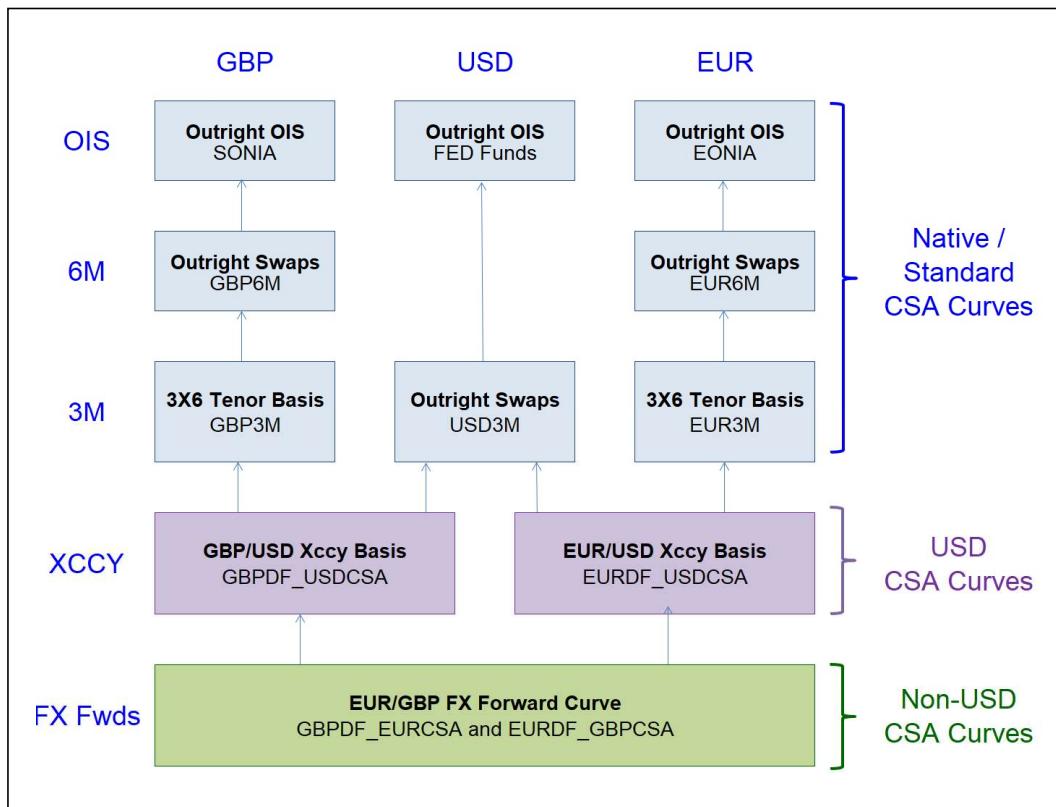


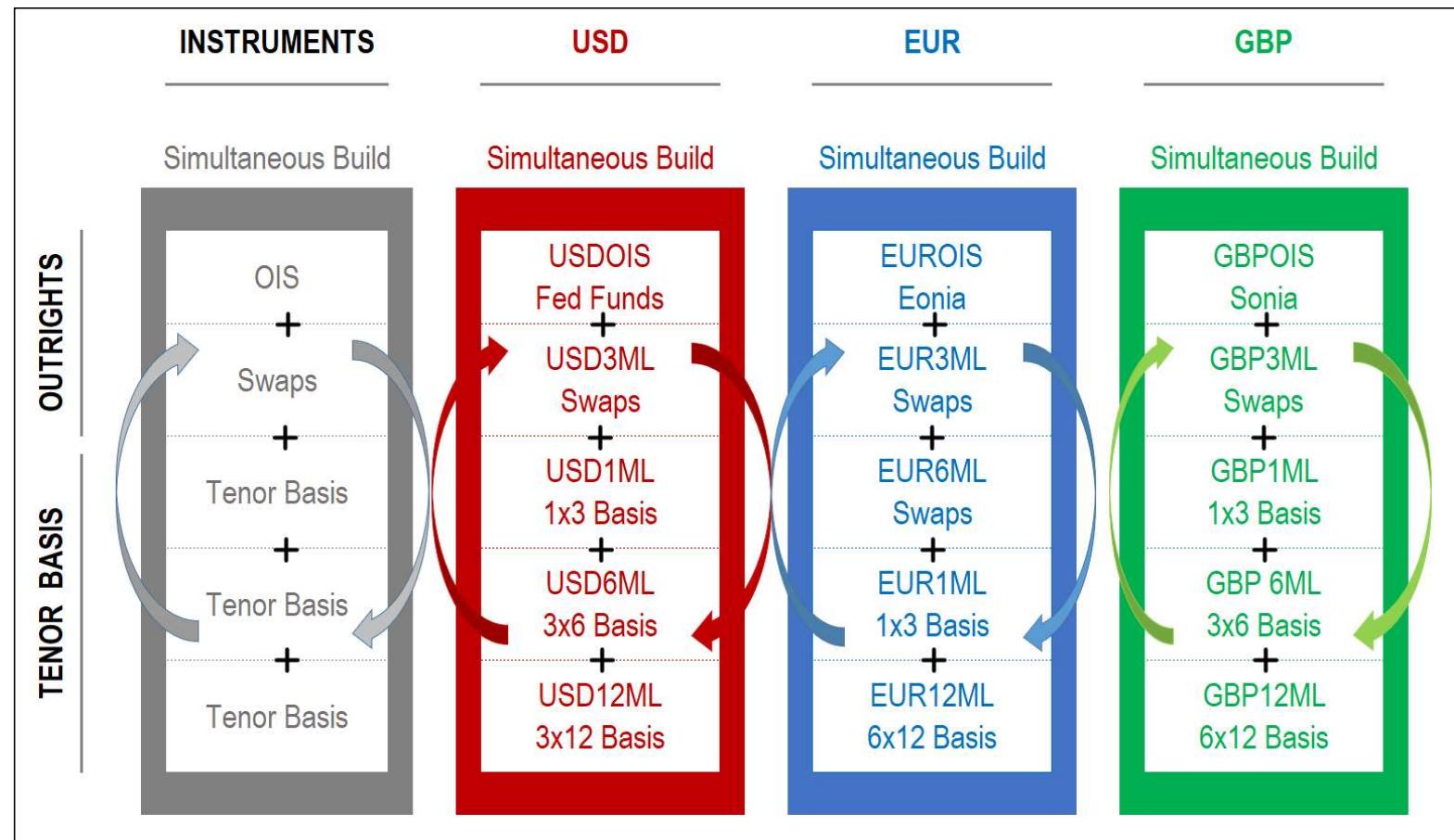


| n | x_{n+1} | x_n | $f(x_n)$ | $f'(x_n)$ | ε |
|-----|-----------|-------|----------|-----------|---------------|
| 1 | 3.39 | 5.00 | 119.00 | 74.00 | 1.608 |
| 2 | 2.36 | 3.39 | 34.63 | 33.51 | 1.033 |
| 3 | 1.74 | 2.36 | 9.76 | 15.69 | 0.622 |
| 4 | 1.43 | 1.74 | 2.50 | 8.04 | 0.311 |
| 5 | 1.33 | 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 |



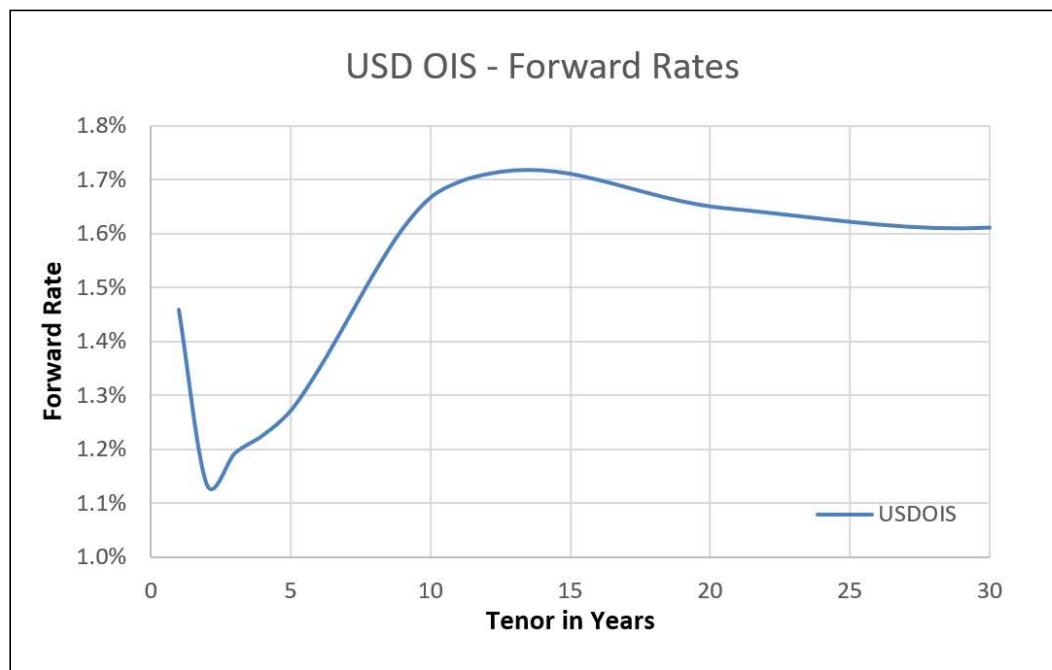


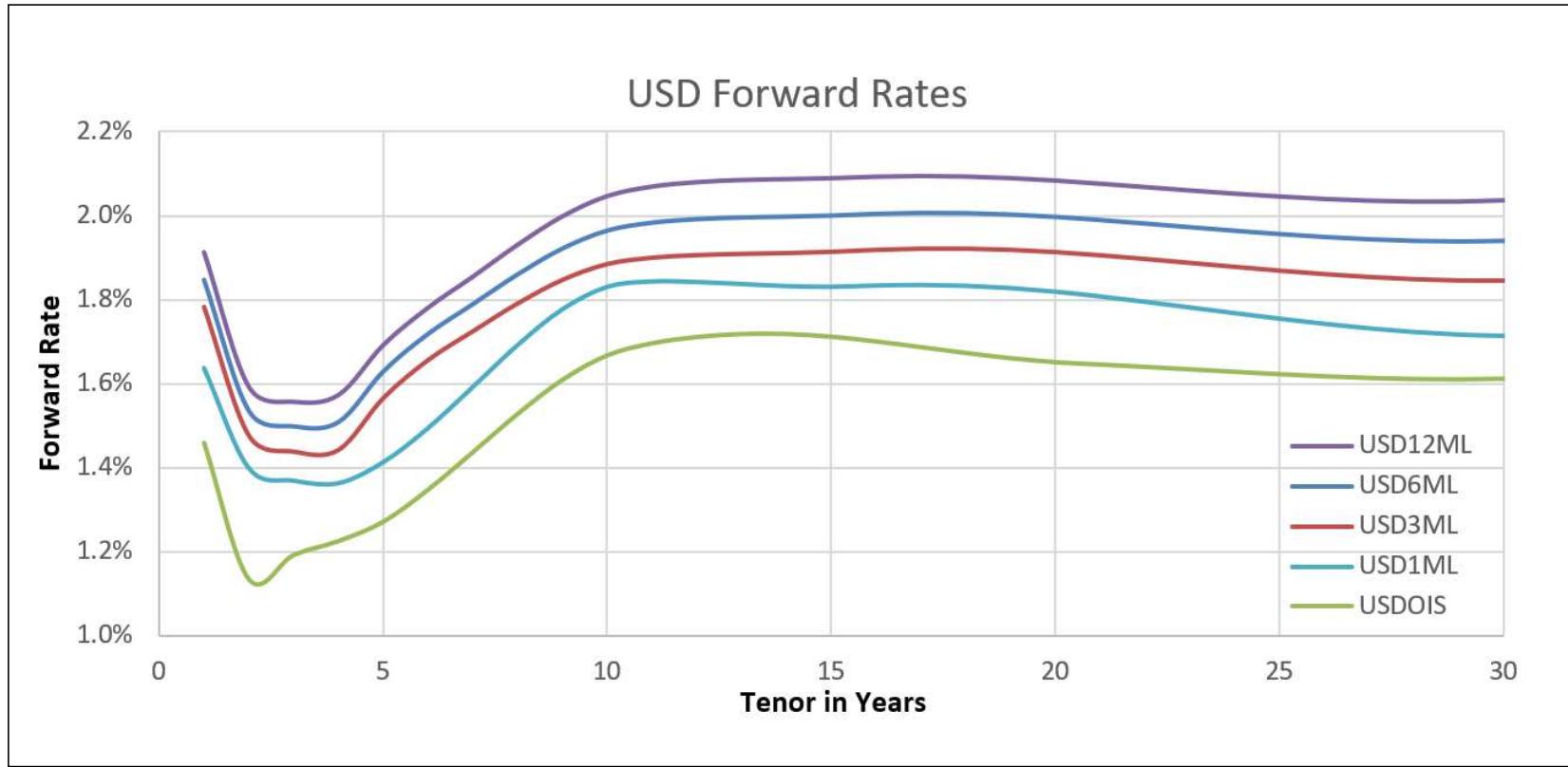
OIS Curve (1D)

| 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

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

Tolerance
1.00E-08RMSE
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, $dS/dP = dS/dL \times dL/dP$

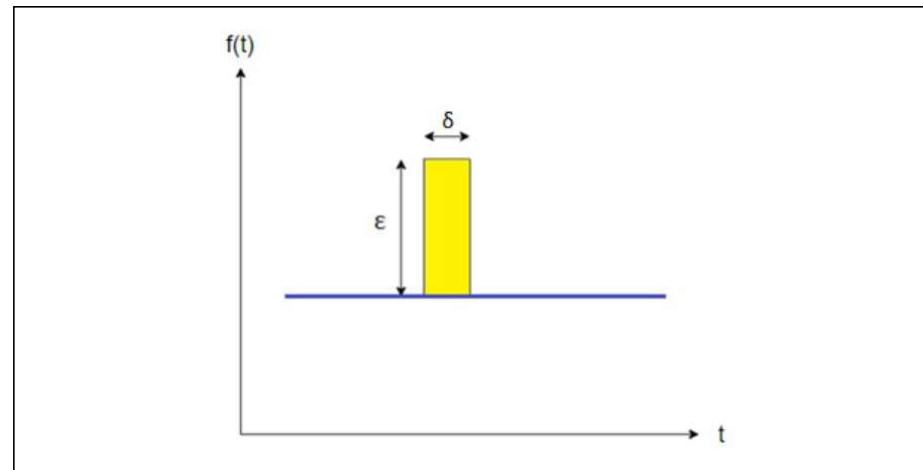
Change in swap value per unit change in market par rates

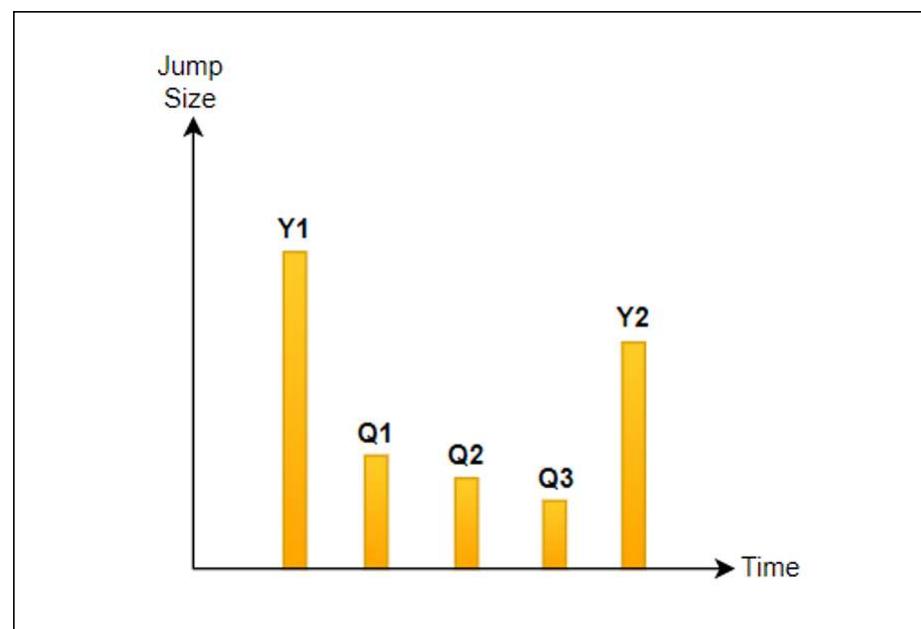
| | dP_{1Y}^{IRS} | dP_{2Y}^{IRS} | dP_{3Y}^{IRS} | dP_{4Y}^{IRS} | dP_{5Y}^{IRS} | Total |
|--------------------|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------------|
| dS_{1Y}^{IRS} | 98 | 0 | 0 | 0 | 0 | 98 IRS(1Y) |
| dS_{2Y}^{IRS} | 0 | 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) |

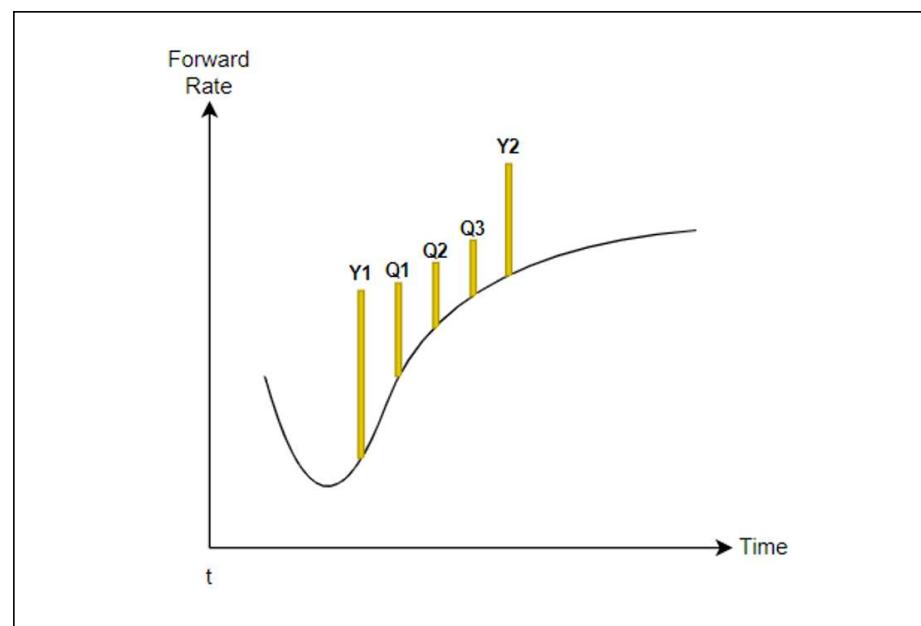
$$\text{Swap Delta} = \frac{dS}{dP} = \frac{dS}{dL} \cdot \frac{dL}{dP} \times \text{Shift Size}$$

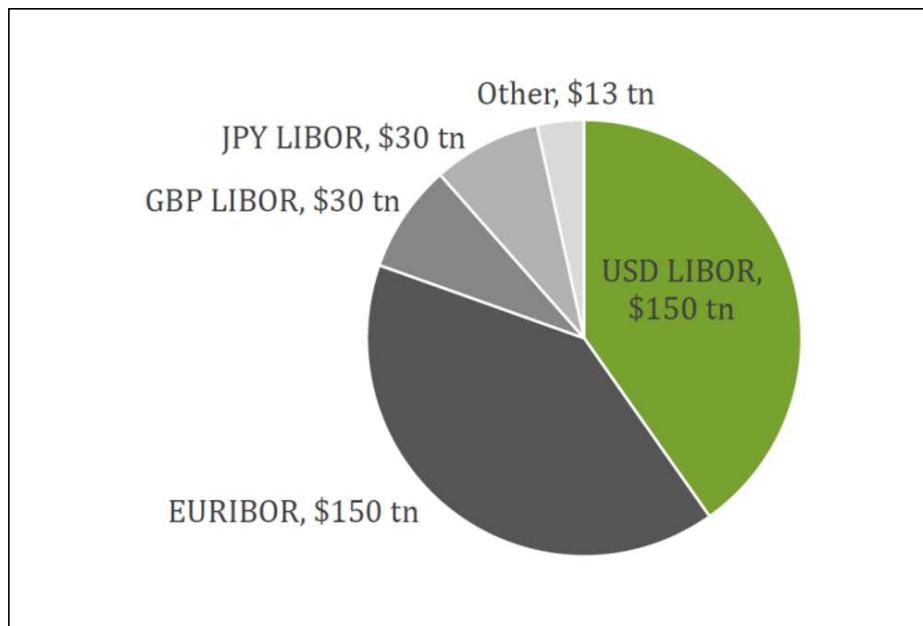


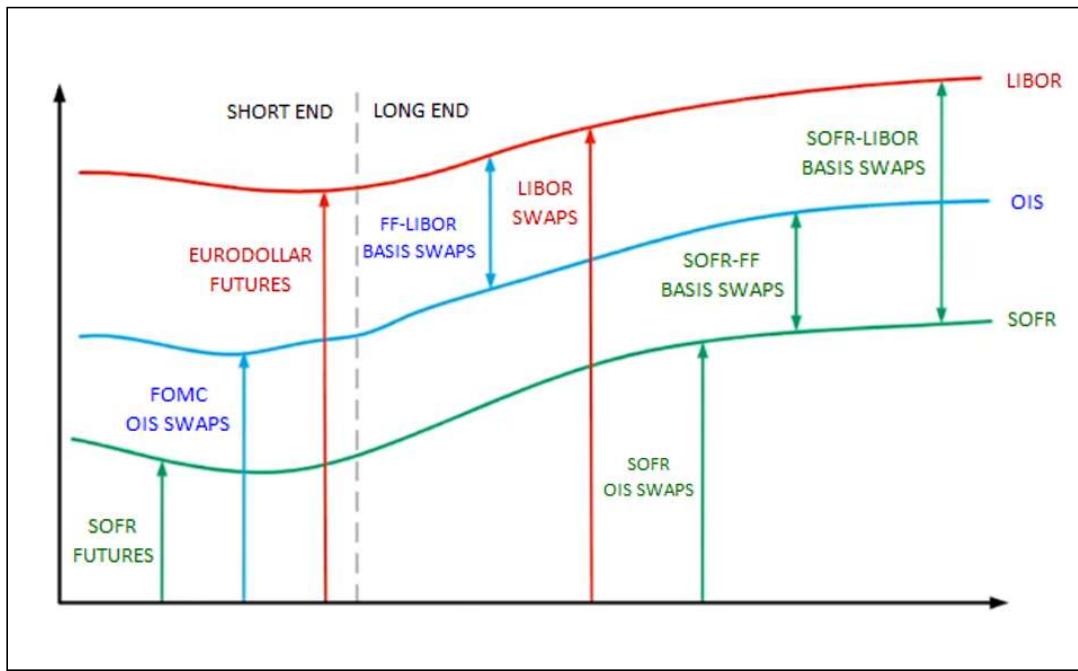
| Instrument | Maturity | Quote | Interpolation Style |
|-------------------|-----------------|--------------|----------------------------|
| Cash Deposit | 1D | 2.12000 | Linear |
| Future 1M | 1M | 97.78734 | Linear |
| Future 1M | 2M | 98.14013 | Linear |
| Future 1M | 3M | 98.42061 | Linear |
| Future 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 |



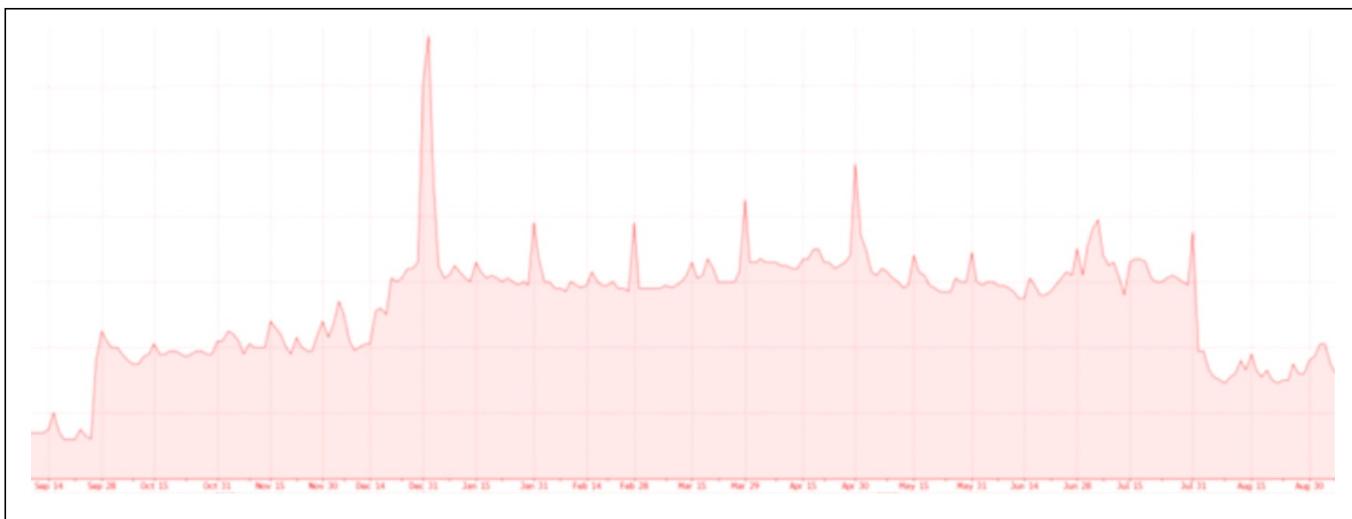




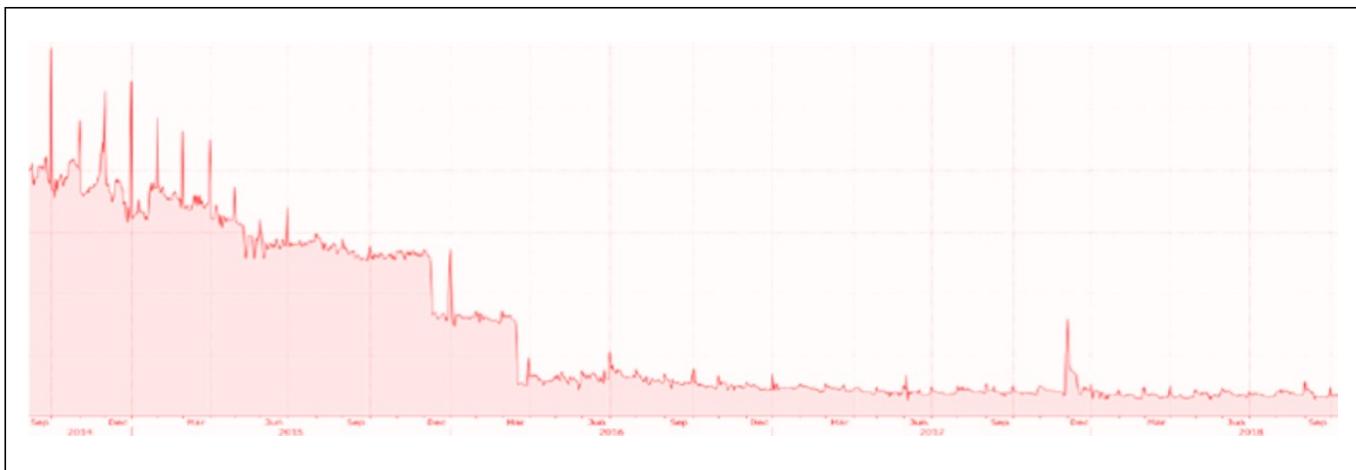




| Instrument | Maturity | Quote | Interpolation Style |
|---------------------------|-----------------|--------------|-------------------------------|
| Cash Deposit | 0.00 | 2.12000 | Linear |
| Monetary Policy SOFR Swap | 1M | 2.21266 | Piecewise-Constant with Jumps |
| Monetary Policy SOFR Swap | 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} |
| dS_{1Y}^{IRS} | 0 | 0 | 0 | 0 | 98 | 0 | 0 |
| dS_{2Y}^{IRS} | 0 | 0 | 0 | 0 | 98 | 97 | 0 |
| dS_{3Y}^{IRS} | 0 | 0 | 0 | 0 | 98 | 145 | 48 |
| dS_{4Y}^{IRS} | 0 | 0 | 0 | 0 | 98 | 145 | 142 |
| dS_{5Y}^{IRS} | 0 | 0 | 0 | 0 | 98 | 145 | 142 |
| $dS_{4Y,5Y}^{IRS}$ | 0 | 0 | 0 | 0 | 0 | 0 | 93 |
| $dS_{4,5Y}^{IRS}$ | 0 | 0 | 0 | 0 | 98 | 145 | 142 |
| | | | | | | | 47 |



Bucketed Trade DV01 Risk

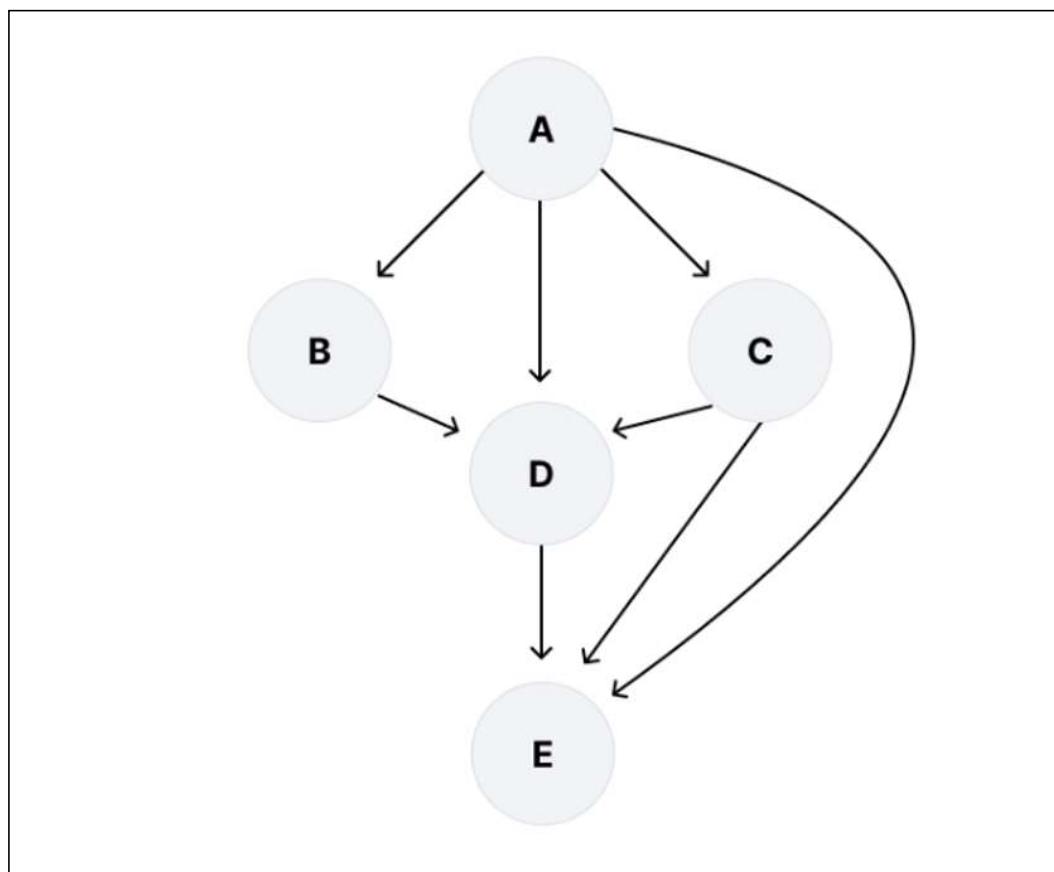
| Risk Bucket | IRS 1Y # | IRS 2Y # | IRS 3Y | IRS 4Y # | IRS 5Y # | IRS(4Y, 5Y) | IRS(4.5Y) |
|-------------|----------|----------|---------------|----------|----------|-------------|-----------|
| OIS 1Y | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OIS 2Y | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| OIS 4Y | 0 | -1 | -1 | -1 | 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     return pv_swap_dot;
```



```
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
}

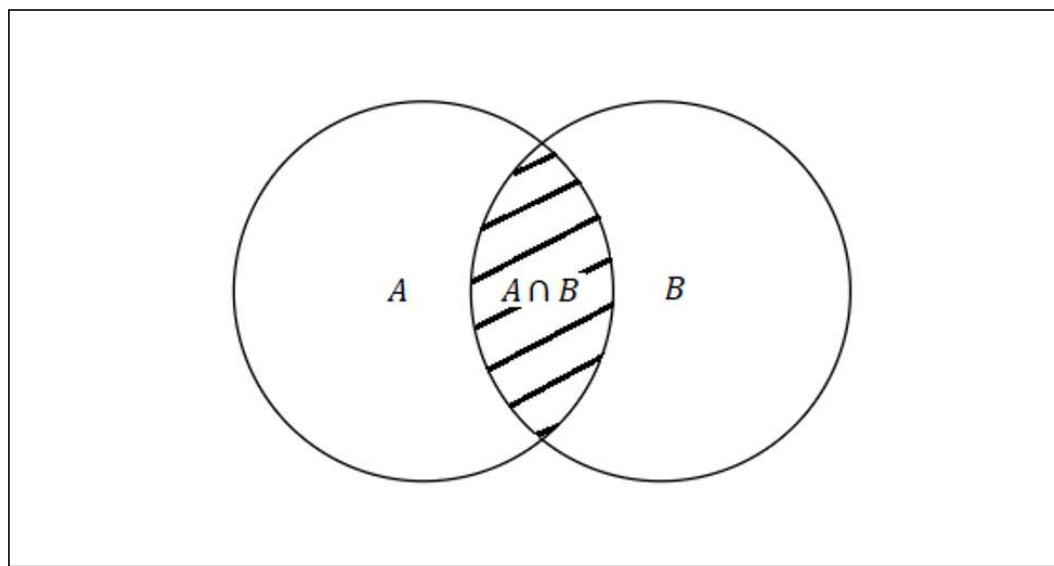
```

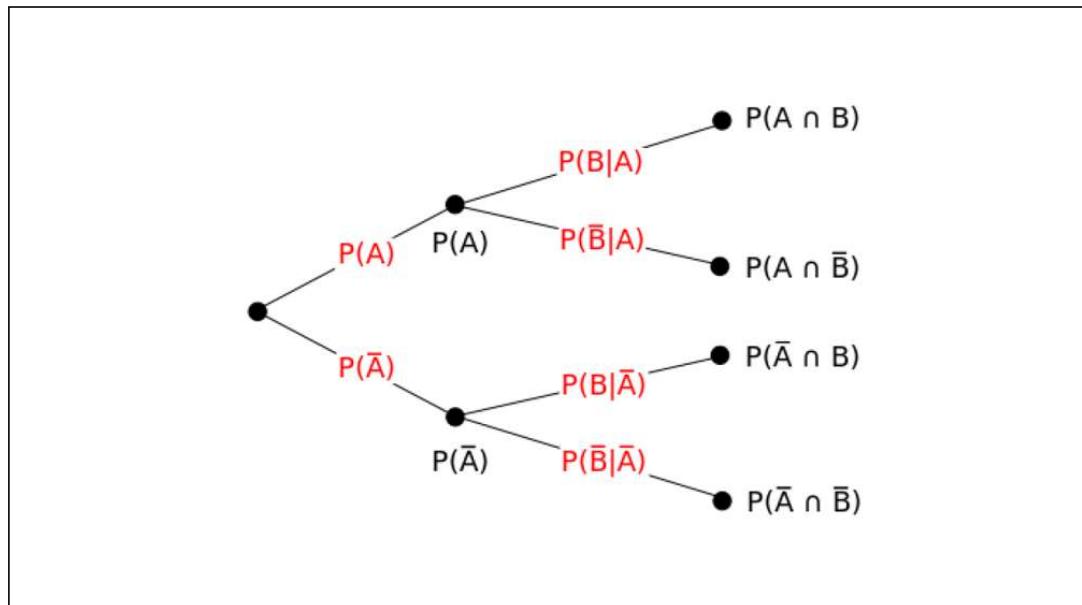


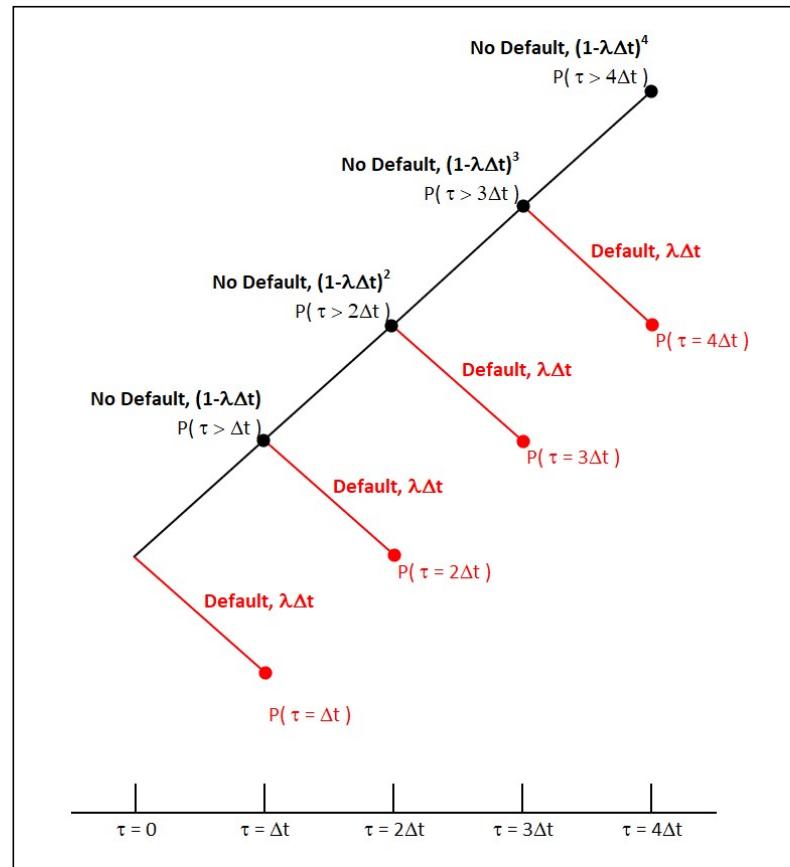
```
01 // inputs( phi, n, r, tau, t, f, s, z, pv_bar )
02 adjoint( 1, 1000000, 0.02, 1, 1, 0.01, 0, 0.02, 1 ); // Output DV01 Risk
```

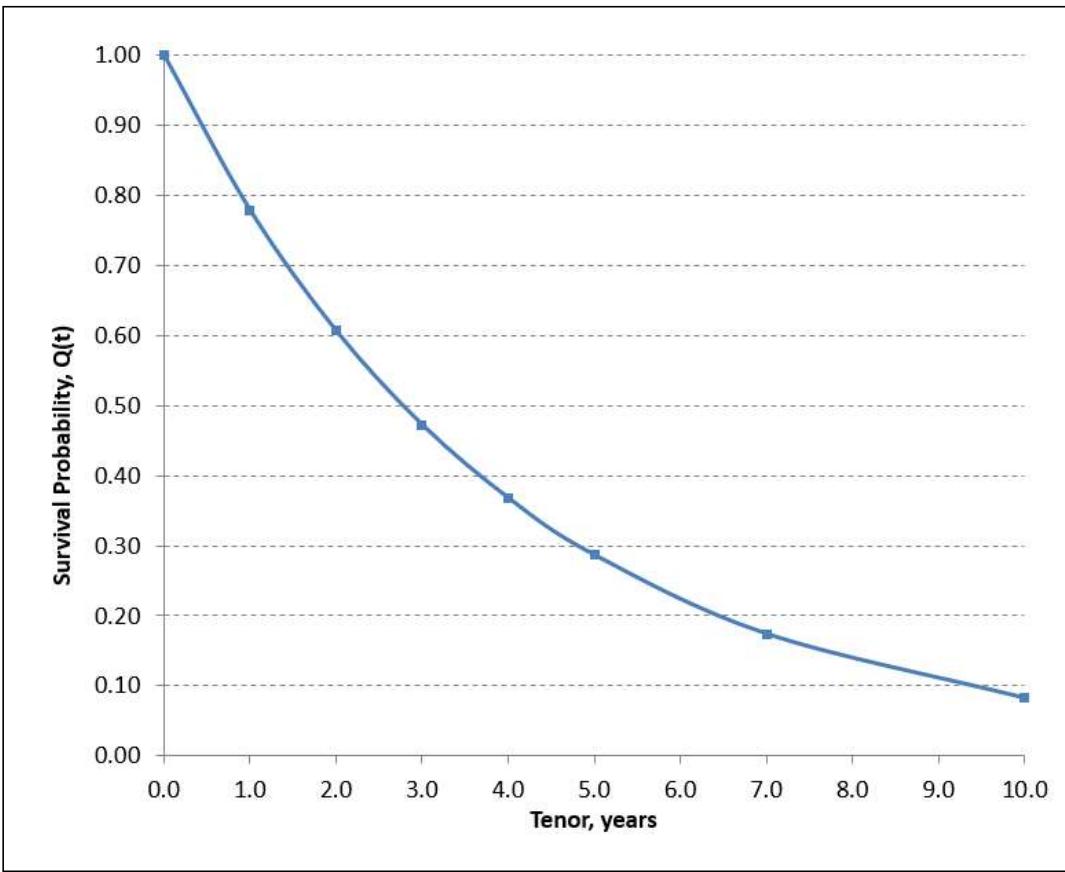


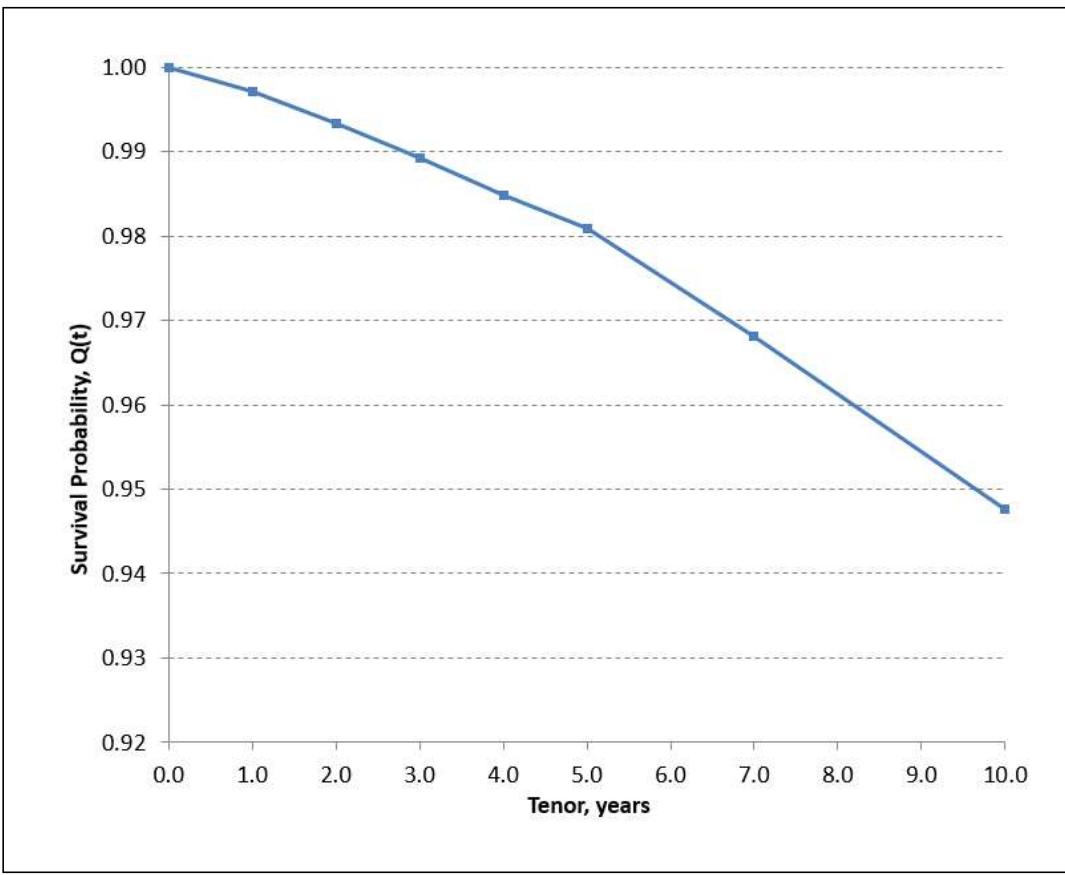
Chapter 6 – Credit Models

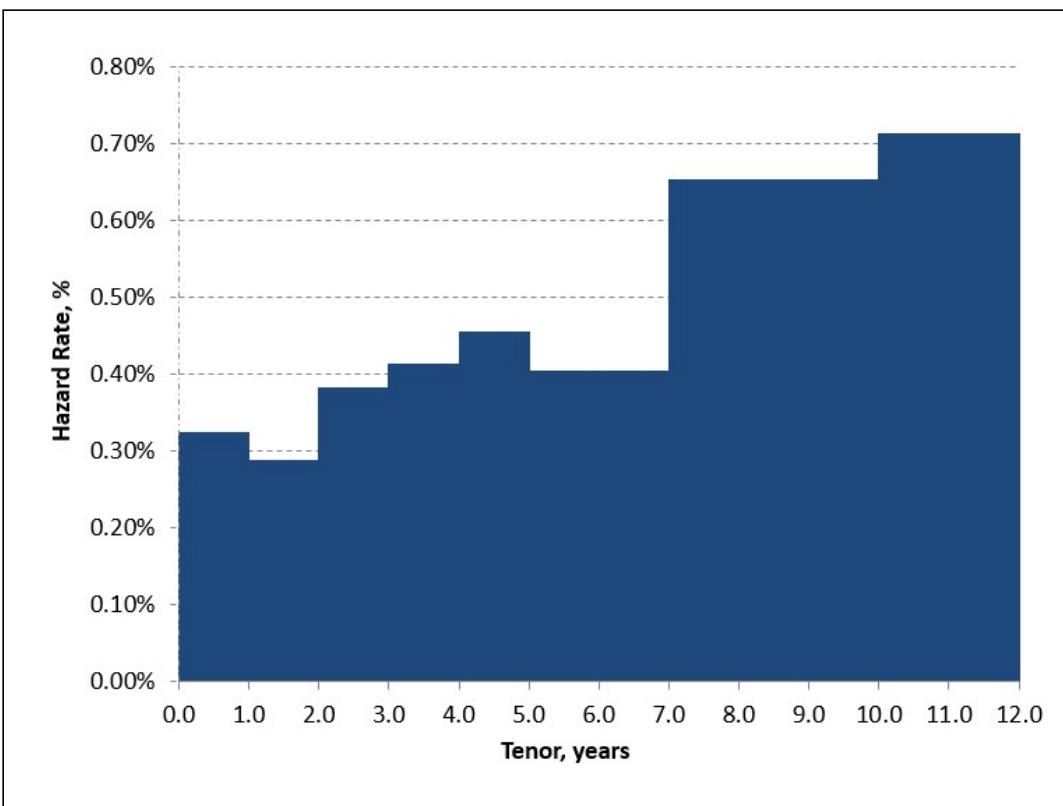


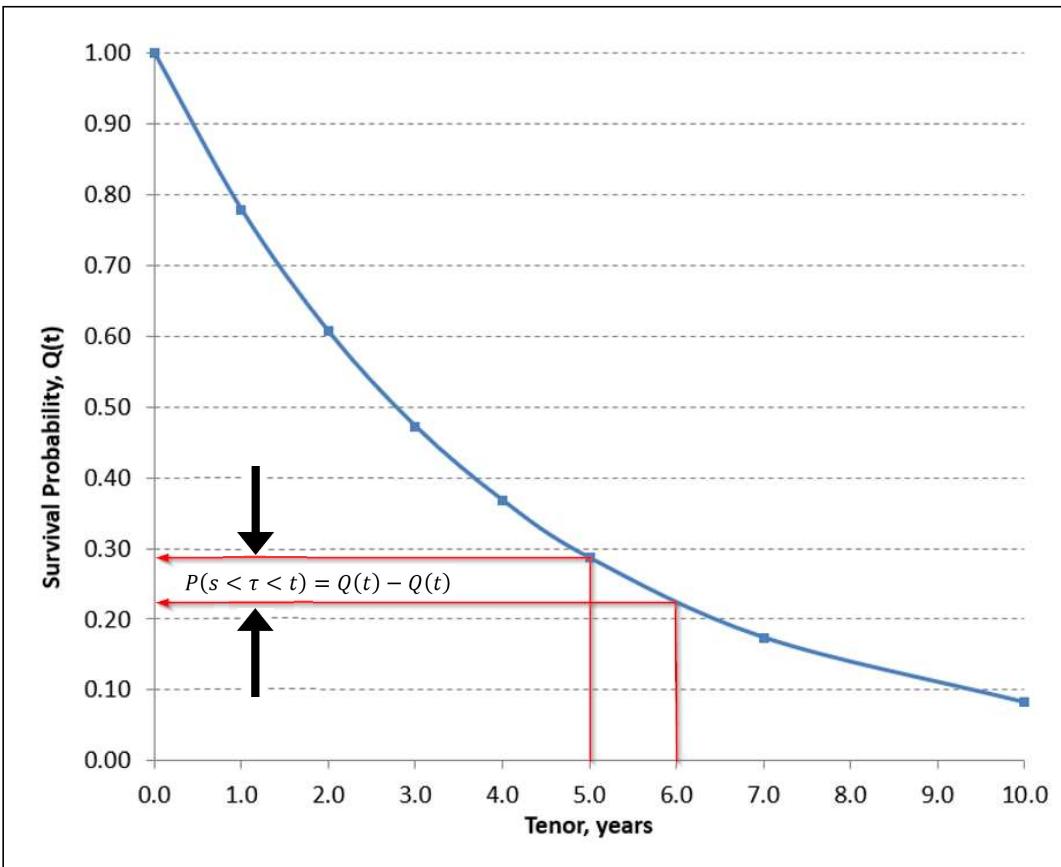












| SWAP LEG | CONVENTION | EUR | USD | GBP | JPY |
|-----------|-----------------------|------------------------|-----------------------|------------------------|-------------------------|
| FLOAT LEG | FREQUENCY DAYCOUNT | SEMI-ANNUAL ACT/360 | QUARTERLY ACT/360 | SEMI-ANNUAL ACT/365 | SEMI-ANNUAL ACT/360 |
| 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 | | | |

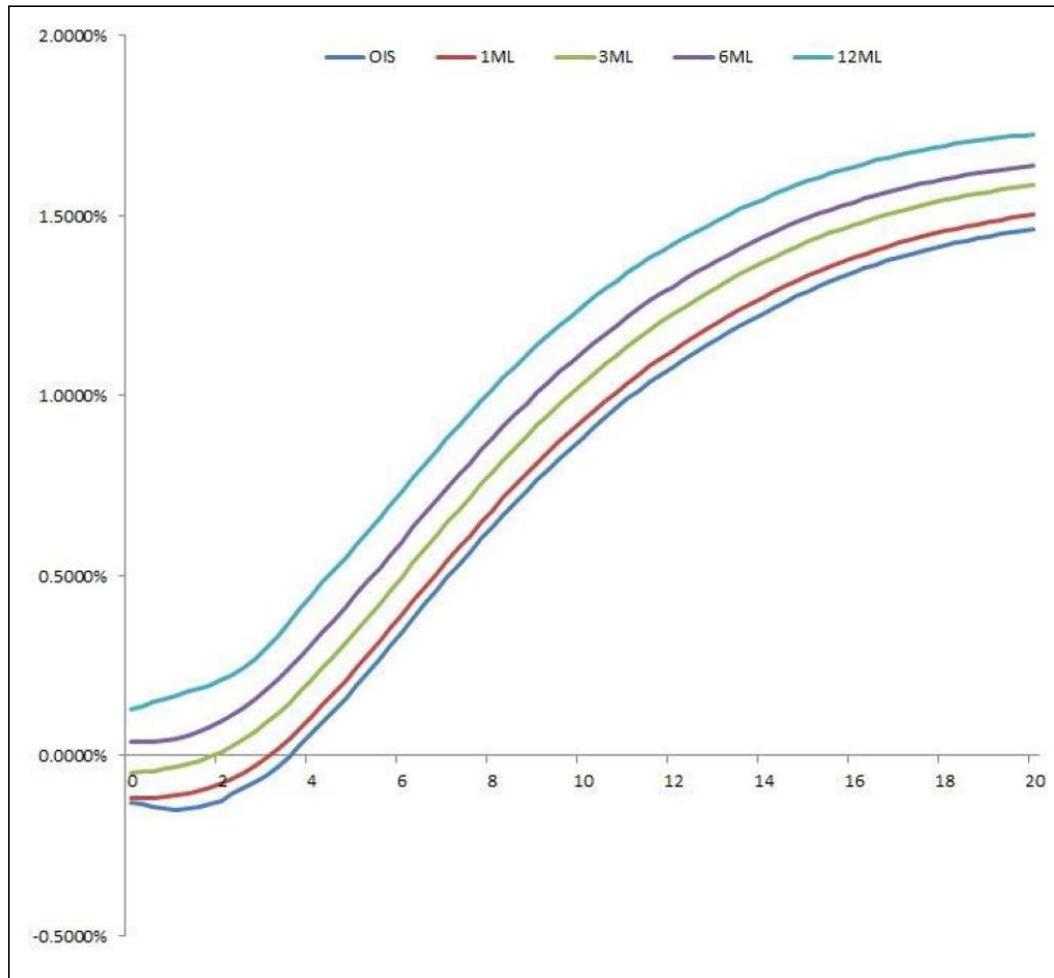
| Trade Template | | |
|----------------------|---------------------|---------------------|
| EUR IRS 5% EUR6ML 5Y | | |
| Swap | LEG1:FIXED | LEG2:FLOAT |
| Pay / Receive | RECEIVE | PAY |
| Notional | 1,000,000 | 1,000,000 |
| Currency | EUR | EUR |
| Effective Date | 2D Tue, 25-Aug-2015 | 2D Tue, 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 | |

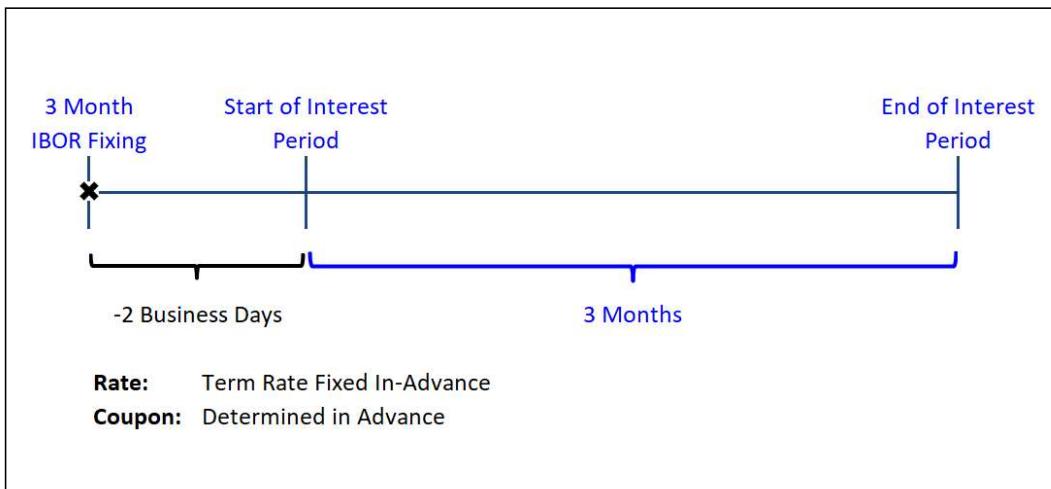
| Trade Template | | USD IRS USDSOFR 1Y | | | |
|-------------------|------------------|--------------------|------------------|--|--|
| Swap | LEG1:FIXED | | LEG2:FLOAT | | |
| | RECEIVE | | PAY | | |
| | 10,000,000 | | 10,000,000 | | |
| | USD | | USD | | |
| | 0D | Mon, 13-Jun-2022 | 0D | | |
| |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

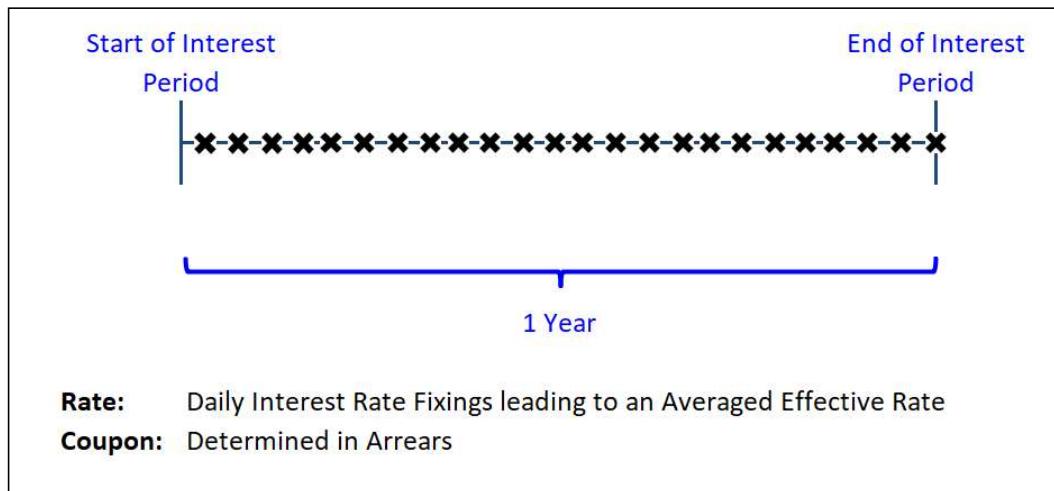
| Trade Template | | EUR IRS EURESTR 1Y | |
|--------------------------|---------------------|---------------------|--|
| Swap | | LEG1:FIXED | |
| Pay / Receive | RECEIVE | PAY | |
| Notional | 10,000,000 | 10,000,000 | |
| Currency | EUR | EUR | |
| Effective Date | 0D Mon, 13-Jun-2022 | 0D Mon, 13-Jun-2022 | |
| 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 | | |

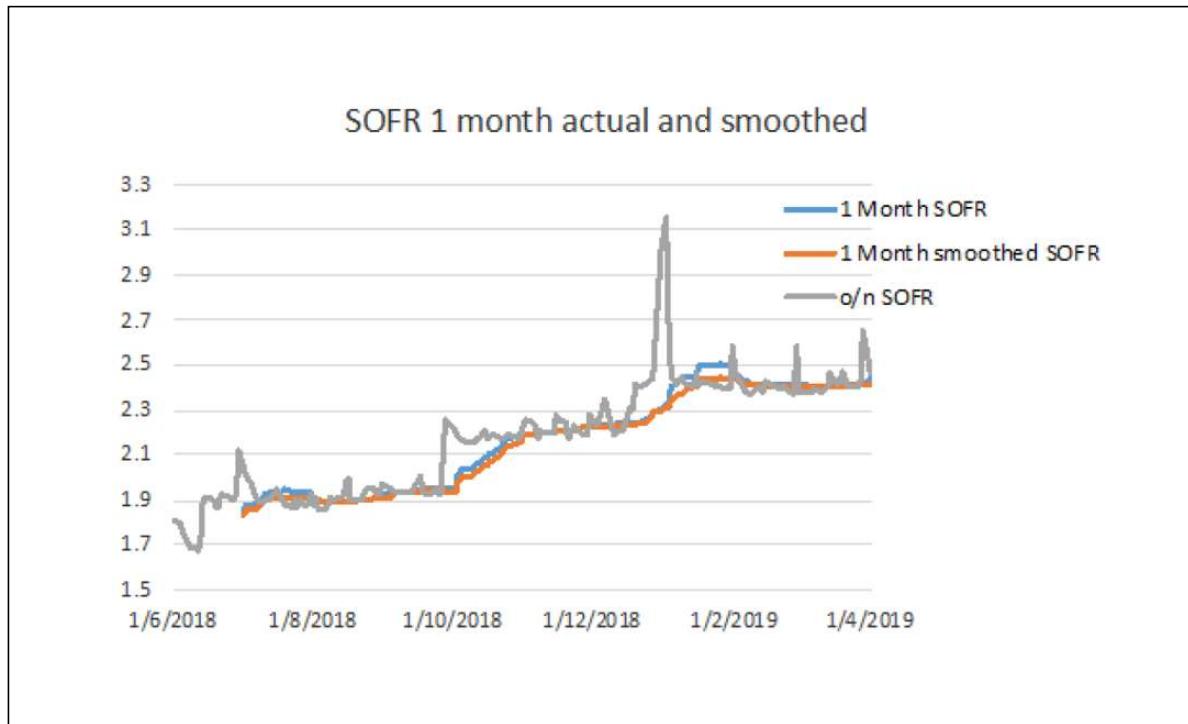
| Trade Template | | GBP IRS GBPSONIA 1Y | |
|--------------------|---------------------|---------------------|------------------|
| Swap | LEG1:FIXED | LEG2:FLOAT | |
| Pay / Receive | RECEIVE | PAY | |
| Notional | 10,000,000 | 10,000,000 | |
| Currency | GBP | GBP | |
| Effective Date | 0D Mon, 13-Jun-2022 | 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 |
| Pay / Receive | | RECEIVE | PAY |
| Notional | | 10,000,000 | 10,000,000 |
| Currency | | JPY | JPY |
| Effective Date | 0D | Mon, 13-Jun-2022 | 0D |
| Maturity Date | 1Y | Tue, 13-Jun-2023 | Tue, 13-Jun-2023 |
| Fixed Rate (%) | | 0.072396% | |
| Float Index | | | 1D 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

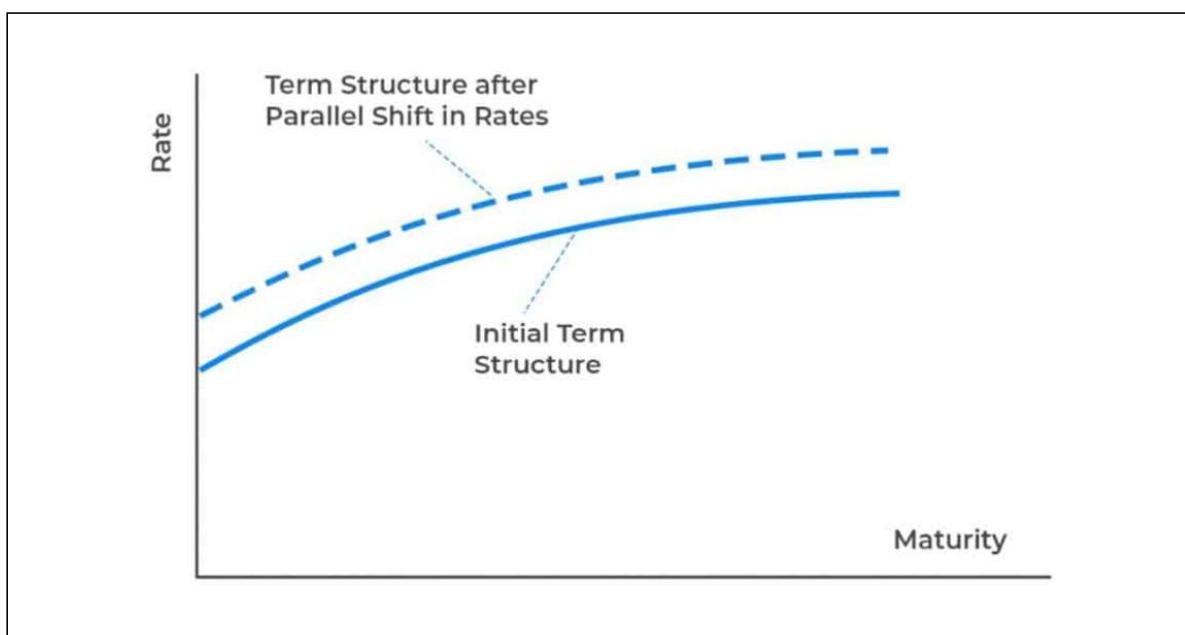
Chapter 7 – Interest Rate Swap Pricing & Risk

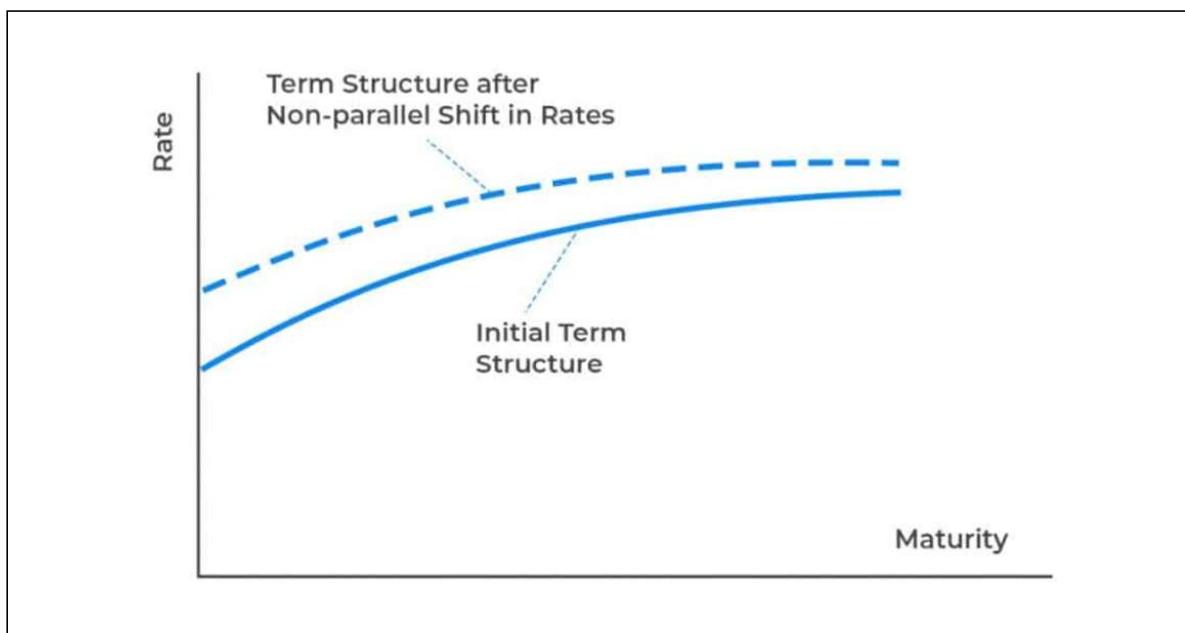
| Trade Template | | EUR IRS 1% EUR6ML 5Y | |
|--------------------|---------------------|----------------------|------------------|
| Swap | LEG1:FIXED | | LEG2:FLOAT |
| Pay / Receive | RECEIVE | PAY | |
| Notional | 1,000,000 | 1,000,000 | |
| Currency | EUR | EUR | |
| Effective Date | 2D Tue, 25-Aug-2015 | 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 |



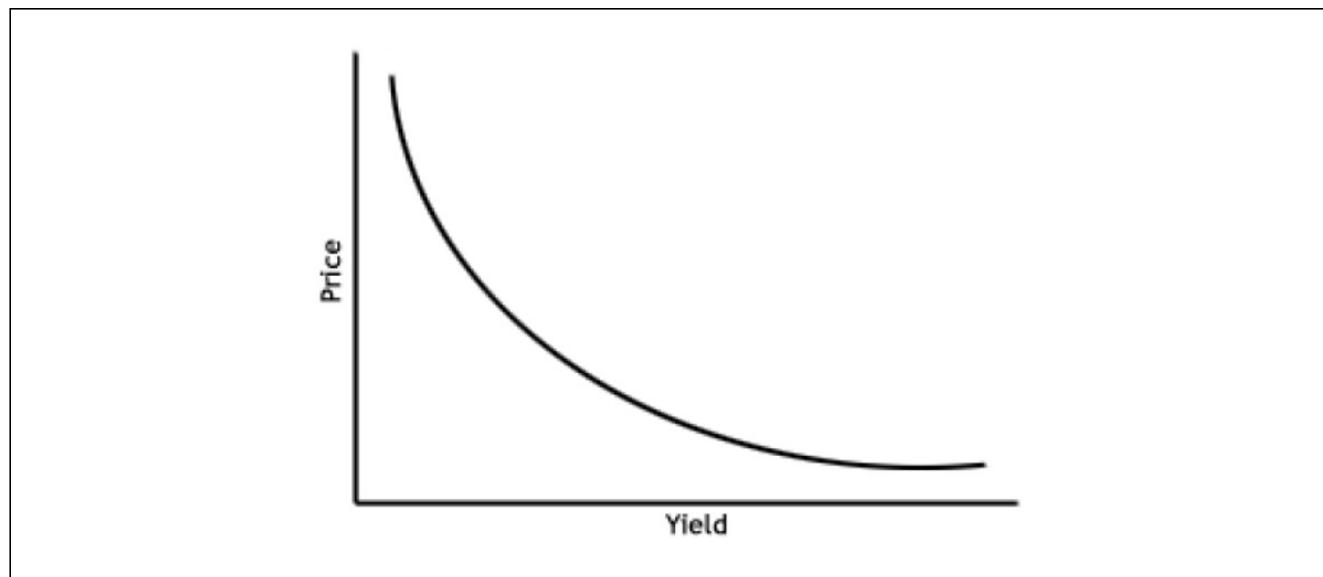
DV01 Decomposition

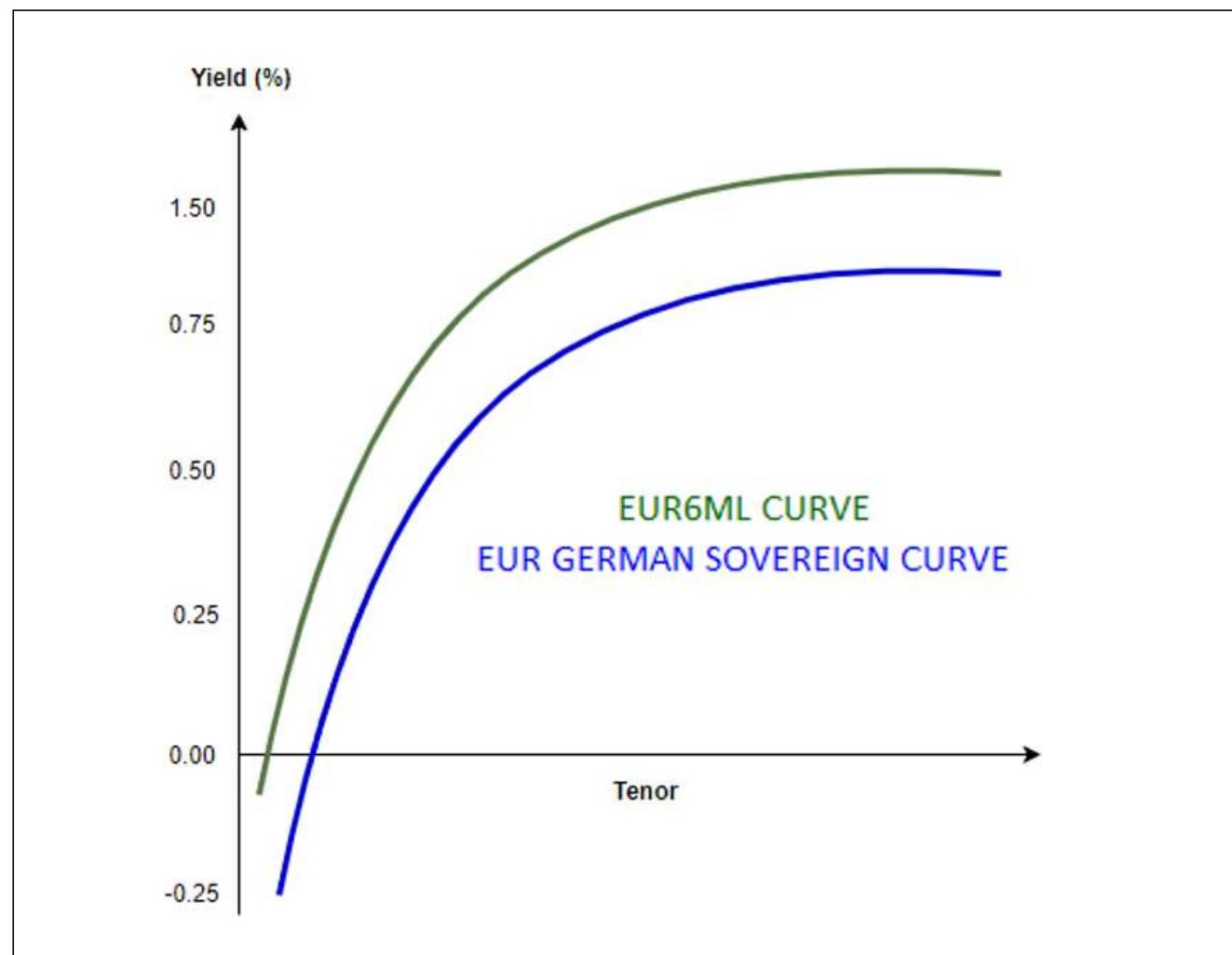
| | | |
|------|----------|---------------|
| PV01 | 1,970.40 | Forward Risk |
| DF01 | 32.44 | Discount Risk |
| DV01 | 2,002.84 | Total Risk |

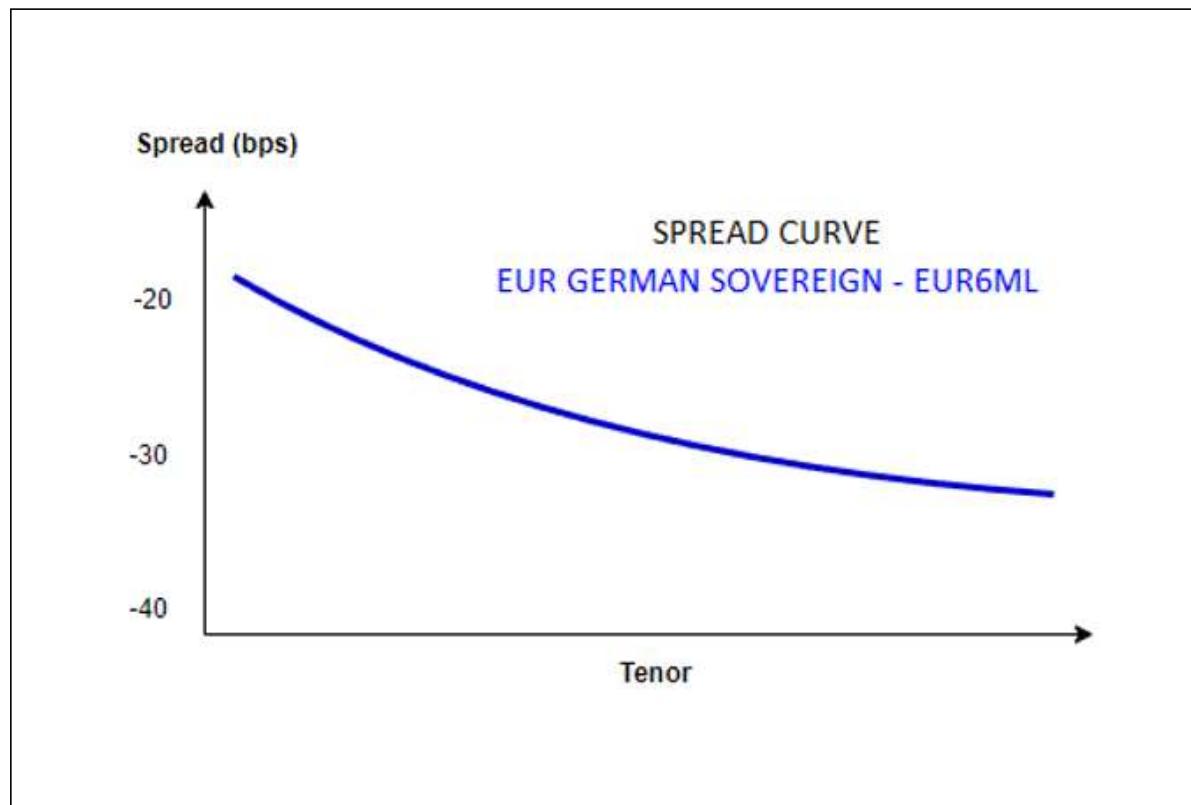


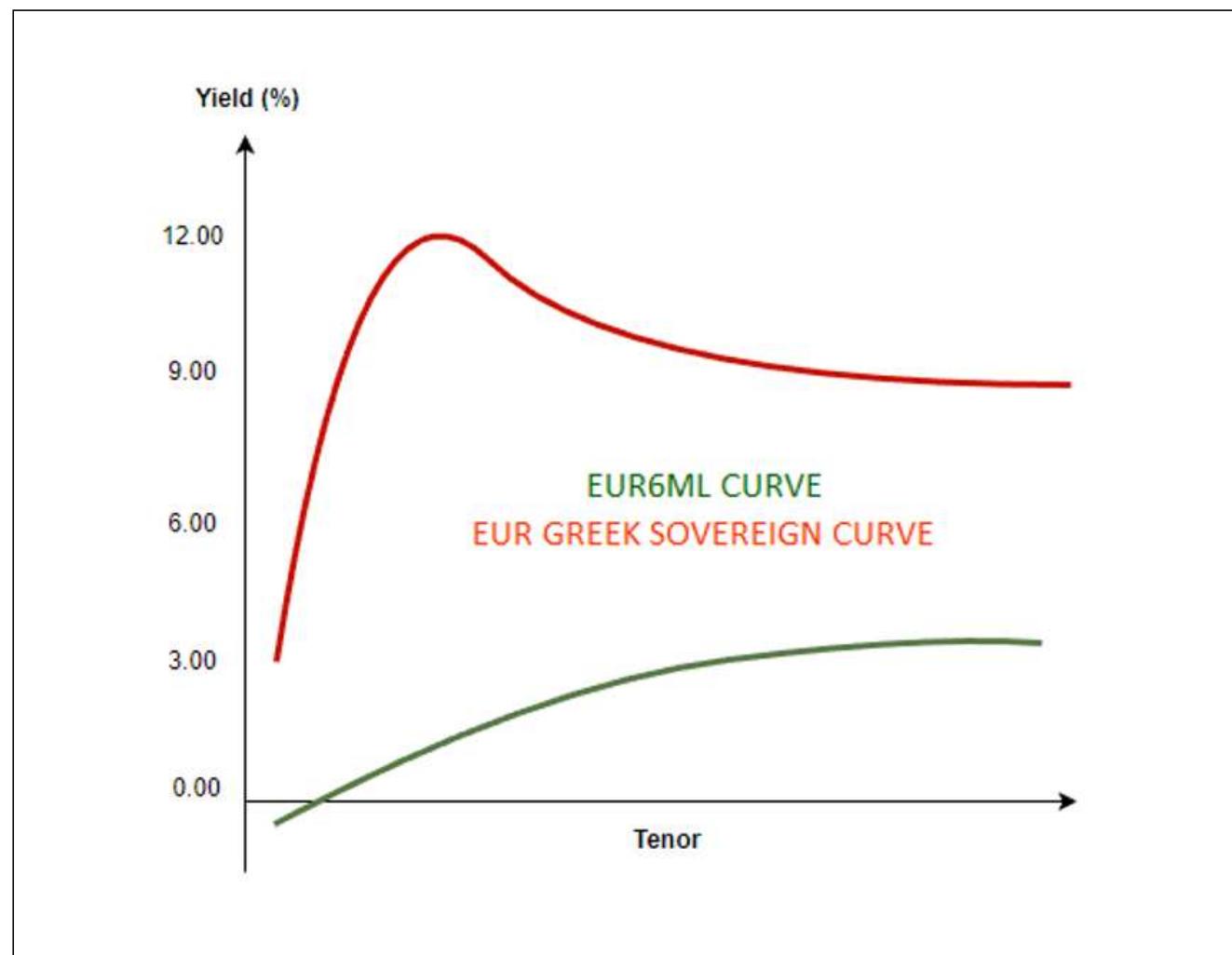
Chapter 9 – Asset Swap Structuring

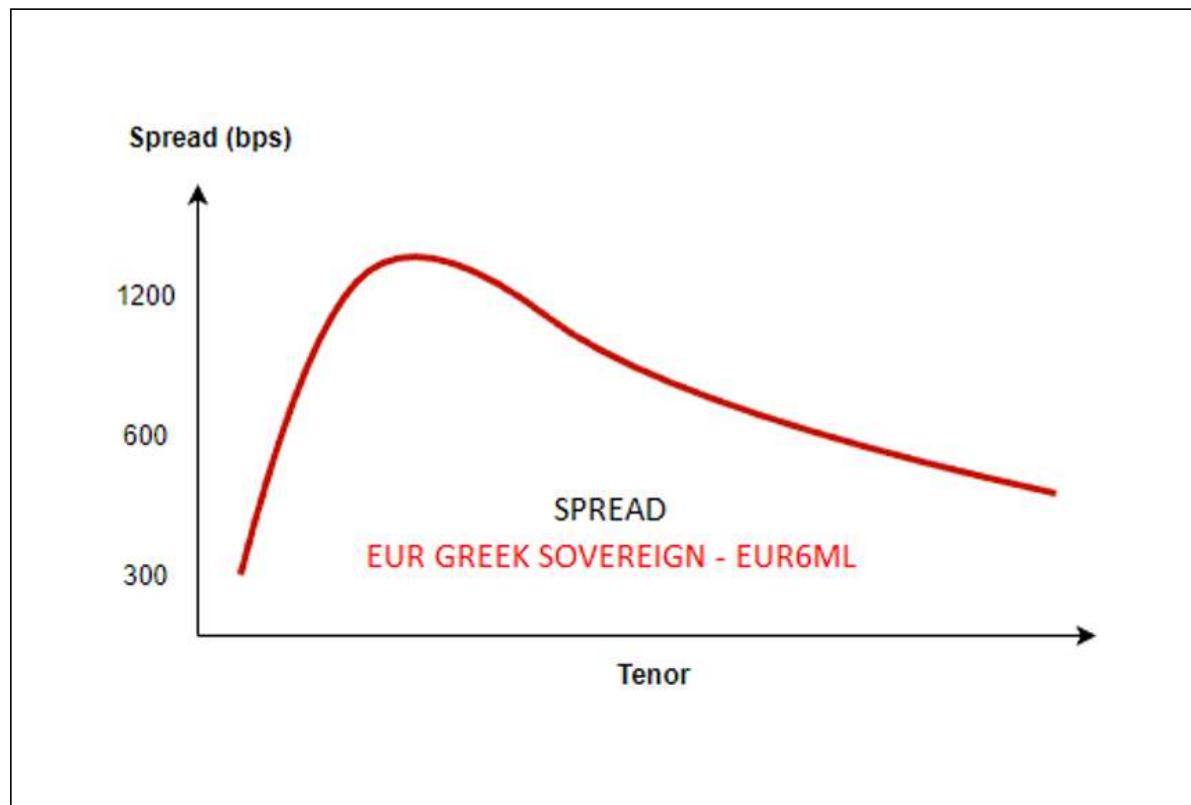


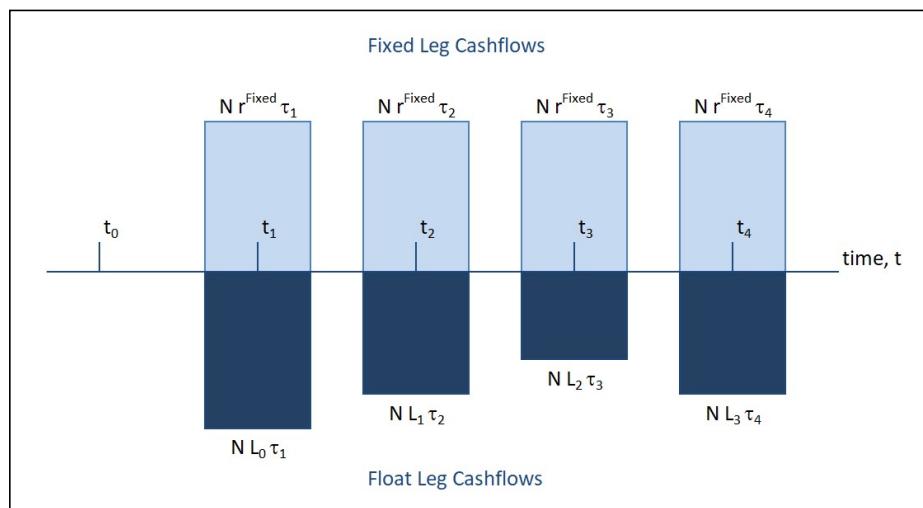








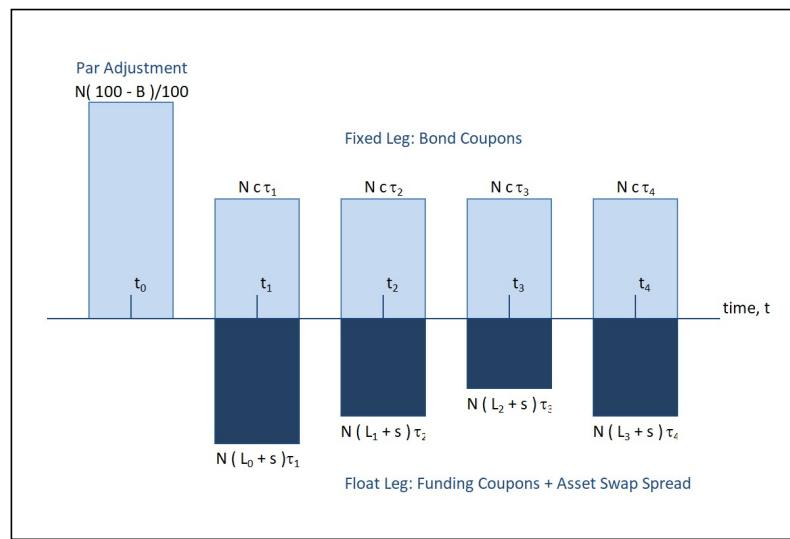


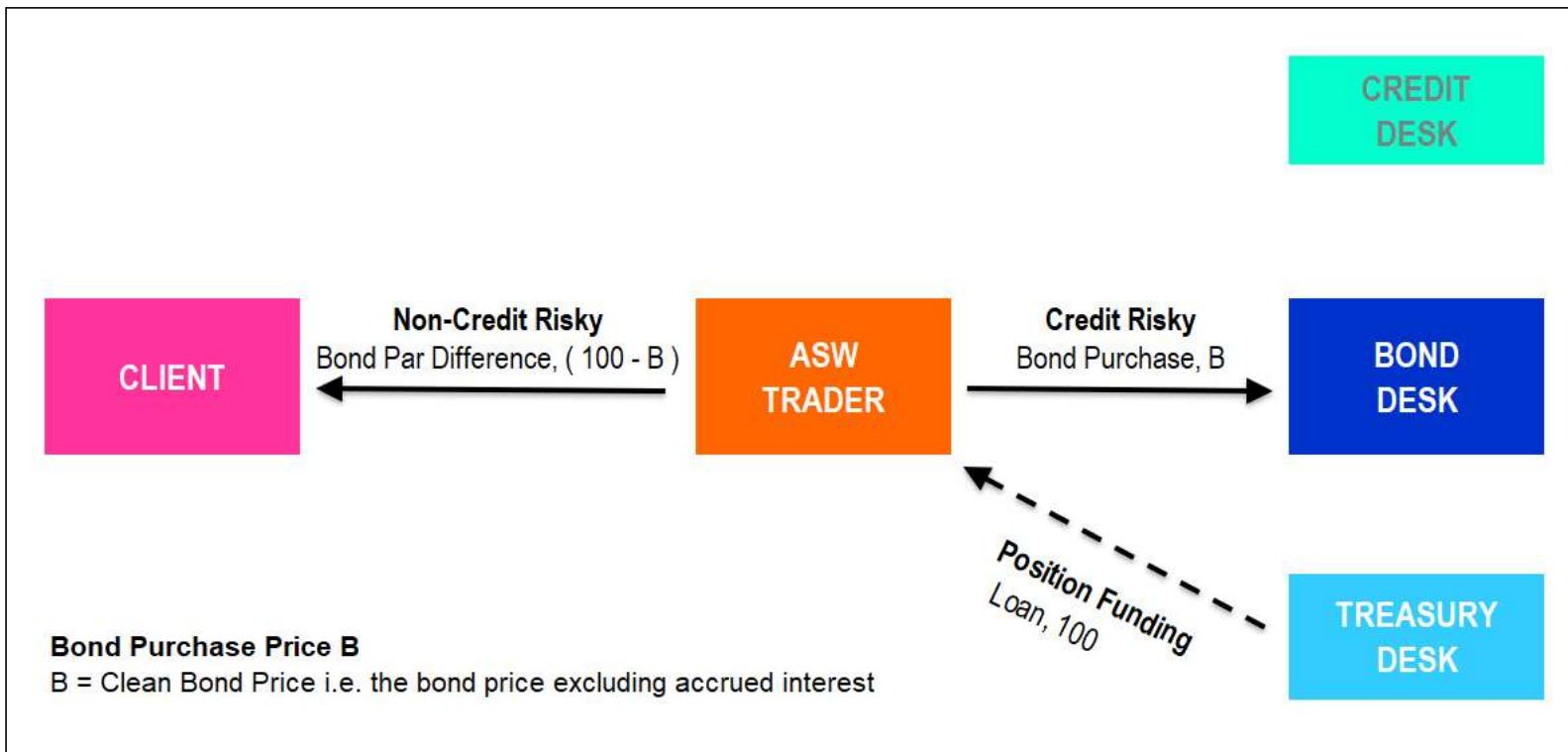


| Year | UST Yield | Spread | Swap Rate |
|------|-----------|---------|-----------|
| 1Y | 0.062% | 0.105% | 0.167% |
| 2Y | 0.225% | 0.091% | 0.316% |
| 3Y | 0.444% | 0.099% | 0.543% |
| 5Y | 0.786% | 0.079% | 0.865% |
| 7Y | 1.057% | 0.012% | 1.069% |
| 10Y | 1.261% | 0.006% | 1.267% |
| 30Y | 1.874%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



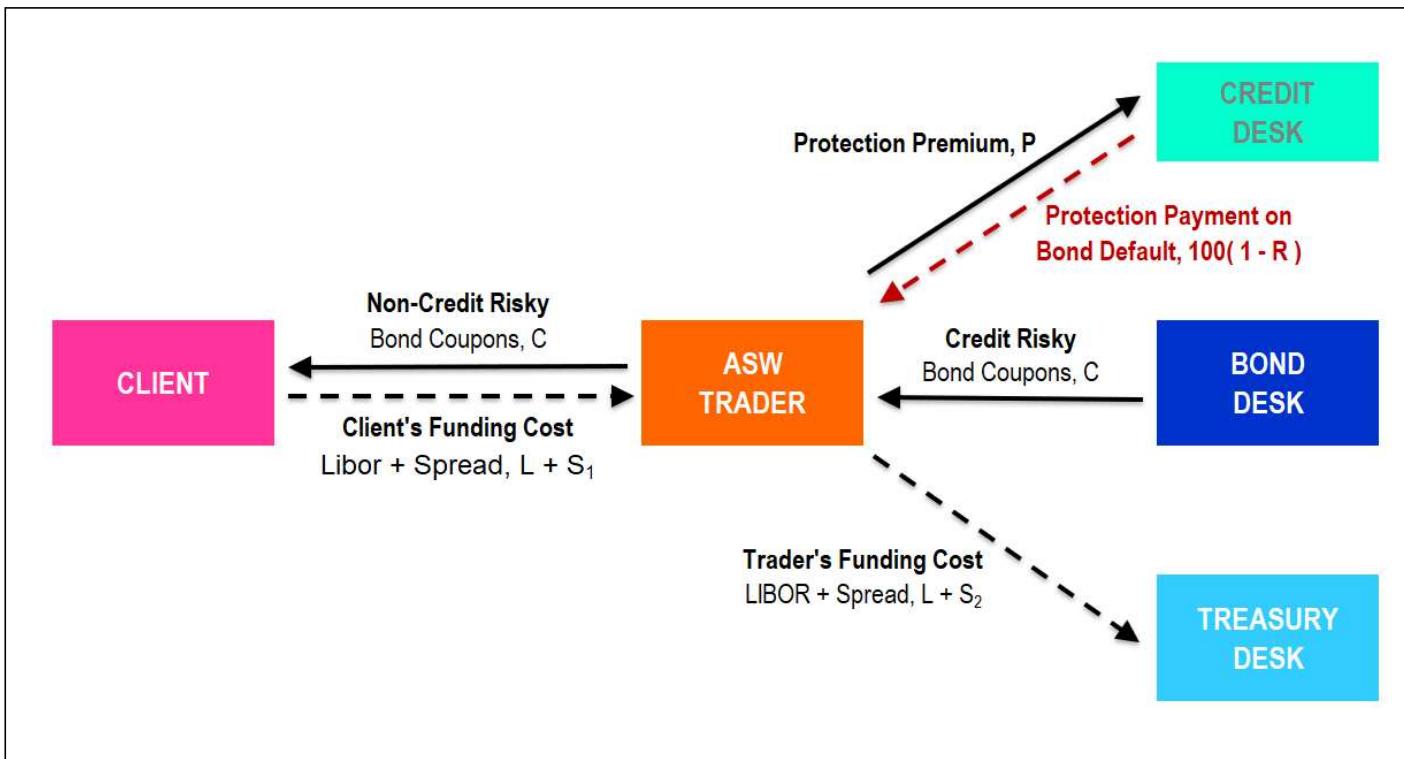


ASW Trader - Initial Cash Flows

| 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 | |

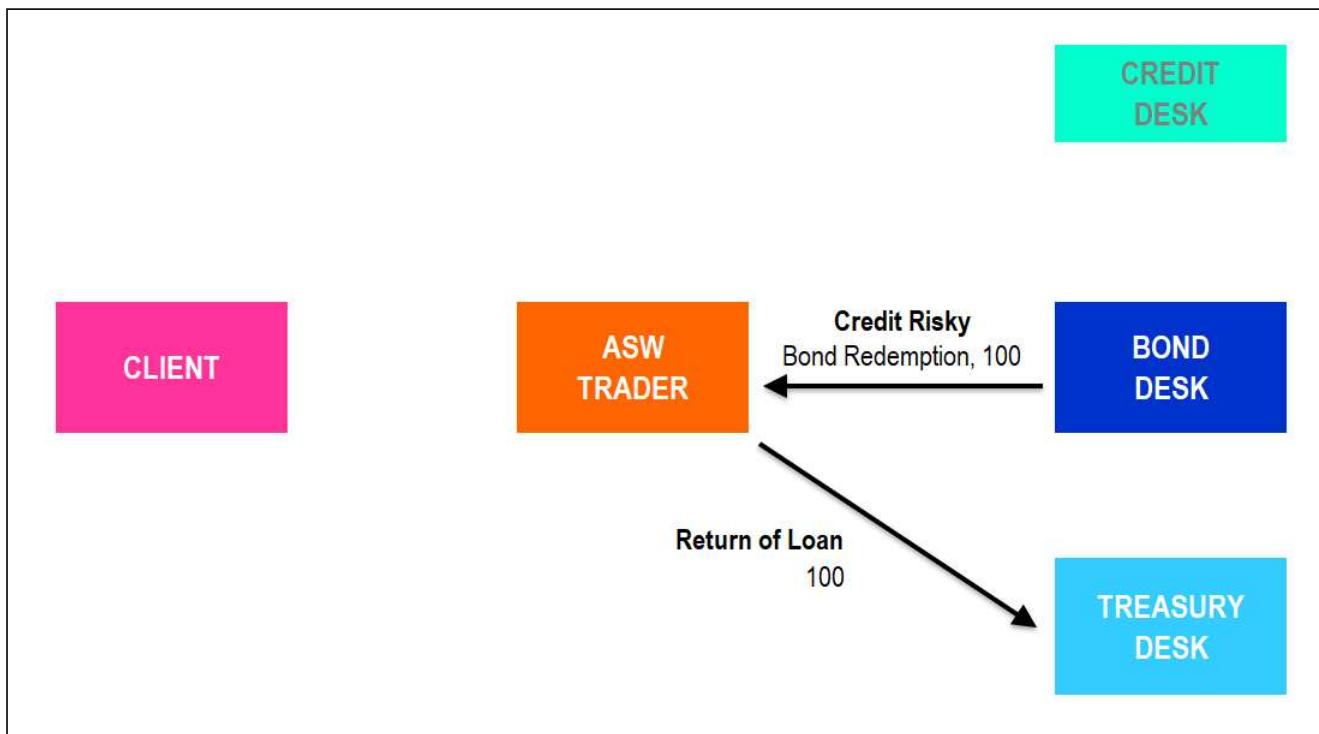
Asset Swap Spread Details:

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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr><td>Bond</td><td>JW503423</td></tr> <tr><td>Description</td><td>DBR 0.5% 15/02/26</td></tr> <tr><td>Coupon (%)</td><td>0.50000%</td></tr> <tr><td>Cpn Frequency</td><td>ANNUAL</td></tr> <tr><td>Day Count</td><td>ACT/ACT</td></tr> <tr><td>Accrual Start Date</td><td>Thu, 15-Jan-2026</td></tr> <tr><td>Maturity Date</td><td>Sun, 15-Feb-2026</td></tr> <tr><td>Maturity Price</td><td>100.0000</td></tr> <tr><td>Price Type</td><td>CLEAN</td></tr> <tr><td>Price</td><td>104.5800</td></tr> </table> | | | Bond | JW503423 | Description | DBR 0.5% 15/02/26 | Coupon (%) | 0.50000% | 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 | | | | | | | | | | | | | | | | |
| Bond | JW503423 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Description | DBR 0.5% 15/02/26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Coupon (%) | 0.50000% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <thead> <tr> <th></th><th>LEG1:FIXED</th><th>LEG2:FLOAT</th></tr> </thead> <tbody> <tr><td>Pay / Receive</td><td>PAY</td><td>RECEIVE</td></tr> <tr><td>Notional</td><td>1,000,000</td><td>1,000,000</td></tr> <tr><td>Currency</td><td>EUR</td><td>EUR</td></tr> <tr><td>Effective Date</td><td>Fri, 15-Jan-2016</td><td>Fri, 15-Jan-2016</td></tr> <tr><td>Maturity Date</td><td>Sun, 15-Feb-2026</td><td>Tue, 25-Aug-2020</td></tr> <tr><td>Fixed Rate (%)</td><td>0.50000%</td><td></td></tr> <tr><td>Float Index</td><td></td><td>6M EUR6ML</td></tr> <tr><td>Float Spread (bps)</td><td></td><td>0.000</td></tr> <tr><td>Reset Frequency</td><td></td><td>SEMI-ANNUAL</td></tr> <tr><td>Pay Frequency</td><td>ANNUAL</td><td>SEMI-ANNUAL</td></tr> <tr><td>Day Count</td><td>ACT/ACT</td><td>ACT/360</td></tr> </tbody> </table> | | | | 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 (%) | 0.50000% | | Float Index | | 6M EUR6ML | Float Spread (bps) | | 0.000 | Reset Frequency | | SEMI-ANNUAL | Pay Frequency | ANNUAL | SEMI-ANNUAL | Day Count | ACT/ACT | ACT/360 |
| | 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 (%) | 0.50000% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr><td>Curve Date</td><td>Thu, 9-Jun-2016</td><td>Thu, 9-Jun-2016</td></tr> <tr><td>Forecast Curve</td><td></td><td>EUR6ML</td></tr> <tr><td>Discount Curve</td><td>EUROIS</td><td>EUROIS</td></tr> </table> | | | Curve Date | Thu, 9-Jun-2016 | Thu, 9-Jun-2016 | Forecast Curve | | EUR6ML | Discount Curve | EUROIS | EUROIS | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Curve Date | Thu, 9-Jun-2016 | Thu, 9-Jun-2016 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Forecast Curve | | EUR6ML | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Discount Curve | EUROIS | EUROIS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Valuation Results | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr><td>Settle Date</td><td>Mon, 13-Jun-2016</td></tr> <tr><td>Par Rate (%)</td><td>0.441040%</td></tr> <tr><td>Par-Par Spread (bps)</td><td>-40.6</td></tr> <tr><td>Yield-Yield Spread</td><td>-41.2</td></tr> </table> | | | Settle Date | Mon, 13-Jun-2016 | Par Rate (%) | 0.441040% | Par-Par Spread (bps) | -40.6 | Yield-Yield Spread | -41.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr><td>Bond</td><td>EJ044543</td><td></td></tr> <tr><td>Description</td><td>GGB 3% 24/02/26</td><td></td></tr> <tr><td>Coupon (%)</td><td>3.000000%</td><td></td></tr> <tr><td>Cpn Frequency</td><td>ANNUAL</td><td></td></tr> <tr><td>Day Count</td><td>ACT/ACT</td><td></td></tr> <tr><td>Accrual Start Date</td><td>Wed, 24-Feb-2016</td><td></td></tr> <tr><td>Maturity Date</td><td>Tue, 24-Feb-2026</td><td></td></tr> <tr><td>Maturity Price</td><td>100.0000</td><td></td></tr> <tr><td>Price Type</td><td>CLEAN</td><td></td></tr> <tr><td>Price</td><td>75.2800</td><td></td></tr> </table> | | | Bond | EJ044543 | | Description | GGB 3% 24/02/26 | | Coupon (%) | 3.000000% | | Cpn Frequency | ANNUAL | | Day Count | ACT/ACT | | Accrual Start Date | Wed, 24-Feb-2016 | | Maturity Date | Tue, 24-Feb-2026 | | Maturity Price | 100.0000 | | Price Type | CLEAN | | Price | 75.2800 | | | | | | | |
| Bond | EJ044543 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Description | GGB 3% 24/02/26 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Coupon (%) | 3.000000% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Cpn Frequency | ANNUAL | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Day Count | ACT/ACT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Accrual Start Date | Wed, 24-Feb-2016 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Maturity Date | Tue, 24-Feb-2026 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Maturity Price | 100.0000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Price Type | CLEAN | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Price | 75.2800 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Swap | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <thead> <tr> <th></th><th>LEG1:FIXED</th><th>LEG2:FLOAT</th></tr> </thead> <tbody> <tr><td>Pay / Receive</td><td>PAY</td><td>RECEIVE</td></tr> <tr><td>Notional</td><td>1,000,000</td><td>1,000,000</td></tr> <tr><td>Currency</td><td>EUR</td><td>EUR</td></tr> <tr><td>Effective Date</td><td>Wed, 24-Feb-2016</td><td>Wed, 24-Feb-2016</td></tr> <tr><td>Maturity Date</td><td>Tue, 24-Feb-2026</td><td>Tue, 24-Feb-2026</td></tr> <tr><td>Fixed Rate (%)</td><td>3.000000%</td><td></td></tr> <tr><td>Float Index</td><td></td><td>6M EUR6ML</td></tr> <tr><td>Float Spread (bps)</td><td></td><td>0.000</td></tr> <tr><td>Reset Frequency</td><td></td><td>SEMI-ANNUAL</td></tr> <tr><td>Pay Frequency</td><td>ANNUAL</td><td>SEMI-ANNUAL</td></tr> <tr><td>Day Count</td><td>ACT/ACT</td><td>ACT/360</td></tr> </tbody> </table> | | | | LEG1:FIXED | LEG2:FLOAT | Pay / Receive | PAY | RECEIVE | Notional | 1,000,000 | 1,000,000 | Currency | EUR | EUR | Effective Date | Wed, 24-Feb-2016 | Wed, 24-Feb-2016 | Maturity Date | Tue, 24-Feb-2026 | Tue, 24-Feb-2026 | Fixed Rate (%) | 3.000000% | | Float Index | | 6M EUR6ML | Float Spread (bps) | | 0.000 | Reset Frequency | | SEMI-ANNUAL | Pay Frequency | ANNUAL | SEMI-ANNUAL | Day Count | ACT/ACT | ACT/360 |
| | LEG1:FIXED | LEG2:FLOAT | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Pay / Receive | PAY | RECEIVE | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Notional | 1,000,000 | 1,000,000 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Currency | EUR | EUR | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Effective Date | Wed, 24-Feb-2016 | Wed, 24-Feb-2016 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Maturity Date | Tue, 24-Feb-2026 | Tue, 24-Feb-2026 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Fixed Rate (%) | 3.000000% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 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 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr><td>Curve Date</td><td>Thu, 9-Jun-2016</td><td>Thu, 9-Jun-2016</td></tr> <tr><td>Forecast Curve</td><td></td><td>EUR6ML</td></tr> <tr><td>Discount Curve</td><td>EUROIS</td><td>EUROIS</td></tr> </table> | | | Curve Date | Thu, 9-Jun-2016 | Thu, 9-Jun-2016 | Forecast Curve | | EUR6ML | Discount Curve | EUROIS | EUROIS | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Curve Date | Thu, 9-Jun-2016 | Thu, 9-Jun-2016 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Forecast Curve | | EUR6ML | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Discount Curve | EUROIS | EUROIS | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Valuation Results | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <table border="1"> <tr><td>Settle Date</td><td>Mon, 13-Jun-2016</td><td></td></tr> <tr><td>Par Rate (%)</td><td>0.444180%</td><td></td></tr> <tr><td>Par-Par Spread (bps)</td><td>573.8</td><td></td></tr> <tr><td>Yield-Yield Spread</td><td>682.4</td><td></td></tr> </table> | | | Settle Date | Mon, 13-Jun-2016 | | Par Rate (%) | 0.444180% | | Par-Par Spread (bps) | 573.8 | | Yield-Yield Spread | 682.4 | | | | | | | | | | | | | | | | | | | | | | | | | |
| Settle Date | Mon, 13-Jun-2016 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Par Rate (%) | 0.444180% | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Par-Par Spread (bps) | 573.8 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Yield-Yield Spread | 682.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| 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 |

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 (%) | | 0.50000% | |
| 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 (%) | 0.50000% | | |
| 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 |

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 | | | | Quick Risk | | Quick Risk | |
|------------------------------|--------|-------------|-----------|------------------------|------------|---|-------|
| Portfolio Risk - Trade Level | | | | Portfolio Risk - Total | | Portfolio Hedges | |
| Risk Bucket | IRS 1Y | IRS(4Y, 5Y) | IRS(4.5Y) | Risk Bucket | Risk Total | Hedge | Qty |
| OIS 1Y | 0 | 0 | 0 | OIS 1Y | 0 | OIS 1Y | 0 |
| OIS 2Y | 0 | 0 | 0 | OIS 2Y | 0 | OIS 2Y | 0 |
| OIS 3Y | 0 | 0 | 0 | OIS 3Y | 0 | OIS 3Y | 0 |
| OIS 4Y | 0 | 0 | 0 | OIS 4Y | 0 | OIS 4Y | 0 |
| OIS 5Y | 0 | 0 | 0 | OIS 5Y | 0 | OIS 5Y | 0 |
| IRS 1Y | 100 | 0 | 0 | IRS 1Y | 100 | IRS 1Y | -1 |
| IRS 2Y | 0 | 0 | 0 | IRS 2Y | 0 | IRS 2Y | 0 |
| IRS 3Y | 0 | 0 | 0 | IRS 3Y | 0 | IRS 3Y | 0 |
| IRS 4Y | 0 | -400 | 200 | IRS 4Y | -200 | IRS 4Y | 0.50 |
| IRS 5Y | 0 | 500 | 250 | IRS 5Y | 750 | IRS 5Y | -1.50 |
| Total Trade DV01 | | | | Total DV01 | |  | |
| IRS 1Y | | IRS(4Y, 5Y) | IRS(4.5Y) | 650 | | | |
| 100 | | 100 | 450 | | | | |

| 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.

Available at Amazon:

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