FX Vanilla Option Product Specification

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Chapter 1

FX Vanilla Option

1.1 Properties of Instrument

An FX vanilla option is a vanilla option with the **cross currency** as the underlying. If we denote the **primary currency** per **cross currency** exchange rate on the **maturity date** by S_T, and the agreed **strike rate** by X, when the **settlement date** is the same as the **maturity date**, a **call option** expires in the money if $S_T > X$ and a **put option** expires in the money if $S_T < X$. If the option expires in the money, the holder of the **call option** (**put option**) buys (sells) the **cross currency amount**, denoted by N_c, at the predetermined **strike rate** X.

The payoff of a FX vanilla option is illustrated in Table 1.1.

Option Type	Condition	Payoff (**primary currency**)
Call	$S_T \leq X$	0
	$S_T > X$	$N_c\,(S_T - X)$
Put	$S_T \geq X$	0
	$S_T < X$	$N_c\,(X - S_T)$

Table 1.1: Payoff at maturity for FX vanilla option

1.2 Definitions

In this section, we define terms that are specific to FX vanilla options.

call option gives the holder the right, but not the obligation, to buy the **cross currency** at the **strike rate** on the **maturity date**.

cross currency is the currency nominated as the underlying asset.

cross currency amount is the deal amount in **cross currency** that will be exchanged if the option is exercised.

maturity date is the date the option expires.

primary currency is the currency the deal is quoted in.

put option gives the holder the right, but not the obligation, to sell the **cross currency** at the **strike rate** on the **maturity date**.

settlement date is the date the **cross currency amount** is exchanged at the **strike rate** if the option is exercised.

strike rate is the agreed exchange rate between **primary currency** and **cross currency** if the option is exercised, quoted in **primary currency** per **cross currency**.

1.3 Representations

In the Risk Engine, products are specified by *representations*. In this section, we provide the representations of FX vanilla options.

1.3.1 Default Representation

The *Default* representation consists of the mandatory trade fields in Table 1.2, the optional trade field in Table 1.3, with their restrictions in Table 1.4.

Field	*Description*	*Data Type*	*Symbol*
Currency	The **primary currency**	string	p
CrossCurrency	The **cross currency**	string	c
CurrencyAmount	The deal amount in *Currency*	double	N_{p}
CrossCurrencyAmount	The deal amount in *CrossCurrency*, *i.e.*, the **cross currency amount**	double	N_{c}
MaturityDate	The **maturity date**	date	MD
PutCall	Put option or call option on *CrossCurrency*	string	PC
BoughtSold	Bought or sold the option	string	BS

Table 1.2: Mandatory trade fields for the Default representation of the FX Vanilla Option

Field	*Description*	*Data Type*	*Symbol*	*Default Value*
SettlementDate	Settlement date	date	SD	MD

Table 1.3: Optional trade field for the Default representation of the FX Vanilla Option

Field	*Restriction*
CrossCurrency	$\mathrm{c} \neq \mathrm{p}$
CurrencyAmount	$N_{\mathrm{p}} > 0$
CrossCurrencyAmount	$N_{\mathrm{c}} > 0$
PutCall	Put, Call, P, C
BoughtSold	Bought, Sold, B, S
SettlementDate	SD $\geq$ MD

Table 1.4: Trade field restrictions for the Default representation of the FX Vanilla Option

1.3.1.1 Required Curves

The following curves are required by an FX vanilla option:

- *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),
- *CrossCurrency discounting curve*: FX Zero Curve — (FX.ZERO.CrossCurrency.ReserveCurrency), and
- *Currency, CrossCurrency volatility grid*: FX Volatility Grid — (FX.GRID.CrossCurrency.Currency).

Field	*Description*	*Data Type*	*Symbol*
Currency	The **primary currency**	string	p
CrossCurrency	The **cross currency**	string	c
CrossCurrencyAmount	The deal amount in *CrossCurrency*, *i.e.*, the **cross currency amount**	double	N_c
Strike	The **strike rate** as *Currency*/*CrossCurrency*	double	X
MaturityDate	The **maturity date**	date	MD
PutCall	Put option or call option on *CrossCurrency*	string	PC
BoughtSold	Bought or sold the option	string	BS

Table 1.5: Mandatory trade fields for the Strike representation of the FX Vanilla Option

Field	*Description*	*Data Type*	*Symbol*	*Default Value*
SettlementDate	Settlement date	date	SD	MD

Table 1.6: Optional trade field for the Strike representation of the FX Vanilla Option

Field	*Restriction*
CrossCurrency	$c \neq p$
CrossCurrencyAmount	$N_c > 0$
Strike	$X > 0$
PutCall	Put, Call, P, C
BoughtSold	Bought, Sold, B, S
SettlementDate	SD $\geq$ MD

Table 1.7: Trade field restrictions for the Strike representation of the FX Vanilla Option

1.3.2 Strike Representation

The *Strike* representation consists of the mandatory trade fields in Table 1.5, the optional trade field in Table 1.6, with their restrictions in Table 1.7.

1.3.2.1 Required Curves

The following curves are required by an FX vanilla option:

- *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),
- *CrossCurrency discounting curve*: FX Zero Curve — (FX.ZERO.CrossCurrency.ReserveCurrency), and
- *Currency, CrossCurrency volatility grid*: FX Volatility Grid — (FX.GRID.CrossCurrency.Currency).

1.4 Formula

In this section, we describe how to value an FX vanilla option in the case where the **settlement date** is the same as the **maturity date**.

If the Valuation Date is less than or equal to the **maturity date**, the value of an FX vanilla option in Base Currency is given by the *FX vanilla option pricing function*[1],

$$\text{FXVanilla}\left(E_{\text{p}}, E_{\text{c}}, X, N_{\text{c}}, r_{\text{p}}, r_{\text{c}}, \sigma, T, \text{indicator}\right), \tag{1.1}$$

where

- E_{p} is the spot exchange rate in units of Base Currency per **primary currency**, from the Currency FX spot curve,
- E_{c} is the spot exchange rate in units of Base Currency per **cross currency**, from the CrossCurrency FX spot curve,
- X is the **strike rate** in units of **primary currency** per **cross currency**,
- N_{c} is the **cross currency amount**,
- r_{p} is the cross currency basis adjusted continuous zero rate of **primary currency** from Valuation Date to **maturity date** in Actual/365 (Fixed) day count convention, from the Currency discounting curve,
- r_{c} is the cross currency basis adjusted continuous zero rate of **cross currency** from Valuation Date to **maturity date** in Actual/365 (Fixed) day count convention, from the CrossCurrency discounting curve,
- σ is the volatility of the exchange rate between **primary currency** and **cross currency** from Valuation Date to **maturity date** in Actual/365 (Fixed) day count convention, from the Currency, CrossCurrency volatility grid,
- T is the time in years from Valuation Date to **maturity date** in Actual/365 (Fixed) day count convention, and
- indicator contains the put/call and bought/sold information.

If the Valuation Date is greater than the **maturity date**, then the FX vanilla option has expired and thus has a value of zero.

In the case where the **settlement date** is greater than the **maturity date**, which is not covered in this section, a variation of FX vanilla option pricing function is used.

1.4.1 Representation Reduction

Equation (1.1) is only defined for the Strike representation. If the trade is specified by other representations, we need to reduce it to the Strike representation.

1.4.1.1 Default Representation

For the Default representation, the **strike rate**, X, is the ratio of CurrencyAmount and CrossCurrencyAmount, given by

$$X = \frac{N_{\text{p}}}{N_{\text{c}}}. \tag{1.2}$$

1.5 Examples

This section provides some deal examples of FX vanilla option.

Example 1.1. An FX vanilla option in Default representation:

- Currency: AUD
- CrossCurrency: GBP
- CurrencyAmount: 100,000,000
- CrossCurrencyAmount: 60,000,000
- MaturityDate: 2013-11-15
- PutCall: Put
- BoughtSold: Bought

[1] See FX Vanilla Option Pricing for details (p.9 of this document).

Using equation (1.2), the **strike rate** of the option is

$$X = \frac{N_{\mathrm{p}}}{N_{\mathrm{c}}} = \frac{100,000,000}{60,000,000} = 1.6667.$$

a) If on 2013-11-15, the option expires in the money with the AUD/GBP exchange rate being 1.6515, the payoff of the option is

$$N_{\mathrm{c}}\,(X - S_T) = 60,000,000 \times (1.6667 - 1.6515) = \$910,000 \text{ AUD}.$$

b) If on 2013-11-15, the option expires out of the money with the AUD/GBP exchange rate being 1.6715, the payoff of the option is 0 as the **strike rate** (1.6667) is less than the AUD/GBP exchange rate (1.6715) on the **maturity date**.

Example 1.2. An FX vanilla option in Strike representation:

- Currency: JPY
- CrossCurrency: USD
- CrossCurrencyAmount: 100,000,000
- Strike: 100.2
- MaturityDate: 2013-11-15
- PutCall: Call
- BoughtSold: Bought

a) If on 2013-11-15, the option expires in the money with the JPY/USD exchange rate being 102.5, the payoff of the option is

$$N_{\mathrm{c}}\,(S_T - X) = 100,000,000 \times (102.5 - 100.2) = \$230,000,000 \text{ JPY}.$$

b) If on 2013-11-15, the option expires out of the money with the JPY/USD exchange rate being 98.4, the payoff of the option is 0 as the **strike rate** (100.2) is greater than the JPY/USD exchange rate (98.4) on the **maturity date**.

Chapter 2

FX Vanilla Option Pricing

2.1 Inputs to Function

Description	*Symbol*	*min*	*max*	*Reasonable range*
Spot rate of primary currency	E_{p}	0^+	$+\infty$	
Spot rate of cross currency	E_{c}	0^+	$+\infty$	
Strike rate as primary currency/cross currency	X	0^+	$+\infty$	
Cross currency amount	N_{c}	0^+	$+\infty$	
Continuous zero rate of primary currency	r_{p}	0^+	$+\infty$	
Continuous zero rate of cross currency	r_{c}	0^+	$+\infty$	
Volatility of exchange rate between primary and cross currencies	σ	0^+	$+\infty$	
Time from value date to maturity in years	T	0^+	$+\infty$	
Put or Call on cross currency	indicator	–	–	"P", "C"
Bought or Sold		–	–	"B", "S"

Table 2.1: Inputs for FX Vanilla Option pricing function

2.2 Formula

The spot exchange rate of primary currency per cross currency is given by

$$S = \frac{E_{\mathrm{c}}}{E_{\mathrm{p}}}.$$

We can value an FX vanilla option by calling the *Black-Scholes generalised pricing function*[1] with appropriate inputs. The value of an FX vanilla option in *base currency* is

$$N_{\mathrm{c}} \times E_{\mathrm{p}} \times \mathbb{I}_{\mathrm{BS}} \times \mathrm{BSG}\left(S, X, r_{\mathrm{p}}, r_{\mathrm{c}}, \sigma, T, \text{indicator}\right),$$

where

$$\mathbb{I}_{\mathrm{BS}} = \begin{cases} 1, & \text{if indicator is 'B',} \\ -1, & \text{if indicator is 'S'.} \end{cases}$$

[1] See pricing specification *Black-Scholes Generalised* for details.

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.