Wharton

The Rodney L. White Center for Financial Research

Predictable Changes in NAV: The wildcard option in transacting mutual fund shares

John M.R. Chalmers
Roger M. Edelen
Gregory B. Kadlec

08-00
Revision of 25-99

The Wharton School
University of Pennsylvania

The Rodney L. White Center for Financial Research
The Wharton School
University of Pennsylvania
3254 Steinberg Hall-Dietrich Hall
3620 Locust Walk
Philadelphia, PA 19104-6367

(215) 898-7616
(215) 573-8084 Fax
http://finance.wharton.upenn.edu/~rlwctr

The Rodney L. White Center for Financial Research is one of the oldest financial research centers in the country. It was founded in 1969 through a grant from Oppenheimer & Company in honor of its late partner, Rodney L. White. The Center receives support from its endowment and from annual contributions from its Members.

The Center sponsors a wide range of financial research. It publishes a working paper series and a reprint series. It holds an annual seminar, which for the last several years has focused on household financial decision making.

The Members of the Center gain the opportunity to participate in innovative research to break new ground in the field of finance. Through their membership, they also gain access to the Wharton School's faculty and enjoy other special benefits.

Predictable changes in NAV: The wildcard option in transacting mutual-fund shares*

John M.R. Chalmers
Lundquist College of Business
1208 University of Oregon
Eugene, OR 97403-1208
jchalmer@oregon.uoregon.edu

Roger M. Edelen
The Wharton School
University of Pennsylvania
Philadelphia, PA 19104-6367
edelen@wharton.upenn.edu

Gregory B. Kadlec
Pamplin College of Business
Virginia Tech
Blacksburg, VA 24060-0221
kadlec@vt.edu

Abstract

This study documents positive autocorrelation in daily mutual fund returns and examines its causes and consequences. We provide evidence that nonsynchronous trading in the underlying assets held by funds is a primary source of the autocorrelation. The autocorrelation in fund returns presents investors with an option to (indirectly) trade fund assets at stale prices. We refer to this option as the mutual-fund wildcard option. We show that just four roundtrip trades in fund shares yields an average abnormal returns of 1.8% in domestic equity funds, 3.8% in high-beta small-cap domestic equity funds, and 4.7% in foreign equity funds. Approximately 45% of the equity fund universe allow this frequency of transacting without load or transaction fees.

First draft: November 1999
Current draft: February 2000

* We thank Marshall Blume, David Dubofsky, Jarrad Harford, Ken Kavajecz, John Rea, and Vijay Singal for their helpful comments and suggestions.

1. Introduction

Daily changes in mutual funds' net asset value per share (NAV) are positively autocorrelated for domestic equity funds, foreign equity, and bond funds. This autocorrelation is both statistically and economically significant. This study documents this autocorrelation and examines its causes and consequences.

Background. Mutual-fund return autocorrelation has been documented in studies dating back to Carlson (1970).[1] However, these studies examine monthly and annual return intervals. The daily autocorrelation documented and analyzed in this paper is likely to arise from different sources than the longer-horizon autocorrelation discussed in the previous literature. In particular, daily autocorrelation is unlikely to be attributable to differences in risk, expense ratios, or other factors found to account for most of the longer-horizon return autocorrelation. Our tests suggest that the primary source of autocorrelation in daily fund returns is nonsynchronous trading and price-adjustment delays in the underlying assets held by the fund.

It is well known that nonsynchronous trading contributes to portfolio return autocorrelation.[2] For example, Kadlec and Patterson (1999) show that nonsynchronous trading is capable of explaining more than 50 percent of the autocorrelation in daily portfolio returns. However, the autocorrelation caused by nonsynchronous trading is generally viewed as an illusion: attempts to trade the stale-priced assets are likely to refresh the asset's price to it's appropriate level (Lo and MacKinlay (1990)). Moreover, even if the autocorrelation were real, transaction costs would likely render such trading strategies unprofitable.

---

[1]For evidence of autocorrelation in long-horizon (annual) mutual fund returns see, e.g., Hendricks, Patel, and Zeckhauser (1993), Goetzmann and Ibbotson (1994), Brown and Goetzmann (1995), and Carhart (1997).
[2]For evidence of autocorrelation in short-horizon (daily/weekly) portfolio returns see, e.g., Cowles and Jones (1937), Fisher (1966), Lebaron (1992), and Mech (1993). For analyses of non-synchronous trading and

While mutual fund shares are claims on portfolios of assets, and thus trades in mutual fund shares are indirect trades in the underlying assets, there are two important distinctions vis à vis trading the underlying assets directly. First, the readjustment effect associated with trading (i.e., marking the asset's price to market with your transaction) does not occur with trade in fund shares. Second, hundreds of funds offer trading in their shares with no costs or frictions, essentially offering unlimited depth at net asset value per share (NAV). Specifically, most funds accept transactions in their shares at any time up to the 4:00 P.M. Eastern close of trading on the major exchanges. These transactions are executed at the NAV reported to the NASD at 5:30 P.M., which is almost universally set using closing prices of the underlying assets of the fund.[3] Closing prices are, in turn, almost always the price of the last trade in the stock. These distinctions make the autocorrelation in daily mutual fund returns potentially exploitable.

The wildcard option. When investors trade fund shares they effectively trade each of the fund's assets at their last recorded transaction price. With a telephone or internet transfer, fund investors can feasibly make their trading decision as late as, say, 3:55 P.M. At 3:55 many of the underlying assets held by the fund have long-since experienced their last transaction of the day, and thus, their closing price (last transaction price) does not fully reflect the day's market news. As a result, fund investors who defer their investment/redemption decision to the end of the day possess an option to trade at least some

---

portfolio return autocorrelation see e.g., Perry (1985), Atchison, Butler, Simonds (1987), Lo and MacKinlay (1990), Boudoukh, Richardson and Whitelaw (1994), and Kadlec and Patterson (1999).

[3]When market quotes are not readily available a fund is permitted to value securities at "fair value" as determined in good faith by the fund's board of directors (rule 2a-4 of the Investment Company Act of 1940). Fair value pricing is commonly used to value non-treasury bonds but rarely used to value equity securities (see i.e., Ogden and O'Hagan (1997), and Bhargava and Dubofsky (1999)).

of the underlying assets of the fund at stale prices.[4] We refer to this option as the mutual fund (MF) wildcard option. The term wildcard option is borrowed from the Treasury-bond futures market and the S&P 100 index options market (see Kane and Marcus (1986) and Harvey and Whaley (1992), respectively) because it is descriptive of options that allow exercise at stale prices.

The underlying asset of the mutual-fund wildcard option is the portfolio of assets held by the mutual fund at the close of business. The exercise price of the wildcard option is the portfolio-weighted price of the last trade in each asset held by the fund. The option expires at 4:00 P.M and it regenerates daily. Investors who currently hold fund shares possess both a wildcard-put and a wildcard-call, whereas all potential mutual fund investors possess a wildcard-call.

At this point an example is useful to illustrate the wildcard option strategy.[5] At 3:50 P.M. Eastern on Tuesday, January 4, 2000, the S&P 500 index was down 3.6% on the day. A Dentist in Kansas owns $100,000 in the Vanguard Extended Market Index (VEXMX). At 3:55 P.M. Eastern, the Dentist recognizes that the market decline that afternoon is unlikely to be fully reflected in the prices of the underlying shares held by VEXMX. Many of the stocks probably haven't traded recently enough to fully reflect the current market conditions. Furthermore, the price of the stocks that have recently traded may still exhibit some delay in reflecting market conditions (Goldman and Sosin (1979)). Thus, the Dentist anticipates a further decline in VEXMX tomorrow, and enters an order to sell $100,000 of VEXMX (2,820.079 shares) at the closing NAV. We refer to this as exercising a wildcard put on

[4] We say that prices are stale if there is extant public information that changes the anticipated price at which the next buyer and seller will agree to transact

[5] While this example uses actual numbers to detail the execution of the mutual-fund wildcard put option, it is, of course, just one observation and is not meant to establish any results.

VEXMX: she is exercising her option to sell the fund prior to an expected decline. Simultaneously she enters a market-on-close buy order for $100,000 in the S&P 500 futures contract. This maintains her market exposure despite the wildcard exercise. The next day, VEXMX fell 0.28%, whereas the S&P 500 Index rose 0.19%. The dentist closes her position in the S&P 500 futures contract and uses the proceeds ($100,190) to purchase 2,883.372 VEXMX fund shares. Note that, on Wednesday, Jan. 5, the Dentist has 0.47% more shares in VEXMX than she had on Tuesday, Jan. 4, *ceteris paribus.* Thus, by exercising her wildcard put option, the dentist captured a (somewhat predictable) one-day return of 0.47%. The exercise of a wildcard call option is symmetric, with the trigger being a large upward move in the market index. Buying at the close and then unwinding the position the following day will capture any tendency for the fund's return to subsequently reflect that market upswing.

Trading strategies. We examine the profitability of trading strategies designed to exploit the autocorrelation in domestic equity, foreign equity, and bond fund returns. Related studies examine trading strategies designed to exploit the cross-autocorrelation between foreign equity funds and U.S. market returns (Bhargava and Dubofsky (1999), Greene and Hodges (2000), and Goetzmann Ivkovich, and Rouwenhorst (2000)). Further, Greene and Hodges examines the cummulated effect of investor flows on days of substantial market moves. While it is not clear that the motive for that flow is exploiting the wildcard option, their study nervertheless indicates that this timely transacting extracts as much as 1% of assets per year at certain funds.

Both our strategies and the strategies in these other papers exploit stale prices using the MF wildcard option. The source of stale prices in other studies is asynchronous times at which the markets are open. We demonstrate that mutual fund wildcard options are not limited to markets that are asynchronously opened and closed. The problem of asynchronous trading and, more generally, price-adjustment delays is economically large *within* markets as well. Our analysis of the MF wildcard option demonstrates surprisingly large gains to exploiting the autocorrelation in domestic equity funds in addition to the more conspicuous opportunities available in foreign equity funds. This result complements the result in Greene and Hodges on the cummulated effect of timely flow.

We find that the average exercise value of the MF wildcard option is approximately 0.26% for domestic equity funds, 0.60% for foreign equity funds, and generally immaterial for bond funds, when exercise is restricted to the bottom and top quintiles of return days. With the 50-roundtrip fund transactions this implies per year, the annual return premium is 26% for domestic equity and 60% for foreign equity funds. Note that this strategy adds no risk to a buy-and-hold equity position, but raises the Sharpe ratio significantly. For example, domestic equity funds offer a Sharpe ratio of about 0.35 (7% excess returns, 20% standard deviation), which rises to about 1.65 with the wildcard-option strategy.

Alternatively, consider a wildcard-option strategy of exercising and hedging with futures. This investment strategy has no market risk, an excess return of 26%, and a standard deviation of about 7-8%. The Sharpe ratio for this strategy is 3 – 4, almost ten times the Sharpe ratio of a buy and hold investment.

Restrictions and constraints. Funds employ a variety of tactics to restrain short-term traders, including load fees, transaction fees, redemption fees, and outright restrictions on trade frequency. For example, about half the funds in our sample employ a load fee, and approximately 22% of the no-load funds in our sample explicitly state in the fund prospectus a limit of 4-6 round-trip transactions per year. While this leaves a substantial number of funds with no explicit transaction limit, we also note that virtually all funds retain the right to refuse short-term traders at will. Therefore, a credible, sustained exercise campaign would have to be disguised. To be conservative we limit the analysis to four round-trip trades per year, which leaves most no-load funds as viable targets. With this restriction on exercise frequency, the annual return premium is 1.8% for domestic equity funds, 4.7% for foreign equity funds (again, conditioning only on the bottom/top quintiles of return days).

Conditional MF wildcard option value. The exercise value of the MF wildcard-option can be enhanced by being more selective over time (when to trade) and in the cross-section (which funds to trade). The hypothesis that nonsynchronous trading is the source of the autocorrelation in fund returns guides our refinements. First, nonsynchronous trading is likely to be a greater problem on days with higher return volatility. We find that the mean exercise value of the wildcard option increases monotonically with return volatility. Second, nonsynchronous trading is likely to be a greater problem at funds holding stocks with greater systematic volatility (greater conditional price moves during non-trading periods), and stocks that trade less frequently. We find that the mean exercise value of the wildcard option is positively related to fund beta and inversely related to market capitalization of holdings (stocks with a smaller market capitalization tend to trade less frequently). As an example of the combined effects of the above time-series and cross-sectional conditioning, the mean return premium from four roundtrip trades is 3.8% for domestic equity funds when exercise is restricted to high-beta small-cap funds on days when the S&P futures return is in the extreme quintiles of the return distribution.

The remainder of this paper is organized as follows. In section 2, we discuss our data sources and sample funds. In section 3, we document the autocorrelation in daily fund returns and examine evidence on the nonsynchronous trading hypothesis. Section 4 calibrates the magnitude of gaming possibilities. Section 5 examines the restrictions imposed by funds that increase the cost of implementing the wildcard strategy. Section 6 discusses current practices and issues in the pricing mutual fund shares. Section 7 concludes the study.

2. Data

The fund-returns data used in this study come from TrimTabs.com of Santa Rosa, California. This vendor has collected daily data on fund NAV (per share) and total assets since February 1, 1998. The sample period ends June 30, 1999. We restrict the TrimTabs sample to funds with at least 100 daily return observations during the sample period. We use investment-objectives provided in the CRSP mutual-fund database to classify our sample funds as domestic equity, foreign equity, or bond funds. Specifically, funds with more than 50% invested in U.S. stocks are classified as domestic equity, funds with more than 50% invested in foreign stocks are classified as foreign equity, and funds with more than 50% invested in government, corporate, or municipal fixed-income securities are classified as bond funds. Our samples consist of 447 domestic equity funds, 132 foreign equity funds, and 276 bond funds. As discussed in the appendix, we filter the data to ensure that data errors and outliers do not influence the results.

The reporting of daily NAV by funds in the TrimTabs data is voluntary. The TrimTabs domestic equity sample funds are larger than the typical domestic equity fund (median $472 million versus $99 million for the universe of domestic equity funds with assets greater than $10 million). About 35% of the domestic equity sample are aggressive growth or sector, 40% growth, and 25% growth and income. The foreign equity sample funds are larger than the typical foreign equity fund (median $126 million versus $73 million for the universe of foreign equity funds with assets greater than $10 million). Finally, the bond sample funds are also larger than the typical bond fund (median $306 million versus $75 million for the universe of bond funds).

Other characteristics of the sample funds are presented in Table 1 for descriptive purposes. Note that each fund has, on average, over one year of daily return data, and that the funds are typically relatively mature. Further, the distinction between equity funds and bond funds is precise. For comparative purposes, we also present basic statistics on S&P 500 and NYSE index-futures returns over the period. The average fund underperformed the S&P 500 index over this period rather substantially (5 basis points per day versus 9), but essentially matched the NYSE index. Since our sample includes large-cap, mid-cap, and small-cap funds, we use both indices in our analysis.

We use index futures rather than spot indices for two reasons. First, the use of index futures outlines an easily implemented trading rule and hedging procedure. Second, index future returns exhibit less nonsynchronous trading effects than spot index returns (Boudoukh, Richardson, and Whitelaw (1994)). The latter issue is particularly important. Our trading strategies exploit autocorrelation in daily mutual fund returns that is due, in part, to nonsynchronous trading. In the context of mutual fund returns, the autocorrelation caused by nonsynchronous trading is real. However, nonsynchronous trading also causes autocorrelation in the returns of a spot index that is an illusion (Lo and MacKinlay (1990)). Thus, to properly gauge the magnitude and significance of the returns to our strategies we require a benchmark that is free from the illusory effects of nonsynchronous trading.

3. Daily fund return autocorrelation

3.1. Return autocorrelation and wildcard value

After filtering for errors, there is evidence of positive autocorrelation in daily fund returns. From Table 1, the average autocorrelation of daily fund returns is 10% for domestic equity funds, 19% for foreign equity funds, and 9% for bond funds. The robustness of the positive autocorrelation in fund returns is confirmed by the fact that the autocorrelation coefficient is positive for 88% of domestic equity funds, 100% of foreign equity funds, and 78% of bond funds. It is worth noting that the autocorrelation of daily returns for the value-weighted NYSE-AMEX index during the sample period (February 1998 - June 1999) is abnormally low, 1%, compared with 14% for the period 1965-1998. Thus, we may be inadvertently using a sample period that is biased against finding profitable trading strategies based on daily return autocorrelation.

The mutual fund return autocorrelation estimates in Table 1 provide a rough sense of the value of the wildcard option offered by mutual funds. For example, with a daily return standard deviation of 1%, an autocorrelation of 10% implies that investors who exercise a put on low-return days and a call on high-return days earn about an 0.10% abnormal return (the square root of the explained variation in next-day returns) per day. Compounded over 250 trading days this is a 25% annual abnormal return. This estimate is on the aggressive side to the extent that the wildcard option is not exercised every day (due to fees, restrictions, etc. – see section 5). On the other hand, the estimate is on the conservative side to the extent that exercise activities would presumably be focused on funds with the greatest prospects for gains.

3.2. Sources of return autocorrelation

We argue that the primary cause of the autocorrelation in daily fund returns is nonsynchronous trading, or delays in *recorded* prices for the underlying assets of the fund.

However, there can also be delays in the incorporation of information into *actual* prices. These price-adjustment delays may further accentuate autocorrelation in daily fund returns.[6] Cohen et al. (1983, 1986) argue that frictions in the trading process can cause price-adjustment delays that are relatively protracted. For example, specialists or dealers may impede the adjustment of price quotations because of exchange stabilization obligations or temporary inventory imbalances (Hasbrouck and Sofianos (1993)). Also, with positive transaction costs, it is optimal for investors to accumulate news until the collective value of the news exceeds the cost of transacting (Goldman and Sosin (1979)). Mech (1993) shows that actual price-adjustment delays cause autocorrelation in portfolio returns in the same manner as nonsynchronous trading (delays in recorded prices).

According to either of these "stale price" hypotheses, the autocorrelation of fund returns is greater; the greater the factor (market) return, the greater the systematic risk of the underlying assets of the fund, and the greater the delay in the adjustment of the fund's underlying asset prices (recorded or actual). In section 3.3 we present evidence on nonsynchronous trading or price-adjustment delays as the source of autocorrelation in daily fund returns.

3.3 Autocorrelation in fund returns and the nonsynchronous trading hypothesis

In this section we document the systematic risk (beta) and non-trading characteristics of the underlying stocks held by domestic equity funds. We then examine how the autocorrelation pattern in fund returns relates to these nonsynchronous trading factors. Our analysis of nonsynchronous trading and fund return autocorrelation focuses on domestic equity funds. We focus on the domestic equity results, in part, to highlight the surprising

[6] Time varying expected returns are also a potential source of autocorrelation in short-horizon portfolio returns.

magnitudes of the wildcard option within the U.S. market. In addition, the availability of information characterizing fund holdings (Morningstar) and transactions level data (TAQ) on trade times of stocks is also more reliably available for our domestic equity sample.

We estimate each fund's beta using monthly fund returns and monthly returns of the value-weighted index of NYSE, ASE, and NASDAQ stocks over the period 1996-1998. We then assign funds to one of three beta categories: low beta (< 0.8), medium beta (0.8 - 1.2), and high beta (> 1.2).

To estimate the non-trading characteristics of funds' holdings we assign funds to one of three market capitalization categories using Morningstar's classifications of fund holdings: large-cap, mid-cap, and small-cap. Morningstar classifies a fund's holdings by ranking the stocks in a fund's portfolio from the largest market-capitalization stock to the smallest, and then calculating the average market capitalization of stocks in the middle quintile of the portfolio. The large-cap category consists of stocks in the top 5%, the mid-cap the next 15% and the small cap the remaining 80% of the 5,000 largest domestic stocks.

To verify that market capitalization is a reasonable proxy for stocks' nontrading characteristics we partition the universe of stocks on the New York Stock Exchange's TAQ database into the three market-cap categories defined by Morningstar. We then document the primary variable relevant to nonsynchronous trading at the close: the elapsed time between the last trade and the market's close. Table 2 presents the distribution of minutes-from-close for the last trade of the day for stocks in each market capitalization category. We see that market capitalization provides information about the non-trading tendencies of stocks. For example, the 90th percentile of minutes-from-close is 6 for large-cap stocks, 6 for mid-cap stocks and 109 for small-cap stocks. The longer the time between the last trade and the

---

See e.g., Keim and Stambaugh (1986), Conrad and Kaul (1988), and Campbell, Grossman, and Wang (1993).

market's close, the greater the opportunity for the arrival of information that changes the true value but not the closing price of the stock. Thus, one would expect to observe the greatest autocorrelation for small-cap funds.

Table 3 presents the results of a simple test of the nonsynchronous trading hypothesis underlying funds' return autocorrelation. Specifically, we report the average daily return autocorrelation for funds in each cell of a three-by-three partition of funds formed on beta and average market capitalization of holdings. The rows correspond to the beta categories while the columns correspond to the market capitalization categories. Consistent with the nonsynchronous trading and price-adjustment delay hypotheses, the autocorrelation of fund returns is increasing in the systematic risk of funds' holdings. From the "beta only" column, the average autocorrelation of daily returns for funds in the low and medium beta category is 9%, whereas the average autocorrelation in the high-beta category is 15%. Also consistent with the nonsynchronous trading hypothesis, the autocorrelation of fund returns is inversely related to market capitalization of holdings. From the "size only" row, the average autocorrelation of daily returns for funds in the small-cap category is 23%, the mid-cap category is 13%, and the large-cap category is 5%. These marginal patterns are generally repeated inside the partition.

4. The mutual fund wildcard option

In this section we estimate the profitability of trading strategies designed to exploit the autocorrelation in mutual fund returns via the mutual fund wildcard option. The trading strategies are guided by the nonsynchronous trading hypothesis.

4.1 Time-series conditioning and wildcard option value

Funds often impose transaction fees and/or restrict the number of transactions allowed (see section 5). In the face of these costs and restrictions, and other nuisance costs associated with trade, a reasonable exercise policy would consider only those days where the exercise value is relatively high. According to the nonsynchronous trading hypothesis, we would expect to observe the largest wildcard option exercise values on days in which the factor return is extreme. The wildcard put is the option to *sell* fund shares that you currently own at stale prices. Wildcard puts should be exercised when factor returns are in the lower tail of the factor's distribution, because the mutual fund's NAV will be slow to reflect the lower value of its holdings. The wildcard call is the option to *buy* any funds' shares at stale prices. Wildcard calls should be exercised when factor returns are in the upper tail of the factor's distribution, because funds' NAV will be slow to fully reflect the increased value of its holdings.

We present a time-series analysis of the MF wildcard-option value conditioning on two factors that are likely to be associated with the value of the wildcard option: the funds' own return and intra-day returns to the S&P 500 futures contract. The own-fund return is likely to be a better proxy for the systematic factor(s) affecting a particular fund's return. However the own-fund NAV is not observable until it is too late to place a buy or sell order. In addition, because we are sorting on own-fund return, at the margin, we will be picking funds on those days when the nonsynchronous trading of their underlying assets is less likely to be a problem. By contrast, the returns to the S&P 500 futures are easily and precisely observed in real time providing a empirical evidence with a factor that provides an implementable trading strategy. The S&P 500 returns are, however, likely to be less highly correlated with the factors that affect a given fund's returns.

4.1.1 Conditioning on extreme values of own-fund returns

Table 4 reports estimates of the average exercise value of the MF wildcard option when exercise is restricted to days when fund returns are in the tails of their daily return distributions. We report results where we define these tails using cutoffs of 30%, 20% and 10% of the largest and smallest daily fund returns in our sample. For each tail, we report the average ranking-day return (Avg $R_{i,t}$), the average next-day return (Avg $R_{i,t+1}$), and the average market adjusted return, where we adjust returns with the return on the NYSE futures index (Avg $R_{i,t+1} - R_{NYSEFutures,t+1}$) and the S&P500 futures index (Avg $R_{i,t+1} - R_{S\&PFutures,t+1}$). Adjusted returns are the next-day payoff to exercising a MF wildcard option and immunizing the change in market risk brought about by that exercise. The columns in Table 4 report the results for the domestic equity, foreign equity and bond funds separately. We do not report the market adjustments for either the foreign equity funds or the bond funds because we do not have a universally appropriate benchmark with which to meaningfully adjust those returns.[7]

The sort for the ranking procedure is global – across funds and days. Thus, low-return observations tend to cluster on certain days and high-return observations tend to cluster on other days, as determined by the market return. Having noted that, we emphasize that Table 4 presents the relation between the return at the individual fund during the ranking period and *that fund's* subsequent day return. The average ranking-day returns for the 30% tails show that in 60% of the distribution daily fund returns are more than 1.25% in absolute value. The standard errors reported in Table 4 are calculated from the time-series of the cross-sectional

[7] Applying S&P futures and NYSE futures adjustments to foreign funds has no material impact on either the magnitudes of the next-day return or the standard errors that we report for the next day returns. For the bond funds the magnitudes of the average next day returns do not change materially however, the standard errors increase significantly given the added noise from the adjustment factor.

mean values calculated for each date on which there are extreme fund returns. The means and the standard errors are weighted by the number of funds in the calculation of each cross-sectional mean.

A number of interesting observations can be drawn from Table 4. First, the average exercise value of the MF wildcard option is large in nearly every instance, both economically and statistically. For the average domestic equity fund, a wildcard put exercised on days when the fund return is in the lower 20% tail of the return distribution would sell the mutual fund one day prior to an average abnormal decline in NAV of 12 basis-points, using the NYSE futures to adjust returns. Likewise, a wildcard call exercise on days when the fund return is in the upper 20% tail of the return distribution would buy the fund one day prior to an average abnormal increase in NAV of 19 basis-points. The next-day returns for the foreign equity funds have very large average next day returns with values for the 20% tails of -41 basis-points for a wildcard put and 33 basis-points for a wildcard call. These foreign-equity wildcard values are similar to those found in Bhargava and Dubofsky (2000) who report returns to a similar strategy in a study of three Vanguard international mutual funds.

The nonsynchronous trading hypothesis predicts that, *ceteris paribus*, there is a greater potential deviation between the exercise price of the wildcard option and the intrinsic value of the underlying fund assets on more-extreme return days. Although the point estimates generally increase as the cutoffs in the return distribution are made more extreme in Table 4, there does not appear to be a statistically reliable increase in exercise value. The *ceteris paribus* assumption may not be appropriate. More-extreme factor return days may also be associated with more frequent trade, decreasing the difference between the average time of last trade for stocks and the market close.

Finally, the *annual* abnormal returns from exploiting the MF wildcard option, implied by the results of Table 4, are similar to those implied by the return autocorrelations of Table 1. However, Table 1 estimates assume daily exercise. Here the exercise frequency is much lower. For example, for the 20% tails of the return distribution, exercise occurs every 2-3 days and garners an uncompounded annualized abnormal return of 16.7% (88 days x .19%). These exercise frequencies are still quite high and few funds are likely to tolerate such frequent exchanges. Thus, an investor trying to optimize his or her trading strategy is likely to carefully choose funds and exercise days that best utilizes a potentially limited number of wildcard exercise opportunities.

4.1.2 Conditioning on extreme values of intra-day S&P 500 returns

In the previous section we show the degree to which the exercise value of the MF wildcard option can be enhanced by conditioning on extreme fund return days. In this section we examine whether the exercise value can be enhanced by conditioning on extreme intra-day return volatility. According to the nonsynchronous trading hypothesis, the optimal return interval for conditioning the exercise depends on two variables: the frequency of trade of the underlying stocks of the funds' portfolio, and the volatility of the factor-return. Because the empirical interaction between trade frequency and factor volatility is unknown, the optimal return interval for conditioning the wildcard exercise is an empirical issue.

Table 5 presents an analysis of average wildcard exercise values conditioning on S&P futures returns during the last 30 minutes, 90 minutes, 180 minutes, and 385 minutes (full day) of the trading day. To portray an implementable strategy, we define the end of the trading day to be 3:55, allowing traders 5 minutes before the market closes to place an order. For example, using this definition the last 30 minutes of S&P futures returns are measured from 3:25 to 3:55 P.M. Eastern Time. We focus exclusively on the 20% tails of the S&P 500 futures return distribution. We report the average next-day return and next-day market-adjusted returns using NYSE and S&P 500 futures returns. We provide estimates of the wildcard exercise value for calls (i.e., up-market days), puts (i.e., down-market days), and a combined value of calls and puts. To combine the put and call exercise values, on low return (sell) days we multiply the next-day returns and adjusted returns by –1. We then average the next-day return on both tails of the distribution by date and report a time series mean and standard deviation of the average exercise values.[8] Note that our sample period covers 356 trading days and therefore 20% tails lead to approximately 70 days on which we estimate the value of wildcard calls and approximately 70 days on which we estimate the exercise value of wildcard puts. Finally, because our proxy for factor returns (S&P 500 futures) is more relevant for equity securities than bond securities we consider only domestic equity funds and foreign equity funds in the intra-day analysis of Table 5.

From Table 5 we observe several interesting aspects of the data. For domestic equity funds the average next-day return from the combined exercise of puts and calls when conditioning on the last 30 minutes of the S&P 500 futures return is .11% (t-statistic = 1.13). The market-adjusted next-day returns are .26% and .19% with t-statistics both greater than 3.3, suggesting that after-removing the noise induced by market returns, the wildcard-exercise value is large and significant. There is not a clear pattern in the optimal interval over which return volatility should be conditioned in the domestic equity funds. Although

[8]The intuition behind this presentation is as follows. Imagine holding a portfolio of positions in various mutual funds, and cash. On extreme low return days we sell our fund holdings, and forego the next-day return. This amounts to exercising a wildcard put. On extreme high return days, we purchase fund shares, and capture the next-day return. This amounts to exercising a wildcard call.

the point estimates of the exercise values generally increase as the conditioning interval is decreased the point estimates are for the most part within one standard error of one another.

The wildcard exercise values for the foreign equity funds are generally 2-3 times greater than the exercise values for the domestic equity funds. In contrast to the domestic equity funds, the greatest exercise value for the wildcard option for foreign equity funds occurs when conditioning on the full-day S&P 500 return. For example, the average exercise value when S&P 500 returns are in the 20% tail of the returns distribution is .52% for the full day return, .46% for the last 180 minute return, .32% for the last 90 minute return, and .31% for the last 30 minutes return. This is consistent with the nonsynchronous trading hypothesis. Since the assets of these funds trade with a lag of several hours (relative to the S&P 500), one is better off conditioning over a longer time interval to capture the days with the greatest overall volatility. Given the gaudy magnitude of the wildcard option exercise values in foreign equity funds, it is not surprising that this is where the stale price issue first came to light in the popular press, academic research, and at the SEC.

4.2. Cross-sectional conditioning and wildcard-option value

In Section 3 we saw that the nonsynchronous trading hypothesis helps to identify those funds with the greatest return autocorrelation. In particular, fund return autocorrelation is positively related to fund beta and inversely related to the market capitalization of holdings. Thus, we predict that the value of the MF wildcard option is greater for funds holding more volatile (higher systematic risk) and less frequently traded stocks. Here we estimate the exercise value of the MF wildcard option for the same three-by-three partition examined in section 3.

Table 6 provides estimates of the average exercise value of the wildcard option for domestic equity funds in each cell of the three-by-three partition, when conditioning on the funds' own returns. Specifically, for each cell we report the average exercise value for the 20% tails of the prior-day fund return. We report the combined exercise value of the wildcard put (the next-day loss avoided by selling fund shares on down-market days) with the exercise value of the wildcard call (the next-day gain associated with purchasing fund shares on up-market days). From Table 6, the average wildcard exercise value increase monotonically with beta for any market capitalization class of fund-holdings. In addition, the exercise value is inversely related to market capitalization of holdings for any level of beta. In the most extreme comparison, the average exercise value of the wildcard option for high-beta, small-cap funds is 30 basis points versus 8 basis points for low-beta, large-cap funds. Thus, consistent with the nonsynchronous trading hypothesis, beta and average market capitalization of holdings provide information regarding funds' susceptibility to the wildcard option.

Table 7 reports estimates of the average exercise value of the wildcard option for domestic equity funds in each cell of the three-by-three partition, when conditioning on the last 30-minutes of the S&P 500 futures return. From Table 7, the estimates of the wildcard exercise values increase monotonically in beta and decrease monotonically in the market capitalization of the funds' holdings. For example, the NYSE futures adjusted exercise value is .46% for funds classified as holding small cap stocks and exhibiting a high beta in past returns. At the opposite extreme the funds holding large cap stocks and having a low beta had an average wildcard exercise value of .19% after adjusting with the NYSE futures return.

Finally, mutual fund distributions can have an important impact on the calculation of NAV, which could in turn affect our estimates of the wildcard-option exercise value. To address this concern we replicate the results in Table 7 using a sample that excludes the months of November and December from the opportunity set of wildcard trades. These are the months in which distributions typically occur. The January – October only version of Table 7 is virtually unchanged in the magnitudes of the wildcard exercise values or their statistical significance.

5. Loads, transaction fees, and transaction restrictions

The results of Section 4 suggest that wildcard exercise is highly profitable in both domestic equity and foreign equity funds. However, the wildcard option may be significantly less profitable in practice. Many mutual funds impose load fees, transaction fees, redemption fees, and various trade restrictions on investors. If the wildcard option value is concentrated in restricted funds, the previous results would have to be taken in context. In this section we consider the potential impact of these frictions on the profitability of the wildcard option.

5.1. Characteristics of funds' trade restrictions

Table 8 presents mutual fund fees and trade restrictions for that portion of our sample for which data are available (660 out of 880 funds). These data are collected from each fund's 1999 prospectus. From Table 8, 54% of the sample funds have load fees and 4% have transaction fees. The magnitude of most load fees typically exceeds the average exercise value of the wildcard option, which would appear to effectively eliminate the value of the wildcard exercise. It is curious to note that load fees are particularly prevalent at bond funds. Among no-load funds, 55% of domestic equity, 49% of foreign equity, and 45% of bond funds do not explicitly limit transactions, although nearly every fund prospectus states that the fund reserves the right to exclude investors that engage in market timing strategies. Through informal discussions and various anecdotes that we have gathered we have found little evidence to suggest that these limitations are acted upon on a regular basis. These ratios indicate that about 25% of the funds are vulnerable to unlimited exploitation of the wildcard option. This represents about 100 very large mutual funds in the Trim Tabs sample alone.

However, the remaining 75% of the sample funds are not immune to wildcard option exercise. First, those with transaction limits typically allow four round-trips, or 8 wildcard exercises per year. Second, load fees often apply upon entry or exit into a fund family, but within that family the investor is free to exchange at will between funds within the family including money market funds. Thus, while the initial fee for a load fund is large, investors who are already invested in load funds, or who plan to do so anyway, can assume no marginal loads in trading between funds within a fund family.

Given this evidence of Table 8, we feel that it is conservative to suggest that 4 roundtrip wildcard exercises per year are available to fund investors in the vast majority of funds.

5.2. Trade restrictions and wild-card option value

The analysis of mutual fund fees and trade restrictions of Table 8 is undertaken to examine the robustness of our estimates of MF wildcard value to real-world frictions. We recalculate the results in Table 5, excluding funds with loads and transaction fees to ensure that wildcard options are not exclusively found in places where they are less likely to be exercisable. The estimates of wildcard option exercise value for funds without loads or transaction fees are nearly identical to the wildcard exercise values found in the full sample. For example, in Table 5 the full sample of domestic equity funds has an average unadjusted next-day return of .11%, a NYSE futures adjusted next-day return of .26%, and an S&P

futures adjusted next-day return of .19% for the days on which the S&P futures return over the final 30 minutes is in either upper or lower 20% of the distribution. The domestic equity funds without loads and transaction fees have an average unadjusted next-day return of .13%, a NYSE futures adjusted next-day return of .27%, and an S&P futures adjusted next-day return of .20% with associated t-statistics of 1.21, 3.27, and 3.41, respectively. Fees and restrictions may impede fund investors from exercising the wildcard option, but their incidence is not concentrated in funds where the problem is particularly severe.

6. The Pricing of Mutual Fund Shares

There has recently been considerable effort directed at understanding the pricing of mutual funds' shares. Ogden and O'Hagan (1997) describe the extant SEC rules (Section 2(a)(41) of the Investment Company Act of 1940) on determining NAV as follows:

> The definition essentially divides the capital markets into two categories. First, if "market quotations are readily available" for a security, the security should be valued at "current market value." Second where market quotation are not "readily available," the security should be valued at "fair value" as determined in good faith by the [fund's] board of directors.

The intent is that mutual fund shares be priced using the latest relevant information. However, these directives are ambiguous. In particular are the issues of what constitutes fair value and when should "fair value" pricing be used.

These issues came to the fore following an Asian market crash on October 28, 1997. As recounted in Ogden and O'Hagan (1997), on October 28, 1997 the Hong Kong market dropped by 14% during the trading day and subsequently was followed by a +6.1% return on the S&P 500 in the U.S. market. Since Hong Kong's market closes 6 hours before the U.S. market opens, the last trade prices of Hong Kong stocks did not reflect the information that the U.S. market rebounded. Ogden and O'Hagan (1997) describe three responses to these events. Some funds maintained standard procedure and did not factor the rebound in the U.S. market into Hong Kong stocks' valuations. Fidelity estimated the prices of Hong Kong securities incorporating the information made available during the U.S. trading day invoking fair value pricing. T. Rowe Price incorporated new information by waiting until the Hong Kong Market opened on October 29th prior to setting NAV. Those funds that failed to factor the rebound in the U.S. market into the value of their Hong Kong shares presented investors with a valuable wildcard call option. That is, they allowed investors to purchase claims on their Hong Kong holdings at prices substantially below their current value.

Not surprisingly, these events precipitated discussion in the popular press, among mutual fund directors, and regulators at the SEC.[9] These events also motivated academic research on the pricing of foreign fund shares. For example, several recent studies attempt to quantify the gains to strategies designed to exploit stale pricing in foreign fund shares (Bhargava and Dubofsky (1999), Goetzmann, Ivkovich, and Rouwenhorst (2000)) and the impact of these strategies on foreign fund returns (Green and Hodges (2000)).

In addition to cases involving the valuation of foreign securities whose markets are open during different hours than U.S. markets, there are other cases when the pricing of fund shares is inherently difficult. Fair value pricing has been implemented by funds when valuing non-treasury bonds, stocks that did not trade during the prior 24 hours, and shares in which trading had been halted prior to the market's close (Bhargava and Dubofsky (1999). In each of these cases a recent market prices is unavailable, and thus, fair value pricing is used instead of potentially stale market prices.

[9] See for example, Business Week, Commentary: Funds: A hidden trick investors should know about, Geoffrey Smith, 1997, Transcript of the Conference on the Role of Independent Investment Company Directors, U.S. Securities and Exchange Commission, Washington D.C. February 23-24 1999.

Fair value pricing is seldom used when valuing domestic equity. Through discussions with officials at the ICI, transcripts of an SEC conference on the role of the board of directors, and officials at the SEC it appears that domestic equity securities are valued at their closing price – the last transaction price during the trading day. However, the evidence of section 3 suggests that this practice results in stale prices even for domestic equity funds.

Although we focus primarily on nonsynchronous trading, the potential for mispricing which arises when funds use closing, or last trade, prices to set NAV extend beyond the effects of nonsynchronous trading. For example, bid-ask bounce – the tendency for closing prices to represent either the bid price or the ask price depending on whether the last transaction of the day was a sale or a purchase – is another potential source of mispricing. Keim and Stambaugh (1984) document systematic patterns in closing prices at the bid and ask across days of the week. In particular, they find that closing prices on Mondays tend to be at the bid while closing prices on Fridays tend to be at the ask. Thus, funds that set NAV using closing prices tend to under-price their shares on Mondays and over-price their shares on Fridays.

Many funds have responded to these pricing problems by setting rather arbitrary redemption fees or trade restrictions that limit the profitability of wildcard strategies. While these fees and trade restrictions may reduce the problem, they do not eliminate wealth transfers. For example, an investor might strategically move money between funds in different complexes according to a schedule that is allowed by each fund, thus, avoiding transaction fees and capturing several (up to 8 or more) exercises of the wildcard option per year. Furthermore, transaction fees and restrictions impose costs on all fund investors not just those engaging in wildcard strategies. We believe that the best way to resolve the wildcard issue is to set the NAV correctly in the first place -- which is the subject of current research (Chalmers, Edelen, and Kadlec (2000)). Fundamentally, the objective of the pricing method is to remove the effects of nonsynchronous trading and bid-ask bounce.

There are a number of possible solutions. An example of one relatively straightforward solution follows. All funds presumably have access to a live data-feed of the composite tape. And all funds of course know their current portfolio. In simplest terms,[10] we advocate developing a standardized system that taps into the live feed and tracks the time of the last trade for each stock in the fund's portfolio. The system must also track the tick by tick return to the S&P 500, and maintains a database of beta estimates for all stocks held by the fund. A simple calculation of the staleness of the fund's NAV as of the 4:00 P.M. market close (calculated using last-trade prices) is then the weighted-average of the stocks' betas times the index return over the non-trading interval. If the fund applies this fair-value adjustment to its daily NAV, the value of the wildcard option is potentially eliminated. Our future research is focussing on the efficiency of this solution and other solutions to the pricing problem.

Finding a solution to the pricing problem seems far more efficient than the current practice of imposing restrictions on *all* shareholders. One of the primary reasons to invest in a fund is to maintain low-cost liquidity whilst holding a diversified portfolio. Fund investors presumably derive utility from liquidity. For example, Edelen (1999) shows that about 72% of the assets of the typical (median) fund either entered in the previous year or will exit in the following year. Imposing costs or frictions on these investors is clearly less efficient than simply pricing the funds' shares accurately in the first place. Further, costs and restrictions on trading fund shares offers no relief to the implicit cost of trading assets at the wrong price. Economists have long held that an efficient price improves welfare, in the $5.2 trillion[11] mutual fund market an efficient price is likely to have large benefits.

7. Conclusions

This study documents the profitability of trading strategies designed to exploit the autocorrelation of daily fund returns caused by nonsynchronous trading and other potential price-adjustment delays. We find evidence that significant abnormal returns are attainable by following these strategies. However, the implications of our study are much more general. We show that the method that most funds currently use to set the NAV of their shares (closing prices) results in inefficient pricing. Inefficient pricing adversely affects the welfare of mutual fund investors, even if there is no deliberate effort to game the mispricing, as described here. Furthermore, the inefficiencies arising from using closing (last trade) prices to set NAV extend beyond the effects of nonsynchronous trading. For example, bid-ask bounce – the tendency for closing prices to represent either the bid price or the ask price depending on whether the last transaction of the day was a sale or a purchase – is another potential source of pricing errors.

The mutual fund wildcard option should be of great concern to mutual funds and their investors. The wildcard option allows a transfer of wealth from passive fund investors to those that exercise wildcard option. We believe that the most fruitful solutions to the MF wildcard option problem should focus on obtaining a corrected NAV. While imposing other

[10] There are many technical issues complicating the procedure. For example, calculating actual price-adjustment delays is substantially more complicated than simply using the last-trade time. Here, the intent is to simply outline the basic idea.

frictions can indirectly reduce the incidence of MF wildcard option exercise, indirect solutions generate their own redistributions of fund holder's wealth and ultimately are unlikely to solve the problem.

[11] Including $1.6 trillion in money market funds the total value is $6.8 trillion for December 1999. Source Investment Company Institute, www.ici.org.

Appendix

Filters. With hand-entered data such as TrimTabs', solitary typographical errors (e.g., NAV = 13.12, 13.17, 1**1.3**2, 13.15) are a concern. Visual inspection of the data (after searching for extreme cases) confirms that such errors are present. A solitary error in the level of NAV (or total assets) induces negative autocorrelation in the changes series. Since the autocorrelation of returns and flow is a key statistic in this study, we want to ensure that inferences are driven by the true processes rather than data errors. Two filters are applied.

The first filter removes observations if the absolute value of the daily return is greater than five standard deviations, where the standard deviation is calculated on a fund by fund basis. A five standard-deviation move in the value-weighted NYSE-AMEX index has happened 14 times since 1965, implying that this a decidedly rare event in the true data. A similar five standard-deviation filter is applied to the daily change in total assets.

The second filter is designed to catch false reversals. It removes observations when a three standard deviation move is followed by a reversal to within 1.5 standard deviations of the original (two days prior) value. A three standard deviation move in the NYSE-AMEX index has happened 92 times over the past 33 years, or about three times a year. However, a subsequent reversal back to within 1.5 standard deviations of the original (two days prior) value has happened only 15 times. Thus, historically, this filter removes less than ¼% of true data. Nevertheless, the data that this filter removes is extremely negatively autocorrelated. Removing true extreme negative autocorrelation biases the remaining data toward positive autocorrelation. To offset this, we also apply a similar filter for continuations: remove if the observation is a three standard deviation move followed by a further 1.5 standard deviation move in the same direction the next day. This happened with the NYSE-AMEX index 26 times between 1965 and 1999.

The autocorrelation of daily returns of the value-weighted NYSE-AMEX index over the 1965 – 1999 period is 14% without filters and 15% with filters. Assuming that the index data are free from errors, this implies that the two filters do not materially distort true autocorrelation. On the other hand, they almost surely remove most data errors. If a data-entry error is present, e.g. a digit transposition, then it is likely to be greater than 3 or 5 standard deviations, or about 5%, in magnitude. For example, digit transpose in NAV is typically about a 10% error if it occurs in the cents' columns and far greater in the dollars columns. While we cannot conduct a similar examination of the bias effect (or lack therein) of filtering the flow data, this suggests that no bias arises.

In the sample fund data, the filters have a tremendous effect on the standard deviation and autocorrelation statistics. For example, the standard deviation of daily equity-fund returns without filtering is 20.7%, shown in Table 1, panel A. This is clearly not a reasonable number. With filters, the standard deviation of daily equity-fund returns is 1.2%. By comparison, the standard deviation of the value-weighted NYSE-AMEX index returns over this period is 0.94% per day. Similar comments apply to the standard deviation of the daily change in assets and flow at equity funds. This indicates data errors in the raw data, suggesting that the filtered data provide more reliable inferences. Throughout the paper we use filtered data.

References

Atchison, M., K. Butler, and R. Simonds, 1987, Nonsynchronous security trading and market index autocorrelation, *Journal of Finance* 42, 111-118.

Bessembinder, H., and M. Hertzel, 1993, Return autocorrelations around nontrading days, *Review of Financial Studies* 6, 155-189.

Bhargava, Rahul and David A. Dubofsky, 1999, A note on fair value pricing of mutual funds, *Journal of Banking and Finance,* forthcoming.

Boudoukh, J., M. Richardson, and R. Whitelaw, 1994, A tale of three schools: Insights on autocorrelations of short-horizon returns, *Review of Financial Studies* 7, 539-573.

Brown, S., and W. Goetzmann, 1995, Performance persistence, *Journal of Finance* 50 (2), 679-698.

Campbell, J., S. Grossman, and J. Wang, 1993, Trading volume and serial correlation in stock returns, *Quarterly Journal of Economics* 108 (4), 905-939.

Carhart, M, 1997, On persistence in mutual fund performance, *Journal of Finance,* 52 (1), 57-82.

Carlson R., 1970, Aggregate performance of mutual funds 1948-1967, *Journal of Financial and Quantitative Analysis* 5 (1), 1-32.

Chalmers, J.M.R., R.M. Edelen, G.B. Kadlec, 2000, On the pricing of open-end mutual fund shares, work in progress.

Cohen, K., G. Hawawini, S. Maier, R. Schwartz, and D. Whitcomb, 1983, Frictions in the trading process and the estimation of systematic risk, *Journal of Financial Economics* 12, 263-278.

Cohen, K., S. Maier, R. Schwartz, and D. Whitcomb, 1986, The microstructure of securities markets: Theory and implications, (Prentice-Hall, Englewood Cliffs, NJ).

Conrad, J. and G. Kaul, 1988, Time varying expected returns, *Journal of Business* 61, 409-425.

Cowles, A., and H. Jones, 1937, Some a posteriori probabilities in stock market action, *Econometrica* 5, 280-294.

Edelen, R., 1999. Investor flows and the assessed performance of open-end mutual funds, *Journal of Financial Economic*, 53, 439-466.

Fama, E. and K. French, 1993, Common risk factors in the returns of stocks and bonds, *Journal of Financial Economics* 33 (1), 3-56.

Fisher, L., 1966, Some new stock market indices, *Journal of Business* 39, 191-225.

Foerster, S., and D. Keim, 1993, Direct evidence of non-trading of NYSE and AMEX stocks, working paper, Wharton.

Goetzmann, W. N. and R.G. Ibbotson, 1994, Do winners repeat? Patterns in mutual fund performance, *Journal of Portfolio Management* 20, 9-18.

Goetzmann, W.N., Z. Ivkovich, and G. Rouwenhorst, 2000, Day trading international mutual funds: evidence and policy solutions, working paper, Yale University.

Goldman, B., and H. Sosin, 1979, Information dissemination, market efficiency, and the frequency of transactions, *Journal of Financial Economics* 7, 29-61.

Greene, J.T. and C.W. Hodges, 2000, The dilution impact of daily fund flows on open-end mutual funds, working paper, Georgia State University.

Harvey and Whaley, 1992, Market volatility, prediction, and the efficiency of the S&P 100 index option market, *Journal of Financial Economics* 31 (1), 43-74.

Hasbrouck, J., and G. Sofianos, 1993, The trades of market makers: and empirical analysis of NYSE specialists, Journal of Finance 48, 1565-1593.

Hendricks, D., J. Patel, and R. Zeckhauser, 1993, Hot hands in mutual funds: short-run persistence of relative performance, 1974-1988, *Journal of Finance* 48, 93-130.

Kadlec, G., and D. Patterson, 1999, A transactions data analysis of nonsynchronous trading, *Review of Financial Studies* 12 (3), 608-630.

Kane, A., and A. Marcus, 1986, Valuation and optimal exercise of the wild card option in the treasury bond futures market, *Journal of Finance* 41 (1), 195-208.

Keim, D., and R. Stambaugh, 1984, A further investigation of the weekend effect of stock returns, *Journal of Financial Economics* 17, 357-390.

Keim, D., and R. Stambaugh, 1986, Predicting returns in the stock and bond markets, *Journal of Finance* 39, 819-835.

Keim, D., 1989, Trading patterns, bid-ask spreads, and estimated security returns: The case of common stocks at calendar turning points, *Journal of Financial Economics* 15, 75-98.

LeBaron, B., 1992, Some relations between volatility and serial correlations in stock market returns, *Journal of Business* 65, 199-219.

Lo, A., and A.C. MacKinlay, 1990a, An econometric analysis of nonsynchronous trading, *Journal of Econometrics* 45, 181-211.

Lo, A., and A.C. MacKinlay, 1990b, When are contrarian profits due to stock market overreaction?, *Review of Financial Studies* 3, 175-205.

Mech, T., 1993, Portfolio return autocorrelation, *Journal of Financial Economics* 34, 307-344.

Ogden, Thomas P. and Cindy J. O'Hagan, 1997, Mutual funds confront dilemmas in trying to value portfolios, The New York Law Journal, December 15, 1997.

Perry, P., 1985, Portfolio serial correlation and nonsynchronous trading, *Journal of Financial and Quantitative Analysis* 20, 517-523.

Table 1: Sample fund characteristics

Summary statistics for sample mutual funds are segregated into domestic equity, foreign equity, and bond funds. The sample includes all mutual funds with at least 100 daily returns available from Trimtabs.com over the period the period 2/1/98 through 6/30/99. The table reports mean and median values for the number of daily observations per fund, fund age, total fund assets at year-end 1998, fraction invested in equity, daily fund return (not annualized), standard deviation of daily return, and first-order autocorrelation coefficient of daily returns. Also reported are the mean, standard deviation, and first-order autocorrelation of daily returns of the NYSE and S&P 500 index futures over the sample period. Fund type, fund age, total assets, and the fraction invested in equity are obtained from the CRSP mutual fund database. NYSE composite returns are obtained from CRSP stock returns database and NYSE futures returns are obtained from Tickdata.com.

Sample Period 2/01/98 – 6/30/99		**Domestic Equity Funds**	**Foreign Equity Funds**	**Bond Funds**	**NYSE Futures**	**S&P Futures**
Number of Funds		447	132	276		
Daily Obs / fund	Mean	282	278	257	334	356
	Median	306	311	270		
Fund Age	Mean	17	8	12		
(in years to 1999)	Median	11	7	10		
Assets (millions)	Mean	1,169	497	556		
	Median	472	126	306		
Percent equity	Mean	88	90	4		
	Median	94	94	0		
Daily fund return	Mean	.05%	.04%	-.01%	.03%	.09%
	Median	.05%	.04%	-.00%	.08%	.12%
Std deviation fund return	Mean	1.15%	1.19%	.19%	1.20%	1.27%
	Median	1.12%	1.15%	.17%		
AR(1) coefficient	Mean	9.66%	18.76%	9.16%	-11.22%	-1.57%
for fund returns	Median	7.84%	19.06%	7.25%	(5.51%)	(5.30%)
% of AR(1) > 0		88%	100%	78%	N/A	N/A

Table 2. Minutes between the last trade and 4:00 P.M. for stocks sorted by market capitalization

For each stock above the 5th size percentile in the TAQ data set during the months 2/1998, 6/1998, 10/1998, 2/1999, 6/1999, the number of minutes between the last trade and 4:00 P.M. Eastern is calculated every day. The 90th, 75th and 50th percentiles and mean of the last-trade distribution are presented for stocks that fit within each market capitalization classification used by Morningstar to characterize funds.

	Small Cap 5th - 80th	**Mid-Cap** 80th – 95th	**Large Cap** Above 95th
90th Percentile	109	6	6
75th Percentile	27	0	0
Median	4	0	0
Mean	34	6	5
Std Deviation	72	32	29
N stocks days	243,649	51,681	16,737

Table 3. Autocorrelation of domestic-equity fund daily returns, partitioned by holdings and beta.
Market capitalization classifications (small-cap, mid-cap, large-cap) of fund holdings are obtained from Morningstar. Beta classifications (low < 0.8, medium 0.8 < beta < 1.2, and high > 1.2). are constructed from fund betas estimated using monthly fund returns and monthly returns on the NYSE composite index. Classification data are missing for 33 of our 447 domestic equity funds. T-statistics for mean autocorrelation coefficients are provided in parentheses. The sample includes all mutual funds with at least 100 daily returns available from Trimtabs.com over the period the period 2/1/98 through 6/30/99.

	Small Cap less than 80th	**Mid-Cap 80th – 95th**	**Large Cap Above 95th**	**By Beta Only**
Low Beta (avg=.64)				
Mean AR(1)	22.00%	10.80%	5.24%	8.85%
Median AR(1)	24.30%	7.40%	4.50%	6.82%
t-statistic for mean	(10.08)	(4.71)	(5.90)	(8.85)
N funds	14	24	64	102
Med Beta (avg=.98)				
Mean AR(1)	24.60%	13.40%	4.92%	8.55%
Median AR(1)	22.20%	16.20%	4.18%	6.66%
t-statistic for mean	(19.67)	(11.17)	(11.37)	(14.76)
N funds	23	45	162	230
High Beta (avg=1.32)				
Mean AR(1)	21.10%	14.60%	8.94%	14.50%
Median AR(1)	21.50%	14.40%	10.70%	14.90%
t-statistic for mean	(20.77)	(19.64)	(6.68)	(18.71)
N funds	21	35	26	82
By Size Only				**All Funds**
Mean AR(1)	22.70%	13.20%	5.41%	9.80%
Median AR(1)	22.20%	14.00%	4.58%	7.81%
t-statistic for mean	(27.63)	(16.80)	(13.90)	(21.91)
N funds	58	104	252	414

Table 4. Wildcard option exercise value following extreme fund return days

Daily fund returns, R_{it}, (fund i, day t) are ranked across all days and funds within each fund category (i.e. domestic equity, foreign equity and bond funds). Avg $R_{i,t+1}$ is the return to a strategy of buying or selling funds given extreme positive or negative rank-day fund returns. Avg(R_{it+1}–$R_{NYSEFuturet+1}$) and Avg(R_{it+1}–$R_{S\&P500Futuret+1}$) subtract from each next-day fund return the return on the NYSE futures and S&P500 index futures for that day, respectively. The standard deviation is calculated by first computing, each day, the variance of returns (or hedged returns) for all funds within the corresponding cell; then computing a weighted average of these daily variances by cell, where the weights are the number of funds in that cell, that day and the average runs across all days. Finally, take the square root. * denotes significance at a 5% level. The sample includes all mutual funds with at least 100 daily returns. All numbers are in percent (i.e., 0.01 = .0001 or one basis point). Standard errors are in parentheses.

Sample Period 2/01/98 – 6/30/99	**Domestic Equity Funds (447 funds)**		**Foreign Equity Funds (132 funds)**		**Bond Funds (276 funds)**	
Return range	Bottom 30%	Top 30%	Bottom 30%	Top 30%	Bottom 30%	Top 30%
Avg R_{it}	-1.27*	1.33*	-1.33	1.32	-.23	.20
	(.03)	(.03)	(.03)	(.03)	(.01)	(.00)
Avg $R_{i,t+1}$	-.11	.24*	-.33*	.30*	-.04*	.02
	(.07)	(.05)	(.06)	(.05)	(.01)	(.01)
$R_{i,t+1}$–$R_{NYFutures,t+1}$	-.09*	.15*				
	(.04)	(.04)				
$R_{i,t+1}$–$R_{S\&Pfutures,t+1}$	-.12*	.05*				
	(.03)	(.03)				
Return range	Bottom 20%	Top 20%	Bottom 20%	Top 20%	Bottom 20%	Top 20%
Avg R_{it}	-1.62*	1.64*	-1.70	1.62	-.30	.26
	(.03)	(.03)	(.04)	(.03)	(.00)	(.00)
Avg $R_{i,t+1}$	-.10	.27*	-.41*	.33*	-.05*	.02*
	(.07)	(.06)	(.07)	(.06)	(.01)	(.01)
$R_{i,t+1}$–$R_{NYFutures,t+1}$	-.12*	.19*				
	(.04)	(.05)				
$R_{i,t+1}$–$R_{S\&Pfutures,t+1}$	-.15*	.07*				
	(.03)	(.03)				
Return range	Bottom 10%	Top 10%	Bottom 10%	Top 10%	Bottom 10%	Top 10%
Avg R_{it}	-2.19*	2.16*	-2.30*	2.13*	-.43	.37
	(.03)	(.03)	(.04)	(.03)	(.01)	(.00)
Avg $R_{i,t+1}$	-.03	.30*	-.42*	.36*	-.06*	.03*
	(.08)	(.07)	(.09)	(.07)	(.01)	(.01)
$R_{i,t+1}$–$R_{NYFutures,t+1}$	-.16*	.28*				
	(.05)	(.06)				
$R_{i,t+1}$–$R_{S\&Pfutures,t+1}$	-.17*	.11*				
	(.04)	(.04)				

Table 5. Wildcard option exercise value following extreme intra-day S&P 500 futures returns

S&P 500 futures returns are ranked across all days for each of four different return intervals: the last 30 minutes (3:25-3:55 EST), last 90 minutes (2:25-3:55), last 180 minutes (12:55-3:55), and full day (9:30-3:55). Avg $R_{it\ SP500}$ is the average rank-interval S&P 500 futures return on days that fall in the indicated extreme quintile of *that* interval's distribution of returns. Avg $R_{i,t+1}$ is the average next-day *fund* return conditioning on the same days. Avg(R_{it+1}–$R_{NYSEFuturet+1}$) and Avg(R_{it+1}–$R_{S\&P500Futuret+1}$) subtract from each next-day fund return the return on the NYSE futures and S&P500 index futures for that day, respectively. For the low S&P 500 return tail, the next-day fund return is multiplied by –1, corresponding to a sale of fund shares on the ranking day. Units are percents (i.e., .01 is one basis point). The t-statistics reported in parentheses are calculated from the time-series standard error using approximately 65 observations for each tail. The sample includes all mutual funds with at least 100 daily returns available from Trimtabs.com over the period the period 2/1/98 through 6/30/99.

	Domestic Equity Funds (447)				**International Funds (126)**			
	Rank on S&P500 return over interval:				*Rank on S&P500 return over interval:*			
	Last 30	Last 90	Last 180	Full Day	Last 30	Last 90	Last 180	Full Day
Both 20% tails								
Avg $R_{i,t+1\ fund}$	0.11	0.03	0.10	0.12	0.31	0.32	0.46	0.52
	(1.13)	(0.30)	(1.14)	(1.27)	(3.31)	(3.42)	(5.76)	(6.33)
Avg $R_{i,t+1}$–$R_{NYFutures,t+1}$	0.26	0.22	0.20	0.22	0.45	0.51	0.58	0.63
	(3.33)	(2.78)	(3.24)	(2.67)	(3.80)	(4.83)	(6.20)	(5.41)
Avg $R_{i,t+1}$–$R_{S\&Pfutures,t+1}$	0.19	0.20	0.18	0.13	0.41	0.48	0.54	0.52
	(3.41)	(4.44)	(3.99)	(2.15)	(3.79)	(5.29)	(6.02)	(5.03)
Top 20% Returns								
Avg $R_{i,t+1\ fund}$	0.09	0.11	0.22	0.15	0.27	0.32	0.44	0.50
	(0.58)	(0.83)	(1.99)	(1.28)	(1.93)	(2.41)	(4.25)	(4.67)
Avg $R_{i,t+1}$–$R_{NYFutures,t+1}$	0.31	0.20	0.17	0.26	0.51	0.42	0.43	0.60
	(3.37)	(2.35)	(1.89)	(2.35)	(3.00)	(3.31)	(3.29)	(4.32)
Avg $R_{i,t+1}$–$R_{S\&Pfutures,t+1}$	0.15	0.07	0.10	0.08	0.37	0.29	0.32	0.43
	(1.83)	(1.53)	(1.87)	(1.26)	(2.26)	(2.47)	(2.64)	(3.56)
Bottom 20% Returns								
Avg $R_{i,t+1\ fund}$	-0.14	0.05	0.03	-0.08	-0.34	-0.31	-0.47	-0.53
	(-1.03)	(0.37)	(0.24)	(-0.59)	(-2.83)	(-2.41)	(-3.91)	(-4.32)
Avg $R_{i,t+1}$–$R_{NYFutures,t+1}$	-0.20	-0.23	-0.24	-0.19	-0.40	-0.60	-0.73	-0.65
	(-1.64)	(-1.78)	(-2.64)	(-1.49)	(-2.36)	(-3.56)	(-5.46)	(-3.54)
Avg $R_{i,t+1}$–$R_{S\&Pfutures,t+1}$	-0.23	-0.32	-0.26	-0.18	-0.45	-0.67	-0.75	-0.61
	(-3.09)	(-4.47)	(-3.62)	(-1.75)	(-3.17)	(-4.96)	(-5.96)	(-3.65)

Table 6: Wildcard option exercise value following extreme fund return days, by fund characteristics

This table replicates the middle-panel of Table 2 (conditioning on 20%-extreme returns) on a partition of Domestic Equity funds. See the Table 2 heading for a description. Market capitalization classifications (small-cap, mid-cap, large-cap) of fund holdings are obtained from Morningstar. Beta classifications (low < 0.8, medium 0.8 < beta < 1.2, and high > 1.2). are constructed from fund betas estimated using monthly fund returns and monthly returns on the NYSE composite index. Classification data are missing for 33 of our 447 domestic equity funds.

	Small Cap less than 80th	**Mid-Cap 80th – 95th**	**Large Cap Above 95th**	**By Beta Only**
Low Beta (avg=.64)				
$R_{i,t}$	1.09	1.07	1.13	1.11
	(49.87)	(58.64)	(55.97)	(66.01)
$R_{i,t+1}$	0.27	0.14	0.06	0.11
	(6.18)	(3.78)	(1.59)	(3.06)
$R_{i,t+1}–R_{NYFutures,t+1}$	0.23	0.13	0.08	0.11
	(4.20)	(2.88)	(2.27)	(3.12)
$R_{i,t+1}–R_{S\&Pfutures,t+1}$	0.20	0.07	0.03	0.06
	(3.85)	(1.69)	(1.08)	(1.96)
Med Beta (avg=.98)				
$R_{i,t}$	1.46	1.79	1.65	1.66
	(50.59)	(59.62)	(52.65)	(64.25)
$R_{i,t+1}$	0.36	0.28	0.09	0.15
	(6.48)	(4.80)	(1.42)	(2.88)
$R_{i,t+1}–R_{NYFutures,t+1}$	0.29	0.23	0.09	0.14
	(5.08)	(4.78)	(2.54)	(4.03)
$R_{i,t+1}–R_{S\&Pfutures,t+1}$	0.29	0.20	0.04	0.09
	(5.00)	(4.67)	(2.05)	(3.94)
High Beta (avg=1.32)				
$R_{i,t}$	1.94	2.07	2.22	2.08
	(41.22)	(47.29)	(44.37)	(52.83)
$R_{i,t+1}$	0.48	0.34	0.16	0.32
	(5.31)	(3.95)	(1.60)	(4.03)
$R_{i,t+1}–R_{NYFutures,t+1}$	0.30	0.24	0.14	0.22
	(4.25)	(3.87)	(1.99)	(3.98)
$R_{i,t+1}–R_{S\&Pfutures,t+1}$	0.28	0.22	0.08	0.19
	(4.84)	(4.83)	(1.91)	(4.93)
By Size Only				**All Funds**
$R_{i,t}$	1.56	1.72	1.57	1.61
	(60.30)	(66.29)	(58.66)	(70.68)
$R_{i,t+1}$	0.38	0.27	0.09	0.17
	(7.45)	(5.19)	(1.64)	(3.66)
$R_{i,t+1}–R_{NYFutures,t+1}$	0.28	0.21	0.1	0.15
	(6.01)	(5.24)	(2.81)	(4.60)
$R_{i,t+1}–R_{S\&Pfutures,t+1}$	0.27	0.18	0.04	0.10
	(6.22)	(5.43)	(2.25)	(4.76)

Table 7: Wildcard option exercise value following extreme intra-day S&P 500 futures returns, by fund characteristics

This table replicates the middle-panel of Table 2 (conditioning on 20%-extreme returns) on a partition of Domestic Equity funds. See the Table 2 heading for a description. Market capitalization classifications (small-cap, mid-cap, large-cap) of fund holdings are obtained from Morningstar. Beta classifications (low < 0.8, medium 0.8 < beta < 1.2, and high > 1.2). are constructed from fund betas estimated using monthly fund returns and monthly returns on the NYSE composite index. Classification data are missing for 33 of our 447 domestic equity funds.

	Small Cap less than 80^{th}	**Mid-Cap 80^{th} – 95^{th}**	**Large Cap Above 95^{th}**	**By Beta Only**
Low Beta (avg=.64)				
$R_{i,t+1}$	0.11	0.06	0.04	0.05
	(1.63)	(0.94)	(0.57)	(0.80)
$R_{i,t+1}–R_{NYFutures,t+1}$	0.27	0.23	0.19	0.21
	(2.89)	(2.49)	(2.33)	(2.50)
$R_{i,t+1}–R_{S\&Pfutures,t+1}$	0.19	0.13	0.11	0.13
	(2.11)	(1.58)	(1.56)	(1.68)
Med Beta (avg=.98)				
$R_{i,t+1}$	0.18	0.17	0.08	0.10
	(1.97)	(1.57)	(0.70)	(0.89)
$R_{i,t+1}–R_{NYFutures,t+1}$	0.33	0.30	0.22	0.24
	(3.54)	(3.99)	(2.38)	(3.17)
$R_{i,t+1}–R_{S\&Pfutures,t+1}$	0.25	0.24	0.15	0.17
	(2.82)	(4.05)	(2.33)	(3.50)
High Beta (avg=1.32)				
$R_{i,t+1}$	0.34	0.26	0.16	0.26
	(2.35)	(1.69)	(0.99)	(1.74)
$R_{i,t+1}–R_{NYFutures,t+1}$	0.46	0.39	0.29	0.39
	(4.12)	(3.83)	(2.12)	(3.63)
$R_{i,t+1}–R_{S\&Pfutures,t+1}$	0.41	0.33	0.23	0.33
	(4.46)	(4.50)	(2.26)	(4.22)
By Size Only				**All Funds**
$R_{i,t+1}$	0.23	0.17	0.07	0.11
	(2.27)	(1.65)	(0.65)	(1.10)
$R_{i,t+1}–R_{NYFutures,t+1}$	0.37	0.31	0.21	0.25
	(4.25)	(4.07)	(2.47)	(3.31)
$R_{i,t+1}–R_{S\&Pfutures,t+1}$	0.30	0.25	0.14	0.19
	(3.88)	(4.32)	(2.33)	(3.44)

Table 8. Restrictions on and costs to trading fund shares

Data on the level of loads, transaction fees, and limitations on trading in fund shares taken from 1999 fund prospectuses. If funds have either a front-end load or back-end load we do not collect transaction fee or exchange limit data. The table averages are calculated using only those funds with a positive value of the indicated variable (i.e., load, transaction fee, or limits on the number of roundtrip transactions).

Restrictions in 1999 Prospectuses	**Domestic Equity Funds**	**Foreign Equity Funds**	**Bond Funds**
Total Sample	447	132	276
less funds missing prospectus data	87	34	56
less funds that were closed	12	3	3
Net Sample	348	95	217
Front-end Loads			
% with front-end load	35%	36%	42%
if load: average front-end load	5.3%	5.2%	4.1%
Back-end Loads			
% with back-end load	19%	25%	34%
if load: average back-end load	4.3%	4.4%	4.1%
Number of funds with any Load	188	58	161
Net Sample for Fees and Limits (no loads)	160	37	56
Transaction Fees			
% with transaction fees	4%	14%	9%
If fee: average fee	1.4%	1.8%	.7%
Limits on Exchanges			
% funds with limits	45%	51%	55%
If limit: average round-trips/year	9	10	9
If limit: mode round-trips/year	4	4	4