
# FX Non-Deliverable Forward Product Specification

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# Chapter 1

# FX Non-Deliverable Forward

## 1.1 Instrument Properties

An FX non-deliverable forward (NDF) is a cash-settled agreement to purchase a predetermined amount of one currency, the **receive currency** against another currency, the **pay currency** at an agreed fixed exchange rate, the **strike rate** on the **maturity date** (MD).

Figure 1.1 illustrates an FX non-deliverable forward that swaps \$100,000 AUD for \$60,000 GBP.

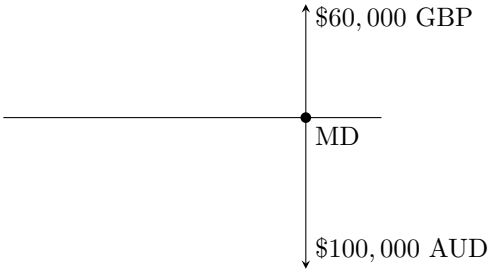


Figure 1.1: FX non-deliverable forward

## 1.2 Definitions

In this section, we define terms that are specific to FX non-deliverable forwards.

**maturity date** is the date the contract expires.

**pay currency** is the currency one agreed to sell.

**receive currency** is the currency one agreed to purchase.

**strike rate** is the agreed exchange rate between **pay currency** and **receive currency**.

## 1.3 Representations

In the Risk Engine, products are specified by *representations*. In this section, we provide the representations of FX non-deliverable forwards.

### 1.3.1 Default Representation

The *Default* representation consists of the mandatory trade fields in Table 1.1, the optional trade fields in Table 1.2, with their restrictions in Table 1.3.

| *Field* | *Description* | *Data Type* | *Symbol* |
|---|---|---|---|
| PayCurrency | The **pay currency** | string | p |
| RecCurrency | The **receive currency** | string | r |
| PayAmount | The amount to be paid in *PayCurrency* | double | $N_{\mathrm{p}}$ |
| RecAmount | The amount to be received in *RecCurrency* | double | $N_{\mathrm{r}}$ |
| MaturityDate | The **maturity date** | date | MD |

Table 1.1: Mandatory trade fields for the Default representation of the FX NDF

| *Field* | *Description* | *Data Type* | *Symbol* | *Default Value* |
|---|---|---|---|---|
| BreakDate | Date of the right to break | date | BD | MD |
| PayCurrencyDiscountReference | Alternative discounting curve for pay leg | string | | |
| RecCurrencyDiscountReference | Alternative discounting curve for receive leg | string | | |

Table 1.2: Optional trade field for the Default representation of the FX NDF

| *Field* | *Restriction* |
|---|---|
| RecCurrency | $\mathrm{r} \neq \mathrm{p}$ |
| PayAmount | $N_{\mathrm{p}} > 0$ |
| RecAmount | $N_{\mathrm{r}} > 0$ |

Table 1.3: Trade field restrictions for the Default representation of the FX NDF

#### 1.3.1.1 Required Curves

The following curves are required by an FX NDF:

- *PayCurrency FX spot curve*: FX Spot Curve — (FX.PRICE.PayCurrency.BaseCurrency),
- *ReceiveCurrency FX spot curve*: FX Spot Curve — (FX.PRICE.ReceiveCurrency.BaseCurrency),
- *PayCurrency discounting curve*: FX Zero Curve — (FX.ZERO.PayCurrency.ReserveCurrency), and
- *ReceiveCurrency discounting curve*: FX Zero Curve — (FX.ZERO.ReceiveCurrency.ReserveCurrency).

When the optional field PayCurrencyDiscountReference or RecCurrencyDiscountReference is provided, the reference curve is used as the PayCurrency discounting curve or the RecCurrency discounting curve respectively.

### 1.3.2 Strike Representation

The *Strike* representation consists of the mandatory trade fields in Table 1.4, the optional trade fields in Table 1.5, with their restrictions in Table 1.6.

#### 1.3.2.1 Required Curves

The following curves are required by an FX NDF:

- *Currency FX spot curve*: FX Spot Curve — (FX.PRICE.Currency.BaseCurrency),
- *CrossCurrency FX spot curve*: FX Spot Curve — (FX.PRICE.CrossCurrency.BaseCurrency),
- *Currency discounting curve*: FX Zero Curve — (FX.ZERO.Currency.ReserveCurrency), and
- *CrossCurrency discounting curve*: FX Zero Curve — (FX.ZERO.CrossCurrency.ReserveCurrency).

When the optional field CurrencyDiscountReference or CrossCurrencyDiscountReference is provided, the reference curve is used as the Currency discounting curve or the CrossCurrency discounting curve respectively.

| *Field* | *Description* | *Data Type* | *Symbol* |
|---|---|---|---|
| Currency | The primary currency | string | p |
| CrossCurrency | The cross currency | string | c |
| CrossCurrencyAmount | The deal amount in *CrossCurrency* | double | $N_c$ |
| Strike | The **strike rate** as *Currency*/*CrossCurrency* | double | $X$ |
| MaturityDate | The **maturity date** | date | MD |
| Direction | Pay and receive direction | string | direction |

Table 1.4: Mandatory trade fields for the Strike representation of the FX NDF

| *Field* | *Description* | *Data Type* | *Symbol* | *Default Value* |
|---|---|---|---|---|
| BreakDate | Date of the right to break | date | BD | MD |
| CurrencyDiscountReference | Alternative discounting curve for currency leg | string | | |
| CrossCurrencyDiscountReference | Alternative discounting curve for cross currency leg | string | | |

Table 1.5: Optional trade field for the Strike representation of the FX NDF

| *Field* | *Restriction* |
|---|---|
| CrossCurrency | $c \neq p$ |
| CrossCurrencyAmount | $N_c > 0$ |
| Strike | $X > 0$ |
| Direction | PayCurrencyReceiveCrossCurrency, ReceiveCurrencyPayCrossCurrency |

Table 1.6: Trade field restrictions for the Strike representation of the FX NDF

### 1.3.3 Cashflows Representation

The *Cashflows* representation consists of the optional trade field in Table 1.7 and the accepted cashflows are

- no interest flow (NoInterest)[1], and
- fixed flow (Fixed)[2].

| *Field* | *Description* | *Data Type* | *Symbol* | *Default Value* |
|---|---|---|---|---|
| BreakDate | Date of the right to break | date | BD | |

Table 1.7: Optional trade field for Cashflows representation of the FX NDF

## 1.4 Cashflow Generation

For an FX NDF, two cashflows are generated:

1) a no interest flow in the pay direction, and

2) a no interest flow in the receive direction,

as illustrated in Table 1.8.

[1] See No Interest Cashflow for details (p.10 of this document).
[2] See Fixed Cashflow for details (p.13 of this document).

| *Field* | *Pay Side* | *Receive Side* |
|---|---|---|
| FlowType | NoInterest | NoInterest |
| PayReceive | Pay | Receive |
| Currency | p | r |
| FlowDate | MD | MD |
| Amount | $N_{\mathrm{p}}$ | $N_{\mathrm{r}}$ |

Table 1.8: Cashflow generation for FX NDF

### 1.4.1 Representation Reduction

The cashflow generation algorithm described in Table 1.8 is only defined for the Default representation. If the trade is specified by other representations, we need to reduce it to the Default representation.

#### 1.4.1.1 Strike Representation

For the Strike representation, the trade fields are set according to the trade field Direction, as illustrated in Table 1.9, with the trade fields in column 1 take the values in either column 2 or 3, depending on the trade field Direction.

| *Direction* | *PayCurrencyReceiveCrossCurrency* | *ReceiveCurrencyPayCrossCurrency* |
|---|---|---|
| PayCurreny | Currency | CrossCurrency |
| RecCurrency | CrossCurrency | Currency |
| PayAmount | Strike $\times$ CrossCurrencyAmount | CrossCurrencyAmount |
| RecAmount | CrossCurrencyAmount | Strike $\times$ CrossCurrencyAmount |
| PayCurrencyDiscountReference | CurrencyDiscountReference | CrossCurrencyDiscountReference |
| RecCurrencyDiscountReference | CrossCurrencyDiscountReference | CurrencyDiscountReference |

Table 1.9: Representation reduction for the Strike representation of the FX NDF

## 1.5 Examples

This section provides some deal examples of FX NDF.

**Example 1.1.** An FX NDF in Default representation:
- PayCurrency: AUD
- ReceiveCurrency: GBP
- PayAmount: 100,000,000
- ReceiveAmount: 60,000,000
- MaturityDate: 2013-11-15

On 2013-11-15, the cash-settled amount is the difference between \$60,000,000 GBP and \$100,000,000 AUD.

**Example 1.2.** An FX NDF in Strike representation:
- Currency: AUD
- CrossCurrency: USD
- CrossCurrencyAmount: 100,000,000
- Strike: 1.0500
- MaturityDate: 2013-11-15
- Direction: PayCurrencyReceiveCrossCurrency

The deal amount in Currency is

$$N_{\mathrm{p}} = X \times N_{\mathrm{c}} = 1.05 \times 100,000,000 = 105,000,000.$$

Given the holder of the FX NDF pays AUD and receives USD, on 2013-11-15, the cash-settled amount is the difference between \$100,000,000 USD and \$105,000,000 AUD.

**Example 1.3.** An FX NDF in Strike representation:

- Currency: JPY
- CrossCurrency: AUD
- CrossCurrencyAmount: 100,000,000
- Strike: 98.1528
- MaturityDate: 2013-11-15
- Direction: ReceiveCurrencyPayCrossCurrency

The deal amount in Currency is

$$N_{\mathrm{p}} = X \times N_{\mathrm{c}} = 98.1528 \times 100,000,000 = 9,815,280,000.$$

Given the holder of the FX NDF pays AUD and receives JPY, on 2013-11-15, the cash-settled amount is the difference between \$9,815,280,000 JPY and \$100,000,000 AUD.

# Chapter 2

# No Interest Cashflow

## 2.1 Properties of Cashflow

A no interest cashflow is a transfer of the **amount** of $N$ in **currency** on the **flow date** (FD), as illustrated in Figure 2.1. Principal repayment of a loan is an example of no interest cashflow.

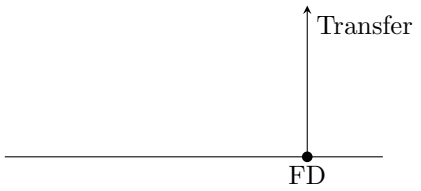


Figure 2.1: No interest cahflow

## 2.2 Definitions

In this section, we define terms that are specific to no interest cashflow.

**amount** is the amount in **currency** that one has to transfer on the **flow date**.

**currency** is the currency that the transfer is in.

**flow date** is the date that the cashflow transfer occurs.

## 2.3 Cashflow Inputs

A no interest cashflow is specified by the mandatory fields in Table 2.1, the optional field in Table 2.2, with their restrictions in Table 2.3.

| *Field* | *Description* | *Data Type* | *Symbol* |
|---|---|---|---|
| PayReceive | The pay/receive direction of the cashflow | string | direction |
| Currency | The **currency** | string | ccy |
| FlowDate | The date of the cashflow payment, i.e. the **flow date** | date | FD |
| Amount | The **amount** of the transfer | double | $N$ |

Table 2.1: Mandatory fields for No Interest Cashflow

| *Field* | *Description* | *Data Type* | *Symbol* | *Default Value* |
|---|---|---|---|---|
| DiscountReference | Alternative discounting curve | string | | |
| LegID | The identifier of the leg | string | | |
| Description | The description of the flow | string | | |

Table 2.2: Optional field for No Interest Cashflow

| *Field* | *Restriction* |
|---|---|
| PayReceive | Pay, Receive, P, R |
| Amount | $N > 0$ |

Table 2.3: Field restrictions for No Interest Cashflow

### 2.3.1 Required Curves

The following curves are required by a no interest cashflow:

- *Currency FX spot curve*: FX Spot Curve — (FX.PRICE.Currency.BaseCurrency), and
- *Currency discounting curve*: Money Market Zero Curve: (MM.ZERO.SWAP.Currency) [1].

When the optional field DiscountReference is provided, the reference curve is used as the Currency discounting curve.

## 2.4 Formula

A no interest cashflow gives a transfer of $N$ in **currency** on the **flow date**.

If the Valuation Date is less than or equal to the **flow date**, the value of a no interest cashflow in Base Currency is

$$N \times E_{\text{ccy}} \times \mathbb{I}_{\text{pr}} \times Df_t,$$

where

- $N$ is the **amount** of the transfer in **currency**,
- $E_{\text{ccy}}$ is the spot exchange rate in units of Base Currency per **currency**, from the Currency FX spot curve,
- the discount factor from Valuation Date to **flow date** is

$$Df_t = e^{-r_{\text{ccy}} t},$$

- $r_{\text{ccy}}$ is the continuous zero rate of **currency** from Valuation Date to **flow date** in Actual/365 (Fixed) day count convention, from the Currency discounting curve,
- $t$ is the time in years from Valuation Date to **flow date** in Actual/365 (Fixed) day count convention, and
- the indicator for pay or receive direction is

$$\mathbb{I}_{\text{pr}} = \begin{cases} 1, & \text{if direction is 'R',} \\ -1, & \text{if direction is 'P'.} \end{cases}$$

If the Valuation Date is greater than the **flow date**, then the no interest flow has expired and thus has a value of zero.

[1] For certain products, e.g. FX Forward or Cross Currency Swap, FX ZERO curve is used for discounting.

## 2.5 Examples

This section provides some deal examples of no interest cashflow.

**Example 2.1.** A no interest cashflow:
- PayReceive: Pay
- Currrency: GBP
- FlowDate: 2013-11-15
- Amount: 60,000,000

On 2013-11-15, there is a payment of $60,000,000 GBP.

**Example 2.2.** A no interest cashflow:
- PayReceive: Receive
- Currrency: AUD
- FlowDate: 2013-11-15
- Amount: 100,000,000

On 2013-11-15, one receives $100,000,000 AUD.

# Chapter 3

# Fixed Cashflow

## 3.1 Properties of Cashflow

A fixed cashflow is a transfer of the interest component of a transfer schedule on the **flow date** (FD) where the interest payment is determined by a **fixed rate** $R$ on an **amount** of $N$ in **currency** for the **accrual period**. The **accrual period** is specified by **accrual start date** (ASD) and **accrual end date** (AED). An example of fixed cashflow is illustrated in Figure 3.1. The coupon payment of bond where the coupon rate is fixed is an example of fixed cashflows.

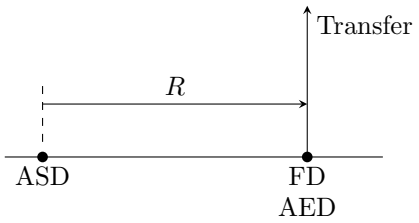


Figure 3.1: Fixed cahflow

## 3.2 Definitions

In this section, we define terms that are specific to fixed cashflow.

**accrual day count fraction** is the day count fraction of the **accrual period**.

**accrual end date** is the end date of the **accrual period**.

**accrual period** is the tenor period over which the **fixed rate** applies.

**accrual start date** is the start date of the **accrual period**.

**amount** is the notional amount in **currency** of the cashflow.

**currency** is currency that the transfer is in.

**fixed rate** is the per annum fixed interest rate that applies to the cashflow.

**flow date** is the date that the cashflow transfer occurs.

## 3.3 Cashflow Inputs

A fixed cashflow is specified by the mandatory fields in Table 3.1, the optional field in Table 3.2, with their restrictions in Table 3.3.

| *Field* | *Description* | *Data Type* | *Symbol* |
|---|---|---|---|
| PayReceive | The pay/receive direction of the cashflow | string | direction |
| Currency | The **currency** | string | ccy |
| InterestStyle | The interest style of the cashflow | string | style |
| AccrualDayCount | The day count convention for the **accrual period** | string | dcc |
| FlowDate | The date of the cashflow payment, i.e. the **flow date** | date | FD |
| Amount | The notional **amount** | double | $N$ |
| FixedRate | The fixed interest rate, i.e. the **fixed rate** | double | $R$ |
| AccrualStartDate | The **accrual start date** | date | ASD |
| AccrualEndDate | The **accrual end date** | date | AED |

Table 3.1: Mandatory fields for Fixed Cashflow

| *Field* | *Description* | *Data Type* | *Symbol* | *Default Value* |
|---|---|---|---|---|
| DiscountReference | Alternative discounting curve | string | | |
| DiscountRate | For Discount flow, standard discounting method applies. This specifies the discount rate. If not specified, the flow will be discounted with the **fixed rate**. | string | $D$ | $R$ |
| DiscountRateDayCount | For Discount flow, standard discounting method applies. This specifies the day count convention for the discount rate. If not specified, it takes the value of the **accrual day count fraction**. | string | $\text{dcc}_\text{D}$ | dcc |
| LegID | The identifier of the leg | string | | |
| Description | The description of the flow | string | | |

Table 3.2: Optional field for Fixed Cashflow

| *Field* | *Restriction* |
|---|---|
| PayReceive | Pay, Receive, P, R |
| InterestStyle | Simple, Discount |
| Amount | $N > 0$ |
| AccrualEndDate | AED > ASD |

Table 3.3: Field restrictions for Fixed Cashflow

### 3.3.1 Required Curves

The following curves are required by a fixed cashflow:

- *Currency FX spot curve*: FX Spot Curve — (FX.PRICE.Currency.BaseCurrency), and
- *Currency discounting curve*: Money Market Zero Curve: (MM.ZERO.SWAP.Currency) [1].

In the case of the optional field DiscountReference is provided, the reference curve is used as the Currency discounting curve instead.

[1] For certain products, e.g. FX Forward or Cross Currency Swap, FX ZERO curve is used for discounting.

## 3.4 Formula

The transfer in **currency** on the **flow date** of a fixed cashflow is

$$\begin{cases} N \times \mathbb{I}_{\text{pr}} \times R\tau, & \text{if style is 'Simple',} \\ N \times \mathbb{I}_{\text{pr}} \times \dfrac{R\tau}{1 + D\tau_D}, & \text{if style is 'Discount',} \end{cases} \tag{3.1}$$

where

- $N$ is the notional **amount** in **currency**,
- $R$ is the **fixed rate**,
- $\tau$ is the **accrual day count fraction**, from **accrual start date** to **accrual end date**, according to the day count convention for the **accrual period** (dcc),
- $D$ is the discount rate,
- $\tau_D$ is the day count fraction from **accrual start date** to **accrual end date**, according to the discount day count convention ($\text{dcc}_\text{D}$), and
- the indicator for pay or receive direction is

$$\mathbb{I}_{\text{pr}} = \begin{cases} 1, & \text{if direction is 'R',} \\ -1, & \text{if direction is 'P'.} \end{cases}$$

## 3.5 Examples

This section provides some deal examples of fixed cashflow.

**Example 3.1** (Simple interest)**.** A fixed cashflow:

- PayReceive: Pay
- Currrency: GBP
- InterestStyle: Simple
- AccrualDayCount: ACT365(FIXED)
- FlowDate: 2013-11-15
- Amount: 60,000,000
- FixedRate: 0.0315
- AccrualStartDate: 2013-08-15
- AccrualEndDate: 2013-11-15

There are 92 days from the **accrual start date** (2013-08-15) to the **accrual end date** (2013-11-15). The **accrual day count fraction** of the cashflow is calculated using the Actual/365 (Fixed) day count convention to give

$$\tau = \frac{92}{365}.$$

Using (3.1), on 2013-11-15, there is a payment of

$$N \times R\tau = 60,000,000 \times 0.0315 \times \frac{92}{365} = \$476,383.56 \text{ GBP}.$$

**Example 3.2** (Discount interest)**.** A fixed cashflow:

- PayReceive: Receive
- Currrency: USD
- InterestStyle: Discount
- AccrualDayCount: 30360
- FlowDate: 2013-11-15
- Amount: 100,000,000
- FixedRate: 0.0145
- AccrualStartDate: 2013-08-15
- AccrualEndDate: 2013-11-15

Using 30/360 day count convention, there are 90 days from the **accrual start date** (2013-08-15) to the **accrual end date** (2013-11-15). The **accrual day count fraction** of the cashflow is

$$\tau = \frac{90}{360} = 0.25.$$

Using (3.1), on 2013-11-15, one receives

$$N \times \frac{R\tau}{1 + D\tau_D} = 100,000,000 \times \frac{0.0145 \times 0.25}{1 + 0.0145 \times 0.25} = \$361,190.68 \text{ USD}.$$

**Example 3.3** (Discount interest with discount rate provided)**.** A fixed cashflow:

- PayReceive: Receive
- Currrency: USD
- InterestStyle: Discount
- AccrualDayCount: 30360
- FlowDate: 2013-11-15
- Amount: 100,000,000
- FixedRate: 0.0145
- AccrualStartDate: 2013-08-15
- AccrualEndDate: 2013-11-15
- DiscountRate: 0.0125
- DiscountRateDayCount: ACT360

Using 30/360 day count convention, there are 90 days from the **accrual start date** (2013-08-15) to the **accrual end date** (2013-11-15). The **accrual day count fraction** of the cashflow is

$$\tau = \frac{90}{360} = 0.25.$$

There are 92 days from the **accrual start date** (2013-08-15) to the **accrual end date** (2013-11-15). The discount rate day count fraction of the cashflow is calculated using the Actual/360 (Fixed) day count convention to give

$$\tau_D = \frac{92}{360}.$$

Using (3.1), on 2013-11-15, one receives

$$N \times \frac{R\tau}{1 + D\tau_D} = 100,000,000 \times \frac{0.0145 \times 0.25}{1 + 0.0125 \times \frac{92}{365}} = \$361,361.46 \text{ USD}.$$

# Glossary

**Base Currency** The currency that the risk engine is configured to return values in.

**Reserve Currency** The currency that all cross currency basis is benchmarked against.

**Risk Engine** The Vector Risk market risk and credit risk system.

**Valuation Date** The date that we value the trades as.