
# FX Single Barrier at-Touch Option
# Product Specification

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# Chapter 1

# FX Single Barrier at-Touch Option

## 1.1 Instrument Properties

An FX single barrier at-expiry option is a single barrier cash-at-expiry option with the **cross currency** as the underlying. The two possible outcomes of an FX single barrier at-touch option are:

1) the **barrier** is not **touched** during the life of the option, the option expires without payout, and

2) the **barrier** is **touched** during the life of the option, there is a payout of **cash payment**, $K$ in **cash payment currency** as soon as the **barrier** is **touched**.

## 1.2 Definitions

In this section, we define terms that are specific to FX single barrier at-touch options.

**barrier** is the **primary currency** per **cross currency** exchange rate level such that, if it is **touched** before or on the **maturity date**, there is a an immediate payout of the **cash payment**.

**barrier direction** is the direction that the **barrier** is considered to be **touched**.

**cash payment** is the amount in **cash payment currency** that the holder of the option receives immediately when the **barrier** is **touched**.

**cash payment currency** is the currency the **cash payment** is quoted in.

**cross currency** is the currency nominated as the underlying asset.

**down** is the **barrier direction** in cases where if the **primary currency** per **cross currency** exchange rate passes below the **barrier** before or on the **maturity date**, the **barrier** is considered to be **touched**.

**maturity date** is the date the option expires.

**primary currency** is the currency that the deal is quoted in.

**touched** means for an option with an **up** (**down**) barrier, the **primary currency** per **cross currency** exchange rate was above (below) the **barrier** before or on the **maturity date**.

**up** is the **barrier direction** in cases where if the **primary currency** per **cross currency** exchange rate passes above the **barrier** before or on the **maturity date**, the **barrier** is considered to be **touched**.

## 1.3 Representation

In the Risk Engine, products are specified by *representations*. In this section, we provide the representations of FX single barrier at-touch options.

### 1.3.1 Default Representation

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

| *Field* | *Description* | *Data Type* | *Symbol* |
|---|---|---|---|
| Currency | The **primary currency** | string | p |
| CrossCurrency | The **cross currency** | string | c |
| Barrier | The **barrier** level as *Currency*/*CrossCurrency* | double | $H$ |
| CashPaymentCurrency | The **cash payment currency** | string | kc |
| CashPayment | The cash payoff in *CashPaymentCurrency*, *i.e.*, the **cash payment** | double | $K$ |
| MaturityDate | The **maturity date** | date | MD |
| UpDown | Direction of the barrier | string | UD |
| BoughtSold | Bought or sold the option | string | BS |

Table 1.1: Mandatory trade fields for the Default representation of the FX Single Barrier at-Touch Option

| *Field* | *Restriction* |
|---|---|
| CrossCurrency | $\mathrm{c} \neq \mathrm{p}$ |
| Barrier | $H > 0$ |
| CashPaymentCurrency | $\mathrm{kc} = \mathrm{p}$ or $\mathrm{kc} = \mathrm{c}$ |
| CashPayment | $K > 0$ |
| UpDown | Up, Down, U, D |
| BoughtSold | Bought, Sold, B, S |

Table 1.2: Trade field restrictions for the Default representation of the FX Single Barrier at-Touch Option

#### 1.3.1.1 Required Curves

The following curves are required by an FX single barrier at-touch 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

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

$$\mathrm{FXSingleBarrierAtTouch}\left(E_{\mathrm{p}}, E_{\mathrm{c}}, H, K, \mathbb{I}_{\mathrm{kc}}, r_{\mathrm{p}}, r_{\mathrm{c}}, \sigma, T, \mathrm{indicator}, \mathrm{flag}\right), \tag{1.1}$$

where

- $E_{\mathrm{p}}$ is the spot exchange rate in units of Base Currency per **primary currency**, from the Currency FX spot curve,
- $E_{\mathrm{c}}$ is the spot exchange rate in units of Base Currency per **cross currency**, from the CrossCurrency FX spot curve,
- $H$ is the **barrier** level in units of **primary currency** per **cross currency**,
- $K$ is the **cash payment** in **cash payment currency**,
- $\mathbb{I}_{\mathrm{kc}}$ indicates if the **cash payment currency** is the same as the **primary currency** or as the **cross currency**,

[1] See FX Single Barrier at-Touch Option Pricing for details (p.7 of this document).

- $r_p$ 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,
- $\sigma$ 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 up/down and bought/sold information.

If the Valuation Date is greater than the **maturity date**, then the FX single barrier at-touch option has expired and thus has a value of zero.

## 1.5 Examples

This section provides some deal examples of FX single barrier at-touch option.

**Example 1.1.** An FX single barrier at-touch option in Default representation:
- Currency: AUD
- CrossCurrency: GBP
- Barrier: 1.6725
- CashPaymentCurrency: AUD
- CashPayment: 100,000
- MaturityDate: 2013-11-15
- UpDown: Up
- BoughtSold: Bought

a) If the AUD/GBP exchange rate passed above the **barrier** (1.6725) on 2013-10-01, the payoff of the option is the **cash payment**, $100,000 AUD on 2013-10-01.

b) If the AUD/GBP exchange rate never passed above the **barrier** (1.6725) before 2013-11-15, the payoff of the option is 0 as the **barrier** was not **touched** before the **maturity date**.

**Example 1.2.** An FX single barrier at-touch option in Default representation:
- Currency: JPY
- CrossCurrency: USD
- Barrier: 97.5
- CashPaymentCurrency: USD
- CashPayment: 150,000
- MaturityDate: 2013-11-15
- UpDown: Down
- BoughtSold: Bought

a) If the JPY/USD exchange rate passed below the **barrier** (97.5) on 2013-10-01, the payoff of the option is the **cash payment**, $150,000 USD on 2013-10-01.

b) If the JPY/USD exchange rate never passed below the **barrier** (97.5) before 2013-11-15, the payoff of the option is 0 as the **barrier** was not **touched** before the **maturity date**.

# Chapter 2

# FX Single Barrier at-Touch Option Pricing

## 2.1 Inputs to Function

| *Description* | *Symbol* | *min* | *max* | *Reasonable range* |
|---|---|---|---|---|
| Spot rate of primary currency | $E_{\mathrm{p}}$ | $0^+$ | $+\infty$ | |
| Spot rate of cross currency | $E_{\mathrm{c}}$ | $0^+$ | $+\infty$ | |
| Barrier as primary currency/cross-currency | $H$ | $0^+$ | $+\infty$ | |
| Indicator for cash payment currency | $\mathbb{I}_{\mathrm{kc}}$ | | | "Currency", "CrossCurrency" |
| Cash amount of payoff in cash payment currency | $K$ | $0^+$ | $+\infty$ | |
| Continuous zero rate of primary currency | $r_{\mathrm{p}}$ | $0^+$ | $+\infty$ | |
| Continuous zero rate of cross currency | $r_{\mathrm{c}}$ | $0^+$ | $+\infty$ | |
| Volatility of exchange rate between primary and cross currencies | $\sigma$ | $0^+$ | $+\infty$ | |
| Time from value date to maturity in years | $T$ | $0^+$ | $+\infty$ | |
| Up or Down | indicator | – | – | "U", "D" |
| Bought or Sold | | – | – | "B", "S" |

Table 2.1: Inputs for FX Single Barrier at-Touch 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 single barrier at-touch option by calling the *single barrier cash at-touch pricing function*[1] or the *single barrier asset at-touch pricing function*[2] or with appropriate inputs. The value of an FX single barrier at-touch option in Base Currency is

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

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 *Single Barrier Cash-at-Touch Optio* for details.
[2] See pricing specification *Single Barrier Asset-at-Touch 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.