Recent Advances in Hedge Funds' Performance Attribution:
Performance Persistence and Fundamental Factors

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Abstract

We survey articles on hedge funds' performance persistence and fundamental factors from the mid-1990s to the present. For performance persistence, we present some pioneering studies that contradict previous findings that hedge funds' performance is a short term matter. We discuss recent innovative studies that examine the size, age, performance fees and other factors to give a 360° view of hedge funds' performance attribution. Small funds, younger funds and funds with high performance fees all outperform the opposite. Long lockup period funds tend to outperform short lockups and domiciled funds tend to outperform offshore funds. This is the first survey of recent innovative and challenging studies into hedge funds' performance attribution, and it should be particularly useful to investors trying to choose between hedge funds.

Keywords: *hedge funds, performance persistence, fundamental factors, risk exposures*

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1   Introduction

In the hedge fund literature there are many studies dealing with performance persistence[1] along with other studies that investigate the relationship between fund

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[1] For example Ammann, Huber and Schimid (2013) and Hentati-Kaffel and Peretti (2015)

returns and fund specific characteristics such size, age and fees[2]. Although these studies use different databases and time periods, they can nevertheless provide a useful guide to investors. Investors expect performance to be stable over time and that some fund managers outperform their peers. Also funds may show an association between their returns and characteristics such as size, age, fees or other fundamental factors. Until now, there has been no survey summarizing all the results and there is no uniform conclusion on these issues, thus creating confusion for investors. Consequently, the present study closes an important gap. The aim of this study is to survey the literature and investigate hedge fund performance in terms of (*i*) return persistence and (*ii*) the relation of fund returns to fund characteristics (fundamental factors) such as size, age, fees and other factors (e.g. lockup and domicile factors as explained in section five). This is the first survey and synthesis of older literature to provide a historical perspective, together with information from recent innovative studies to delineate advances in performance persistence and the attributes of individual hedge funds. Our findings both assist hedge fund investors and unravel opportunities for further research, as we describe later. Despite the difference in studies, there are some consistent trends and patterns that reveal useful aspects about hedge fund behaviour in terms of performance persistence and the relation between performance and fund characteristics.

Our main conclusions are that early studies (e.g. Agarwal and Naik, 2000a, Bares, Gibson and Gyger, 2003) showed that there is short term persistence (less than a year). Moreover, there is evidence that some non-directional strategies (e.g. e.g. Convertible Arbitrage or Merger Arbitrage strategies) present more persistence than directional strategies (e.g. Long Only or Short Bias strategies). The difference in persistence is mainly related to the type of strategy each fund follows. However, some later studies (e.g. Kosowski, Naik and Teo, 2007; Jagannathan, Malakhov and Novikov, 2010; Amman, Huber and Schmid, 2013) have challenged the above studies and showed that there is persistence beyond one year and possibly up to five years. Concerning the fundamental factors and fund returns, most studies show that there is a negative relationship between fund size and performance. Regarding the age factor there is a clear negative relationship between age and performance. There is also a positive

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[2] E.g. Frumkin and Vandegrift (2009); Joenvaara, Kosowski and Tolonen (2012); Bae and Yi (2012)

relationship between incentive fees and fund performance. Funds imposing lockups outperform funds that do not impose lockups and on-shore funds outperform off-shore registered funds.

Our paper makes a number of important contributions to the understanding of the literature. First of all, we close a gap by presenting a survey that summarizes all the results concerning hedge fund return persistence and the relation between fund characteristics and fund returns. In addition, we present a historical perspective by combining older and newer, innovative studies. Thus the reader is able to observe the dynamic nature of the literature in explaining fund return persistence and fund returns according to the underlying fundamental factors. Our study helps investors in their asset allocation process as it enables them, firstly, to assign the appropriate weight (according to their needs) in fund selection based on their past returns. Secondly, it enables them to know what to expect from funds with different characteristics. Moreover, we have identified some gaps for future research, such as the absence of a unified framework that examines the effect of fundamental attributes and their interactions on hedge fund performance. We detail these research opportunities in the Conclusion.

In section 2 we provide a necessarily brief overview of the hedge fund industry. Section 3 describes the different categories of models for hedge fund returns. Section 4 surveys the literature on hedge funds' performance persistence and section 5 covers the literature that seeks to explain hedge fund returns using their characteristics. In these two parts we review all these issues and then discuss some logical observations about the underlying studies. In the final section 6 we present and summarize the key conclusions and reveal some gaps that should be covered in future research.

2   The Hedge Fund Industry

In this section we briefly introduce the reader to the hedge fund industry, as an extensive analysis would be outside the scope of this paper. We first look at some issues to do with the nature of hedge funds and their different characteristics in relation

to more traditional investments. We then present the composition and growth of the hedge fund industry in terms of assets under management and returns.

2.1 An Idiosyncratic Industry

Hedge funds are private in nature and all the characteristics of the hedge fund industry derive from this. These investment vehicles are not accessed by the general public and are largely unregulated by the SEC. Therefore fund managers are not obliged to disclose information to investors and authorities as other conventional investments (e.g. mutual funds) are. Consequently, there is no transparency and as far as the compensation structure is concerned, hedge funds rely mostly on incentive fees. On average, fund managers receive a one percent annual management fee on AUM (assets under management) and 20 percent annually on any profits. Most funds use a bonus incentive fee (called the "high-water mark").

Fund managers are able to exploit a wide range of "toolkits" such as buying and selling using a cash account, buying on margin, short selling and securities lending, leverage (borrowing) and derivatives. A cash account is the simplest and most common form of transaction because there is no further commitment, as such transactions do not involve any loan or require any collateral.

The hedge fund industry is very competitive and demanding as it focuses on providing accredited investors with the best possible performance. There are many categories and strategies of hedge funds depending on their investment style/strategy and/or region that invest in. Unfortunately, there is no universal classification scheme for hedge funds. In the literature there are several classification schemes (e.g. Tran, 2006; Kosowski, Naik and Teo, 2007 or Bali, Brown and Caglayan, 2011) or those provided by the various private database vendors. A hedge fund may have many structures (e.g. Limited Liability Company or Partnership, Onshore or Offshore) and require many service providers to operate.

The hedge fund industry is complex by its nature and investors cannot easily cope with this when evaluating hedge funds unless they have specialized knowledge and access to specific information. Hedge funds do not provide full information disclosure (not

only about the fund itself but sometimes about the fund management team, as well) and there are many benchmark indices in the market, thus making investors' decision processes even more difficult. However, one aspect that investors try to rely on in their asset allocation process is fund performance persistence and the relation between fund returns and fund characteristics. Hence, in this survey we summarize all the results concerning hedge fund return persistence and the relation between fund characteristics and fund returns, which should be particularly useful for investors trying to choose between hedge funds.

2.2 Industry Growth in Assets Under Management

The decade to 2015 has seen considerable growth in the hedge fund industry. Except for 2008 and 2011 all the other years were profitable. As of 2015Q2 total assets under management for hedge funds were more than $2.7 trillion. This figure does not include Fund of Funds and Commodity Trading Advisors (CTAs) that account for approximately $500 billion and $330 billion respectively. In Figure 1 we provide some numbers for assets under management (AUM) as of 2015Q2. We can observe that four strategies (Fixed Income, Multi-Strategy, Emerging Markets and Event Driven) account for 51 percent of the total AUM. On the contrary, the four least popular strategies (Convertible Arbitrage, Merger Arbitrage, Equity Market Neutral and Other) account for only seven percent of the total AUM. As we will see in section four, some non-directional strategies (e.g. Convertible Arbitrage, Merger Arbitrage, Relative Value or Event Driven) and Emerging Market strategies demonstrate more persistence than aggressively directional strategies (e.g. Global Macro, Long Short, Long Only or Short Bias strategies).
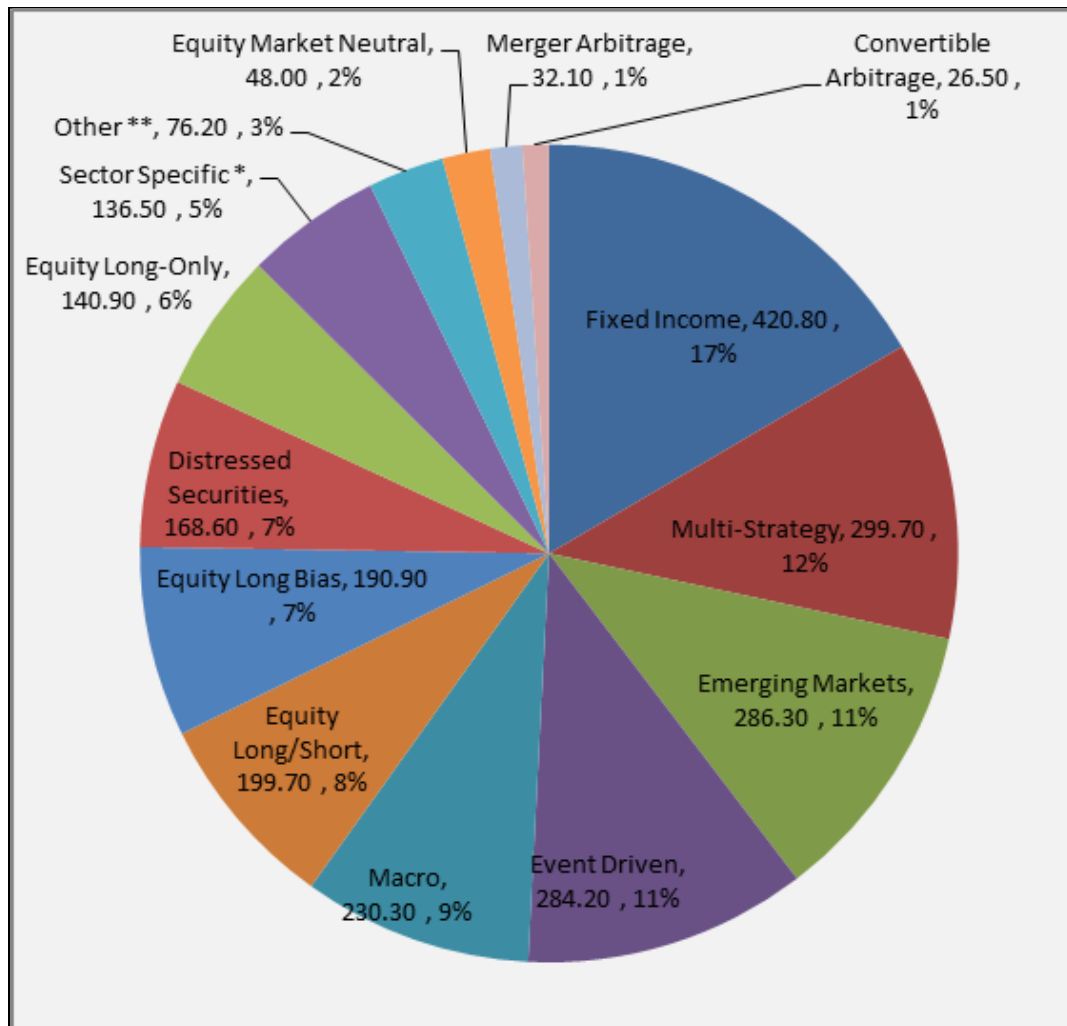
Assets Under Management (USD Billions)

Figure 1: Assets allocated per strategy (source: BarclayHedge, 2015)

Currently the number of hedge funds is more than 10,000 globally. The growth in the hedge fund industry is due to the appreciation of assets and new money entering the industry. In Figure 2 we present the historical growth of the assets for non-directional strategies. We observe that during the early 2000s there was substantial growth in the industry, reaching its peak before the financial crisis in 2008. After the 2008-9 losses we observe this significant growth in assets continuing.

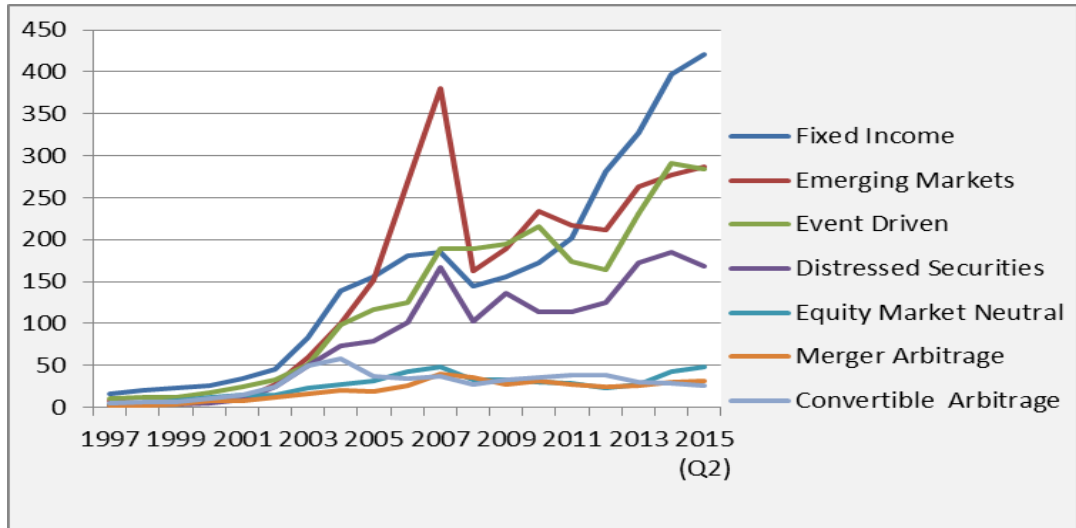Hedge Fund Industry AUM – Non Directional Strategies

Figure 2: Non-directional strategies Assets Under Management (source: BarclayHedge, 2015)

In Figure 3 we present the historical growth in assets for directional strategies. We observe that during the early 2000s there was substantial growth in the industry (more than in non-directional strategies) that reaching its peak before the financial crisis in 2008. Again, the 2008-9 losses have largely been made up (or more) by 2015.
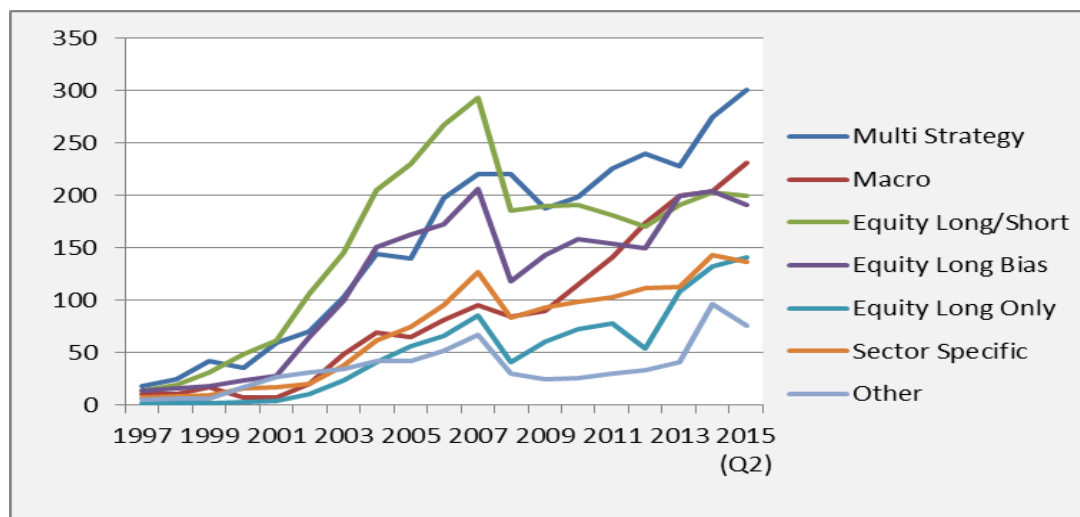
Hedge Fund Industry AUM – Directional Strategies

Figure 3: Directional strategies Assets Under Management (source: BarclayHedge, 2015)

2.3 Returns

In Figure 4 we present accumulated returns for indicative non-directional strategies. (In general, figures in this section provide indicative-only information on the hedge fund industry as an extensive representation and analysis would be out of the scope of this paper.) We observe that from late 1999 to 2015(Q3) the average investor could have earned between 3.1 and 4.2 times her initial capital. The indices were moving upwards for the whole period except for 2008 (financial crisis) and 2011 (Eurozone crisis). This reduction in returns coincides with the reduction in AUM, particular in 2008.

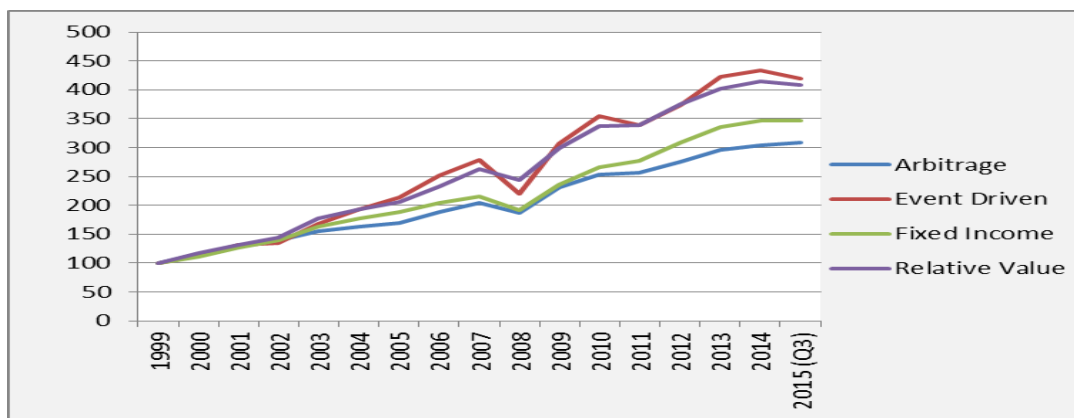Hedge Fund Industry Returns – Non-Directional Strategies

Figure 4: Strategy Indices, Base=100 (Dec 99) (source: Eurekahedge, 2015)

Finally, in Figure 5 we present accumulated returns for indicative directional strategies. From late 1999 to 2015(Q3) the average investor could have earned between 3.8 and 4.4 times her initial capital. These returns are higher than those of non-directional strategies because directional strategies are usually more aggressive, having higher volatility than non-directional strategies. As for non-directional strategies, the indices were moving upwards for the whole period except for 2008 and 2011.

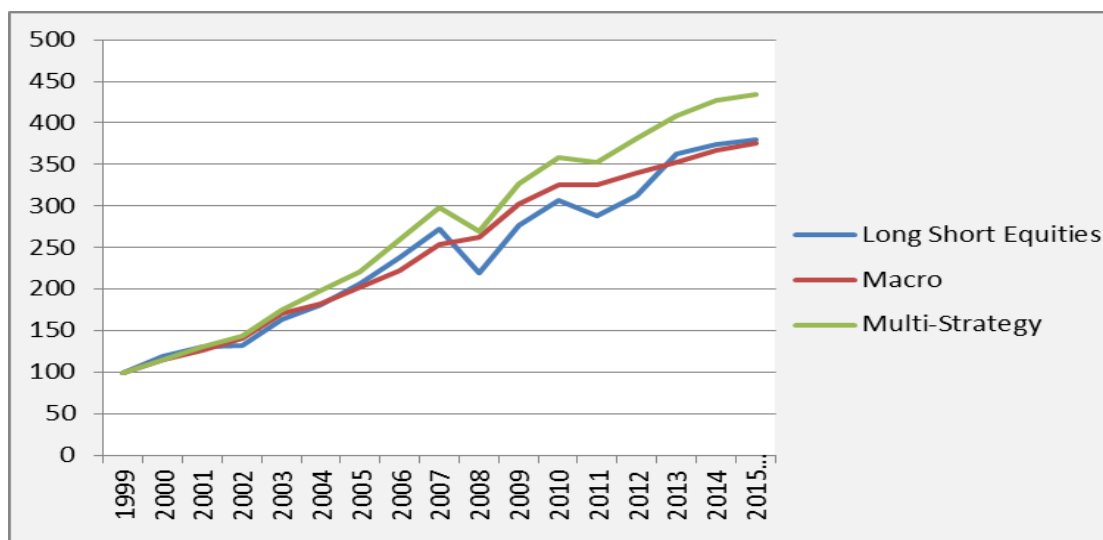Hedge Fund Industry Returns- Directional Strategies

Figure 5: Composite Index, Base=100 (Dec 99) (source: Eurekahedge, 2015)

3 Categorising Models of Hedge Fund Returns

In this section we present a general overview of the various types of hedge fund models that are applied to all hedge funds. Each type of model represents a different approach to measuring the performance of all hedge fund strategies. In general, asset pricing models are divided in two main categories (Lhabitant, 2004): (*i*) absolute pricing models and (*ii*) relative value models. The first category includes fundamental equilibrium models and consumption-based models in conjunction with many macro-economic models. All the models that we mention in this section refer to the category of relative price models which price or evaluate hedge funds relative to market or any other risk factors.

Amenc, Sfeir and Martellini (2003) recorded four categories of factor models. These are:

(1) *Explicit macro factors*: These are macro-economic variables that are computed either as predictive variables or used ex-post to measure market sensitivities with regard to particular macroeconomic parameters.

(2) *Explicit index factor model*: The underlying factor of these models is investable and reflects some index or fund available as a futures contract or ETF (Exchange Traded Fund).

(3) *Explicit micro factor models*: These microeconomic parameters (or variables) reflect fund-specific features that are estimated and forecast in a similar manner to the explicit factor models. We discuss this perspective in this paper.

(4) *Implicit factor models*: These implicit factors are extracted through Principal Component Analysis (PCA) or Common Factor Analysis (CFA) and are considered a purely statistical approach.

A similar classification is proposed by Connor (1995) with three categories of factor models that are available for examining asset returns. These are: *Macroeconomic factor models, Fundamental factor models* and *Statistical factor models*.

Regarding the statistical or implicit factor models there are two widely-used methodologies that are used to identify the underlying factors: (i) *Principal Component Analysis (PCA)* and (ii) *Common Factor Analysis*. PCA was invented by Pearson (1901). The purpose is to justify the return series of observed variables via a smaller group of non-observed implicit variables or principal components. The second methodology, common factor analysis, is similar to PCA in that it transforms a number of correlated variables into a smaller number (dimensionality reduction) of uncorrelated variables, that is, factors. However, there is a great difference with PCA. Here, the selected factors are observable and clearly decided by a combination of confirmatory and/or explanatory analysis. They are not just implied by the data. As with PCA the number of factors should be kept as small as feasible in order to have the advantages of dimensionality reduction.

Explicit micro-factor models are selected factors that refer to fund specific features, such as size, age, fund manager tenure and performance fees. As we discuss below (section five), there are many studies that deal with that issue.

4 Performance Persistence

Performance persistence is one perspective by which we can evaluate hedge funds. Other perspectives include hedge funds biases that are inherent from various databases, hedge funds as portfolio diversifiers and hedge funds' survivability. Other authors have tried to explain and evaluate hedge funds using risk-adjusted returns and volatility, and also multi-factor models (that we mentioned earlier) showing their low or negative correlation with market indices. In this section we review studies that cover performance persistence.

4.1 Evaluating Performance Persistence

The term 'Performance Persistence' is used to denote how steady hedge funds' performance is. In other words, how constantly hedge funds perform in a positive or negative manner. Performance persistence is usually measured in the short term (less than or equal to a year) and long term (more than a year).

There are many studies concerned with hedge fund performance persistence and we present some of them. Most pre-2007 findings argued that there is short term performance persistence (from one to three months). At most persistence lasts up to one year. However, beyond this there appears to be no persistence. Also some strategies appear to be more consistent than others. This is intuitive especially for non-directional strategies. However, during the last five years some studies, using more advanced econometric methods, have found that there is long term performance persistence. In some cases the performance persistence reaches up to five years. Below we analyse and critique the relevant studies in detail. We look at short-term persistence in returns, long-term persistence and then how researchers or investors can best exploit what is known. Table 1 shows the relevant studies.

Table 1. Performance Persistence

This Table presents the main characteristics and results of the studies on hedge fund performance persistence. Abbreviations: CISDM: Centre for International and Securities Markets, GMM: Generalized Method of Moments, GR: Generalized Runs Tests, HFR: Hedge Fund Research, Lipper/TASS: Tremont Advisory Shareholders Services, MSCI: Morgan Stanley Capital International, SDI: Strategy Distinctiveness Index. Some databases (e.g. Lipper and TASS) have been merged.

Study	Sample	Methodology	Results
Agarwal, V. and Naik, N. (2000a)	HFR, 1982-1998	Regression, chi square, cross product ratio, Kolmogorov Smirnov	Persistence at quarterly horizon
Agarwal, V. and Naik, N. (2000b)	HFR, 1995-1998	Regression, cross product ratio	Persistence at quarterly horizon
Ammann, M. Huber, O. and Schmid, M. (2013)	Lipper/TASS and CISDM, 1994-2008	Panel probit regression	Persistence up to three years
Bae. K.H. and Yi, J. (2012)	TASS, 1994-2008	Probit regression, comparison of rankings	Persistence at least yearly
Bares, P.A., Gibson, R. and Gyger, S. (2003)	FRM, 1992-2000	Regression, benomial representation, comparison of rankings	Persistence up to three months
Brown, S. and Goetzmann, W. (2003)	TASS, 1989-1999	Regression	Persistence at less than a year
Capocci, D. (2009)	HFR, MAR, TASS, Barclays, 1995-2002	Regression, comparison of rankings	Persistence at less than a year
Capocci, D. and Hubner, G. (2004)	HFR and MAR, 1984-2000	Regression, comparison of rankings	Persistence at less than a year
Eling, M. (2009)	CISDM, 1996-2005	Regression, chi square, cross product ratio, Spearman, Kolmogorov Smirnov	Persistence up to six months
Harri, A. and Brorsen, B. (2004)	LaPorte Asset Allocation, 1977-1998	Regression, Spearman	Persistence up to four months
Hentaki-Kaffel, R. and Peretti, P. (2015)	HFR, 2000-2012	Regression, GR tests	Persistence less than a year
Jagannathan, R., Malakhov, A. and Novikov, D. (2010)	HFR, 1996-2005	Regression-GMM	Persistence over three years
Joenvaara, J., Kosowski, R. and Tolonen, P. (2012)	BarclayHedge, EurekaHedge, HFR, Morningstar and TASS, 1994-2011	Contingency table, regressions, comparison of rankings	Persistence up to one year
Koh, F., Koh, W. and Teo, M. (2003)	Eurekahedge and AsiaHedge, 1999-2003	Cross product ratio, chi square, Kolmogorov Smirnov	Persistence up to quarter
Kosowski, R., Naik, N. and Teo, M. (2007)	TASS, HFR, CISDM and MSCI, 1990-2002	Bayesian approach, bootstrap approach, regression	Persistence over a year
Park, J., Staum, J. (1998)	TASS, 1986-1997	Chi square, Spearman	Persistence at yearly horizon
Wang, A. and Zheng, L. (2008)	TASS, 1994-2007	Regression, SDI	Persistence up to five years

4.1.1   Short-Term Persistence

In their early study Park and Staum (1998) examined hedge fund performance persistence using the TASS database from 1986 to 1997. They used regressions taking into consideration non-adjusted returns for the risk-free rate. More specifically they used the ratio α/σ where α is the return in excess of an index benchmark and σ the standard deviation of the fund. They found that there is performance persistence for a year. That element could give some indication of future performance. However, the strength of the persistence seemed to vary substantially from year to year. Similar results were also found for CTAs (Commodity Trading Advisors).

In their research, Agarwal and Naik (2000a) investigated the extent of pre-and post-fee hedge funds persistence from 1982 to 1998 using the Hedge Fund Research database. They used a multi-period framework and the traditional two-period framework. Within the former there is less likelihood that the observed persistence will be by chance. They also measured whether the persistence is sensitive due to returns measured over quarters (short term) or over years (long term). Finally, they investigated whether fees affect the degree of persistence observed among hedge funds.

Regarding their methodology, they used regression-based (parametric) and table-based (non-parametric) methods. In the first approach, they regressed alphas (appraisal ratios) during the current period against those of the previous period. A positive slope coefficient means that a hedge fund that performed well in the previous period, performed well also in the given period. For the second methodology they constructed a contingency table of winners and losers. In this table, a hedge fund is considered a winner if the alpha of that fund is higher than the median alpha of all the hedge funds that follow a comparable strategy, in that specific period. Otherwise that hedge fund is a loser. The techniques were a cross-product ratio/CRP and Chi-square statistic.

Agarwal and Naik (2000a) found a substantial amount of persistence at the quarterly horizon. This characteristic weakened as they moved to yearly returns. Hence, hedge fund persistence is mainly short term in nature. The persistence did not appear to be related to the type of strategy followed by the hedge fund. The degree of persistence

realized in a multi-period framework was significantly smaller than that realized based on the traditional two-period framework. Moreover, the multi-period framework had almost no persistence when examined in relation to yearly returns. Short term persistence was not affected by the imputation of performance fees.

In the same year, Agarwal and Naik (2000b) using the HFR database from 1995 to 1998 examined hedge fund persistence using parametric and non-parametric methods. More specifically, they used similar approaches in their (2000a) study such as regression-based (appraisal ratios) and contingency-table-methods of winners and losers with the cross-product-ratio/CPR statistic. They had similar results to their previous study, showing that there is persistence mainly at a quarterly horizon in various hedge fund strategies: fund losers continue to be losers instead of winners continuing to be winners.

Similarly, Bares, Gibson and Gyger (2003) examined the performance persistence of hedge funds across short and long term investment horizons using the Financial Risk Management (FRM) database from 1992 to 2000. They relied on non-parametric tests. They regarded a fund as a winner a fund if its performance was above average for a given period and the opposite for a loser. They found that the Specialist Credit and Relative Value strategies were the most persistent strategies (they contained the highest percentage of managers who were continuously outperforming their median peers). This is different from Agarwal and Naik (2000a) who found that persistence did not pertain to any type of strategy. Nevertheless, that persistence disappeared rapidly as the time horizon extended. The authors also analysed the duration of performance persistence. They observed significant short term (one to three months) persistence.

In the same year, an interesting study from Koh, Koh and Teo (2003) examined Asian hedge funds regarding their style, fund characteristics and persistence. They used the databases of EurekaHedge Advisors Pte Ltd (now Eurekahedge) and HedgeFund Intelligence (hereafter AsiaHedge). The data sample was from 1999 to 2003. Using two-period and multi-period tests (Kolmogorov-Smirnov statistic), they found that Asian hedge funds' returns persisted more vigorously at monthly periods to quarterly

periods. That persistence diminished considerably after lengthening the measurement time interval beyond a quarter did not seem to be because of the charging of fees.

Harri and Brorsen (2004) used data from 1977 to 1998 provided by LaPorte Asset Allocation. They examined hedge fund persistence and the relation between fund size and performance. They identified seven styles of hedge fund strategy: global, global macro, sector, market neutral, short sales, event driven and long only. Also, there were two categories of Fund of Funds (FoF): U.S. and offshore FoF. The authors used three alternative methodologies: (*i*) a regression between current returns and past returns, (*ii*) a style analysis resembling Sharpe (1992) and Fung and Hsieh (1997) and (*iii*) a sample test using Spearman rank correlation. They found an indication of short-term performance persistence for almost all styles apart from short sales. However, the performance persistence was small. There was a need for a large number of observations and rigorous techniques were necessary to detect it despite the fact that they used data covered a long period of time and used three alternative methodologies. Their results were very similar to those of Agarwal and Naik (2000a) who similarly found some performance persistence in hedge funds except from short-sales strategies. The styles that showed the largest persistence were market neutral and the two FoF styles (U.S and offshore FoFs). Global, global macro and event driven also showed some performance persistence. Agarwal and Naik (2000a) also discovered that some hedge fund styles exhibited greater performance persistence than others.

In the same vein, one study considering a long period of hedge funds returns was by Capocci and Hubner (2004). They examined hedge fund performance using the HFR and MAR databases from 1984 to 2000. They found (using 10 and 14-factor regression models) that the top performer funds followed momentum strategies whereas the bottom performers followed contrarian strategies (and significantly invested in emerging markets bonds, unlike top performers). Also, there was no performance persistence for the best and worst performing hedge funds. By contrast, there was performance persistence in the middle quintile of funds. In addition, funds that experienced average returns often bought high book-to-market stocks. Conversely, those funds that were the best and worst performers were in favour of low book-to-market stocks. Concerning strategies, they found that two of them systematically out-performed markets: Global Macro and Market Neutral, which out-performed the

market for 1994 to 2000. However, there is a concern about the statistical reliability of return observations for the period from 1984 to 1993 due to survivorship and instant history biases (there is lack of data for funds that were dissolved prior to 1994 in the databases).

Extending his previous study (Capocci and Hubner, 2004) and using the same methodology but adding two more databases (TASS and Barclays), Capocci (2009) considered criteria that enable hedge funds to outperform equities and bond indices over bull and bear markets. The period was 1995-2002 (that contained the peak of the NASDAQ composite index). The evaluations used include the returns, the volatility, the Sharpe score, the alpha, the beta, the skewness and the kurtosis. He found that hedge funds with stable returns and low volatility and/or low exposure to the market were able to significantly outperform the market indices in a consistent way under all market conditions.

In the same year, another very important study of performance persistence was from Eling (2009). He reviewed a number of studies into hedge funds' performance persistence. Jointly evaluating these results showed him that there was hedge fund persistence for short time periods of up to six months. However, the longer the time period, the lower the significance of hedge fund performance persistence. Eling additionally presented an empirical study of hedge funds' performance persistence.

Eling used data from CISDM and six different methodologies (cross-product ratio test (CPR), chi-square test (CS), rank information coefficient (RIC), Spearman rank correlation (SRC), cross-sectional regression (CSR) and Kolmogorov-Smirnov test (KS)). The data sample was from 1996 to 2005. He considered 18 hedge fund strategy groups with six time horizons: monthly, bimonthly, quarterly, half-yearly, yearly and two-yearly. He also considered six performance measures (raw returns, Sharpe ratio, two versions of alpha and the two associated appraisal ratios).

Most of the tests showed high levels of persistence for horizons of up to six months. The persistence levels weakened slightly as the time horizon was extended beyond six months. However it is important to mention that the level of persistence varied widely depending on the methodology. Eling confirmed the conclusions of Agarwal and Naik

(2000a) that the level of performance persistence realized in a multi-period framework is substantially smaller than that noticed in a two-period framework.

Eling found differences in performance for different hedge fund strategies. The Convertible Arbitrage and Emerging Markets strategies had very high levels of persistence. In contrast, strategies such as Equity Long Only had smaller levels of significance. Furthermore, Merger Arbitrage and Sector strategies preserved their high levels of significance across time horizons, contrary to all the other strategies where the significance level decreased as Eling extended the time horizon. Eling concluded that hedge funds' performance persistence is related to the specific style of fund management (they found that 20% of the cross-sectional variability of funds' returns can be attributed to the style management).

Concerning the performance measures and their relation with performance persistence, Eling found that there are small differences in the levels of significance among these different performance measures. The persistence significance levels weakened as he extended the horizon. However, the appraisal ratios keep a very stable level of significance. It appears that the level of hedge fund performance persistence is not associated with the choice of performance measure.

An important study that first challenged all the above studies is from Kosowski, Naik and Teo (2007). They used four databases: TASS, HFR, CISDM and MSCI. The sample period was from 1990 to 2002. Exploiting a bootstrap procedure, they found that the best hedge fund performance cannot be justified by chance. Furthermore, there is hedge fund performance persistence at annual horizons. In addition, using Bayesian measures they overcame the negative issue of the short sample period (many of the top funds have very short return histories so produced alphas overestimate the performance of top funds and underestimate the performance of the bottom funds). Kosowski *et al*. argued that early researchers imprecisely measured performance and relied too much on the frequency probability of returns in short periods. That is, they focused too much how returns behaved in short time periods.

The authors took into consideration other explanations of the persistence results (persistence in fees or short-term serial correlation in returns), but found evidence of

inconsistency in these justifications. For example the evidence for persistence is weaker for hedge funds with high inflows. Last but not least, hedge fund performance persistence is stronger for some hedge funds strategies such as Long/Short Equity, Directional Traders, Relative Value and Fund of Funds.

A recent comprehensive study with similar results to Kosowski *et al.* (2007) is from Joenvaara, Kosowski and Tolonen (2012) that used five databases from 1994 to 2011. The databases were BarclayHedge, EurekaHedge, HFR, Morningstar and TASS. They considered three periods: Quarterly, semi-annual and annual. They found marginally significant performance persistence at annual horizons. In detail, small funds showed persistence even at an annual horizon, whereas short-term persistence was difficult to exploit due to share restrictions (lockup, notice and redemption periods). Larger funds' persistence is much weaker. They emphasized the effects of database differences and biases in hedge funds' average performance persistence and cross-sectional relations between funds' characteristics and risk-adjusted returns. They documented that hedge fund performance, persistence and cross-sectional differences are sensitive to the choice of database. Also, performance persistence is sensitive to share restrictions, fund size, rebalancing frequency and weighting schema.

Hentati-Kaffel and Peretti (2015) used the HFR database from 2000 to 2012 to analyse the statistical properties of hedge fund returns in terms of randomness. They used the generalized runs test which allows checking for the null of randomness (i.e. no persistence), against a broad and undefined alternative including structural breaks or first and second-order dependence. They found that less than 50 percent of the sample was based on independent, identically distributed random variables but that this behaviour depended on the strategy. Under their new framework which deals with randomness and the persistence of hedge fund returns, greater persistence allowed some strategies (e.g. Relative Value or Event Driven) to be clustered better than other funds (e.g. Equity Hedge and Macro Strategies).

To sum up, the overall view is that short term persistence exists (Agarwal and Naik, 2000a; Bares *et al.,* 2003) but seems that non-directional strategies show persistence more clearly (Bares *et al.*, 2003; Eling, 2009). More details concerning the nature of this short-term persistence are still emerging, for example there is differential

persistence between different strategies (Harri and Brorsen, 2004; Eling, 2009) and between different fund characteristics such as size (Joenvaara, Kosowski and Tolonen, 2012).

4.1.2   Long–Term Persistence

An innovative study came from Wang and Zheng (2008) who first introduced the 'Strategy Distinctiveness Index' (SDI). They examined the TASS database from 1994-2007 using regression analysis (with the Fung and Hsieh 7-factor model, the Carhart model and Fama-MacBeth analysis). The SDI index is a measure of a hedge fund's distinctiveness and is based on historical return data. They found a substantial cross-sectional variation in SDI and a strong persistence in fund SDI for up to five years. Their results also showed that, on average, higher SDI is linked with better performance. Furthermore, their results showed that smaller funds, younger funds and funds containing higher incentive fees display higher SDI. Ultimately, there is evidence that the SDI index is an indicator of the fund manager's innovation and could be used by investors.

A recent study that is related closely to the previous study is from Ammann, Huber and Schmid (2013). They examined hedge fund performance over time horizons between 6 to 36 months, using the Lipper/TASS and CISDM databases from 1994 to 2008. They used the probit regression method to distinguish the fund characteristics that significantly affect hedge funds' performance persistence. They also used two-way sorted portfolios (depending on past performance and fund characteristics). In this model the dependent value can only take two values (i.e. persistent or non-persistent HF performance) and the purpose is to estimate the probability that an observation with particular characteristics (i.e. size, age, leverage) will fall into a specific category. They found that there is alpha persistence for up to three years. The persistence in raw returns was substantial for two years although statistically significant only over a six-month period. Ammann *et al*. also examined fund characteristics such as: fund size, age, flows, the length of the notice and the redemption period, management and intensive fees, leverage, a pseudo variable for whether the fund is closed to new investments, and a pseudo variable for whether the fund manager is personally invested in the fund. An additional variable was used:

'Strategy Distinctiveness Index' (SDI). This index was first introduced by Wang and Zheng (2008) and measures the extent to which a fund's strategy differentiates from the strategies of peer funds. Ammann *et al.* showed that all these characteristics are significantly associated with performance persistence but the SDI index has the ability to systematically enhance performance persistence up to a two-year horizon. However, the high score SDI are indications linked with lower returns in the crisis of 2008. This means that these funds took larger risks during the crisis and delivered lower returns.

An important study that also challenges the results regarding short term persistence is from Jagannathan, Malakhov and Novikov (2010). They measured performance persistence using hedge fund style benchmarks using Getmansky, Lo and Makarov (2004) methodology and the HFR database from 1996 to 2005. They developed a method for evaluating hedge funds' performance based on an appropriately-constructed peer group, taking into consideration the fact that hedge funds strategies have option-like features and serial correlation (or autocorrelation) in their returns due to investments in illiquid assets. They also took into consideration the backfill bias and illiquid assets (e.g. the chance that a hedge fund may be liquidated or closed and exit the data set). Jagannathan *et al.* found evidence of hedge fund performance persistence over a three-year horizon, particularly among the top performing funds. However, they found little evidence of persistence among bottom performing funds. Furthermore, they argued that the estimation period of performance persistence should be at least three years. This is because many hedge funds have issues that are related to illiquidity such as lockup, redemption and notice periods.

An additional perspective on the above studies is given by the pioneering study (in terms of using in-out flow restrictions) of Bae and Yi (2012), which used the TASS database from 1994 to 2008. Like Ammann *et al.* (who also examined fund characteristics such as size and age) they examined the impact of flow restrictions on hedge funds' performance persistence. They used non-parametric methods (based on a contingency table) and parametric methods (based on regression). They found that flow restrictions resulted in superior performance persistence in hedge funds. In detail, they found that not only money *outflow restrictions* such as redemption notice period, payout period and lock period, but also *inflow restrictions* such as minimum investment amount, close-end (do not issue or redeem shares) and closing to individual

investors were positively associated with winner persistence. However, between outflow and inflow restrictions, the first was considered a more important factor than the second. Managerial incentives also had a positive relation to winner persistence.

To sum up, the above innovative strategies (in terms of econometric methods) showed that there is long-term returns persistence in hedge funds. As for short-term persistence, the details depend on individual fund characteristics. More specifically, Wang and Zheng (2008) found long term persistence that depends on different fund styles/innovation strategies. This is similar to Ammann, Huber and Schmid (2013) who also found long term persistence that is affected by strategy/style innovation and fund specific characteristics (e.g. size, inflows/outflows and fees). Likewise, Jagannathan, Makakhov and Norvikov (2010) found long term persistence especially for top performing funds. Bae and Yi (2012) found long term performance persistence for funds that impose flow restrictions, with outflows being the more important factor.

4.1.3 Exploiting Performance Persistence

An initial conclusion to draw from the above studies is that the different methodologies are one of the major reasons for the different results found in the hedge fund literature. Moreover, different databases and different time horizons play an important role. Several studies such as Joenvaara, Kosowski and Tolonen (2012) have examined results from four or more different databases. Another issue that certainly does not facilitate comparisons is the different time periods that various studies examine. Most pre-2007 findings indicate that there is some persistence but it is mainly in the short run (for instance one to three months). Nevertheless, if this length of time is extended then there appears to be no persistence. Also, Agarwal and Naik (2000b) suggested that performance persistence appears to be driven more by losers continuing to be losers rather than winners persisting being winners. This is contrary to Capocci and Hubner (2004) that there is performance persistence in the middle quintile funds. Another important element is that some strategies appear to be more consistent than others (Eling, 2009; Brown and Goetzmann, 2003; Harri and Brorsen, 2004). This is a point that is intuitively logical, especially for non-directional strategies.

However, during the last five years there have been a few innovative studies (Kosowski *et al*., 2007; Jagannathan *et al*., 2010; Wang and Zheng, 2008) that used more advanced econometric methods (e.g. a Bayesian approach or a probit regression approach) and converged on the same opinion: there is persistence in hedge fund performance beyond one year and possibly up to five years. It is evident that with the use of more advanced econometric tools, along with the introduction of other innovative parameters (e.g. Strategy Distinctiveness Index - SDI), they were able to produce results that cannot achieved by older methods and definitions. As an example, the Bayesian method is an approach to stock (or fund) assessment that facilitates taking fuller account of the uncertainties related to models and parameter values. On the contrary, the majority of other methods are based on maximum likelihood (or least squares) estimation involving fixed values of parameters that may have an important influence in the outcome about which there is a considerable uncertainty. One of the major benefits of the Bayesian approach is the ability to incorporate prior information (from historical data or expert knowledge) about the underlying parameters of the model.

Furthermore, an important aspect is fund characteristics (e.g. Amman *et al*., 2010). For example, young and emerging funds realized strong performance persistence. Also, funds not open to new investments are more likely to be persistent winners. In addition, some strategies such as Emerging Markets, Equity Market Neutral, Event Driven and Managed Futures exhibit alpha persistence over a twelve month horizon. In general it is intuitive that non-directional strategies have more persistence rather than aggressively directional strategies with higher volatility. Also, Bae and Yi (2012) found that flow restrictions resulted in superior performance persistence in hedge funds. However outflow restrictions were considered a more important factor that the inflow restrictions.

There are also two important elements that a researcher or a practitioner should consider. First, short term performance persistence is affected by the smoothing of returns and by liquidity restrictions (e.g. lockups periods) that hedge funds impose on investors. The former can distort our results because of returns manipulation by the fund manager. The latter has great impact because the fund manager has to re-balance her portfolio's net positions, especially in the case of redemptions. There are many

studies (e.g. Bollen and Pool, 2006; Eling, 2009) that deal with that issue. These are presented in the next section.

4.2 Concerns about Performance Persistence

4.2.1 Managing Prices

The term *smoothing returns* mean the mitigation of the unexpected returns (surprise) either upwards either downwards. It is exploited (*i*) either by investing in illiquid assets or (*ii*) by managing prices (returns). Concerning (*i*), when fund managers invest in illiquid assets they subjectively evaluate these assets because there are no objective prices in the market. Furthermore when they invest in non-marketable securities in over-counter-markets (OTC) there is again no objective market price for these securities. So, in both cases there is either no objective price evaluation or lagged prices, at best. Regarding (*ii*), fund managers are managing prices in a way that is more palatable to investors. It is not easy to do that in marketable securities where there is a known market price. However, this is possible when there is some flexibility on the valuation (exploiting spreads from various brokers) of the asset traded by the funds. Table 2 details the relevant papers.

Table 2. Performance Smoothing

This Table presents the main characteristics and results of the studies on performance smoothing. Abbreviations: CISDM: Centre for International and Securities Markets, CRSP: Centre for Research in Security prices, HFR: Hedge Fund Research, Lipper/TASS: Tremont Advisory Shareholders Services, MSCI: Morgan Stanley Capital International.

Study	Sample	Methodology	Results
Agarwal, V. Daniel, N. and Naik, N. (2011)	CISDM, HFR, MSCI, TASS and Eurekahedge, 1994-2006	Regression	Return manipulation, December spike, timing in reporting earning and losses
Bollen, N. and Pool, V. (2006)	CISDM, 1994-2003?	Regression, descriptive comparisons	Return manipulation, conditional serial correlation.
Eling, M. (2009)	CISDM, 1996-2005	Regression, descriptive comparisons	Return manipulation, serial correlation,
Getmansky, M., Lo, A. and Makarov, I. (2004)	TASS, 1977-2001	Regression	Return manipulation, serial correlation
Huang, Liechy and Rossi (2009)	CISDM, 1994-2005	Bayesian approach, regression	Return manipulation, serial correlation
Itzhak, B.D., Franzoni, F., Landlier, A. and Moussawi, R. (2013)	TASS, CRSP, Compustat, 2000-2013	Regression, high frequency econometrics	Return manipulation particularly critical reporting dates
Malkiel, B.G. and Saha, A. (2005)	TASS, 1996-2003	Chi square, comparison of rankings	Return manipulation, survivorship and instant history bias affect

Smoothing returns might help to explain the short-term persistence of hedge funds. These non-synchronous pricing problems, either because of stale or managed prices, are an important matter in monthly hedge funds returns that can underestimate hedge funds' risk. Also, they overestimate the delivered alpha within any period (Asness, Krail and Liew, 2001). As a result, funds that act in illiquid markets such as Convertible securities or Mortgage-backed securities show high persistence whereas other more liquid funds such as Equity Markets demonstrate less persistence. Artificial smoothing of hedge fund returns can be observed in the form of serial correlation coming from illiquidity exposures and smoothed returns (see Getmansky, Lo and Makarov, 2004). Likewise, according to Eling (2009) the highest serial correlation (or autocorrelation) is found in illiquid markets. These were Convertible Arbitrage, Relative Value Multi Strategy and Fixed Income Mortgage-backed securities (MBS) and showed high persistence. On the other hand the lowest serial correlation is found in liquid markets. These were in Global Macro, Equity Long Only and Short Bias and showed low levels of persistence. However, Huang, Liechy and Rossi (2009) found

that even relatively liquid strategies (such as Equity hedge funds) can have smoothed returns causing an upward bias in excess performance measures and a downward bias in risk measures.

Eling (2009) explored the four factors that could generate artificial performance persistence. These are the use of: first, option-like strategies, second, return smoothing, third, survivorship bias and fourth, backfilling or instant history bias. Concerning the first factor, he examined 250 hedge funds that were using option-like strategies and found that, whatever the time horizon, these strategies had no performance persistence. Concerning the second factor (return smoothing) Eling measured the serial correlation strategy by strategy and found that it is possible to explain the high levels of short-term persistence realized by some strategies (e.g. Convertible Arbitrage).

Concerning the third and fourth factors (survivorship and instant history biases) he found that they can at least partially explain the performance persistence, confirming the findings of other authors (such as Malkiel and Saha, 2005) who examined hedge funds biases and found that they affect funds' performance persistence. In detail, the level of persistence was slightly higher when *only* surviving funds were examined. Living funds tended to have higher returns and lower standard deviations compared to dead funds. On the other hand, dead funds had lower levels of persistence. Even though survivorship bias can have an impact on the level of persistence, it is nevertheless not able to explain the differences among hedge fund strategies.

As far as the backfilled bias is concerned, Eling reproduced the investigation for the level of hedge funds' performance persistence after he had dropped the first 24 months of returns for each hedge fund from the database. He found a lower level of persistence. Thus, it appears that survivorship and backfill bias at least partially explains performance persistence.

4.2.2 Other Smoothing Returns Techniques

In this sub-section we present some recent studies about smoothing return techniques that can distort performance persistence: conditional correlation and critical reporting dates.

Illustrating conditional correlation, Bollen and Pool (2006) found that if a fund manager distributes true returns but fully reports gains and delays reporting losses, then the reported returns will display conditional serial correlation. They also found evidence that conditional serial correlation is a prominent indicator of fraud because it indicates price management or other illegal activities by fund managers. Hedge funds with conditional serial correlation tended to have greater volatility of fund flows resulting in higher risk. In addition, funds which have been investigated for fraud by the SEC (Security Exchange Commission) are more likely to display conditional serial correlation than other funds. Hence, regulators should develop statistical techniques (e.g. filters) to focus on hedge funds with an increased risk of fraud.

An important related study is from Agarwal, Daniel and Naik (2011). They used five databases: CISDM, HFR, MSCI, TASS (now Lipper) and Eurekahedge with a sample period from 1994 to 2006. They found that during December hedge funds returns are significantly higher (December spike) than returns during the rest of the year. This applied to funds that have high incentive fees and more opportunities to artificially increase returns. Thus, hedge funds manage their returns upwards in an opportunistic way so as to have higher fees. Furthermore, they found strong evidence that funds artificially increase their returns in December by underreporting returns earlier in the year. However, there is only weak evidence that hedge funds borrow from next year's (January) returns.

In relation to the above study, Itzhak, Franzoni, Landlier and Moussawi (2013) used the TASS hedge fund database from 2000 to 2013, while they used CRSP and Compustat for daily stocks returns and stock characteristics. They used also the NYSE TAQ (Trade and Quote) intraday trades data to compute the intraday return and volume information. They found that hedge fund managers manipulate stock prices during critical reporting dates. Stocks in the top quartile of hedge fund holdings showed abnormal returns of 0.3% on the last day of the quarter and a reversal of 0.25% on the following day. An analysis of an intraday volume and order imbalance showed that a significant part of the return is earned during the last minute of the trading.

Having discussing the above smoothing related studies, it is clear that it is very difficult to evaluate hedge funds' performance persistence. Earlier studies showed that

the persistence is short term in nature but studies using more advanced quantitative techniques revealed that there is long term persistence even for five years. However there are important issues that have to do with hedge funds' illiquidity and managing returns. There is a need for more advanced techniques to allow the researcher to manage these problematic issues. The hedge fund industry evolves very quickly and fund managers are able to find ways to maximize their performance in an artificial way, especially in the short term, thus increasing apparent persistence.

Consequently, the researcher or the investor should use more advanced econometric tools using delayed time (lag) variables in order to capture those smoothing techniques. We should always be sceptical when dealing with hedge funds' performance persistence. The situation would be much better if *all* hedge funds had independent administrators for their NAV (net asset value) calculations and performance reporting. However, in order to do this there must be increased transparency and a stricter regulatory framework for the hedge fund industry.

5   Hedge Funds Returns and Characteristics

Having discussed performance persistence, we now continue our review of modelling hedge funds. As presented in part two, there are alternative perspectives to explain hedge fund returns. We refer here to the fundamental factor models or explicit factor models (size assets under management, age, fees and liquidity/restrictions) that are able to explain hedge funds returns using individual hedge funds characteristics. Regarding size and performance, the majority of studies conclude that there is a negative relationship, i.e. smaller hedge funds perform better. Age and performance seems to have a positive relationship, i.e. older funds outperform younger ones. Fees and performance also appear to have a positive relationship.

In the next subsections we analyse and critique the relevant studies for each characteristic (size, age and performance fees). We also briefly cover other micro factors such as lockup periods and fund domicile.

5.1 Size

The term 'size' in hedge funds refers to the Assets under Management (AUM). A typical categorization is small (less than $100 million), medium (between $100 million and $500 million) and large (over $500 million) (Pertrac Corp., 2012). Many scholars deal with the size of the fund and the performance but the findings are contradictory with a slight tendency in favour of small size. We discuss this below in detail, with the papers being listed in Table 3.

Table 3. Performance and Size Factors

This Table presents the main characteristics and results of the studies on performance and the size factors. Abbreviations: CAPCO: Financial Institution, CISDM: Centre for International and Securities Markets, FAV: Favorable Positioning Metric, HFR: Hedge Fund Research, Lipper/TASS: Tremont Advisory Shareholders Services, ZCM/MAR: Zurich Capital Markets.

Study	Sample	Methodology	Results
Agarwal, V., Daniel, N. and Naik, N. (2004)	HFR, TASS and ZCM/MAR, 1994-2000	Regression, comparison of rankings	Small funds outperform large funds
Amenc, N. and Martellini, L. (2003)	CISDM, 1996-2002	Regression, comparison of rankings	Large funds outperform small funds
Ammann, M. and Moerth, P. (2005)	TASS, 1994-2005	Regression, comparison of rankings	Small funds outperform large funds
Getmansky, M. (2004)	TASS, 1994-2002	Regression, Monte Carlo simulations, comparison of rankings , FAV	Large funds outperform small funds
Gregoriou, G. and Rouah, F. (2002)	Zurich Hedge Fund and LaPorte, 1994-1999	Correlations, descriptive comparizons	No relationship
Harri, A. and Brorsen, B. (2004)	LaPorte Asset Allocation, 1977-1998	Regression	Small funds outperform large funds
Hedges, J. (2003)	CAPCO, 1995-2002	Descriptive comparison of rankings	Small funds outperform large funds, but mid-size funds perform worst
Joenvaara, J., Kosowski, R. and Tolonen, P. (2012)	BarclayHedge, EurekaHedge, HFR, Morningstar and TASS, 1994-2011	Cross-sectional regression, comparison of rankings	Small funds outperform large funds
Koh, F. Koh, W. and Teo, M. (2003)	Eurekahedge and AsiaHedge, 1999-2003	Cross-sectional regressions	Large funds outperform small funds
Meredith, J. (2007)	HFR, HedgeFund.net, Altvest and Barclays Global HedgeSource,	Comparizon of rankings, Monte Carlo simulations	Small funds outperform large funds
Pertrac Corporation (2012)	BarclayHedge, Channel Capital Group, Cogent Investment Research, Eurekahedge, HFR, Lipper, MondoHedge and Morningstar, 1996-2011	Descriptive comparison of rankings	Small funds outperform large funds
Schneeweis, T., Kazemi, H. and Martin, G. (2002)	HFR, 1996-2000	Regression, comparison of rankings	Small funds outperform large funds

5.1.1 Small Hedge Funds Outperform

In this section we present papers demonstrating evidence that there is negative relationship between hedge fund performance and size. Performance measurement is mainly on fund returns, risk and risk-adjusted returns.

Schneeweis, Kazemi and Martin (2002) examined the impact of fund specific factors such as size, age and performance fees on Value, Growth and Small styles using the HFR database (hedge fund indices) from 1996 to 2000. They presented results of fund size compared to fund return, risk and risk adjusted performance. In particular, they computed the correlation between fund size and fund return, risk and risk adjusted returns. In general, smaller funds out-performed larger funds but had a higher risk.

There were further interesting details if the data were disaggregated into sub-strategies. For example, small risk arbitrage funds had higher returns but lower risk. Those results are consistent with smaller asset size funds that benefit the risk arbitrage strategies, unlike large size funds that may lack flexibility. This indicates that high returns may not always come at the expense of higher risk.

Two years later, Harri and Brorsen (2004) (see section 3.1 for more information) found similar results. Their results showed a strong negative correlation between hedge fund size and return. This was consistent with the author's assumption that small hedge fund managers benefit from market inefficiencies. The reason for this is that the profit to be made from market inefficiencies is relatively fixed; hence allocating more money to exploit those inefficiencies causes the returns to decrease.

Another case in favour of small funds is the research from Agarwal, Daniel and Naik (2004) that used one comprehensive database culled from three commercial databases: HFR, TASS and ZCM/MAR. The sample period was from 1994 to 2000. They analysed how money inflows are affected by future performance and discovered that larger funds with greater inflows were linked to lower future performance, a consequence that is consistent with the decreasing returns to scale.

Similarly to the above, another important study was from Ammann and Moerth (2005) that used data from 1994 to 2005 on the TASS database and examined the influence of fund size on returns, Sharpe ratios and alphas generated from a multi-asset class factor model. Using cross-sectional regression techniques they showed a negative relationship between returns and fund size. However, they found that very small funds underperform on average. One possible explanation of this given by the authors is that very small hedge funds suffer from higher total expense ratios.

Ammann and Moerth (2005) also discovered a negative relationship between standard deviation and fund sizes. In most cases, larger hedge funds tended to have lower volatilities but similar Sharpe ratios. Consequently, very small hedge funds suffered a handicap when competing with medium and larger-sized funds.

A few years later, Meredith (2007) examined the impact of fund age and size on hedge fund performance from 1996 to 2006. He used the Hedge Fund Research, HedgeFund.net, Altvest from InvestorForce and Barclays Global HedgeSource databases. We reference that study in detail later in this section (5.2) when discussing hedge fund age and performance. Using Monte Carlo simulations, his final conclusion is that if investors want to maximise return then they should search for younger and smaller funds. If they want to maximise capital preservation they should search for larger, older funds.

Except for academic studies there are also some commercial studies on how these micro factors affect hedge fund performance. The Pertrac Corporation (2012) examined the impact of size and age on hedge fund performance from 1996 to 2011. They used fifteen databases from eight different data providers, a number that it is obviously an advantage over other papers. These were: BarclayHedge, Channel Capital Group, Cogent Investment Research, Eurekahedge, Hedge Fund Research, Lipper (A Thomson Reuters Company), MondoHedge and Morningstar.

As far the size factor is concerned, the Pertrac Corporation found that the average small fund outperformed the average mid-sized and large fund for all years except for 2008, 2009 and 2011. However the average large fund outperformed the average small and medium sized fund in the negative performance years of 2008 and 2011. Also, small funds outpaced the mid-size and large funds with regard to the number of months that their returns were above 2%.

Similarly, Joenvaara et al. (2012) in their research (please see section 3.1 for more details) showed that smaller firms and funds outperformed their larger peers.

5.1.2   Large Hedge Funds Outperform

Amenc and Martellini (2003) examined the alphas of hedge fund managers and their risks, taking into consideration different models and examining many funds' characteristics (for instance fund size, age, performance and incentive fee). They used the CISDM database from 1996 to 2002.

Concerning the size factor, the authors investigated the effect of a fund's size on performance. For each fund they calculated the average assets over the time period used for that research. Afterwards, they divided the funds into two equally-sized groups. For each class they calculated the average alpha obtained with each method. For all methods the mean alpha for large funds significantly exceeded the mean alpha for small funds. Furthermore, in most of the methods the difference in mean alpha between large and small funds was statistically significant. This demonstrated that, on average, large funds do in fact outperform small funds.

Similarly to the above, Koh, Koh and Teo (2003) examined Asian hedge funds (please see section 3.1 for more information). They argued that there is evidence that there are economies of scale in the hedge fund industry. Consequently, funds managed by larger holding companies tend to outperform funds managed by smaller ones.

One year later, Getmansky (2004) using the TASS database from 1994 to 2002 and regressing between monthly returns on asset size, found a positive but concave relationship between current performance and past asset size. In other words, there are decreasing returns to scale. He found also that there is an optimal asset size for obtaining best returns. Hence, investors should seek to invest in hedge funds that are closest to their optimal size. It is important to mention that the asset size / performance relationship exhibits various forms for different hedge funds strategies. For example the relationship is curved and the optimal size can be obtained for more illiquid strategies such as 'Emerging markets' and 'Convertible arbitrage'. Those hedge funds strategies realize high market impact and are contingent on limited opportunities. On the other hand, Funds of Funds are less affected by negative economies of scale than individual funds.

According to these results Getmansky suggested that fund managers with large assets should decide to close the fund to new investors in preference to suffering a decrease in returns and an increase in the probabilities of liquidation. As far as an investor is concerned, he suggested choosing hedge fund strategies that do not have as asset size greater than the optimum. However, in practice it is difficult for investors to calculate this optimum, unless they have private information.

5.1.3   No Relationship – Other Approaches

Other papers have found no evidence for a size – performance relationship.

Gregoriou and Rouah (2002) used data from 1994 to 1999 exploiting the Zurich Hedge Fund Universe and LaPorte Asset Allocation Systems. They focused on the connection between the size of hedge funds and their performance. The size of the hedge fund was denoted by the total asset amount at the beginning of their calculation period. The authors found no evidence of relationship between the size of the hedge fund (or FoF) and its performance, either unadjusted or adjusted (Sharpe and Traynor ratios).

A year later, an interesting study that provided slightly different results to the majority of authors was from Hedges (2003). He examined the size versus performance issue from 1995 to 2002 using three size-mimicking portfolios of equally weighted monthly returns. He classified hedge funds based on assets under management into three buckets: small, medium and large. Hedges showed that smaller funds outperformed larger funds. However, mid-sized funds performed the worst. This fact suggested the notion of 'mid-life crises' for hedge fund managers as mid – size firms tend to be inefficient in terms of exploiting opportunities and processes to reach optimum performance.

5.1.4   Summary

Several papers deal with the size/performance relationship of hedge funds, but there are some contradictory results. Amenc and Martellini (2003) and Koh *et al*. (2003) found that there is a positive correlation. Getmansky (2004) found that there is a positive and concave correlation and suggested that there is an optimal asset size. In contrast, Gregoriou and Rouah (2002) found no evidence of any relationship either for

unadjusted or for adjusted returns (Sharpe and Traynor ratios). We should mention that Gregoriou and Rouah used the AUM at the inception date of each fund, and not the average that is most commonly used by the other authors. Agarwal *et al*. (2004) have completely opposite results to those of Koh *et al*. (2003), although Koh, Koh and Teo considered only Asian hedge funds. The former found that there is a negative correlation and diseconomies of scale whereas the later found positive correlation and economies of scale. The results may well be different because they use different time periods, databases and different methodologies. Nevertheless, the majority of studies conclude that there is a negative relationship between hedge fund size and performance. These results are in alignment with commercial studies (e.g. Pertrac Corp.) So, we could summarise that there is some negative correlation between size and hedge fund performance. However, for an investor it is one of many factors to consider.

5.2 Age

The term 'age' when applied to hedge funds has to do with when the fund was launched, or the time that it was introduced in to the database, or (most commonly) the time we consider it to have existed for if we eliminate the backfill or instant history bias. The majority of scholars come to the conclusion that there is a negative relationship between age and performance, i.e. younger hedge funds outperforms older ones. Table 4 shows the relevant studies on fund age.

Table 4. Performance and Age Factors

This Table presents the main characteristics and results of the studies on performance and the age factors. Abbreviations: CISDM: Centre for International and Securities Markets, HFR: Hedge Fund Research, Lipper/TASS: Tremont Advisory Shareholders Services.

Study	Sample	Methodology	Results
Amenc, N. and Martellini, L. (2003)	CISDM, 1996-2002	Regression, comparison of rankings	Young funds outperform old funds
Frumkin, D. and Vandegrift, D. (2009)	Bloomberg, 2005-2007	Panel regressions	Young funds outperform old funds
Howell, M.J. (2001)	TASS/Tremont, 1994-2000	Comparison of rankings	Young funds outperform old funds
Meredith, J. (2007)	HFR, HedgeFund.net, Altvest and Barclays Global HedgeSource, 1996-2006	Comparison of rankings, Monte Carlo simulations	Young funds outperform old funds
Pertrac Corporation (2012)	BarclayHedge, Channel Capital Group, Cogent Investment Research, Eurekahedge, HFR, Lipper, MondoHedge and Morningstar, 1996-2011	Descriptive comparison of rankings	Young funds outperform old funds
Schneeweis, T., Kazemi, H. and Martin, G. (2002)	HFR, 1996-2000	Regression, comparison of rankings	Old funds outperform young funds

Howell (2001) emphasized the relationship between hedge fund age and performance. His data were from 1994 to 2000 and used the TASS/Tremont database. He defined younger hedge funds as those that had a track record of less than three years. Howell sorted the funds into deciles in regard to their maturity. On the basis of unadjusted returns, the youngest deciles realized 23.2% whereas the median returned 13.4%.

However the percentage was rather overestimated because it did not take into account a potentially higher failure rate. In order to proceed, Howell (2001) adjusted the returns by applying the likelihood of failure to report to the surviving funds. He also adjusted the returns by applying the likelihood of future survival to the survivor's returns by age decile. But the adjusted results were similar to the non-adjusted results: the youngest decile delivered a return of 21.5% whereas the whole sample median showed a return of 13.9%.

It is clear that hedge funds' performance becomes worse with age, even when the risk of failure is taken into consideration. Therefore, the youngest funds appear especially attractive.

Similarly, Amenc and Martellini (2003) (please see section 4.1) defined the age as the length of time in operation before the beginning of their study. In order to investigate the impact of a fund's age on its performance they divided the funds into two categories: (*i*) newer funds (age of one or two years) and (*ii*) older funds (age greater than two years). For each category, they computed the average alpha using many different methods.

It is noticeable that for all methodologies they used, the mean alpha for newer funds exceeded the mean alpha for older funds. The range was from 1.16% to 3.66%. Those differences varied in significance across the methodologies. The most significant findings were obtained with the CAPM and Explicit Factor models.

Meredith (2007) (please see section 4.1) studied the impact of fund age and size on hedge fund performance: whether smaller, younger hedge funds offer higher performance than larger, older hedge funds. He studied the performance, volatility and risk profiles of different fund groups, using indices compounded from six subsets of hedge fund data (small, medium, large, young, mid-age and old) as well as Monte Carlo simulations. According to his results, if an investor wishes to maximise returns, she should start by aiming for younger and smaller funds. On the other hand, if the investor wishes to maximize capital preservation, she should start seeking larger and older hedge funds. However, the author suggested that an investor should also take into consideration the qualitative aspects of a given fund. It is evident from this study that younger and smaller hedge funds have greater prospects for maximising returns but on the other hand are more risky. Hence the risk-averse investor should search for hedge funds that are less risky and able to preserve capital.

Two years later, Frumkin and Vandegrift (2009) analysed the effects of beta, fund size and age as a consequence of Rule 203 (b) (3)-2. This regulation requires hedge funds to be registered with the SEC, resulting in an increase of the net worth requirement to $1.5 million for accredited investors who are more educated (or ill-educated but rich) providing hedge funds with a more stable asset base. They exploited a fixed-effects panel data model to better perceive the effects of regulation across the entire hedge funds industry from 2005 to 2007 (over nine quarters) using the Bloomberg database.

Age had a negative relationship to hedge fund returns. In addition, as a hedge fund's age increases, its managers suffer from style drift, leading to lower returns.

Pertrac Corporation (2012) classified young funds as those that were less than two years old, mid-age those that were between two and four years old and tenured those that were older than four years. They found that the average young fund outperformed both the average mid-age and tenure funds. In addition to that young funds kept a lower volatility profile.

An exception to the above studies was that of Schneeweis, Kazemi and Martin (2002) (please see section 4.1) who examined the age / performance relationship using the TASS database because of its wide coverage, with much data on 'dead' funds and comprehensive data coverage from 1991 to 2000. It is intuitive that funds which start in different market environments may have very different track records. The authors computed the 12-month average information ratio for all funds within a specific style that started in the same month. The cyclical variation in information ratios was an indication of possible issues in comparing funds that performed under different market conditions. When the authors disaggregated data into strategies, they found that some strategies (e.g. small risk arbitrage) delivered higher returns and lower risk. To our knowledge, this in the only study that takes into consideration the *same starting month* for funds and shows a positive relationship between age and performance but on the aggregate level.

Summarizing the findings, there is a clear negative relationship between hedge fund age and performance. However, a question that arises is whether indeed there is any point in comparing hedge funds with different lengths of tracks records that started in different market environments. In our opinion, that concern is important because the results of these comparisons are misleading and are not likely to give a real picture of hedge funds' performance. At least, the evaluator should take into consideration the market conditions and make some adjustments to her appraisal regarding hedge funds' performance. Ultimately, examining the above studies, the general conclusion (negative relationship) holds true.

5.3 Performance Fees

It is commonly known that hedge fund managers charge performance and administration fees to investors. An administration or management fee is the percentage rate of compensation and is very often reported to vendors' databases for each fund. The fee is a fixed percentage (set at the fund's launch) of the assets under management, is calculated monthly and is deducted from the fund's performance reported to the database. The performance fee is a fixed percentage rate on the fund's profits and is payable to the manager, often at the end of each month. Usually performance fees are approximately 20% of profits whereas administration fees are 1%-2% of assets under management. However the important question that arises is whether there is any relationship between performance fees and hedge fund performance. Below, we present some studies deal that with that issue. We conclude that a positive relationship between incentive fees and fund performance exists and the extra returns outweigh the extra costs. This result is rather intuitive and easily explicable as there is alignment between fund managers' interests and investors' interests. Table 5 lists all the studies that research performance fees.

Table 5. Performance and the Fee Factor

This Table presents the main characteristics and results of the studies on performance and the fee factor. Abbreviations: CISDM: Centre for International and Securities Markets, HFR: Hedge Fund Research, Lipper/TASS: Tremont Advisory Shareholders Services, PCA: Principal Component Analysis.

Study	Sample	Methodology	Results
Ackermann, C., McEnally, R. and Ravenscraft, D. (1999)	HFR, MAR, 1988-1995	Correlations, regressions	Higher fees, higher performance
Amenc, N. and Martellini, L. (2003)	CISDM, 1996-2002	Regression, PCA, comparison of rankings	Higher fees, higher performance
Bae, K.H. and Yi, J. (2012)	TASS, 1994-2008	Probit regression, comparison of rankings	Higher fees, higher performance
Joenvaara, J., Kosowski, R. and Tolonen, P. (2012)	BarclayHedge, EurekaHedge, HFR, Morningstar and TASS, 1994-2011	Cross-sectional regressions, comparison of rankings	Higher fees, higher performance
Koh, F., Koh, W. and Teo, M. (2003)	Eurekahedge and AsiaHedge, 1999-2003	Cross-sectional regressions	No Relationship
Schneeweis, T., Kazemi, H. and Martin, G. (2002)	HFR, 1996-2000	Regression, comparison of rankings	No Relationship

5.3.1   Higher Fees, Higher Performance

Starting our survey, Ackermann, McEnally and Ravenscraft (1999) found that incentive fees were related to high performance using the MAR and HFR databases from 1988 to 1995. This was, they claimed, because of incentive alignment between their interests and investors interests. However performance fees are not able to explain the increased total risk that hedge funds included compared to other 'traditional' investments.

Arguing for a positive relationship between fees and performance, Amenc and Martellini (2003) examined the impact of fees on hedge fund performance. They investigated the incentive fees as well as the management fees. With respect to incentive fees that are expressed as a percentage of profit, they divided the funds into two categories: those that had incentive fees greater or equal to 20% and those that charged less than 20%. For each category they calculated the average alpha (each with many methods).

For all methodologies the mean alpha for high incentive funds exceeded the mean for low incentive funds. The highest different was 7.72% whereas the lowest was 1.44%.

The significance in the differences was high for all the methods except for the implicit factor method, that is, PCA (Principal Component Analysis). The lack of significance in the PCA method suggested a possibility that the fund managers of high-incentive funds may take some risks that were not captured by the other nine methods/models.

When the authors looked at management fees they followed a similar approach. They divided the funds into two groups: those funds that had administration fees greater or equal to 2% and those funds that had administration fees lower than 2%. There was no significant difference at the 5% level between funds with higher or lower administration fees.

A few years later, Joenvaara *et al*. (2012) also found that hedge funds with greater managerial incentives produced superior performance. This is in alignment with Bae and Yi (2012) who found that management fees and managerial fees such as incentive fees or high water mark awards had an influence on winners' persistence.

5.3.2   No Relationship Between Fees and Performance

Other authors have however found no evidence in favour of performance fees.

Schneeweis *et al*. (2002) examined the impact of performance fees (along with other fund specific factors mentioned before) for Value, Growth and Small styles using the HFR database from 1996 to 2000. Their results showed that fees had little effect on performance. For most hedge funds (hedged equity) there was little evidence of the impact of performance fees. Similarly, there was a small effect for lockup affecting overall performance. What was more important is whether the funds belonged to the growth, value, or small firm strategies. Overall, the difference in return (before fees were charged) between the value, growth and small fund hedged equity funds with 20% incentive and those with less than 20% were tiny. Hence, Schneeweis *et al*. could make no conclusion from these results concerning the effects of fees on performance.

Another substantial piece of research was by Koh, Koh and Teo (2003), which explored Asian hedge funds in terms of return persistence, style and fund characteristics (please see section 3.1 for more details). They also found no evidence

to support the idea that hedge funds with higher management or performance fees attained higher returns.

5.3.3 Performance Fees Summary

Most studies show that there is a positive relationship between performance fees and hedge funds' performance. The exceptions are Koh *et al.* (2003) and Schneeweis *et al.* (2002) who found that no conclusion could be made as to the effects of fees on performance. Maybe in some very specific situations such as growth equity hedge funds there was a positive relationship but it was small. Ackermann *et al.* (1999) found a positive relationship between incentive fees and performance. Similarly, Amenc and Martellini (2003) found a positive relationship between performance fees and hedge funds' performance. However, it is important to mention that they found no significant differences using the PCA method, which means that high-incentive fund managers may take some risks that are not captured by the other methods. Concerning management fees, they found no significant difference between funds with higher or lower administration fees. Later studies such as Joenvaara *et al.* (2012) and Bae and Yi (2012) also found a positive relation between incentive fees and performance.

It is intuitively correct for an investor to expect that a higher performance fee means implicitly that the manager has high abilities (you get what you pay for). On the other hand she should know that in other cases these fees are excessive and do not justify managers' skills. Those skills are based on alpha, in other words the excess return due to managers' abilities (e.g. stock picking) and not on premia derived from hedge fund exposures (e.g. liquidity, credit risk). In addition to that, high performance fees do not guarantee future success (with respect to absolute returns). Last but not least, management and incentive fees are very often high thus eroding investors' capital and gains. Ultimately, the rule of 'you get what you pay for is' valid in the hedge fund industry and the extra costs deserve the extra returns (particularly regarding performance fees).

5.4 Other Micro Factors

Several other micro factors (such as lockup or notice redemption period and domicile) should be taken into account when we try to attribute hedge funds returns. Table 6 shows the two studies that have researched this area.

Table 6. Performance and Other Micro Factors

This Table presents the main characteristics and results of the studies on performance and other micro factors.

Abbreviations: HFR: Hedge Fund Research, Lipper/TASS: Tremont Advisory Shareholders Services.

Study	Sample	Methodology	Results
Aragon, G. (2007)	TASS, 1994-2001	Probit regression, comparison of rankings	Lockup funds outperform no lockup funds
Joenvaara, J., Kosowski, R. and Tolonen, P. (2012)	BarclayHedge, EurekaHedge, HFR, Morningstar and TASS, 1994-2011	Cross-sectional regressions, comparison of rankings	Onshore funds outperform offshore funds and lockup funds do not significantly outperform no lockup funds

Lockup periods are important. Long lockup periods means that fund managers are able to invest in more illiquid assets with a liquidity premium that results in higher returns. Aragon (2007) found that funds with lockup restrictions outperformed funds with non-lockups restrictions. However, Joenvaara *et al*. (2012) found that hedge funds imposing lockups did not produce significantly higher risk-adjusted returns compared to hedge funds with no lockup periods. Nevertheless, these two studies are close showing that there is a positive relationship between lockup periods. Ultimately, it is important for an investor should consider the balance of high lockup periods and liquidity premium that she may receive.

The domicile effect might indicate a relationship with fund performance. In their study Joenvaara *et al*. (2012) took into consideration the domicile aspect of hedge funds' performance. They found that on-shore hedge funds delivered higher performance than that of offshore-registered funds. However, investors invest in onshore or offshore hedge funds depending on their tax-exempt status. Certainly, from an economic perspective, no tax-exempt investor is willing to pay taxes through investing in an onshore hedge fund unless there is a very strong reason.

5.5 Returns and Characteristics Summary

Concluding, examining the micro-factors (specific to fund) we consider that there is a negative correlation between size and hedge fund performance. However, an investor should not choose the appropriate hedge fund based only on the size factor. Regarding the age, it seems that younger hedge funds tend to outperform older hedge funds. Nevertheless, different market conditions should be also taken into consideration. Concerning performance fees there appears to be a positive relationship but again the investor should not rely only on that criterion. Long lockup period funds tend to outperform short lockups.

One important issue is that each fund should have an appropriate track record (at least two years) in order to have sufficient data to make calculations and judgments. Many private database vendors (such HFR) require at least two years of tracking records so as to include them in investable indices (HFRX). Furthermore, it is intuitively valuable to have at least two or three years of data in order to apply different econometrics and statistical models with reliable results.

6   Conclusion

In this review we have discussed two important topics that can help explain observed hedge fund returns: hedge fund performance persistence in the short and long term, and the factors idiosyncratic to individual hedge funds. We presented a synthesis of older literature to provide a historical perspective together with information from recent papers to illustrate advances in those topics. Our findings both help hedge funds investors and make clear the opportunities for further research.

Contrary to earlier studies, a few later studies using advanced econometric methods showed that hedge funds do have long term performance persistence. However, further research is needed to confirm the results of these recent advanced studies. Furthermore, there is evidence that some non-directional strategies (e.g. Convertible Arbitrage or Merger Arbitrage strategies) demonstrate more persistence than aggressively directional strategies (e.g. Long Only strategy or Short Bias). However the difference in persistence is mainly related to the type of strategy each fund follows. Another important issue is that there is strong evidence that illiquidity and smoothing

returns practices are widespread. This constitutes an essential element that a researcher that should take into consideration when examining short term persistence. Further research is needed to examine all these practices and use the appropriate quantitative models to identify and handle them. The question arises whether fund managers are able to handle hedge funds returns in a 'sophisticated way' to make their manipulation invisible to current models or techniques (e.g. autocorrelation identification).

As far the fundamental factors are concerned, they are able to explain a large part of hedge fund returns. There is also a relationship between certain hedge funds characteristics and performance. In particular, there is a negative correlation between size and hedge fund performance. Younger hedge funds tend to outperform older hedge funds. Concerning performance fees it appears to be a positive relationship. Long lockup period funds tend to outperform short lockups and domicile funds tend to outperform offshore.

In this survey, we provided a framework to the investor to help her understand and evaluate funds with different characteristics. Ultimately, the investor should acknowledge all the above things together (e.g. performance persistence and micro-factors) and consider the factors that are important to her to get a deeper understanding of hedge fund performance attribution. She should get at least two years of track records so as to have sufficient basis for her calculations. She can use all the above factors as a guide in her investment decision process, knowing what to expect from hedge funds with certain micro-characteristics. For even better results, already having the broader picture, she should examine her underlying short–listed hedge funds with other complementary performance measures such as risk-adjusted returns and exposures. She should incorporate our findings in to her due diligence process so as to maximize her benefits. All the above results are useful to investors; however, a limitation of our survey is that there are differences in studies due to industry heterogeneity and authors using different hedge fund databases and time periods. This is a common issue for other authors as well, when they compare their results with earlier authors using different samples, methods and time periods. As is said in the fund management industry, "Past performance is no guide to future performance, but it's all we've got." Despite this limitation, there are some consistent trends and patterns that can reveal useful dimensions about hedge fund behaviour.

Identifying gaps for our future research, there is not yet any unified model that is able to include all these factors and to quantify how they influence hedge fund performance and interact. This will include identifying the proportion of alpha for a given strategy that it is generated by each of these factors (e.g. including trading in illiquid securities, leverage and lockup periods). The performance persistence should be examined not considering one only dimension (such as only hedge fund strategy/style or only to specific attributes) but on a unified framework that utilizes all these dimensions together exploiting their interactions. Similarly, hedge fund performance (in terms of alphas and exposures) should be regarded not only on specific factors or hedging strategies/styles separately, but in an integrated framework.

Even though we may in the future get more robust research results regarding performance persistence or the explanations of hedge funds returns based on fundamental factors, every investor should evaluate hedge fund performance on an individual basis. This is simply because what appears to be valid in the past does not guarantee a successful decision on an individual hedge fund basis. Beyond quantitative analysis there are many important qualitative criteria. For example, an investor should access other resources and, where possible, interview fund managers to verify the fund's risk management practices, investment policies, operational capabilities and management experience. Reviewing hedge funds' financial statements and business procedures and getting them certified by a reliable external firm, are pre-requisites for a successful investment decision.

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