Additional Research on the Ability to Reverse Engineer the Proposed Precidian ETF

August 2015

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Purpose and Scope of This Research

This research is designed to explore specific follow up questions raised by the SEC after reviewing the white paper **Precidian's Proposed ETF and the Possibility of Reverse Engineering** Cooper (2015) [1]. The specific scope of this research is to answer two questions:

1. If the composition of the portfolio does not change, what is the feasibility of reverse engineering the portfolio over a multiple day window, given the proposed reporting structure?

2. What is the correlation of the displayed price under the proposed reporting structure with the unscaled price of the ETF, and how would this affect hedging activity?

For details on the structure of Precidian's proposed ETF and the method of filtration proposed to generate a reported ETF price, the reader is referred to Cooper (2015).

Structure and Results of the Reverse Engineering Test

For this test a portfolio of 40 stocks was chosen at random from the 100 possible Nasdaq-100 stocks. Each stock chosen was held at an equal weight; that is, each received a 2.5% weight in the portfolio. Furthermore, the average portfolio weight across all securities in the universe was 1%. To ensure comparability, the analysis performed in Cooper (2015) was replicated. Specifically, the recovery of the portfolio weights was attempted utilizing a least squares optimization, with portfolio weights constrained to be less than 10%, greater than or equal to 0%, and summing to 100%. The scaled ETF price and the mid-spread price of the 100 stocks were used to create a ten day time series of one second returns. The mean square error across the 100 assets was recorded at the end of each n-day estimation period. For example, Table 1 reports mean squared error of 0.00683 is based on two complete days of one second returns. The experiment was repeated four times, using 40 of the 44 days originally sampled in the previous study.

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[1] This white paper is available on Edgar, as part of Precidian's filing, at https://www.sec.gov/Archives/edgar/data/1396289/000114420415048013/v417803_40appa.htm

Table 1

Average Absolute Errors in In Weights of an Unchanging Portfolio

Num Obs	Days	Trial 1	Trial 2	Trial 3	Trial 4	Ave. Err.	% Err.
23400	1	0.00814	0.01056	0.01096	0.00901	0.00967	96.67%
46800	2	0.00675	0.00591	0.00856	0.00611	0.00683	68.33%
70200	3	0.00445	0.00522	0.00431	0.00439	0.00459	45.90%
93600	4	0.00344	0.00383	0.00407	0.00317	0.00363	36.25%
117000	5	0.00363	0.00300	0.00381	0.00176	0.00305	30.49%
140400	6	0.00345	0.00297	0.00341	0.00138	0.00280	28.02%
163800	7	0.00262	0.00223	0.00219	0.00091	0.00198	19.85%
187200	8	0.00209	0.00132	0.00195	0.00085	0.00155	15.53%
210600	9	0.00160	0.00123	0.00174	0.00091	0.00137	13.70%
234000	10	0.00157	0.00103	0.00135	0.00089	0.00121	12.10%

Table 1 indicates that the one day error is very similar to the error reported in Cooper (2015). The slight variation is due to the fact that this table reports a sample of four regressions over one day periods, and the previous study reported a sample of 44 regressions over one day periods. The per-cent error is relative to the average portfolio weight of 1%. As one would expect, the ability to estimate a static portfolio improves as more observations become available, and given enough data, the regression parameters would eventually converge to the correct values.

It is important to note that the reduction in the percentage error is surprisingly gradual, and even after ten days significant error remains. For example, the regression fails to recover the actual ETF weights to within 10% accuracy even after observing 234,000 returns.

Structure and Results of the Correlation Test

An open question is whether the inability to reverse-engineer the ETF's underlying portfolio weights also means the relationship with the quoted ETF price and the precise ETF price is stable. Table 2 presents correlations of the change in the scaled ETF prices and the unscaled prices. That is, the unscaled prices referred to in Table 2 are calculated with full precision. The first and second columns respectively report the length in seconds of each each non-overlapping period and the correlation of the two price series across the 44 trial days. The third and fourth columns report the corresponding standard deviations of the return for the scaled and unscaled ETF price changes. Both, the correlations and standard deviations are the average daily values across the 44 days of the study.

Table 2
Correlations and Standard Deviations in Changes of ETF Prices

These correlations and standard deviations are for non-overlapping samples of various period lengths, indicated by the seconds column. These statistics are average daily numbers across 44 days.

Period in Seconds	correl.	scaled std. dev.	unscaled std. dev.
1	0.33	0.0015	0.0031
60	0.85	0.0082	0.0398
300	0.96	0.0167	0.0893
600	0.97	0.0234	0.1243
1800	0.98	0.0370	0.1819

Looking at the numbers, one observes that the one second reporting period generates a .33 correlation between the scaled and unscaled prices. The reason for this low correlation is that the scaled prices will often not change over a second even though the unscaled prices have changed one or two cents. The correlation of .33 is not insignificant, but results in a large amount of error were one to attempt trying to reverse engineer the underlying portfolio components.

At lower frequencies the correlations improve. For example, at a one minute reporting period, the correlation improves to .85. At a 30 minute reporting period, the correlation improves further to .98. Thus, at for any period outside of the realm of ultra-high frequency, the movements in the scaled price are very highly correlated with the movements in the unscaled price.

Although the correlation improves with lower frequency estimation windows, it does not follow that one could reverse engineer the underlying portfolio. This follows because lower frequency data does not have enough observations per day to effectively achieve this task. The primary conclusion of Table 2 is that it appears that any hedging activity could be efficiently executed using the scaled ETF price. The only consideration is the inherent "basis" risk between the scaled and unscaled price changes at relatively high-frequency reporting intervals.

Concluson

The main point of this research is to shed more light into the nature of inability to reverse engineer Precidian's proposed ETF, and the implication of their price reporting structure for hedging applications. The results may be summarized as follows:

1. The reporting mechanism of Precidian reduces the correlation of the reported price quotes each second and the corresponding unscaled prices to .33, based on our stylized methodology as described in Cooper (2015). This reduction in correlation is the primary factor that prevents the reverse engineering of the ETF's positions in the underlying stocks even after ten days of unchanging weights;

2. The correlation of the movements over longer periods, especially 30 minute intervals, is closely related enough, that the ETF hedges accurately any risk that the underlying ETF could also hedge. This is due to the fact that the 30 minute correlation is a .98 and even the five minute correlation is .96;

3. The short term correlation is strong enough that any systematic bias in the relationship between the reported ETF price and the actual underlying securities would invite trading from

motivated market participants to drive it out. From a statistical arbitrage traders perspective .33 is non-trivial and would attract arbitrage trading should prices get out of line.

In almost every sense it would appear that the proposed ETF structure strikes an appropriate balance between the competing goals of prevention of reverse engineering, ability to be used as a hedging vehicle, and strong enough short term correlation with the underlying issues to invite arbitrage trading should any systematic bias form in the ETF price.

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Biography:

Ricky "Rick" Cooper is Assistant Professor of Finance at IIT Stuart School of Business. Throughout his academic career, Dr. Cooper has taught all aspects of financial theory, investments, and corporate finance at Wayne State University, Harvard University, and Vanderbilt University.

Dr. Cooper began his professional career with State Street Global Advisors in Boston, MA, where he quickly rose from Active International Portfolio Manager, to co-founder of the Enhanced Index Group, to co-founder and Associate Director of the Advanced Research Center.

He then returned to his hometown of Chicago, where he worked as Senior Partner and Director of Analytics for Harris Investment Management. In this role, he modernized the analytic systems, and led the revamping of the models with a commensurate uptick in investment performance. Dr. Cooper also spent several years as Owner and Chief Investment Officer of his own firm. He currently serves as a research consultant and Director of Risk Management for Xambala, Inc.'s proprietary high frequency trading systems.

Dr. Cooper's research has been published in The *Journal of Futures Markets*, *The Financial Analyst's Journal*, *The Journal of Financial Economics*, and several other books and journals. Dr. Cooper has been a speaker at numerous conferences, and has been quoted in both the *Wall Street Journal* and *Crain's Chicago Business*.

Affiliated Programs:

M.S. in Finance

Ph.D. in Management Science