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FX Binary Option Product Specification

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Chapter 1

FX Binary Option

1.1 Instrument Properties

An FX binary option is a binary cash option with the **cross currency** as the underlying and the payoff is the **cash payment** in **cash payment currency**. 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 option receives the **cash payment**, K amount of the **cash payment currency** on the **settlement date**. The payoff of an FX binary option is illustrated in Table 1.1.

Option Type	Condition	$Payoff ({\bf cash \ payment \ currency})$
Call	$S_T \le X$ $S_T > X$	$\begin{array}{c} 0 \\ K \end{array}$
Put	$S_T \ge X$ $S_T < X$	$0 \\ K$

Table 1.1: Payoff at maturity for FX binary option

1.2 Definitions

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

- call option gives the holder the right to receive the cash payment if the primary currency per cross currency exchange rate on the maturity date is greater than the strike rate.
- **cash payment** is the amount in **cash payment currency** that the holder of the option receives if the option is exercised.
- cash payment currency is the currency the cash payment is quoted in.
- **cross currency** is the currency nominated as the underlying asset.
- maturity date is the date the option expires.
- **primary currency** is the currency that the deal is quoted in.
- **put option** gives the holder the right to receive the **cash payment** if the **primary currency** per **cross currency** exchange rate on the **maturity date** is less than the **strike rate**.

settlement date is the date the cash payment is received 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.

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1.3 Representation

In the Risk Engine, products are specified by *representations*. In this section, we provide the representation of FX binary 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	р
CrossCurrency	The cross currency	string	с
Strike	The strike rate as Currency/CrossCurrency	double	X
CashPaymentCurrency	The cash payment currency	string	kc
CashPayment	The cash payoff in CashPaymentCurrency, i.e., the cash	double	K
	payment		
MaturityDate	The maturity date	date	MD
PutCall	Put option or call option on CrossCurrency	string	\mathbf{PC}
BoughtSold	Bought or sold the option	string	BS

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

Field	Description	Data Type	Symbol	Default Value
SettlementDate	The settlement date \mathbf{A}	date	SD	MD

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

Field	Restriction
CrossCurrency	$c \neq p$
Strike	X > 0
CashPaymentCurrency	kc = p or kc = c
CashPayment	K > 0
PutCall	Put, Call, P, C
BoughtSold	Bought, Sold, B, S
SettlementDate	$\mathrm{SD} \geq \mathrm{MD}$

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

1.3.1.1 Required Curves

The following curves are required by an FX binary 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 binary 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 binary option in Base Currency is given by the FX binary option pricing function¹,

FXBinary
$$(E_{\rm p}, E_{\rm c}, X, K, \mathbb{I}_{\rm kc}, r_{\rm p}, r_{\rm c}, \sigma, T, \text{indicator}),$$
 (1.1)

where

- $E_{\rm p}$ is the spot exchange rate in units of Base Currency per **primary currency**, from the Currency FX spot curve,
- $E_{\rm c}$ 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,
- *K* is the **cash payment** in **cash payment currency**,
- \mathbb{I}_{kc} indicates if the **cash payment currency** is the same as the **primary currency** or as the **cross currency**,
- 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 binary 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 binary option pricing function is used.

1.5 Examples

This section provides some deal examples of FX binary option.

Example 1.1. An FX binary option in Default representation:

- Currency: AUD
- CrossCurrency: GBP
- Strike: 1.6685
- CashPaymentCurrency: AUD
- CashPayment: 10,000
- MaturityDate: 2013-11-15
- PutCall: Put
- BoughtSold: Bought
- a) If on 2013-11-15, the option expires in the money with the AUD/GBP exchange rate being 1.6515, the holder of the option receives the **cash payment**, \$10,000 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** (1.6685) is less than the AUD/GBP exchange rate (1.6715) on the **maturity date**.

¹See FX Binary Option Pricing for details (p.8 of this document).

Example 1.2. An FX binary option in Default representation:

- Currency: JPY
- CrossCurrency: USD
- Strike: 100.2
- CashPaymentCurrency: USD
- CashPayment: 20,000
- 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 holder of the option receives the **cash payment**, \$20,000 USD.
- 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 Binary Option Pricing

2.1 Inputs to Function

Description	Symbol	min	max	Reasonable range
Spot rate of primary currency	$E_{\rm p}$	0+	$+\infty$	
Spot rate of cross currency	$E_{\mathbf{c}}^{r}$	0^{+}	$+\infty$	
Strike rate as primary currency/cross currency	X	0^{+}	$+\infty$	
Cash amount of payoff in cash payment currency	K	0^{+}	$+\infty$	
Indicator for cash payment currency	$\mathbb{I}_{\mathbf{kc}}$			"Currency", "CrossCurrency"
Continuous zero rate of primary currency	$r_{ m D}$	0^{+}	$+\infty$	
Continuous zero rate of cross currency	r_{c}	0^{+}	$+\infty$	
Volatility of exchange rate between primary and	σ	0^{+}	$+\infty$	
cross currencies				
Time from value date to maturity in years	T	0^{+}	$+\infty$	
Put or Call on cross currency	• 1• /	_	_	"P", "C"
Bought or Sold	maicator	_	_	"B", "S"

Table 2.1: Inputs for FX Binary Option pricing function

2.2 Formula

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

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

We can value an FX binary option by calling the *binary cash-or-nothing option pricing function*¹ or the *binary asset-or-nothing option pricing function*² with appropriate inputs. The value of an FX binary option in Base Currency is

$$\begin{cases} E_{\rm p} \times \mathbb{I}_{\rm BS} \times \text{BinaryCash} \left(S, X, K, r_{\rm p}, r_{\rm c}, \sigma, T, \text{indicator}\right), & \text{if } \mathbb{I}_{\rm kc} = \text{Currency}, \\ E_{\rm p} \times \mathbb{I}_{\rm BS} \times K \times \text{BinaryAsset} \left(S, X, r_{\rm p}, r_{\rm c}, \sigma, T, \text{indicator}\right), & \text{if } \mathbb{I}_{\rm kc} = \text{CrossCurrency}, \end{cases}$$

where

π	1,	if indicator	is	'В',
$\operatorname{BS} - 1$	(-1,	if indicator	is	'S'.

 $^{^1 \}mathrm{See}$ pricing specification $Binary\ Cash-or-Nothing\ Option$ for details.

 $^{^2}$ See pricing specification Binary Asset-or-Nothing Option 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.