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Hedge Fund Indexation And Replication

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For many years, academic research has shown that hedge fund returns, like those of individual securities and mutual funds, comprise systematic ("beta") and idiosyncratic ("alpha") components. (Investments in hedge funds are speculative and entail substantial risk. Hedge funds typically use leverage that can magnify losses and engage in short-selling that can result in the entire loss of a principal amount invested.) William Sharpe [1992], William Fung and David Hsieh [1997, 2000, 2001, 2002, 2004] and Andrew Lo and Jasmina Hasanhodzic [2007] have written most prominently on this topic. More recently, this research has motivated fund managers, some with academic roots,¹ to attempt to reproduce hedge fund returns with compact portfolios of conventional assets, such as exchange-traded products. For most of that time, however, investors seem to have shown far less interest in this work than the managers and academics conducting it.

The mixed performance of some of the early replication efforts may explain part of this indifference, but more significantly, before 2008, hedge fund replication was largely a solution to a problem no investors seemed to have. The conventional model of hedge fund investing that tolerated the illiquidity and lack of transparency of hedge funds in exchange for their uncorrelated returns had not yet broken. After 2008, interest in replication began to grow as investors sought remedies for three glaring problems they encountered with their hedge fund investments in 2008.

- Transparency – some hedge fund portfolios contained assets not fully disclosed in their offering memoranda.
- Liquidity – some managers could not or did not liquidate investments as required to meet redemption requests.
- Fidelity – some portfolio valuations turned out to be inaccurate.

Stung by these problems, some investors began to look more favorably at efforts to capture some of the returns of hedge funds without their relative structural disadvantages (i.e., illiquidity and general lack of

transparency) as a potential component of their alternative investment allocations. Their interest, which is still modest in comparison to the direct demand for hedge funds, has produced a nascent asset class of exchange-traded products, mutual funds and separately managed accounts that all attempt in a variety of ways to marry the return profiles of hedge funds with the liquidity, transparency and business risk of more conventional investment funds.

This article describes in general the three main analytical approaches to hedge fund replication today. It then discusses the factor-based approach, the most widely used of the three, in greater detail. Finally, it seeks to identify and answer the following basic questions about this relatively new asset class:

- How does hedge fund replication work?
- What benefits does hedge fund replication offer and what are its weaknesses?
- How can investors use replication strategies to help manage investments?
- What makes a factor-based replication strategy successful?
- How does hedge fund replication vary by hedge fund strategy?
- How have replication products performed?

Known variously as hedge fund replication, alternative beta, liquid alternatives or some combination thereof, these assets attempt to resolve many of the problems institutional investors experienced in 2008. In addition, they offer investors who are not otherwise eligible to invest in the alternative asset class access to alternative strategies.

How Does Hedge Fund Replication Work?

Hedge fund replication comes in three flavors: mechanical,² distributional³ and factor-based. Each method has proponents, but the commercial applications currently available to investors rely primarily on factor-based replication, with a smaller number using the mechanical approach. Each method springs from a belief that one can mimic the behavior of groups of hedge fund managers with incomplete knowledge of their true behavior. The mechanical approach copies actual positions held by hedge funds. The distributional approach attempts to infer the exposures of hedge fund portfolios from the statistical properties of time series of their returns. The factor-based approach identifies correlations between hedge fund indexes and conventional investment indexes (Figure 1).

Figure 1

Features Of Different Hedge-Fund Replication Strategies			
Replication Strategy	Seed Information	Methodology	Financial Assets Used
Factor-based	Hedge fund indexes	Correlational	ETFs, government bonds, financial futures, foreign exchange
Mechanical	Transaction data	Experiential	All
Distributional	Fund statistics	Inferential	Financial futures

In the mechanical approach, managers populate portfolios with positions characteristic of particular hedge fund strategies to attempt to reproduce such strategies' returns. Because of its construction, some call it "trade-related" replication.⁴ Managers have applied mechanical replication primarily to two hedge fund strategies: merger arbitrage and event-driven activism. The mechanical approach works in both instances because the information required for each is publicly available. For merger arbitrage, replicators take positions in announced mergers, especially those to which both parties have agreed to the terms of the merger. In the activist case, replicators review public records; e.g., 13F filings of large

investors, to help identify strategic positions. In both of these applications, the copying of the positions most widely held by managers tends to reproduce the returns individual managers have in common. Only a small but notable segment of the participants in this market take this approach.

The distributional method uses portfolios of futures contracts to attempt to reproduce the statistical properties of the targeted hedge fund strategy. Amin and Kat [2003] presented a model that used only combinations of the S&P 500 Index futures contract and cash over time to create distributions of returns whose first four statistical moments⁵ resemble those of individual hedge funds. While mathematically satisfying, this approach generally does not provide investors with an *ex ante* alternative superior to a direct investment in a portfolio of hedge funds. That may account for its lack of commercial success.

Most purveyors of hedge fund replication use linear factor replication to create their indexes and products. In this approach, a multivariate linear regression identifies financial risk factors that explain as much of the returns of a hedge fund index as possible. Regression breaks hedge fund index returns down into random and nonrandom components by computing the correlations between the latter and some explanatory variables that correspond either to financial risk factors or, in one special case, to an undefined factor. Regressions of hedge fund returns usually help identify correlations with financial risk factors such as broad equity indexes, sector equity indexes, interest rates, commodity prices and foreign exchange. In the language of statistics, each such correlation constitutes a regression "beta."

Financial analysts have a special name for the beta of the undefined factor. They call it "alpha," and in the business of marketing individual hedge funds, have bestowed upon it plaudits like "managerial skill" that can potentially exaggerate its statistical meaning. The beta of the constant term in a multivariate regression of hedge fund returns, or "alpha"—as virtually all financial analysts and fund managers call it—is simply the correlation of those returns with nonrandom phenomena not identified elsewhere in the regression. A failure to identify nonrandom behavior in the returns of a single hedge fund may signify something about a fund's management, but it may also reveal only an analyst's failure to consider the right combination of risk factors in the regression. At the index level, alpha indicates that the strategy as a whole identifies some behavioral pattern in markets. The inability to identify an investable proxy for such a pattern means that factor-based replication cannot reproduce it in an investable form.

The nonrandom returns explained collectively by these correlations with known risk factors constitute the systematic return or "beta" of the hedge fund index. Factor-based replication products aim to reproduce this hedge fund beta with portfolios of investable proxies for the individual regression betas. Generally such proxies comprise exchange-traded funds and notes ("ETPs"), government bonds, interest rate and commodity futures contracts, and foreign exchange in proportions equal to the regression betas. Again, since no ETF exists for alpha, factor-based replicators can only seek to reproduce hedge fund beta.

Benefits And Weaknesses

In late 2009 and early 2010, Geczy [2010] surveyed the 50 largest institutional investment consultants by assets under advisement to obtain their views of the most important issues then facing their hedge fund investors. He received responses from 15 consultants advising on collectively more than \$7 trillion. All of them cited a need for greater transparency, and most also indicated preferences for lower fees, greater liquidity and more due diligence on target hedge funds.⁶ Replication strategies aim to address all of these issues directly.

Real-time publication of holdings, common for most replication strategies, solves the transparency issue.

If such holdings include only highly liquid assets such as listed securities, government bonds, futures contracts and foreign exchange, the funds themselves can offer their investors continuous liquidity. Many of the replication products currently available to investors do that. When implemented in a passive and systematic manner using only the weights computed by the regression analysis and no discretion, replication funds may cost much less to manage than actively managed hedge funds. Replication funds can pass these savings along to investors in the form of lower fees. Finally, as long as replication funds do not invest in any instruments associated with individual managers, as with funds of hedge funds, they pose no headline or fraud risk.

Hedge funds attract many types of investors, from high net worth individuals to university endowments and pension funds. These investors vary in their abilities to evaluate and monitor the hedge funds in which they invest. Sophisticated individual investors, especially those with backgrounds in finance, and large institutional investors with significant analytical and operational support teams, can and usually do manage their own hedge fund investments. In contrast, investors without expertise in finance or the resources to acquire it may rely on consultants or fund-of-hedge-fund managers to screen hedge funds for them. In general, large investors tend to invest directly, while smaller ones often invest via funds of hedge funds. On a purely operational level, hedge fund replication may reduce the amount of work and thus the cost of evaluating and monitoring hedge fund investments for all of these investors.

Respondents to Geczy's survey also expressed concern about "model risk," by which they meant the dependence of replication models on backtests of time series data. Inevitable and unknowable differences between past and future financial environments may make such systematic trading prone to large amounts of tracking error.⁷ The consultants surveyed also had negative views of the passive management of replication strategies.

Using Replication Strategies To Manage Investments

Products that replicate hedge fund returns with a high degree of accuracy can aid portfolio managers in different ways: as investable benchmarks, investment substitutes and complements to alternative asset portfolios. The benchmark application simply sets a standard against which investors may measure the performance of their own hedge funds individually or their hedge fund portfolio as a whole. While no replication fund is identical to any individual hedge fund, a relatively high correlation between the returns and volatility of a fund or a portfolio and a replication strategy in which one can invest makes the latter a legitimate performance benchmark (Figure 2).

Figure 2

Uses Of Replication Strategies	
Replication Method	Usage
Investable Benchmarks	Return comparisons
Investment Substitutes	Core/satellite, transition tool, long-only equity substitute
Portfolio Complements	Tactical portfolio management, balance sheet enhancement

Investors managing diversified hedge fund portfolios may increase their liquidity by substituting a liquid replication product for direct investments in hedge funds. Replication strategies have three uses as investment substitutes: core/satellite; transition tool; and long-only equity substitute. In the core/satellite approach to portfolio management, a manager builds a ring of alternative investments in more esoteric and possibly less liquid assets around a liquid core of one or more replication products. If the replication

products are simpler to understand and easier to buy and sell than hedge funds, then a manager can devote more analytical resources to the more exotic strategies, while preserving the core alternative returns of the asset class with the replication strategies.

Portfolio managers may use replication products as transition tools to alter their alternative exposures quickly while they wait to invest in or redeem from hedge funds that offer only intermittent liquidity. For example, a manager who wishes to decrease exposure to a particular hedge fund strategy could use a short position in a liquid replication product to attempt to offset long exposure from funds scheduled for redemption in a few months. Similarly, a long position in a replication product could provide some positive exposure to an alternative sector while managers search for a long-term allocation.

As replication products become available as mutual funds or ETFs, some investors may treat them simply as another type of equity investment. Because they can capture the behavior of partially hedged portfolios of conventional assets, most alternative assets have significant positive correlations to conventional assets. In many instances, these correlations may make replication products behave like slightly out-of-the-money call options on long-only positions in equity or fixed-income indexes and funds linked to them.⁸ As such, investors who do not trade options themselves may use the replication products instead. Additionally, options traders may find them interesting as delta-hedging vehicles for out-of-the-money puts and calls.

Replication products may also play a complementary role in portfolio management. The tactical portfolio management application involves keeping a certain portion of an alternative portfolio liquid in order to make funds readily available to the portfolio manager to make new investments without the time lag involved in redeeming most alternative investments. While one can solve this problem simply by holding cash, a liquid replication product that generates returns typical of alternative assets potentially enables managers to maintain higher total exposure to alternatives with enhanced liquidity.

Finally, replication products may enhance balance sheet liquidity by preserving exposure to alternative asset classes without the reduced liquidity of many alternative investment funds. Institutional investors that must meet liquidity targets or standards may find that their monitors⁹ tolerate greater overall exposure to alternative assets when they can liquidate them with the same ease as they do conventional holdings of stocks and bonds.

What Makes A Factor-Based Replication Strategy Successful?¹⁰

The inimitable nature of hedge fund alpha means that the success of a factor-based replication effort depends completely on two factors: the magnitude of the hedge fund index's beta signal; and the serial correlation of the index itself. Regressing a time series of hedge fund returns attributes 100 percent of the returns to the three sources identified above,¹¹ but factor-based replicators can only attempt to reproduce the portion classified as hedge fund beta. As a result, the coefficient of determination or R² of the regression that measures the portion of hedge fund returns explained by the hedge fund beta indicates *ex ante* how successful a replication effort may be. The R² itself depends on the homogeneity of the index constituents. Because replicators must extract risk factor sensitivities from the indexes they seek to replicate, they require indexes that comprise hedge funds driven by the same risk factors. A good index, then, should comprise hedge funds responsive to the same risk factors. The choice of hedge funds included in an index determines the strength of the risk factor sensitivities, i.e., the "betas" a replicator seeks to capture.

In general, hedge fund indexes fall into two categories: single strategy and multistrategy. Assigning funds to single-strategy classifications, while simple in principle, becomes complicated when one encounters funds whose investments span two or three related strategies. For example, many convertible arbitrage funds overlap significantly with credit funds focused primarily on high-yield corporate debt. Similarly, some long/short equity funds have much in common with some event-driven funds. Other event-driven funds have much in common with distressed investment funds. Multistrategy indexes, while useful as measures of overall hedge fund performance, are statistically poor choices for replication strategies because they tend to mask factor sensitivities. Hedge fund replicators face, therefore, a "garbage in/garbage out" problem. An index comprising funds that do not share factor sensitivities cannot produce a reliable replication strategy.

Of course an accurate explanation of past performance does not guarantee future success. That only occurs when the future resembles the past, a phenomenon known in statistics as "serial correlation." Put simply, from a statistical standpoint, if the past performance of a hedge fund index turns out to be a good predictor of its future performance—a hypothesis that statisticians can test by regressing a time series against a lagged version of itself—then a strategy based on a replication of an index's past performance may perform reasonably well as a predictor of its future. Conversely, if a lagged time series of an index does not explain a nonlagged series of itself, then a regression-based replication of it will probably not work well either.

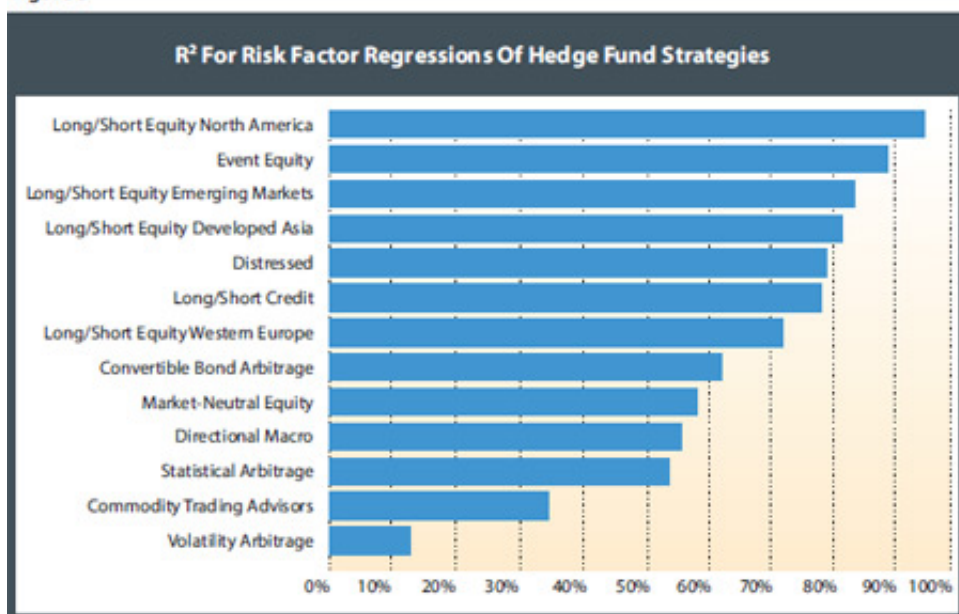
In addition to a useful index, a replicator needs access to tradable proxies for the risk factors that drive the returns of a particular index. The recent proliferation of ETFs and the abundance of futures contracts traded on various exchanges offer a plethora of such proxies, but some risk factors remain difficult to capture with a single liquid asset. A replicator can capture changes in equity indexes, interest rates on government bonds, commodity prices and foreign exchange with extremely liquid and easily valued instruments. In contrast, exposure to credit risk—while easily identified by regression analysis—is difficult to obtain because of the illiquidity, lack of transparency, and basis risk posed by credit derivatives. Additionally, tracking errors in commodity ETFs—such as those caused by the transaction costs of rolling futures contracts—create portfolio management challenges for replicators inclined to use them.

How Does Hedge Fund Replication Vary By Hedge Fund Strategy?

Only some hedge fund strategies produce indexes with both strong beta signals and serial correlation, as described in the previous section. Hedge fund strategies typically differ from each other in two dimensions: the level of turnover in the assets held by the funds; and the number of trading strategies their managers employ to implement them. Research shows that strategies with low portfolio turnover and fewer trading strategies tend to produce more robust risk-factor correlations than strategies with high portfolio turnover and more trading strategies. Furthermore, our research shows that directional strategies of hedge funds that focus on fundamental analysis of corporate securities, such as long/short equity, event-driven equity, and credit fixed income, yield the highest R² statistics. In contrast, relative value and arbitrage strategies with high rates of portfolio turnover, such as statistical arbitrage and volatility arbitrage, produce very low R² statistics. That makes them poor candidates for replication strategies.

Figure 3 shows the R² statistics for risk-factor regressions of hedge fund indexes computed from the monthly returns of more than 5,000 hedge funds for the period from 2001-2010.

Figure 3



Source: eVestment

These results suggest to us that hedge fund replicators ought to focus their efforts narrowly on those strategies for which one can identify strong risk-factor correlations. Because this limits the scope of its applicability, we believe hedge fund replication seems likely to serve portfolio managers best as an additional tool of a broader alternative investment strategy. Investors who seek exposure to the return profile of hedge fund strategies amenable to replication with more liquidity and transparency than that available from direct investments in hedge funds or funds of hedge funds may benefit from hedge fund replication. Proponents of replication who attempt to apply it more broadly than that may undermine their own efforts by overstating its strengths.

Replication Product Performance

To earn a place in investor portfolios, we believe hedge fund replication products must deliver performance that meets reasonable expectations based on their structural similarities and differences with the hedge fund indexes they aim to reproduce. Beta constitutes the primary similarity between the replicas and the indexes. The alpha of the hedge fund indexes and its absence from the replication products differentiates them, but so too do the transactional differences mentioned at the beginning of this paper—transparency, liquidity and fidelity.

Because replication funds can capture only the "beta" of hedge fund indexes, we believe their returns generally should differ from those of the indexes by the amount of alpha embedded in them. A replica of an index with positive alpha should return less than the index itself, and vice versa. In all circumstances, however, we believe replication funds should generally have lower volatility than the indexes because alpha is more volatile than beta. This combination of medianlike returns and lower-than-average volatility suggests that successful replication products should have higher Sharpe ratios¹² than a majority of the funds in the indexes on which they are based.

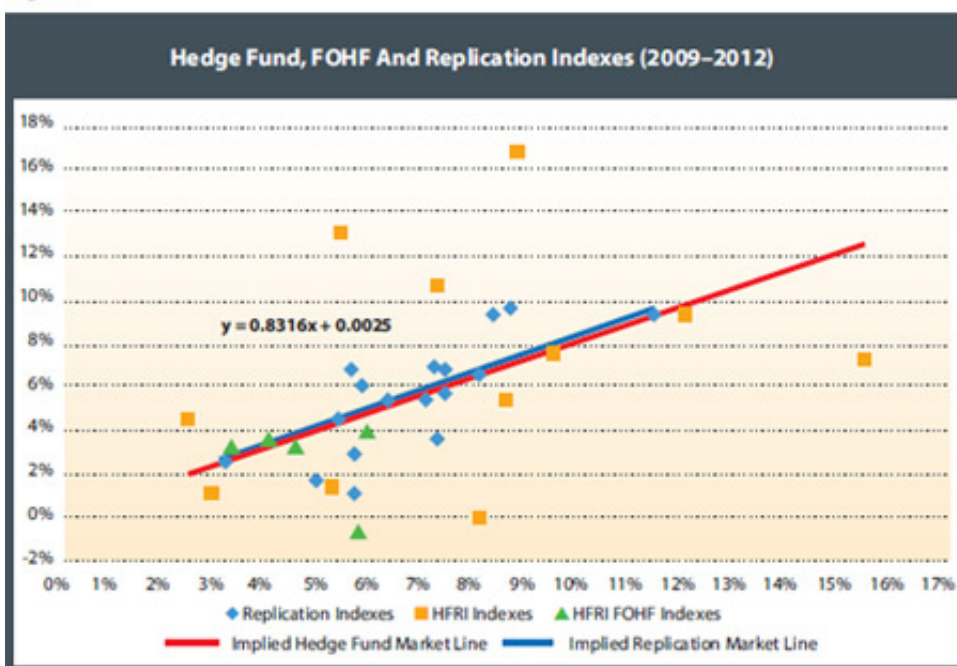
As described above, the value of the transactional differences between replication products and their underlying funds requires hedge funds and their indexes to produce higher returns than their replicas. Indeed, one might reasonably attribute a portion of any observed positive alpha as compensation for the

transactional disadvantages of individual hedge funds. While alpha oscillates between positive and negative values, however, the transactional advantages of replication funds generally have positive value for investors. This suggests that individual hedge fund returns must exceed the sum of the return of a hedge fund index replication fund and a transactional premium before they deliver any alpha.

Finally, funds of hedge funds offer a third way to assess the potential value of replication funds. These funds market themselves as gatekeepers that select and monitor hedge fund investments for investors who cannot or choose not to do so themselves. Since these services have value, funds of hedge funds should generally return less than hedge funds. Additionally, because their manager selection services ought to outperform the naive selection process inherent in most replication strategies while providing an alternative to their transactional benefits,¹³ in our view, they ought to perform at least as well as replication funds net of any differences in fees between them. Formal tests of these three hypotheses lie outside the scope of this paper, but Figure 4 provides some visual evidence indicating the results one might obtain from such tests.

Figure 4 shows three data sets¹⁴: indexes of hedge fund returns;¹⁵ returns from a collection of replication indexes and products;¹⁶ and indexes of funds of hedge funds.¹⁷ We may interpret trend lines plotted through an estimate of the risk-free rate since 2009 (0.25 percent) for the hedge fund indexes and the replication funds as implied market lines. The location of most of the replication indexes closer to the market line than most of the hedge fund indexes supports the first hypothesis that replication funds deliver only beta while the indexes capture alpha and beta. The broader distribution of the hedge fund indexes lends credence to our assertion that hedge funds have higher volatility than replication strategies because they deliver alpha that may be positive or negative. The almost identical slopes of the trend lines that we may view as estimates of Sharpe ratios for each group (0.83 for the replication indexes versus 0.82 for the hedge fund indexes) do not, in our opinion, refute the second hypothesis, that replication strategies may have higher Sharpe ratios than hedge funds. The data shown does not support, however, the third hypothesis, that funds of hedge funds should outperform replication funds. All five indexes of funds of hedge funds have underperformed the mass of replication indexes over the past four years.

Figure 4



Sources: Hedge Fund Research, Bloomberg

We believe these differences show that replication products cannot replace direct investments in well-performing hedge funds. They may outperform, however, diversified portfolios of individual hedge funds that collectively produce an indexlike return. In addition, they may offer an alternative to funds of hedge funds as a way for indirect hedge fund investors to build their alternative portfolios. Finally, they provide all hedge fund investors with meaningful performance benchmarks.

Appendix A¹⁸ : Replication indexes And Funds In Figure 4

Bloomberg Ticker	Description	Standard Deviation	Annualized Return
MLEIFCTR Index	Merrill Lynch Factor Model	6.21%	5.70%
GARTX US Equity	Goldman Sachs Absolute Return Tracker Fund	5.54%	1.05%
HFBETA Index	AlphaSimplex Hedge Fund Beta Replication Index	7.24%	6.94%
DBDBAPI Index	Deutsche Bank Dynamic Alternative Portfolio Index	7.16%	3.61%
IQHGMST Index	IndexIQ Hedge Multi-Strategy Index Total Return	5.31%	4.62%
IQMNAT Index	IndexIQ ARB Merger Arbitrage Index Total Return	6.92%	5.67%
CSLAB Index	Credit Suisse Liquid Alternative Beta Index	5.70%	6.06%
CSLABMA Index	Credit Suisse Liquid Alternative Beta Merger Arbitrage Index	3.96%	3.60%
CSLABED Index	Credit Suisse Liquid Alternative Beta Event Driven Index	8.23%	9.41%
CSLABLS Index	Credit Suisse Liquid Alternative Beta L/S Equity Index	7.99%	6.80%
RYMQX US Equity	Guggenheim Multi-Hedge Fund Strategies Fund	4.84%	1.84%
ADAIX US Equity	AQR Diversified Arbitrage Fund	3.10%	2.73%
MVLSNATR Index	Market Vectors North American L/S Equity Hedge Fund Beta Index	8.53%	9.77%
MVLSWETR Index	Market Vectors Western European L/S Equity Hedge Fund Beta Index	5.63%	3.01%
MVLSDATR Index	Market Vectors Developed Asia L/S Equity Hedge Fund Beta Index	7.35%	5.78%
MVLSMTR Index	Market Vectors Emerging Market L/S Equity Hedge Fund Beta Index	11.35%	9.64%
MVLSGLTR Index	Market Vectors Global L/S Equity hedge Fund Beta Index	7.07%	7.05%
MVEVEQTR Index	Market Vectors Global Event Driven L/S Equity Hedge Fund Beta Index	5.57%	6.95%

Appendix B¹⁹: HFR Hedge Fund Indexes In Figure 4

HFR Index	Strategy Type	Index Name	Standard Deviation	Annualized Return
HFRIMAI	Event Driven	Merger Arbitrage	2.30%	4.84%
HFRISEN	Equity Hedge	Sector – Energy/Basic Materials	15.37%	7.64%
HFRIEMNI	Equity Hedge	Equity Market Neutral	2.85%	1.30%
HFRIENHI	Equity Hedge	Quantitative Directional	8.50%	5.48%
HFRISTI	Equity Hedge	Sector – Technology/Healthcare	7.13%	10.66%
HFRIEHI	Equity Hedge	Equity Hedge (Total)	9.31%	7.78%
HFRIEM	Various	Emerging Markets (Total)	11.96%	9.56%
HFRIMTI	Macro	Systematic Diversified	7.91%	0.12%
HFRIMI	Macro	Macro (Total)	5.13%	1.68%
HFRICAI	Relative Value	Fixed Income – Convertible Arbitrage	8.67%	17.07%
HFRIFIHY	Relative Value	Fixed Income - Corporate	5.31%	13.14%
HFRIFI	Relative Value	Multi-Strategy	4.41%	10.37%

Appendix C²⁰: HFR Fund-Of-Funds Indexes In Figure 4

HFR Index	Description	Standard Deviation	Annualized Return
HFRIFOFC	Fund of Funds Conservative	3.21%	3.47%
HFRIFOFM	Fund of Funds Market Defensive	5.58%	-0.41%
HFRIFOFD	Fund of Funds Diversified	3.98%	3.70%
HFRIFOFS	Fund of Funds Strategic	5.76%	3.92%
HFRIFO	Fund of Funds Composite	4.45%	3.56%

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Endnotes

- ¹ Andrew Lo of MIT is also the founder of hedge fund replicator AlphaSimplex, now a part of Natixis. Thomas Schneeweis, of the University of Massachusetts, is the founder of hedge fund replicator S Capital.
- ² Also called "rule based" or "trade related."
- ³ Professor Harry Kat of the Cass Business School in London is the primary proponent of this approach. The references at the end of this paper contain multiple citations of his work on this topic.
- ⁴ Geczy [2010] uses this terminology.
- ⁵ The first four moments of a statistical distribution are its mean, standard deviation, skewness and kurtosis.
- ⁶ Geczy [2010], pg. 3.

⁷ *ibid.* pg. 6.

⁸ A short position in a replication product could act like a slightly out-of-the-money put option. The option analogy could produce demand for these products from investors not currently investing in hedge funds.

⁹ "Monitors" refers to risk managers, accountants, auditors and regulators.

¹⁰ This section focuses on factor-based replication because it is the most common methodology used by the current universe of commercial replication products. These answers are generally applicable to mechanical replication as well, but are inadequate as a basis for analyzing the distributional approach.

¹¹ The section titled "How Does Hedge Fund Replication Work?" explains how a linear regression of a hedge fund index against a set of economic variables allocates the index returns to random and nonrandom components while further dividing the nonrandom component into correlated ("beta") and uncorrelated ("alpha") parts.

¹² A Sharpe ratio is a measure that indicates the average return minus the risk-free rate of return divided by the standard deviation of return on an investment.

¹³ The monitoring services that funds of hedge funds perform address transparency and business-risk issues, and aim to align investors' portfolios with their liquidity preferences, thus managing actively the three transactional issues that replication addresses passively.

¹⁴ Index performance represents past performance and is no guarantee of future results. Index performance does not reflect the deduction of any fees or charges that would lower performance. An investor cannot invest in an index.

¹⁵ Source: Hedge Fund Research. Appendix B lists the indexes and the data shown in Figure 4.

¹⁶ Source: Bloomberg. Appendix A lists the replication indexes and funds shown in Figure 4.

¹⁷ Source: Hedge Fund Research. Appendix C lists the indexes and the data shown in Figure 4.

¹⁸ Index performance represents past performance and is no guarantee of future results. Index performance does not reflect the deduction of any fees or charges that would lower performance. An investor cannot invest in an index.

¹⁹ *ibid.*

²⁰ *ibid.*