VIII. Time-zone arbitrage in United States mutual funds: Damaging to financial integration between the United States, Asia and Europe?

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Summary

Historically, United States mutual funds have often calculated their asset values for international mutual funds using stale prices, because some fund components finish trading before the market closes. This resulted in daily fund returns becoming predictable. This allows an arbitrage opportunity for investors who move their money at the end of the United States trading day to profit from the next-day change in Asian and European equities. This acts as a tax on other investors in mutual funds that hold non-United States assets. This paper quantitatively traces the history of this phenomenon, known as time-zone arbitrage (TZA), in various mutual funds, particularly the Vanguard Fund Family, before and after the phenomenon became well known. The opportunity for TZA has diminished but not disappeared. This shrinkage together with the advent of Exchange-Traded Funds – which are not subject to time-zone arbitrage – makes investment in Asia and Europe more profitable for American mutual fund investors. This should increase United States investment in Asia and Europe and enhance the integration of these markets.

Introduction

> "The soaring use of market timing by the average fund owner – not only the illegal late trader nor the unethical time-zone trader – indicated that ordinary investors, using the finest vehicle for long-term investing ever designed, were engaging in excessive short-term speculation in fund shares. There's a lot of money sloshing around the mutual fund system." – John C. Bogle (2005; p. 152), founder and, for many years, CEO of Vanguard.

In the above passage, John Bogle describes the phenomenon known as market timing that has shocked many investors. Using market timing, some investors were able to securely profit, detracting value from the average buy-and-hold investor. This paper shows that Vanguard international index funds were not immune to the opportunity to profit from stale prices and market timing. However, no evidence was found that market timing caused the returns of these funds or of other fund families to sink below those of their corresponding

indexes. This appears to be so because, investors with Vanguard and other firms made limited use of market timing opportunities.[1]

In the past, market timers were able to capitalize on short-term structural inefficiencies in the global marketplace. There is no single standard framework for mutual funds to calculate the value of their assets after markets close. Further, it is still important to calculate accurate and up-to-date values in a globalized trading system where markets across the globe open and close at different times. European markets close at various times until 11 a.m. Eastern Time (ET) and Pacific markets close after midnight ET. Information and news never stop; long after the market in one time-zone closes, events and news are released that affect asset prices. Research has shown that increases in globalization, improvements in technology, and liberalized capital flows correspond to a larger correlation between all markets, particularly United States market movement and subsequent next-day European movement (Bhargava, Bose and Dubofsky, 1998). When a foreign market closes, the assets traded on that exchange will artificially freeze in value as they are no longer actively traded; this value for a mutual fund is called net asset value (NAV). These NAVs, if used hours later, are termed "stale prices."

Historically, United States-based mutual funds have calculated their value using stale prices for the assets that trade in foreign markets. The predictability of change in the stale prices when the foreign market opens creates an arbitrage opportunity. Consider an example: an investor stores her money in a United States market mutual fund and waits for a market signal such as significant increase in the United States market throughout the day. From this signal, she switches her money close to the end of the United States trading day to a mutual fund holding a large proportion of European assets, because she expects a similar increase in the European market when the market opens. The investor gains both the return in the United States market and the expected corresponding rise in Europe. Similarly, when the United States market declines, the investor with funds in Europe can switch back at the end of the day, avoiding the loss in both the United States and European markets. This technique of exploiting the market discrepancy is a type of "market timing" or, more specifically, "time-zone arbitrage." Normally, once traders and investors are aware of possible arbitrage opportunities, the market reacts quickly and the opportunities disappear. This does not apply to the case of TZA with mutual funds – there is not an efficient market mechanism to eliminate profitability.

The existence of TZA has been documented in the past. Academics have published studies about the interrelation of markets for decades, and the specific trading strategies have been described since 1998. In September 2003 Eliot Spitzer, then-New York Attorney-General, publicly announced that he had evidence of mutual funds engaging in illegal trading arrangements (Houge and Wellman, 2005). Most of these charges were levied against funds for allowing late trading – which was clearly illegal – but some charges included colluding with favoured investors to exploit TZA. Ultimately, Spitzer recovered more than US$ 3.1

[1] Vanguard, at different times either charged a frequent trading fee (much like all international funds do now) or restricted frequent trading. Some funds at some times had purchase and redemption fees, and have inhibited trading by requiring that trades be initiated by mail.

billion in mutual fund settlements (Houge and Wellman, 2005). In response to time-zone market timing behaviour, many funds instituted more stringent trade limits, trade fees and account monitoring (Houge and Wellman, 2005). While time-zone market timing is not explicitly illegal, the practice clearly dilutes shareholder value (Zitzewitz, 2003. What is illegal is allowing favoured investors to engage in market timing while barring others. On the other hand, it is legal for the general market timers to exploit the arbitrage at the expense of the buy-and-hold investors – a fact which has shocked the mutual fund industry (Houge and Wellman, 2005).

The analysis of TZA practices in this paper focuses on the Vanguard mutual fund family, as it is widely considered among the most reputable funds families and a standard-setter for fund behaviour. It also is the leader in providing international index funds, so it is natural to compare the performance of its international index funds with the international indexes in order to assess the damage that TZA has done to buy-and-hold investors. Vanguard founder and CEO, John Bogle, has also written extensively about mutual funds and long-term investment strategy. Bogle (2005) states:

> "The shocking truth about time-zone trading is that it went on for so long without significant defense being erected by managers. It has hardly been a secret. Academics have been publishing papers about it at least since the late 1990s."

This paper analyses stale prices and time-zone trading strategies in Vanguard funds. It compares Vanguard funds to their competitors and the Spitzer-investigated fund families. The objectives of this paper are to:

(a) Reveal how the opportunities and profitability for time-zone arbitrage differed between fund families and different funds;
(b) Discover if and when the opportunities for time-zone arbitrage disappeared;
(c) Explore the cost of time-zone arbitrage to Vanguard index fund investors;
(d) Develop an alternative (and better) signalling mechanism for fund transfers;
(e) Use a symmetric criterion for transferring funds back and forth between United States and foreign mutual funds. Similar to some of the previous studies, the profitability calculations are carried out using a strategy in which the investors are always fully invested in either domestic or foreign equities;
(f) Explore the causes and consequences of Eliot Spitzer's investigation of certain mutual fund families. Specifically, did those fund companies he investigated demonstrate markedly inferior performance prior to the investigation, and did they markedly improve behaviour after being identified by his office?

Here is how this paper is organized. Section A reviews the existing literature on market timing and stale prices. Sections B to D explain the data and methods used. Section E asks whether there was an opportunity for TZA in the Vanguard European Index fund. Section F asks how profitable TZA was in the Vanguard European Index Fund while section G asks how TZA opportunities compared between fund families. Section H provides a brief history of restrictions on frequent trading. Section I asks how long the opportunities for TZA lasted. Section J explores the morality of time-zone arbitrage and its analysis while section K

asks whether, in spite of TZA, international fund returns beat their tracking indexes. Section L draws conclusions about TZA. Section M considers the implications of the shrinkage of TZA opportunities and the advent of exchange traded funds for the integration of international capital markets.

A. State-of-the-art

Market-timing in mutual funds was first documented in an academic paper by Bhargava, Bose and Dubofsky (1998). Zitzewitz (2003) noted that "this arbitrage opportunity has been understood by the industry for 20 years and exploited since at least 1998…" The existing literature on market timing and stale prices in mutual funds focuses on two segments. The first segment documents various signalling mechanisms and trading strategies to prove that large excess returns are possible with TZA in mutual funds. The second segment focuses on documenting the loss in shareholder value caused by market timing and the possible solutions to prevent time-zone arbitrage. This paper explores both segments of the literature.

TZA has been documented by several different academic studies. The first publication to document returns from time-zone arbitrage was produced by Bhargava, Bose, and Dubofsky (1998), who used a 1.5 standard deviation increase in the S&P from the previous day's closing price level to signal the investor to transfer from the S&P 500 index to a basket of five foreign equity funds. The investor returns funds to the United States at the end of the first day that the S&P declines. They documented the fact that that following this strategy generated a return of 800 basis points a year above that of the S&P 500.

Chalmers, Edelen and Kadlec (2001) showed the predictability of foreign fund returns, using a sample of 943 mutual funds from February 1998 to March 2000. They regressed foreign fund returns on daily lagged S&P index returns (the previous day close to 3.55 p.m.), and returns over the last two hours that the United States market was open (1.55 p.m. to 3.55 p.m.). They discovered that the former trigger generated a higher return. Their investment strategy, using cash or a combination of cash and futures markets to reduce risk, was more complex than the strategy used in this paper of switching back and forth between domestic and foreign equity mutual funds. Also, they aggregated funds whereas this paper looks at a set of individual funds. Boudoukh and others (2002) analysed stale prices in mutual funds. They focused on excess profits and Sharpe ratios to demonstrate the benefits of exploiting stale pricing. They examined the 1997-2001 time period using 15 international mutual funds to track trading strategy performance. The strategy they employed switched capital between a money market account and the mutual fund based on the movement of the futures market, using the S&P for the European funds and Nikkei 225 futures for the Japanese/Pacific funds. For a signal, they used (a) the difference between the closing Nikkei level in Japan and the implied Nikkei level at 4 p.m. traded on the Chicago Mercantile Exchange (CME), (b) the within-day change on the S&P 500 and (c) a combination of the two. Ultimately, the combination performed the best. Boudoukh and others (2002) used two thresholds of 0.5 per cent and 1 per cent expected excess returns to signal a switch from the money market to the mutual fund. On days that the expected excess is less than zero the

investor moves out of the international fund. They measured returns to the strategy against a benchmark of buy-and-hold returns of the particular mutual fund.

As in this paper, Boudoukh and others (2002) had a section that focused on Vanguard funds. They used Vanguard International Growth, Vanguard Pacific Equity Index and the Vanguard European Equity Index to demonstrate an S&P signal trading strategy that moved funds from the Prime Money Market fund (which invests in high-quality, short-term commercial paper) to a basket of international Vanguard funds or the reverse if the signal was negative. They used the period from January 1997 to November 2000, finding that there was a large excess return from replacing buy-and-hold with either the 0.5 per cent or the 0.25 per cent expected return thresholds over that period. Their trading strategy, unlike that discussed in this paper, has capital in the international funds for less than 10 per cent of the time.

Bhargava and Dubofsky (2001) also considered TZA in Vanguard international index funds, calculating the return from TZA and calling for more fair-value pricing.

The Greene and Hodges (2002) study focused primarily on the dilution of value to buy and hold investors, caused by volatile fund flows from stale prices and market timing. They used the S&P as an indicator. The trader switches to the international fund if the S&P daily return is positive and holds cash the next day if the S&P is negative. The authors used the period from 1 January 1993 to 31 December 1997. They used 84 international funds to measure the average return of each strategy. Greene and Hodges also examined the correlation between the movement in a fund's net fund flow and the following day's return. The average correlation was found to be 0.0512 for international funds, exhibiting apparent market timing activity. These results are different from the 2001 findings by Goetzmann, Ivkovic and Rouwenhorst, who found almost no correlation between fund flows and fund returns for international mutual funds. This paper examines a longer and more recent period and does not analyse net fund flow.

Goetzmann, Ivkovic and Rouwenhorst (2001) documented the inflows and outflows caused by time-zone arbitrage. They used a diverse 391-fund sample to test whether the daily S&P 500 index return was a profitable indicator for short-term international investment decisions. They found, through high correlations between the return of the S&P and the international mutual funds next day returns, that almost every fund was vulnerable to stale pricing. They also compared the change in the NAV of the funds with the magnitude of the in/out money flow. This yielded an overall small positive correlation between net fund flows into international funds and next-day international fund returns. Not all of their correlations were positive; the spread of the correlations between fund flows and next-day fund returns was -0.029 to 0.083.

Zitzewitz (2003) documented TZA and suggested possible solutions for protecting the long-term buy–and-hold investors. Zitzewitz used the TrimTabs database and filled in missing data with figures from Yahoo to get the daily returns of various mutual funds for January 1998 to October 2001. Unlike the other studies that compared returns to a buy-and-hold strategy, Zitzewitz measured excess returns against a mixture of cash and funds that had

the same daily fund exposure. Zitzewitz also analysed domestic small-cap equities, and high-yield and convertible bonds that traded infrequently and had wide bid-ask spreads, making them susceptible to stale pricing. He discovered that excess returns were highest in international equity funds, a finding consistent with the rest of the literature. Among other triggers, he used the change in the S&P 500 index from the previous close until 11.30 a.m. and from 11.30 a.m. until its close. This paper uses a finer grid of times. In analysing time-zone arbitrage, Zitzewitz wrote:

> "These abnormal returns come at the expense of long-term shareholders, dilution of whom has grown in international funds from 56 basis points in 1998-99 to 114 basis points in 2001. The speed and efficacy of a fund's actions to protect shareholders from dilution is negatively correlated with its expense ratios and the share of insiders on its board, suggesting that agency problems may be the root cause of the arbitrage problem."

These considerations led the authors of this paper to expect less dilution in Vanguard funds.

The basic framework explaining TZA has been placed. This paper builds on this literature by using a much longer and more recent period (1 January 1997-31 December 2007), and by employing a strategy that is clearer and more feasible for many investors. This makes it possible to evaluate when the arbitrage opportunity from market-timing ended. The trading strategy and calculation of the constrained regression is a new methodology that is accessible to the unsophisticated investor and simple to execute.

B. Futures data

The sample in this paper uses two different sets of data: mutual fund daily closes adjusted for dividends and five-minute changes in the S&P 500 index. The data used in the regressions are quotes for the S&P 500 futures index for the next available settlement date rather than the actual S&P 500 index. But as documented below, the two series are very similar, so this choice does not significantly affect the results.

Table 1. Correlation between the proportional change in the actual S&P 500 and S&P futures

Year	Correlation
1997	0.986
1998	0.991
1999	0.987
2000	0.988
2001	0.993
2002	0.998
2003	0.998
2004	0.999

The data track the five-minute movement in S&P 500 futures prices, generally to the next settlement date. To ensure that the S&P futures accurately measure the actual S&P, the correlation was calculated between the day-to-day proportional changes in the S&P futures 4 p.m. price and the S&P 500 adjusted close, using daily data from Yahoo. Table 1 shows the correlations between the two proportional changes; every year has an extremely high correlation, the lowest year being a still very high 0.986 in 1997. The high correlations indicate that the futures data are close enough to the actual S&P that the indicators and signalling will be accurate enough for the purpose of this paper.

C. Fund selection

Sixteen mutual funds in three categories are examined: Vanguard Family, Vanguard Competition and families investigated by Eliot Spitzer. Within the Vanguard family the focus is on its index funds: **VEURX** – Vanguard European Stock Index; **VEIEX** – Vanguard Emerging Market Index; and **VPACX** – Vanguard Pacific Index. It also used **VINEX** – Vanguard International Explorer, a managed fund of medium-sized company stocks.

For the analysis of non-Vanguard funds, from several of the various fund families a fund was selected that existed for as much of the 11-year period from 1997 to 2007 as possible, with a preference for funds that closely tracked the European index, and had neither a value nor a growth orientation. As discussed below, TZA opportunities were likely to be greatest for European funds, so those funds were generally selected. The final part of this paper compares fund performance with a basket of indexes that mimics fund returns. MSCI indexes for international value, international growth and international small company stocks became available from the beginning of 1997, so the international funds that did not focus on the characteristics of small value, or growth, were generally selected.

For the Vanguard competition, four fund families were selected that closely competed with Vanguard for business, attracting customers who valued low expenses and investment expertise DFA, Fidelity, GMO, and T. Rowe Price (the first three of which are discussed by Tower and Yang (2008), Zheng and Tower (2004 and 2008) and Tower (2008), although DFA and GMO are appropriate only for high wealth investors. Within each fund family, generally the fund with the lowest expense ratio and highest proportion of European assets that were in existence for most of 1 January 1997-31 December 2007 was selected. Those with a high proportion of European assets were chosen because the Vanguard European Index Fund is the largest of Vanguard's international index funds; thus, time-zone arbitrageurs would be likely to feel that their activity would be least likely to be noticed in this fund.

European funds tend to be relatively large for other fund companies as well. However, in the case of Vanguard, the Admiral Class Funds – which had lower expense ratios than the investment class funds – were not used because some of the Admiral Class Funds were introduced after the time series used for this paper began. The four funds in the

Vanguard competition are: DFIVX – DFA International Value I; FIEUX – Fidelity Europe Fund; GMOFX – the GMO Foreign Fund III; and PRESX – T. Rowe Price Euro Stock.

The Spitzer category consists of: AEDBX – AIM European Growth; EUGAX – Morgan Stanley European Equity F; FIECX – Federated International Equity Fund C; GSIFX – Goldman Sachs Concentrated International Equity A; JAOSX – Janus Overseas; MGEBX – Van Kampen Global Value Equity B; MWEFX – MFS Global Equity A; and PEUGX – Putnam European Equity Fund A. One fund each from several of those families investigated by Spitzer[2] was selected.

D. Trading Strategy

The sample of mutual fund data used here for devising and assessing trading strategy is from Yahoo. The data are easily accessible online. Any unsophisticated investor could easily obtain the information for the purpose of studying or exploiting time-zone arbitrage. A time-zone arbitrageur would, however, need to record the data to ascertain patterns, since the data disappears from Yahoo after five days. The S&P futures data were available only through 2004, so tables 1 and 2 terminate then.

Trading hours in Europe briefly overlap with trading hours in the United States – about one and a half hours, between 9.30 a.m. and 11 a.m. This leads to the belief that the European market already reflects the news and information from the early part of the United States' trading day, leaving the afternoon hours for the information sets behind values in the two markets to diverge. Different European markets close at different times, and some foreign markets close before the United States market opens. Proportional changes in international mutual fund dividend-adjusted price were regressed on the proportional changes in the dividend-adjusted price of the S&P 500 index over various previous periods. The logic of time-zone arbitrage indicates that movements in the price of the S&P should be accompanied by subsequent movements in the international mutual fund price in the same direction. Consequently, all regression coefficients were constrained to be positive.

Six distinct time periods were used: 9.35 a.m.-4 p.m., 10 a.m.-4 p.m., 10.30 a.m.-4 p.m., 11 a.m.-4 p.m., 11.30 a.m.-4 p.m. and the previous day's close at 4 p.m-4 p.m. The change in each time period was calculated by dividing the change in the S&P over the period to the 4 p.m. close by the S&P value at the beginning of the period. The mutual fund return was calculated by using the proportional change of the end-of-day adjusted return, where "adjusted" means adjusted for dividends.

[2] The four original mutual fund companies that the New York Attorney-General focused on were Bank of America, Janus Capital Group, Bank One and Strong Capital Management. Since the investigation and settlement, many of those original funds have been shut down, so they are not included in this paper. Spitzer subsequently investigated eight additional fund families – Van Kampen, Goldman Sachs, Morgan Stanley, Putnam, Federated, AIM, Janus and MFS. Those fund families have been charged, probed or fined by his office. The authors reviewed reports online from various sources such as the *Wall Street Journal*, *CNN/Money*, *Business Week* and *Fortune* to get this list of fund families.

The TZA opportunity model was calculated for each year using daily data. The data were divided into annual segments to explore whether the opportunity changed as investors and mutual fund families became aware of the issue. In calculating the profitability of the strategy, time-zone arbitrageurs were assumed to behave as if the model from the previous year obtained. Thus time-zone arbitrageurs made decisions using current day (and previous day's close) data along with the last year's coefficients.

The S&P trade indicator was calculated by multiplying the regression coefficients from the previous year times the corresponding time period proportional change in the S&P and adding them together. Trades were assumed to occur at the United States market close of 4 p.m. Four threshold levels for predicted changes in the international mutual fund were tested: 0.1 per cent, 0.5 per cent, 0.7 per cent and 1 per cent. The arbitrageur was assumed to move from the United States into the foreign mutual fund whenever the indicator exceeds the threshold level, and move back from Europe into the United States whenever the indicator exceeds the threshold level in the opposite direction. For example, for the 1 per cent threshold, the investor buys the European fund whenever she anticipates that the next day's return on the European fund will exceed 1 per cent, and sells it when she anticipates that the next day's loss on the European fund will exceed 1 per cent. Programming Excel to perform the calculations is easy.

The profitability of time-zone arbitrage was measured as the annualized excess return of the trading strategy over an annualized benchmark return. The benchmark return is what the return would have been from investing a constant fraction, K, of the portfolio in the foreign mutual fund and the rest of the portfolio in the Vanguard 500 index fund, where K is the fraction of the portfolio that under the arbitrage strategy is invested in the foreign mutual fund. The Vanguard 500 index fund mimics the return of the S&P 500 index. This benchmark strategy assumes daily rebalancing. The benchmark return is calculated by weighting each day's return in the United States and Europe by the proportion of time in each market under the arbitrage strategy:

$$B(r) = K^{*}R_{e} + (1-K)^{*}R_{a}$$

where B(r) is the benchmark return, K is the proportion of time in Europe, R_e is the return in Europe and R_a is the return in the United States.

E. Was there vulnerability to TZA in the Vanguard European Index Fund?

The regression coefficients of the Vanguard European Index Fund from 1997 to 2004 are presented in table 2. The sum of the coefficients demonstrates the strength of the S&P's predictive power on Vanguard Europe's return the following day. Each year has a large coefficient sum, demonstrating a significant ability for market timers to use the S&P signals to exploit the Vanguard Europe Index.

The constant term in the regressions was ignored, and the analysis focused on predicted changes in the international funds due to changes in the S&P. For 1997, a 1 per

cent change in the S&P overnight, with no further changes, predicts a 0.170 per cent change in the same direction for the international fund the following day. A 1 per cent change in the S&P 500 index fund between 11.30 a.m. and 4 p.m., with no changes before then, results in a predicted change equal to the sum of the coefficients, 0.462 per cent. Thus, more recent changes have bigger impacts than earlier changes.

The F statistic of 31.272 indicates that the model is significant at the 0.01 per cent level.[3] The continuously compounded geometric average return of the Vanguard S&P 500 index, including dividends, is 27.5 per cent per year, and the continuously compounded return of the Vanguard Europe fund is 23.5 per cent per year.

The years with the lowest sum of the regression coefficients are 2000 and 2001 while the year with the highest sum is 2003 with 0.527. The F-Test is highly significant in every year. In efficient markets, one would expect F-Statistics less than 2.067 (the 1 per cent level of significance).

Last, each of the six time periods indicate varying impacts of the S&P on Vanguard Europe. The lack of constancy of the distribution of the coefficients from year to year shows some variation in the predictive power of the S&P returns.

The method of calculation was as follows. Microsoft Excel's solver add-in was used. This easy-to-use add-in allows one to select weights to minimize a variable subject to constraints. Excel's solver was programmed to select the weights on the returns of the S&P and the constant term that minimized the variance of the return differential between the international mutual fund and the weighted sum of the previous S&P returns, augmented by the constant term, such that no weight is negative (signifying that the S&P moves the international fund in the same direction on the following day).

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[3] The F-test was used to measure the significance of the results. It is used to derive the statistical significance of the explanatory power of a model over that of an alternative. F is calculated as:

$$F = \frac{\left(\frac{RSS_1 - RSS_2}{p_2 - p_1}\right)}{\left(\frac{RSS_2}{n - p_1}\right)}$$

where RSS_2 is the residual sum of squares of the dependent variable (the variance not explained by the model, p_2 is the number of parameters in the model, p_1 is the number of parameters in the alternative and n is the number of observations. In the present case, the model has p_2 equal to the number of non-zero coefficients (including the constant term), so p_2 is less than, or equal to seven. The alternative model is that the dependent variable is independent of any explanatory variables except for a constant, so $p_1 = 1$. The authors used daily data. There are approximately 250 daily observations on the stock market in each year, so n is roughly 250. The F-test significance table indicates that with these parameters the model is significantly better than the alternative at the 1 per cent level, if F exceeds 2.067.

Table 2. TZA predictors for the Vanguard European Index Fund: Does the S&P predict next-day return?

Year	1997	1998	1999	2000	2001	2002	2003	2004
9:35am-4 pm	0.204	0.000	0.306	0.000	0.011	0.000	0.000	0.000
10:00am-4pm	0.061	0.014	0.000	0.000	0.164	0.000	0.043	0.000
10:30am-4pm	0.028	0.355	0.000	0.000	0.183	0.416	0.000	0.000
11:00am-4pm	0.000	0.000	0.146	0.000	0.000	0.000	0.361	0.000
11:30am-4pm	0.000	0.151	0.000	0.000	0.000	0.021	0.124	0.000
Previous Day Close-4pm	0.170	0.000	0.000	0.377	0.000	0.000	0.000	0.379
Sum of Coefficients[1]	**0.462**	**0.520**	**0.452**	**0.377**	**0.358**	**0.437**	**0.527**	**0.379**
Standard Deviation of Europe Return[2]	0.009	0.0135	0.009	0.012	0.0138	0.0172	0.0111	0.0084
Standard Deviation of Unexplained Europe return	0.0073	0.0125	0.008	0.0107	0.0132	0.0163	0.0104	0.0079
F-Statistic	**31.272**	**10.154**	**14.910**	**15.568**	**4.783**	**7.352**	**9.391**	**7.473**
S&P return CC	-0.008	0.236	0.178	-0.107	-0.253	-0.266	0.234	0.086
Europe return CC	0.007	0.254	0.155	-0.170	-0.297	-0.198	0.327	0.190

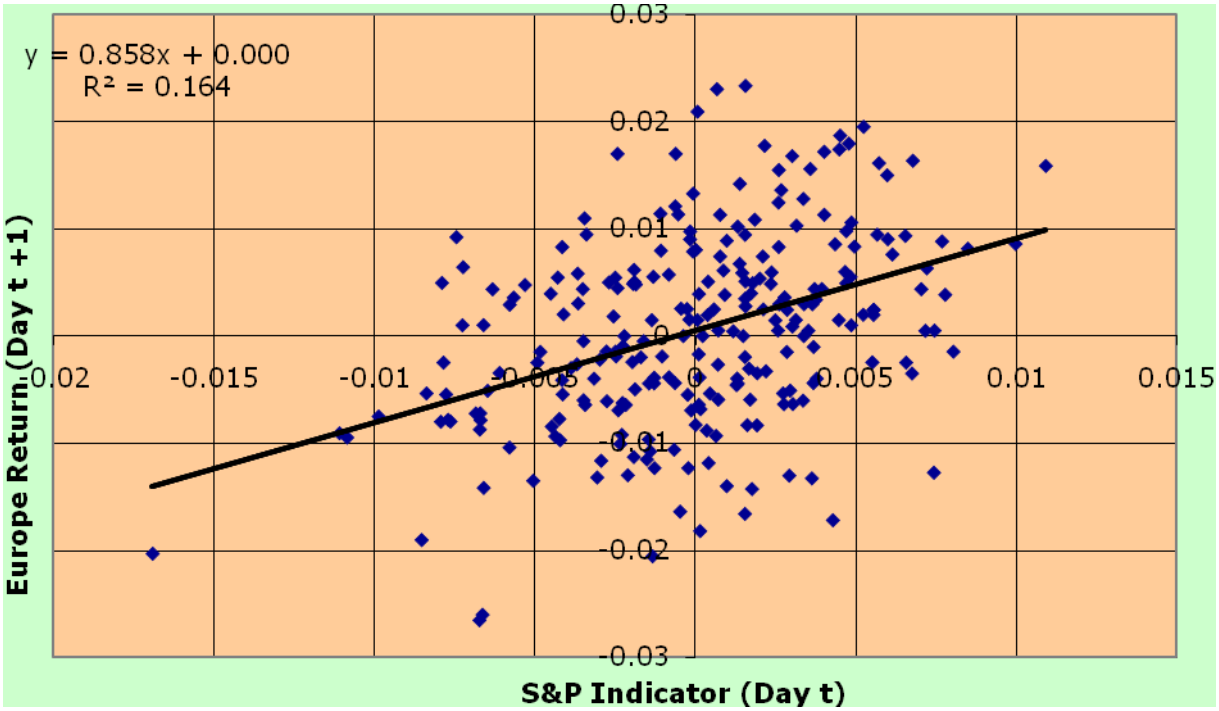
1. Coefficients are sensitivities of next day Europe returns to S&P returns. A change between 11:30 a.m. and 4 p.m. predicts a change equal to the sum of the coefficients.

2. Standard deviations of Europe return are proportions/day. Returns CC are continuously compounded geometric average returns expressed as proportions/year.

Figure 1 shows the reliability of the S&P indicator with the previous year's coefficients for 1999. For the Vanguard Europe Index Fund in 1999 it is apparent that the indicator has a strong impact on the actual European return the following day, with a regression coefficient of 0.86, meaning that a prediction of a 1 percentage point rise results in a next-day return on average of 0.86 percentage points above the mean value. In 1999, the sum of the coefficients was 0.452, also reflecting the arbitrage possibility for profiting from recent changes in the S&P. Had the study used the coefficients obtained for 1999 to evaluate predictions in that same year, it necessarily would have obtained a slope of 1, when the actual return is graphed on the predicted return.[4]

[4] Had the authors chosen to regress the subsequent performance differential of the European fund over that of the S&P 500 index fund, a closer fit would have been obtained. However, using the differential as the dependent variable would not have changed the analysis so long as movements in the S&P 500 index fund were not auto-correlated.

Figure 1. Vanguard Europe 1999: reliability of the predictions (proportional changes of axes)



F. How profitable was TZA in the Vanguard European Fund?

To illustrate the possibility of time-zone arbitrage concretely, a simple trading strategy with the Vanguard European Fund is used. Initially, 100 per cent of the portfolio is held in an S&P 500 index fund. The calculations use the Vanguard fund (VFINX). If on a given day the indicator exceeds the threshold and the assets are not already in the European index than the funds are transferred at the end of the United States' day to the European Index. The capital is switched back to an S&P fund if the predicted Vanguard European return is more negative than the negative threshold.

Table 3 reports the number of fund switches, the fraction of time spent in the European mutual fund, and the returns from the benchmark and strategy. As shown by table 3, this trading strategy is highly successful in producing excess returns. Excess returns are highest using the 0.1 per cent threshold and they then decrease as the threshold increases. Using a 0.1 per cent indicator, the highest annualized excess return was in 2003 – 106 per cent per year annualized. This is the return over the entire year of the strategy minus that of the benchmark. The number of switches stayed in the range of 90 to 120 year-to-year and the time spent in the European fund hovered around 50 per cent.

The 0.1 per cent threshold returns the highest excess return. Even at the 0.5 per cent indicator level, the strategy always made a large excess return over the benchmark. As the threshold for the signals increases, the excess return decreases. At the 1 per cent level the strategy is not reliably more profitable than the benchmark.

With the 0.1 per cent threshold, the excess return (continuously compounded) is greater than 24 per cent per year through 2004. With 0.5 per cent, it exceeds 21 per cent per year through 2003, but is still over 4 per cent in 2004. With 0.7 per cent, it exceeds 11 per cent per year through 2001. With 1 per cent, it is positive only in 1999, 2000 and 2001.

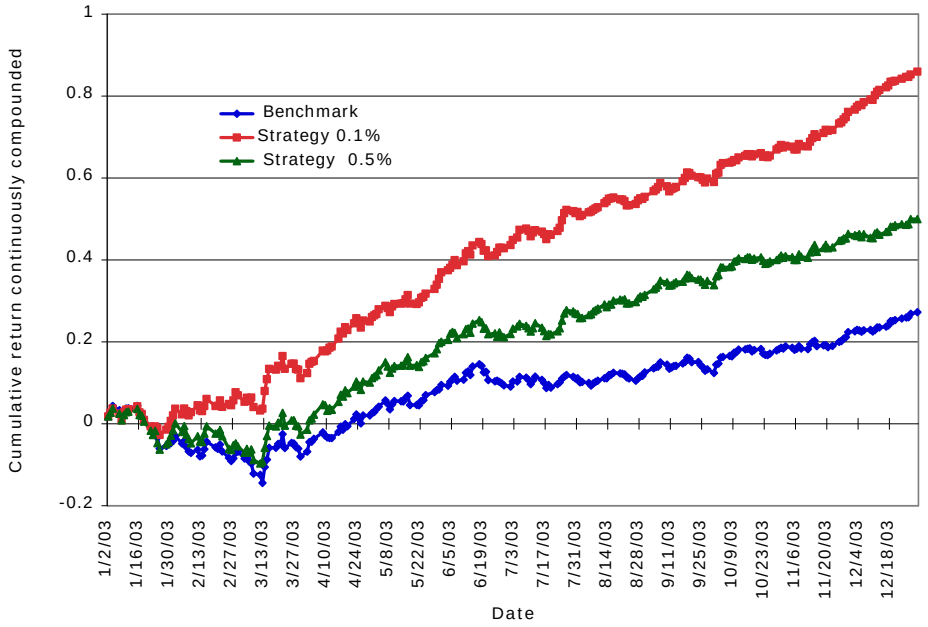
Table 3 shows that trading 115 times produced a continuously compounded return of 86.8 per cent in that year. From table 3, the large benchmark return of 27.8 per cent in that year helped generate the larger excess return between the benchmark and 0.1 per cent strategy when total return is used instead of the continuously compounded excess return (106 per cent as opposed to 58.9 per cent).

Figure 2 charts the natural log of wealth arising from the trade strategy at the 0.1 per cent threshold, the 0.5 per cent threshold and the benchmark in 2003, starting with US$ 1.00.. A more intuitive name is “cumulative return, continuously compounded.” The intercept of 0.868 for the 0.1 per cent threshold indicates that during 2003 that strategy produced an 86.8 per cent return, continuously compounded. The graph clearly illustrates the consistency of the excess returns from the market timing strategy. The 0.1 per cent strategy performed the best with the 0.5 per cent positioned securely between the 0.1 per cent strategy and the benchmark.

Table 3. Vanguard Europe: Return from time-zone arbitrage

Year	1998	1999	2000	2001	2002	2003	2004
0.1% indicator							
Switches per year	107	120	99	94	109	115	90
time share in Europe	0.548	0.508	0.488	0.550	0.494	0.608	0.520
benchmark return CC	0.230	0.158	-0.112	-0.315	-0.262	0.278	0.135
Strategy Return CC	0.607	0.547	0.130	0.114	0.315	0.868	0.442
Excess Return CC	0.377	0.390	0.242	0.429	0.576	0.589	0.307
Excess Return Annualized	0.576	0.558	0.245	0.391	0.600	1.060	0.411
0.5% indicator							
Switches per year	29	33	41	21	33	24	14
time share in Europe	0.718	0.496	0.512	0.661	0.542	0.608	0.596
benchmark return CC	0.231	0.158	-0.111	-0.324	-0.258	0.278	0.284
Strategy Return CC	0.473	0.395	0.115	-0.066	0.043	0.502	0.320
Excess Return CC	0.241	0.237	0.226	0.259	0.302	0.224	0.036
Excess Return Annualized	0.344	0.313	0.227	0.213	0.272	0.331	0.048
0.7% indicator							
Switches per year	14	15	26	7	11	7	2
time share in Europe	0.802	0.448	0.603	0.900	0.482	0.773	0.131
benchmark return CC	0.231	0.159	-0.109	-0.344	-0.262	0.293	0.094
Strategy Return CC	0.412	0.330	0.008	-0.182	-0.268	0.348	0.132
Excess Return CC	0.181	0.171	0.117	0.162	-0.006	0.056	0.038
Excess Return Annualized	0.250	0.219	0.111	0.125	-0.004	0.077	0.043
1% indicator							
Switches per year	5	2	6	2	3	1	0
time share in Europe	0.226	0.234	0.825	0.992	0.518	0.259	0.000
benchmark return CC	0.225	0.161	-0.105	-0.345	-0.260	0.246	0.080
Strategy Return CC	0.200	0.255	-0.089	-0.255	-0.315	0.211	0.086
Excess Return CC	-0.025	0.094	0.015	0.090	-0.055	-0.035	0.006
Excess Return Annualized	-0.031	0.116	0.014	0.067	-0.041	-0.044	0.007
All returns are proportions per year.							

Figure 2. Cumulative return, continuously compounded for arbitrage between the Vanguard European Index Fund and Vanguard S&P 500 Index Fund



G. Were all fund families vulnerable to TZA?

Table 4 displays the regression coefficients of all 16 mutual funds in 1999. From the grouping of mutual funds, the Vanguard family funds on average demonstrate greater predictive strength than the competitive funds of DFA, Fidelity, GMO and T. Rowe Price. In 1999, Vanguard funds averaged a 0.398 sum of coefficients, with competitive funds averaging 0.360 and Spitzer's funds highest at 0.434. One should not over-analyse the results of the fund group averages, as each fund had distinct load fees, management and investment strategy (e.g., growth versus value) and country composition. What is important is that market timing opportunities existed for the wide range of funds in all three classes, not only those formally investigated. All the funds exhibited significant F-tests, exposing them to the possibility of arbitrage.

Table 4. Time-zone arbitrage predicators for 1999

	09:35	*10:00*	*10:30*	*11:00*	*11:30*	*Pre-vious Day*	***Sum of Coef-ficients***	***F***
Vanguard								
VEURX Europe Index	0.306	0.000	0.000	0.146	0.000	0.000	0.452	14.9
VINEX Intl Explorer (mid size stocks)	0.099	0.000	0.012	0.000	0.000	0.179	0.290	15.1
VEIEX Emerging Markets	0.000	0.000	0.000	0.000	0.000	0.395	0.395	13.2
VPACX Pacific	0.000	0.000	0.000	0.000	0.000	0.454	0.454	12.8
Competition								
DFIVX DFA International Value I	0.149	0.000	0.000	0.000	0.000	0.160	0.309	14.4
FIEUX Fidelity Europe Fund	0.293	0.000	0.000	0.105	0.000	0.037	0.435	13.4
GMOFX GMO Foreign Fund III	0.007	0.000	0.000	0.052	0.000	0.208	0.267	7.0
PRESX T. Rowe Price Euro Stock	0.292	0.000	0.000	0.138	0.000	0.000	0.430	14.3
Spitzer's Funds[1]								
MGEBX Van Kampen Global Value Equity B	0.188	0.000	0.000	0.000	0.000	0.009	0.197	6.3
GSIFX Goldman Sachs Int'l Equity A	0.235	0.038	0.000	0.027	0.000	0.158	0.458	13.2
EUGAX Morgan Stanley European Equity F	0.343	0.011	0.000	0.216	0.000	0.000	0.570	20.0
PEUGX Putnam European Equity Fund A	0.328	0.000	0.000	0.167	0.000	0.021	0.516	18.4
FIECX Federated Intl Equity Fund C	0.167	0.000	0.000	0.000	0.000	0.335	0.503	20.1
AEDBX Aim European Growth	0.340	0.000	0.000	0.000	0.000	0.091	0.431	17.8
JAOSX Janus Overseas	0.278	0.000	0.000	0.000	0.000	0.257	0.535	20.7
MWEFX Global Equity A	0.205	0.000	0.000	0.000	0.000	0.054	0.259	9.1
Vanguard Average	0.101	0.000	0.003	0.036	0.000	0.257	**0.398**	14.0
Competitors Average	0.185	0.000	0.000	0.074	0.000	0.101	**0.360**	12.3
Spitzer Average	0.261	0.006	0.000	0.051	0.000	0.116	**0.434**	15.7

H. Restrictions on frequent trading: A brief history

During the period covered by this paper, Vanguard had rules that restricted frequent trading. But Dan Wiener noted in 1999 in *The Independent Advisor for Vanguard Investors* that Vanguard permitted frequent small trades for rebalancing purposes, so the restriction of frequent trading was not complete.

To some degree that is still the case. The redemption fee is currently applied on a first-in-first-out basis. If one has purchased the bulk of his holdings in the Vanguard European Stock Index Fund more than 60 days ago, and then purchases 1 per cent more and the next day sells 2 per cent of his holdings – on those shares that he has held for more than 60 days, he does not pay the 2 per cent redemption fee. An investor who has sold shares in the European Stock Index Fund in the past 60 days may buy back shares only by mail – not via the Internet or by telephone. An investor can, however, engage in telephone or online

rebalancing every day by using two accounts, e.g., an employer account and an IRA, one for sales and one for purchases.

The existence of opportunities for time-zone arbitrage put financial advisors in an awkward position. They had a fiduciary duty to their clients to use strategies to maximize client returns, so those who were aware of opportunities for time-zone arbitrage were obligated to time rebalancing and United States dollar cost averaging in order to take advantage of it.

In December 2009, the Vanguard Emerging Markets Index Fund had a purchase fee of 0.5 per cent and a redemption fee of 0.25 per cent, which was paid into the fund. Vanguard European Stock Index Fund, Vanguard International Explorer Fund, Pacific Stock Index Fund all have a redemption fee if held for less than two months, which again is paid into the fund.

In two 2005 articles, Dale discussed the tightening of restrictions on frequent trading at that time. Dale (2005a) noted that:

> "Vanguard Group is moving to clamp down on investors who frequently move in and out of its mutual funds.
>
> As of 30 September, investors will not be able to buy shares of a Vanguard fund by phone or online within 60 days of selling shares in the same fund. The firm will allow the repurchase of shares within 60 days by mailed check, however.
>
> The mutual-fund company currently allows investors to make unlimited round trips between funds, as long as it does not deem the trades large enough to have an adverse impact on managing the funds."
>
> **…**
>
> "Vanguard has long charged fees to investors who redeem shares of its funds within a given holding period. For many funds, investors are charged 1 per cent if they sell shares within one year. Beginning 30 September, the firm plans to begin levying the 1 per cent fee on fund shares sold through a financial advisor during the specified holding period. The fees will apply to participants in employer-sponsored retirement plans, starting 31 December 2005."

Dale (2005b) also noted that:

> "Last month, Vanguard Group became the latest fund company to say it will levy redemption fees on participants in employer-sponsored retirement plans that use its funds. Vanguard has long charged the 'retail', or individual, investors in many of its funds a 1 per cent fee if they sell shares within a year of purchasing them. Beginning 31 December, the company will extend these fees to retirement plans.
>
> Vanguard does not expect many plan participants to pay the new fees, because nearly 90 per cent do not make an exchange in a given year, said John Demming, a Vanguard spokesman. Fees could potentially be triggered by

annual rebalancing of 401(k) portfolios, but many plan participants do not rebalance within a year, he said.

Employees enrolled in company retirement plans used to fly under the radar when trading in and out of funds within a short time span. But mutual funds are clamping down on the activity, largely because of regulatory probes into rapid trading, also known as market timing."

…

"T. Rowe Price charges redemption fees only on transactions that it believes can be used for market-timing activities… T. Rowe began charging fees on funds in 401(k) plans in January.

Before the Securities and Exchange Commission (SEC) proposal (that fund companies assess a mandatory 2 per cent redemption fee on trades within a five-day period), most funds did not charge redemption fees in 401(k) plans. Fidelity was the first to require that any custodian using its funds track each investor's position. Late in 2003, the company began notifying omnibus account holders that they would be required to assess and collect redemption fees at the individual investor level in retirement plans – or cease offering Fidelity funds that carried redemption fees."

On 11 March 2005, SEC adopted rule 22c-2:

"…to help address abuses associated with short-term trading of fund shares… Rule 22c-2 provides that (the vast majority of funds) must consider whether to impose a fee up to 2 per cent of the value of shares redeemed shortly after their purchases ('redemption fee'). The rule also requires such a fund to enter into agreements with its intermediaries that provide the fund management with the ability to identify investors whose trading violates fund restrictions on short-term trading."

Thus, redemption fees are not required.[5]

I. Has vulnerability to TZA gone?

Excess returns earned by time-zone trading come at the expense of the long-term investor. As Bogle (2005) stated: "Long-term fund investors pay a heavy penalty for investor activity by short-term fund owners. When equity funds hold cash as a redemption reserve, long-term returns are diluted." Much of the literature has examined and measured fund dilution from market timing by calculating the profits that arbitrageurs make from buying the fund when prices are stale and subtracting them from the return of the fund (Zitzewitz, 2003).

[5] One reader reported that he used TZA extensively with Vanguard through the 1990s, within the context of his Vanguard 401-k plan. Since then, fair market pricing and stringent frequent trading rules have made TZA unprofitable. Another reader reported receiving a letter from Vanguard in late 1999, which threatened to cut off trading privileges unless he reduced the frequency of his trades. He moved his 401k account to another provider who never complained about frequent trades. Yet another reader wrote: "I played the game for about 21 months in my 401k. I was able to grow my portfolio approximately 70 per cent by moving between a stable value fund and a Berstein international fund (during a period of a down market). Near the end of 2003 I had to end this strategy due to menacing letters from my 401k provider, and trading restrictions that they started to impose."

The available S&P futures data only go up to and include 2004. It is important to discover as much history as possible of the TZA vulnerability for a number of mutual funds – the Vanguard index funds, Vanguard's competitors and the Spitzer prosecuted families.

Consequently, a simpler but feasible model was estimated. The goal was to find the benefit from switching between a United States mutual fund and a foreign mutual fund. Consequently, the proportional return of each mutual fund minus that of the Vanguard 500 index fund was regressed on the S&P 500 adjusted proportional return from the previous day. The coefficients from these regressions are shown in table 5. All observations from each year were used, except 2009 data, ending on 5 December. The regression coefficients indicate the effect of a 1 per cent increase in the S&P 500 index on the next day return as a per cent due to switching into the foreign fund. The name chosen for the coefficient is "return sensitivity."

Table 5 shows that for all the 16 funds considered, there is only a single negative coefficient from 1997 through 2008. In 2009, all but two are positive, the average coefficient for the three groups – Vanguard, Vanguard's competitors and the Spitzer funds – are all positive, but all the averages are less than 0.04. Thus, TZA vulnerability persisted until 5 December 2009. However, all the averages in 2009 were less than one-tenth of what they were in 1997.

Figure 3 shows the average regression coefficients for the Vanguard funds, its competitors and the Spitzer funds. The averages include all 16 funds. Over the period covered, the average return sensitivity showed a downward trend, but for each group it was positive in every year. Thus the opportunity for TZA has still not disappeared. Bogle's concern about the issue still had some relevance up to 5 December 2009. In 2009, for the average Vanguard fund, 4 per cent of movements in the S&P 500 index were reflected in the next-day differential return to investing abroad, down from 54 per cent in 1997.

Is TZA a problem for Vanguard's electronically traded funds? In table 6, this is explored for five of Vanguard's ETFs. The same calculation as in table 5 and figure 3 is performed. The average return sensitivity is less than 0.037 in each year and is negative in 2007. The conclusion is that sensitivity to TZA is not present for Vanguard's ETFs. Since Vanguard's ETFs clone its regular index funds, it is puzzling why the susceptibility to TZA exists for Vanguard's regular mutual funds. For fair pricing, all a fund manager would need to do is match the ETF price.[6]

[6] Braham (2003) identified problems with fair value pricing. He noted that two years earlier the SEC had permitted mutual funds holding non-United States stocks to use fair value. Since then, 75 per cent of fund managers have done so. Such permission is effective whenever a "significant event" occurs after markets close. However, regulators have not defined "significant event." "Nor has the SEC delineated any specific methodology for calculating fair value" and "methodologies differ widely across the fund industry. What this ultimately means is that two foreign funds could own exactly the same stocks and price them differently at the end of the day, Braham pointed out. "This creates a potential for conflicts of interest. For instance, if a fund manager has a big shareholder redemption, he could intentionally mark the fund's value down so he has to pay out less."

Table 5. Regression coefficients for the impact of proportional changes in S&P 500 on next-day fund net return – 1997 to 5 December 2009

Year	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	AVG
Vanguard														
VEIEX Emerging Markets	0.49	0.46	0.39	0.43	0.26	0.22	0.46	0.48	0.29	0.40	0.11	0.02	0.03	0.31
VEURX Europe Index		0.33	0.27	0.25	0.14	0.27	0.35	0.23	0.16	0.15	0.02	0.06	-0.01	0.19
VINEX Intl Explorer (medium stocks)			0.73	0.45	0.34	0.16	0.33	0.25	0.31	0.35	0.14	0.08	0.09	0.29
VPACX Pacific	0.59	0.24	0.45	0.31	0.00	-0.04	0.29	0.18	0.16	0.12	0.01	0.03	0.04	0.18
Competition														
DFIVX DFA International Value I	0.44	0.29	0.26	0.18	0.23	0.35	0.41	0.08	0.20	0.20	0.10	0.12	0.03	0.22
FIEUX Fidelity Europe Fund	0.38	0.26	0.30	0.28	0.37	0.39	0.41	0.19	0.37	0.33	0.21	0.09	-0.02	0.28
GMOFX GMO Foreign Fund III	0.40	0.26	0.24	0.16	0.15	0.28	0.37	0.09	0.14	0.12	0.02	0.06	0.00	0.18
PRESX T. Rowe Price Euro Stock	0.67	0.31	0.42	0.39	0.32	0.34	0.34	0.03	0.21	0.12	0.18	0.10	0.03	0.27
Spitzer's Funds														
AEDBX Aim European Growth		0.48	0.33	0.58	0.35	0.32	0.33	0.11	0.33	0.29	0.06	0.12	0.03	0.28
EUGAX Morgan Stanley Europe F	0.44	0.41	0.35	0.38	0.40	0.45	0.47	0.14	0.21	0.15	0.00	0.13	0.02	0.27
FIECX Federated Intl Equity Fund C	0.44	0.38	0.45	0.43	0.29	0.35	0.31	0.06	0.18	0.14	0.12	0.08	0.03	0.25
GSIFX Goldman Sachs Int'l Equity A	0.48	0.38	0.36	0.34	0.36	0.36	0.39	0.04	0.20	0.22	0.01	0.06	0.03	0.25
JAOSX Janus Overseas	0.85	0.40	0.44	0.29	0.37	0.69	0.61	0.12	0.23	0.46	0.28	0.07	0.08	0.38
MGEBX	0.38	0.22	0.14	0.13	0.13	0.25	0.31	0.05	0.09	0.08	0.05	0.08	0.05	0.15

Van Kampen Globl Value B														
MWEFX Global Equity A	0.31	0.25	0.21	0.23	0.22	0.22	0.22	0.06	0.22	0.11	0.04	0.07	0.04	0.17
PEUGX Putnam Europe Equity A	0.49	0.44	0.34	0.35	0.33	0.35	0.37	0.07	0.20	0.21	0.13	0.12	0.01	0.26
Vanguard Average	**0.54**	**0.34**	**0.46**	**0.36**	**0.18**	**0.15**	**0.36**	**0.29**	**0.23**	**0.25**	**0.07**	**0.05**	**0.04**	**0.26**
Competitors Average	**0.47**	**0.28**	**0.30**	**0.25**	**0.27**	**0.34**	**0.38**	**0.10**	**0.23**	**0.20**	**0.13**	**0.09**	**0.01**	**0.24**
Spitzer Average	**0.48**	**0.37**	**0.33**	**0.34**	**0.31**	**0.37**	**0.38**	**0.08**	**0.21**	**0.21**	**0.09**	**0.09**	**0.03**	**0.25**

Figure 3. Regression coefficients for the impact of proportional changes in the S&P 500 on next-day fund net returns, 1997-5 December 2009.

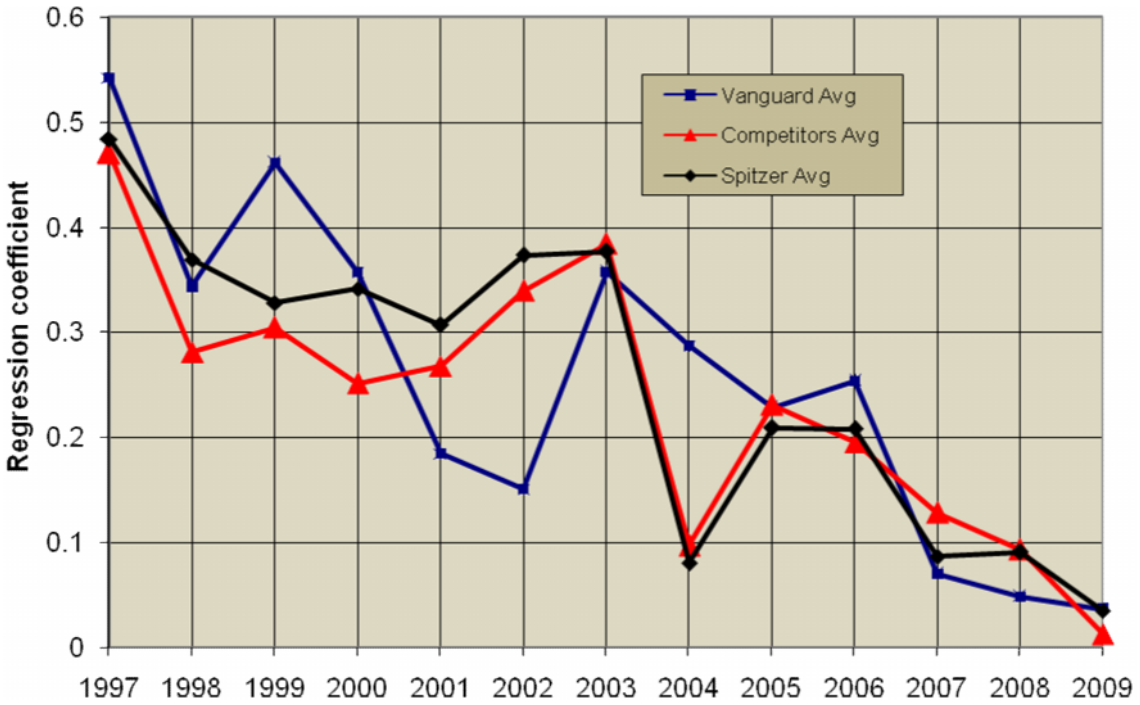


Table 6. Vanguard ETFs: Regression coefficients for the impact of S&P return on next-day fund net return

Name	Inception	2005	2006	2007	2008	2009	Average
VWO Vgd Emerging Markets	03/04/2005	0.063	-0.018	0.185	0.146	0.111	0.0975
VEA Vgd Europe Pacific	07/02/2007			0.020	-0.080	0.063	0.0009
VGK Vgd European	03/04/2005	-0.017	-0.096	0.043	-0.054	0.052	-0.0143
VEU Vgd FTSE All-World ex-US	03/02/2007			0.040	-0.041	0.072	0.0238
VPL Vgd Pacific	03/04/2005	-0.105	-0.009	-0.070	0.004	0.042	-0.0274
Average net return coefficient		-0.019	-0.041	0.044	-0.005	0.068	**0.0093**
SP500 on SP500 lagged		-0.139	0.011	-0.170	-0.153	-0.119	**-0.1141**
VFINX on SP500 lagged		-0.141	0.009	-0.170	-0.152	-0.119	**-0.1146**
Average gross return coefficient		-0.160	-0.032	-0.126	-0.157	-0.051	**-0.1052**

J. Is this inquiry moral?

Jeffrey Molitor Director of Portfolio Review at The Vanguard Group, in a letter to the editor of *The Financial Analysts Journal*, Molitor (2002), criticized the decision to publish Boudoukh and others (2002).

> "However, your decision to publish an article that outlines how investors can profit by taking advantage of pricing differences in international mutual funds raises serious questions about the policies, oversight and judgment applied in selecting articles for the *FAJ*. Specifically, how could an organization whose motto is "Setting a Higher Standard for Investment Professionals Worldwide" publish (and, by inference, endorse) an article on how to take advantage of the average mutual fund shareholder? (The article could have been subtitled "Here's how to steal money from your fellow shareholders.") Obviously, the ethical shortcomings of this article were abundantly clear to your editors. The article's introduction states: "The gains from these strategies are matched by offsetting losses by buy-and-hold investors."
>
> Publishing such a piece in a publication that is aimed solely at financial professionals is a bad idea in the best of times, but is abhorrent in a period when investor confidence is already shaken by corporate greed and fraud, bad accounting and a bear market overall. My concern is not with the accuracy of the article itself (although it should be noted that the use of "fair value pricing" has effectively closed the arbitrage), but rather with the absence of perspective and ethical guidance applied in approving this article. Providing the direction on what represents scholarship, insight, and proper

> ethics is the responsibility of AIMR's (Association for Investment Management and Research) Board. The *FAJ* is the most public representation of AIMR and should reflect the best, in all dimensions, of what the CFA charter is expected to represent. Publishing articles that may be "technically correct" but inconsistent with the concept of "setting a higher standard" reflects an unfortunate lack of oversight by the Board. AIMR has historically stood for trust, integrity and high ethics. I hope that this focus will be reflected in future *FAJ* articles."

This criticism applies also to the efforts described in this paper. What can economists do to destroy market distortions? Bhagwati (1988), in a marvelous rhetorical flourish, articulated what he called the Dracula effect. Just as Dracula shrivels into nothingness when the morning sunlight hits him, "exposing evil to sunlight helps to destroy it." Similarly, it is the role of economists to illuminate the costs and unintended consequences of various distortions. Figure 3 shows that when the letter was published, fair value pricing had not eliminated the arbitrage opportunity. Nor had the opportunity entirely disappeared in 2009 according to table 5. Is it worse to expose a distortion or to mislead investors by pretending that it does not exist?

It is worth recalling the logic of Tullock (1967). For him, the welfare cost of theft is not what is stolen, because that is a transfer from the victim to the thief. It is the cost of the thief's jimmy, the opportunity cost of his time and the costs of locks to make homes secure. To this one should add the reluctance to work and accumulate consumer durables for fear of theft. Similarly, the cost of TZA to the economy is not the profit made from TZA, for that is a transfer from long term buy and hold investors to time-zone arbitrageurs. Rather, it is the cost of the extra liquidity held by funds, the extra transactions costs imposed on them by TZA, the opportunity cost of the time of the authors and readers of this study, and the consequences of reduced diversification into international funds: greater portfolio risk and altered savings and investment behavior.

Additionally does the immorality lie with the regulations that perpetuated the arbitrage opportunity, the mutual fund company that permited the distortion to be exploitable, or with the investor who exploited it?

K. Did fund returns beat their indexes in spite of TZA?

Did TZA beat the returns of international funds down below that of the indexes, which track them? Tables 7 and 8 as well as figure 4 address this issue.

A technique is employed that was developed by Sharpe (1992) and used recently by Blanchett (forthcoming), Rodriguez and Tower (2008), Tower and Yang (2008) and Tower (2009a and 2009b) to find the basket of indexes that best tracks a mutual fund, the tracking index. The indexes used are MSCI Emerging Markets, Europe, Pacific Ex Japan, Pacific, World Ex United States, EAFE, EAFE Value, EAFE Growth and EAFE Small Cap. All indexes are in United States dollars, include reinvested dividends and subtract withholding

taxes on dividends. The EAFE Value and Growth start at end-1998, while EAFE Small Cap starts in 2001. The late start of three of these indexes results in gaps in table 8 for funds, whose tracking index should include these indexes.

Solver is employed to search for the basket of indexes that, when rebalanced monthly, most closely tracks that of the mutual fund. The criterion for close tracking is the minimum standard deviation of the differential between the return of the basket and the return of the mutual fund. Monthly data from Morningstar's Principia Pro Disks are used.

The technique is to regress the fund monthly return on those of the indexes, while constraining all the coefficients to be positive and add up to 1. The regression coefficients are interpreted as the portfolio shares of the various indexes in the tracking index basket. That they are all positive reflects the assumption of no short sales. That they add up to 1 reflects the assumption that the index shares in each tracking index must add up to one.

The portfolios are described in table 7. The shares are consistent with intuition. For example, the Vanguard European Index Fund is best tracked by a tracking index consisting of 100 per cent of the MSCI Europe Index. The R^2s show how well the tracking indexes track the fund. The Aim Europe Growth C Fund has an R^2 of only 0.788, so one should have less faith that the tracking index has captured the investment style of the fund than is the case for all the other funds.

Table 8 shows the gross performance differentials – that is, gross of expenses. The annual figures show the average geometric return of the fund minus that of the corresponding index basket, continuously compounded, with the expense ratio subtracted, to yield the differential gross return, expressed in percentage points per year. The bottom four rows show the averages for four groups of funds (Vanguard, Vanguard competitors, all the Spitzer funds and the Spitzer funds that exhibited an R^2 of 0.9 or greater when fitted to their tracking indexes). This last set is included in order to exclude those funds for which good tracking indexes could not be found. The next two columns show the average performance differentials for the period prior to the resolution of Eliot Spitzer's investigation of the mutual fund industry (1997-2002) and post-investigation (2004-2007); 2003, when the investigation was occurring, was left out.

The expected result was that the Spitzer funds performed better after the investigation. In fact, their average gross return differential dropped by 4.59 per cent – 2.23 per cent = 2.36 per cent per year or 2.35 per cent per year, depending on whether the average, or the average with high R^2s, is used. Vanguard's average differential rose (by 0.19 per cent per year) and the competitor's dropped (by 0.82 per cent per year).

For the whole period, the average gross performance differential for each group was positive (0.98 per cent for Vanguard, 1.96 per cent for the competitors, 3.36 per cent for all Spitzer and 2.06 per cent for high R^2 Spitzer. The Spitzer funds were expected to perform the worst, relative to other funds in 1997-2003. In fact, they performed better than the other two groups during that period. For each group, the average gross differential performance was positive over the whole period, with only one fund showing a negative average differential

over the entire period, and one fund showing a negative average return in the pre-Spitzer period. This indicates that for the most part, TZA was not severe enough to cause international mutual fund gross returns to underperform the tracking indexes.[7]

Table 7. Tracking indexes

Fund ticker and name	Composition of funds (in percent)									R^2 between fund & tracking index returns
	EM	*Europe*	*Pacific Ex Japan*	*Pacific*	*World Ex US*	*MSCI EAFE*	*EAFE Value*	*EAFE Growth*	*EAFE Small Cap*	
AEBDX Aim Europe Growth C	6	94	0	0	0	0	0	0	0	0.788
DFEMX DFA Emerging Mkts I	75	12	13	0	0	0	0	0	0	0.965
EUGAX MS European Equity A	0	96	0	0	2	2	0	0	0	0.969
FIECX Federated Intl Equity C	6	0	0	0	0	0	0	94	0	0.899
FIEUX Fidelity Europe	13	87	0	0	0	0	0	0	0	0.952
GMOFX GMO Foreign Fund III	0	0	14	7	0	43	36	0	0	0.971
GSIFX Goldman Sachs Conctd Intl A	0	32	0	0	61	7	0	0	0	0.968
JAOSX Janus Overseas	30	0	0	0	0	0	0	70	0	0.902
MEMCX MFS Emerging Markets C	85	13	0	2	0	0	0	0	0	0.966
MSRCX Van Kampen Emerg Mkts C	100	0	0	0	0	0	0	0	0	0.969
PEUGX Putnam Europe Equity A	1	97	2	0	0	0	0	0	0	0.975
PRESX T. Rowe Price Euro Stock	1	97	0	0	1	1	0	0	0	0.984
VEIEX Vanguard Emerging Mkts Index	80	0	20	0	0	0	0	0	0	0.987
VEURX Vanguard Europe Index	0	100	0	0	0	0	0	0	0	0.999
VINEX Vanguard Intl Explorer	12	27	0	0	0	0	0	0	61	0.975
VPACX Vanguard Pacific Index	0	0	0	98	0	2	0	0	0	0.996

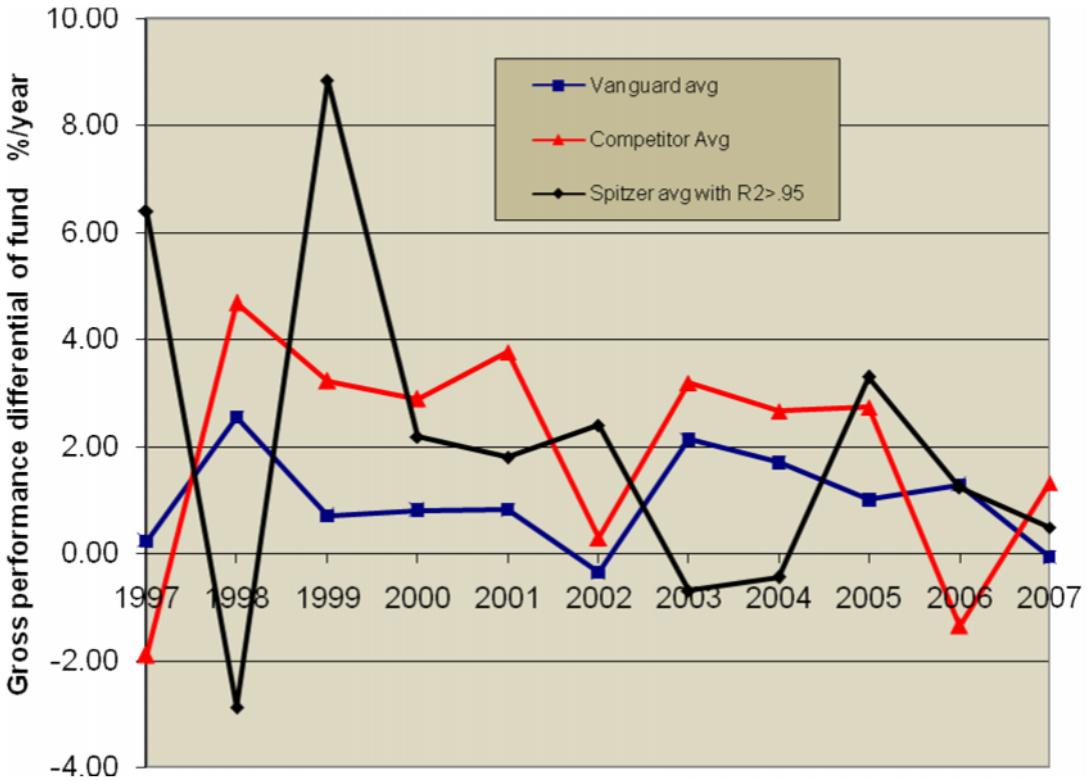
However, since investors are concerned with net returns average, expense ratios over the 11-year period were subtracted to obtain net return differentials. Again, these are positive for all three groups. One should not make too much of these net return calculations, since the

[7] Expenses and transactions costs drag down the fund returns, and any income made from the lending of securities, engaged in by DFA and Vanguard, should raise them. This last effect may explain the positive differential, but we were unable to quantify it.

expense ratios depend on the class of fund considered, and front and back end-loads are ignored.

Figure 4 shows the annual figures for the averages in table 8 for the three groups (excluding all Spitzer). It dramatizes the fact that for all these fund groups the average gross differential return is positive over the whole 11-year period and in the two sub-periods.[8]

Figure 4. Fund return differentials in per cent per year, continually compounded



[8] Schwartz and Potter (2006) found that "equity funds involved in a scandal outperformed their peers during the pre- and post-scandal period, but significantly underperformed their peers during the scandal period (March 2000-August 2003), even after adjusting for market effects and fund characteristics. The dates reflect the implication that several funds engaged in late trading with Canary Capital Partners in March 2000; one could read of the first investigations on 3 September 2003. Figure 4 does not show such a clear pattern.

Table 8. Fund return differentials in per cent per year, continually compounded

NAME	Gross Differential Returns														Expense ratio %/year	Net superiority to tracking index %/year
	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	pre Spitzer (1997-2002)	post Spitzer (2004-2007)	whole period		
AEBDX Aim Europe Growth C		14.09	35.93	8.84	-5.48	11.22	4.75	11.27	3.86	5.94	0.74	12.92	5.31	9.12	2.72	6.4
DFEMX DFA Emerging Mkts I	-6.94	12.47	11.12	-1.78	0.75	0.22	7.75	6.11	4.07	-0.18	2.84	0.22	4.12	3.47	0.77	2.7
EUGAX M S European Equity A	-4.75	-1.62	11.43	5.26	3.95	1.19	-5.73	-5.78	0.27	-1.52	2.83	2.58	-1.99	0.5	1.54	-1.04
FIECX Federated Intl Equity C			32.4	-0.28	-5.65	-8.2	2.45	-0.29	-3.14	-1.36	-5.09	4.57	-1.48	1.2	2.46	-1.26
FIEUX Fidelity Europe	4.97	1.84	-1.59	4.03	3.18	-9.62	5.57	7.27	6.36	-5.16	0.76	0.47	2.96	1.6	1.05	0.55
GMOFX GMO Foreign Fnd III			-0.19	5.91	11.17	10.02	-0.1	-0.03	0.23	0.35	-0.45	10.02	0	1.67	0.75	0.92
GSIFX Goldman Sachs Concentrated Intl Equity A	-1.98	-1.31	7.24	-0.52	-0.46	-1.32	-2.02	-4.78	2.19	-3.6	-4.05	0.27	-2.45	-0.97	1.58	-2.55
JAOSX Janus Overseas			29.69	11.43	-4.65	-11.84	0.25	1.34	12.12	17.68	5.25	6.16	7.33	6.81	0.92	5.89
MEMCX MFS Emerg Mkts C	22.74	-13.9	-3.87	8.99	6.81	9.16	3.84	5.61	8.06	2	3.75	4.99	4.65	4.83	0.9	3.94
MSRCX Van Kampen E Mkt C	14.61	4.04	22.96	-7.54	1.68	3.49	4.54	3.57	4.3	7.62	5.04	6.54	5.01	5.85	2.95	2.9
PEUGX Putnam Europe Equity A	1.37	-1.54	6.49	4.75	-2.95	-0.51	-4.06	-0.81	1.66	1.7	-5.14	1.27	-1.33	0.09	1.36	-1.28
PRESX T. Rowe Price Euro Stock	-3.75	-0.24	3.58	3.39	-0.06	0.53	-0.45	-2.71	0.30	-0.43	2.13	0.58	-0.23	0.21	1.06	-0.85
VEIEX Vanguard E Market Index	1	7.44	1.73	2.21	3.44	0.76	5.17	2.45	4.4	0.1	2.98	2.76	3.02	2.88	0.53	2.35
VEURX Vanguard Europe Index	0.06	0.05	0.07	0.04	-0.02	0.07	0.04	0.02	0.01	0.01	0.02	0.05	0.02	0.03	0.29	-0.26
VINEX Vanguard Intl Explorer						-2.71	2.98	4.13	-0.78	5.11	-2.96	-2.71	1.7	0.96	0.61	0.35
VPACX Vanguard Pacific Index	-0.38	0.15	0.32	0.18	-0.95	0.48	0.34	0.20	0.40	-0.10	-0.31	-0.03	0.10	0.03	0.36	-0.33
Vanguard average	**0.23**	**2.55**	**0.71**	**0.81**	**0.82**	**-0.35**	**2.13**	**1.70**	**1.01**	**1.28**	**-0.07**	**0.79**	**0.98**	**0.98**	**0.45**	**0.53**
Competitor Average	**-1.91**	**4.69**	**3.23**	**2.89**	**3.76**	**0.29**	**3.19**	**2.66**	**2.74**	**-1.36**	**1.32**	**2.16**	**1.34**	**1.96**	**0.91**	**0.83**
All Spitzer average	**6.40**	**-0.04**	**17.78**	**3.87**	**-0.84**	**0.40**	**0.50**	**1.27**	**3.66**	**3.56**	**0.42**	**4.59**	**2.23**	**3.36**	**1.80**	**1.62**
Spitzer avg with R^2>0.95	**6.40**	**-2.87**	**8.85**	**2.19**	**1.81**	**2.40**	**-0.69**	**-0.44**	**3.30**	**1.24**	**0.49**	**3.13**	**0.78**	**2.06**	**1.67**	**0.39**

L. Conclusions about time-zone arbitrage

The objective was to examine the ability of an investor to use lagged S&P data to predict fund returns the following day in Vanguard's international index mutual funds and for samples from other fund families. This paper has demonstrated that an unsophisticated trader had an opportunity to use a time-zone arbitrage strategy to gain large excess returns. That opportunity had diminished but not completely disappeared even by 5 December 2009.

Time-zone arbitrage opportunities were found to have existed in the Vanguard fund family – and at levels similar to other families. Vanguard is one of the most reputable mutual fund families in that it charges low expenses to all classes of investor, keeps transactions costs low, has stayed free of scandal and was not one of the families investigated by the New York Attorney General. Despite Vanguard CEO and founder John Bogle's testimony on the negative impact of time-zone arbitrage, even Vanguard's funds were found to be vulnerable to time-zone arbitrage. However, in no year were the Vanguard international index funds found to underperform their corresponding indexes, gross of expenses. So no evidence emerges of dilution of buy-and-hold investors' returns by time-zone arbitrageurs to the point that Vanguard underperformed the indexes.

By 2003, the SEC was under tremendous pressure to enact regulations aimed at limiting time-zone arbitrage (Hogue and Wellman, 2005). There are several main solutions that mutual fund can employ to prevent fund dilution:

(a) Funds can correct for the stale prices in NAVs, as was the case in 2007;

(b) They can discourage short-term trading with fees and trade limits;

(c) They can institute limits on the number of trades one can make a year, as most funds have done;

(d) Finally, mutual fund families could require that trades involving stocks traded on foreign exchanges be placed prior to the close of those markets.

The evidence for time-zone arbitrage runs contrary to the "efficient markets" hypothesis, which implies that with the exception of long-term trends, future stock prices are very difficult to impossible to predict. One of the most cited advocates of this proposition is Malkiel (2005) who wrote:

> "Although the preponderance of statistical evidence supports the view that market efficiency is high, some gremlins are lurking about that harry the efficient-market theory and make it impossible for anyone to state that the theory is conclusively demonstrated."

In the case of time-zone arbitrage, the gremlin was institutional complicity with the arbitrageurs or institutional carelessness. Time-zone arbitrage demonstrates that news does not travel instantaneously and that institutions did not adjust prices to reflect all relevant news. In fact, time-zone arbitrage vulnerability, according to the findings detailed in this paper, existed for at least 10 years.

This paper demonstrates that time-zone arbitrage opportunity existed in Vanguard and other international funds long after the market timing strategies became publicly known. This is an important discovery for both Vanguard and other mutual fund families. The authors do not know why this arbitrage opportunity has not been eradicated, although one possibility is the difficulty of implementing fair value pricing. Still, the opportunity now is a shadow of its former self.

M. Implications for the integration of international capital markets

The opportunity for TZA has diminished but not disappeared. This shrinkage, together with the advent of exchange-traded funds, which are not subject to time-zone arbitrage, make investment in Asia and Europe more profitable for American mutual fund investors. When TZA opportunities were huge, Tower shrank his foreign investments, fearing that he was being implicitly taxed. It is likely that this was also true of other investors, and would have been increasingly true as more investors learnt about TZA. Tower's Duke University Retirement Plan does not permit him to invest in ETFs, so the only way for him and some others to invest abroad was through mutual funds subject to TZA. The reduction of the opportunities for TZA should increase United States investment in Asia and Europe, and enhance the integration of these three markets.

For many investors, ETFs offer a better way to invest abroad than with mutual funds. In 1996, Barclays Global Investors introduced 17 ETFs which track MSCI (Morgan Stanley Capital International) indexes. As Wikipedia notes, these funds "gave casual investors easy access to foreign markets." Some of these, such as the "MSCI South Korea Index Fund" (**EWY**) and the "MSCI Taiwan Index Fund" (**EWT**). Shares initially charged expense ratios as high as 0.99 per cent per year. These particular rates have come down to 0.63 per cent and 0.67 per cent, respectively. Barclays Emerging Markets still charges 0.72 per cent. Vanguard's Emerging Market fund charges only 0.39 per cent, but due to high transactions costs in developing countries a fee of 0.5 per cent must be paid when purchasing the emerging market fund and 0.25 per cent when selling it. However, the Vanguard ETF, which holds the same portfolio of stocks, charges only 0.27 per cent, making it a more attractive vehicle. Similarly, Vanguard's European and Pacific mutual funds charge 0.29 per cent, while Vanguard's Europe Pacific ETF charges only 0.16 per cent. ETFs are open both to regular investors and those with independent retirement accounts (IRAs).

From a social standpoint these ETFs are beneficial. A mutual fund must buy or sell stocks as clients purchase or sell the fund. However, purchases and sales of ETFs by clients simply move the price of the fund up or down, until the price of the fund deviates from the value of the securities it holds by enough to make it worth while for authorized participants to trade shares of the ETFs for the underlying securities. This means that each ETF acts like a closed-end mutual fund, except its value is kept roughly in line with that of the underlying securities by arbitrage. This reduces the transactions costs that eat into the efficiency of the saving and investment process. The expense ratios quoted above are in addition to any transactions cost a fund must incur in transacting in its underlying securities, so ETFs provide a saving in addition to the savings brought by the lower expense ratio.

There is another implication of ETFs. Investors with foreign addresses are not allowed to hold accounts with some American brokerage firms. Vanguard is one of these. Fidelity and Ameriterade are not. Some American mutual funds permit themselves to be held by non-Americans, e.g., Fidelity funds. Some do not (e.g., Vanguard funds). However, an investor with a foreign address can purchase the low-expense Vanguard and other ETFs through a non-Vanguard brokerage account. This is an efficient way for foreigners to access the United States capital market, facilitating capital market integration.

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