BARCLAYS

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FX-options in POINT®

Summary

The POINT team is pleased to announce the availability of FX-options in POINT-preview as of October 14, 2014. This feature is in Beta with this release. All FX-options in POINT are user-defined instruments.

An FX-option in POINT will be represented as a delta equivalent amount of an underlying FX-forward, as well as a head to capture additional analytics. The delta and, hence the amount of the underlying, will change from day to day, given market rates. The head will include residual market value, as well as Greeks such as delta, gamma, vega, theta, and rho.

Analytics on FX-options are also supported in the Global Risk Model and Hybrid Performance Attribution.

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How to use this document?

In this document, you will find some brief overview sections which summarize in less technical detail the nature of FX-options in POINT, as well as sections with much greater detail near the end of the document around the specifics of various calculations and models. These latter sections also include color on FX-forwards as they are tied in so fundamentally with FX-options. So, if you do not find what you are looking for in one of the overview sections near the beginning of the document, please consider referring to the more detailed sections toward the end of the document.

Introduction

An FX-option is the right but not the obligation to enter into an FX trade at a pre-agreed strike rate on a specified date. Most FX-options are OTC instruments and there is a growing market for options on FX-futures which are traded on exchanges. In POINT, one may represent either type as an FX-option, which is always a user-defined instrument.

Overview of Creating FX-options

To upload an FX-option into POINT, one must use the File > Import > Instruments or use similar functionality in batch. The following are mandatory fields for defining an FX-option in POINT:

- Identifier: User-defined identifier.
- InstType: Must be “Fxoption” for the instrument to be an FX-option.
- OptionType: Call or Put.
- NotionalCurrency: Three character ISO Code for this currency. Sometimes this is referred to as the “foreign” currency.
- OtherCurrency: Three character ISO Code for the other currency. Sometimes this is referred to as the “domestic” currency.

- Strike: Strike of option in units of OtherCurrency per 1 unit of NotionalCurrency.
- ExpirationDate: Date on which option expires.

The following fields are optional for defining an FX-option in POINT:

- Description: Text description of the instrument.
- Contractsize: This defaults to 1. It may be set to something else when the option is being used to represent an option on FX-futures.
- DeliveryMethod: Physical or Cash. This affects when, on expiration, there are cash effects in both currencies or just the Notional currency. The default setting is Physical.

Display of FX-options

FX-options in the positions view may be viewed in expanded or collapsed mode. In collapsed mode, an FX-option will appear as a single line instrument. In expand mode, an FX-option will appear as a head and two legs of an underlying FX-forward. The amount of the underlying FX-forward is delta adjusted. In other words, it will change daily depending upon the delta of the option.

The display setting may be changed via a toggle in the Basket Instruments tab in Portfolio Preferences. All aggregated analytics for FX-options in POINT are based on the expanded mode. By always aggregating in expanded mode, the FX-exposures are properly represented in POINT, as the market value in the legs represents FX-exposures associated with the underlying FX-forward.

Pricing and Pricing Conventions for FX-options

In POINT, the price of an FX-option is the value of the option per 1 unit of the Notionalcurrency. For example, an FX-option with Notionalcurrency USD and other OtherCurrency MXN might have an at-the-money strike of around 14. POINT supports two Quote_Types for FX-options:

- Price. The Quote_Value should be supplied as value per 1 unit of the Notionalcurrency. I.e. Quote_Value is a price using POINT's price convention.
- Implied_Vol. The Quote_Value should be the implied volatility of FX-rates as a decimal. In other words, if the implied volatility is 10%, then the Quote_Value should be given as 0.10.

Overview of analytics for FX-options

Analytics on the head of an FX-options include market value, Delta, Gamma, Vega, Theta, and Rho.

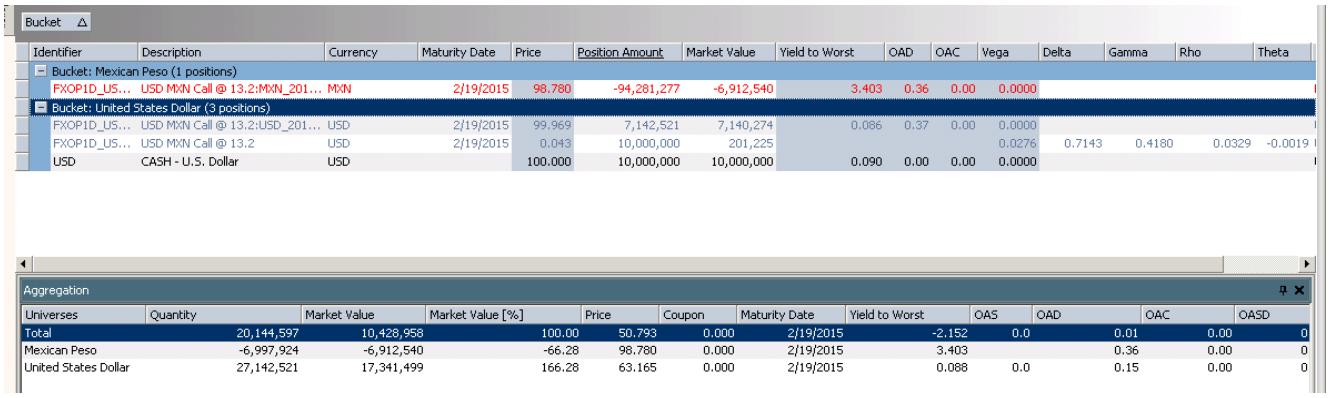
In expand mode, the market value of the head is a residual which reflects any market value that remains in the option after adjusting for the market value of the delta-adjusted amount of the underlying.

Delta represents the change in value of the option for a change in value of the underlying. Deltas are negative on puts and positive in calls and, in general, the absolute value of the delta will be less than or equal to 1.

Analytics on the legs of an FX-option are the same analytics that are populated on FX-forwards. For example, there are interest rates sensitivities (OAD) in the two currencies.

Figure 1 shows an FX-option and cash in the positions view in the expand mode.

FIGURE 1
Position View of FX-options



Bucket

Identifier	Description	Currency	Maturity Date	Price	Position Amount	Market Value	Yield to Worst	OAD	OAC	Vega	Delta	Gamma	Rho	Theta
Bucket: Mexican Peso (1 positions)														
FXOP1D_US...	USD MXN Call @ 13.2:MXN_201...	MXN	2/19/2015	98.780	-94,281,277	-6,912,540	3.403	0.36	0.00	0.0000				
Bucket: United States Dollar (3 positions)														
FXOP1D_US...	USD MXN Call @ 13.2:USD_201...	USD	2/19/2015	99.969	7,142,521	7,140,274	0.086	0.37	0.00	0.0000				
FXOP1D_US...	USD MXN Call @ 13.2	USD	2/19/2015	0.043	10,000,000	201,225				0.0276	0.7143	0.4180	0.0329	-0.0019
USD	CASH - U.S. Dollar	USD		100.000	10,000,000	10,000,000	0.090	0.00	0.00	0.0000				

Aggregation

Universes	Quantity	Market Value	Market Value [%]	Price	Coupon	Maturity Date	Yield to Worst	OAS	OAD	OAC	OASD
Total	20,144,597	10,428,958	100.00	50.793	0.000	2/19/2015	-2.152	0.0	0.01	0.00	0
Mexican Peso	-6,997,924	-6,912,540	-66.28	98.780	0.000	2/19/2015	3.403		0.36	0.00	0
United States Dollar	27,142,521	17,341,499	166.28	63.165	0.000	2/19/2015	0.088	0.0	0.15	0.00	0

Source: Barclays Research

Overview of FX-options in portfolio models in POINT

FX-options are supported in the Global Risk Model for all currencies in which FX-forwards are supported in the Global Risk Model. In some currencies, generic factor loadings are used.

Figure 2 shows a partial view of the factor detail page of the Global Risk Model for a portfolio consisting of an FX-option and cash.

FIGURE 2
Factor Exposure in Global Risk Model

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POINT® Global Risk Model

Factor Exposure - Full Details

Portfolio: Portfolio102
Benchmark: USD Cash
Reporting Units: Returns in bps/month

Run Date: 10/09/2014
As of Date: 10/8/2014
Base Currency: USD

Factor name	Sensitivity/Exposure	Portfolio exposure	Benchmark exposure	Net exposure	Factor volatility	TE impact of an isolated 1 std. dev. up change	TE impact of a correlated 1 std. dev. up change	Marginal contribution to TEV	Percentage of tracking error variance (%)	Contribution to TEV
CURRENCY										
USD (US Dollar)	MW%	168.47	100.00	68.47	0.00	0.00		0.000	0.00	0.00
MXN (Mexican Nuevo Peso)	MW%	-66.28	0.00	-66.28	2.94	-194.68	-227.56	-2.866	81.48	189.99
FX Option Implied Volatility Core (EUR)	FX Volatility	0.017	0.000	0.017	1,347.43	23.11	150.82	871.529	6.41	14.95
FX Option Convexity Core (EUR)	FX Convexity	3.88	0.00	3.88	11.49	44.62	134.04	6.603	11.00	25.65
KEY RATES AND CONVEXITY										
USD 6M key rate	KRD (Yr)	0.251	0.000	0.251	6.59	-1.65	-16.28	0.460	0.05	0.12
USD Convexity	OAC (Yr^2/100)	0.002	0.000	0.002	1.96	0.00	85.56	0.718	0.00	0.00
MXN 2Y Key Rate	KRD (Yr)	-0.239	0.000	-0.239	27.68	6.60	100.36	-11.913	1.22	2.84
SWAP SPREADS										
USD 6M swap spread	SSKRD (Yr)	0.251	0.000	0.251	6.67	-1.67	52.19	-1.493	-0.16	-0.37

Source: Barclays Research

FX-options are supported in Hybrid Performance Attribution (HPA) in POINT. All FX-options are treated as FX-hedges; the returns of the FX instruments are shown as a standalone FX exposure report. The FX return is excluded from asset allocation/security selection and return splits.

Figure 3 shows the FX Outperformance Details report from HPA for a portfolio consisting of an FX-option and cash.

FIGURE 3
FX Outperformance Details Report in HPA Model

Market	FX	Depo Rate Return	MV%		Returns						Outperformance (bps)						
			Port	Bench	FX	FX/Local Cross Term	Local	Option	Intra-Day Port	Intra-Day Bench	FX	FX/Local Cross Term	HedgingEffects: Intra-Day	HedgingEffects: Local Return over Depo	HedgingEffects: Option	HedgingEffects: Hedge MV Effect	Total
Total											20.6	0.6	0.0	4.8	-6.8	0.0	19.2
USD											-0.0	0.0	0.0	177.9	-6.8	0.0	171.1
FXOP1D_USDMXN_CALLAT:USD_20150219	(base currency)	0.0	66.8	0.0	0.0	0.0	266.2	0.0	0.0	0.0	0.0	0.0	0.0	177.9	0.0	0.0	177.9
FXOP1D_USDMXN_CALLAT	(base currency)	0.0	2.0	0.0	0.0	0.0	0.0	-338.0	0.0	0.0	-0.0	0.0	0.0	0.0	-6.8	0.0	-6.8
USD - Settled	(base currency)	0.0	96.1	100.0	0.0	0.0					-0.0	0.0					0.0
MXN											20.6	0.6	0.0	-173.0	0.0	0.0	-151.9
FXOP1D_USDMXN_CALLAT:MXN_20150219	MXN/USD	0.8	-64.9	0.0	-31.7	-0.9	266.7	-0.0	0.0	0.0	20.6	0.6	0.0	-173.0	0.0	0.0	-151.9

Source: Barclays Research

FX-options are not handled in the optimizer, factor-based scenarios, or standard scenarios in POINT currently. In the next three sections, we will focus on the details of the pricing model, risk model, and performance attribution model for FX-options.

Detail on Pricing Models for FX-forwards and FX-options

FX-forwards

FX-forwards are constructed as two currency legs, each as a zero coupon non corporate bond in the local currency. There is no head line for the instrument; nor does there exist prices or any analytics at the forward (head) level.

Pricing Model for each leg:

$$\text{Price}_t = \frac{100}{(1 + i_{N-t} + \text{LOAS}(0))^{N-t}}$$

N is maturity date.

i_{N-t} is the Yield to worst. i_t is the local currency Libor zero curve1, as there is only one cash flow at the maturity date, the only rate that matters is the one at the maturity point (i_{N-t}), which is the yield to worst.

L-OAS and OAS are set to zero for the calculation.

Market value is the same as duration basis for each leg. It is the product of the option price and the position amount /100 adjusted by the FX rate.

OAD and L-OAD are the price sensitivity to a parallel shift in the zero Libor curve up and down.

KRD and L-KRD are the price sensitivity to a ramp shift in the zero Libor curve key points (6m, 2y, 5y, 10y, 20y ,and 30y) up and down. Individual points vary in some currencies.

OAC and L-OAC are the second order price sensitivity with respect to the Libor curve shifts.

FX-Options

FX-options can show in collapsed (head only) or expanded (head plus two legs) modes in POINT. The head contains option information, while the legs carry the currency information. POINT uses a Garman-Kohlhagen model to create the option Greeks (Delta, Gamma, Vega,

[1] For most currencies, the price of the forward leg is the discount factor based on the LIBOR curve; however, in some currencies short tenor swap curves are used.

Theta and Rho). The legs are basically the underlying FX forward, with the positions and exposures Delta-adjusted. In particular, the call and put prices are:

$$C = S * e^{-r_f(T-t)}N(d_1) - K * e^{-r_d(T-t)}N(d_2)$$

$$P = K * e^{-r_d(T-t)}N(-d_2) - S * e^{-r_f(T-t)}N(-d_1)$$

Where

$d_1 = \frac{\ln(\frac{S}{K}) + (r_d - r_f + \frac{\sigma^2}{2})(T-t)}{\sigma\sqrt{T-t}}$ and $d_2 = d_1 - \sigma\sqrt{T-t}$

Notation

C: Call option price in domestic (other) currency

P: Put option price in domestic (other) currency

S: Underlying FX forward rate to the expiration date denoted in notional currency/other currency

$T - t$: Time to expiration, in years

K: Strike FX rate denoted in notional currency/other currency

r_d: Risk free annual rate for the domestic (other) country. This is the country-specific continuous Treasury zero rate.

r_f: Risk free annual rate for the foreign country (notional).

σ: Volatility of the FX forward rate.

$N()$: Cumulative distribution function of the standard normal distribution.

$\phi()$: Probability density function of the standard normal distrubtion.

Analytics

FX option's price is the domestic price divided by spot rate S, to denote in the notional currency.

$$C^F = \frac{C}{S}, P^F = \frac{P}{S}$$

Market Value is defined on both the head and leg level. In particular, the market value of the head varies across the collapsed and expanded modes. In the collapsed mode, the market value is simply the product of the option price and the position amount adjusted by the notional FX rate. In the expanded mode, the market value is actually the residual amount net of the market value from the two legs. This is to guarantee that the market value of the expanded lines ties up to the collapsed head. The market value on the legs is defined similarly to the legs of the underlying FX forwards, with the position amount adjusted by the option delta.

The option Greeks is only populated on the head line; legs have blank values for those attributes.

Delta captures the price sensitivity to the underlying FX forward rate S.

Gamma is the second derivative of the option price to the underlying FX forward rate. It is also the sensitivity of Delta with respect to a change in the forward rate. Gamma is smallest for deep OTM/ITM options and highest for ATM.

Vega is the price sensitivity to implied volatility shift of 1%. Vega falls as the option gets closer to expiration.

Theta is the price sensitivity to time to maturity, expressed in value per year. It is the rate of decline of the time-premium as expiration nears. It is typically largest (in absolute value) for ATM options.

Rho is the price sensitivity to domestic risk free rate r_d shift of 1% per annum. The overall effect on the value of an option from a change in the risk free rate is generally insignificant.

The analytics, such as OAD, OAC, OASD, OASC, KRDs and their Libor counterparties are only available at the legs level, with the value equivalent to the ones of the underlying FX forwards. Those attributes at the head level are blank.

Detail on FX-forwards and FX-options in the Global Risk Model

The risk model works on the expanded mode for FX-option. The risk can be classified into three categories, delta risk, convexity risk, and implied volatility risk. In this section, we detail each category, as well as the risk model for FX-forward as that is the base for the delta risk.

FX-forwards

The risk of the FX-forward contract is treated as the risk of a long/short portfolio that contains two non corporate zero coupon bonds in the corresponding two currencies. For each leg, the return is decomposed into:

$$\mathrm{Ret}_t^{\mathrm{Total}} = \mathrm{Ret}_t^{\mathrm{FX}} + \mathrm{Ret}_t^{\mathrm{YC}} + \mathrm{Ret}_t^{\mathrm{SS}} + \varepsilon_t$$

In particular, each leg loads on three sets of systematic risk factors: FX, yield curve, and swap spread factors. The idiosyncratic risk for the FX-forward is set to zero.

FX-Options

As mentioned before, the risk model operates on the expanded mode (head plus two legs), with three major components in the risk model – delta, convexity, and volatility. Delta risk is captured on the leg level while the other two are captured at the head level. To adjust to the fact that the option price is denoted in foreign currency, we need to divide by the spot rate in the risk loadings.

$$\frac{\partial C^F}{C^F} \approx \left[\frac{Delta * S}{C^F} * \frac{\partial S}{S} + \frac{Vega * \sigma}{C^F} * \frac{\partial \sigma}{\sigma} + \frac{Gamma * S^2}{2C^F} * \left(\frac{\partial S}{S}\right)^2\right] / S$$

All of the FX options factors are observed. The linear FX factors, $\frac{\partial S}{S}$ are defined as the percentage change of the FX rate. FX convexity factors, $\left(\frac{\partial S}{S}\right)^2$ are derived factors based on the linear FX factors. The volatility factors, $\frac{\partial \sigma}{\sigma}$ are calculated as the percentage change of the implied volatility. Next, we will focus on the risk exposure for each of them respectively.

Delta risk on the leg level

The treatment on the delta risk is the same as the legs for FX-forwards: Each leg exposes to FX risk, curve risk, and SS risk. Because the positions, exposures, Market Value, and Duration Basis are all delta adjusted, the Delta risk is the first order approximation of the option risk.

Convexity risk on the head level

There are six convexity risk factors in the model, three of which are square convexity factors, namely, Generic (EUR), GBP, and JPY. The other three are cross convexity factors,

namely, EUR-GBP, JPY-GBP, and EUR-JPY. Those factors are squares or cross products of the corresponding FX factors. Each currency will map to a reference FX factor for the gamma risk calculation. The rule of mapping is based on the historical analysis on the correlation of the FX factors.

- Currencies in (USD, HKD, CNH, CNY, AED, BHD, JOD, OMR, OAR, VEB, and N/A) do not load on reference factor (or zero reference factor)
- JPY and GBP load to its own FX factor
- All other currencies load to EUR factor

We apply a currency-specific parameter in the risk loading, based on the ratio of the currency's FX factor volatility over the mapped FX factor volatility, to adjust to the different levels of currency convexity risks.

Vega component on the head level

There are seven FX Vega factors: EUR/CHF, EUR/GBP, other Europe (EUR/SEK), GBP (GBP/USD), CHF (USD/CHF), JPY (USD/JPY), and a core (EUR/USD) implied volatility factor, which are defined as percentage changes in the generic implied vol. Each option pair will map to one of the volatility factors. The rule of mapping is based on the historical analysis on the correlation of the implied volatilities. For the pairs that are not directly covered by the seven implied volatility factors above, the mapping rule follows:

- If one of the currency in the pair is JPY, map USD/JPY
- Else if one of the currency is in (NOK, SEK, MAD, DKK, CZK, HUF, PLN or HRK), map EUR/SEK
- Else if one of the currency is CHF, map USD/CHF
- Else if one of the currency is GBP, map GBP/USD
- Otherwise the option will map EURUSD (Generic)

Each currency pair will have a specific parameter dependent on the volatility of both the two currencies in the option and the two currencies mapped. As the volatility factors are calibrated with ATM options with one month in maturity, we apply a volatility decay function that adjusts for longer term of maturity. The parameters in the decay function are calibrated to the implied volatilities of ATM options across different tenors.

Detail on FX-forwards and FX-options in HPA

All the FX-related returns are reported separately in the FX allocation and hedging report in the HPA model. Consistent with our treatment of FX instrument in the performance attribution, the returns from FX-options are not included for asset allocation or security selection. The FX instruments are not present in the portfolio security return split reports either. Instead, the security return details can be shown in the FX outperformance Details report once the report option is turned on.

FX-options will operate in HPA as expanded mode (three lines) only. The two legs capture the currency returns from the underlying FX forward. Their local returns are defined as the price return of each leg minus the overnight deposit rate of that currency. The head line captures the residual option return, defined as the option price return net of the returns from the two legs.

Next, we explain each of the return components on the FX Outperformance Details reports (Figure 3).

- Return FX is the currency return containing deposit rate, which is the annualized overnight Libor rate.
- Return Local is the local price return minus the deposit rate.
- Return FX/Local cross term is the product of FX return and the Local return.
- Return Option is the residual option price return net of the returns from the two legs.
- Outperformance FX is equal to the product of the net MV% (Portfolio with Hedges – Benchmark with Hedges) and the excess return over FX allocation hurdle rate.
- Outperformance FX/Local Cross Term is equal to the product of the net MV% and the FX/Local Cross Term return.
- Hedging Effects Local Return over Depo. is the product of the net MV% and the local return.
- Hedging Effect Option is the difference between the option pricing return contribution and the return contributions from the two legs.
- Hedge MV Effect is the return contribution due to holding forwards with a non-zero market value (difference between Hedged and unhedged market values in each currency).

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