

New Step Indices Validation

Squad - Derived Indices

Report Date : 22 April 2024

Introduction

Due to delay-based exploits at the release of cTrader and to diversify our offerings, new variations of Step Indices are to be released in cTrader & MT5, while the original Step Index will stay in dTrader. The parameters of the upcoming indices are as below, with the original Step Index from dTrader as comparison:

DTrader

Old Indices	Step Size	Threshold	Starting Spot	Spread Value
Step Index 100	0.1	0.5	10,000	0.1

MT5

New Indices	Step Size	Threshold	Starting Spot	Spread Value
Step Index 200	0.2	0.5	10,000	0.2
Step Index 500	0.5	0.5	10,000	0.5

cTrader

New Indices	Step Size	Threshold	Starting Spot	Spread Value
Step Index 300	0.3	0.5	10,000	0.3
Step Index 400	0.4	0.5	10,000	0.4

The step size, threshold and spread value are set in the config file, `steprng.yaml` .

Product Information

Product Description

Product Specifications

- Clickup: <https://app.clickup.com/t/20696747/FEED-331>
- Github PR: <https://github.com/regentmarkets/bom-feed/pull/1269>
- Specs: <https://docs.google.com/spreadsheets/d/1VC6oDYmyhKvkQJsqLBZ2pE4yRUMpHVNp6Q3Hj0yAfds/edit#gid=0>
- Trading Conditions: <https://docs.google.com/spreadsheets/d/1VC6oDYmyhKvkQJsqLBZ2pE4yRUMpHVNp6Q3Hj0yAfds/edit#gid=0>

The step indices are based on the additive random walk, a discrete process. It can be viewed as an approximation of stock prices in the real world, assuming steps are modelled additively, with fixed step sizes, as opposed to geometrically, like the Geometric Brownian Motion (Vol XX).

The index is generated every second.

The currently offered indices are:

- Step Index 100
- Step Index 200
- Step Index 300
- Step Index 400
- Step Index 500

Offered in the platforms described in the introduction.

Construction -- Index

The spot price at time t is defined based on the spot price a timestep before:

$$S_t = S_{t-1} + s \cdot U$$

Where

S = Spot Price

s = Step Size

U = Bernoulli Variable: $\mathcal{B}\left(1, -1; \frac{1}{2}\right)$

Where a Bernoulli distribution: $\mathcal{B}(a, b; p)$ has two outcomes, a, b with probability $p, 1 - p$ respectively.

Construction -- Spread

The Step Index 100 spread was originally defined as an asymmetric spread to ensure that a pipsize of 0.1 is attained:

$$\begin{aligned} S_{bid} &= S_t \\ S_{ask} &= S_t + 0.1 \end{aligned}$$

This is extended to the rest of the indices using the following formula:

$$\begin{aligned} S_{bid} &= S_t - 0.1 * \left\lfloor \frac{10s}{2} \right\rfloor \\ S_{ask} &= S_t + 0.1 * \left\lceil \frac{10s}{2} \right\rceil \end{aligned}$$

Where $\lfloor \cdot \rfloor$ is the floor function and $\lceil \cdot \rceil$ is the ceiling function. For example:

1. Step Index 100. We recover the existing (asymmetric) spread:

$$S_{bid} = S_t - 0.1 * \left\lfloor \frac{10 \cdot 0.1}{2} \right\rfloor = \text{spot} - 0.1 * \lfloor 0.5 \rfloor = \text{spot}$$

$$S_{ask} = S_t + 0.1 * \left\lceil \frac{10 \cdot 0.1}{2} \right\rceil = \text{spot} + 0.1 * \lceil 0.5 \rceil = \text{spot} + 0.1$$

2. Step Index 400 (Symmetric spread):

$$S_{bid} = S_t - 0.1 * \left\lfloor \frac{10 \cdot 0.4}{2} \right\rfloor = \text{spot} - 0.1 * \lfloor 2 \rfloor = \text{spot} - 0.2$$

$$S_{ask} = S_t + 0.1 * \left\lceil \frac{10 \cdot 0.4}{2} \right\rceil = \text{spot} + 0.1 * \lceil 2 \rceil = \text{spot} + 0.2$$

NOTE: Spreads are set per platform, and not in BE/BO. As such, the only downloadable tick history that contains the spread is the MT5 spread.

In summary:

Index	Bid Spread	Ask Spread
Step Index 100	0	+0.1
Step Index 200	-0.1	+0.1
Step Index 300	-0.1	+0.2
Step Index 400	-0.2	+0.2
Step Index 500	-0.2	+0.3

Important Dates:

Date	Event
19 March 2024	DevServer release
20 March 2024	Random number fix (See next section)
22 March 2024	Spreads applied in platforms
26 March 2024	CTrader Demo release
4 April 2024	MT5 Demo release

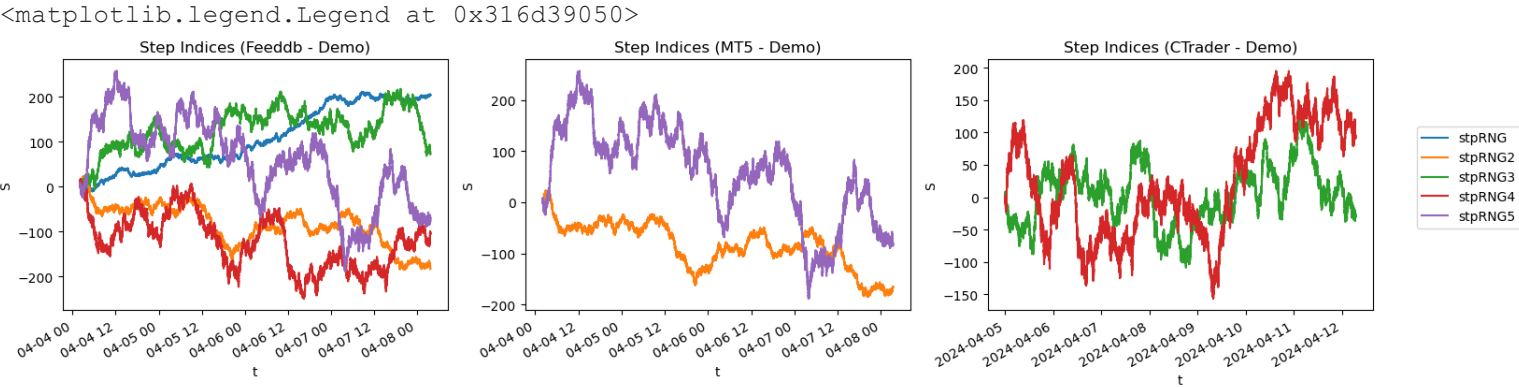
Model Validation

Summary

For the validation of Step Indices, we cover the below areas and conclude the outcomes. More details can be found in the respective sections. Data Feeds are from the Demo release dates onwards.

Section	Area	Validation	Outcome	Passed?
1	Correlations	Correlations of the indices were checked. To prevent potential pair-wise trading advantages or arbitrage exploits, all pairwise correlation should be at 0.	Issue (19 March 2024): The indices all had correlation 1 due to using the same random numbers. Update (Resolution - 20 March 2024): Each index started using different random numbers; Pair-wise correlations were 0 from then on.	Passed

2	Long term moments & convergence	<ul style="list-style-type: none"> • Feed moment data computation and cross-checking with simulation moments • Moment convergence speed testing 	<ul style="list-style-type: none"> • Feed volatilities match match simulations • Moments converge approximately within a week 	Passed
3	Parameter Estimation	Parameters are backward engineered from the feed data: <ul style="list-style-type: none"> • Step size; • Threshold; • Spread. 	The recovered parameters are accurate to pre-defined parameters	Passed
4	Client Trading Statistics	Win rates & Hit ratios for each index are checked	Investigations found some high-PnL clients (Over \$1k profit per trade), but they are few, and likely emboldened by the large margins from Demo.	Passed
4	Probability of going negative	Since the indices use additive noise, there is a non-zero chance they can hit 0 in a specified time	Higher step sizes means higher chance to hit 0. In particular, Step Indices 400 & 500 have over 0.5% chance to hit 0 in 3 or 5 years	Passed



1. Correlations

We check correlations of the log returns. We expect all pair-wise correlations to be 0, otherwise it opens up arbitrage exploits and pair-wise trading opportunities across Step Indices.

We check:

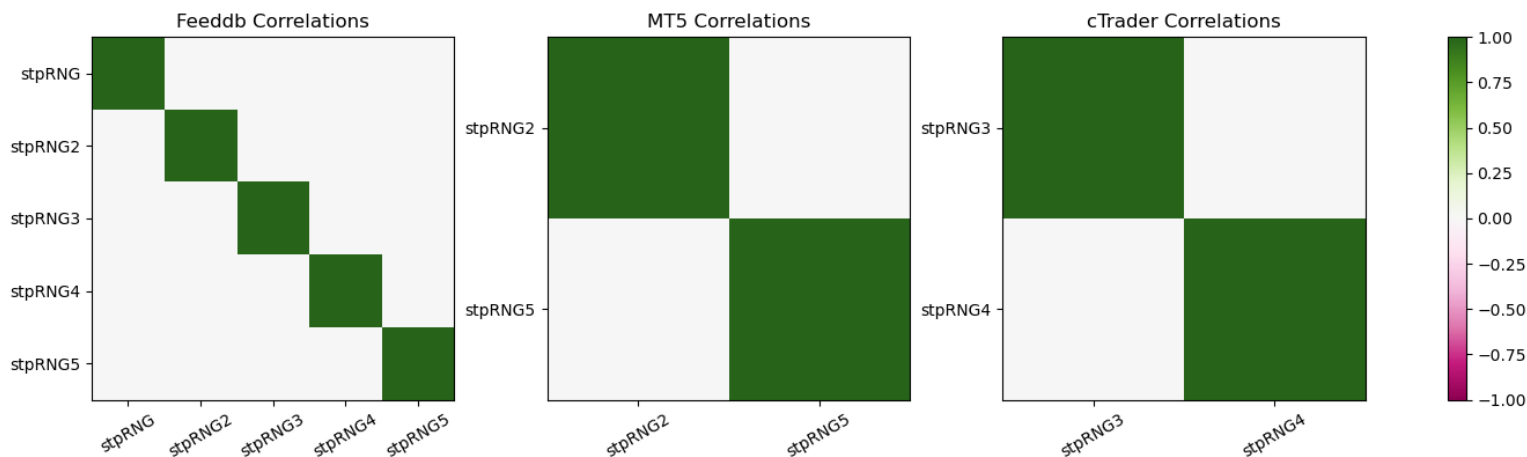
- All Step Indices;
- MT5 Step Indices;
- cTrader Step Indices.

Observations

Between 19-20 March 2024, all the step indices used the same random numbers during generation, hence all correlations were exactly 1. This issue has been resolved since 20 March 2024.

Result

We clearly see that no step indices are pairwise-correlated.



2. Long Term Moments & Convergence

We check the long-term moments of the log returns.

- By symmetry, we would like skew and drift to be 0, but drift may be far from 0 due to the very tiny relative change per step.
- Volatility is expected to be roughly around the following values based on previous Monte-Carlo calculations:

Index	Volatility
Step Index 100	7%
Step Index 200	11%
Step Index 300	16%
Step Index 400	23%
Step Index 500	30%

- Excess kurtosis is expected to be around -2, i.e it is thinner tailed than the normal distribution

Note that in longer periods of time, the moments can converge to different values due to the indices' additive nature.

Results

The moments are within expected values.

Feeddb - Demo Moments	drift	vol	skew	E. kurtosis
stpRNG	2.237478	0.068643	-0.011600	-1.999531
stpRNG2	-1.612218	0.110206	0.005189	-1.999875
stpRNG3	0.616094	0.158678	-0.001337	-1.999879
stpRNG4	-0.953597	0.228578	0.001479	-1.999834
stpRNG5	-0.679673	0.303070	0.000808	-1.999559

MT5 - Demo Moments	drift	vol	skew	E. kurtosis
stpRNG2	-1.462504	0.110204	0.004777	-1.999702
stpRNG5	-0.814987	0.303056	0.000965	-1.999559

CTrader - Demo Moments	drift	vol	skew	E. kurtosis
stpRNG3	-0.120483	0.158535	0.000356	-1.999660
stpRNG4	0.464615	0.227817	-0.000865	-1.996621

Convergence

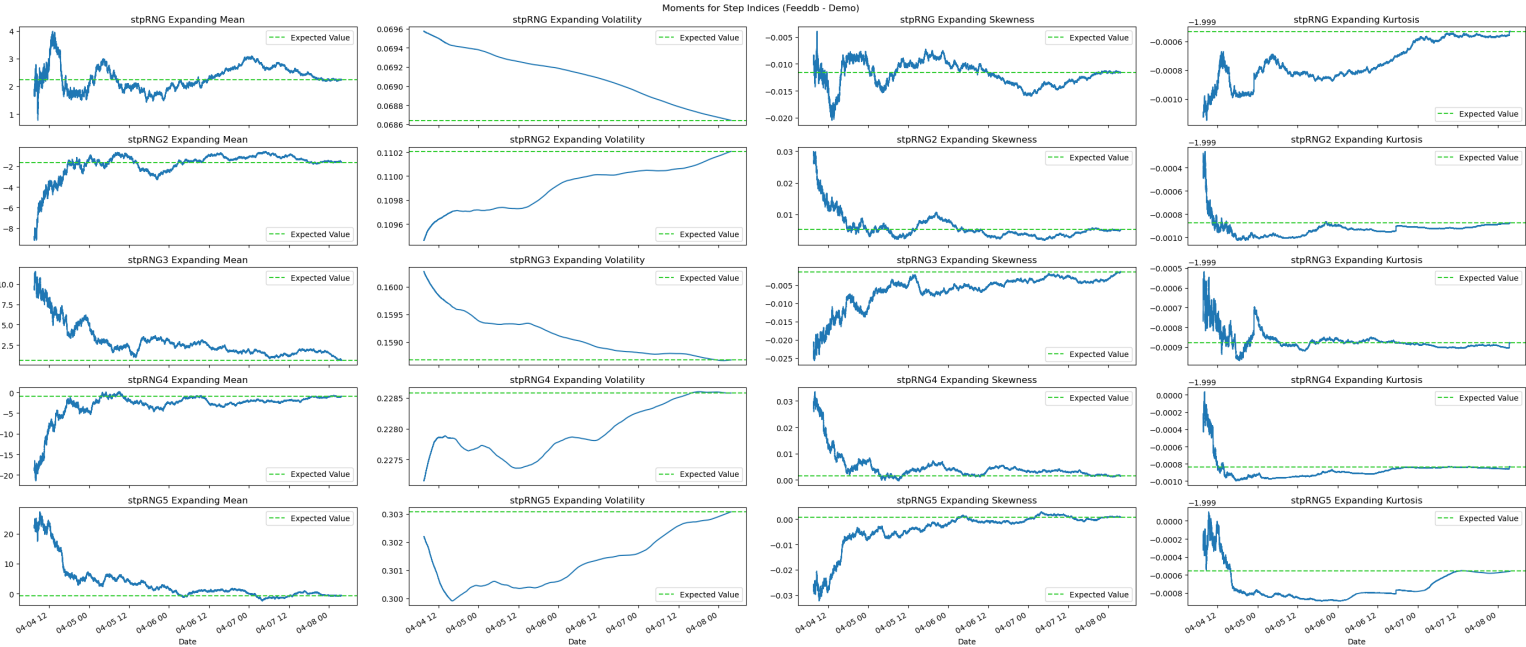
The faster the convergence of moments the better.

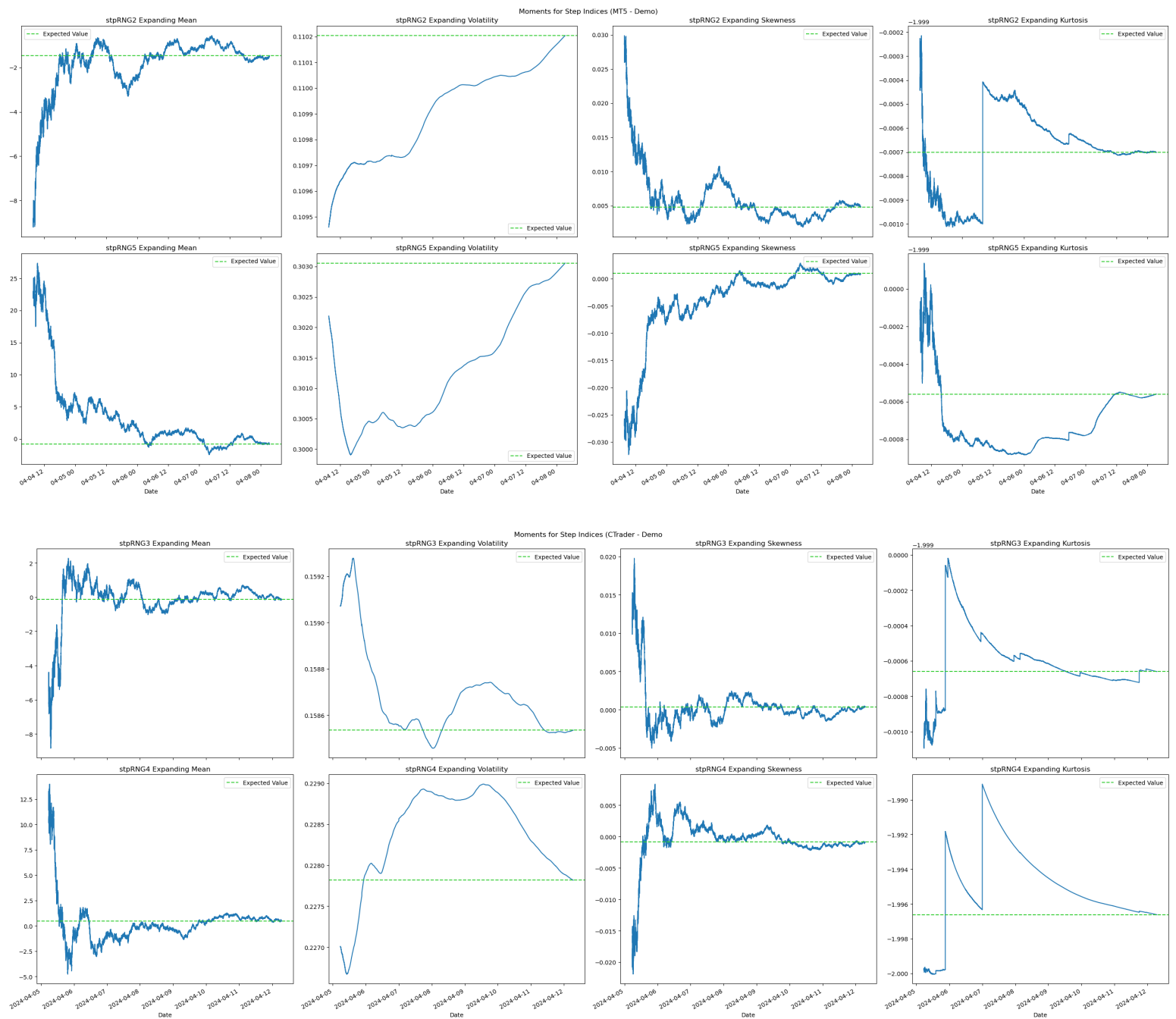
Note that the drift and volatility will particularly slowly converge as they give more weight to smaller movements (all of them, if you consider log returns) as opposed to skew and kurtosis.

Results

The drift, skew and kurtosis converge within 3 days. Volatility seems to have a hard time converging however, though this is no issue, since log-returns on Step Indices are inherently biased to low values & the movement of the indices will heavily affect the final value.

Do note the jumps in the cTrader indices. These result from some short feed losses.





3. Parameter Estimation

We estimate the index parameters as a sanity check.

Step size

Step sizes should be constant for each index

Results

All step sizes match the specs

Feeddb - Demo Step Sizes	expected	average	error
stpRNG	0.1	0.100000	-0.000003
stpRNG2	0.2	0.199999	0.000003
stpRNG3	0.3	0.300001	-0.000003

	stpRNG4	0.4	0.399999	0.000003
	stpRNG5	0.5	0.499999	0.000003
MT5 - Demo Step Sizes	expected	average	error	
	stpRNG2	0.2	0.200001	-0.000003
	stpRNG5	0.5	0.499999	0.000003
CTrader - Demo Step Sizes	expected	average	error	
	stpRNG3	0.3	0.300002	-0.000006
	stpRNG4	0.4	0.400003	-0.000006

Threshold

The step distribution must be symmetrical, that is there is an equal chance of going up or down.

Results

We see all the probabilities are 0.5, as expected.

Feeddb - Demo Probabilities	expected	average	error	
	stpRNG	0.5	0.502899	-0.005798
	stpRNG2	0.5	0.498697	0.002606
	stpRNG3	0.5	0.500339	-0.000677
	stpRNG4	0.5	0.499624	0.000751
	stpRNG5	0.5	0.499798	0.000404
MT5 - Demo Probabilities	expected	average	error	
	stpRNG2	0.5	0.498814	0.002372
	stpRNG5	0.5	0.499759	0.000482
CTrader - Demo Probabilities	expected	average	error	
	stpRNG3	0.5	0.499920	0.000161
	stpRNG4	0.5	0.500172	-0.000345

Spread

We check the feeds to recover and verify the expected spread structure. Note that since spreads are implemented per platform, only MT5 feeds contain the spread. However, cTrader and dTrader do display the spreads in their live feeds.

Results

The MT5 spreads below are accurate to the expected spread. Both DTrader and CT show the correct spread in their respective platforms.

MT5 Spreads	expected	average	error
stpRNG2	0.2	0.2	5.551115e-16

4. Client Trading Statistics

We check the win rates and hit ratios (Company-side) per symbol. Trades are from Demo launch to 16 April 2024:

CT:

Step Index 200

win rate: 0.4326315464997996

hit ratio: 0.5227078152666138

Step Index 500

win rate: 0.4621082230299705

hit ratio: 0.5128024458913704

MT5:

Step Index 100 (Real)

win rate: 0.4108049653002795

hit ratio: 0.5482392331207934

Step Index 300

Hit Ratio: 0.5378588601916308


Win Rate: 0.5017886178861789

Step Index 400

Hit Ratio: 0.3138068732494188

Win Rate: 0.3970238095238095

Despite the sub-par win rates, investigation of clients & their trading behaviours indicate no particular strategies or exploits being used. A bulk of client profits were made with high volume trades due to high margins from Demo, which typically netted over \$1,000 profit per trade for the client.

MV team agrees with the Specialized Dealers (Slack) that these trades are no indicator of a greater problem, and will likely subside when margins are more meaningful, or be offset by general client trades once released to Real.

5. Probability of going negative in specified time

We note that since these indices are additive, there is a non-zero chance that at some point, the index will go to 0 (and hence negative). We estimate the likelihood this happens within 1, 3, 5 years.

We do so using the following formula (c.f appendix):

$$\mathbb{P}(S_n \leq 0) = \mathbb{P}\left(Z \leq \frac{-S_0}{s\sqrt{n}}\right)$$

For initial spot S_0 and step size s . For example, if we had a step index with steps ± 1 starting at 10,000, the probability of going negative within a year would be

$$\mathbb{P}(10,000 + S_n \leq 0) \approx \mathbb{P}\left(Z \leq \frac{-10,000}{\sqrt{86400 \cdot 365}}\right) \approx 3.6\%$$

Evidently, at some point, the indices are likely to require a reset, most notably stpRNG4 & stpRNG5, with over 0.5% chance of hitting 0 beyond 3 years

	1 year	3 years	5 years
stpRNG	3.104674e-69	4.290870e-23	8.352448e-14
stpRNG2	2.702672e-17	1.369980e-05	3.419468e-03
stpRNG3	1.462546e-07	3.051382e-02	3.970747e-01
stpRNG4	4.257457e-04	5.081196e-01	2.324537e+00
stpRNG5	1.844071e-02	1.988146e+00	5.561058e+00

Appendix

Step Index Moments

We can formulate the Step Index as the following:

Let $X \sim B_p(a, b)$ where $B_p(a, b)$ is a Bernoulli distribution on support $\{a, b\}$ with $\mathbb{P}(X = a) = p$. Then consider X_i independent and identically distributed to X and a starting point X_0 . For any given $n > 0$, the step index is:

$$S_n = S_0 + \sum_{i=1}^n X_i$$

We notice further that:

$$S_n - S_0 = \sum_{i=1}^n X_i$$

has a binomial distribution, which will make way for the normal approximation used in the next section. That aside, the mean/variance of X and S_n are as follows:

$$\mathbb{E}[X] = pa + (1 - p)b$$

$$\mathbb{V}[X] = pa^2 + (1 - p)b^2 - (pa + (1 - p)b)^2 = p(1 - p)(a - b)^2$$

$$\mathbb{E}[S_n] = S_0 + n\mathbb{E}[X] = S_0 + n[pa + (1 - p)b]$$

$$\mathbb{V}[S_n] = n\mathbb{V}[X] = np(1 - p)(a - b)^2$$

For step indices, this reduces to:

$$\mathbb{E}[X] = 0$$

$$\mathbb{V}[X] = s^2$$

$$\mathbb{E}[S_n] = S_0$$

$$\mathbb{V}[S_n] = ns^2$$

Where s is the step-size.

Probability of going negative in a specified time

We'd like to estimate the probability of the step index hitting 0 (and consequently, going negative). We do so via a normal approximation:

By the Central Limit Theorem, as $n \rightarrow \infty$ the distribution of the step index converges (in distribution) to a normal random variable. I.e, for sufficiently high n ,

$$\frac{S_n/n - \mathbb{E}[X]}{\sqrt{\mathbb{V}[X]/n}} \sim \mathcal{N}(0, 1)$$

Equivalently:

$$\frac{S_n - \mathbb{E}[S_n]}{\sqrt{\mathbb{V}[S_n]}} \sim \mathcal{N}(0, 1)$$

Therefore, if we wanted to estimate the probability of a step index starting at X_0 going negative:

$$\begin{aligned} \mathbb{P}(S_n \leq 0) &= \mathbb{P}(S_n - \mathbb{E}[S_n] \leq -S_0) \\ &= \mathbb{P}\left(\frac{S_n - \mathbb{E}[S_n]}{\sqrt{\mathbb{V}[S_n]}} \leq \frac{-S_0}{\sqrt{\mathbb{V}[S_n]}}\right) \\ &\approx \mathbb{P}\left(Z \leq \frac{-S_0}{\sqrt{\mathbb{V}[S_n]}}\right) \end{aligned}$$

Where $Z \sim \mathcal{N}(0, 1)$. Substituting the moments in, we get the expression:

$$\mathbb{P}(S_n \leq 0) \approx \mathbb{P}\left(Z \leq \frac{-S_0}{|a - b|\sqrt{np(1 - p)}}\right)$$

For step indices with step size s , we get the simplified expression:

$$\mathbb{P}(S_n \leq 0) \approx \mathbb{P}\left(Z \leq \frac{-S_0}{s\sqrt{n}}\right)$$

R&D effort needs to be in line with Deriv's vision and mission as formulated by our CEO. Therefore all R&D projects are carefully selected by our C-Level senior management represented by JY and Rakshit and resources for the projects are only allocated after review and shortlisting based on their vision and priorities.

In line with the standards and criterias set out by the CEO, the Model Validation team has validated the product/indices as documented in this report.