Precidian Investments

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June 13, 2016

VIA ELECTRONIC SUBMISSION

Brent J. Fields
Secretary
Securities and Exchange Commission
100 F Street, N.E.
Washington, DC 20549-1090

Re: SR-NYSEArca-2016-08

Dear Mr. Fields:

Precidian Funds LLC ("Precidian") feels compelled to respond to the Order Instituting Proceedings to Determine Whether to Approve or Disapprove a Proposed Rule Change ("Request for Comment") by the Securities and Exchange Commission ("SEC") in order to ensure potential commenters have all of the relevant information (all of which will be provided for in subsequent filings) necessary to provide accurate and meaningful responses. Specifically, in order to respond to question #6 in the SEC's request for comments, on "how a broker-dealer authorized participant engaging in creation and redemption activity might fulfill its obligation to maintain a minimum level of net capital in compliance with Rule 15c3-1 under the Act and how such an authorized participant would comply with the books and records requirements of Rules 17a-3 and 17a-4 under the Act," it is important for commenters to know that Precidian intends to publish the Maximum Net Capital Haircut on the daily Pro Rata Basket as determined under Rule 15c3-1 via the public website and through dissemination to all Trusted Agents.

In addition, below we have restated the questions in the SEC's request for comments, followed by our views on each.

1. Do commenters believe that MM's will be able to engage in effective and efficient arbitrage in the Shares without knowledge of the contents of the Funds' portfolios? Do commenters believe that MM's will be able to engage in effective and efficient arbitrage in the Shares while delegating trading in the portfolio securities to an intermediary, rather than trading in those securities directly? Do commenters believe that the Shares of a Fund will trade at secondary market prices that are closely aligned with the value of the Fund's portfolio?

RESPONSE: Yes, as declared by NYSE Arca in the Proposed Rule Change and through our ongoing discussions with Lead Market Maker's ("LMMs") and other Market Maker's ("MM's") it has been made clear that, with the availability of a Verified Intra-Day Indicative Value (VIIV) every second providing full pricing transparency on a per-share basis, the ability for MM's and other market participants to build correlated portfolios for hedging purposes, and the option for MM's and other market participants to engage in bona fide arbitrage, MM's feel confident that they can make efficient markets in the funds being proposed. With respect to the delegation of trading, to clarify, all trading decisions will be retained by the APs and non-AP MM's. In addition, like all ETFs, hedging will happen through correlated baskets constructed by MM's and market participants, leaving all execution in the hands of the LMM,

MM's, and other market participants. When market participants, who have established a Confidential Account with a Trusted Agent to engage in Bona Fide Arbitrage, or AP's create or redeem, a Trusted Agent will be engaged as a broker dealer in a fiduciary capacity to provide execution services. Even in such an event, trading decisions (e.g., buying or selling the fund's constituent securities for purposes of Bona Fide Arbitrage or creation & redemption events) will be made by the market participants and APs.

2. Do commenters believe that the trading characteristics – such as bid/ask spread and premium or discount to NAV – of a Fund will be comparable to the trading characteristics of a fully transparent ETF with similar assets and a similar strategy?

RESPONSE: Yes, given the universe of securities covered in Precidian's Application, the availability of a Verified Intra-Day Indicative Value (VIIV) every second providing full pricing transparency on a per-share basis, the ability for market participants to build correlated portfolios for hedging purposes, and the availability of a mechanism for engaging in bona fide arbitrage, we fully expect spreads to be competitive with comparable products.

3. What are commenters' views concerning the proposed use of a VIIV as opposed to the IIV commonly used by other ETFs? Do commenters believe that the VIIV will provide sufficient information to market participants to ensure that the Funds are appropriately priced in secondary trading? Do commenters believe that the VIIV will provide sufficient information to market participants in periods of market volatility, including periods in which securities underlying a Fund's portfolio encounter trading halts or pauses? Do commenters believe that the proposed parameters that apply to the accuracy of the VIIV – i.e., the requirement that the two independent calculations not disagree by more than 25 basis points for 60 seconds or more – are appropriate?

RESPONSE: The Verified Intra-Day Indicative Value (VIIV) provides more accurate information than the current Intra-Day Indicative Value (IIV) utilized by existing ETFs. Based upon the actual portfolio constituents, utilizing midpoint of the bid/ask spreads to more accurately reflect current market sentiment, price feeds from at least two independent pricing agents that are reconciled and distributed by a Verification Agent every second of the trading day, investors and MM's will have an accurate per-share value of the fund's current indicative value every second. Additionally, Precidian's Application includes an additional investor protection that requires the Fund to halt trading in the event of bad or incomplete pricing information, to ensure investors and MM's will not trade on inaccurate information. Furthermore, as stated in the Proposed Rule Change, "if there is no closing price for a particular portfolio security, such as when it the subject of a trading halt, a Fund will use fair value pricing. That fair value pricing will be carried over to the next day's VIIV until the first trade in that stock is reported unless the "Adviser" (defined below) deems a particular portfolio security to be illiquid and/or the available ongoing pricing information unlikely to be reliable. In such case, that fact will be immediately disclosed on each Fund's website, including the identity and weighting of that security in a Fund's portfolio, and the impact of that security on VIIV calculation, including the fair value price for that security being used for the calculation of that day's VIIV." In addition, given the universe of securities covered in Precidian's Application, the proposal for halting trading strikes the right balance between accuracy of the VIIV and continuous trading.

4. What are commenters views regarding whether market participants will be able to use the VIIV – by itself or in conjunction with other public data – to reverse engineer a Fund's portfolio holdings? What factors might affect the susceptibility of a Fund to such reverse engineering? If such reverse engineering

were possible, what effect would it have on the Fund? What effect would reverse engineering have on shareholders in the Fund?

RESPONSE: Precidian engaged Dr. Rick Cooper of the Stuart School of Business at the Illinois Institute of Technology and former Active International Portfolio Manager and co-founder of the Enhanced Index Group/co-founder and Associate Director of the Advanced Research Center at SSgA to conduct a thorough review of the Precidian structure and the ability of market participants to reverse engineer the portfolio constituents. Dr. Cooper performed multiple empirical studies on the ability/inability to reverse engineer the portfolios. His conclusions confirm the inability of accurately determining the portfolio constituents and weights with the information provided by the VIIV (please see attached studies). As Dave Nadig of ETF.com stated, regarding VIIV, in an article last August, "[a]t best, it will do what it's supposed to do—give you a good idea of what you might be able to use as a hedge, based on how other securities are moving intraday." Precidian Ups Ante With Active ETF Rebuttal (Aug. 11, 2015) http://www.etf.com/sections/blog/precidian-ups-ante-active-etf-rebuttal.

The studies show conclusively that the portfolio constituents and weights could not be reversed engineered with any confidence, thereby eliminating the economic certainty necessary to engage in front-running and eliminating the possibility of free-riding because of the economically significant margin of error. If, however, the fund manager were forced to disclose the portfolio holdings, it would provide the economic certainty and motivation for professionals to front run portfolio changes and/or free ride based on the manager's intellectual property. The impact of front running on fund performance in certain circumstances could result in diminished returns. The manager could mitigate some of the drag by modifying the fund's trading but, the long term loss of the manager's intellectual property would significantly restrict the number of managers willing to offer access to their professional management, to the investing public, in this far more efficient structure.

5. What are commenters views about the selective disclosure of portfolio holdings to the Trusted Agents, as described above?

RESPONSE: The use of trusted agents and executing broker dealers, is a common practice that has been employed for decades with no deleterious effects on the capital markets. Mutual funds, closed-end funds, hedge funds, ETFs and others, consistently rely upon broker dealer agents acting as fiduciaries to execute trades on their behalf and in a manner that ensures confidentiality. In the case of the Funds described in the Proposed Rule Change, Trusted Agents will be selected by the AP's and confirmed by the Fund, and enter into a contractual/fiduciary obligation with the Fund to ensure that confidential data is not disclosed to APs, non-AP MM's, or investors. As such, all investors will have the same access to the information concerning the portfolio constituents and, therefore, will eliminate the possibility of disparate information.

6. In light of the non-transparency of the basket of securities underlying the proposed Funds, the Commission seeks comment on how a broker-dealer authorized participant engaging in creation and redemption activity might fulfill its obligation to maintain a minimum level of net capital in compliance with Rule 15c3-1 under the Act and how such an authorized participant would comply with the books and records requirements of Rules 17a-3 and 17a-4 under the Act. For example, how would an authorized participant that is a broker-dealer apply an appropriate haircut to positions included in the Creation Basket when the authorized participant is unaware of the securities included in the basket? In addition, how would the authorized participant determine an appropriate price for such securities?

Moreover, how would such an authorized participant make and keep current the records required under Rule 17a-3, including the daily blotter and daily stock record required under paragraphs (a)(1) and (a)(5), respectively, of that rule?

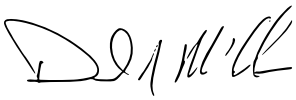
RESPONSE: In order to provide APs and non-AP MM's with the requisite information to comply with Rule 15c3-1, Precidian intends to publish the Maximum Net Capital Haircut on the daily Pro Rata Basket as determined under Rule 15c3-1. That information, along with the value of the Pro Rata Basket, which is provided every second throughout the day through the dissemination of the VIIV, will allow an AP or a non-AP MM, to always fulfill its requirement to maintain minimum level of net capital. With respect to the recordkeeping requirements, the Trusted Agent, pursuant to Rule 17a-4(i), would enter into an undertaking to retain, and provide to the SEC upon demand, the records of each AP and non-AP MM.

* * * * *

Finally, we believe it is important to note that the only comment letter submitted in objection to the Proposed Rule Change comes from Gary L. Gastineau, President, ETF Consultants.com, Inc. Mr. Gastineau is the developer of a competing product structure. As Mr. Gastineau notes in his letter, "In 2005, Managed ETFs™ LLC (Managed ETFs), of which I am a principal, filed an application for exemptive relief to permit the offering of certain actively managed ETFs (File No. 812-13228 (May 29, 2005); no longer active). The intellectual property developed by Managed ETFs was subsequently sold to an affiliate of Eaton Vance Corp. (Eaton Vance) and forms much of the basis for the new NextShares™ exchange-traded managed funds (NextShares), for which the Commission granted exemptive relief in December 2014 and Eaton Vance launched the first fund in February 2016. Eaton Vance staff assisted in the preparation of this letter."

Thank you for the opportunity to submit this letter and for your consideration of these comments. Questions regarding these comments may be directed to the undersigned.

Sincerely,



Daniel J. McCabe
CEO, Precidian Investments LLC

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

August 2015

Prepared by

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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.

[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.

Ricky (Rick) Cooper

Assistant Professor of Finance

Stuart School of Business, Illinois Institute of Technology

Education:

Ph.D., Vanderbilt University, Finance

M.B.A., Vanderbilt University, Finance

B.S., University of Chicago, Mathematics (with General Honors)

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

Precidian's Proposed ETF and the Possibility of Reverse Engineering

July 2015

Prepared by

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Chicago, IL

Purpose and Scope of this Research

The overall purpose of this research is to determine the ease or difficulty a person would encounter in attempting to reverse engineer the portfolio weights of the proposed Precidian actively managed exchange traded fund. This research consisted of:

1) Modeling the essential elements of the proposed Precidian ETF construction methodology;

2) Using this modeled construction methodology, and relevant statistical techniques, determine if the previous night's closing portfolio weights could be reconstructed (these are weights on which the intra-day quotes are based);

3) Using this modeled construction methodology, and relevant statistical techniques, determine if the time series of estimated portfolio weights could be used to forecast future changes in the weights.

This research did not attempt to model the effect of active trading on the predictability of returns. Also, this research used 1 second bar data. This means that the pricing information of all assets were synchronous, based on the last trade or quote within a second, as constructed from historical data. The real time quotes being released would be based on data sampled from within a second and would necessarily have asynchronous quotes. This source of noise would cause an unknown effect in size, but in direction certainly would make the discovery of the reverse engineering process more difficult.

Finally, this research also assumed that changes in the attractiveness rankings of stocks were not predictable. That is, we assumed that the "alpha model" of the active manager is unknown to the outside world.

Summary of the Results

The major findings of this research were as follows:

1) The system of price quotation proposed by Precidian does not allow one to successfully recover the previous night's weights from the time series of quotes and asset prices;

2) The lesser reason for the previous result are that Precidian will quote the ETF price using the mid-spread of the top of book bid and ask for each constituent security each second, as opposed to the last traded price;

3) The greater reason for the previous result is that Precidian is scaling the price of the ETF to an initial value of $20. This scaling dampens price volatility of the ETF and makes statistical techniques less effective at reverse engineering the constituents;

4) The changes in the portfolio weights from day to day may not be forecasted accurately for realistic portfolio construction techniques, making knowledge of the next day's target weights unobtainable;

5) The previous result is a function of the fact that given Precidian plans to use a proprietary model to change its portfolio holdings, meaning changes in holdings will appear random.

6) Additionally, the noise in the time series of forecasted weights is such that small predictabilities in the changes in portfolio weights are not discernible in the final series of estimated weights.

The conclusion drawn from these findings is that it is not possible to ascertain with any degree of accuracy the previous day's portfolio weights, nor is it likely that anyone will, with any great accuracy, be able to ascertain the changes in portfolio weights being executed by the portfolio manager.

Facts about Precidian ETF Modeled , Data Employed, and Methods Used

The Precidian ETF being considered is an actively managed ETF, with a proprietary stock selection system, and a non-algorithmic, opportunistic trading system. The ETF will offer pricing once per second, based on the previous night's portfolio weights, and the mid-spread price of each of its constituent securities. The price will be scaled to equal $20 at the beginning of trading. The ETF will divulge its actual holdings once per quarter with a delay of approximately two months.

In constructing this test certain simplifying assumptions were made to model the facts stated above. These assumptions are designed to make the experiment tractable, but also made in such a way that any bias in the test should be towards discovery of the underlying ETF portfolio. The following paragraphs document the specifics of the data and methods employed.

The universe of stocks from which the portfolio is chosen was fixed as being from the NASDAQ-100 universe as currently composed, this universe is smaller than any currently envisioned universe for the proposed ETF. Specifically the data analyzed consisted of 1-second spaced observations, from 9:30:01 to 16:00:00 for each of the 100 stocks of the current active top of book bid price, top of book ask price, and last traded price. This data was analyzed for 44 trading days from 05/01/2014 to 07/02/2014. Mid-spread prices were created for each security using the formula msp=(Bid price + Ask price)/2.

In order to construct portfolios a fake attractiveness, or "alpha", score was created for each stock each day. The alpha score was constructed to guarantee a certain correlation between the score of one day and the next. This construction guaranteed a certain level of continuity among the portfolio weights from one day to the next. Specifically, each day's stock forecast was generated using the formula

$$\alpha_t = \rho\alpha_{t-1} + \sqrt{1-\rho^2}\,N(0,1)$$

where rho is the desired level of daily auto-correlation and N(0,1) is a random variable. The first day's forecast was simply 100% of N(0,1). To test various scenarios alpha forecasts were created for six different correlations— 0.8, 0.85, 0.90, 0.95, 0.99, and 0.999. The random noise takes as given that the alpha process is unknowable to the outside observer at face value. This research did not attempt to model the actual alpha process and Precidian did not reveal any details of it in conjunction with this research project

The portfolio construction methodology was to simply hold the top 40 stocks at an equal weight of 2.5% each day and the other 60 at 0%. The discovery techniques were not given this information, since the number of actual assets held will vary through time. In practice, however the simple structure of this construction was likely easier to discover than the actual portfolios in a live ETF. Trading was not modeled. Since, the reported portfolio weight is based on the previous night's closing weight, the modeling of trading was not required. However, leaving out opportunistic trading also skewed the results towards discovery of predictability in the pattern of weights.

Statistics and Results

Table 1 gives turnover of each of the six alpha processes studied. All tests were run on all of the alpha models, though all results are only presented where turnover played a role in the analysis. Only alphas 5 and 6 represent realistic turnover numbers, though the others will be useful for illustrating a later result.

Table 1

Daily Turnover Implied by the Six Portfolio Alphas

	Alpha 1	Alpha 2	Alpha 3	Alpha 4	Alpha 5	Alpha 6
correlation	0.8	0.85	0.9	0.95	0.99	0.999
Turnover	0.28	0.22	0.18	0.12	0.06	0.01

The first battery of tests involved using restricted least squares estimation. In order to test the role of Precidian's method of reporting ETF prices in determining the ease of reverse engineering the underlying portfolio, Table 2 reports three different experiments and a naïve control. In the first test the dependent variable is the one second ETF price calculated as the portfolio weighted sum of the last traded price of each of the stocks. The independent variables are the last traded price of each of the 100 stocks. The regressions are run daily and the coefficients are restricted to be between 0 and .1, as well as to sum to 1 across all securities. The number .1 was chosen as an upper bound since it was considered safe to assume there would be some diversification in the portfolio. The accuracy of the regression is reported using the square root of the mean square error in the weights averaged across the 44 days. That is, the reported statistic is:

$$\sqrt{\frac{1}{100\times 44}\sum_{t=1}^{44}\sum_{i=1}^{100}\left(\hat{w}_{i,t}-w_{i,t}^{p}\right)^{2}}$$

where w-hat is the restricted least squares parameter estimate of stock i for day t and w-p is the effective portfolio weight for the day. The results were the same regardless of alpha model chosen, since the results do not depend on portfolio changes or turnover. However, these specific numbers are reported for the fifth alpha model.

Notice that in this first case the error is extremely low, meaning that with complete price information and high decimal precision, the ETF constituent weights are easy to reproduce.

Table 2
Average Errors of the Potfolio Weights
Least squares regressions on 44 days of pricing, weights restiructed between 0 and .1
Erorrs reported based on estimated obtained at end of day

Test	Ave. Error	Max. Error
I. Unrounded ETF price reported based on last traded price of stocks	0.0000	0.0000
II. Rounded ETF price reported based on mid-spread prices of stocks	0.0012	0.0188
III. Scaled ($20) and Round ETF price reported based on mid-spread prices of stock	0.0104	0.0764
IV. Control-- Naïve equal weighted index	0.0122	0.0150

The second regression test uses mid-spread prices to report the ETF prices, but still does not scale the ETF price. The price reported for the ETF is the portfolio weighted mid-spread price of the underlying stocks. Also, the final ETF price is rounded to the nearest penny. The independent variables are switched to the unrounded mid-spread price of the stocks to maximize the chance of the regression finding the correct answers. As the table shows, the results are worse than in the first case, but not terrible. The square root of mean square error of .0012 is about 12% of the magnitude of the average portfolio weight (.01). A 12% error is not a great amount, though it makes building a replicating portfolio difficult without more information.

The reason for this result is two-fold. Primarily, mid-spread prices do not convey as much information as last traded prices. Last traded prices bounce from bid to ask and these bounces correlate with small changes in the price of the ETF. However, the mid-spread prices do not bounce this way. Furthermore, any change in price of the ETF is now rounded so that any change less than half a penny goes unnoticed.

The third regression test is like the second except ETF price is scaled to begin the day at $20. This scaling greatly diminishes the precision of the regression. For example, the actual unscaled ETF price is approximately $100. This means a five cent move must occur in the unscaled ETF price to create a one cent move in the scaled price. When combined with rounding to the nearest penny this make reverse engineering very difficult. This is confirmed as the square root of mean square error is .0104. This is an average error of 100% of the average weight. Moreover, the maximum error found is an extremely large value of .0764.

This result is comparable to the error of a naïve tracking portfolio. For the purposes of this experiment an appropriate naïve tracking portfolio is the equal weighted NASDAQ-100 portfolio for which it is easily derived analytically the square root of mean square error in the weights is .0122. This

implies that reverse engineering is likely to achieve the same success by the end of the day as a naïve index tracking strategy would achieve. Or, put another way, the naïve portfolio has as much information at the start of the day as the reversed engineered portfolio does at the end.

One caution is that some attention must be paid to the scaling of the ETF. The information dampening effect described above is tied to the average price of the underlying holdings versus the reported price of the ETF. A universe of stocks with a much lower average price than the NASDAQ-100 should have the EFT scaled to a lower price. This is not really an issue with most large capitalization US indices, especially given the other sources of noise inherent in the price reporting process, but it is a point to keep in mind if the ETF expands into many different universes.

Bayesian Analysis on the Data

Some consideration was given to applying a Bayesian regression methodology on this data set, and indeed a Bayesian, independent normal gamma regression using Gibb's sampling was run on several days with the result that the estimation did not improve. This is not unexpected because for the NASDAQ-100 universe the number of seconds per day creates a data matrix with enough degrees of freedom that the data overwhelms any prior of less than 100% certainty (which of course means one is ignoring the data because he or she already knows the answer). In fact, feeding the true portfolio weights at the beginning of the day as a prior to the Bayesian regression (with an estimated prior variance of only 0.0001) did not substantially help the estimation error obtained in the scaled ETF regression. This is because the error is inherently "cooked into" every quote provided. The inherent imprecision in the data creates uncertainty that overwhelms even a perfect Bayesian prior. The way to think about this result is that the reporting mechanism for prices in of the ETF makes it impossible to confirm statistically any intuition one has about the portfolio weights.

Time Series Properties of the Weight Estimates

The purpose of this section is to investigate the role of the ETF reporting mechanism in masking any auto-correlation in the portfolio changes. Given the nature of the portfolio construction used in this investigation one would expect there to be negative auto-correlation in the portfolio weights. Since the possible portfolio weights are only 2.5% or 0%, there is a non-zero probability of the weights reverting to their other possible value but no chance of the weight continuing upwards or downwards. That is, the simple portfolio weighting scheme built for this paper has negative autocorrelation similar to the bid-ask bounce in stock prices. There is no reason to expect a real portfolio construction to have auto-correlation but the purpose of this section is to examine to what extent the fuzzy estimation of portfolio weights presented in the last section would, or would not, mask the actual auto-correlation in weights of the portfolios.

Table 3 presents statistics for the five portfolios constructed for this test. The table reports the number of stocks out of 100 that had significant auto-correlations (at 5%) in weight changes for the 44 days tested, and the number of parameter estimates that had significant auto-correlations for the day

tested. The first conclusion is that the number of stocks with significant auto-correlation decreases as turnover decreases. This is because, given the construction method of this paper, the more random fluctuation allowed in the alpha model, the more bouncing between 0% and 2.5% there will be in the portfolio. Only, the last alpha models have realistic turnover in them. For Alpha 6, even with the stylized portfolio construction, only 12 stocks out of 100 have significant auto-correlation.

Table 3

Number, out of 100 of Stocks with Significant Auto-correlation in Portfolio Weight Changes

Results computed for 44-days, six different alpha models, significance at 5%

	Alpha 1	Alpha 2	Alpha 3	Alpha 4	Alpha 5	Alpha 6
actual weights	55	44	37	35	22	12
estimated weights	27	28	22	19	14	6

However, the real focus of this table is the decline in significance in the number of stocks with significant auto-correlation in the weights when the parameter estimates are used. At every level of turnover the amount of significance in auto-correlated stocks diminishes tremendously. The effect is strong enough that, for the lowest turnover alpha model (Alpha 6), even with this portfolio construction methodology there would not appear to be a more than random number of significantly auto-correlated stocks (at 5% significance level one could expect up to 10 stocks to have statistical significance, without there actually being any significant auto-correlation).

The conclusion is that the fuzziness of the portfolio weight estimation will mask any small level of auto-correlation in weights that the portfolio construction might induce. The effect appears to be strong enough that any likely real world construction system will have random appearing time series properties in its portfolio weights.

Conclusion

This research studied the Precidian ETF construction methodology using a small universe of securities, a stylized portfolio construction and the price quote methodology they propose. The primary result is that given three components of their proposed reporting methodology—mid-spread pricing, rounding to the nearest penny, and scaling the price to $20 at the start—the underlying portfolio weights are not recoverable with any great degree of accuracy. The main driver of this result is the scaling.

The other result of this research is that it is highly unlikely that anyone will discern any pattern in the time series of portfolio weight changes for any likely real world portfolio construction because the fuzziness in the daily weight estimation masks all but very large auto-correlated weight changes.

The summary conclusion is that it seems rather unlikely that the Precidian ETF construction methodology will result in a product that can be reverse engineered for purposes of front running, or that can be tracked with an engineered portfolio better than a simple naïve index portfolio can track.

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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*.

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