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Hedge fund replication using strategy specific factors

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Abstract

Hedge funds have traditionally served wealthy individuals and institutional investors with the promise of delivering protection of capital and uncorrelated positive returns irrespective of market direction, allowing them to better manage portfolio risk. However, the financial crisis of 2008 has heightened investor sensitivity to the high fees, illiquidity, lack of transparency, and lockup periods typically associated with hedge funds. Hedge fund replication products, or clones, seek to answer these challenges by providing daily liquidity, transparency, and immediate exposure to a desired hedge fund strategy. Nonetheless, although lowering cost and adding simplicity by using a common set of factors, traditional replication products might offer lower risk-reward performance compared to hedge funds. This research explores hedge fund replication further by examining the importance of constructing clones with specific factors relevant to each hedge fund strategy, and then compares the strategy specific clone risk and reward performance against both actual hedge fund performance and hedge fund clones constructed using a more general set of common factors. Testing shows that using strategy specific factors to replicate common hedge fund strategies can offer superior risk-reward performance compared to previous general model clones.

Keywords: Hedge funds, Hedge fund replication, Regression, Trading strategies, Strategy specific factors

Introduction

Hedge fund replication products have received increased attention as an alternative to investing in hedge funds. Hedge funds have been pessimistic to regulation and disclosure as they fear that regulation can constraint their money making abilities and that full disclosure would lead to others copying their trades. Investors were happy with the elusive and non-transparent structure of hedge funds when they delivered double digit returns and low market correlation, however, the 2008–2009 economic crisis and recovery has shown that hedge funds are not entirely immune to market events (Sourd 2009).

Hedge funds engage in techniques such as shorting to protect against adverse market returns and to maintain a lower correlation to the overall market. However, studies have shown that although they exhibit low correlation and superior returns during market uptrends, they tend to be severely affected during market downturns (Agarwal and Naik 2004). Investors are beginning to question the value they receive in exchange

for paying the high fees charged by hedge funds, which have typically charged a management fee of 1–2% of assets and an incentive-based performance fee of 15–20% (Fung and Hsieh 1999). Growing investor concerns are beginning to encourage investors to look for alternatives that offer complete transparency along with daily liquidity, helping to avoid lock-up periods often associated with hedge funds (Suarez 2011). Agarwal and Naik (2000) found that performance persistence decreases as the return measurement period increases, and that persistence in losers is higher than among winners, making hedge fund selection important. Malkiel and Saha (2005) also showed a lack of persistence in the performance of hedge funds.

There is also evidence that the allure of hedge funds might be overstated. Hedge fund indexes showing stellar performance include funds that are closed to new investments, with the performance of investable funds having been found to be significantly inferior to the performance of the non-investable indexes (Feldman et al. 2009). Choosing a hedge fund that is available to new investors in another challenge that needs extensive and expensive due diligence. This is somewhat addressed by investing in fund-of-funds hedge funds, which handle the due diligence and diversification process effectively, but this comes at the cost of an additional layer of fees. Research found that the average fund-of-funds hedge fund does not offer statistically significant alpha (Fung et al. 2008), with any alpha delivered often consumed by fees (Fung and Hsieh 2007). A lack of consistency among hedge fund index providers also casts doubts over their usefulness; the heterogeneity across providers makes performance measurement of hedge fund categories difficult to analyze, and research has found convertible arbitrage to be the only truly homogenous category of hedge funds across hedge fund index providers (Kugler et al. 2010). The effects of missing returns in hedge fund databases are often debated. However, Edelman et al. (2012) showed that this is not a serious concern as missing returns of liquidated funds are offset by successful funds that choose to stop reporting.

After Sharpe (1992) used an asset class factor model to decompose the performance of mutual funds, the focus shifted to hedge funds and substantial research has established that a significant component of hedge fund returns are made up of systemic exposures that can be expressed in terms of liquid tradable instruments. Fung and Hsieh (2004) used a seven-factor model showing that up to 80% of the variance of returns of some broad hedge fund indexes can be explained by using a combination of equity and options based factors. Fung and Hsieh (2001) used look-back straddles to replicate the returns of trend followers. Jaeger and Wagner (2005) used a multi-linear asset factor model that showed good results for strategies such as long/short and short bias, but performed poorly for complex strategies such as managed futures and equity market neutral. Li et al. (2013) used factor models to highlight potential applications in hedging market exposure for estimating daily VaR and the daily performance of hedge funds.

Within the last few years, researchers have also been replicating hedge fund returns (Hasanhodzic and Lo 2007; Kat and Palaro 2005), with hedge fund replication products, or clones, being a viable alternative to hedge funds for investors who are unable to meet the accreditation requirements needed to invest in hedge funds, as well as those investors challenged by the high minimum investments that hedge funds typically require. Institutional and sophisticated investors could consider hedge fund clones as they provide a significant cost advantage over hedge funds, offer daily liquidity, and are scalable to the capacity of investments that institutional investors can make. The clones

also have an advantage in terms of transparency and ease of monitoring. The difficulty associated with selecting a hedge fund make clones an accessible choice that an investor can use to gain immediate exposure to the desired hedge fund strategy.

Hedge fund replication can be broadly classified into three categories: distribution replication, rules-based replication, and factor modeling. Distribution replication focuses the replication on the statistical properties of the hedge fund returns rather than tracking the monthly returns of the funds (Kat and Palaro 2005). This strategy is complex and can be difficult to implement, sometimes becoming more complicated than the underlying hedge fund trading strategies. Rules-based replication uses a set of defined trading rules to capture the core processes of specific hedge fund styles; a sub-category of this type of replication often used is mechanical replication. Mechanical replication seeks to mimic the holding of hedge funds, however, limitations in disclosures by hedge funds make this an ineffective strategy that suffers from lag even when copying the holdings revealed in the 13F filing of top managers. Factor modeling offers a simple and easy to implement model that can be used to effectively replicate or clone various sub-styles of hedge funds. Hasanhodzic and Lo (2007) showed that by using a simple factor model made up of easily tradable factors, replication of funds could be achieved to a great extent. Although using a common set of factors can result in a low cost approach for replicating hedge fund returns, there should be some benefit for improving clone risk-reward performance from using strategy specific factors. Therefore, this work extends the traditional hedge fund replication analysis to cover individual hedge fund strategies that now focus on the importance of selecting the factor exposures that are economically relevant to each fund strategy.

After discussing the modeling building methodology and approach used for this research, the selection of strategy specific factors are discussed in detail. A results comparison of the strategy specific clone risk and reward performance against both actual hedge fund performance and hedge fund clones constructed using a more general set of common factors are then presented; testing shows that using strategy specific factors to replicate common hedge fund strategies can offer superior risk-reward performance compared to previous general model clones. Finally, concluding remarks are provided.

Methodology

Initial motivation

Hasanhodzic and Lo (2007) showed that it is possible to construct clone portfolios that offer comparable performance to a number of hedge fund categories by using a basket of common and diverse risk factors that are easily tradable through liquid financial instruments. The hedge fund clones were constructed by regressing the individual hedge fund returns against five factors: 1) U.S. Dollar Index Return; 2) S&P 500 Total Return; 3) Spread between the Lehman Corporate Bond Index and the Lehman Treasury Index; 4) Lehman Corporate AA Intermediate Bond Index; and 5) Goldman Sachs Commodity Index Total Return. Each clone is a portfolio of the factors that are used to run a constrained regression on hedge funds in each fund category in order to obtain portfolio weights of the risk factors in the clones. Two models are presented in the form of a fixed weight model (where the portfolio weights of the factors remain constant) and a

rolling window model (where portfolio weights are rebalanced monthly). Hasanhodzic and Lo (2007) found that while the fixed weight clones performed well for a number of hedge fund strategies, the performance of the rolling window model was not quite as good. The fixed weight and rolling window models are outlined below.

Fixed weight model

The fixed weight model is constructed using an ordinary least squares algorithm with the regression coefficients constrained to sum to one. Dropping the intercept forces the least square algorithm to use the factors to fit the means returns of the fund, thereby giving an optimized portfolio where the beta coefficients are interpreted as the factor weights in the clone for each respective fund.

$$R_{it} = \beta_{i1} F_{1t} + \beta_{i2} F_{2t} + ... + \beta_{in} F_{nt} + \varepsilon_{it},$$
$$t = 1, 2...T$$
$$subject\ to\ \beta_{i1} + ... + \beta_{in} = 1 \tag{1}$$

The estimated regression coefficients are used as the portfolio weights to give the portfolio returns $\{R^*_{it}\}$. $\{R^*_{it}\}$ is then renormalized to obtain the clone portfolio return, $\{R_{it}^{clone}\}$.

$$R*_{it} = \beta*_{i1} F_{1t} + \beta*_{i2} F_{2t} + ... + \beta*_{in} F_{nt} \tag{2}$$

$$R_{it}^{clone} = \gamma_i R*_{it}, with\ \gamma_i = \sigma_R/\sigma_{R*} \tag{3}$$

The portfolio weights and renormalization factors of the fixed-weight clones stay constant over time for each clone.

Rolling window model

The rolling window model uses a 24-month rolling window regression to estimate the portfolio weights of the risk factors. This is a more dynamic model compared to the fixed weight model and can be seen as suitable for investors who want to actively rebalance their portfolios to capture the non-stationary nature in the hedge fund return series (Hasanhodzic and Lo 2007).

$$R_{it-k} = \beta_{it1} F_{1t-k} + \beta_{it2} F_{2t-k} + ... + \beta_{itn} F_{nt-k} + \varepsilon_{it-k}$$
$$k = 1, 2...24$$
$$subject\ to\ \beta_{it1} + ... + \beta_{itn} = 1 \tag{4}$$

Rebalancing is now done each month for every clone.

$$R*_{it} = \beta*_{it1} F_{1t} + \beta*_{it2} F_{2t} + ... + \beta*_{itn} F_{nt} \tag{5}$$

$$R_{it}^{clone} = \gamma_{it} R*_{it}, with\ \gamma_{it} = \frac{\sqrt{\sum_{k=1}^{24}\left(R_{it-k}-\mu_{Rit}\right)^2}}{\sqrt{\sum_{k=1}^{24}\left(R^*_{it-k}-\mu_{R*it}\right)^2}} \tag{6}$$

Modeling approach

Fixed-weight and rolling-window models similar to the ones used by Hasanhodzic and Lo (2007) are used to analyze a sample of 1495 hedge funds with monthly returns from August 1996 to September 2008. Data was obtained from the Hedge Fund Research Database. The rolling window model requires the calibration of the 24-month rolling

window regression and renormalization factor, and hence has the first 47 months excluded from the performance comparison of the funds and clones. However, all 145 months are used for analyzing the fixed-weight model. The sample includes funds belonging to various categories, such as convertible arbitrage, dedicated short bias, emerging markets, equity market neutral, event driven, fixed income arbitrage, long/short equity, global macro, managed futures, multi-strategy, and fund-of-funds. For each strategy, the factors used in the model are selected based on the characteristics of the underlying hedge fund category. The performance of the clones developed using these factors are compared to the funds and the clones constructed from the factors listed in Section 2.1.

Three data selection procedures are used in the construction of the hedge fund clones that will give investors a more customizable clone model that offers the choice between the clones constructed using all funds, funds with higher Sharpe ratios, and funds with higher average returns. The performance of the clones constructed from factors specific to each hedge fund are again compared against those of the top performing funds to analyze if these clones continue to deliver better performance against a higher benchmark. Throughout the remainder of the paper, clone2 stands for the clones constructed from the factors considered specifically for each individual hedge fund category, while clone1 represents the clones that used the general set of factors listed in Section 2.1, and previously used by Hasanhodzic and Lo (2007).

Strategy overview

This section provides an overview of each hedge fund strategy and lists the factors used to construct clone2 under each category. The factors used to model clone2 are selected specifically for each hedge fund strategy.

Convertible arbitrage

The convertible arbitrage category of hedge funds is a relative value strategy focused on capturing inefficiencies in the convertible bond market. Around $40 billion was under management in convertible arbitrage funds as of 2010, returning an average of 9.3% annualized with a volatility of 7.7% between 1994 and 2010 (Credit Suisse 2011a). A strategy utilized by these funds involves going long a convertible bond and taking a short position in the underlying stock. The hedge can also be in the form of credit default swaps, as well as interest rate and volatility derivatives. However, hedging only equity risk is more characteristic of convertible arbitrage hedge funds (Agarwal et al. 2011).

The convertible bond market is very illiquid and the majority of the positions are held by convertible arbitrage funds. Although this illiquidity is often the source of their returns, it can quickly squeeze the funds into liquidating the bonds at losses during a credit crunch. The factors used to form the clones are selected with the goal of maintaining an overall consistency with the investment objectives of the respective hedge funds. The factors selected to form the convertible arbitrage clone include *Large Cap US Stocks*: S&P 500 Total Return, *Bond*: Lehman Corporate AA Intermediate Bond Index, and *High Yield Bond*: Merrill Lynch High Yield Master 2 Index.

Dedicated short Bias

Dedicated short bias funds take both long and short exposures to equities while maintaining a net short position. This category performs well when the markets are in a downtrend, but suffers in bull markets. Managers change their net short exposure according to their outlook on the overall market. The factors used to replicate this strategy include *Large Cap US Stocks*: S&P 500 Total Return, *Small Cap US Stocks*: Russell 2000 Small-Cap Index, and *Treasury Rates*: Lehman Treasury Index.

Emerging market

Emerging market hedge funds seek to exploit opportunities developed by political, currency, credit, and interest rate uncertainties that occur in emerging markets, while also investing in their corresponding equity markets. These opportunities are also used by global macro and event driven hedge funds. The factors used to develop emerging market clones include *Emerging Market*: MSCI Emerging Market Index, *High Yield Bond*: Merrill Lynch High Yield Master 2 Index, *Bond*: Lehman Corporate AA Intermediate Bond Index, *Currency*: U.S. Dollar Index Return, and *Credit Spreads*: The spread between the Lehman Corporate Bond Index and the Lehman Treasury Index.

Equity market neutral

Equity market neutral hedge funds aim to exploit certain opportunities presented by a specific group of stocks while staying neutral to the broad market. This strategy sometimes overlaps with relative value and long/short equity. It performed relatively well, losing fewer than 3% on average in 2008 and had the lowest volatility in a ten-year window between July 1999 and June 2009 (Low 2009). Equity market neutral managers perform frequent to moderate rebalancing of their portfolio to maintain market neutrality.

Although they are broadly market-neutral, equity market neutral hedge funds have exposures to a wide range of equity classes. Value and momentum factors perform well in different market environments and hence offer a balance to the portfolio. Equity market neutral funds also have exposures to the U.S. and emerging market equities, and high yield bonds (Feldman et al. 2009). The factors used to construct the equity market neutral clone include *Market Momentum*: MSCI USA Momentum Index, *Large Cap US Stocks*: S&P 500 Total Return; *Value Stocks*: MSCI USA Value Index, *Emerging Market*: MSCI Emerging Market Index, *High Yield Bond*: Merrill Lynch High Yield Master 2 Index, and *Bond*: Lehman Corporate AA Intermediate Bond Index.

Event driven

The event driven category of hedge funds capitalizes on opportunities that develop in the short-term, causing mispricing in equities, bonds, and global markets. Key events can include mergers, acquisitions, and corporate restructuring. Event driven hedge funds perform poorly during down trending markets, as deals are more likely to fall through during those times (Agarwal and Naik 2004). The factors used to replicate the event driven strategy include *High Yield Bond*: Merrill Lynch High Yield Master 2 Index, *Emerging Market*: MSCI Emerging Market Index, *Value Stocks*: MSCI USA Value Index, and *Small Cap US Stocks*: Russell 2000 Small-Cap Index.

Fixed income arbitrage

Fixed Income arbitrage is another relative value strategy used to exploit bond market inefficiencies. As of 2010, these funds have about $120 billion worth of assets under management and have delivered an average of 5.3% annualized return with 6% volatility between 1994 and 2010 (Credit Suisse 2011b). This strategy performs well in a low volatility environment. However, it is particularly susceptible to crowed trades and needs to take on very high leverage to deliver substantial returns. The strategy typically profits by holding long positions in higher yielding bonds and short positions in lower yielding bonds. This strategy is known to have exposure to fixed income spreads, and though a number of spread combinations can be chosen as a factor, the credit spread is the best option because of its' long history and how widening credit spreads usually result in other spreads also widening (Fung and Hsieh 2002).

The Long-Term Capital Management story stands out to underscoring the risks prevalent with fixed income arbitrage trades as crowding out the yield spread trade can cause the spreads to narrow, thereby limiting the possible return, causing the funds to take on more risk with higher leverage and potential margin calls (Jorion 2000). The factors selected to form the fixed income arbitrage clone include *Credit Spreads*: the spread between the Lehman Corporate Bond Index and the Lehman Treasury Index, *Large Cap US Stocks*: S&P 500 Total Return, *Bond*: Lehman Corporate AA Intermediate Bond Index, and *High Yield Bond*: Merrill Lynch High Yield Master 2 Index.

Global macro

The global macro hedge fund is a category that especially appeals to institutional investors due to its liquidity. Global macro is one of the few hedge fund strategies that lost less than 5% in 2008 when most hedge fund strategies had double-digit percentage losses (Low 2009). Its robustness can be seen in its performance between 2000 and 2010 where it returned an average of near 12% annualized return with a volatility of 5.5%, illustrating how the strategies of global macro funds perform well in volatile market environments, with about $290 billion under management (Casano 2010). The global macro strategy invests in a very broad range of asset classes and geographies. The factors used to construct the clones of global macro include *Bond*: Lehman Corporate AA Intermediate Bond Index, *Large Cap US Stocks*: S&P 500 Total Return, *Emerging Market*: MSCI Emerging Market Index, and the *Currency*: U.S. Dollar Index Return, and *Commodity*: Goldman Sachs Commodity Index Total Return.

Long/short equity

Long/short hedge funds take both long and short positions in a broad range of equity classes spread across different size, style, and regions. These funds benefit from a positive equity environment and delivered an annualized return of 9.5% and volatility of 10.6% between January 1998 and October 2009. This strategy will underperform long-only strategies during a strong bull market, however, the long/short strategy will outperform over a full market cycle (Bruce and Reynolds 2010).

The long/short strategy has become the most established hedge fund strategy with over 30% of all the assets under management in hedge funds invested in long/short funds, comprising over 43% of all hedge funds (Feldman et al. 2009). Although these

funds are typically long biased, their strategies sometimes overlap those of equity market neutral funds in times of market downturns. The factors used to construct the clones for long/short equity hedge funds include a wide range of equity factors to which the funds usually have exposures. The factors used to construct long/short clones include *Large Cap US Stocks*: S&P 500 Total Return, *Small Cap US Stocks*: Russell 2000 Small Cap Index, *Developed International Markets*: MSCI EAFE Index, *Market Momentum*: MSCI USA Momentum Index, and *Bond*: Lehman Corporate AA Intermediate Bond Index.

Managed futures

Managed futures hedge funds seek to capture returns by capitalizing on trends across a range of asset classes, including equities, commodities, fixed income, and currencies. Managed futures was the best performing hedge fund strategy in 2008, returning over 16% when most of the other strategies ended the year in negative territory and had over $330 billion in assets under management by the end of 2012 (Drachman 2013). The strategy also has a very low correlation to broad market indices and has returned over 8.6% annualized with 12.2% volatility between September 2000 and September 2010 (Casano 2010).

The flexibility of this strategy also results in high variation in the performance between different managers. The best performing managed futures fund in 2012 returned over 13%, while the worst performer lost over 27%, yet these funds have the ability to capture both uptrends and downtrends and have a history performing well in either type of trending market (Till and Eagleeye 2011). The managed futures strategy returned over 35% during the technology downturn between September 2000 and December 2002, and over 31% in the following market bull-run ending in October 2007 (Drachman 2013). The factors used to replicate the managed futures funds include *Currency*: U.S. Dollar Index Return, *Treasury Rates*: Lehman Treasury Index, *Commodity*: Goldman Sachs Commodity Index Total Return, *Large Cap US Stocks*: S&P 500 Total Return, and *Market Volatility*: CBOE Volatility Index.

Multi-strategy

Multi-strategy hedge funds often develop from successful single strategy funds that extend their services to accommodate incoming capital when it reaches a capacity that managers see as the optimum threshold beyond that which they believe they will be inefficient in using fresh capital towards a single strategy. This category can be expected to offer diversification, higher capacity, and consistency in the long term. The factors used to construct multi-strategy clones include *Credit Spreads*: The spread between the Lehman Corporate Bond Index and the Lehman Treasury Index, *Large Cap US Stocks*: S&P 500 Total Return, *High Yield Bond*: Merrill Lynch High Yield Master 2 Index, *Emerging Market*: MSCI Emerging Market Index, and *Bond*: Lehman Corporate AA Intermediate Bond Index.

Fund-of-funds

Investors who want to construct a portfolio of hedge funds in order to increase diversification, while also decreasing correlation to the overall markets, will often consider

using a fund-of-funds hedge fund category. Constructing a portfolio of hedge funds requires extensive due diligence and access to performance information that is not easily available. Fund-of-funds hedge funds take care of the due diligence, manager selection, and risk monitoring in exchange for an additional layer of fees, typically in the range of 10% asset management fees and 1% performance fees. Fund-of-funds hedge funds can vary from one another in terms of the weighting to different managers, liquidity, strategy exposures, and extent of rebalancing between the managers (Suppal and Garza 2012). The factors selected to clone the fund-of-funds include *Credit Spreads*: The spread between the Lehman Corporate Bond Index and the Lehman Treasury Index, *Large Cap US Stocks*: S&P 500 Total Return, *High Yield Bond*: Merrill Lynch High Yield Master 2 Index, *Emerging Market*: MSCI Emerging Market Index, and *Bond*: Lehman Corporate AA Intermediate Bond Index.

Results

This section discusses the results of the replication process using the fixed weight and rolling window clone models discussed in Section 2, and then compares the benefits of selecting factors specific to the underlying hedge fund strategy versus simply using a broad set of factors covering basic sources of risk associated with stocks, bonds, currency, credit, and commodities. While the fixed weight model is suitable for investors wanting a more passive approach to using their hedge fund clones, the rolling window model is for investors who prefer active monthly rebalancing. For this work, and to compare against both the performance of the actual hedge funds being modeled and the replication clones themselves, we have used a dataset covering the period from August 1996 to September 2008, as used in related work (Hasanhodzic and Lo 2007). Please note that while statistical out of sample tests were not performed due the limitations of the hedge fund data set (i.e., with only 145 months available and 47 months needed to calibrate the rolling window clones, out of sample tests could not be performed without severely affecting the replication), the commonly used descriptive statistics of mean return and Sharpe ratios were used to compare the replication models.

Also covered in this section are the results of the clones constructed from the funds with the highest Sharpe ratios and the funds with the best average returns. The selection bias inherent in the cloning process is used to the benefit of the investors to allow for more customization of the clones and the ability to model them according to their preferences for risk and return. Investors prioritizing a more balanced risk-reward ratio can choose the clones constructed from the top Sharpe ratio funds, while investors seeking higher returns can use the clones constructed from the top returning funds.

All funds

Table 1 shows the performance comparison for the clones created using all funds for the fixed weight model. The results for clone2 (strategy specific factors) are impressive across several categories and are significantly better than that of clone1 (common/general set of factors) for all hedge fund strategies, with the exceptions of dedicated short bias and managed futures. Please note that one of the goals in selecting factors specific to the hedge fund strategy is to obtain clones with mean returns closer to that of the hedge funds. Therefore, in the case of managed futures, although clone1 has higher

Table 1 Performance comparison for fixed weight model for all funds and their clones

Fixed Weight Model - All Funds			Annual Mean Return %		Annual SD %		Annual Sharpe	
	Categories	Sample Size	Mean	SD	Mean	SD	Mean	SD
Funds	Convertible Arbitrage	53	8.64	3.72	6.30	4.79	2.33	3.24
Clone1	Convertible Arbitrage	53	4.70	3.22	6.30	4.79	1.03	0.46
Clone2	Convertible Arbitrage	53	8.17	3.06	6.30	4.79	1.55	0.38
Funds	Dedicated Short Bias	13	4.82	5.46	23.18	8.69	0.18	0.26
Clone1	Dedicated Short Bias	13	8.05	9.23	23.18	8.69	0.37	0.37
CLone2	Dedicated Short Bias	13	11.82	6.33	23.18	8.69	0.57	0.28
Funds	Emerging Markets	67	16.80	7.99	18.78	11.89	1.23	0.99
Clone1	Emerging Markets	67	9.37	4.90	18.78	11.89	0.67	0.42
CLone2	Emerging Markets	67	17.04	8.14	18.78	11.89	1.09	0.43
Funds	Equity Market Neutral	76	7.65	4.32	9.15	9.60	1.45	1.40
Clone1	Equity Market Neutral	76	9.44	10.41	9.15	9.60	1.12	0.39
CLone2	Equity Market Neutral	76	10.48	5.32	9.15	9.60	1.43	0.39
Funds	Event Driven	59	10.68	5.42	8.56	4.23	1.44	0.76
Clone1	Event Driven	59	6.40	3.08	8.56	4.23	0.84	0.36
CLone2	Event Driven	59	7.79	4.69	8.56	4.23	0.90	0.21
Funds	Fixed Income Arbitrage	42	8.52	2.79	6.69	4.13	2.14	2.55
Clone1	Fixed Income Arbitrage	42	6.62	3.48	6.69	4.13	1.17	0.45
CLone2	Fixed Income Arbitrage	42	7.88	4.14	6.69	4.13	1.31	0.36
Funds	Global Macro	62	13.39	6.82	15.00	7.78	0.99	0.46
Clone1	Global Macro	62	13.86	10.15	15.00	7.78	1.00	0.48
CLone2	Global Macro	62	16.88	8.02	15.00	7.78	1.24	0.43
Funds	Long/Short Equity Hedge	498	12.35	6.69	14.41	7.95	0.97	0.44
Clone1	Long/Short Equity Hedge	498	8.15	6.80	14.41	7.95	0.65	0.41
CLone2	Long/Short Equity Hedge	498	11.73	5.20	14.41	7.95	0.94	0.38
Funds	Managed Futures	211	13.57	7.60	18.85	10.26	0.79	0.38
Clone1	Managed Futures	211	22.12	12.45	18.85	10.26	1.24	0.40
CLone2	Managed Futures	211	15.37	8.98	18.85	10.26	0.84	0.26
Funds	Multi Strategy	91	9.35	5.75	9.42	7.34	1.35	0.85
Clone1	Multi Strategy	91	6.81	7.92	9.42	7.34	0.93	0.53
CLone2	Multi Strategy	91	10.42	8.99	9.42	7.34	1.25	0.55
Funds	Fund of Funds	323	9.13	3.00	7.65	4.84	1.47	0.65
Clone1	Fund of Funds	323	6.76	3.29	7.65	4.84	1.05	0.41
CLone2	Fund of Funds	323	9.46	4.26	7.65	4.84	1.37	0.33

average mean return (22.12% clone1 vs. 15.37% clone2 vs. 13.57% funds), the performance of clone2 is preferable given that its return is closer to the actual funds and its standard deviation among mean returns is lower than clone1. In the case of dedicated short bias, although clone1 appears to have an average mean return closer to that of the fund, the higher standard deviation among mean returns, combined with the lower Sharpe ratio, makes clone2 the preferred choice. Equity market neutral provides for an interesting observation with clone2 providing much higher mean returns, but with comparable variance in mean returns. They also have very close Sharpe ratios (1.43 clone2 vs. 1.45 clone1).

The average mean return of clone2 is strikingly close to the average mean return of the funds in the case of convertible arbitrage (8.17% clone2 vs. 8.64% funds), emerging

markets (17.04% clone2 vs. 16.80 funds), fixed income arbitrage (7.88% clone2 vs. 8.52% funds), long/short equity hedge (11.73% clone2 vs. 12.35% funds), and fund-of-funds (9.46% clone2 vs. 9.13% funds). The standard deviation among mean returns is also close in these cases. Multi-strategy also offers clones with comparable mean returns and Sharpe ratio. The average Sharpe ratio of clone2 is higher than that of clone1 in all cases except managed futures, and is close to the mean Sharpe ratio of the funds for several categories. As illustrated by the results in Table 1, clone2 is preferred over clone1 for all hedge fund strategies when constructed using all funds, and provides notably close performance to the funds in most cases.

The rolling window comparison of the performance of both the clones and that of the corresponding funds for all the funds is provided in Table 2. These results show that clone2 remains the preferred choice among all hedge fund strategies. Clone2 continues to offer highly comparable performance to the funds with the rolling window model having a few exceptions coming in the categories of event driven, fixed income arbitrage, and multi-strategy. Convertible arbitrage (10.11% clone2 vs. 8.91% funds) and global macro (14.83% clone2 vs. 13.05% funds) have higher average mean returns for the clone2 models, although the variance in mean returns is much higher for global macro clones2 (11.88% clone2 vs. 6.37% funds). However, the comparable Sharpe ratios (1.16 clone2 and 1.1 funds) make it a clone worth considering. Emerging markets and fund-of-funds categories have their clones2 perform close to the funds in terms of mean returns, while having slightly higher variance in mean returns. Long/short equity hedge and equity market neutral strategies have the clone2 models perform remarkably well, both in terms of their average mean returns and the variance in mean returns.

The results for rolling window and fixed weight clone2 models for all funds show that selecting the factors relevant to the underlying hedge fund strategy will offer significant benefits, both in terms of replication quality and overall performance of the clones.

Top 50% Sharpe ratios

Next we look at the performance of clones constructed from the top 50% of the funds having the highest Sharpe ratios. The clones generated from these funds will benefit from the balanced risk reward properties of its corresponding funds. Although matching this higher benchmark is more difficult, using the relevant factors significantly improves the performance of the clones. Clone2 continues to outperform clone1 in terms of replication quality across all hedge fund strategies.

Table 3 offers the comparison of the fixed weight clones and the funds selected under this strategy. It can be seen that despite the challenges of a higher benchmark, clones2 still offers significantly comparable performance across many categories, including emerging markets (15.81% clone2 and 17.98% funds), equity market neutral (7.68% clone2 and 8.89% funds), long/short equity (11.54% clone2 and 13.85% funds), fund-of-funds (7.52% clone2 and 9.12% funds), multi-strategy (8.38% clone2 and 10.76% funds), managed futures (13.35% clone2 and 15.11% funds) and global macro (14.98% clone2 and 15.51% funds). There is also a similar variance in mean returns for clone2 and their corresponding funds for these strategies. Fixed income arbitrage, event driven, and convertible arbitrage categories have the clones underperform their corresponding funds. These strategies largely gain from illiquidity risk and have significant

Table 2 Performance comparison for rolling window model for all funds and their clones

Rolling Window Model - All Funds								
	Categories	Sample Size	Annual Mean Return %		Annual SD %		Annual Sharpe	
			Mean	SD	Mean	SD	Mean	SD
Funds	Convertible Arbitrage	53	8.91	4.62	5.54	4.56	3.02	5.09
Clone1	Convertible Arbitrage	53	2.45	4.24	5.66	4.54	0.59	0.58
Clone2	Convertible Arbitrage	53	10.11	4.95	6.17	4.51	1.88	0.47
Funds	Dedicated Short Bias	13	3.37	4.84	18.98	8.31	0.17	0.39
Clone1	Dedicated Short Bias	13	−1.05	5.99	15.93	6.41	−0.16	0.47
CLone2	Dedicated Short Bias	13	7.58	3.57	14.92	5.77	0.58	0.30
Funds	Emerging Markets	67	21.50	10.60	15.43	9.80	1.77	1.15
Clone1	Emerging Markets	67	9.53	9.20	14.64	8.81	0.73	0.40
CLone2	Emerging Markets	67	19.69	13.36	14.56	8.97	1.40	0.35
Funds	Equity Market Neutral	76	7.16	5.20	7.66	7.14	1.75	2.46
Clone1	Equity Market Neutral	76	4.15	5.24	7.20	6.53	0.65	0.55
CLone2	Equity Market Neutral	76	7.69	5.55	7.41	7.30	1.18	0.47
Funds	Event Driven	59	11.48	5.72	7.11	3.41	1.81	0.90
Clone1	Event Driven	59	5.86	4.58	7.75	4.30	0.86	0.52
CLone2	Event Driven	59	7.63	5.80	7.59	4.48	1.10	0.46
Funds	Fixed Income Arbitrage	42	8.83	3.13	4.64	2.72	3.13	4.25
Clone1	Fixed Income Arbitrage	42	3.04	3.49	5.03	3.45	0.79	0.49
CLone2	Fixed Income Arbitrage	42	4.14	2.54	4.97	3.54	1.03	0.46
Funds	Global Macro	62	13.05	6.37	13.38	6.18	1.10	0.54
Clone1	Global Macro	62	9.05	10.92	13.55	7.54	0.69	0.65
CLone2	Global Macro	62	14.83	11.88	13.34	7.32	1.16	0.64
Funds	Long/Short Equity Hedge	498	12.90	7.63	12.24	6.74	1.19	0.54
Clone1	Long/Short Equity Hedge	498	9.94	8.40	12.47	6.75	0.83	0.47
CLone2	Long/Short Equity Hedge	498	11.21	6.72	11.92	6.71	1.05	0.48
Funds	Managed Futures	211	12.21	7.08	17.43	9.75	0.81	0.49
Clone1	Managed Futures	211	16.01	13.39	17.78	10.74	0.92	0.49
CLone2	Managed Futures	211	14.38	12.72	17.23	10.68	0.87	0.51
Funds	Multi Strategy	91	9.96	5.36	7.45	5.40	1.75	1.11
Clone1	Multi Strategy	91	4.02	8.51	8.32	6.33	0.77	0.67
CLone2	Multi Strategy	91	6.61	10.63	8.31	6.23	1.06	0.79
Funds	Fund of Funds	323	9.32	3.49	6.20	4.25	1.88	0.84
Clone1	Fund of Funds	323	5.16	3.39	5.83	4.19	0.96	0.29
CLone2	Fund of Funds	323	8.38	6.47	5.82	4.11	1.45	0.29

left tail exposure; the top Sharpe ratio criterion is therefore likely to select the funds with the most illiquid exposures, making them more challenging to replicate.

The rolling window results of the clones and the selected hedge funds are provided in Table 4. As seen in the table, clone2 outperforms clone1 in all hedge fund categories with the exception of managed futures, where clone2 still offers comparable performance to the funds. The most notable clone performances are for convertible arbitrage (8.26% clone2 vs. 9.71% funds), dedicated short bias (8.88% clone2 vs. 7.13% funds), and global macro (15.79% clone2 vs. 15.26% funds). While the standard deviation in mean returns is also close for convertible arbitrage and dedicated short bias, the standard deviation in mean returns for global macro clone2 is significantly higher than that for the funds. The comparable Sharpe ratios indicate that clone2 offers some benefits. Clone2 for the rest

Table 3 Performance comparison for fixed weight model for top 50% Sharpe ratio funds and their clones

Fixed Weight Model - Top 50% Sharpe Ratios Funds								
	Categories	Sample Size	Annual Mean Return %		Annual SD %		Annual Sharpe	
			Mean	SD	Mean	SD	Mean	SD
Funds	Convertible Arbitrage	26	9.56	3.60	4.13	2.13	3.68	4.24
Clone1	Convertible Arbitrage	26	4.68	2.05	4.13	2.13	1.25	0.31
Clone2	Convertible Arbitrage	26	6.50	2.70	4.13	2.13	1.69	0.26
Funds	Dedicated Short Bias	6	9.50	3.90	24.26	8.16	0.41	0.15
Clone1	Dedicated Short Bias	6	13.34	11.65	24.26	8.16	0.60	0.46
CLone2	Dedicated Short Bias	6	13.82	8.45	24.26	8.16	0.62	0.33
Funds	Emerging Markets	33	17.98	6.99	13.09	8.57	1.82	1.12
Clone1	Emerging Markets	33	10.00	4.68	13.09	8.57	0.95	0.41
CLone2	Emerging Markets	33	15.81	8.00	13.09	8.57	1.38	0.37
Funds	Equity Market Neutral	38	8.89	3.75	4.92	2.41	2.31	1.54
Clone1	Equity Market Neutral	38	6.00	3.30	4.92	2.41	1.26	0.32
CLone2	Equity Market Neutral	38	7.68	3.49	4.92	2.41	1.63	0.28
Funds	Event Driven	29	11.48	5.59	6.51	3.58	1.95	0.73
Clone1	Event Driven	29	6.09	2.63	6.51	3.58	1.04	0.34
CLone2	Event Driven	29	7.78	3.26	6.51	3.58	1.31	0.30
Funds	Fixed Income Arbitrage	21	8.93	2.66	3.79	1.73	3.37	3.17
Clone1	Fixed Income Arbitrage	21	5.65	3.00	3.79	1.73	1.47	0.28
CLone2	Fixed Income Arbitrage	21	5.85	2.88	3.79	1.73	1.53	0.20
Funds	Global Macro	31	15.51	6.88	12.16	6.50	1.35	0.37
Clone1	Global Macro	31	11.78	6.30	12.16	6.50	1.02	0.37
CLone2	Global Macro	31	14.98	7.33	12.16	6.50	1.31	0.37
Funds	Long/Short Equity Hedge	249	13.85	6.85	11.13	5.70	1.30	0.35
Clone1	Long/Short Equity Hedge	249	9.26	6.99	11.13	5.70	0.85	0.36
CLone2	Long/Short Equity Hedge	249	11.54	4.94	11.13	5.70	1.13	0.31
Funds	Managed Futures	105	15.11	7.46	15.60	8.29	1.04	0.37
Clone1	Managed Futures	105	18.66	11.35	15.60	8.29	1.27	0.43
CLone2	Managed Futures	105	13.35	7.81	15.60	8.29	0.87	0.24
Funds	Multi Strategy	45	10.77	4.73	5.60	2.80	2.03	0.58
Clone1	Multi Strategy	45	6.49	4.18	5.60	2.80	1.18	0.31
CLone2	Multi Strategy	45	8.38	5.51	5.60	2.80	1.47	0.28
Funds	Fund of Funds	161	9.12	2.66	4.86	1.85	1.98	0.50
Clone1	Fund of Funds	161	6.20	2.94	4.86	1.85	1.28	0.26
CLone2	Fund of Funds	161	7.52	3.30	4.86	1.85	1.54	0.20

of the categories perform poorly in terms of mean returns, but the benefit of choosing the factors with consideration to the hedge fund strategy is clearly evident in the significantly higher average Sharpe ratios relative to clone1 across every strategy, except managed futures.

Top 50% returns

In this section we see the performance of clones constructed from the top 50% of funds with the best average returns. These clones are for investors who prioritize seeking higher returns and benefit from this focus in constructing the clones. Clone2 again out-performs clone1 in terms of replication quality for all strategies and in terms of average

Table 4 Performance comparison for rolling window model for top 50% Sharpe ratio funds and their clones

		Rolling Window Model - Top 50% Sharpe Ratios Funds						
	Categories	Sample Size	Annual Mean Return %		Annual SD %		Annual Sharpe	
			Mean	SD	Mean	SD	Mean	SD
Funds	Convertible Arbitrage	26	9.71	4.08	3.67	1.93	4.85	6.84
Clone1	Convertible Arbitrage	26	3.39	2.76	3.49	1.94	0.96	0.34
Clone2	Convertible Arbitrage	26	8.26	5.01	3.91	2.21	2.08	0.20
Funds	Dedicated Short Bias	6	7.13	4.01	18.93	8.65	0.45	0.39
Clone1	Dedicated Short Bias	6	0.59	5.87	15.99	6.16	0.00	0.43
CLone2	Dedicated Short Bias	6	8.88	4.53	15.20	5.46	0.68	0.40
Funds	Emerging Markets	33	20.38	9.20	11.01	8.13	2.40	1.34
Clone1	Emerging Markets	33	9.66	11.77	10.94	8.98	0.91	0.43
CLone2	Emerging Markets	33	17.68	15.98	11.11	9.32	1.59	0.36
Funds	Equity Market Neutral	38	8.61	3.86	4.33	2.19	2.87	3.08
Clone1	Equity Market Neutral	38	4.42	3.72	4.84	3.14	0.91	0.34
CLone2	Equity Market Neutral	38	5.58	3.87	4.77	3.08	1.22	0.42
Funds	Event Driven	29	11.90	5.69	5.49	2.88	2.37	0.90
Clone1	Event Driven	29	5.60	3.47	6.01	3.88	1.00	0.39
CLone2	Event Driven	29	6.64	4.08	5.73	3.61	1.22	0.41
Funds	Fixed Income Arbitrage	21	8.69	2.98	2.98	1.52	4.75	5.60
Clone1	Fixed Income Arbitrage	21	3.17	2.51	3.68	2.87	0.92	0.39
CLone2	Fixed Income Arbitrage	21	3.62	2.37	3.50	2.63	1.18	0.46
Funds	Global Macro	31	15.26	6.16	10.89	5.54	1.51	0.43
Clone1	Global Macro	31	10.92	13.00	11.84	7.41	0.90	0.66
CLone2	Global Macro	31	15.79	14.46	11.53	7.11	1.35	0.72
Funds	Long/Short Equity Hedge	249	14.03	7.53	9.47	4.78	1.54	0.44
Clone1	Long/Short Equity Hedge	249	9.32	5.94	10.25	5.34	0.95	0.41
CLone2	Long/Short Equity Hedge	249	10.11	5.03	9.77	5.28	1.15	0.47
Funds	Managed Futures	105	13.49	6.36	14.08	7.63	1.09	0.53
Clone1	Managed Futures	105	14.62	10.44	14.05	8.13	1.05	0.53
CLone2	Managed Futures	105	11.67	8.75	13.59	8.21	0.92	0.51
Funds	Multi Strategy	45	10.90	4.42	4.54	2.26	2.62	0.90
Clone1	Multi Strategy	45	4.63	3.04	4.44	2.11	1.05	0.41
CLone2	Multi Strategy	45	6.12	4.08	4.50	2.14	1.32	0.49
Funds	Fund of Funds	161	9.10	2.47	3.94	1.67	2.50	0.69
Clone1	Fund of Funds	161	4.22	2.08	3.91	1.81	1.09	0.20
CLone2	Fund of Funds	161	6.08	3.46	3.90	1.82	1.52	0.20

returns and Sharpe ratio for all categories except managed futures, but clone2 remains the preferred clone model. The top 50% Sharpe ratio funds and top 50% return funds are the same for dedicated short bias category.

The fixed weight model performance for the clones and funds that are selected using the higher returns strategy are provided in Table 5. Extremely good clones are obtained for emerging markets (21.41% clone2 vs. 22.55% funds) and equity market neutral (11.11% clone2 vs.10.53% funds) given their close variation in mean returns. Global macro and managed futures categories give performance very close to their respective

Table 5 Performance comparison for fixed weight model for top 50% return funds and their clones

Fixed Weight Model - Top 50% Return Funds			Annual Mean Return %		Annual SD %		Annual Sharpe	
	Categories	Sample Size	Mean	SD	Mean	SD	Mean	SD
Funds	Convertible Arbitrage	26	11.32	3.32	7.91	6.20	2.80	3.83
Clone1	Convertible Arbitrage	26	4.70	4.37	7.91	6.20	0.96	0.57
Clone2	Convertible Arbitrage	26	8.49	3.27	7.91	6.20	1.39	0.47
Funds	Dedicated Short Bias	6	9.50	3.90	24.26	8.16	0.41	0.15
Clone1	Dedicated Short Bias	6	13.34	11.65	24.26	8.16	0.60	0.46
CLone2	Dedicated Short Bias	6	13.82	8.45	24.26	8.16	0.62	0.33
Funds	Emerging Markets	33	22.55	7.29	22.94	14.20	1.43	1.12
Clone1	Emerging Markets	33	12.24	4.78	22.94	14.20	0.73	0.41
CLone2	Emerging Markets	33	21.41	8.96	22.94	14.20	1.14	0.42
Funds	Equity Market Neutral	38	10.53	4.19	10.40	11.77	1.69	1.17
Clone1	Equity Market Neutral	38	12.09	13.46	10.40	11.77	1.27	0.36
CLone2	Equity Market Neutral	38	11.11	5.79	10.40	11.77	1.39	0.44
Funds	Event Driven	29	14.92	4.30	10.44	4.20	1.57	0.51
Clone1	Event Driven	29	7.78	3.49	10.44	4.20	0.83	0.39
CLone2	Event Driven	29	9.66	4.44	10.44	4.20	0.93	0.23
Funds	Fixed Income Arbitrage	21	10.67	2.27	7.04	4.75	2.65	3.02
Clone1	Fixed Income Arbitrage	21	7.79	4.00	7.04	4.75	1.27	0.41
CLone2	Fixed Income Arbitrage	21	9.04	4.89	7.04	4.75	1.39	0.27
Funds	Global Macro	31	18.24	6.27	18.57	8.65	1.12	0.47
Clone1	Global Macro	31	15.72	12.52	18.57	8.65	0.91	0.49
CLone2	Global Macro	31	18.85	8.80	18.57	8.65	1.13	0.42
Funds	Long/Short Equity Hedge	249	17.00	6.26	17.36	8.77	1.10	0.39
Clone1	Long/Short Equity Hedge	249	10.83	7.88	17.36	8.77	0.72	0.43
CLone2	Long/Short Equity Hedge	249	13.67	5.82	17.36	8.77	0.88	0.35
Funds	Managed Futures	105	19.18	6.78	24.26	10.97	0.89	0.39
Clone1	Managed Futures	105	27.01	13.84	24.26	10.97	1.17	0.42
CLone2	Managed Futures	105	19.91	9.49	24.26	10.97	0.86	0.25
Funds	Multi Strategy	45	13.51	4.52	10.99	8.85	1.59	0.71
Clone1	Multi Strategy	45	9.35	10.15	10.99	8.85	1.07	0.50
CLone2	Multi Strategy	45	14.67	9.58	10.99	8.85	1.44	0.38
Funds	Fund of Funds	161	11.26	2.69	9.10	5.19	1.52	0.68
Clone1	Fund of Funds	161	8.04	3.84	9.10	5.19	1.06	0.47
CLone2	Fund of Funds	161	11.31	4.56	9.10	5.19	1.38	0.38

funds for clone2 in terms of both average mean returns and Sharpe ratios. Fixed income arbitrage (9.04% clone2 vs. 10.67% funds), multi-strategy (14.67% clone2 vs. 13.51% funds), and fund-of-funds (11.31% clone2 vs. 11.26% funds) also exhibit good replication results. Long/short equity, event driven, convertible arbitrage, and dedicate short bias had poor replication performance, but the value of using the strategy specific factors can clearly be seen both in terms of average mean returns and Sharpe ratios relative to clone1.

Table 6 presents the performance results for the rolling window model for the clones and funds selected for the higher return strategy. Clone2 again provides a better replication performance relative to clone1 across all hedge fund categories and has better

overall performance in terms of average returns and Sharpe ratio for all fund strategies, except managed futures. As before with managed futures, clone2 is still preferred to clone1. Event driven is the worst performing clone2 in terms of difference in average mean returns (9.39% clone2 vs. 15.98% funds). This is the only category that performed poorly on all clone2 models. Fixed income arbitrage clone2 also performed poorly (4.5% clone2 vs. 10.72% funds). In general, this category also performed poorly for the other rolling window data selection strategies tested. Fung and Hsieh (2002) demonstrated that fixed income arbitrage funds have primarily static exposures and the nature of fixed income arbitrage funds may cause it to perform poorly when used to model rolling window clones where the portfolio weights in a clone are rebalanced each month.

Good clone performance can be seen for convertible arbitrage (10.51% clone2 vs. 12.1% funds) and dedicated short bias (8.88% clone2 vs. 7.13% funds) where the standard deviation in mean returns is also comparable. Global macro (16.7% clone2 vs. 17.05% funds), managed futures (18.51% clone2 vs. 17.15% funds), and fund-of-funds (10.29% clone2 vs. 11.28% funds) have comparable performance in terms of average mean returns, but have much larger variation in mean returns compared to their respective funds. The other strategies offered fairly comparable performance, with the benefits of selecting the factors based on the underlying hedge fund strategy once again clearly evident across all hedge fund strategies.

Conclusion

Selecting factors specific to the underlying hedge fund strategy has been demonstrated to offer advantages over those constructed using a general broad set of factors for each strategy. Clone2, which used strategy-specific factors, outperformed clone1 in almost every case, and usually by a significant margin in terms of replication performance and risk-reward ratio. Using different fund selection strategies provides investors with additional options for their hedge fund replication products.

The clones constructed using all the funds exhibited excellent replication for both the fixed and rolling window models with only a few exceptions. The benefits of selecting the factors in accordance to the hedge fund strategy were also visibly evident across all strategies. The top 50% Sharpe ratio funds selection strategy resulted in strong replication performance for most categories, barring fixed income arbitrage, event driven, and dedicated short bias for the fixed weight model. The rolling window model offered good replication for dedicated short bias, convertible arbitrage, managed futures, and global macro strategies. While the clone performed poorly for the other categories, there was a good performance over the general clone1 model. The top 50% return funds selection strategy yielded clones that offered attractive replication performance for several strategies except in the cases of long/short equity hedge, convertible arbitrage, event driven, and dedicate short bias for the fixed model. The rolling window model offered good clones for convertible arbitrage, dedicated short bias, global macro, managed futures, and fund-of-funds strategies. The difference in performance of hedge funds over the three fund selection procedures highlights the difficulty and importance of selecting hedge funds suitable to an investor's preference. While there is also a difference in the performance of the clones constructed by the three clone procedures, the

Table 6 Performance comparison for rolling window model for top 50% return funds and their clones

	Categories	Sample Size	Annual Mean Return %		Annual SD %		Annual Sharpe	
			Mean	SD	Mean	SD	Mean	SD
Funds	Convertible Arbitrage	26	12.10	4.47	7.14	5.96	3.71	5.91
Clone1	Convertible Arbitrage	26	3.31	5.53	6.87	5.90	0.75	0.63
Clone2	Convertible Arbitrage	26	10.51	5.65	7.32	5.69	1.77	0.60
Funds	Dedicated Short Bias	6	7.13	4.01	18.93	8.65	0.45	0.39
Clone1	Dedicated Short Bias	6	0.59	5.87	15.99	6.16	0.00	0.43
CLone2	Dedicated Short Bias	6	8.88	4.53	15.20	5.46	0.68	0.40
Funds	Emerging Markets	33	27.85	10.74	18.73	11.68	2.01	1.27
Clone1	Emerging Markets	33	11.25	11.83	17.10	9.89	0.72	0.48
CLone2	Emerging Markets	33	24.31	15.91	17.16	10.25	1.45	0.38
Funds	Equity Market Neutral	38	10.13	5.32	8.26	7.37	1.81	1.15
Clone1	Equity Market Neutral	38	5.04	4.91	6.83	3.83	0.79	0.52
CLone2	Equity Market Neutral	38	7.29	5.11	6.91	3.99	1.09	0.42
Funds	Event Driven	29	15.98	4.59	8.65	3.18	1.98	0.56
Clone1	Event Driven	29	7.76	5.41	8.56	3.76	0.96	0.58
CLone2	Event Driven	29	9.39	4.08	8.53	3.83	1.18	0.38
Funds	Fixed Income Arbitrage	21	10.72	3.07	5.33	3.36	3.49	4.44
Clone1	Fixed Income Arbitrage	21	3.36	4.31	5.73	3.72	0.81	0.53
CLone2	Fixed Income Arbitrage	21	4.51	2.29	5.63	3.96	1.03	0.45
Funds	Global Macro	31	17.05	6.36	16.15	6.45	1.19	0.54
Clone1	Global Macro	31	9.91	13.62	15.97	8.81	0.64	0.67
CLone2	Global Macro	31	16.70	15.13	15.75	8.50	1.08	0.67
Funds	Long/Short Equity Hedge	249	16.91	8.37	14.57	7.48	1.30	0.52
Clone1	Long/Short Equity Hedge	249	11.71	9.31	14.01	7.49	0.88	0.42
CLone2	Long/Short Equity Hedge	249	12.36	6.98	13.64	7.35	1.02	0.44
Funds	Managed Futures	105	17.15	6.61	22.20	10.57	0.91	0.51
Clone1	Managed Futures	105	21.55	15.51	22.78	11.80	1.00	0.51
CLone2	Managed Futures	105	18.51	14.89	22.32	11.86	0.87	0.49
Funds	Multi Strategy	45	13.58	4.60	8.94	6.30	1.97	0.97
Clone1	Multi Strategy	45	7.11	6.26	8.37	6.04	0.95	0.46
CLone2	Multi Strategy	45	10.59	6.80	8.37	6.05	1.37	0.45
Funds	Fund of Funds	161	11.28	3.61	7.51	4.55	1.85	0.83
Clone1	Fund of Funds	161	6.21	4.00	6.88	4.20	0.97	0.29
CLone2	Fund of Funds	161	10.29	7.03	6.92	4.14	1.49	0.31

expense and complexity in choosing and investing in a normal hedge fund makes the clones a more favorable choice.

It is also important to recognize that costs associated with rebalancing, leveraging, and transaction costs must be considered before choosing and implementing the clones. Another point to note is that hedge funds are capable of deviating from their stated styles, and more complicated models may be needed to account for these style drifts. This is not visible when a large number of funds are averaged together, as seen in the excellent performance of clones constructed from using all funds. However, by

reducing the number of funds considered in forming the clones, the style drift may become more apparent and difficult to capture for certain hedge fund strategies.

It is encouraging to see that using factors relevant to the hedge fund replication strategy resulted in clones that offered similar performance to the average hedge fund. The results also show that setting a higher benchmark for the clones by selecting the top performing funds continues to produce good replication performance for the clones across many strategies. The added benefits of lower fees, daily liquidity, and complete transparency make the clones appear as an attractive choice even when they slightly underperform their fund counterparts. With the view of the clones as investable products or alternatives to hedge funds, the choice in the clone construction technique depends on the desires of the investor, including clone replication performance, clone return, or clone risk-reward performance.

Authors' contributions
SS contributed to the development, coding, factor selection, and testing of the hedge fund replication modeling. DE contributed to the development and factor selection of the hedge fund replication modeling. Both authors read and approved the final manuscript.

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Competing interests
The authors declare that they have no competing interests.

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