

**EDHEC Alternative
Investment Days
2007**

Bringing Academic Insights to
Alternative Investment

14:30-16:00
**Stream 1A: Passive Replication of Hedge Funds:
New Frontier or Mirage?**

Chairman:

Jean-Christophe Meyfredi, Professor of Finance and Head of Department,
EDHEC Business School

Speaker:

Lionel Martellini, Professor of Finance and Scientific Director, EDHEC Risk and
Asset Management Research Centre

Panellists:

Michael Markov, CEO, Director of Research, Markov Processes International

Thomas Schneeweis, Director, Center for International Securities and
Derivatives Markets

Chris Woods, Investment strategist, Man Global Strategies

Alex Ypsilanti, Head of European Equity Derivatives Strategy, Merrill Lynch



EDHEC-RISK
Asset Management Research

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Passive Replication Hedge Fund – New Frontier or Mirage?

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Overview

- The Myths & Limits of HF Replication
- Factor-Based Approach to HF Replication
- Payoff-Distribution to HF Replication
- Conclusion & Directions for Further Research

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- The Myths & Limits of HF Replication
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The Myths and Limits of HF Replication

Beta versus Alpha Drivers

- HF returns basic decomposition:

$$\text{HF Returns} = \text{Traditional Factor Exposures} + \text{Alternative Factor Exposures} + \text{Alpha}$$

- Following recent initiatives by major investment banks such as Merrill Lynch and Goldman Sachs, there has been a renewed interest in the financial industry concerning the subject of passive hedge fund replication, long a subject of interest in academic circles.
- The (probably not exhaustive) list of hedge fund replication product providers currently includes: *AlphaSwiss, Barclays, Bear Stearns, Deutsche Bank, Goldman Sachs, IceCapital Fund Management Company, IndexIQ, JP Morgan, Morgan Stanley, Merrill Lynch, Partners Group, Rydex Investments, SGAM Alternative Investments, State Street Global Advisors, Stonebrook Capital Management LLC.*

The Myths and Limits of HF Replication


Replicating Beta Components of HF Performance

- In a nutshell, these initiatives are meant to replicate the beta component of hedge fund returns through investment in a set of rules-based passive strategies.
- Replicating the systematic components of hedge fund returns is a priori an attractive value proposition because:
 - Beta benefits of hedge funds may be more reliable and in the end more attractive to investors than their alpha benefits.
 - Passive replication involves allows investors to avoid the main drawbacks of investment in active hedge funds of funds of funds: lack of liquidity, double-digit fee structure, lockup period, expensive due diligences, etc.
- In what follows, we provide a critical discussion of state-of-the-art practices in hedge fund replication.

The Myths and Limits of HF Replication

Performance versus Payoff Replication

- There are two possible definitions for what “passive replication of hedge fund returns” actually means.
- The first definition is replicating *hedge fund performance* on a monthly basis.
- The second definition is replicating the *distribution of hedge fund returns* at some time-horizon.
- If one can replicate the time-series performance (definition 1), one also replicates the distributional properties (definition 2), but the converse is not true.

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Factor-Based Approach to HF Replication

Basic Principles

- Traditional approach to hedge fund replication is based on factor models.
- Aim is to find long/short positions in a set of suitably-selected risk factors that best approximate hedge fund returns:

$$R_t^{HF_i} = \sum_{k=1}^K \hat{\beta}_{ik} F_{kt} + \hat{\varepsilon}_{it}$$

- The next step is just to passively hold the mimicking portfolio in an out-of-sample period:

$$R_t^{Clone_i} = \sum_{k=1}^K \hat{\beta}_{ik} F_{kt}$$

- The performance of these models is moderate on an in-sample basis and poor on an out-of-sample.

Factor-Based Approach to HF Replication

Main Hurdles

- Concern over misspecification in the choice of factors.
 - ⇒ specification risk
- Need for non-linear models: linear factor model cannot satisfactorily capture hedge fund risk exposure.
 - ⇒ model risk
- Results are very sensitive to the presence of outliers.
 - ⇒ sample risk
- Need for conditional models: factor exposure of hedge fund managers is time-varying.
 - ⇒ stationarity risk

Factor-Based Approach to HF Replication

Literature Review

Authors	Strategies	ABS/RBS	(In-sample period) In-sample results	(Out-of-sample period) Out-of-sample results
Agarwal, Fung, Loon, Naik (2005)	Convertible Arbitrage	ABS	R ² 14.67% to 55.95%	n/a
Agarwal, Naik (2004)	Convertible Arbitrage Equity Long/Short Equity Non Hedge Event Driven Relative Value Restructuring Risk Arbitrage Short Selling	ABS	(1990-2000) R ² 40.50% R ² 72.50% R ² 91.63% R ² 73.40% R ² 52.20% R ² 65.60% R ² 44% R ² 82%	(2000-2001) approximate replication of index returns (standard t-test & Wilcoxon sign-test)
Fung, Hsieh (2002)	Convertible Bond High-Yield Mortgage-Backed Arbitrage Diversified	RBS/ABS	(1990-2000) R ² 70% to 75% R ² 78% to 79% R ² 59% to 66% R ² 66% R ² 64%	n/a
Fung, Hsieh (2004)	Multi-strategy portfolio	ABS	(1994-2002) R ² 55%	n/a
Jaeger, Wagner (2005)	Convertible Arbitrage Distressed Securities Equity Long/Short Equity Market Neutral Event Driven Fixed Income Global Macro Merger Arbitrage Short Selling	ABS	(1994-2004) R ² 54% R ² 68.40% R ² 88.50% R ² 35.30% R ² 79.30% R ² 40.5% R ² 49.70% R ² 52.90% R ² 81.20%	(2003-2005) <i>RFS in % / HFRI / HFRX</i> +7.6 / +2.4 / -5.3 +20.1 / +44.8 / +23.3 +27.8 / +32.8 / +16 +6.2 / +10.9 / -3.9 +29.8 / +40 / +24.1 +7.8 / +16.3 / n/a +16.7 / +24.6 / +10.1 +13 / +15.3 / +10.9 -28.2 / -23 / n/a

Factor-Based Approach to HF Replication

Empirical Results

- In what follows, we have chosen to reproduce the results reported in Hasanhodzic and Lo (2006).
- The reason we have chosen to focus on this particular model is essentially related to the fact that it is a simple parsimonious approach that is not suspected of data mining.
- The authors have introduced a factor model based on the following 6 factors for all strategies:
 - US Dollar Index
 - Lehman Corporate AA Intermediate Bond Index
 - Spread between the Lehman Corporate BAA Bond Index and the Lehman Treasury Index
 - S&P 500
 - Goldman Sachs Commodity Index
 - First difference of the end-of-month value of the CBOE Volatility Index (removed in the out-of-sample analysis)

Factor-Based Approach to HF Replication

Empirical Results – Out-of-Sample Performance

Hedge Fund Index	Mean	SD	Min	Max	VaR
Convertible Arbitrage	0.0077	0.0108	-0.0316	0.0344	-0.0112
CTA Global	0.0053	0.0259	-0.0543	0.0682	-0.0365
Distressed Securities	0.0112	0.0125	-0.0209	0.0421	-0.008
Emerging Markets	0.0134	0.029	-0.0541	0.123	-0.0386
Equity Market Neutral	0.0066	0.0054	-0.0082	0.0253	-0.0008
Event Driven	0.0094	0.0132	-0.03	0.0429	-0.013
Fixed Income	0.0061	0.0051	-0.0092	0.0208	-0.0025
Arbitrage					
Global Macro	0.0074	0.0148	-0.0304	0.0612	-0.0114
Long/Short Equity	0.0084	0.0199	-0.0389	0.0745	-0.0213
Merger Arbitrage	0.0069	0.009	-0.0267	0.0272	-0.0095
Relative Value	0.0076	0.0089	-0.0221	0.0333	-0.006
Short Selling	0.0009	0.0537	-0.134	0.1657	-0.102
Funds of Funds	0.0077	0.015	-0.0269	0.0666	-0.014
Linear Clone					
Convertible Arbitrage	0.0027	0.0131	-0.0384	0.0406	-0.0188
CTA Global	0.0027	0.0293	-0.0724	0.0792	-0.0437
Distressed Securities	0.003	0.0164	-0.0425	0.0559	-0.0252
Emerging Markets	0.0039	0.0391	-0.1449	0.104	-0.0636
Equity Market Neutral	0.0011	0.0065	-0.015	0.0265	-0.0103
Event Driven	0.0032	0.0158	-0.0346	0.0579	-0.019
Fixed Income	0.0018	0.0102	-0.0271	0.04	-0.0122
Arbitrage					
Global Macro	0.0017	0.0166	-0.0596	0.0521	-0.0262
Long/Short Equity	0.0019	0.0202	-0.0816	0.0661	-0.0286
Merger Arbitrage	0.0025	0.0107	-0.0235	0.045	-0.0134
Relative Value	0.0019	0.0102	-0.0223	0.036	-0.0148
Short Selling	0.0031	0.0705	-0.1332	0.336	-0.0987
Funds of Funds	0.0016	0.0181	-0.0867	0.0658	-0.026

Out-of-sample results of Edhec hedge fund index replication based on Hasanhodzic and Lo's 5 factor model. Sample period is January 1997 to December 2006 (monthly returns).

Factor-Based Approach to HF Replication

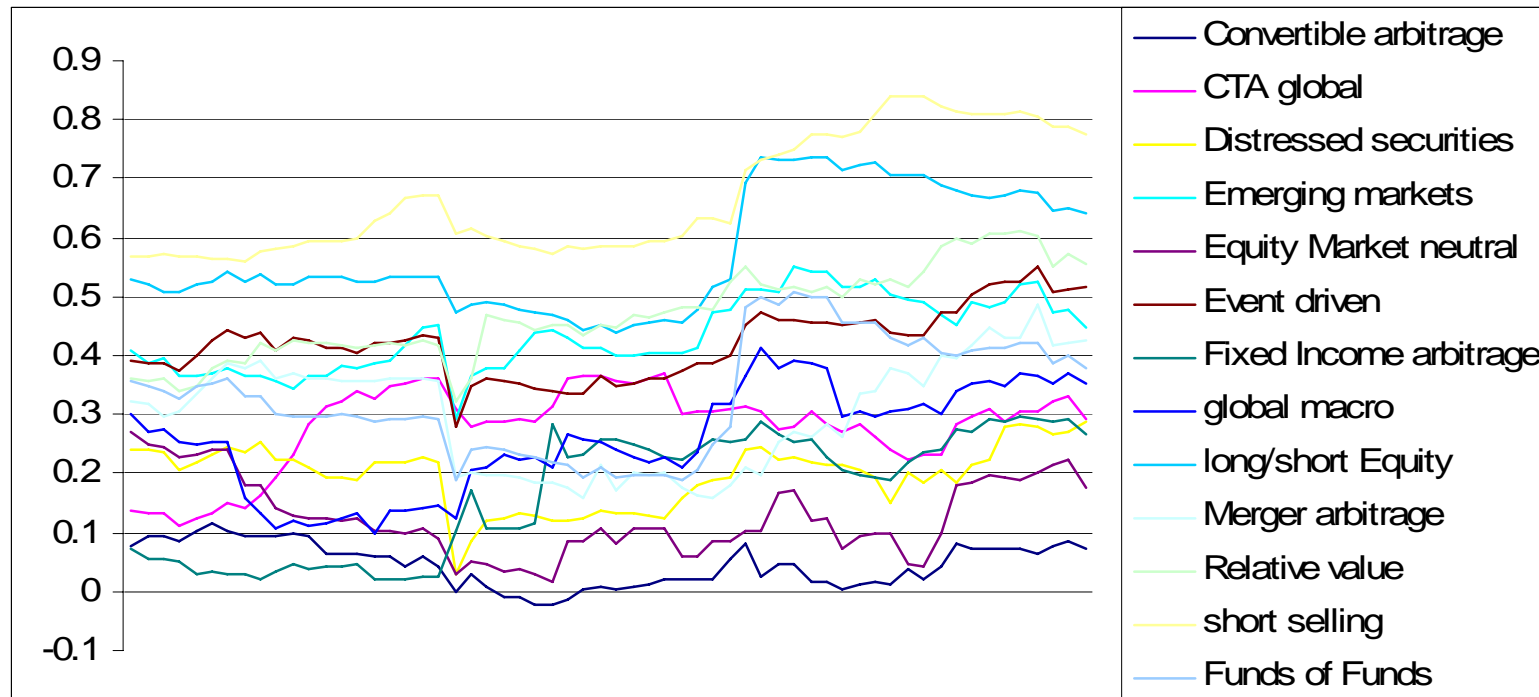
Empirical Results – Correlation & R-Squared

	Correlation	R-Squared
Convertible Arbitrage	16.28%	2.65%
CTA Global	40.99%	16.80%
Distressed Securities	31.33%	9.82%
Emerging Markets	60.22%	36.26%
Equity Market Neutral	27.41%	7.51%
Event Driven	49.76%	24.76%
Fixed Income Arbitrage	18.28%	3.34%
Global Macro	36.11%	13.04%
Long/Short Equity	61.42%	37.72%
Merger Arbitrage	31.01%	9.62%
Relative Value	43.23%	18.69%
Short Selling	71.58%	51.24%
Funds of Funds	45.35%	20.57%


Out-of-sample results of Edhec hedge fund index replication based on Hasanhodzic and Lo's 5 factor model. Sample period is January 1997 to December 2006.

Factor-Based Approach to HF Replication

Robustness Analysis



In-sample results of EDHEC hedge fund index replication based on Hasanhodzic and Lo's 5 factor model. The graph shows the time-series evolution of adjusted R2 when a 5-year rolling window is used (initial date is January 1997, final date is December 2006).

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Payoff Distribution Approach

Basic Principles

- There exists a second approach, known as the payoff-distribution approach, that merely aims at replicating hedge fund return distributions.
- This approach has been first developed by Amin and Kat (2003) in a performance measurement context.
- It is based on a (weaker) re-interpretation of the replication concept.

$$\Pr(R_t^{Clone} = R_t^{HF}) = 1 \quad (1) \quad \Pr(R_t^{Clone} < x) = \Pr(R_t^{HF} < x) \quad (2)$$

- In (1), the two variables are said equal almost surely; In (2), the variables are said equal in distribution.
- (1) implies (2) but (2) does not imply (1).

Payoff Distribution Approach

Basic Principles

- The process is simple and based on the following three-step process:
 - First: consider some underlying asset (called reserve or reference asset) and estimate the payoff function that maps the asset return into a hedge fund return.
 - Second: price this payoff function
 - Third: derive the replicating strategy
- After all, the only new thing consists in creating a payoff function that is synthetic.

Payoff Distribution Approach

Basic Principles

- To obtain the payoff function g , we note that:

$$\Pr(HF_T \leq y) = \Pr(g(Index_T) \leq y) = \Pr(Index_T \leq g^{-1}(y))$$
$$\Rightarrow F_{hf}(y) = F_{Index}(g^{-1}(y)) \Rightarrow y = F_{hf}^{-1}[F_{Index}(g^{-1}(y))]$$

- Using

$$y = g(x)$$

$$x = g^{-1}(y)$$

we finally obtain $g(x) = F_{hf}^{-1}(F_{index}(x))$

- For example, assume there is a 10% probability that an index return over a horizon $T=1$ year takes on a value higher than 20%; hence, we have that:

$$\Pr(Index_T \leq 20\%) = F_{index}(20\%) = 0.9$$

- We then define $g(20\%)$ as the value that is such that the hedge fund return to be replicated has only a 10% chance of being higher, or:

$$g(20\%) = y \text{ such that } \Pr(HF_T \leq y) = F_{hf}(y) = 0.9$$

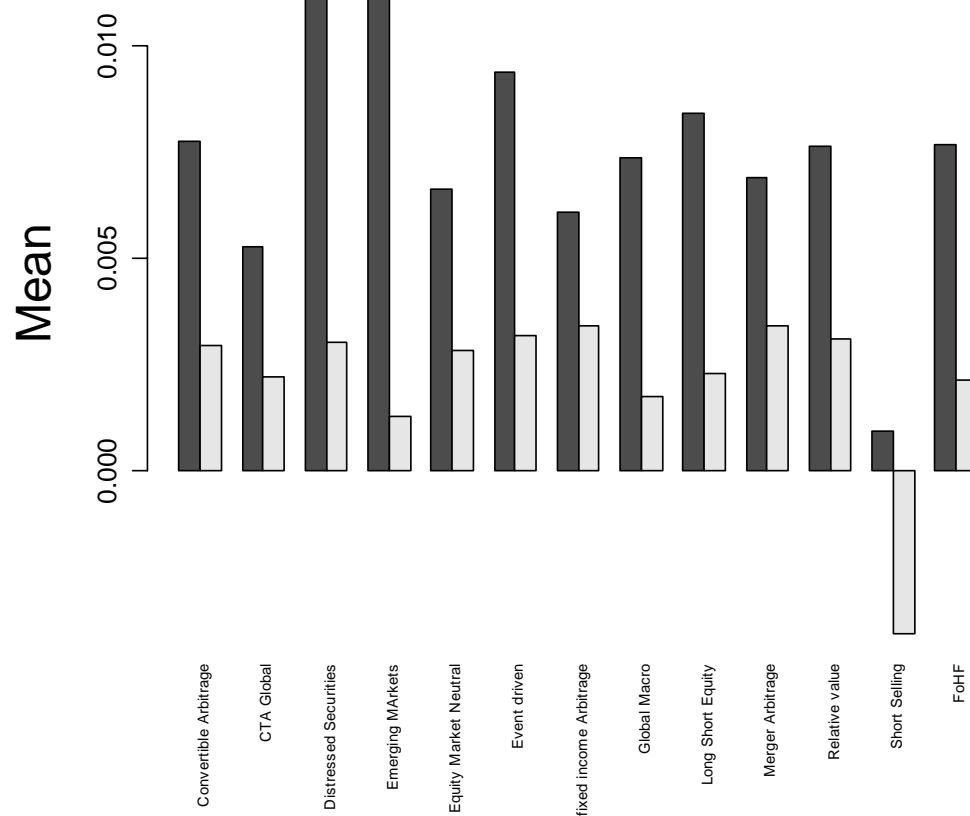
Payoff Distribution Approach

Empirical Results

- We have decided to get a better feel for the performance of their methodology.
- Application to 13 EDHEC hedge fund indices between 01/1997 to 12/2006.
- We use nearby futures contract on the S&P500 index as the reserve asset and the 3 months Eurodollar as a proxy for the risk free rate.
- For each monthly date t starting as of January 1999, we construct the payoff distribution on a sample period ranging from January 1997 the current date (excluded).
- We use Monte-Carlo analysis to price the payoffs and derive the replicating strategies (delta).

Payoff Distribution Approach

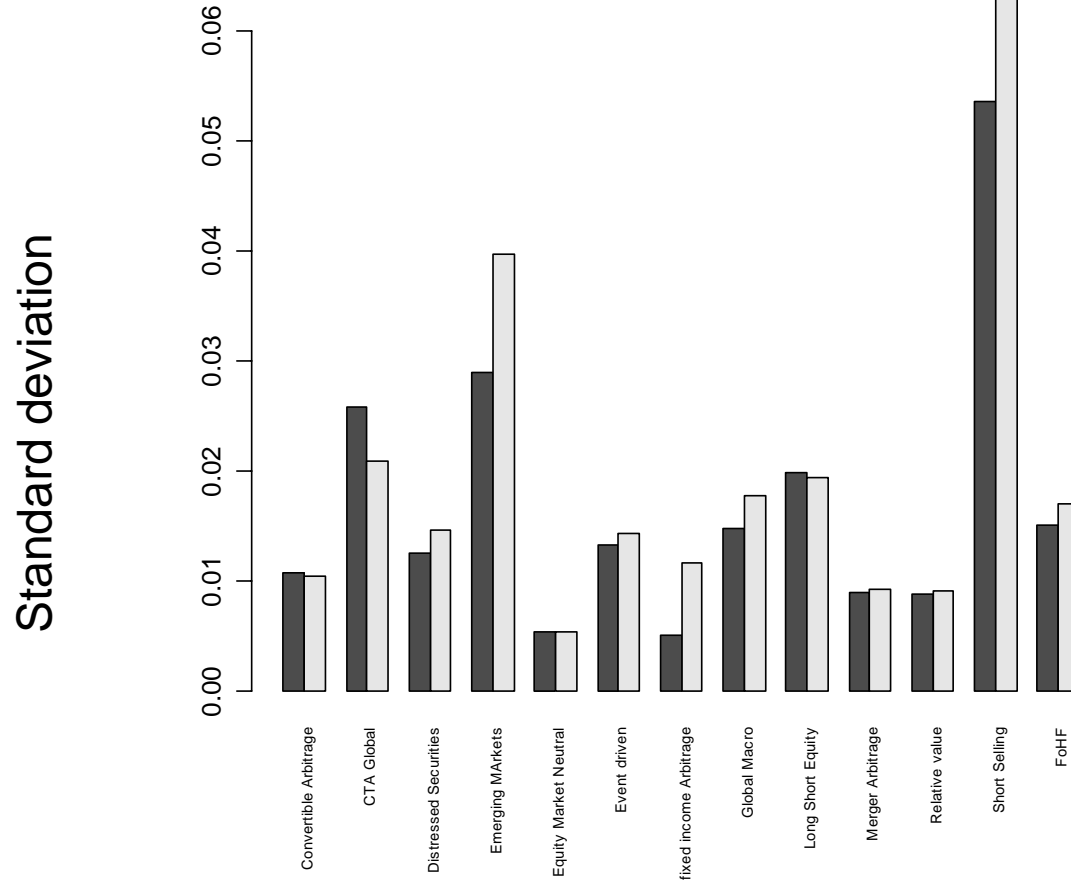
Empirical Results



- Average performance of the clones is much lower than average performance of indices.
- This is contrast to Amin and Kat, who focus on a time-period that does not include the bear equity market.
- Performance (arguably an important question for the investor!) is not controlled by the method (only higher moments are).

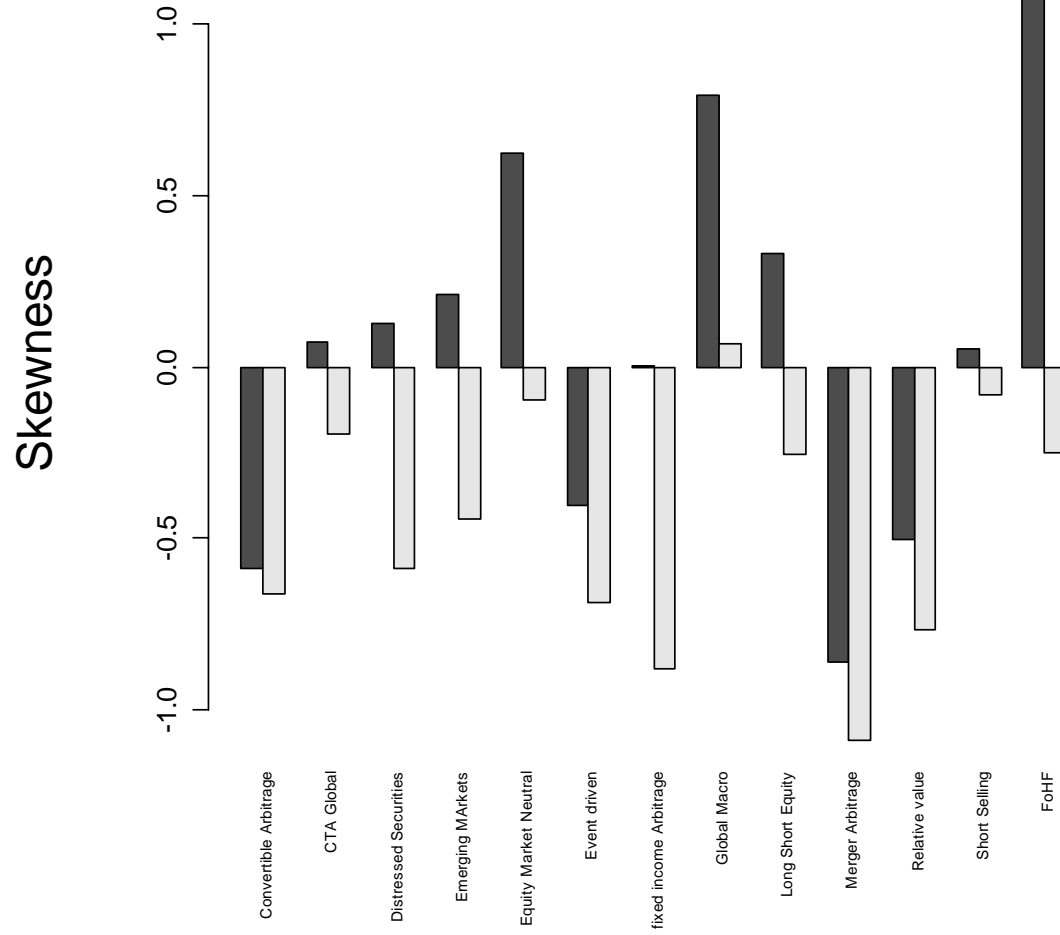
Payoff Distribution Approach

Empirical Results



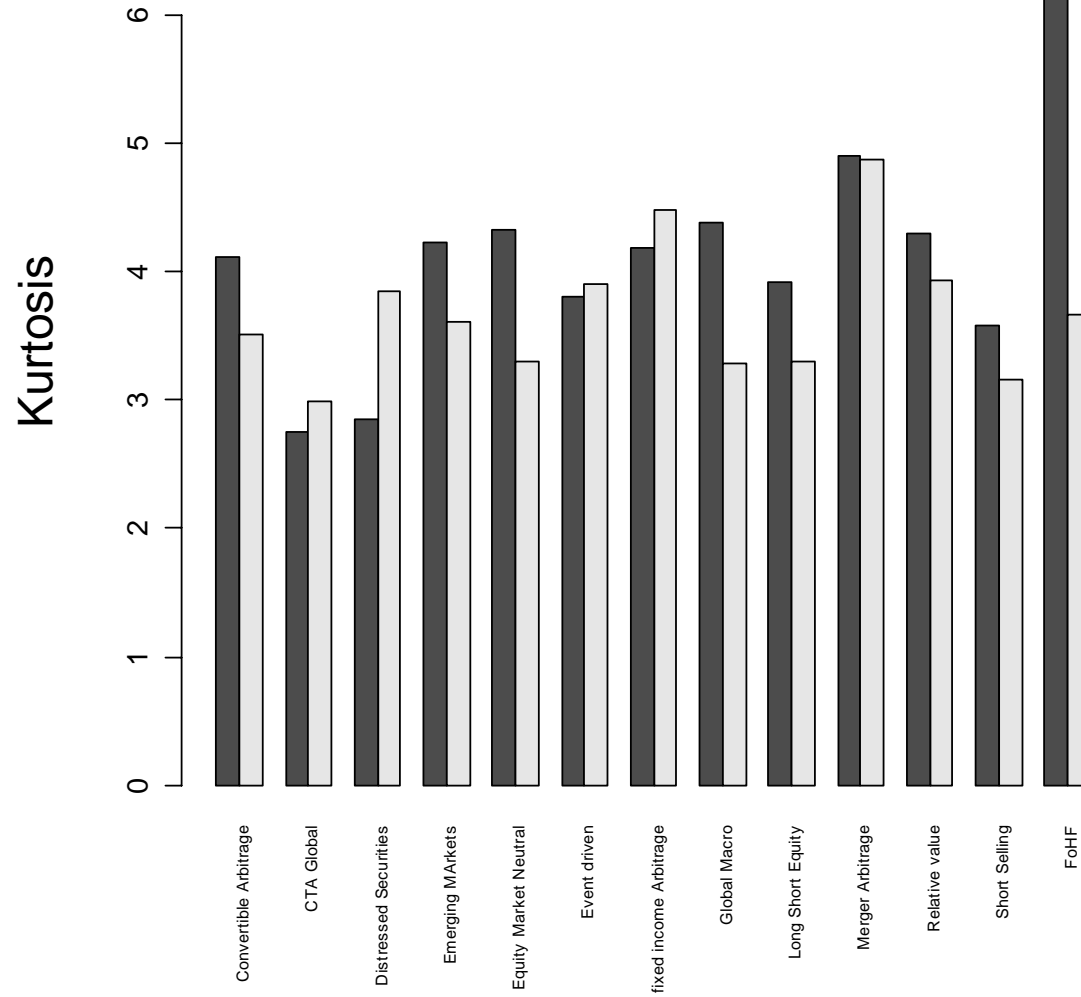
Payoff Distribution Approach

Empirical Results



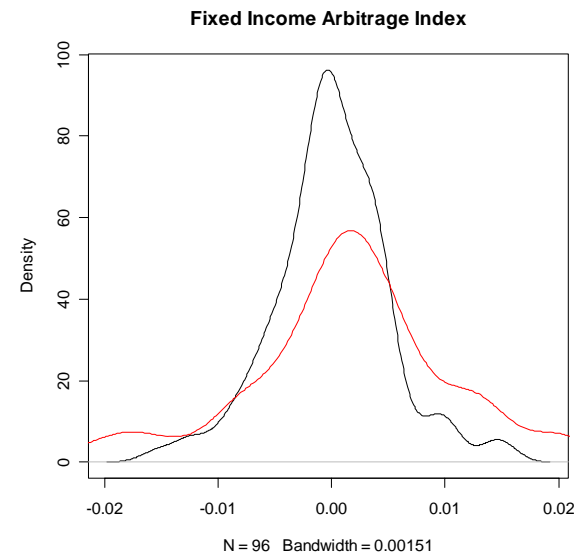
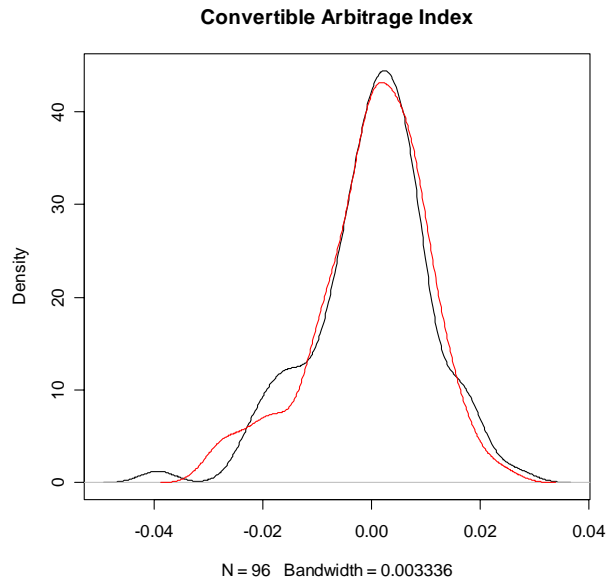
Payoff Distribution Approach

Empirical Results



Payoff Distribution Approach

Empirical Results



Best and worst distribution fits.

Watch out: distributions have been centred – mean performance can vary a lot!

Payoff Distribution Approach

Empirical Results

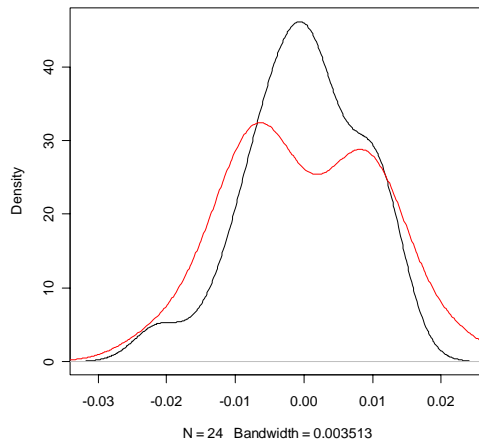
- Those results were obtained when a long out-of-sample period is used (96 monthly observations corresponds to 8 years!)
- The same methodology for a smaller out-of-sample period (01/1999 to 12/2000) leads to a rejection of the Merger Arbitrage and Relative Value indices in addition to the Fixed-Income Arbitrage index.
- We need a patient investor!

Payoff Distribution Approach

Empirical Results

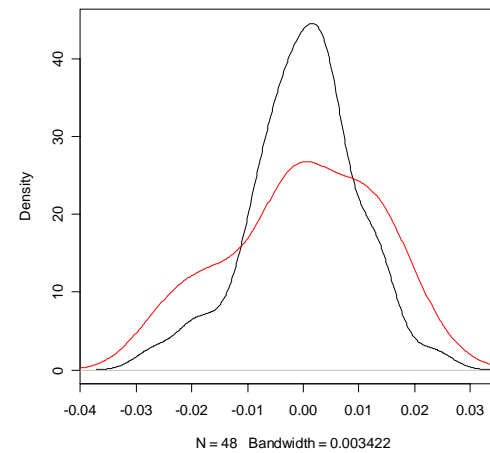
01/1999 to 12/2000

Convertible Arbitrage Index



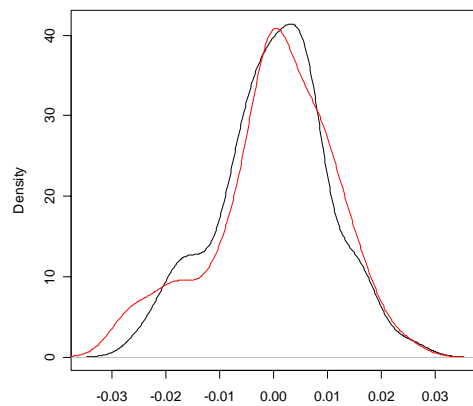
01/1999 to 12/2002

Convertible Arbitrage Index



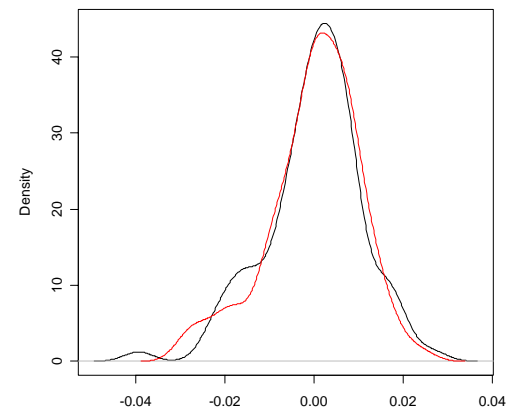
01/1999 to 12/2004

Convertible Arbitrage Index



01/1999 to 12/2006

Convertible Arbitrage Index



Payoff Distribution Approach


Empirical Results – Time-Series Properties

	Correlation between the clone and the index	R-squared of a regression of the clone return on the index return	Tracking error of the clone with respect to the corresponding index return
Convertible Bond Arbitrage	0.1402	1.97%	4.82%
CTA global	-0.1782	3.18%	12.49%
Distressed Securities	0.3701	13.70%	5.30%
Emerging markets	0.6233	38.85%	10.86%
Equity market neutral	0.3106	9.65%	2.18%
Event driven	0.5861	34.35%	4.37%
Fixed income arbitrage	0.0886	0.78%	4.28%
Global macro	0.3253	10.58%	6.61%
Long/short Equity	0.6740	45.43%	5.50%
Merger arbitrage	0.5369	28.83%	3.03%
Relative value	0.6555	42.97%	2.59%
Short selling	-0.7495	56.18%	38.79%
Funds of funds	0.4725	22.33%	5.74%

Payoff Distribution Approach

Empirical Results Time-Series Properties

- Monthly differences between replicated values and actual prices are too large to make this approach suitable for an investor aiming at replicating hedge fund returns.
- 6 indices exhibit a monthly difference higher than [-50 bps; +50 bps]!
- We also test the evolution of \$100 invested in both the Convertible Arbitrage index and in its clone.

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Conclusion

Factor-Based Replication

- Factor-based hedge fund replication models have mostly failed in thorough empirical tests to produce satisfactory results on an out-of-sample basis.
- Because of the non-linear and dynamic exposure of hedge fund returns with respect to underlying risk factors, and in the absence of a true modelling of the time-variations in these factor exposures, simple stepwise linear regression techniques, which simply match the average *past* exposures of hedge fund managers to underlying risk factors, are bound to perform poorly on an out-of-sample basis.
- Factor-approach will not work until we develop satisfactory conditional and/or non-linear factor models, which is still a subject of academic research, including ours.

Conclusion

Directions for Further Research

- A necessary condition for satisfactory hedge fund return replication is the introduction of novel econometric techniques allowing for either the statistical estimation of non-linear functions relating underlying factors to hedge fund returns, or equivalently the statistical estimation of parsimonious conditional factor models.
- While this is still very much work in progress, available results are not yet overly conclusive.
- Even if one is to remain cautious with respect to the prospects of hedge fund replication techniques, this area of research may generate useful insights for ex-post hedge fund performance evaluation and risk management for hedge fund portfolios.

Directions for Further Research

Conditional Factor Models

- Heuristic rule-based approaches
 - “Rule-based strategies” (Jaeger and Wagner 2005)
 - “Primitive trading strategies” (Fung and Hsieh 2007)
- Econometric approaches
 - Auto-regressive models (Bollen and Whaley 2007)
 - Regime-switching model (Billioy, Getmansky and Pelizzonx 2006), kalman filter models, or use of instrumental variables (Basu and Stremme 2007), Kazemi and Li (2007)

Directions for Further Research

Non-Linear Factor Models

- Heuristic attempts to introduce ad-hoc option portfolios to improve the performance of a hedge fund factor model.
 - Systematic analysis: Schneeweis and Spurgin (2000) and Agarwal and Naik (2004) (see also Fung and Hsieh 2004)
 - Specific strategies: pair trading (Gatev, Goetzmann and Rouwenhorst 2006), event arbitrage (Mitchell and Pulvino (2001)), trend-following strategies (Fung and Hsieh 2004) or fixed-income arbitrage (Fung and Hsieh (2002))
- Statistical models aiming at extracting implied option payoffs from hedge fund return observations (Diez de los Rios and Garcia 2006).

Directions for Further Research

From HF Replication to Alternative Beta Generation

- Overall, we believe that so-called hedge fund replication strategies may remain as a cost-efficient way to access alternative betas through mechanical trading strategies.
- In the end, the relevant question may not be “does hedge fund replication really work?” but instead “are such solutions useful for investors?”.

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**Stream 1A: Passive Replication of Hedge Funds:
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Chairman:

Jean-Christophe Meyfredi, Professor of Finance and Head of Department,
EDHEC Business School

Speaker:

Lionel Martellini, Professor of Finance and Scientific Director, EDHEC Risk and
Asset Management Research Centre

Panellists:

Michael Markov, CEO, Director of Research, Markov Processes International
Thomas Schneeweis, Director, Center for International Securities and
Derivatives Markets

Chris Woods, Investment strategist, Man Global Strategies

Alex Ypsilanti, Head of European Equity Derivatives Strategy, Merrill Lynch



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