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Hedge Funds and Stock Price Formation

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Using comprehensive quarterly data on hedge fund stock holdings, we study the role of hedge funds in the process of stock price formation. We find that hedge funds tend to hold undervalued stocks and that both hedge fund ownership and trading by hedge funds are positively related to the degree of stock mispricing. A portfolio of undervalued stocks with high hedge fund ownership generated a risk-adjusted return of 0.40% per month (4.8% annually), and the profit remained even after transaction costs. Hedge fund ownership and trades also precede the dissipation of stock mispricing. These patterns are either nonexistent or much weaker for other institutional investors. Our results suggest that hedge funds exploit and help correct mispricing but the process is not instantaneous.

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Hedge funds have become the Galápagos Islands of finance.

—*Andrew W. Lo, Adaptive Markets, 2017*

In November 2016, Goldman Sachs launched a brand-new exchange-traded fund (ETF), GVIP, to track the performance of its hedge fund index, the VIP. The VIP is based on fundamentally driven hedge fund managers' "very important positions," which are those that appear most frequently among their top 10 long equity holdings. The VIP has outperformed the S&P 500 Index by an average of more than 2% annually since the index inception in 2001. The ETF GVIP offers investors a portfolio of the top holdings of Appaloosa Management, Icahn Associates, Maverick Capital, Millennium Management, Paulson & Co., Viking Global Investors, and so on.

Motivated by the information content and potential investment value of hedge fund holdings, we address the following issue in this article: Do hedge funds, as a group, exploit and correct price inefficiencies in the stock market? In particular, for the study reported here, we examined whether hedge funds target undervalued stocks that plot above the security market plane. Focusing on such stocks, we further studied whether hedge funds profit from these trades and whether

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their trades reduce mispricing. These questions are of great importance for academics, practitioners, and regulators in understanding the role that hedge funds play in the stock market.

For our analysis, we manually assembled a large dataset of stock holdings of 1,517 hedge fund management companies for the period 1981–2015. This dataset is, to our knowledge, one of the most comprehensive in the literature. It covers all major hedge funds that hold US stocks.[1] Using the long-position data, we studied the role of hedge funds in the stock price formation process.

First, we examined whether hedge funds exploit stocks with mispricing. Because long positions for arbitrage purposes should target undervalued stocks, we focused on undervalued stocks as positive-alpha stocks plotting above the security market plane dictated by asset pricing models.[2] Second, we investigated whether hedge fund holdings in undervalued stocks can predict future stock returns. Our results suggest that significant investment value can be derived from hedge fund holdings. We also show the importance of studying positive-alpha stocks rather than the universe of all stocks, because the implication of hedge fund trades in general is ambiguous.

In addition, we show that undervalued stocks with higher hedge fund ownership and trading in one quarter are more likely to have mispricing corrected in the next quarter, suggesting that hedge funds help reduce mispricing, although price correction does not occur instantaneously. This result complements the finding of Cao, Liang, Lo, and Petrasek (forthcoming) that hedge fund trading generally improves market efficiency (measured by stock price deviation from the random walk model). We also document remarkable differences in the information content of equity holdings between hedge funds and other institutional investors, including banks, insurance companies, and mutual funds.

Data

Our study combines data about stock holdings by institutional investors, including hedge fund companies and other types of institutions, and information about common stocks.

Hedge Fund Companies. Although hedge fund companies have historically been exempt from registering with the US SEC, they have been subject to the Form 13F disclosure requirement. Hedge fund companies with more than $100 million in assets under management (AUM) are required to file quarterly disclosures of equity holdings. All common stock positions greater than 10,000 shares or $200,000 in market value are subject to reporting, but short positions are not required to be reported.

Because 13F filings do not indicate which institutions are hedge fund companies, we identified them by compiling a master list of hedge fund company names culled from six hedge fund databases: TASS (Lipper Hedge Fund Database), Hedge Fund Research (HFR), the Center for International Securities and Derivatives Markets, BarclayHedge, Morningstar, and Bloomberg. We then matched the list with the names of 13F institutions to screen for hedge fund companies. Among the matched institutions, we ensured that hedge fund management was, indeed, their primary business. We first checked whether they were registered with the SEC. Following Brunnermeier and Nagel (2004), we included unregistered companies because hedge funds were not required to register with the SEC for most of our sample period. If an adviser was registered with the SEC, however, we followed Brunnermeier and Nagel and Griffin and Xu (2009) in checking its Form ADV and included it in our sample only if the following two criteria were both satisfied: (1) More than 50% of its clients were high-net-worth individuals or more than 50% of its investment was listed as "other pooled investment vehicles," and (2) the adviser was compensated with performance-based fees. Because Dodd–Frank Act regulations, which required qualified hedge fund companies to register with the SEC, became effective in 2013, we examined all ADF filings since 2013 to identify fund companies on the basis of the two criteria and added these to our master list of hedge fund names from the commercial databases. Finally, to overcome the challenge that some hedge fund companies neither registered with the SEC nor reported to any database in the early years, we manually checked company websites and other online sources for each of the unmatched 13F institutions to determine whether any was a hedge fund company. This multistep procedure ensured that our stock-level measure of hedge fund ownership, although subject to measurement imperfection (e.g., small hedge fund companies were neglected), was, by and large, accurate.

Our final sample included 1,517 hedge fund companies with all the major hedge funds trading in the US stock market during the sample period, 1981–2015. Because a management company often offers

multiple funds, the hedge fund companies in our sample collectively manage more than 5,000 individual hedge funds.[3]

Other Institutional Investors. After identifying hedge fund companies, we classified the 13F institutions into six categories: hedge funds, banks, insurance companies, investment companies (mainly mutual funds), independent investment advisers, and others. The classifications of banks and insurance companies were based on the type codes available from CDA/Spectrum before 1998 and then the procedure of Bushee (2004) for the post-1998 period.[4] We used mutual fund holdings information from the Thomson Reuters S12 (i.e., S-1-2) data. The group of investment advisers in our sample includes small independent advisers, broker/dealers, and major investment banks that were not registered as bank holding companies before 2008. Finally, the "others" category includes university and private endowments, philanthropic foundations, and corporate pension funds.

Figure 1 plots the average fraction of shares held by various types of institutions for the first quarter of 1981 through the fourth quarter of 2015. Previous studies (e.g., Gompers and Metrick 2001; Bennett, Sias, and Starks 2003) documented the fast growth of stock ownership by total institutional investors. Our data show a disproportionately rapid increase in hedge fund ownership relative to other types of institutions. The total institutional ownership of common stocks increased from 11.4% in 1981 to 54.4% (about five times) at the end of 2015, but hedge fund ownership grew from 0.02% to 9% (about 450 times) over the same period. By 2015, hedge funds controlled 16.4% of shares held by all institutions, whereas mutual funds and banks controlled 39.2% and 14.4%, respectively. To streamline the empirical analysis, we combined all the non-hedge-fund categories into one group.[5]

Common Stocks. To facilitate our analysis at the *stock* level, we merged the 13F data with the CRSP and Compustat data for common stocks listed on the NYSE, AMEX, and NASDAQ. We obtained daily stock returns from CRSP and accounting data from the merged CRSP/Compustat quarterly industrial file. For each quarter, we required the included stocks to have at least 30 daily returns during the previous quarter, market capitalization that was not missing, and a nonnegative book value at the end of the previous quarter. We excluded the last quarter for any company delisted during the sample period.[6] Our merged data contain 444,059 company-quarter observations over the sample period 1981–2015.

Based on the merged data from the CRSP, Compustat, and 13F sources, **Table 1** reports stock characteristics at the company-quarter level for the full sample and for a subsample of stocks with top-decile hedge fund ownership in each quarter. The average book/market of 0.67 (with a median of 0.58) for the full sample is slightly higher than the average book/market for stocks with top-decile hedge fund ownership. Stocks with high hedge fund ownership tend to be smaller companies; the average market capitalizations for the full sample and for stocks with

Figure 1. Evolution of Stock Ownership by Institutional Investors, 1981–2015

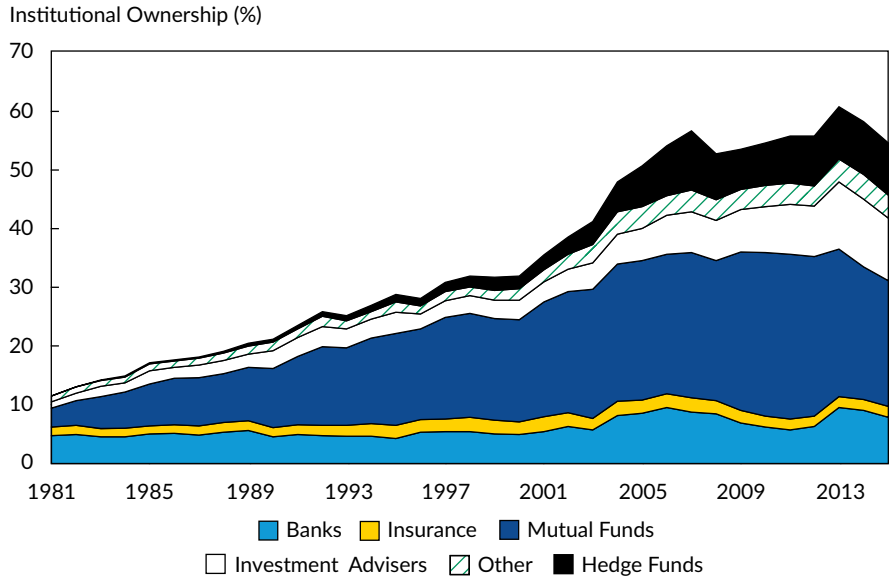


Table 1. Summary Statistics

	Mean	Std. Dev.	25%	Median	75%
A. All stocks in full sample					
Book/Market	0.67	0.42	0.35	0.58	0.89
Market cap ($ billions)	2.67	13.51	0.08	0.29	1.16
Dividend yield (%)	0.36	0.51	0.00	0.00	0.60
Age (months)	200.27	188.91	62.00	146.00	270.00
Share price ($)	24.85	26.94	10.88	18.63	31.00
S&P 500 dummy	0.12	0.33	0.00	0.00	0.00
B. Stocks belonging to top decile of hedge fund ownership					
Book/Market	0.64	0.43	0.31	0.54	0.87
Market cap ($ billions)	0.98	2.33	0.13	0.34	0.95
Dividend yield (%)	0.20	0.43	0.00	0.00	0.22
Age (months)	158.99	165.63	44.00	105.00	212.00
Share price ($)	22.94	22.86	10.60	17.50	28.75
S&P 500 dummy	0.07	0.26	0.00	0.00	0.00

Notes: The dividend yield is per quarter share price. The full sample is based on merged data for 1981–2015.

top-decile hedge fund ownership are $2.67 billion and $0.98 billion, respectively. Stocks with high hedge fund ownership have lower dividend yields, younger age, and a lower percentage of S&P 500 membership than stocks in the full sample.

Hedge Fund Activities and Stock Mispricing

In this section, we discuss how we measured stock mispricing and then analyze how hedge fund ownership and trading are related to the degree of mispricing in the cross section of stocks.

Measuring Stock Mispricing. We used the alpha estimate from the Fama–French–Carhart (Carhart 1997) four-factor model to determine whether a stock deviated from the security market plane. In theory, alpha captures abnormal return in excess of what is predicted by the model. Although hedge funds may identify inefficiencies by using heterogeneous techniques (e.g., on the basis of factor models or stock characteristics), the use of alpha to measure relative mispricing is common among both practitioners and academics.[7]

Using daily stock returns for each quarter, we applied the following regression to estimate alpha for each stock in the sample:

$$r_{i,\tau} = \text{Alpha} + \beta_1 \text{MKT}_\tau + \beta_2 \text{SMB}_\tau + \beta_3 \text{HML}_\tau + \beta_4 \text{UMD}_\tau + \varepsilon_\tau, \quad (1)$$

where $r_{i,\tau}$ is the excess return on stock i on day τ; MKT is the value-weighted market excess return; and SMB (small minus big), HML (high minus low), and UMD (up-trend minus down-trend) are, respectively, the returns of the zero-net-investment portfolios for size, book/market, and one-year return momentum.[8] For robustness, we also used the capital asset pricing model of Sharpe (1964), the Fama–French (1993) three-factor model, and the Daniel, Grinblatt, Titman, and Wermers (1997) measure to estimate stock mispricing; our inferences remain unchanged.

Hedge Fund Ownership and Stock Mispricing. As our first test, we examined whether hedge funds tend to hold undervalued stocks that have positive alphas. A positive-alpha stock is defined as having an average daily positive alpha (statistically significant at the 5% level in a one-tailed test). Theory

suggests that arbitrageurs should go long undervalued stocks. We tested for the lead–lag relationship between hedge fund ownership measured at the end of quarter t and stock alpha estimated over quarter $t - 1$. We obtained similar results when examining the contemporaneous relationship between hedge fund activities and stock alpha.

To examine the relationship between hedge fund ownership and past stock mispricing, we first performed a quarter-by-quarter Fama and MacBeth (1973) cross-sectional regression of hedge fund ownership on two dummy variables that indicated either significant positive or significant negative stock alphas. The omitted dummy variable was for insignificant alphas. For comparison purposes, we also ran this regression for non-hedge-fund institutions. The regression had the following specification for the full sample of stocks:

$$\begin{aligned} IO_{i,t} &= a_t + b_t^{POS} D\left(\text{PositiveAlpha}_{i,t-1}\right) \\ &+ b_t^{NEG} D\left(\text{NegativeAlpha}_{i,t-1}\right) \\ &+ c_t' \mathbf{X}_{i,t-1} + \varepsilon_{i,t}, \end{aligned} \tag{2}$$

where $IO_{i,t}$ is hedge fund ownership (or non-hedge-fund institutional ownership) as the fraction of shares held by all hedge funds (or non-hedge-fund institutions) over total shares outstanding in stock i measured at the end of quarter t, $D(\text{PositiveAlpha}_{i,t-1})$ is a dummy variable indicating whether stock i had a significantly positive alpha over quarter $t - 1$, $D(\text{NegativeAlpha}_{i,t-1})$ is a dummy variable indicating whether stock i had a significantly negative alpha over quarter $t - 1$, and $\mathbf{X}_{i,t-1}$ is a vector of stock characteristics.

The stock characteristics include one-quarter-lagged values of the book/market, market capitalization, dividend yield, company age, share price, and a dummy variable indicating S&P 500 membership. Following the literature, the dependent and independent variables (except for the dummy variables) were standardized each quarter so that the regression coefficients could be compared across different years. Because stock ownership is measured as a percentage, we took the natural log for all stock characteristics (except for the dummy variables) so that the variables would have similar interpretations. The logarithmic transformation for dividend yield is Ln[1 + (*D*/*P*)] because not all stocks pay dividends in each quarter.

Table 2 reports the regression results. For hedge fund ownership, the average coefficient on the positive-alpha dummy is positive and significant at the 1% level. This result indicates that undervalued

Table 2. Hedge Fund Ownership and Stock Mispricing: Full Sample Results

	(1)	(2)	(1) – (2)
Variable	HF Ownership$_t$	Non-HF Ownership$_t$	*p*-Value of Difference
$D(\text{PositiveAlpha})_{t-1}$	0.060**	–0.005	0.00
$D(\text{NegativeAlpha})_{t-1}$	0.017	–0.026	0.00
$\text{Ln(Book/Market)}_{t-1}$	0.030**	0.082**	0.00
$\text{Ln(Market cap)}_{t-1}$	0.174**	0.588**	0.00
$\text{Ln(Dividend yield)}_{t-1}$	–0.167**	–0.210**	0.00
Ln(Age)_{t-1}	–0.080**	0.080**	0.00
Ln(Price)_{t-1}	–0.061**	0.116**	0.00
$\text{S\&P 500 dummy}_{t-1}$	–0.270**	–0.239**	0.15
Constant	0.035**	0.035**	
Adjusted R^2	0.070	0.418	

Note: The reported *p*-value is from a test of the null hypothesis that there is no difference in the regression coefficient between regression 1 and regression 2.

*Significant at the 5% level.

**Significant at the 1% level.

stocks, relative to stocks with insignificant alphas, are associated with higher hedge fund ownership. We found no significant relationship, however, between non-hedge-fund ownership and the positive-alpha dummy. Moreover, the *p*-value strongly rejects the null that the regression coefficient is the same for hedge funds and non-hedge-fund institutions.

At the same time, hedge fund ownership is not significantly related to negative-alpha stocks. Although negative-alpha stocks have lower institutional ownership by non-hedge-fund institutions, the relationship is not significant at the 5% level. Because the SEC does not require institutions to disclose their short positions, our remaining analysis focuses on the long positions and positive-alpha stocks.

Table 2 also reports the relationship between hedge fund holdings and stock characteristics. On average, compared with other institutions, hedge funds tend to hold small, growth, young, low-price stocks and stocks not listed in the S&P 500.

Finally, the adjusted R^2 is 7% for hedge fund ownership and 42% for non-hedge-fund ownership, suggesting greater heterogeneity in hedge fund strategies compared with other institutions. Fung and Hsieh (1997) found that in a regression of fund returns on traditional asset class returns, hedge funds show smaller R^2s than mutual funds.

Hedge Fund Ownership and the Degree of Mispricing. We tested whether hedge fund ownership is cross-sectionally related to mispricing in the subset of *positive-alpha* stocks. We did not include all stocks because our focus was on stocks that deviate from the security market plane; we expected fairly priced stocks not to show a systematic relationship to speculative holdings by hedge funds.

We performed this test with the following Fama–MacBeth (1973) regression of hedge fund ownership on one-quarter-lagged alpha among positive-alpha stocks:

$$IO_{i,t} = a_t + b_t \text{Alpha}_{i,t-1} + c_t' \mathbf{X}_{i,t-1} + \varepsilon_{i,t}, \quad (3)$$

where $IO_{i,t}$ is hedge fund ownership (or non-hedge-fund ownership) in stock i at the end of quarter t, $\text{Alpha}_{i,t-1}$ is the measure of deviation from the security market plane for stock i over quarter $t-1$, and $\mathbf{X}_{i,t-1}$ is a vector of stock characteristics. For a stock to be included in the analysis in quarter t, we required the t-statistic associated with its lagged alpha to be greater than 1.65 (significant at the 5% level in a one-tailed test) in quarter $t-1$.

We show the results in **Table 3**. The average coefficient on Alpha (i.e., coefficient b_t) for hedge funds is positive and statistically significant at the 1% level, suggesting that stocks with a larger alpha in the

Table 3. Regressions of Hedge Fund Ownership for Positive-Alpha Stocks

Variable	(1) HF Ownership$_t$	(2) Non-HF Ownership$_t$	(1) – (2) *p*-Value of Difference
Alpha_{t-1}	0.091**	–0.025	0.00
$\text{Ln(Book/Market)}_{t-1}$	0.038**	0.082**	0.01
$\text{Ln(Market cap)}_{t-1}$	0.196**	0.540**	0.00
$\text{Ln(Dividend yield)}_{t-1}$	–0.140**	–0.186**	0.00
Ln(Age)_{t-1}	–0.078**	0.049**	0.00
Ln(Price)_{t-1}	–0.067**	0.097**	0.00
$\text{S\&P 500 dummy}_{t-1}$	–0.262**	–0.212**	0.26
Constant	–0.071**	0.104**	
Adjusted R^2	0.145	0.392	

Note: The reported *p*-value is from a test of the null hypothesis that there is no difference in the regression coefficient between regression 1 and regression 2.

*Significant at the 5% level.

**Significant at the 1% level.

previous quarter are associated with significantly higher hedge fund ownership in the current quarter. In contrast, we found no significant relationship between non-hedge-fund ownership and stock alpha. We also examined the relationship between hedge fund ownership and stock characteristics, and the evidence we found is similar to that in Table 2 that was based on the full sample of stocks. The adjusted R^2s are 15% and 39% for, respectively, hedge fund ownership and non-hedge-fund ownership.

A test for differences in the coefficient on lagged alpha between hedge funds and non-hedge-fund institutions strongly rejects the null hypothesis that there is no difference. These results provide support for the hypothesis that hedge funds seek price inefficiencies by holding undervalued stocks but other types of institutional investors do not pursue a similar strategy.

We also investigated whether hedge funds, while seeking inefficiencies, bear the cost associated with arbitrage. To this end, we examined the cross-sectional relationship, among positive-alpha stocks, between hedge fund ownership and idiosyncratic volatility of stock returns, which is a proxy for arbitrage cost (Pontiff 1996; Shleifer and Vishny 1997). In untabulated tests, we found a significant relationship between lagged idiosyncratic volatility and hedge fund ownership (but not non-hedge-fund ownership). This finding is consistent with the view that hedge funds bear arbitrage costs when exploiting price inefficiencies.

Hedge Fund Trades and the Degree of Mispricing. In our third set of tests, following Chen, Jegadeesh, and Wermers (2000), we examined hedge fund trades as measured by changes in the stock ownership. Specifically, using the following specification, we performed a Fama–MacBeth (1973) regression of hedge fund trades on stock alpha:

$$\Delta IO_{i,t} = a_t + b_t \text{Alpha}_{i,t-1} + c_t' \mathbf{X}_{i,t-1} + \varepsilon_{i,t}, \quad (4)$$

where $\Delta IO_{i,t}$ is change in hedge fund ownership (or non-hedge-fund ownership) from the end of quarter $t-1$ to the end of quarter t, $\text{Alpha}_{i,t-1}$ is the measure of alpha over quarter $t-1$, and $\mathbf{X}_{i,t-1}$ is a vector of stock characteristics. As previously, we focused on stocks that had positive alpha with a t-statistic greater than 1.65 over the previous quarter.

Table 4 shows that lagged alpha is significantly associated with hedge fund trades at the 1% level but not with trades of non-hedge-fund institutions. That is, for undervalued stocks, hedge funds increase their purchases with the degree of underpricing, but the same process is not true for non-hedge-fund institutions. In untabulated tests, we also found that among positive-alpha stocks, lagged idiosyncratic volatility

Table 4. Regression of Change in Hedge Fund Ownership for Positive-Alpha Stocks

	(1)	(2)	(1) – (2)
Variable	ΔHF Ownership$_t$	ΔNon-HF Ownership$_t$	p-Value of Difference
Alpha$_{t-1}$	0.044**	0.027	0.23
Ln(Book/Market)$_{t-1}$	0.008	–0.018	0.17
Ln(Market cap)$_{t-1}$	0.020	0.001	0.41
Ln(Dividend yield)$_{t-1}$	0.002	–0.001	0.85
Ln(Age)$_{t-1}$	0.009	–0.086**	0.00
Ln(Price)$_{t-1}$	–0.014	–0.099**	0.00
S&P 500 dummy$_{t-1}$	–0.030	–0.032	0.96
Constant	–0.062	0.067*	
Adjusted R^2	0.069	0.104	

Note: The reported p-value is from a test of the null hypothesis that there is no difference in the regression coefficient between regression 1 and regression 2.

*Significant at the 5% level.

**Significant at the 1% level.

is positively and significantly associated with hedge fund trades. In contrast, we found no significant relationship between the trades of non-hedge-fund institutions and idiosyncratic volatility.

Return Predictability of Hedge Fund Activities in Positive-Alpha Stocks

Our fourth test addressed the question, Do hedge fund positions in positive-alpha stocks predict future stock returns? As discussed previously, stock alphas in our main analysis were estimated for the previous quarter. If the market is perfectly efficient, mispricing will be fully corrected within the same quarter and picking stocks with high past alphas will not subsequently generate abnormal performance. Similarly, if stock alpha mainly captures noise or temporary buying pressure, including positive-alpha stocks will not improve future performance. If the market has inefficiencies and mispricing persists, however, exploiting stocks with high past alphas may be profitable.

Portfolio Formation. We used a portfolio approach to assess the predictability of hedge fund ownership and trades. Our test was designed to compare the investment returns of alternative portfolios. At the beginning of each quarter t, we identified significantly-positive-alpha stocks over the previous quarter, $t - 1$. The stocks were sorted into two equal-weighted portfolios on the basis of whether their hedge fund activity exceeded the median level of all positive-alpha stocks at the end of quarter t. Then, the portfolios were held for the next three months before being rebalanced each quarter. We obtained a time series of monthly returns for each of the two portfolios. Note that the portfolios were formed by combining two pieces of information: (1) the stocks' having positive alpha and (2) hedge fund activities in the stocks. For comparison purposes, we similarly constructed two portfolios based on non-hedge-fund activities.

Table 5 reports the empirical results—that is, the performance of the portfolios formed on fund ownership. Panel A shows that among positive-alpha stocks, those with high hedge fund ownership subsequently outperformed those with low ownership. The high- (low-) ownership portfolio has an average return of 1.53% (1.11%) per month, resulting in a return spread of 0.42 percentage points per month. Although the high-ownership portfolio has a higher return volatility, it exhibits a higher Sharpe ratio (the average monthly excess return per unit of return volatility) and information ratio (the average monthly excess return per unit of idiosyncratic volatility), indicating that it has a more attractive risk–return trade-off.

Panel B of Table 5 focuses on risk-adjusted returns by using the Fama–French–Carhart four-factor model. Positive-alpha stocks with high hedge fund ownership generated significantly higher abnormal returns than their counterparts. The high-ownership portfolio shows an alpha of 0.40% (t-statistic 3.36) per month, whereas the low-ownership portfolio has an insignificant alpha of 0.02% (t-statistic 0.16) per month. The difference in abnormal returns between the two portfolios—0.38 percentage points per month—is both economically and statistically significant. **Figure 2,** which plots the cumulative excess returns for the portfolios, clearly shows the difference in returns between the two portfolios. For additional comparison purposes, we show cumulative monthly excess returns on the CRSP equal-weighted portfolio of all stocks.

We also tracked the portfolio returns in longer horizons than one quarter after the portfolios were formed. As shown in **Figure 3**, the high-ownership portfolio continued to significantly outperform the low-ownership portfolio in quarter $t + 2$. The return predictability over the next two quarters was more consistent with an informative nature of hedge fund holdings than with the temporary price impact. Practically, hedge fund companies are usually allowed to file 13F disclosures with a delay of 45 days after the quarter-end, but the documented investment value extends beyond the delay period.

In stark contrast to the case of hedge fund ownership, little difference can be seen in Table 5 in the raw returns or risk-adjusted returns between the two portfolios based on equity holdings of other types of institutional investors. Among positive-alpha stocks, the level of non-hedge-fund ownership is unrelated to future stock returns. Echoing the results in the previous section, this finding indicates fundamental differences in the information content of equity holdings between hedge funds and other types of institutional investors.

Table 6 reports the return predictability of hedge fund trades (i.e., changes in hedge fund ownership) among positive-alpha stocks. We formed two portfolios on the basis of hedge fund trades. The portfolio with large hedge fund trades significantly outperformed the portfolio with small trades. For

Table 5. Performance of Positive-Alpha Portfolios Sorted by Hedge Fund Ownership

	Portfolios Based on HF Ownership			Portfolios Based on Non-HF Ownership		
Measure	Low	High	High – Low	Low	High	High – Low
A. Summary statistics of portfolio returns						
Mean return	1.11	1.53	0.42	1.28	1.36	0.08
Median return	1.57	1.95	0.38	1.67	1.68	0.01
Standard dev.	5.14	6.37	1.23	5.48	6.03	0.56
Sharpe ratio	0.15	0.19	0.04	0.17	0.17	0.00
Information ratio	0.36	0.56	0.20	0.42	0.48	0.06
Mean Amihud measure	0.24	0.11	−0.13	0.31	0.06	−0.25
Mean zeros measure	0.15	0.10	−0.05	0.17	0.09	−0.07
B. Regression results from the Fama–French–Carhart four-factor model						
Alpha	0.02	0.40**	0.38**	0.16	0.25*	0.09
$R_m - R_f$	0.98**	1.13**	0.15**	0.97**	1.13**	0.16**
SMB	0.49**	0.77**	0.28**	0.70**	0.56**	−0.14**
HML	0.25**	−0.06	−0.31**	0.18**	0.01	−0.17*
MOM	0.04	0.10**	0.06	0.11*	0.03	−0.07
Adjusted R^2	0.83	0.89	0.33	0.83	0.88	0.13

Notes: The Amihud (2002) illiquidity measure is the average ratio of the daily absolute return to daily trading volume at a monthly frequency, and the "zeros" measure (see Lesmond, Ogden, and Trzcinka 1999) is the proportion of trading days with zero returns. Both the Amihud and zeros measures were taken as natural logarithm. $R_m - R_f$ is the market return minus the risk-free rate. MOM stands for momentum in the four-factor model. Portfolio returns are reported in percentage per month. The monthly return series for the portfolios is from July 1981 to March 2016.

*Significant at the 5% level.

**Significant at the 1% level.

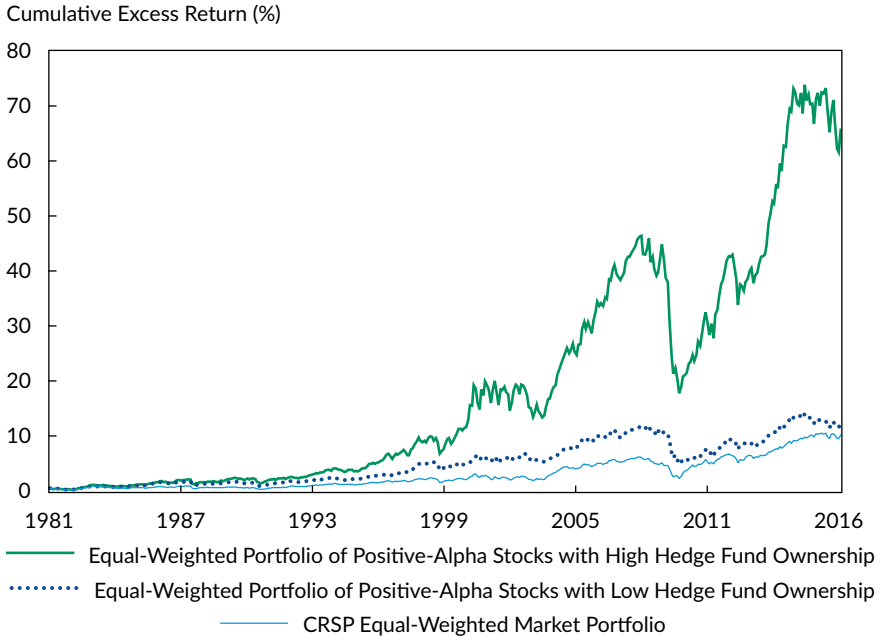
example, the large-trade portfolio has an alpha of 0.36% (*t*-statistic 3.21) per month, significantly higher than the alpha per month for the small-trade portfolio, which is 0.04% (*t*-statistic 0.32). In contrast, we found little difference between the portfolios formed by the trades of non-hedge-fund institutions.

Unlike previous studies that examined hedge fund positions in the entire universe of stocks, we linked hedge fund holdings to positive-alpha stocks and found strong evidence of return predictability of hedge fund activities.[9] In addition, by examining fund holdings, we have provided some details about the source of hedge fund performance documented in prior research (e.g., Ackermann, McEnally, and Ravenscraft 1999; Brown, Goetzmann, and Ibbotson 1999; Liang 1999; Cao, Chen, Liang, and Lo 2013).[10]

Transaction Costs. For the strategies described in previous sections to be implementable in practice, transaction costs must be taken into account. We assessed the potential effect of transaction costs on the portfolio returns from several aspects. First, the alpha of 0.40% per month, or about 4.8% per year, from the portfolio with high hedge fund ownership (in Table 5) seems to exceed conventional estimates of trading costs. According to Jones (2002), for example, the average round-trip trading cost was below 1% over our sample period.

Second, compared with popular investment strategies, such as the momentum strategy with monthly rebalancing, the *quarterly* rebalanced portfolios in our article should incur relatively low trading costs.

Figure 2. Cumulative Excess Returns on the Portfolios of Positive-Alpha Stocks with High Hedge Fund Ownership vs. Portfolios with Low Hedge Fund Ownership, July 1981–March 2016



Note: Excess returns are relative to the risk-free rate.

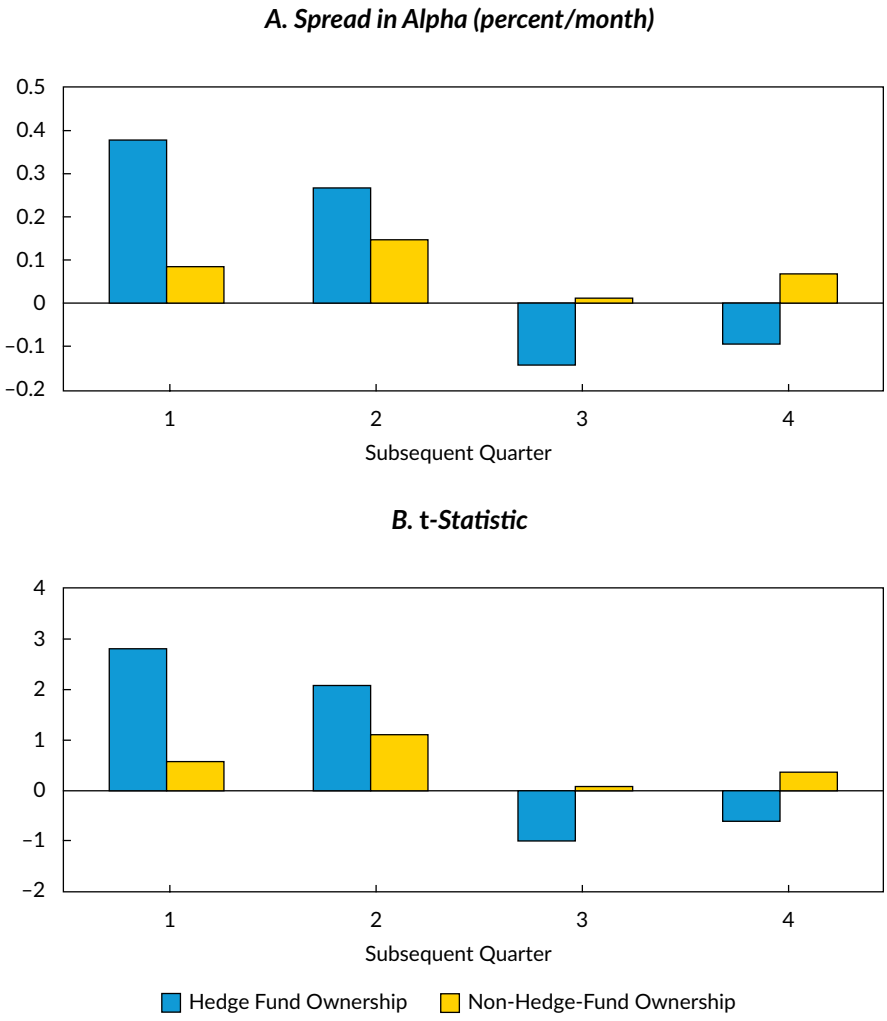
Third, we checked whether the stocks in the portfolio with high hedge fund ownership were more illiquid than those in the portfolio with low hedge fund ownership. In particular, we used two illiquidity measures to compare the average illiquidity for the two portfolios: (1) the Amihud (2002) illiquidity measure based on the ratio of daily absolute return to daily trading volume and (2) the zeros measure proposed by Lesmond, Ogden, and Trzcinka (1999) based on the proportion of trading days with zero returns. These measures have been shown to be related to stock returns in both cross-sectional and time-series studies (e.g., Amihud 2002; Lesmond et al. 1999; Jones 2002; Chen, Eaton, and Paye, forthcoming). As reported in Table 5, we found no evidence, as reflected by both measures, that stocks in the portfolio with high hedge fund ownership are more illiquid than those with the lower hedge fund ownership. Thus, transaction costs are unlikely to be the main driver of the difference in portfolio performance. Finally, both the portfolios are long only with no short positions allowed. Compared with long–short strategies (such as a momentum strategy), they avoid short-selling costs, which sometimes are substantial. Taken together, these findings indicate that the profits documented in this section are robust to transaction costs.

Hedge Fund Activities and Mispricing Correction

As our fifth and last test, we examined the relationship between hedge fund activities (level and change of ownership) and the subsequent dissipation of mispricing in the universe of stocks. In particular, we were interested in the case where a stock had a significantly positive alpha in the past quarter but its alpha was no longer significant in the current quarter. That is, we tested whether hedge fund activities are associated with the *dissipation* of mispricing. Because our tests allowed for the case in which an undervalued stock subsequently became fairly priced, we included all stocks, not only undervalued stocks, in the analysis.

Table 7 reports the results of logit regressions in which the dependent variable was a dummy variable, $D(\text{Alpha dissipation})_t$, that equaled 1 if the stock had a significantly positive alpha in quarter $t - 1$ but the alpha had become insignificant by the end of quarter t and equaled 0 otherwise. The explanatory variables include hedge fund ownership (also non-hedge-fund ownership) at the end of quarter $t - 1$ and hedge fund trades of the stock over quarter t (i.e., change in ownership from the end of quarter $t - 1$ to the end of quarter t) as well as stock characteristics and time fixed effects. Standard errors clustered at the stock level.

Figure 3. Spreads in Alpha between the Portfolios of Positive-Alpha Stocks with High Hedge Fund Ownership and Those with Low (or No) Hedge Fund Ownership in Quarters after Portfolio Formation, 1981–2016



Notes: At the beginning of each quarter *t*, starting with 1981:Q1, we identified positive-alpha stocks as those with a *t*-value for their alpha greater than 1.65 over the previous quarter *t* – 1. We then sorted stocks into two equal-weighted portfolios on the basis of whether their hedge fund ownership (or non-hedge-fund ownership) exceeded the median level at the end of quarter *t*. We tracked the monthly portfolio returns in subsequent quarters, *t* + 1, *t* + 2, *t* + 3, and *t* + 4. The portfolios were rebalanced quarterly. Based on the time series of monthly portfolio returns, we estimated the alphas from the Fama–French–Carhart four-factor model.

An odds ratio greater (smaller) than 1 in Table 7 indicates that the explanatory variable is positively (negatively) related to the dissipation of mispricing. According to the odds ratios, both hedge fund ownership and trades in one quarter are significantly positively related to the likelihood of positive alpha dissipating in the next quarter. From the model specification (3), the odds ratio associated with hedge fund ownership is 1.069 and the odds ratio associated with hedge fund trades is 1.062; both are statistically significant, at the 1% and 5% levels, respectively.[11] In contrast, the odds ratio for non-hedge-fund ownership is below 1, suggesting that such ownership impedes mispricing correction.

Some prior studies, such as Brunnermeier and Nagel (2004) and Griffin, Harris, Shu, and Topaloglu (2011), indicated that hedge funds appear to have destabilized the market during the technology bubble, but our result suggests that hedge fund activities at the aggregate level, on average, precede the dissipation of stock mispricing. Recently, Cao et al. (forthcoming) found that hedge fund trading improves market efficiency, although such a role is impeded during financial crises. Our evidence is also consistent with the findings

Table 6. Performance of Positive-Alpha Portfolios Sorted by Change in Hedge Fund Ownership

	Portfolios Based on ΔHF Ownership			Portfolios Based on ΔNon-HF Ownership		
Measure	Low	High	High – Low	Low	High	High – Low
A. Summary statistics of portfolio returns						
Mean return	1.14	1.48	0.34	1.27	1.36	0.09
Median return	1.46	1.90	0.44	1.81	1.55	–0.26
Standard dev.	5.64	5.76	0.12	5.33	6.08	0.75
Sharpe ratio	0.14	0.20	0.06	0.17	0.16	–0.01
Information ratio	0.38	0.57	0.19	0.44	0.52	0.08
Mean Amihud measure	0.18	0.15	–0.03	0.18	0.16	–0.02
Mean zeros measure	0.13	0.12	–0.01	0.14	0.11	–0.03
B. Regression results from the Fama–French–Carhart four-factor model						
Alpha	0.04	0.36**	0.32*	0.23	0.20	–0.03
$R_m - R_f$	1.04**	1.07**	0.03	1.00**	1.11**	0.11**
SMB	0.62**	0.63**	0.01	0.54**	0.72**	0.18**
HML	0.12*	0.06	–0.06	0.16**	0.03	–0.13*
MOM	0.05	0.09**	0.04	0.02	0.12**	0.10**
Adjusted R^2	0.86	0.88	0.01	0.84	0.89	0.20

Notes: The portfolio returns are reported in percentage per month. The monthly return series for the portfolios is from July 1981 to March 2016. See also the notes to Table 5.

*Significant at the 5% level.

**Significant at the 1% level.

of Akbas, Armstrong, Sorescu, and Subrahmanyam (2015) and Kokkonen and Suominen (2015) that hedge fund activities attenuate stock return anomalies whereas aggregate flows to mutual funds exacerbate mispricing.[12]

We wish to point out an important caveat about our analysis. We examined the aggregate holdings of all hedge funds for a given stock, so the information is stock specific rather than hedge fund specific. We used this approach because of the nature of 13F data, which are reported at the firm level rather than the fund level. As a result, we were unable to perform analyses on the basis of specific hedge fund strategies. Existing studies on hedge fund activism (e.g., Brav, Jiang, Partnoy, and Thomas 2008; Klein and Zur 2009) found that activist hedge funds tend to target undervalued companies and that companies targeted by activist hedge funds experience abnormal stock returns and improvements in operating performance. Our findings on price formation could be related to hedge fund activism. According to HFR's Hedge Fund Industry Report (HFR 2016), total global AUM of hedge funds is approximately $3.02 trillion and of that total, activist hedge funds account for 4.01%.[13] Given this small fraction of activist hedge funds in the entire hedge fund industry, however, how much of our findings can be attributed to hedge fund activism is unclear. We leave this interesting topic for future research.

In summary, we found that among all stocks, undervalued stocks with large hedge fund activity show a tendency to revert to the security market plane. This pattern does not exist, however, for other types of institutional investors. Our results support the hypothesis that hedge funds play a significant role in exploiting and reducing stock

Table 7. Logit Regression of Alpha Dissipation on Institutional Ownership

Variable	(1)	(2)	(3)
HF ownership$_{t-1}$	1.060**		1.069**
Non-HF ownership$_{t-1}$	0.887**		0.887**
ΔHF ownership$_t$		1.055	1.062*
ΔNon-HF ownership$_t$		1.016	1.004
Ln(Book/Market)$_{t-1}$	0.775**	0.769**	0.775**
Ln(Market cap)$_{t-1}$	1.193**	1.127 *	1.192**
Ln(Dividend yield)$_{t-1}$	1.136**	1.155**	1.138**
Ln(Age)$_{t-1}$	1.017	1.002	1.018
Ln(Price)$_{t-1}$	1.044	1.027	1.046
S&P 500 dummy$_{t-1}$	0.687**	0.695**	0.689**
Quarter dummies	Yes	Yes	Yes
Stock-quarter obs.	414,688	414,688	414,688
Pseudo R^2	0.027	0.026	0.027

Notes: The dependent variable is D(Alpha dissipation)$_t$. The control variables are lagged stock characteristics, including a dummy variable indicating S&P 500 membership, and lagged quarterly stock returns. All the variables, except the dummy variables, were standardized each quarter. Quarter dummies were included in the regression.

*Significant at the 5% level.

**Significant at the 1% level.

mispricing, although mispricing is not corrected instantaneously.

Conclusion

Using manually assembled data about hedge fund stock holdings during the period 1981–2015, we examined the role of hedge funds in the stock price–formation process. Our analysis reveals a significant relationship between hedge fund holdings and stock undervaluation. Furthermore, in the cross section of undervalued stocks, both hedge fund ownership and trades by hedge funds are positively related to the level of mispricing. The results suggest that hedge funds, as a group, pursue arbitrage opportunities in stock markets.

We also examined whether hedge fund activities predict future stock returns. Focusing on undervalued stocks, we found that for our sample, stocks with high hedge fund ownership and trading, on average, significantly outperformed those with low hedge fund ownership and trading, even after adjusting for risk exposures and taking transaction costs into account. We showed that hedge fund activities tend to be associated with subsequent dissipation of stock mispricing. These findings suggest that hedge funds are informed about stock mispricing.

Our article offers practitioners some guidance in investment management. We show that it can be profitable to form stock portfolios by combining the information about whether a stock is undervalued with aggregate hedge fund ownership of the stock. In addition to examining how hedge fund positions are related to stock mispricing, we constructed, and rebalanced quarterly, portfolios of common stocks that were (1) likely to be undervalued *and* (2) associated with high hedge fund activities (i.e., level and change of aggregate hedge fund ownership).

We provided an illustration that such an investment strategy yields sizable risk-adjusted returns—as high as 0.40% per month (4.8% annually). The strategy needs only quarterly rebalancing, and the stocks involved in this strategy are not particularly illiquid, so the profits are robust to transaction costs.

Editor's Note

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Notes

1. Edelman, Fung, and Hsieh (2013) emphasized the challenge of identifying large hedge funds that do not voluntarily report to commercial databases. Our approach required augmenting automated search processes with a significant amount of manual information collection.

2. Some long positions of arbitrageurs are held for hedging purposes to offset systematic risk exposures associated with speculative short positions, and such stocks in long positions are not necessarily undervalued.

3. Note that 5,000 funds is a lower bound because fund-level information is available only when a hedge fund company reports to one of the hedge fund databases and even then, the hedge fund company may report only a few of its funds instead of all of them. In the rest of this article, we use the terms "hedge funds" and "hedge fund companies" interchangeably for simplicity, although the stock holdings data are at the hedge-fund-company level rather than at the fund level. To our knowledge, fund-level holdings data for hedge funds are not available on a large scale.

4. The "type code" variable from CDA/Spectrum has classification errors in recent years; most institutions are improperly classified in the "others" group in 1998 and afterwards. See Bushee (2004) for a discussion.

5. We conducted the analysis for each of the non-hedge-fund categories, and our main conclusion remains unchanged.

6. As is commonly done with the Compustat data, we winsorized the company-quarter data on accounting variables at both the upper and lower 2.5% levels to mitigate the impact of outliers.

7. Chen, Da, and Huang (2018) examined the relationship between hedge fund activities and returns on anomaly stocks. In that context, anomalous returns were also measured against asset pricing models.

8. We are grateful to Kenneth French for making the data on the four factors available for download from his website at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.

9. In untabulated tests, we compared returns between the portfolio of *positive-alpha* stocks with high hedge fund ownership and the portfolio of *all* stocks with high hedge fund ownership. The positive-alpha portfolio had significantly higher risk-adjusted returns than the all-stock portfolio. This result confirms the importance of concentrating on positive-alpha stocks to infer arbitrage activities of hedge funds.

10. Note that our evidence does not necessarily imply that the average hedge fund earns high abnormal returns. Our analysis was conducted at the stock level, and we used information on *aggregate* hedge fund ownership. In recent years, when more and more hedge funds have begun to operate in stock markets, their aggregate impact on stock prices may have been much stronger than previously but the average fund performance might have become weaker as a result of keener competition in the hedge fund industry.

11. This result is inconsistent with an argument that the documented alpha reflects a return premium for exposure to missing risk factors because there is no apparent reason for such a risk premium to disappear over a quarter.

12. Edelen, Ince, and Kadlec (2016) also found that institutional trades tend to be on the wrong side of the mispricing implied by stock return anomalies; that is, institutional investors increase their ownership of overvalued stocks and decrease their ownership of undervalued stocks. These authors did not, however, study hedge funds separately from other types of institutional investors.

13. This amount is similar to the data in the 2017 Activist Investing Annual Review, which stated that "assets under management of primary focus funds globally fell from $194 billion in 2015 to $176 billion" (which represents 6.07% of the 2015 total hedge fund assets of $2.9 trillion).

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