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Convexity Adjustment Calculation Interest Rate Futures

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Abstract

Convexity adjustments are required for interest rate instruments which pay on a different date from the natural payment of their underlying rate. This only applies when the future value of the rate is a non-deterministic quantity, in which case it can be modelled as a random variable. Convexity adjustments preclude arbitrage under risk neutral modelling assumptions. A Convexity adjustment is a general concept important in many Fixed-Income derivative models in which the rate of an instrument is adjusted to reflect the applicable convexity for that instrument. The definition of this adjustment varies depending on the context of the derivative instrument; there is no unique standardized model.

Forward rate agreements (FRA) and floating periods of swaps exhibit no convexity when their payment is assumed at the maturity of the rate and the resulting cash flow is discounted to present time under risk neutral assumptions. In contrast, the rates underlying interest rate futures, such as Eurodollars, require a convexity adjustment before they become equivalent to FRA rates on the same period. This is because futures contracts pay a rate at present time (whose non-deterministic value is) determined in the future. As such, futures rates should not be used as inputs for building yield curves without being convexity adjusted.

This document describes the convexity adjustment whereby the rate underlying an interest rate future is converted into an equivalent FRA rate. This adjustment generates a lower rate for the futures contract, and becomes more pronounced the longer the expiry date of the futures contract.

The convexity adjustments described here should not be confused with the convexity arising from the non-linear relationship between the price and the yield of a bond security.

Keywords. Convexity correction, IR Futures, Forward Rates, SWDF, ICVS.

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1 Convexity Correction Formulas

From a quantitative point of view, the origin of the convexity correction can be expressed as the fact that futures and forwards are expected values of the forward rate but *under different measures*. The futures rate, due to its daily margining feature, is the expected value of the forward rate under the risk neutral measure. This differs from the forward rate which is a model dependent quantity, which is to say that it depends on the *dynamics* of the interest rate curve. A common approach to compute the convexity correction is to use a so-called *short-rate model* for the interest rate evolution. A popular choice of short-rate model is that of Hull and White, where one models the short-rate under the risk neutral measure according to the following a normal diffusion process with (constant) volatility σ and speed of mean reversion a.

For quartely IMM futures the convexity correction equals FRA rate - futures rate. However, for monthly overnight futures, such as SOFR, the convexity correction is OIS (daily compounded rate) - futures rate (daily averaged). Hence it also encompasses the basis between daily compounding and daily averaging. Also note that the futures rate accrues on the number of calendar days in the contract month, while the FRA accrual period may vary according to holiday adjustments.

If a monthly overnight futures contract is in-accrual the known overnight fixings included in the futures rate would have been averaged, while the same fixings included in the OIS rate would have been compounded.

2 Convexity Adjustment Settings

2.1 Mean Reversion Speed

The mean reversion constant a represents the speed with which the short-rate reverts to its long term mean. The typical range of values for mean reversion is $a \in [10^{-3}, 10^{-1}]$, where the lower bound is associated with negligible reversion, while the upper bound is associated with quite high mean reversion. Its inverse a^{-1} is the time-scale on which mean reversion takes place.

2.2 Rate Volatility

The default value used for the short-rate volatility σ is the normal (Bachelier) ATM volatility[1] of a Cap of an appropriately chosen maturity specific to a particular currency[2].

As an example, for USD one uses the ATM volatility of the Cap of maturity 5Y:

Rate volatility (%) = 5-yr cap volatility {USCNSQ5} / 100

[1] The choice of normal volatility is due in part to the historical prevalence of negative rates in certain currencies. In the event that the ATM normal volatility quote is not available (due to liquidity), then an approximation may be obtained by multiplying the Black volatility (if available) by the corresponding swap rate.

[2] Note that lognormal (Black) volatilities were in use historically for certain currencies, but their use has been retired as of 2023-04-22. If an historical curve of a given currency is used with a curve-date which precedes 2023-04-22, then it is possible that a Black volatility may yet be used.

The choice of maturity for the ATM Cap volatility is specific to each particular currency, and will depend on the most relevant market characteristics (*e.g.* liquidity) for each swap curve and the constituent tenors from which it is stripped.

In Table 2.1 below we enumerate the maturities used by the most pertinent currencies:

Currency	**Maturity**	**Ticker (BVOL)**	**Curves**	**Comment**
USD	5Y	USCNSQ5	S490, S42, S528	S23 and S47 use USCV10
EUR	5Y	EUNS05		
GBP	5Y	BPNRFR5	S141	S22 and S222 use BPNS06
JPY	5Y	JPCNTS5	S13, S371, S373, S308	
CHF	5Y	SFCNSQ5	S234	also S21 and S254
CAD	5Y	CDCNVI05	S147, S4, S330	
AUD	5Y	ADNV5	S159,S1,S303	
SEK	5Y	SKNOA5		
HKD	2Y	HDNS02	S10	S1/S303 use ADCV5/ADSWAP5
NZD	1Y	NDSN011		1Yx1Y-Swaption ATM-Vol (BBIR)

Table 2.1: ATM Cap volatility tickers of the appropriate maturity for selected currencies.

2.3 Bloomberg Screens

Figure 2.1: Construction of the USD SOFR curve S490.

For the derivation of the convexity formulas please see [Blo2, Th. 4.1, Th. 4.3] and [Blo2, Th. 2.2] also [KN] and [He, §6.2].

References

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