Man vs. Machine: Comparing Discretionary and Systematic Hedge Fund Performance

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December 2016

EXECUTIVE SUMMARY

- This study compares the performance of discretionary versus systematic hedge funds, split into macro and equity strategies, using data from 1996-2014
- Some investors suggest that systematic strategies perform worse, have returns more easily explained by risk factors and are more homogeneous than their discretionary counterparts
- We note 74% of assets are discretionary, perhaps reflecting these views
- Our data suggest that these beliefs are incorrect

- **Performance**
  - We examine the manager performance by forming average monthly returns in each category
  - **Discretionary equity managers have delivered higher raw returns than systematic equity managers.** However they take more risk and have higher factor exposures. After adjusting for these, **the appraisal ratio for systematic managers is slightly higher**
  - **Discretionary macro managers have underperformed systematic macro managers.** After adjusting for volatility and factor exposures the underperformance is still clear (lower discretionary appraisal ratio)

- **Factor attribution**
  - We select a set of factors that were well known at the beginning of our analysis
  - **For discretionary equity managers, more of the returns can be attributed to factor exposures** compared to systematic equity managers. This mainly comes from a long equity exposure
  - For macro managers, both discretionary and systematic have a long exposure to the bond market factor and a volatility factor. Discretionary managers also have exposure to the equity market and FX carry factors. The total amount of returns attributable to factors is again more for discretionary than for systematic managers

- **Homogeneity**
  - We find that **discretionary and systematic managers have similar levels of performance spread** between top and bottom quartile managers in each category

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The authors would like to thank Nick Granger and Shanta Puchtler for their comments, Goldman Sachs for providing option price data, and Kathrin Weder for the design and illustration.

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A version of the paper is available at: https://ssrn.com/abstract=2880641

INTRODUCTION

We compare the performance and risk exposures of discretionary and systematic managers. Discretionary managers rely on human skills to interpret new information and make day-to-day investment decisions. Systematic managers, on the other hand, use strategies that are rules-based and implemented by a computer, with little or no daily human intervention.

In our experience, some allocators to hedge funds, including some of the largest in the world, either partially or entirely avoid allocating to systematic funds. The authors have heard various reasons, such as: systematic funds are homogeneous, systematic funds are hard to understand, the investing experience in systematic has been worse than discretionary, systematic funds are less transparent than discretionary and that they are bound to perform worse than discretionary because they only use data from the past. These reasons seem to be consistent with a distrust of systems, or "algorithm aversion", as illustrated by a series of experiments in Dietvorst, Simmons, and Massey (2015). In line with our experience and algorithm aversion, only 31% of hedge funds are systematic and they manage just 26% of the total of assets under management (AUM), as at the end of 2014.

In this paper, we show that the lack of confidence in systematic funds is not justified in our opinion when comparing their performance to that of their discretionary counterparts. Our analysis covers over 9,000 funds from the Hedge Fund Research (HFR) database over the period 1996-2014. We classify funds as either systematic or discretionary based on algorithmic text analysis of the fund descriptions, as the categories used by HFR do not provide an exact match for our research question. We consider both macro and equity funds.

Our main results are summarized in Exhibit 1. In the first row, we report the average (unadjusted) return for the different styles considered. All returns are in excess of the local short-term interest rate. Hedge fund returns are averaged across funds of a particular style (i.e., we form an index) and are after transaction costs and fees. Based on unadjusted returns, systematic macro funds outperform discretionary macro funds, while the reverse is true for equity funds.

In the second row, we report the amount of the return that can be attributed to well-known and easy-to-implement risk factors, based on a regression analysis. For discretionary funds, more of the return can be attributed to factors than for their systematic counterparts. We consider three sets of risk factors: traditional factors (equity, bond, credit), dynamic factors (stock value, stock size, stock momentum, FX carry), and a volatility factor. The latter is defined as a strategy of buying one month, at-the-money S&P 500 calls and puts (i.e., straddles) at month-end and letting them expire at the next month's end. In rows three to five of Exhibit 1, we show the attribution to the three underlying sets of factors. For all four styles, the return attributed to traditional factors is meaningful, as it ranges from 1.5% to 2.2%. The return attributed to dynamic factors is also positive in all cases, ranging from 0.2% to 1.3%. The return attributed to the volatility factor is negative for systematic and discretionary macro funds, at -3.2% and -1.3% respectively, and close to zero for equity funds. Macro funds on average have a long exposure to the volatility factor, which has negative returns over time. The negative risk premium for the long volatility factor makes sense, given that being long volatility can act as a hedge for holding risky assets in general. Correcting macro funds' returns for their long volatility exposure essentially gives them credit for this hedging characteristic.

In the sixth row of Exhibit 1, we report the average risk-adjusted return, which is simply the difference between the average unadjusted return and the return attributed to risk factors. Systematic macro stands out with an average risk-adjusted return of 4.9%. Discretionary macro has an average risk-adjusted return of 1.6%, while systematic and discretionary equity funds have similar values at 1.1% and 1.2% respectively. However, the risk-adjusted returns of systematic macro also have the highest volatility, as shown in the seventh row. In the eighth row of Exhibit 1, we report the ratio of the average risk-adjusted return to its volatility, called the appraisal ratio, and see that systematic macro still outperforms, but by less.[1]

Exhibit 1: Performance of different hedge fund styles

Reported statistics are for the returns of four hedge fund styles, averaged across funds of a particular style, in excess of the short-term interest rate, and annualized. The first row reports unadjusted average returns, while subsequent rows report the output based on a regression of hedge fund returns on returns of risk factors. We consider well-known and easy-to-implement risk factors: traditional (equity, bonds, credit), dynamic (size, value, momentum, FX carry), and volatility (buying one-month, at-the-money S&P 500 calls and puts at month-end). Only aggregate factor attributions are reported here. Exhibits 3 and 4 show full regression results, as well as the attribution to individual factors. We use monthly data from HFR for the June 1996 to December 2014 period.

	Systematic Macro	Discretionary Macro	Systematic Equity	Discretionary Equity
Return average	5.01%	2.86%	2.88%	4.09%
Return attributed to factors	0.15%	1.28%	1.77%	2.86%
Traditional	2.08%	1.58%	1.47%	2.19%
Dynamic	1.28%	0.98%	0.23%	1.08%
Volatility	-3.21%	-1.28%	0.07%	-0.41%
Adjusted return average (alpha)	4.85%	1.57%	1.11%	1.22%
Adjusted return volatility	10.93%	5.10%	3.18%	4.79%
Adjusted return appraisal ratio	0.44	0.31	0.35	0.25

1. The appraisal ratio is given by the ratio of the average risk-adjusted return and the standard deviation of the risk-adjusted return. It is the risk-adjusted analogue to the Sharpe ratio, which is based on the average and standard deviation of unadjusted returns.

All in all, the above results show that the hedge fund styles we consider have historically realized positive alphas, which are determined: (1) in excess of the short-term interest rate, (2) after transaction costs and fees, and (3) corrected for any return attributed to risk factors. We note that the factors themselves (especially the dynamic factors) cannot be produced for zero cost, and so a manager simply implementing these factor exposures would undoubtedly show a negative alpha.

The empirical analysis conducted in this paper allows us not only to comment on performance statistics, like the alpha and appraisal ratio, but also on the return variances explained by the risk factors. We find that for systematic funds a slightly smaller proportion of variance is explained by the factors (both for macro and equity funds). A much larger proportion of variance is explained by factors for equity funds than for macro funds. This is mostly driven by a long equity market exposure in equity funds. For investors who already have a meaningful investment in equites outside of their hedge fund portfolio, it seems imperative to take this into account.

Finally, we look at the dispersion of manager returns (results discussed above were based on an index for each category). We establish that the dispersion in Sharpe and appraisal ratios across funds within a hedge fund style is similar (and large) for systematic and discretionary funds. This means that the common investor complaint that systematic funds are more homogeneous does not appear to stand up to scrutiny. So, in addition to style selection, fund selection seems to be just as important in each category. Particular attention should be paid to this when holding a concentrated portfolio of hedge funds.

This paper proceeds as follows. In Section 1, we describe the hedge fund data and text analysis used to classify funds as either systematic or discretionary. In Section 2 we discuss the risk factors. We analyse the alpha and exposure to risk factors for systematic and discretionary macro funds in Section 3. In Section 4 we repeat our empirical analysis for equity funds. We discuss the diversification potential of different hedge fund styles and some fund-level results in Section 5. Finally, we offer some concluding remarks in Section 6.

1) CLASSIFICATION OF FUNDS

In this paper we use hedge fund data from the HFR database. We exclude backfilled returns from before the moment a fund was added, and include the graveyard database to mitigate selection and survivorship bias concerns respectively. We start our analysis in 1996 due to the widely held view that hedge fund databases suffer from measurement biases prior to the mid-1990s.[2] We exclude a limited number of funds that report less frequently than monthly, or for which the reported performance is not classified as "Net of All Fees". See the Appendix for more details on the fund selection filters and the fund classification method, which we discuss next.

We use the two largest strategy types covered in the HFR database: Equity Hedge (6955 funds) and Macro (2182 funds). Within the HFR Macro category, the two main sub-strategies conveniently cover:

- Systematic Diversified: *"…with little or no influence of individuals over the portfolio positioning."*
- Discretionary Thematic: *"… interpreted by an individual or group of individuals who make decisions on portfolio positions."*

For Equity Hedge, the HFR-provided categorization is less tailored to our research question though. None of the sub-strategy names contain the word "systematic" or "discretionary" and none of the HFR descriptions clearly specify whether the decision making is done by algorithms or by humans. Some Equity Hedge sub-strategy names and descriptions contain the word "quantitative", but most hedge funds will employ some form of quantitative analysis, which does not mean they take trading decisions without human overlay. To illustrate this, we find that the word "quantitative" occurs in the description of Systematic Diversified macro funds only 1.7 times more often than it does for Discretionary Thematic.

Because we feel the HFR categorization does not provide a good way to bifurcate equity funds into systematic and discretionary, we chose to rely on text analysis of the fund descriptions. Following a formal method for picking the words used, which utilizes the HFR-provided split into systematic and discretionary macro funds as learning set (see Appendix), we arrive at the following classification rule:

- Systematic if the fund description contains any of the following as (part of a) word: "algorithm", "approx", "computer", "model", "statistical", "system".
- Discretionary if the fund description contains none of the systematic words described above.

For consistency, and because funds may be misclassified by HFR, we also use our classification for macro funds (instead of the HFR classification). Sampling the Macro Systematic Diversified funds that we classify as discretionary, there does not generally seem to be a clear indication that the fund is in fact systematic. So we deem it probable that the fund is not purely systematic but rather partially systematic or quantitative, but not rules-based.[3]

2. For example, Fung and Hsieh (2002) mention that vendors started collecting hedge fund performance data in the early 1990s and that "post-1994 hedge fund data are less susceptible to measurement biases".
3. That said, as a robustness check, we confirmed that the alpha and exposure to factors for systematic and discretionary macro funds (which we will discuss later in this paper) is comparable when using the HFR classifications for Macro instead.

2) RISK FACTORS

We want to evaluate whether hedge funds add value over and above any performance that can be attributed to factors that: (1) were well known by 1996, when our sample period starts, and (2) are easy to implement. In this section, we discuss three types of factors: traditional, dynamic, and a volatility factor. See Exhibit 2 (Panel A) for the full list of factors included.

As traditional factors, we include the main large and easily investable asset classes: equities (S&P 500 index), bonds (Barclays US Treasury Index), and credit (Citigroup US Big High-Grade Credit Index minus the Barclays US Treasury Index). The data are from Bloomberg.[4]

The dynamic factors we include are the three Fama-French US stock factors and an FX carry factor. The Fama-French factors are: size (small-minus-big US stocks), value (high-minus-low book value US stocks), and momentum (winner-minus-loser US stocks). These factors were well known by the mid-1990s, following papers by Fama and French (1993) on size and value and Jegadeesh and Titman (1993) on the cross-sectional momentum factor.[5] The returns for these three factors can be obtained from Kenneth French's website.[6] The FX carry factor is applied to the most liquid G10 currency pairs. The existence of an FX carry factor is a direct implication of the failing of the "uncovered interest rate parity", which has been extensively discussed in the academic finance literature, going back to Meese and Rogoff (1983) and Fama (1984). The data for the FX carry factor are from Deutsche Bank.[7]

We do not include dynamic factors that only recently became better known and documented; typically after hedge funds had profitably exploited them, and they had thus garnered widespread attention (macro trend-following, for example). As Frazzini, Kabiller, and Pedersen (2013) show, with the benefit of hindsight even

> *"… Buffett's performance can be largely explained by exposures to value, low-risk, and quality factors" together with "a leverage of about 1.6-to-1".*

While cross-sectional momentum strategies applied to US stocks were well known before 1996, time-series momentum applied to futures has been documented only much more recently, and is therefore not included.[8]

Finally, we would note that our analysis by its nature is backward looking. It is an analysis of the past, rather than a suggestion for the future. While we are aware that an analysis starting at the time of writing would most likely use a simple macro time-series momentum factor as well as fixed income and commodity carry, for example, our objective here is to explain returns using factors known at the inception of the strategies, rather than on an ex-post basis. Clearly if these funds are to remain successful, they will need to innovate beyond currently known factors, as they have previously shown themselves capable of doing.

The volatility factor that we include is a long one month, at-the-money S&P 500 straddle (call and put option) position, bought at month end and held to expiry. The data come from Goldman Sachs who provided us with mid prices for OTC options.[9] Hedge funds may have an exposure to the volatility factor due to positions in non-linear instruments, like options. Hedge funds may also end up with an exposure to volatility due to the nature of their dynamic trading strategies, e.g., Hamill, Rattray, and Van Hemert (2016) draw a parallel between a trend-following strategy and the dynamic replication of a straddle position. Finally, hedge funds may be exposed to the volatility factor if they trade in securities that are disproportionately hit at times of crisis, like CDOs.

Comparing the risk factors discussed above to what Bali, Brown, and Caglayan (2014) refer to as a set of "standard risk factors", we notice three main differences. First, instead of using the change in yield for the bond and credit factor, we believe it is important to express all factor returns as investment returns. Second, we augment the list of dynamic factors with an FX carry factor, as described above. Third, we don't use the Fung and Hsieh (2001) volatility factors. The main reason for this is that these would, in our opinion, not be straightforward (or cheap) to implement.[10]

All factor returns are determined on an unfunded basis, which is done by using futures, a dollar-neutral long-short portfolio, or returns in excess of the three month money market rate. We scale all factors to have 10% volatility (ex post). The alphas and risk-adjusted returns are not affected by this scaling. The scaling allows for an easy comparison of betas to different factors: the larger the beta, the more variance is explained by the factor (in a multivariate sense). Exhibit 2 (Panel B) shows the cumulative factor returns, where we do not compound returns, so a straight line would correspond to a constant performance over time. The Sharpe ratios of each factor are presented in parentheses in the legend and are calculated as the ratio of the mean to the standard deviation of the monthly excess returns, annualized by multiplying by the square root of 12. The traditional and dynamic factors have a positive risk premium; while the S&P 500 volatility factor carries a negative premium (i.e., a long volatility strategy has a negative return on average) with a Sharpe ratio of -1.21. This is mostly driven by the put leg of the straddle, for which the price is bid up by the large demand to hedge against sudden equity market drawdowns.

In Exhibit 2 (Panel C) we report the correlation between the different risk factors. The highest correlation (0.49) is between the equity and FX carry returns.

4. Bloomberg tickers: SPX Index, LUATTRUU Index, and SBC2A10P Index for equity, bond, and credit, respectively.
5. Carhart (1997) introduces the use of a momentum factor in relation to mutual fund performance.
6. See: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.
7. Bloomberg ticker: DBHTG10U Index.
8. See Goyal and Wahal (2015), who at the start of their paper provide a timeline of academic research on momentum and mention 2012 as the year the first paper on time-series futures momentum was published. Our results are robust to ending our study at the end of 2011.
9. Alternatively, one can use listed S&P 500 options, expiring on the third Friday of the month. We confirmed that the volatility factor we use has similar return and risk characteristics and is highly correlated to this alternative volatility factor. We prefer to use options expiring at the end of the month, as it is a more natural match to the monthly data used for hedge fund returns.
10. The Fung and Hsieh (2001) PTFS risk factors require trading 26 pairs of straddles. The straddles are rolled to the new at-the-money contract whenever the underlying reaches a new high or low price, so as to replicate the behaviour of a lookback straddle. Because several recent academic papers use the Fung and Hsieh volatility factors, we reran our regression analysis with them instead of the S&P 500 volatility factor and found that the risk-adjusted performance is similar for equity funds and slightly better for macro funds. To conserve space, these results are not included in the paper.

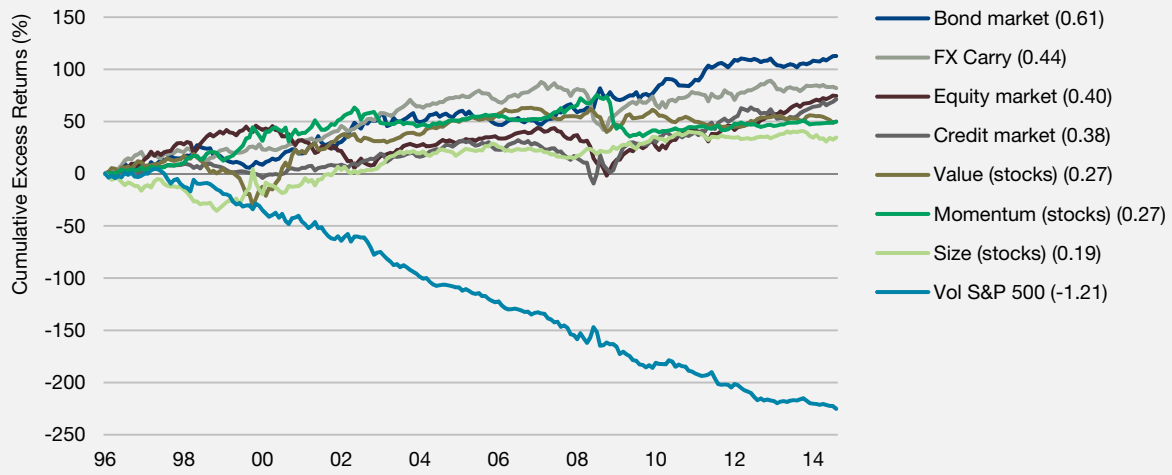
Exhibit 2: Risk factors

In Panel A, we list the risk factors considered in this paper. Panel B shows the cumulative excess returns over the June 1996 to December 2014 sample period, where we scale the annualized volatility (ex-post) to 10% to facilitate comparison. The realized Sharpe ratio for each factor is reported in parentheses in the legend. In Panel C we report the correlation between the monthly factor returns.

Panel A: Description risk factors

Category	Name	Instruments
Traditional	Equity market	S&P 500 index
	Bond market	Barclays US Treasury Index
	Credit market	Citigroup US BIG High-Grade Credit Index minus the Barclays US Treasury Index
Dynamic	Size (stocks)	Small-minus-big US stocks
	Value (stocks)	High-minus-low book value US stocks
	Momentum (stocks)	Winner-minus-loser US stocks
	FX carry	Deutsche Bank G10 currency carry index
Volatility	Vol S&P 500	Straddles for S&P500

Panel B: Cumulative excess returns of the risk factors, scaled to 10% volatility (Sharpe ratios added to legend)



Panel C: Correlation risk factor returns

	Equity market	Bond market	Credit market	Size (stocks)	Value (stocks)	Momentum (stocks)	FX Carry	Vol S&P 500
Equity market		-0.23	0.25	0.11	-0.16	-0.33	0.49	-0.13
Bond market	-0.23		0.40	-0.16	0.04	0.15	-0.12	0.00
Credit market	0.25	0.40		0.03	0.02	-0.13	0.27	-0.27
Size (stocks)	0.11	-0.16	0.03		-0.35	0.09	0.11	-0.18
Value (stocks)	-0.16	0.04	0.02	-0.35		-0.15	0.11	0.08
Momentum (stocks)	-0.33	0.15	-0.13	0.09	-0.15		-0.11	0.06
FX Carry	0.49	-0.12	0.27	0.11	0.11	-0.11		-0.14
Vol S&P 500	-0.13	0.00	-0.27	-0.18	0.08	0.06	-0.14	

3) ANALYSIS OF MACRO FUNDS

We select the subset of funds that we deem institutional-sized by applying an AUM cut-off of $100m in December 2014, and before that a value in proportion to the size of the overall hedge fund industry relative to December 2014 (i.e., $10m in December 1996). This size filter is implemented at the start of each calendar year, based on the median of the prior year's monthly AUMs.[11]

Also, we endeavour to remove funds which are repeats of each other. We identify repeats based on the similarity in fund name, taking into account that strings like "class A" and "LLP" tend to be uninformative about the underlying strategy and are more reflective of particular structures. Having identified a group of repeated funds, we use the fund with the longest history as the representative of that group. Lastly, we sum AUMs across these groups of repeated funds, assigning the total AUM to the selected representative before applying the size screen mentioned above.

We conduct our performance analysis on hedge fund excess returns, so deduct the short-term interest rate of the currency the returns are denominated in. In 74% of cases, the funds are US dollar denominated and we deduct the three month money market rate. Most of our empirical analysis performed for the average returns of funds in a particular category, like systematic macro. The average is taken at each point in time using the then-available funds, hence forming an index return series. In Section 5 we will also provide some results based on individual funds' returns.

In Exhibit 3, we report the results for the following regression:

$$R_t = \alpha + \sum_i \beta^i F_t^i + \varepsilon_t, \qquad [1]$$

where *R* is the excess return, *F* are factor excess returns, α and β are the regression coefficients, and ε is the error term.

In Panel A, we report the regression coefficients for systematic (left side) and discretionary (right side) macro funds. We indicate whether a coefficient is significant at the 10%, 5%, and 1% significance level with *, **, and *** respectively (using a Newey-West adjustment with one lag).[12] In the left column, we only include a constant, in which case the alpha (which we annualize) simply equals the average unadjusted (annual) return.

In the second column, we include traditional factors. For systematic macro managers, the long bond exposure (significant at the 1% significance level) stands out, which is intuitive given that many systematic macro managers employ trend signals, and bond prices have trended upwards over the 1996–2014 sample period. Discretionary macro managers have a meaningful long exposure to both equites and bonds.

In this third column, we also add dynamic factors. For systematic macro managers, there is a large exposure to US stock momentum, which again can be understood from the prevalence of trend following in this category. Discretionary macro managers have a modest positive exposure to US stock momentum, and also to FX carry.

In the fourth column, we add the long S&P options straddle (volatility) factor, which systematic macro managers have a (highly significant) positive exposure to. Hamill, Rattray, and Van Hemert (2016) show this is almost by construction for a trend following manager by showing it would hold positions that are similar to what a straddle delta-replication strategy would imply. For discretionary macro funds the coefficient on volatility is positive also, but less large and less significant.

Finally, Panel A of Exhibit 3 also reports the R^2 statistic, i.e., the proportion of the return variance explained by the factors. For our baseline case (including traditional, dynamic, and vol S&P 500 factors), this is 16% for systematic macro managers and 25% for discretionary macro managers. So the majority of the return variation is, in fact, not explained by the well-known factors.

Panel B of Exhibit 3 reports annualized performance statistics, including the return attributed to factor exposures. The latter can be extracted from the regression analysis by taking the average over time of the left- and right-hand side of Equation [1] and recognizing that the average error is zero by construction:

$$Avg\{R\} = \alpha + \sum_i \beta^i Avg\{F^i\}. \qquad [2]$$

Concretely, in Panel B we report the average annual return, *12*Avg{R}*, in the first row. The return attributed to factors, i.e., *12*β*Avg{F}*, aggregated over all factors is reported in the second row, and the attribution to individual factors is reported below that. Next we report the annualized alpha, *12*α*, the annualized volatility of adjusted returns, *σ(ε)* times square-root 12, and the ratio of the two, which is known as the appraisal ratio and given by:

$$AppraisalRatio = \frac{\alpha}{\sigma(\varepsilon)} * \sqrt{12}. \qquad [3]$$

For systematic macro funds, the average unadjusted excess return is 5.01% (first row). Based on the baseline case specification (i.e., including traditional, dynamic, and the vol S&P 500 factors), 2.01% of that is attributed to the bond factor and -3.21% to the vol S&P 500 factor, leaving an alpha of 4.85% after taking into account the smaller effects of other factors as well. In regards to the risk-adjustment for the vol S&P 500 exposure, notice that systematic macro funds have a long exposure to the volatility factor, which has negative returns over time. The negative risk premium for the volatility factor is intuitive given that being long volatility can act as a hedge. Correcting systematic macro funds' returns for the long volatility exposure essentially gives them credit for this hedging feature.

For discretionary macro funds, the average unadjusted return is 2.86%. Based on the baseline case specification, 0.74% of that is attributed to the equity factor, and also 0.74% to the bond exposure. The attribution to the vol S&P 500 factor is -1.28%, leaving an alpha of 1.57% after taking into account the smaller effects of other factors as well.

11. The median is used here because it is robust to the occasional order-of-magnitude error we observe in the monthly AUM figures.
12. The significance levels are only suggestive. Given that hundreds of factors have been tested, we are fully aware that a coefficient that is only two standard errors from zero is unlikely to be "significant" at the 5% level. See Harvey, Liu and Zhu (2016).

Exhibit 3: Regression analysis for macro funds

*We run regressions of systematic macro (left side) and discretionary macro (right side) returns on different subsets of the risk factor returns. The factors are (ex-post) scaled to 10% volatility to facilitate interpretation of the reported coefficients in Panel A, where significance is indicated by *, **, *** for the 10%, 5%, and 1% significance level respectively. Panel B reports annualized performance statistics for the different subsets of risk factors considered, including the return attributed to factors, which is computed as the coefficient times the average factor return. Panel C shows the unadjusted (blue line), and risk-adjusted (grey line) cumulative excess returns, as well as the correction (green line). The risk-adjusted return is corrected for any variation explained by the exposure to traditional, dynamic, and vol S&P 500 factors (the fourth specification in Panels A and B). The classification of funds into systematic and discretionary is done using text analysis. We use monthly data from HFR for the June 1996 to December 2014 period.*

Panel A: Regression coefficients

Systematic Macro

	None	Traditional	Traditional +Dynamic	Traditional +Dynamic +Vol S&P500
Alpha (annualized)	5.01%*	3.08%	1.85%	4.85%*
Equity		0.01	0.03	0.03
Bond		0.36***	0.36***	0.33***
Credit		-0.08	-0.09	-0.01
Size (stocks)			0.02	0.06
Value (stocks)			0.09	0.08
Momentum (stocks)			0.18**	0.18**
FX Carry			0.10	0.11
Vol S&P 500				0.26***
R-squared	0%	8%	11%	16%

Discretionary Macro

	None	Traditional	Traditional +Dynamic	Traditional +Dynamic +Vol S&P500
Alpha (annualized)	2.86%**	1.24%	0.38%	1.57%
Equity		0.21***	0.19***	0.19***
Bond		0.12**	0.13***	0.12**
Credit		0.01	-0.01	0.02
Size (stocks)			0.06	0.07*
Value (stocks)			0.03	0.03
Momentum (stocks)			0.09*	0.09*
FX Carry			0.11**	0.12***
Vol S&P 500				0.11**
R-squared	0%	15%	22%	25%

Panel B: Performance (annualized)

Systematic Macro

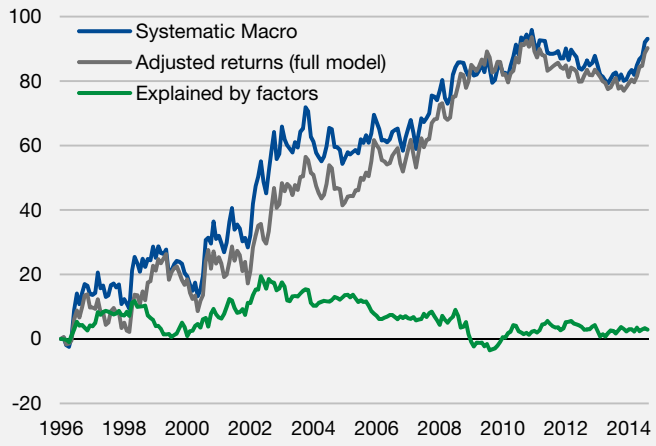
	None	Traditional	Traditional +Dynamic	Traditional +Dynamic +Vol S&P500
Return average	5.01%	5.01%	5.01%	5.01%
Attributed to factors	0.00%	1.94%	3.17%	0.15%
Equity		0.04%	0.14%	0.11%
Bond		2.21%	2.16%	2.01%
Credit		-0.31%	-0.34%	-0.04%
Size (stocks)			0.04%	0.11%
Value (stocks)			0.25%	0.22%
Momentum (stocks)			0.49%	0.47%
FX Carry			0.43%	0.48%
Vol S&P 500				-3.21%
Adj. return avg. (alpha)	5.01%	3.08%	1.85%	4.85%
Adj. return volatility	11.71%	11.29%	11.19%	10.93%
Appraisal ratio	0.43	0.27	0.17	0.44

Discretionary Macro

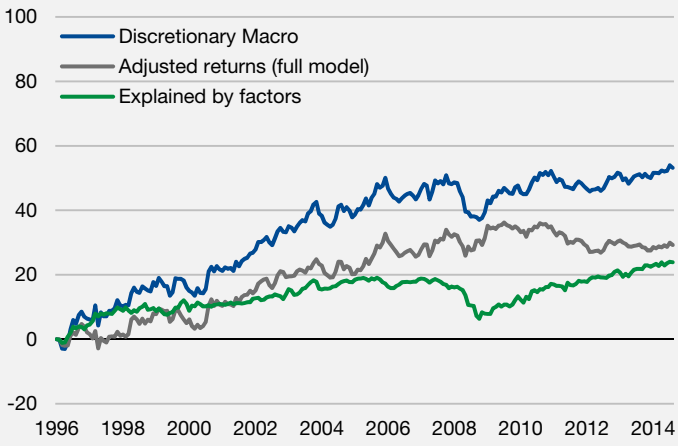
	None	Traditional	Traditional +Dynamic	Traditional +Dynamic +Vol S&P500
Return average	2.86%	2.86%	2.86%	2.86%
Attributed to factors	0.00%	1.62%	2.48%	1.28%
Equity		0.83%	0.75%	0.74%
Bond		0.73%	0.80%	0.74%
Credit		0.06%	-0.02%	0.10%
Size (stocks)			0.11%	0.14%
Value (stocks)			0.09%	0.08%
Momentum (stocks)			0.25%	0.24%
FX Carry			0.50%	0.52%
Vol S&P 500				-1.28%
Adj. return avg. (alpha)	2.86%	1.24%	0.38%	1.57%
Adj. return volatility	5.77%	5.37%	5.19%	5.10%
Appraisal ratio	0.50	0.23	0.07	0.31

Panel C: Risk-adjusted returns (correcting for traditional, dynamic, and vol S&P 500 factor exposures)

Systematic Macro



Discretionary Macro



Looking at the appraisal ratio rather than the alpha, the performance difference between systematic and discretionary macro funds is smaller, e.g. for the baseline case we observe 0.44 and 0.31, respectively. The reason is that systematic macro returns are more volatile, both in terms of unadjusted returns and the unexplained returns (regression error term).

Finally, in Panel C of Exhibit 3, we plot the risk-adjusted returns, which are obtained by re-arranging Equation [1]:

$$R_t^{Adj} = R_t - \sum_i \beta^i F_t^i = \alpha + \varepsilon_t \,. \qquad [4]$$

For this figure, we use the baseline case specification with traditional, dynamic, and the vol S&P 500 factors. We show the history of the unadjusted (blue line) and risk-adjusted (grey line) cumulative returns, where, as before in Exhibit 2, we do not compound returns. We also show the difference, i.e., what is explained by the factors (green line). For systematic macro managers the unadjusted and risk-adjusted cumulative returns are fairly close, i.e., adjustments for the various risk factors, notably the bond and volatility factors, are mostly offsetting. For discretionary macro managers, the risk-adjusted returns are well below unadjusted returns and the dip in unadjusted returns at the end of 2008 can be largely explained by factor exposures (particularly the long equity exposure).

We ran an additional regression with the difference between the systematic and discretionary macro return as dependent variable, and all factor returns as explanatory variables. The alpha difference (captured by the constant) for the baseline case is 3.28% (annualized), which (of course) is identical to the difference of the alphas reported in Exhibit 3. More informative is the fact that the t-stat on the alpha difference is only 1.66, failing to exceed two standard errors from zero.

At minimum, our results suggest that systematic macro funds have performed at least as well as discretionary macro funds; a conclusion that is robust to using a number of performance metrics (average unadjusted return, average risk-adjusted return, and appraisal ratio).

4) ANALYSIS OF EQUITY FUNDS

In Exhibit 4, we repeat our analysis for systematic equity (left panel) and discretionary equity (right panel) funds.

In Panel A, the large (and significant) positive exposure to the equity market factor stands out, for both systematic (left table) and discretionary (right table) equity managers. While many equity managers may advertise their funds as being market-neutral, these results show that this does not hold up for the group in aggregate. The bond and credit factors are significant but have small coefficient values, which implies less economic meaning because the factors were scaled to equal volatility (as previously described).

Looking at the third column, where we also add dynamic factors, we note that both systematic and discretionary equity managers have a sizable exposure to the stock size factor, suggesting that there is a tendency to be long small cap / short large cap stocks on average. One possible explanation for this is that, for the short side, it may be more feasible (and cheaper) to use the futures contract on a large-cap index, like the S&P 500 index. Alternatively, it may just be easier for managers to find opportunities in small caps. For discretionary equity funds, there is also an important long exposure to the FX carry factor. A possible explanation is that discretionary equity funds find (long) investment opportunities in less liquid stocks, which (just like FX carry) may suffer when liquidity suddenly dries up.

The reported R^2 statistic in Panel A of Exhibit 4, is 73% for systematic equity managers and 77% for discretionary equity managers in the baseline case (i.e., including traditional, dynamic, and the vol S&P 500 factor). This is much higher than the 16% and 25% that we reported before for systematic and discretionary macro funds, respectively. The equity factor is the dominant driver of the R^2 statistic.

In Panel B of Exhibit 4, we report different performance statistics (for the method, see the discussion and formulas in the previous section). For systematic equity funds, the average unadjusted return is 2.88% (see first row). Based on the baseline case specification, 1.70% of that is attributed to the equity factor, leaving an alpha of 1.11% after taking into account the smaller effects of other factors as well.

For discretionary equity funds, the average unadjusted return is 4.09%. Based on the baseline case specification, 2.51% of that is attributed to the equity factor, leaving an alpha of 1.22% after taking into account the smaller effects of other factors as well. Hence for the baseline case specification, the alpha for discretionary equity funds is slightly higher than it is for systematic equity funds. However, the appraisal ratio is slightly lower with a value of 0.25 for discretionary equity funds, versus 0.35 for systematic equity funds.

As we did for macro funds in the previous section, we plot in Panel C of Exhibit 4 the history of the unadjusted (blue line) and risk-adjusted (grey line) cumulative returns. Given the dominance of the equity risk factor, for both systematic and discretionary equity funds, the difference between the unadjusted and risk-adjusted returns (green line) follows closely the returns of the S&P 500 index, with drawdowns when the tech bubble burst in 2000 and during the financial crisis in 2008.

We also ran an additional regression with the difference between the systematic and discretionary equity return as dependent variable, and all factor returns as explanatory variables. The alpha difference for the baseline case is an insignificant -0.11% (annualized) with a t-statistic of -0.11.

In sum, while the average unadjusted return is higher for discretionary equity than it is for systematic equity, when we control for risk factors the performance is similar (both the alpha and appraisal ratio are similar).

Exhibit 4: Regression analysis for equity funds

*We run regressions of systematic equity (left side) and discretionary equity (right side) returns on different subsets of the risk factor returns. The factors are (ex-post) scaled to 10% volatility to facilitate interpretation of the reported coefficients in Panel A, where significance is indicated by *, **, *** for the 10%, 5%, and 1% significance level respectively. Panel B reports annualized performance statistics for the different subsets of risk factors considered, including the return attributed to factors, which is computed as the coefficient times the average factor return. Panel C shows the adjusted (blue line), and risk-adjusted (grey line) cumulative excess returns, as well as the correction (green line). The risk-adjusted return is corrected for any variation explained by the exposure to traditional, dynamic, and vol S&P 500 factors (the fourth specification in Panels A and B). The classification of funds into systematic and discretionary is done using text analysis. We use monthly data from HFR for the June 1996 to December 2014 period.*

Panel A: Regression coefficients

Systematic Equity

	None	Traditional	Traditional +Dynamic	Traditional +Dynamic +Vol S&P500
Alpha (annualized)	2.88%*	1.36%	1.17%	1.11%
Equity		0.45***	0.42***	0.42***
Bond		-0.08***	-0.07***	-0.07***
Credit		0.05	0.05	0.05
Size (stocks)			0.09***	0.09***
Value (stocks)			-0.09**	-0.09**
Momentum (stocks)			0.05*	0.05*
FX Carry			0.04	0.04
Vol S&P 500				-0.01
R-squared	0%	66%	73%	73%

Discretionary Equity

	None	Traditional	Traditional +Dynamic	Traditional +Dynamic +Vol S&P500
Alpha (annualized)	4.09%	1.80%	0.83%	1.22%
Equity		0.69***	0.62***	0.62***
Bond		-0.16***	-0.11***	-0.12***
Credit		0.13***	0.10**	0.11**
Size (stocks)			0.27***	0.28***
Value (stocks)			-0.10**	-0.10**
Momentum (stocks)			0.08*	0.08*
FX Carry			0.14***	0.14***
Vol S&P 500				0.03
R-squared	0%	63%	77%	77%

Panel B: Performance (annualized)

Systematic Equity

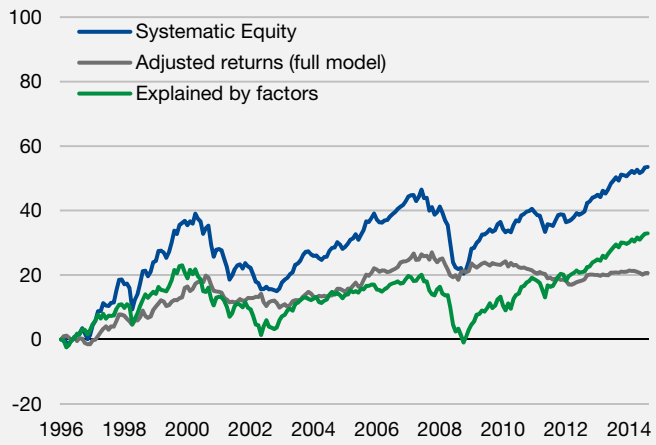
	None	Traditional	Traditional +Dynamic	Traditional +Dynamic +Vol S&P500
Return average	2.88%	2.88%	2.88%	2.88%
Attributed to factors	0.00%	1.51%	1.71%	1.77%
Equity		1.79%	1.70%	1.70%
Bond		-0.48%	-0.41%	-0.41%
Credit		0.20%	0.19%	0.18%
Size (stocks)			0.17%	0.17%
Value (stocks)			-0.23%	-0.23%
Momentum (stocks)			0.13%	0.13%
FX Carry			0.16%	0.16%
Vol S&P 500				0.07%
Adj. return avg. (alpha)	2.88%	1.36%	1.17%	1.11%
Adj. return volatility	5.97%	3.53%	3.17%	3.18%
Appraisal ratio	0.48	0.39	0.37	0.35

Discretionary Equity

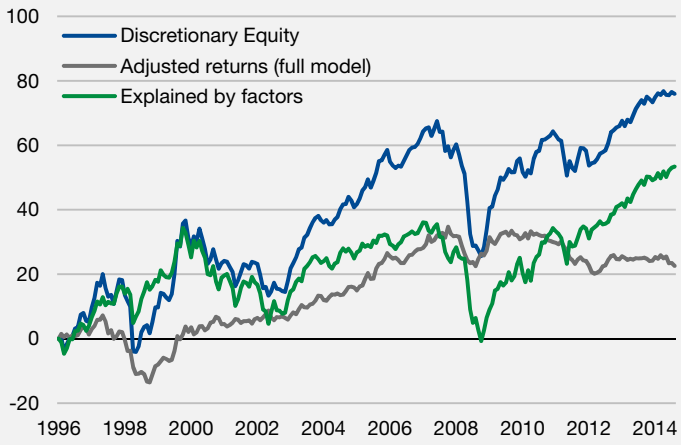
	None	Traditional	Traditional +Dynamic	Traditional +Dynamic +Vol S&P500
Return average	4.09%	4.09%	4.09%	4.09%
Attributed to factors	0.00%	2.29%	3.25%	2.86%
Equity		2.78%	2.51%	2.51%
Bond		-1.00%	-0.70%	-0.72%
Credit		0.51%	0.36%	0.40%
Size (stocks)			0.51%	0.52%
Value (stocks)			-0.26%	-0.27%
Momentum (stocks)			0.22%	0.21%
FX Carry			0.61%	0.62%
Vol S&P 500				-0.41%
Adj. return avg. (alpha)	4.09%	1.80%	0.83%	1.22%
Adj. return volatility	9.78%	5.96%	4.79%	4.79%
Appraisal ratio	0.42	0.30	0.17	0.25

Panel C: Risk-adjusted returns (correcting for traditional, dynamic, and vol S&P 500 factor exposures)

Systematic Equity



Discretionary Equity



5) DIVERSIFICATION POTENTIAL

In Exhibit 5, we report the correlations between the different hedge fund styles using unadjusted returns (left panel) and risk-adjusted returns (right panel). Macro and equity funds returns historically have a low correlation with each other (in the 0.0 to 0.5 range), allowing for potentially substantial diversification benefits when combining both asset classes. However, discretionary and systematic funds within macro or within equity are historically more highly correlated (in the 0.6 to 0.9 range). This suggests to us that discretionary and systematic manager's investment strategies are more similar than one might think.

So far we have evaluated index returns, by means of looking at returns averaged over all the funds in a particular category.[13] Next we turn our attention to fund-level returns. In order to conduct a meaningful statistical analysis, we require that funds have a minimum of 36 months of data. This may create a survivorship bias, affecting the overall performance level. However, our main goal is to get a sense for the dispersion in performance which is likely less affected by the selection method. It should also be noted that one cannot directly compare the fund-level results with the previous index-level results. For example, in the index-level results funds with a longer history implicitly get more weight because they are constituents for longer.

In Exhibit 6, we show the 25th, 50th, and 75th percentile of the average return and Sharpe ratio distribution for unadjusted fund returns (panel A) and similarly the alpha and appraisal ratio for risk-adjusted returns (panel B). The risk-adjusted returns are for the baseline case, which uses traditional, dynamic, and the vol S&P 500 factor. The analysis is performed on individual fund returns for each of the four different hedge fund styles. The spread between the 75th and 25th percentile average return ranges from 5.5% to 7.7% and the spread in alpha values is even larger, ranging from 5.9% to 10.5%. Dispersion between best and worst managers therefore is large for each of the hedge fund styles. Again, discretionary and systematic managers are historically more similar than some observers might think.

In Exhibit 6, we also report the 25th, 50th, and 75th percentile of the R^2 statistic of the regression underpinning the risk-adjustment. Risk factors explain a slightly larger proportion of the return variance for equity funds than they do for macro funds. At the index level (Exhibits 3 and 4), where idiosyncratic risk is diversified, we found that the contrast is much bigger, with R^2 statistics of 16% and 25% for systematic and discretionary macro funds, and 73% and 77% for systematic and discretionary equity funds.

6) CONCLUSION

In this paper, we have used text analysis to categorize hedge funds as systematic (employing rules-based or algorithmic strategies) or discretionary (relying on human decision making). Our main focus is on risk-adjusted returns. These are corrected for any variation in returns that is simply due to an exposure to risk factors that were well known already in 1996, when our empirical analysis starts. We found that for equity strategies, systematic and discretionary funds have historically had similar average risk-adjusted returns. For macro strategies, systematic funds outperform their discretionary counterparts on a risk-adjusted basis for the periods tested.

Our results show that an aversion to systematic managers, as displayed by some allocators, and in line with a more general "algorithm aversion" phenomenon, may be unjustified.
Our results should not be misconstrued to imply that systematic funds are intrinsically superior to discretionary. We believe it is likely that some market inefficiencies are more suitable for a systematic approach while others are better exploited by a discretionary approach. Also, most of our analysis was for hedge fund style index returns. The outlook for an investor that is skilled at selecting the best managers within a style may be quite different.

One could argue that the term "hedge fund" suggests hedged (or zero net) exposure to well-known risk factors. As a by-product of our risk-adjustment methodology, we mapped out the dominant risk factors for the different hedge fund styles. We find that in many cases the exposure is statistically significant and economically meaningful. We believe it is important for investors who allocate to hedge funds as part of a larger portfolio to be aware of the specific risk exposures of the different styles, as the non-hedge fund investments may have a meaningful exposure to the same risk factors.

13. The average return approach essentially implies rebalancing fund weights to equal weights each month and, as such, is different from what a buy-and-hold position in each of the index constituents would give. See Granger et al. (2014) for a further discussion on this issue.

Exhibit 5: Correlation between different hedge fund style returns

Correlations between the unadjusted excess returns (left panel) and risk-adjusted returns (right panel) of different categories using monthly data from HFR for the June 1996 to December 2014 period. The risk-adjusted return is corrected for any variation explained by the exposure to traditional, dynamic, and vol S&P 500 factors.

Unadjusted returns

		Macro		Equity	
		systematic	discretionary	systematic	discretionary
Macro	systematic		0.72	0.02	0.00
	discretionary	0.72		0.47	0.47
Equity	systematic	0.02	0.47		0.89
	discretionary	0.00	0.47	0.89	

Risk-adjusted returns

		Macro		Equity	
		systematic	discretionary	systematic	discretionary
Macro	systematic		0.77	0.22	0.16
	discretionary	0.77		0.44	0.41
Equity	systematic	0.22	0.44		0.63
	discretionary	0.16	0.41	0.63	

Exhibit 6: Fund-level statistics

In this exhibit we report the 25th, 50th, 75th and percentile of the average return and Sharpe ratio distribution for unadjusted fund returns (panel A) and similarly the alpha and appraisal ratio for risk-adjusted fund returns based on the baseline case with eight risk factors (panel B). For the risk-adjusted returns we also report the R^2 statistic. We only include funds with at least 36 months of return data. The sample period is June 1996 to December 2014.

Panel A: No factors (unadjusted returns)

Average return (annualized)

	Macro		Equity	
	Systematic	Discretionary	Systematic	Discretionary
25th percentile	0.79%	0.82%	0.40%	1.42%
50th percentile	3.78%	3.27%	4.47%	5.40%
75th percentile	6.96%	6.36%	8.05%	9.02%
Spread 75th-25th	6.17%	5.54%	7.65%	7.60%

Sharpe ratio (annualized)

	Macro		Equity	
	Systematic	Discretionary	Systematic	Discretionary
25th percentile	0.06	0.10	0.05	0.13
50th percentile	0.28	0.33	0.46	0.43
75th percentile	0.48	0.63	0.83	0.78
Spread 75th-25th	0.42	0.53	0.78	0.65

Panel B: Baseline case factors (risk-adjusted returns)

Alpha (annualized)

	Macro		Equity	
	Systematic	Discretionary	Systematic	Discretionary
25th percentile	-4.35%	-2.02%	-0.55%	-0.97%
50th percentile	1.67%	1.78%	2.03%	2.76%
75th percentile	6.10%	5.98%	5.31%	6.19%
Spread 75th-25th	10.45%	8.00%	5.86%	7.16%

Appraisal ratio (annualized)

	Macro		Equity	
	Systematic	Discretionary	Systematic	Discretionary
25th percentile	-0.36	-0.19	-0.07	-0.12
50th percentile	0.13	0.20	0.29	0.33
75th percentile	0.47	0.72	0.75	0.70
Spread 75th-25th	0.83	0.91	0.82	0.82

R^2 statistic

	Macro		Equity	
	Systematic	Discretionary	Systematic	Discretionary
25th percentile	15%	21%	24%	30%
50th percentile	24%	34%	39%	46%
75th percentile	34%	50%	57%	63%
Spread 75th-25th	19%	29%	33%	33%

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APPENDIX: FUND CLASSIFICATION

We use the HFR database on hedge funds, which classifies all hedge funds into four broad strategies: Equity Hedge, Event Driven, Macro, and Relative Value.[14] We focus on the Equity Hedge and Macro strategies, which are the largest and second-largest in terms of number of funds, respectively, and which naturally allow for both a discretionary and a systematic approach. For both strategies, we omit sub-strategies referred to as "multi-strategy", as it is likely hard to pinpoint the trading style, and sector-specific sub-strategies like "Equity Technology/Healthcare" or "Macro Commodity-Agriculture". Doing so, we are left with the top four Equity Hedge and top two Macro sub-strategies in terms of fund count (see Exhibit A).

Using Macro funds as learning set, we search for "systematic words" defined as words that are more likely to occur in Macro Systematic Diversified than in Macro Discretionary Thematic fund descriptions. More precisely, we considered all strings of consecutive letters with a length of four or more and with the first letter coinciding with the start of a word. So the string "system" is counted not only if it occurs as standalone word, but also if "systems" or "systematic" occurs. We use three formal criteria that all need to be met:

1. **Material**. The difference between the percentage of systematic funds with the specified word and the percentage of discretionary funds with that word needs to be at least 6 percentage points.
2. **Polarizing**. The ratio of the percentage of systematic funds with the specified word and the percentage of discretionary funds with that word needs to be at least 4 times.
3. **Universal**. The ratio of the percentage of equity funds with the word and the percentage of macro funds with the word needs to be 0.21 times.[15]

The three criteria serve to only select words that are material, polarizing, and universal in that sense that they are also relevant in an equity context. In Exhibit A, we present the words that satisfy the three criteria (rows labelled as "this paper"). The statistics associated with the three criteria are shown in the final three columns. Often several similar words satisfy the criteria, e.g. "compute" and "computer", in which case we typically went for the longer word, unless it had a noticeably lower score on any of the three criteria used. The default choice for the longer word is to reduce the chance of the word being used in an unexpected way in a different context (notably the equity fund context).

A related paper by Chincarini (2014) compares performance and fees of quantitative and qualitative (as he calls it) funds. This is quite different from our study as quantitative techniques are widely used (to a greater or lesser degree) by both systematic and discretionary funds. Also, Chincarini classifies Equity Market Neutral funds as quantitative by default. This is particularly problematic for comparing the equity market exposure (i.e., beta) of quantitative and qualitative funds: his finding that quantitative funds are more market neutral may be a direct result of the chosen categorization method. Comparing our words to those used by Chincarini (2014) (who partially relies on sub-strategy classifications as well), and referred to as such in Exhibit A, one can see many differences. We pick up on "approx", "computer", and "system", which are highlighted green for contrast. On the other hand, we don't use words like "econometric" (which actually occur more often in Discretionary Thematic descriptions) and "quantitative" which is quite common in Discretionary Thematic descriptions also.

Putting it all together, we classify funds for which the description contains at least one systematic word as systematic and all other funds are classified as discretionary. We considered using a list of discretionary words also, but we found that it is harder to identify many words that are specific to discretionary managers and thus discretionary funds are best identified as not having any systematic words in their fund description. The fraction of funds classified as systematic for each HFR category is therefore given by the ANY row of the section labelled "this paper" in Exhibit A. For consistency, and because funds may be misclassified, we also use our classification for macro funds, rather than using the HFR classification. From Exhibit A, Macro Systematic Diversified funds are classified as systematic in 68% of the cases, while for Macro Discretionary Thematic this is only 18%. Looking through the Macro Systematic Diversified funds that we don't classify as systematic, there typically doesn't seem to be a clear indication that the fund is in fact systematic, and we deem it probable that the fund is rather partially systematic or quantitative, but not rules based. For equity funds, 49% of Equity Market Neutral, 41% of Quantitative Directional, 14% of Fundamental Growth, and 18% of Fundamental Value funds are classified as systematic.

In addition, we browsed through a number of descriptions for Equity Quantitative Directional funds not classified as systematic (so classified as discretionary) and typically found no suggestions that the fund is actually systematic and, in fact, often found language suggestive of a discretionary approach, such as *"also opportunistically trades dislocations"* or *"identify investment opportunities through extensive meetings with company managements"*.

14. See https://www.hedgefundresearch.com/hfr-hedge-fund-strategy-classification-system for an overview of strategy and sub-strategy names and descriptions.
15. The cut-off values were chosen as the least-strict values for which only words that we consider germane to systematic strategies satisfy the criteria.

Exhibit A: HFR category names, fund count, systematic words used

We present for our six chosen HFR sub-strategies the name, fund count, and the percentage of fund descriptions containing a given word. In the last three columns, we also present the three criteria that all need to be met for a word to be deemed a "systematic word". We will classify funds with at least one systematic word in its description as systematic and other funds as discretionary (see ANY row in the blue block, labelled "This paper"). For contrast, we also show the statistics for the words used in Chincarini (2014) (see green block), where we highlight in red words and statistics not satisfying our criteria. The other way around, we highlight in green words we will use and Chincarini (2014) does not.

		HFR sub-strategies						Criteria for "systematic words"		
		EQUITY Eq. Market Neutral	EQUITY Quantitative Directional	EQUITY Fundamental Growth	EQUITY Fundamental Value	MACRO Systematic Diversified	MACRO Discretionary Thematic	%Systematic - %Discretionary (Cutoff: >6.0%)	%Systematic / %Discretionary (Cutoff: >4.0)	%EQUITY / %MACRO (Cutoff: >0.21)
		Total fund count								
		1152	689	2084	3030	1440	742			
	Word	**Descriptions containing word (% of total)**						**Material**	**Polarizing**	**Universal**
This paper	algorithm	4.2%	8.3%	0.2%	0.3%	6.7%	0.3%	6.4%	24.7	0.37
	approx	9.6%	6.2%	3.3%	4.0%	9.1%	1.8%	7.3%	5.2	0.75
	computer	2.8%	5.4%	0.3%	0.5%	8.8%	0.5%	8.2%	16.2	0.22
	model	28.5%	24.1%	7.2%	10.3%	30.8%	7.3%	23.5%	4.2	0.60
	statistical	12.2%	5.8%	0.3%	1.1%	11.3%	1.9%	9.4%	6.0	0.39
	system	18.8%	23.8%	4.8%	5.5%	54.0%	11.5%	42.6%	4.7	0.24
	ANY	**48.8%**	**40.9%**	**14.0%**	**17.8%**	**68.4%**	**18.1%**	**50.3%**	**3.8**	**0.47**
Chincarini (2014)	algorithm	4.2%	8.3%	0.2%	0.3%	6.7%	0.3%	6.4%	24.7	0.37
	automate	2.1%	3.2%	0.0%	0.2%	3.9%	0.1%	3.8%	28.9	0.28
	econometric	0.8%	0.7%	0.0%	0.0%	0.6%	1.1%	-0.5%	0.5	0.29
	mathematical	2.0%	0.7%	0.2%	0.3%	4.9%	0.7%	4.3%	7.3	0.17
	model	28.5%	24.1%	7.2%	10.3%	30.8%	7.3%	23.5%	4.2	0.60
	quantitative	26.8%	21.2%	4.8%	8.2%	22.6%	13.2%	9.4%	1.7	0.59
	statistic	12.3%	6.0%	0.5%	1.2%	11.6%	2.3%	9.3%	5.1	0.39
	ANY	**45.9%**	**42.4%**	**11.3%**	**16.5%**	**47.7%**	**18.5%**	**29.2%**	**2.6**	**0.59**

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