Cboe Hanweck™

Borrow Intensity Indicators™

Methodology Overview

Statement of Purpose

This document summarizes the methodologies used to compute the Hanweck Borrow Intensity Indicators data.

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Introduction

This document provides analytic overview of Hanweck Borrow Intensity Indicators™ and is intended to accompany the **Borrow Intensity Indicators File Description Document**.

Overview of Hanweck Borrow Intensity Indicators

The Borrow Intensity Indicators comprise a set of constant maturity metrics, typically from 45 to 360 days, provided for each underlying asset in the OPRA universe (equities and ETFs with listed options in the U.S.) The indicators display a term structure of synthetic lending rates that is transformed from implied borrow rates computed in real-time within Hanweck Option Analytics.

The synthetic lending rates expressed in the indicators are expressed in a “rebate rate” format consistent with stock borrow rebate rates. Following securities financing convention, the rebate rate is defined as a risk-free rate – implied lending-fee (or spread). When the lending fee is very large, as occurs with Hard-to-Borrow (HTB) or high intrinsic collateral, then the rebate rate can be a significant negative value (e.g., -15%).

Borrow Intensity Indicators provide a consistent set of term rebate rates that update intraday in a format that can be conveniently modeled as a time series. The motivation is to enable a consolidated data view without regard to the specifics of each option expiry, strike and other individual option detail that generates an enormous amount of data and cannot be readily followed across time.

The Borrow Intensity Indicators are processed from real-time calculations in the Hanweck Option Analytics framework, using market data for options and related underliers including equities, ETFs, indices and future, real-time interest data, and discrete dividend forecasts that includes data from major vendors.

Supporting Computations

Hanweck Option Analytics

Hanweck Options Analytics uses a Cox-Ross-Rubenstein (CRR) binomial tree model.[1] The model accommodates both American and European style options, and incorporates full interest rate curves, and discrete dividends.

Discrete dividends are handled in a manner similar to that described by Hull.[2] The tree is constructed in terms of the forward price to expiration, with the underlying spot price at each node derived from the forward price, interest rates and dividends to expiration.

Hanweck Options Analytics uses a proprietary model to compute and update borrow rates for each underlying at each option expiry implied by option analytic inputs including market and reference data, and resultant implied volatilities.

The Volera® Compute Engine

Hanweck Options Analytics is powered by the proprietary Volera® compute engine, a high-performance, hardware-accelerated system capable of performing millions of option valuations per second. Volera’s proprietary calculation process ensures that the latest available prices are used for each computation, while Volera’s supercomputing hardware can tackle the most demanding of market conditions. Volera scales readily to meet ever-increasing message rates.

[1] *Cox, John, Stephen A. Ross, and Mark Rubinstein. “Option Pricing: A Simplified Approach,” Journal of Financial Economics, 7, 1979, pp. 229-263.*

[2] *Hull, John. Options, Futures and Other Derivatives (6th ed.), Prentice-Hall, 2006, pp. 402-5.*

Interest Rates and Dividends

Interest Rates

Hanweck Options Analytics publishes real-time interest-rate curves it uses for option valuation. The curve used for USD is derived from interest rate futures following industry standard methodology, that (as of this writing) is based upon the Libor complex, but is expected to move to SOFR as the industry and SOFR ETPs liquidity increases.

Dividends

Dividend forecasts and announcements are sourced from top-tier industry vendors, and further managed by Hanweck's team of market data experts.

Implied Borrow

Hanweck Options Analytics employs a proprietary model to imply borrow rates from option prices.

Given interest-rate curves observed in the market, and dividend forecasts (from industry providers), Hanweck Options Analytics infers a borrow curve that minimizes the difference in implied volatilities between puts and calls of the same strike and expiration using a binary tree option pricing process that handles both European and American option exercise styles.

Listed options on U.S. stocks are American style options. It is useful however, to first consider the European option case. For European options, the relationship of option prices and borrow rates can be readily determined by the put-call parity relationship as follows:

Eq. (1)

$$FV_T(C - P) = Se^{bT} - \sum_{i \leq T} FV_T(D_i) - K$$

Where:

- FVT(x) = Forward Value (x) at T
- C= Price of Call with strike K, time to expiration T
- P= Price of Put with strike K, time to expiration T
- S = Price of underlying Stock
- D = Discrete dividend
- K = Option Strike
- b = borrow/rebate rate = (r [risk free rate] – q [lending fee/spread])

Eq. (1) shows how the difference of the forward values of Call and Put prices is dependent upon forward values of borrow rate and discrete dividends. Discrete dividends are fixed based upon forecast (i.e. treated as a known). The risk free rate is observed from market inputs. The spread q is a single value associated with the option expiration time so that there is a given rebate rate b for a given time T to option expiration.

The American option pricing problem becomes more complex due to risk of early exercise. The Volera pricing methodology considers the choices of value at ex-dividend date with no exercise vs. value upon exercise (i.e., option "alive" vs. "dead"), choosing the larger value at each node of choice. Those cases where the value of dividend capture exceeds lost interest value and time value of the option will make the choice of exercise.

Then a rebate rate, b, may be found that minimizes FV(C-P). The above process is computed for all option expiration time periods (i.e. across all Ts).

Volera computes these values intraday, observing multiple near-the-money option strikes in order to minimize observation noise. Additional techniques, including dynamic filtering methods such as Kalman filters, are employed to improve quality of estimates, increasing robustness to changing option prices and varying market conditions including changing bid-ask spreads throughout the trading day.

Implied borrow expiration term rates will differ from overnight rates, and can be difficult to compare directly against stock collateral rates, especially since there is little transparency in term collateral rates.

Hanweck Borrow Intensity Indicator™

Construction

The Borrow Intensity Indicator aggregates, weights, and transforms large sets of implied borrow observations across the option surface into more compact constant maturity indicators. An asset's Borrow Intensity Indicator for each term is based in part on implied borrow values across the entire expiration range of listed options for each asset. The contribution of each implied borrow observation to the Borrow Intensity calculation depends upon factors including:

- Proximity of implied borrow expiration to target indicator maturity
- Correlations of multiple expirations implied borrow rates
- Characteristics of the option data including adjustment for options newly entering or soon to be leaving the estimation time window
- Bid-Ask spread of each option at moment of each implied borrow calculation (used to build confidence statistics)
- Predictive analytics for additional noise reduction measures

Presentation and Confidence

Borrow Intensity Indicator data is presented as term rebate values for terms ranging from 45 to 360 days. Borrow Intensity is a metric denominated in the format of a rebate percentage that tracks theoretical term rebate rates. Borrow Intensity Indicator values are not the same as overnight rates, given the spread between term and overnight rates. Indicator values can sometimes appear unusually positive (exceeding risk free rate) where there is significant uncertainty in the market around the timing or amount of the next dividend, as can occur either in distress situations or also in the event of uncertain special dividends.

Changes in Borrow Intensity tend to parallel changes in overnight borrow rates, and the statistical behavior of Borrow Intensity indicators (changes and momentum) may presage analgous shifts in regimes of overnight rates. This can be useful for predicting for example, rising short situations or persistent mildly hard-to-borrow conditions.

A confidence statistic is presented with each Indicator update that is a value between 0 and 1, with confidence based upon both the market quality (liquidity) of the underlying options used to estimate the Indicator, and the maturity of the indicator.

Longer expiries tend to have better confidence values all else being equal, because the annualized rate impact of an .01 in price is less for a longer maturity than for a shorter maturity. Shorter maturity indicators are more sensitive therefore to bid-ask noise even at the smallest trading price increment. For example, confidence values of 0.5 for 180 days is at the 30th percentile vs. the 55th percentile for 45 days.

Also, confidence tends to decrease sharply for stocks at prices of $5 or less, or most generally where the option strike distances are large relative to the price of the stock. Confidence also decreases for securities that have large and somewhat variable frequent cash payouts (e.g. energy and mineral trusts), and leveraged ETFs.

Hard-To-Borrow (HTB) securities are a distinct statistical cohort from normal borrow or General Collateral (GC) securities. The different confidence profiles illustrated here are from the period of 2018.

Profiling of confidence scores by percentiles for HTB and GC universes

We analysed confidence data across the general collateral (GC) and hard-to-borrow (HTB) populations for the period of 2018. As described above the meaning of the raw confidence score can vary depending upon the term of the Borrow Intensity (BI) rate. The goal here was to normalize the confidence scores by percentiles of observations to better understand distribution of confidence across both different terms and the two cohorts of GC and HTB.

The HTB set was defined as those securities with Borrow Intensity levels below the corresponding term risk free rate, and GC included all other securities.

The charts below shows selected percentiles and associated confidence levels for a range of Borrow Intensity terms. The confidence percentiles as illustrated below may be roughly interpreted as follows:

Confidence Percentile	Guidance
.80 - 1.00	Excellent
.50 - .79	Good
.20 - .49	Fair
.15 - .19	Poor
Below .15	Illiquid names

Table 1 - Confidence Ranges and Interpretation by Percentile (HTB or GC analysis)

In the GC space, roughly 3500 names are included

Collateral (GC)	Confidence by Index Term (45day - 360day)					
Percentile	Idx 45	Idx 60	Idx 90	Idx 180	Idx 270	Idx 360
0.8	0.754	0.766	0.797	0.891	0.916	0.922
0.5	0.471	0.497	0.560	0.749	0.800	0.807
0.2	0.119	0.139	0.192	0.381	0.445	0.454
.15	0.075	0.090	0.130	0.283	0.336	0.345

In the GC space, roughly 3500 names are included

Hard-to-Borrow (HTB)	Confidence by Index Term (45day - 360day)					
Percentile	Idx 45	Idx 60	Idx 90	Idx 180	Idx 270	Idx 360
0.8	0.427	0.449	0.500	0.673	0.732	0.747
0.5	0.126	0.144	0.190	0.350	0.407	0.422
0.2	0.012	0.015	0.025	0.063	0.074	0.076
.15	0.005	0.006	0.011	0.030	0.033	0.033

Borrow Intensity Indicator and Synthetic financing

The Borrow Intensity Indicator is based upon an underlying best-fit process that uses mid-point pricing of options. In this respect, the Indicator is useful for tracking relative opportunity of, and providing alerts on, synthetic financing opportunities (e.g. reverse conversions) including with dividend paying stocks. Borrow Intensity calculations account for exercise risk, while more basic methods of assessing conversion opportunities do not (e.g., estimating synthetic carry cost from summing value of C-P+K-S, and annualizing that quantity divided by K).

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