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# Exchange-traded funds, persistence in tracking errors and information dissemination

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ABSTRACT

We estimate tracking errors from 26 exchange-traded funds (ETFs) utilizing three different methods and test their relative performance using Jensen's model. We find that tracking errors are significantly different from zero and display persistence. Based on Jensen's alpha, risk adjusted returns are significantly inferior to benchmark returns for all ETFs with two exceptions at conventional significance levels revealing that passive investment strategy does not outperform market returns. We then examine the degree to which frequently used factors such as expense ratio, dividends, exchange rate and spreads of trading prices may be underlying sources of tracking errors causing this underperformance. We find that the change in the exchange rate is a significant source of tracking errors. Our serial correlation test, runs test and panel regression analysis reveal that Asian markets display relatively greater persistence and therefore are less efficient in disseminating information and noisier in filtering the information contained in returns.

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## 1. Introduction

The Exchange-traded funds (ETFs) were launched in 1993 and S&P Depository Receipts (SPDRs) are the very first ETFs, which track S&P 500 stock index. Thereafter, the market share of ETFs has rapidly grown. ETFs are defined as investment companies that are legally classified as open-end companies or Unit Investment Trust (UITs), but different from those in the way they are traded. ETFs issue their shares in large blocks known as creation units and sell or buy the creation units with securities instead

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of cash.[1] Investors are able to trade the individual shares on a secondary market. With the differences in the trading system, Poterba and Shoven (2002) and Miffre (2004) list some advantages of ETFs over the traditional mutual funds. First, ETFs provide investors with high liquidity because investors can trade ETFs on the market whenever they want while mutual funds are possible to trade only at the close of the market. Second, the in-kind process enables investors to save tax by delaying capital gain up to the end to pay for redemption. Third, ETFs charge low annual fees compared to the fees charged by mutual funds, so that investors consider ETFs as an efficient way to maintain portfolio over the long-run for the buy-and-hold investors at a low cost.

This study contributes to the existing literature on ETFs in the following distinct ways. First, we evaluate the relative performance of ETFs to their benchmarking indexes using Jensen's model. Second, we test dependence of ETF price premiums/discounts, defined as discrepancies between market value and NAV, on their historical price movements by employing the serial correlation test and runs test and by observing how each market reacts to the discrepancy. Third, we conduct panel regression analyses using five factors that may affect ETF premiums/discounts, and compare the difference in patterns of the reaction to premiums/discounts between Asian and the U.S. markets by introducing dummy variables. Fourth, we investigate whether factors such expense ratio, daily volatility, dividends, and exchange rate changes have any effect on tracking errors.

Our findings reveal that significant tracking errors exist between performance of ETFs and their benchmarks. The three types of tracking errors calculated from NAVs appear to be consistently affected by changes in the exchange rate and only one of them appears to be affected by changes in volatility. Further, negative Jensen's alphas support the existence of statistically significant tracking errors and show that passive investment strategy does not defeat market returns. We also find that Asian and the U.S. markets have different patterns in the reaction to the premiums/discounts. That is premiums/discounts of Asian ETFs are positively related to the 2 days lagged momentum variable while those of the U.S. ETFs are not. These findings support our conclusion that Asian markets have relatively longer persistence in premiums/discounts than the U.S. markets and are noisier in filtering the information contained in returns.

Through these results, we identify the following contributions to the international financial management literature. The finding that passive investment strategy does not outperform market returns due to mostly negative Jensen's alpha implies that investing in ETFs does not provide a significant benefit compared to their benchmark returns. Authorized participants acting as market makers provide liquidity of the ETF shares and ensure that market price approximates to the net asset value of the underlying assets. Our findings indicate that there appears to be a greater divergence between the market price and the net asset value of ETFs for the Asian markets. Therefore liquidity risk, a different kind of risk, reflected in a wide bid-ask spread or large price movements appears to be relatively higher for Asian ETFs. A noisy market may result in prolonged periods of mispricing due to momentum trading and speculative behavior away from fundamental value. A comparison of ETFs from different regions indeed reveals that Asian markets appear to be relatively noisier and more prone to momentum trading. Therefore these findings imply that a relatively active ETF investment strategy may be more appropriate for Asian markets than the U.S. markets. Lastly, a depreciation of the U.S. dollar leads to an increase in the net asset value of the ETFs, increasing the dispersion between NAV and benchmark returns. This increase in the dispersion results in wider tracking errors. Thus, our findings are consistent with the view that international investors that invest in Asian ETFs may benefit from a depreciating dollar.

The remainder of this study is structured as follows. Section 2 reviews the literature. Section 3 presents data and descriptive statistics. Section 4 describes the econometric methodology. Section 5 reports the estimation results, and conclusion in Section 6.

## 2. Literature review

The performance of mutual funds has received substantial research interest in the recent past. Most of these studies report that the mutual funds have not outperformed market returns. Transaction costs

[1] www.sec.gov.

such as fees are found to be the main cause of this poor performance. Thus, merely replicating market portfolio yields better returns than solely investing in the mutual funds.

Elton et al. (2002) find that the NAV of SPDRs tracks S&P 500 index very closely excluding management fees and dividends on the underlying securities. However, they find that SPDRs underperform its benchmark and index funds. The deviations disappear in a day, indicating that the market is efficient. Olienyk et al. (1999) examine the deviations using cointegration and Granger causality tests, and find short-term causal relationships, indicating the existence of short-term arbitrage opportunities.

Pennathur et al. (2002) examine the diversification efficacy of iShares and closed-end country funds using the single-factor model and two-factor model. Although iShares have been marketed as a vehicle for international diversification, there is much debate whether the U.S. exchange-listed securities really do provide diversification. As the market prices of country funds are determined in the U.S. and NAVs in the home country, the two prices are affected by different risk exposures. The test results show that although there is a little diversification potential for iShares, they behave much like the U.S. market. Further, closed-end funds also do not provide any diversification benefits.

Kostovetsky (2003) develops a simple one-period model, and then expands to multiple-period model. The two models are useful to compare ETFs and index funds depending on their features. He claims that the differences between ETFs and index funds are mainly attributed to management fees, shareholder transaction fees, taxation efficiency, and qualitative difference. The qualitative features refer to the convenience in trade, the ability to buy on margin and sell short, and simplicity for participation.

Harper et al. (2006) compare the risk and return performance of ETFs for foreign markets and closed-end country funds (CEFs). They find that tracking errors are uniformly negative but none of them is significant, meaning ETFs track the benchmarks well. They also find that ETFs exhibit better performance than CEFs in the mean return and Sharpe ratio, and conclude that a passive investment strategy using ETFs may be superior to an active investment strategy with CEFs.

Gallagher and Segara (2005) investigate the tracking errors of ETFs on the Australian stock exchange and compare the tracking error volatility between ETFs and equity index funds operated off-market. They argue that ETFs are better to track their benchmarks than off-market index funds, and conclude that investors with a long-term horizon will be able to still earn returns similar to the index returns. In addition, they examine the market efficiency using the deviations between the NAV and trading price of ETFs and have the results that support the market efficiency as Elton et al. (2002).

Milonas and Rompotis (2006) examine the performance and the trading characteristics of a sample of 36 Swiss ETFs. They find that Swiss ETFs underperform their benchmark indexes while having investors exposed to greater risk and that tracking errors are positively related to the management fees and risk of ETFs and expenses are negatively related to the performance.

Since persistence of premiums/discounts is associated with arbitrage opportunities, some studies investigate what explains the ETF premiums/discounts. Delcoure and Zhong (2007) for example, conduct panel regression analysis using factors explaining the international ETF premiums/discounts based on the previous studies, and find that the size of premiums/discounts is determined by institutional ownership, bid-ask spread, trading volume, exchange rate volatility and financial and economic crisis. Ackert and Tian (2008) investigate the pricing of ETFs relative to their benchmarks, and argue that the mispricing of country ETFs is related to momentum, illiquidity, and size effect.

## 3. Data and descriptive statistics

The net asset values (NAVs) of ETFs, expense ratios, dividends and their benchmark indexes are obtained from iShares of BlackRock Institutional Trust Company. NAV is calculated in accordance with the formula for valuing mutual fund shares: the value of assets minus its liabilities divided by the number of outstanding shares.[2] ETFs' trading price (market value) and volume, daily high and low trading prices, highest bid and lowest ask price, and number of outstanding shares are obtained from

[2] www. iShares.com.

**Table 1**
List of exchange-traded funds employed (as of 9/09/2008).

| | Fund name | Ticker | Inception date | Total NAV (thousand) | Expense ratio |
|---|---|---|---|---|---|
| 1 | Dow Jones U.S. Index Fund | IYY | 6/12/2000 | $598,223 | 0.20% |
| 2 | NYSE Composite Index Fund | NYC | 3/30/2004 | $115,907 | 0.25% |
| 3 | S&P 1500 Index Fund | ISI | 1/20/2004 | $212,069 | 0.20% |
| 4 | Russell 2000 Value Index Fund | IWW | 7/24/2000 | $474,418 | 0.27% |
| 5 | Russell 3000 Index Fund | IWV | 5/22/2000 | $2,879,809 | 0.21% |
| 6 | Russell 3000 Growth Index Fund | IWZ | 7/24/2000 | $513,632 | 0.25% |
| 7 | MSCI Canada Index Fund | EWC | 3/12/1996 | $1,813,003 | 0.52% |
| 8 | MSCI Brazil Index Fund | EWZ | 7/10/2000 | $5,815,128 | 0.68% |
| 9 | MSCI Mexico Investable Market Index Fund | EWW | 3/12/1996 | $919,874 | 0.51% |
| 10 | MSCI Taiwan Index Fund | EWT | 6/20/2000 | $2,611,932 | 0.68% |
| 11 | MSCI South Korea Index Fund | EWY | 5/09/2000 | $1,948,407 | 0.68% |
| 12 | MSCI Singapore Index Fund | EWS | 3/12/1996 | $1,227,319 | 0.51% |
| 13 | MSCI Malaysia Index Fund | EWM | 3/12/1996 | $384,631 | 0.51% |
| 14 | MSCI Japan Index Fund | EWJ | 3/12/1996 | $6,995,953 | 0.52% |
| 15 | MSCI Hong Kong Index Fund | EWH | 3/12/1996 | $1,509,275 | 0.52% |
| 16 | MSCI Australia Index Fund | EWA | 3/12/1996 | $924,494 | 0.51% |
| 17 | MSCI UK Index Fund | EWU | 3/12/1996 | $803,381, | 0.51% |
| 18 | MSCI Switzerland Index Fund | EWL | 3/12/1996 | $407,418 | 0.51% |
| 19 | MSCI Sweden Index Fund | EWD | 3/12/1996 | $211,922 | 0.51% |
| 20 | MSCI Spain Index Fund | EWP | 3/12/1996 | $368,347 | 0.51% |
| 21 | MSCI Netherlands Investable Market Index Fund | EWN | 3/12/1996 | $210,686 | 0.51% |
| 22 | MSCI Italy Index Fund | EWI | 3/12/1996 | $172,803 | 0.52% |
| 23 | MSCI Germany Index Fund | EWG | 3/12/1996 | $648,939 | 0.51% |
| 24 | MSCI France Index Fund | EWQ | 3/12/1996 | $315,780 | 0.51% |
| 25 | MSCI Belgium Investable Market Index Fund | EWK | 3/12/1996 | $86,796 | 0.51% |
| 26 | MSCI Austria Investable Market Index Fund | EWO | 3/12/1996 | $203,711 | 0.51% |

Table reports the name, ticker, inception date, total NAV, and expense ratio of the 20 iShares Morgan Stanley Capital International (MSCI) Country Funds and 6 iShares Broad U.S. Equity Market Funds.

the Center for Research in Security Prices (CRSP). Finally, exchange rates of each foreign currency to dollar are acquired from Datastream of Thomson Financial Limited. All data, except annual expense ratios and dividends, are collected in daily frequency and range from July 2004 to June 2007.

Table 1 reports the profiles – including name of fund, ticker, inception date, total NAV, and expense ratio – of the 20 iShares Morgan Stanley Capital International (MSCI) Country Funds and 6 iShares Broad U.S. Equity Market Funds. In 1996, 17 ETFs benchmarking foreign markets were launched. The 17 ETFs have in general larger fund size than those benchmarking the U.S. markets. Expense ratios range from 0.2% to 0.68%. Expense ratios for the 17 ETFs are more than twice those ETFs benchmarking the U.S. market, but still less than half of those for general close-end funds.

## 4. Methodology

### 4.1. Return and risk

Before conducting the tests, we first analyze return and risk characteristics of ETFs and their benchmark indexes and simply compare the performance of ETFs with that of their benchmarks. The returns of individual ETFs and their benchmarks are expressed by the following equations:

$$NR_{i,t} = \frac{NAV_{i,t} - NAV_{i,t-1}}{NAV_{i,t-1}} \text{ or } IR_{i,t} = \frac{Index_{i,t} - Index_{i,t-1}}{Index_{i,t-1}} \tag{1}$$

where $NR_{i,t}$ = the return on ETF $i$'s NAV in day $t$; $IR_{i,t}$ = the return on benchmark $i$ in day $t$; $NAV_{i,t}$ = the net asset value of ETF $i$ in day $t$; $Index_{i,t}$ = the benchmark of ETF $i$ in day $t$.

And, the risks of ETFs and indexes are defined using the standard deviation of returns:

$$\sigma_{NAVi} = \sqrt{\frac{\sum_{t=1}^{n}(NR_{i,t} - \overline{NR}_i)^2}{n-1}} \text{ or } \sigma_{Indexi} = \sqrt{\frac{\sum_{t=1}^{n}(IR_{i,t} - \overline{IR}_i)^2}{n-1}} \quad (2)$$

where $\overline{NR}_i$ is the average return of ETF *i*'s NAV; $\overline{IR}_i$ is the average return of benchmark *i*.

### 4.2. Measurements of tracking errors

Tracking errors are defined as the deviation between the performance of ETFs and their benchmark indexes, and measured in various ways in the previous literature. Harper et al. (2006) use just the difference between return on ETFs and their benchmarks. However, this approach may underestimate the error because the differences can cancel each other out. Milonas and Rompotis (2006) and Gallagher and Segara (2005) estimate tracking errors using the most commonly applied methods such as the average absolute differences, standard errors from regression analysis and standard deviation of return differences. Similarly in this study, we apply all three methods.

First, tracking errors can be simply estimated with the average absolute differences between the returns on ETFs and their benchmark indexes. Therefore, the equation to calculate the average daily tracking errors is:

$$NTE_1 = \frac{\sum_{t=1}^{n}\left|NR_{i,t} - IR_{i,t}\right|}{n} \quad (3)$$

where $NTE_1$ = the average daily tracking errors based on the absolute difference between the return on ETF *i's* NAV and its benchmark.

The second method to estimate the tracking error is to use standard errors from the regression analysis using daily return on each ETF and its benchmark index. The model is:

$$NR_{i,t} = \alpha_i + \beta_i \cdot IR_{i,t} + \varepsilon_{i,t} \quad (4)$$

The alpha coefficient, $\alpha_i$, indicates the excess return which the ETF *i* can earn above its benchmark. Due to the various expenses associated with management of ETFs, alpha coefficients are expected to be zero or negative but not positive. The beta coefficient, $\beta_i$, indicates systematic risk and replication strategy of ETFs, so that the coefficient gets closer to 1 if the ETF replicates its benchmark well. However, the alpha and beta coefficients are not the components that should be acquired from the regression model. In this model the standard errors from the regressions proxy tracking errors. If ETFs perfectly replicate their benchmark indexes, then the standard deviation of residuals from regression must be zero.

The third method to estimate tracking error is the standard deviation of differences between returns on ETFs and the benchmark indexes, and can be calculated using the following equation:

$$NTE_3 = \sqrt{\frac{\sum_{t=1}^{n}(ND_{i,t} - \overline{ND}_i)^2}{n-1}} \quad (5)$$

where $ND_{i,t}$ = the difference between the return on ETF *i's* NAVs and its benchmark in day *t*.

If the funds replicate the indexes they benchmark, then the average tracking errors should be close to zero. To test this conjecture we perform *t*-tests to see if there is a statistically significant difference between the performance of ETFs and their benchmarks. If the results of the *t*-tests are statistically insignificant, we then conclude that the ETFs track their benchmark index well.

### 4.3. Factors affecting tracking errors

Several factors may affect tracking errors. Frino and Gallagher (2001), Kostovetsky (2003), and Milonas and Rompotis (2006) mention expenses, fund cash flows, dividends, and index composition changes as factors that drive index fund tracking errors. In this study consistent with previous studies, we choose annual expense ratio including all costs to manage ETFs, volatility of ETFs' daily trading prices, log-transformed daily average trading volume, annual dividend, and daily return on exchange rates as factors to predict the average tracking errors.

The regression equation for the factors postulated to affect tracking errors can be expressed as:

$$NTE_i = a_1 + a_2 \cdot FeeRatio_i + a_3 \cdot DVolatility_i + a_4 \cdot LVolume_i + a_5 \cdot Dividend_i + a_6 \cdot ExchRate_i + e_i \quad (6)$$

where $e_i$ is error term.[3]

The volatility of ETFs' daily market price (*DVolatility*) is the average rate of daily price changes and calculated by the following equation:

$$DVolatility = \frac{1}{n} \cdot \sum_{t=1}^{n} \frac{P_{t,high} - P_{t,low}}{P_{t,close}} \quad (7)$$

where $P_{t,high}$ = the highest trading price in day $t$; $P_{t,low}$ = the lowest trading price in day $t$; $P_{t,close}$ = the closing price in day $t$.

Volatility of the daily market value can give us an idea of how the daily market price changes affect tracking errors. The log-transformed average daily trading volume (*Lvolume*) measures the liquidity of each ETF. In dividend (*Dividend*), not all ETFs acquire dividends in the same interval so that we annualize them by dividing the sum of dividends by 3, which is the number of years of sample periods. There is often a time lag when dividends are paid to ETFs. ETFs cannot re-invest the dividends. Therefore, the dividends are expected to have certain amount of impact not only on the performance of ETFs, but also on tracking errors. The change in the exchange rate (*ExchRate*) is used to measure how changes in the exchange rates affect tracking errors. ETFs other than those benchmarking the U.S. market indexes are composed of stocks traded in foreign exchanges in foreign currency while they are traded in the United States. One would naturally expect that the ETFs benchmarking foreign market indexes are exposed to exchange rate risk.

### 4.4. Performance of ETFs

Since tracking errors are not well suited to measuring the performance of ETFs, we employ Jensen's model:

$$(NR_{i,t} - R_{ft}) = \alpha_{ni} + \beta_{ni}(IR_{i,t} - R_{ft}) + \varepsilon_{i,t} \quad (8)$$

where $R_{ft}$ represents the risk free rate acquired using the 3-month U.S. T-bill rates. Beta, $\beta_{ni}$, in the model is the same as one in the Capital Asset Pricing Model, describing the relation of risk adjusted returns of ETFs and their benchmarks. A positive beta of one implies that the ETF perfectly follows its benchmark. Then, we can use the intercepts, $\alpha_{ni}$, as a measure of the performance. If alpha is significantly positive, then we conclude that the ETFs perform better than its benchmark; if alpha is significantly negative, then we conclude that the ETF is inferior to its benchmark; and if alpha is insignificant, the conclusion is that the ETF is not generally different from its benchmark in performance.

Similar to the discussion of tracking errors, since ETFs are designed to mimic their benchmarks, we expect insignificant alphas if ETFs perform properly. If the test results are statistically significant in either direction, they support the existence of tracking errors. On the other hand, insignificant test results support non-existence of tracking errors.

### 4.5. Testing for persistence

If information is disseminated quickly, the opportunities for arbitrage disappear in a short period of time due to the price pressure formed by rational investors. To test persistence, we employ

[3] In order to control for country level effect on NTE1, we conduct the following regression analysis for each ETF: $\left| NR_{i,t} - IR_{i,t} \right| = a_i + b_i \cdot IR_{i,t} + e_{i,t}$. We use the standard errors from the analysis as a dependent variable for Eq. (6).

serial correlation test and runs test used in Fama (1965), Ko and Lee (1991) and Islam et al. (2005).[4]

The serial correlation coefficient, $\rho_\tau$, measures the relationship between the value of a random variable in $t$ and its value in $t-\tau$, and is estimated by:

$$\rho_\tau = \frac{cov(d_t, d_{t-\tau})}{var(d_t)} \tag{9}$$

where $d_t$ is the premiums/discounts in U.S. dollars at the close of day $t$, and $\tau = 1, 2, \ldots, 7$ is the lag length. The premiums/discounts are widely defined in the current literature as deviations of the market price from the NAV (Yang and Lau, 2005; Engle and Sarkar, 2006). Since the sample size, $N$, for each ETF is large, the standard error of serial correlation coefficient is given by:

$$\sigma_\rho = (N-\tau)^{-1/2} \tag{10}$$

If the serial correlation coefficient is statistically insignificant, then we conclude that there is no relationship between $d_t$ and $d_{t-\tau}$ and that the market is efficient at least as a weak form. Also, the square of serial correlation coefficient is the same as the $R$-squared statistics of the regression model. That is, the square of serial correlation coefficient is the fraction of the variation of $d_t$ explained by $d_{t-\tau}$.

Since the correlation coefficient tends to be heavily biased by outliers, runs test can be an alternative method that overcomes the drawbacks of serial correlation test.[5] Fama (1965) defines run as a sequence of price changes of the same sign. The larger is the positive serial dependence in price changes, the smaller is the actual number of runs than the expected number of runs. Assuming that price changes are independent, the total expected number of runs, $m$, can be obtained by:

$$m = \frac{N(N+1) - \sum_{i=1}^{3} n_i^2}{N} \tag{11}$$

where $N$ is the total number of price changes and $n_i$ is the number of price changes of each sign. The expected number of runs is compared with actual number of runs, and the significance of the difference is tested by the standardized variable, $K$, which is approximately normal with zero mean and unit variance. The standard variable is obtained by:

$$K = \frac{(R+1/2) - m}{\sigma_m} \tag{12}$$

and

$$\sigma_m = \left[\frac{\sum_{i=1}^{3} n_i^2 \left(\sum_{i=1}^{3} n_i^2 + N(N+1)\right) - 2N\sum_{i=1}^{3} n_i^3 - N^3}{N^2(N-1)}\right]^{1/2} \tag{13}$$

where $R$ is the actual number of runs and $\sigma_m$ is the standard error of $m$. If the future price changes are positively correlated with historical price changes, we can expect the actual number of runs significantly less than the expected number of runs.

### 4.6. Determinants of ETF premiums/discounts

In this section, we perform panel regression analysis. Panel regression analysis allows us to capture any time-series and cross-sectional variation of premiums/discounts simultaneously. The model for

[4] Fama (1965), Ko and Lee (1991), and Islam et al. (2005) apply serial correlation test and runs test to investigate market efficiency of the U.S. and Asian stock markets. Fama (1965) and Ko and Lee (1991) find little evidence exhibiting the inefficiency of the U.S. stock market, while Islam et al. (2005) find the inefficiency of the Thai stock market and attribute it to the lack of a developed financial system. Ko and Lee (1991) also provide evidence supporting inefficiency of Japan, Korea, Singapore, and Taiwan.

[5] Elton et al. (2006, p. 410).

the factors postulated to explain the ETF premiums/discounts can be expressed as:

$$d_{i,t} = b_0 + b_1 \cdot Sprd_{i,t} + b_2 \cdot LnVol_{i,t} + b_3 \cdot Exchrate_{i,t} + b_4 \cdot Mom_{i,t-1} + b_5 \cdot Mom_{i,t-2} + b_6 \cdot Cap_{i,t} + \varepsilon_{i,t} \quad (14)$$

where $d_{i,t}$ is the premiums/discounts of ETF $i$ in the day $t$; $Sprd_{i,t}$ is the difference between the highest bid and the lowest ask prices; $LnVol_{i,t}$ is the natural logarithm of daily trading volume; $ExchRate_{i,t}$ is the change in exchange rates; $Mom_{i,t-j}$ is the momentum in the NAVs in the day $t-1$ and $t-2$; and $Cap_{i,t}$ is the natural logarithm of the ETF's market capitalization.

Delcoure and Zhong (2007) use bid-ask price spread as a proxy for transaction costs. Arbitrage pricing model states that if an asset deviates from its equilibrium price, arbitragers will step in short or long transaction until the premiums/discounts disappear. However, higher transaction costs can interrupt arbitrage procedures by reducing incentives to arbitrage. Therefore, we expect a positive relationship between bid-ask price spread and size of ETF premiums/discounts. Blume et al. (1994) argue that investors trade assets because of different beliefs about the fundamental value of assets. They argue that investors use trading volume statistics in updating their beliefs, and state that volume affects the behavior of the market. Therefore, a higher level of trading volume may indicate a greater difference in beliefs and, hence, greater premiums/discounts. The momentum variable is obtained by calculating the percentage change in the NAV. Ackert and Tian (2008) claim that if the ETFs' price reacts slowly to a change in the NAV, the premiums/discounts will be positively related to the past momentum. We utilize up to 2 days lagged momentum variables in the model. ETF's capitalization is a proxy for the ETF's size. Since it might be easier for investors to collect information about large firms, the size holds a negative relationship with premiums/discounts (Bergström and Tang, 2001; Yang and Lau, 2005). Further, we conduct an additional panel regression analysis to see how different factors affect premiums/discounts for the U.S. and Asian ETFs by introducing dummy variables. The model for the comparison of the U.S. and Asian ETFs can be expressed as:

$$\begin{aligned} d_{i,t} &= c_0 + c_1 \cdot Sprd_{i,t} + c_2 \cdot DM_i \times Sprd_{i,t} + c_3 \cdot LnVol_{i,t} + c_4 \cdot DM_i \times LnVol_{i,t} \\ &+ c_5 \cdot Exchrate_{i,t} + c_6 \cdot DM_i \times Exchrate_{i,t} + c_7 \cdot Mom_{i,t-1} + c_8 \cdot DM_i \times Mom_{i,t-1} \\ &+ c_9 \cdot Mom_{i,t-2} + c_{10} \cdot DM_i \times Mom_{i,t-2} + c_{11} \cdot Cap_{i,t} + c_{12} \cdot DM_i \times Cap_{i,t} + \varepsilon_{i,t} \end{aligned} \quad (15)$$

where $DM_i$ denotes the dummy variable that is 1 if ETF $i$ mimics Asian market or 0 if ETF $i$ mimics the U.S. market. A finding of a significant difference in the momentum variables between the U.S. and Asian ETFs would imply strong evidence in favor of the dissemination of information discrepancies between the two markets.

## 5. Empirical results

### 5.1. Return and risk of ETFs

Table 2 reports the average daily returns and standard deviations on 26 ETFs and their benchmark indexes for the yearly and entire sample period. The overall returns on ETFs underperform those of their benchmark indexes. The differences between the returns on ETFs and their benchmarks for the overall sample period range from 0.001% to 0.014% on a daily basis, which may be explained by factors such as expenses, dividends, exchange rates. In more detail, the ETFs benchmarking American stock markets exhibit substantially high average returns and standard deviations. ETFs of the U.S. market have the lowest returns compared to the ETFs of Asian and European market indexes in the average level of returns. The standard deviation, which is a proxy for risk, gives us useful information on the dispersion of returns. It appears from Table 2 that ETFs with high average returns display high risk while those with low average returns display low risk. The results appear to be generally consistent with the Markowitz type risk-return trade-off.

[7] For space considerations, the remaining graphs are excluded but are available from the authors on request.

**Table 2**
Average returns and standard deviations of 26 ETFs.

| Area | Ticker | Year 1 NR | Year 1 IR | Year 1 IR-NR | Year 2 NR | Year 2 IR | Year 2 IR-NR | Year 3 NR | Year 3 IR | Year 3 IR-NR | Overall NR | Overall IR | Overall IR-NR |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Panel (A): average return | | | | | | | | | | | | | |
| Asia | EWA | 0.1183 | 0.1300 | 0.0117 | 0.0683 | 0.0804 | 0.0120 | 0.1332 | 0.1499 | 0.0167 | 0.1066 | 0.1200 | 0.0134 |
| | EWH | 0.0875 | 0.0978 | 0.0104 | 0.0350 | 0.0483 | 0.0133 | 0.0973 | 0.1073 | 0.0100 | 0.0732 | 0.0845 | 0.0112 |
| | EWJ | −0.0057 | −0.0013 | 0.0045 | 0.1251 | 0.1299 | 0.0047 | 0.0292 | 0.0333 | 0.0041 | 0.0495 | 0.0540 | 0.0044 |
| | EWM | 0.0265 | 0.0373 | 0.0108 | 0.0265 | 0.0451 | 0.0186 | 0.1932 | 0.2051 | 0.0119 | 0.0817 | 0.0955 | 0.0138 |
| | EWS | 0.0786 | 0.0880 | 0.0094 | 0.0660 | 0.0806 | 0.0146 | 0.1820 | 0.1959 | 0.0138 | 0.1086 | 0.1213 | 0.0126 |
| | EWT | 0.0554 | 0.0597 | 0.0042 | 0.0254 | 0.0373 | 0.0119 | 0.0942 | 0.1043 | 0.0101 | 0.0582 | 0.0670 | 0.0087 |
| | EWY | 0.1232 | 0.1260 | 0.0027 | 0.1451 | 0.1537 | 0.0086 | 0.1209 | 0.1227 | 0.0019 | 0.1298 | 0.1342 | 0.0019 |
| *Average* | | 0.0691 | 0.0768 | 0.0077 | 0.0702 | 0.0822 | 0.0120 | 0.1214 | 0.1312 | 0.0098 | 0.0868 | 0.0966 | 0.0094 |
| Europe | EWD | 0.0676 | 0.0706 | 0.0030 | 0.0965 | 0.1041 | 0.0075 | 0.1490 | 0.1542 | 0.0052 | 0.1042 | 0.1095 | 0.0052 |
| | EWG | 0.0436 | 0.0495 | 0.0059 | 0.1075 | 0.1104 | 0.0029 | 0.1551 | 0.1639 | 0.0088 | 0.1018 | 0.1077 | 0.0059 |
| | EWI | 0.0666 | 0.0755 | 0.0090 | 0.0724 | 0.0793 | 0.0069 | 0.0769 | 0.0860 | 0.0091 | 0.0719 | 0.0802 | 0.0083 |
| | EWK | 0.0954 | 0.1015 | 0.0061 | 0.0722 | 0.0908 | 0.0186 | 0.1086 | 0.1186 | 0.0100 | 0.0921 | 0.1036 | 0.0116 |
| | EWL | 0.0405 | 0.0422 | 0.0017 | 0.1028 | 0.1073 | 0.0045 | 0.0890 | 0.0843 | −0.0047 | 0.0774 | 0.0779 | 0.0005 |
| | EWN | 0.0521 | 0.0606 | 0.0085 | 0.0793 | 0.0875 | 0.0082 | 0.1248 | 0.1338 | 0.0090 | 0.0853 | 0.0938 | 0.0086 |
| | EWO | 0.1423 | 0.1597 | 0.0174 | 0.1058 | 0.1079 | 0.0021 | 0.1131 | 0.1289 | 0.0158 | 0.1205 | 0.1322 | 0.0117 |
| | EWP | 0.0805 | 0.0845 | 0.0039 | 0.0860 | 0.0963 | 0.0102 | 0.1362 | 0.1385 | 0.0024 | 0.1008 | 0.1063 | 0.0055 |
| | EWQ | 0.0542 | 0.0596 | 0.0054 | 0.0943 | 0.1003 | 0.0059 | 0.1048 | 0.1116 | 0.0068 | 0.0843 | 0.0904 | 0.0060 |
| | EWU | 0.0530 | 0.0633 | 0.0103 | 0.0646 | 0.0794 | 0.0147 | 0.0838 | 0.1001 | 0.0163 | 0.0671 | 0.0808 | 0.0138 |
| *Average* | | 0.0696 | 0.0767 | 0.0071 | 0.0882 | 0.0963 | 0.0082 | 0.1141 | 0.1220 | 0.0079 | 0.0905 | 0.0982 | 0.0077 |
| America | EWC | 0.0996 | 0.1036 | 0.0040 | 0.1106 | 0.1147 | 0.0041 | 0.0976 | 0.1035 | 0.0059 | 0.1026 | 0.1073 | 0.0046 |
| | EWW | 0.1355 | 0.1453 | 0.0098 | 0.1358 | 0.1442 | 0.0084 | 0.2152 | 0.2091 | −0.0061 | 0.1620 | 0.1661 | 0.0041 |
| | EWZ | 0.2191 | 0.2329 | 0.0139 | 0.2050 | 0.2210 | 0.0160 | 0.1964 | 0.2044 | 0.0080 | 0.2069 | 0.2195 | 0.0126 |
| *Average* | | 0.1514 | 0.1606 | 0.0092 | 0.1505 | 0.1600 | 0.0095 | 0.1697 | 0.1723 | 0.0026 | 0.1572 | 0.1643 | 0.0071 |
| US | ISI | 0.0224 | 0.0301 | 0.0077 | 0.0307 | 0.0373 | 0.0066 | 0.0684 | 0.0758 | 0.0074 | 0.0404 | 0.0477 | 0.0072 |
| | IWV | 0.0274 | 0.0356 | 0.0082 | 0.0292 | 0.0363 | 0.0071 | 0.0680 | 0.0750 | 0.0070 | 0.0415 | 0.0489 | 0.0074 |
| | IWW | 0.0475 | 0.0571 | 0.0096 | 0.0360 | 0.0460 | 0.0100 | 0.0697 | 0.0792 | 0.0095 | 0.0510 | 0.0608 | 0.0097 |
| | IWZ | 0.0072 | 0.0127 | 0.0055 | 0.0223 | 0.0267 | 0.0044 | 0.0666 | 0.0712 | 0.0046 | 0.0319 | 0.0368 | 0.0049 |
| | IYY | 0.0277 | 0.0353 | 0.0076 | 0.0295 | 0.0366 | 0.0071 | 0.0697 | 0.0767 | 0.0070 | 0.0422 | 0.0495 | 0.0073 |
| | NYC | 0.0376 | 0.0484 | 0.0108 | 0.0489 | 0.0565 | 0.0076 | 0.0787 | 0.0878 | 0.0091 | 0.0551 | 0.0642 | 0.0092 |
| *Average* | | 0.0283 | 0.0365 | 0.0082 | 0.0328 | 0.0399 | 0.0071 | 0.0702 | 0.0776 | 0.0074 | 0.0437 | 0.0513 | 0.0076 |
| Average | | 0.0694 | 0.0771 | 0.0078 | 0.0777 | 0.0868 | 0.0091 | 0.1124 | 0.1200 | 0.0077 | 0.0864 | 0.0946 | 0.0081 |

Table 2 (*Continued* )

| Area | Ticker | Year 1 | | | Year 2 | | | Year 3 | | | Overall | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | NR | IR | IR-NR | NR | IR | IR-NR | NR | IR | IR-NR | NR | IR | IR-NR |
| Panel (B): standard deviation | | | | | | | | | | | | | |
| Asia | EWA | 0.9134 | 0.8908 | 0.2194 | 1.1152 | 1.0955 | 0.2204 | 1.0146 | 0.9978 | 0.2955 | 1.0166 | 0.9972 | 0.2472 |
| | EWH | 0.7477 | 0.7409 | 0.1483 | 0.8013 | 0.7904 | 0.1791 | 0.8722 | 0.8759 | 0.1258 | 0.8078 | 0.8034 | 0.1525 |
| | EWJ | 0.9636 | 0.9659 | 0.0495 | 1.2825 | 1.2836 | 0.0531 | 1.0329 | 1.0384 | 0.0551 | 1.1015 | 1.1043 | 0.0526 |
| | EWM | 0.5932 | 0.5870 | 0.1507 | 0.6408 | 0.5669 | 0.2679 | 1.0182 | 1.0319 | 0.1466 | 0.7764 | 0.7614 | 0.1964 |
| | EWS | 0.6944 | 0.6572 | 0.2477 | 0.9549 | 0.9379 | 0.2347 | 1.1083 | 1.1003 | 0.1841 | 0.9343 | 0.9164 | 0.2237 |
| | EWT | 1.0868 | 1.0951 | 0.0583 | 1.2342 | 1.2499 | 0.0883 | 1.0274 | 1.0289 | 0.1383 | 1.1186 | 1.1275 | 0.1003 |
| | EWY | 1.2516 | 1.2609 | 0.1316 | 1.4313 | 1.4513 | 0.0880 | 1.0484 | 1.0622 | 0.0657 | 1.2524 | 1.2670 | 0.0657 |
| *Average* | | 0.8930 | 0.8854 | 0.1436 | 1.0658 | 1.0536 | 0.1617 | 1.0174 | 1.0193 | 0.1445 | 1.0011 | 0.9967 | 0.1483 |
| Europe | EWD | 0.9485 | 0.9494 | 0.0511 | 1.3152 | 1.3138 | 0.1201 | 1.2183 | 1.2196 | 0.0772 | 1.1695 | 1.1697 | 0.0875 |
| | EWG | 0.7915 | 0.8027 | 0.0750 | 1.1188 | 1.1184 | 0.0437 | 0.9884 | 0.9869 | 0.1202 | 0.9751 | 0.9775 | 0.0854 |
| | EWI | 0.6833 | 0.6917 | 0.1688 | 0.9487 | 0.9594 | 0.1568 | 0.8069 | 0.8048 | 0.1342 | 0.8190 | 0.8248 | 0.1538 |
| | EWK | 0.7193 | 0.7304 | 0.1134 | 0.9657 | 0.9612 | 0.2728 | 0.8599 | 0.8882 | 0.1448 | 0.8531 | 0.8640 | 0.1898 |
| | EWL | 0.7284 | 0.7693 | 0.1074 | 0.9382 | 0.9421 | 0.1037 | 0.7732 | 0.7858 | 0.0862 | 0.8176 | 0.8354 | 0.0995 |
| | EWN | 0.7487 | 0.7730 | 0.1171 | 0.9780 | 0.9907 | 0.1553 | 0.8662 | 0.8828 | 0.1216 | 0.8686 | 0.8859 | 0.1323 |
| | EWO | 0.9041 | 0.9320 | 0.1139 | 1.2093 | 1.2465 | 0.1156 | 0.9566 | 0.9557 | 0.2116 | 1.0308 | 1.0534 | 0.1537 |
| | EWP | 0.7246 | 0.7437 | 0.1258 | 0.9570 | 0.9572 | 0.1389 | 0.9486 | 0.9546 | 0.0782 | 0.8822 | 0.8896 | 0.1173 |
| | EWQ | 0.7613 | 0.7669 | 0.0850 | 1.0445 | 1.0427 | 0.0795 | 0.8916 | 0.8940 | 0.0873 | 0.9055 | 0.9072 | 0.0839 |
| | EWU | 0.6251 | 0.6229 | 0.1247 | 0.9350 | 0.9152 | 0.1920 | 0.8196 | 0.7956 | 0.2134 | 0.8022 | 0.7860 | 0.1803 |
| *Average* | | 0.7635 | 0.7782 | 0.1082 | 1.0410 | 1.0447 | 0.1378 | 0.9129 | 0.9168 | 0.1275 | 0.9123 | 0.9193 | 0.1283 |
| America | EWC | 0.8635 | 0.8557 | 0.0801 | 1.0749 | 1.0775 | 0.0473 | 0.8766 | 0.8794 | 0.0724 | 0.9421 | 0.9416 | 0.0680 |
| | EWW | 1.0397 | 1.0517 | 0.1346 | 1.5253 | 1.5524 | 0.1493 | 1.4051 | 1.4224 | 0.1246 | 1.3376 | 1.3568 | 0.1366 |
| | EWZ | 1.6334 | 1.6001 | 0.5733 | 2.2300 | 2.1153 | 0.8714 | 1.7319 | 1.6171 | 0.5770 | 1.8809 | 1.7913 | 0.6874 |
| *Average* | | 1.1789 | 1.1692 | 0.2627 | 1.6101 | 1.5818 | 0.3560 | 1.3379 | 1.3063 | 0.2580 | 1.3869 | 1.3633 | 0.2973 |
| US | ISI | 0.6973 | 0.6863 | 0.1401 | 0.6844 | 0.6834 | 0.0472 | 0.6538 | 0.6516 | 0.0518 | 0.6782 | 0.6734 | 0.0904 |
| | IWV | 0.6993 | 0.6977 | 0.0633 | 0.6950 | 0.6956 | 0.0515 | 0.6637 | 0.6645 | 0.0506 | 0.6856 | 0.6855 | 0.0554 |
| | IWW | 0.6834 | 0.6815 | 0.0704 | 0.7062 | 0.7054 | 0.0727 | 0.6411 | 0.6410 | 0.0683 | 0.6767 | 0.6758 | 0.0704 |
| | IWZ | 0.7518 | 0.7509 | 0.0437 | 0.7077 | 0.7083 | 0.0291 | 0.7091 | 0.7105 | 0.0298 | 0.7227 | 0.7230 | 0.0348 |
| | IYY | 0.6887 | 0.6874 | 0.0570 | 0.6885 | 0.6881 | 0.0519 | 0.6523 | 0.6535 | 0.0507 | 0.6761 | 0.6759 | 0.0532 |
| | NYC | 0.6214 | 0.6187 | 0.0879 | 0.7156 | 0.7153 | 0.0536 | 0.6804 | 0.6778 | 0.0646 | 0.6729 | 0.6711 | 0.0701 |
| *Average* | | 0.6903 | 0.6871 | 0.0771 | 0.6996 | 0.6994 | 0.0510 | 0.6667 | 0.6665 | 0.0526 | 0.6854 | 0.6841 | 0.0624 |
| Average | | 0.8294 | 0.8311 | 0.1284 | 1.0345 | 1.0294 | 0.1494 | 0.9333 | 0.9316 | 0.1298 | 0.9386 | 0.9371 | 0.1380 |

Table reports the average daily returns in Panel (A) and standard deviations in Panel (B) on 26 ETFs and their benchmark indexes for the yearly and entire sample period. ETFs are partitioned into the four different regions – Asia, Europe, America, and the U.S. – depending on the market the fund benchmarks. In Panel (A), the numbers in the columns of NR, IR and IR-NR are the average daily returns on NAV of ETFs and their benchmark indexes, and the difference of the two returns, respectively. Similarly, In Panel (B), the numbers in the columns of NR, IR and IR-NR are the standard deviations of the daily returns on NAV of ETFs and their benchmark indexes, and the difference of the two returns.

Fig. 1 plots the distributions of simple tracking errors. The difference between returns on the NAV and the benchmark is computed in Panel (A) and the standardized differences between market value and NAV ([(market price − NAV)/NAV] × 100) are computed in Panel (B). We select ETFs of Japan (EWJ), Germany (EWG) and Dow Jones (IYY) to represent Asia, Europe and the United States, respectively. We observe in Panel (A) that the simple tracking errors in the U.S. are more closely concentrated around zero even though all the three countries are categorized under similar level of economic development. We conjecture that Asian ETFs, consisting mostly of emerging markets, may have larger deviations

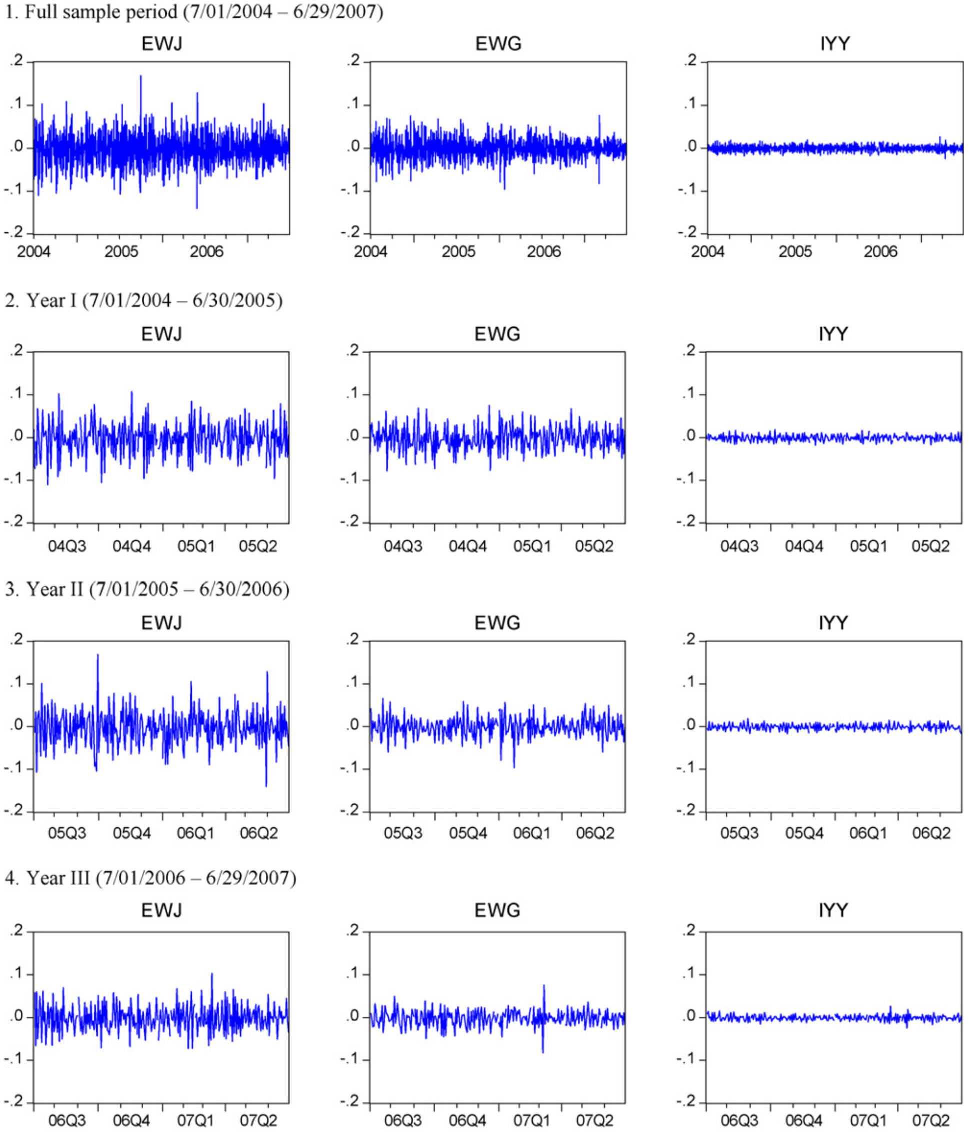


**Fig. 1.** (A) Simple difference between returns on the NAV and benchmark after replacing outliers with mean for easier exposition. ETFs of Japan (EWJ), Germany (EWG) and Dow Jones (IYY) representing Asia, Europe and the U.S. are selected for comparison, respectively.[7] (B) Standardized differences between market value and NAV as [(market price − NAV)/NAV] × 100. ETFs of Japan (EWJ), Germany (EWG) and Dow Jones (IYY) representing Asia, Europe and the U.S. are selected for comparison, respectively.

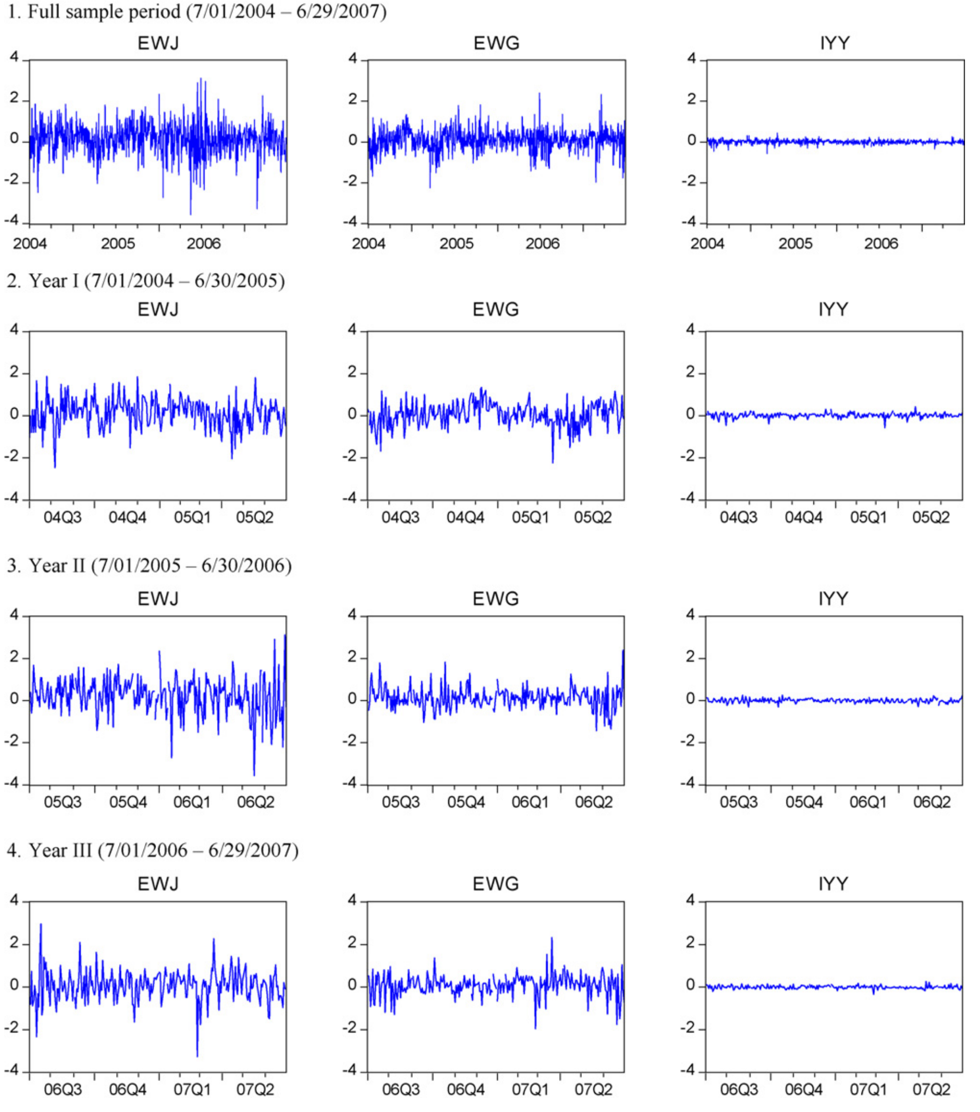


**Fig. 1.** (*Continued*).

from zero. Indeed, relatively high standard deviations for other Asian ETFs in Table 2 support our conjecture. Furthermore, we find the standardized differences in Fig. 1, Panel (B) between market price and NAV for Asian ETFs to be higher than those of the United States. Authorized participants acting as market makers provide liquidity of the ETF shares and ensure that market price approximates to the NAV of the underlying assets. Therefore this result may imply that the greater the divergence is between the market price and the NAV for the Asian markets relative to the U.S. markets, the less liquid these markets are. Consequently, lower liquidity may imply higher liquidity risk.

### 5.2. *Tracking errors*

As explained in Section 4, tracking errors are estimated utilizing three different methods. Table 3 reports tracking errors and *t*-statistics for the 26 ETFs and categorizes ETFs depending on the region

**Table 3**
Tracking errors.

| Area | Ticker | NTE1 | *t*-Stat | NTE2 | *t*-Stat | NTE3 | *t*-Stat |
|---|---|---|---|---|---|---|---|
| Asia | EWA | 0.036 | 3.992 | 0.247 | 82.484 | 0.247 | −1.494 |
| | EWH | 0.035 | 6.367 | 0.152 | 77.799 | 0.153 | −2.023 |
| | EWJ | 0.033 | 21.999 | 0.052 | 81.750 | 0.053 | −2.321 |
| | EWM | 0.053 | 11.813 | 0.196 | 77.504 | 0.196 | −2.392 |
| | EWS | 0.058 | 7.289 | 0.225 | 73.892 | 0.224 | −1.542 |
| | EWT | 0.040 | 11.813 | 0.099 | 77.504 | 0.100 | −2.392 |
| | EWY | 0.064 | 23.104 | 0.097 | 80.850 | 0.099 | −1.222 |
| *Average* | | 0.045 | | 0.153 | | 0.153 | |
| Europe | EWD | 0.022 | 7.170 | 0.087 | 74.987 | 0.087 | −1.646 |
| | EWG | 0.025 | 8.314 | 0.085 | 81.988 | 0.085 | −1.892 |
| | EWI | 0.049 | 9.172 | 0.153 | 82.582 | 0.154 | −1.486 |
| | EWK | 0.068 | 10.606 | 0.187 | 78.335 | 0.190 | −1.674 |
| | EWL | 0.075 | 31.286 | 0.097 | 83.585 | 0.100 | −0.136 |
| | EWN | 0.053 | 11.898 | 0.130 | 80.468 | 0.132 | −1.779 |
| | EWO | 0.084 | 18.004 | 0.150 | 75.208 | 0.154 | −2.101 |
| | EWP | 0.049 | 12.483 | 0.116 | 82.115 | 0.117 | −1.291 |
| | EWQ | 0.020 | 6.697 | 0.084 | 81.930 | 0.084 | −1.981 |
| | EWU | 0.029 | 4.440 | 0.180 | 82.770 | 0.180 | −2.100 |
| *Average* | | 0.047 | | 0.127 | | 0.128 | |
| America | EWC | 0.023 | 9.665 | 0.068 | 89.115 | 0.068 | −1.879 |
| | EWW | 0.093 | 25.791 | 0.134 | 75.073 | 0.137 | −0.822 |
| | EWZ | 0.509 | 30.228 | 0.687 | 81.309 | 0.687 | −0.505 |
| *Average* | | 0.208 | | 0.296 | | 0.297 | |
| US | ISI | 0.019 | 5.966 | 0.090 | 81.713 | 0.090 | −2.199 |
| | IWV | 0.012 | 5.960 | 0.055 | 82.447 | 0.055 | −3.694 |
| | IWW | 0.013 | 5.109 | 0.070 | 80.350 | 0.070 | −3.791 |
| | IWZ | 0.012 | 9.877 | 0.035 | 84.559 | 0.035 | −3.833 |
| | IYY | 0.012 | 6.488 | 0.053 | 82.117 | 0.053 | −3.747 |
| | NYC | 0.014 | 5.574 | 0.070 | 79.844 | 0.070 | −3.591 |
| *Average* | | 0.014 | | 0.062 | | 0.062 | |
| *Average* | | 0.062 | | 0.133 | | 0.134 | |

Table reports tracking errors and *t*-statistics for the 26 ETFs partitioned into the four different regions – Asia, Europe, America, and the U.S. – depending on the market the fund benchmarks. NTE$i$ ($i$ = 1, 2, 3) denote the tracking errors obtained using returns on the NAV of ETF and its benchmark. In detail, NTE1 is obtained from the average absolute difference between the returns on the NAV of ETF and its benchmark, $NTE_1 = (1/n)\sum_{t=1}^{n} \left| NR_{i,t} - IR_{i,t} \right|$; NTE2 is the standard error from the regression of returns on ETF's NAV on the returns on its benchmark, $NR_{i,t} = \alpha_i + \beta_i \cdot IR_{i,t} + \varepsilon_{i,t}$; and NTE3 is obtained from the standard deviation of simple difference between returns of the NAV of ETF and its benchmark, $NTE_3 = \sqrt{1/(n-1)\sum_{t=1}^{n}(ND_{i,t} - \overline{ND}_i)^2}$, where $ND_{i,t} = |NR_{i,t} - IR_{i,t}|$.

where the country is located. From the results of *t*-tests, we find that tracking errors are significantly different from zero indicating that ETFs do not mimic their corresponding indexes well. The U.S. ETFs exhibit the lowest level of tracking errors while American ETFs and Asian and European ETFs show higher level of tracking errors. These findings are consistent with the results in Table 2, in which Asian ETFs exhibit higher simple tracking errors and standard deviations relative to the U.S. ETFs.

Following previous literature, we select five variables to include in our regressions. Table 4 reports the results from the regressions using the three types of tracking errors calculated from NAVs. Changes in the 'exchange rate' variable appear to be the only statistically significant factor among the five variables, while the volatility of daily market price is significant for NTE1 only. After controlling for country level effects for NTE1, the volatility of daily market price is found to be no longer statistically significant. However, all the three models explain about 70% of variation in tracking errors.

In our formulation, an increase in the exchange rate corresponds to a depreciation of the U.S. dollar. Our findings show that, when converted from local currency to U.S. dollars, a depreciation of the U.S. dollar leads to an increase in the net asset value of the ETFs, increasing the dispersion between NAV

**Table 4**
Results of regressions testing factors affecting tracking errors.

| | Dependent Variable | | | |
|---|---|---|---|---|
| | NTE1 | NTE1 (A) | NTE2 | NTE3 |
| Expense ratio | −0.136 | −0.007 | −0.096 | −0.9 |
| *Dvolatility* | 0.136* | 0.004 | 0.069 | 0.071 |
| *Lvolume* | 0.005 | 0.017 | 0.02 | 0.02 |
| *Dividend* | 0.046 | 0.055 | 0.076 | 0.076 |
| Exchange rate | 3.142* | 4.080** | 5.529** | 5.488** |
| Constant | −0.174 | −0.177 | −0.266 | −0.262 |
| *R*-squared | 0.702 | 0.631 | 0.707 | 0.707 |

Table reports the results from the regression analyses using the three types of tracking errors. The regression analysis is conducted to find factors postulated to affect tracking errors and the can be expressed as: $NTE_i = a_1 + a_2 \cdot FeeRatio_i + a_3 \cdot DVolatility_i + a_4 \cdot LVolume_i + a_5 \cdot Dividend_i + a_6 \cdot ExchRate_i + e_i$. 'FeeRatio' denotes the expense ratios of ETFs; '*Dvolatility*' is the volatility of ETFs' daily market prices and computed as $DVolatility = (1/n)\sum_{t=1}^{n}(P_{t,high} - P_{t,low})/P_{t,close}$, where $P_{t,high}$, $P_{t,low}$, and $P_{t,close}$ denote the highest and lowest trading prices and closing price in day $t$, respectively; '*LVolume*' denotes the natural logarithm of the average daily trading volume; '*Dividend*' denotes the returns on the dividend from the stocks each ETF owns in the portfolio; and '*ExchRate*' denote the changes in exchange rate. NTEi ($i$ = 1, 2, 3) denotes the dependent variables used for the regression analyses. NTE1 denote the average absolute difference between the returns on the NAV of ETF and its benchmark, $NTE_1 = (1/n)\sum_{i=1}^{n}\left|NR_{i,t} - IR_{i,t}\right|$; NTE2 is the standard error from the regression of returns on ETF's NAV on the returns on its benchmark, $NR_{i,t} = \alpha_i + \beta_i \cdot IR_{i,t} + \varepsilon_{i,t}$; and NTE3 is obtained from the standard deviation of simple difference between returns of the NAV of ETF and its benchmark, $NTE_3 = \sqrt{1/(n-1)\sum_{t=1}^{n}(ND_{i,t} - \overline{ND_i})^2}$. For NTE1 (A), we use as dependent variable the standard errors for each ETF from the following regression model to control for country level effects on NTE1: $\left|NR_{i,t} - IR_{i,t}\right| = a_i + b_i \cdot IR_{i,t} + e_{i,t}$. Numbers in the columns are the coefficients from each regression analysis.

* Coefficients significant at 5%.
** Coefficients significant at 1%.

and benchmark returns. This increase in the dispersion results in wider tracking errors. Therefore, these results provide evidence in favor of the view that international investors that invest in Asian ETFs may benefit from a depreciating dollar.

## 5.3. Performance of ETFs

Table 5 reports alpha and beta values from Jensen's model for NAVs of ETFs.[6] The alpha values are all significant and negative with the two exceptions, EWL and EWW. Jensen (1968) claims in his study on mutual funds that negative alphas indicate the underperformance of mutual funds and attributes this to the generation of too many expenses. Wermers (2000) provides evidence in favor of mutual funds performance being superior to market over the sample period from 1975 to 1994, and claims that it can be attributed to fund managers' stock picking ability. However, the excess returns fail to cover expenses that occur by active trading, so that passive management is pervasive even in other types of investment vehicles. ETFs are designed to benchmark market index and to generate little expense and taxes relative to mutual funds. However, the sizes of negative alpha values for NAVs of ETFs are unexpectedly large. The statistically significant and negative alpha values imply inability of fund managers in designing funds to mimic benchmark and also support our finding that there exist significant tracking errors in ETFs.

We compute the tracking errors by averaging the simple differences used in the Harper et al. (2006) and perform $t$-tests for significance. Table 6 reports the results including the sum of tracking errors and number of positive and negative errors. All ETFs have negative sum of daily tracking errors. The proportion of negative tracking errors is relatively greater than that of positive errors. Eighteen out of twenty six ETFs have statistically significant negative errors at the 10% level. Further, column (F)

[6] When Jensen's alphas are calculated from market value of ETF, the results are exactly the same as NAV in terms of statistical significance.

**Table 5**
Performance of ETFs from Jensen's model.

| | Alpha($\alpha_{ni}$) | Beta($\beta_{ni}$) |
|---|---|---|
| Asia | | |
| EWA | −2.930** | 0.954** |
| EWH | −3.402** | 1.003** |
| EWJ | −1.130** | 0.987** |
| EWM | −3.705** | 0.980** |
| EWS | −2.569** | 0.949** |
| EWT | −1.777** | 0.937** |
| EWY | −1.824** | 0.981** |
| Europe | | |
| EWD | −1.159** | 0.971** |
| EWG | −0.887** | 0.964** |
| EWI | −1.690** | 0.941** |
| EWK | −2.929** | 0.931** |
| EWL | 0.535** | 0.944** |
| EWN | −1.193** | 0.941** |
| EWO | −2.478** | 0.981** |
| EWP | −2.183** | 1.010** |
| EWQ | −1.296** | 0.970** |
| EWU | −2.676** | 0.913** |
| America | | |
| EWC | −1.276** | 0.988** |
| EWW | 1.036** | 0.931** |
| EWZ | −1.292** | 0.921** |
| US | | |
| ISI | −1.855** | 0.980** |
| IWV | −1.979** | 0.993** |
| IWW | −2.619** | 0.990** |
| IWZ | −1.225** | 0.988** |
| IYY | −1.904** | 0.990** |
| NYC | −2.234** | 0.976** |

Table reports alpha and beta values from Jensen's Model: $(NR_{i,t}-R_{ft})=\alpha_{ni}+\beta_{ni}(IR_{i,t}-R_{ft})+\varepsilon_{i,t}$. $NR_{i,t}$ and $IR_{i,t}$ denote the returns on the NAV of ETF and the benchmark $i$ in day $t$; and $R_{ft}$ denotes the risk free rate of return in day $t$. Beta, $\beta_{ni}$, in the model is the same as one in the Capital Asset Pricing Model that describes the relation of risk adjusted returns of ETFs and their benchmarks. The intercept, $\alpha_{ni}$, measures the performance of ETFs.

** Significant at 1%.

reports that the sum of the tracking errors is negative for all ETFs regardless of the region. In the case of Asia, however, the negative sums appear to be greater than the rest of the regions and where the smallest sums belong to the United States. This finding is in contradiction to the expectation of errors cancelling each other out or producing sums very close to zero despite a large sample of observations utilized in this study. Negative tracking errors lead us to expect negative risk premia in testing the performance of ETFs, which is consistent with negative Jensen's alpha results earlier. When we do the calculation without taking the absolute value, we still find $t$-test statistics statistically significant, further justifying earlier findings that ETFs underperform relative to their benchmarks.

### 5.4. *Persistence*

Fig. 2 plots the correlograms of the serial correlation on ETFs in Asian and the U.S. markets to check for persistence. The movements of serial correlation over seven lags in Asian markets seem to be more positively serially correlated than those in the U.S. market, in which serial correlations appear to be mostly spread around zero.

Table 7 reports the results of serial correlation tests by testing dependence of future price changes on historical price changes. Since serial correlation test examines the relationship between price changes in $t$ and $t-\tau$, future price changes may be predicted if the serial correlation coefficients

**Table 6**
Characteristics of tracking errors obtained from simple difference between the performances of ETFs and benchmarks.

| | (A) | (B) | (C) | (D) | (E) | Total | (F) | *t*-Statistics |
|---|---|---|---|---|---|---|---|---|
| Asia | | | | | | | | |
| EWA | 386 | 51.1 | 369 | 48.9 | 0 | 755 | −10.15 | −1.49 |
| EWH | 361 | 47.8 | 390 | 51.7 | 4 | 755 | −8.48 | −2.02** |
| EWJ | 362 | 47.9 | 393 | 52.1 | 0 | 755 | −3.35 | −2.32** |
| EWM | 342 | 45.3 | 379 | 50.2 | 34 | 755 | −10.39 | −1.92* |
| EWS | 377 | 49.9 | 378 | 50.1 | 0 | 755 | −9.52 | −1.55 |
| EWT | 344 | 45.6 | 397 | 52.6 | 14 | 755 | −6.59 | −2.39** |
| EWY | 377 | 49.9 | 372 | 49.3 | 6 | 755 | −3.32 | −1.22 |
| *Average* | 364.1 | 48.2 | 382.6 | 50.7 | 8.3 | 755 | −7.40 | −1.85 |
| Europe | | | | | | | | |
| EWD | 346 | 45.8 | 409 | 54.2 | 0 | 755 | −3.96 | −1.65* |
| EWG | 358 | 47.4 | 397 | 52.6 | 0 | 755 | −4.44 | −1.89* |
| EWI | 369 | 48.9 | 386 | 51.1 | 0 | 755 | −6.28 | −1.49 |
| EWK | 366 | 48.5 | 389 | 51.5 | 0 | 755 | −8.73 | −1.67* |
| EWL | 374 | 49.5 | 380 | 50.3 | 1 | 755 | −0.37 | −0.14 |
| EWN | 355 | 47.0 | 400 | 53.0 | 0 | 755 | −6.47 | −1.78* |
| EWO | 351 | 46.5 | 404 | 53.5 | 0 | 755 | −8.87 | −2.10** |
| EWP | 392 | 51.9 | 363 | 48.1 | 0 | 755 | −4.16 | −1.29 |
| EWQ | 351 | 46.5 | 404 | 53.5 | 0 | 755 | −4.57 | −1.98** |
| EWU | 327 | 43.3 | 428 | 56.7 | 0 | 755 | −10.40 | −2.10** |
| *Average* | 358.9 | 47.5 | 396 | 52.5 | 0.1 | 755 | −5.82 | −1.61 |
| America | | | | | | | | |
| EWC | 359 | 47.5 | 395 | 52.3 | 1 | 755 | −3.51 | −1.88* |
| EWW | 377 | 49.9 | 378 | 50.1 | 0 | 755 | −3.08 | −0.82 |
| EWZ | 377 | 49.9 | 378 | 50.1 | 0 | 755 | −9.53 | −0.50 |
| *Average* | 371.0 | 49.1 | 383.7 | 50.8 | 0.3 | 755 | −5.37 | −1.07 |
| US | | | | | | | | |
| ISI | 343 | 45.5 | 409 | 54.2 | 2 | 754 | −5.46 | −2.20** |
| IWV | 340 | 45.0 | 413 | 54.7 | 2 | 755 | −5.62 | −3.69** |
| IWW | 317 | 42.0 | 438 | 58.0 | 0 | 755 | −7.33 | −3.79** |
| IWZ | 336 | 44.5 | 418 | 55.4 | 1 | 755 | −3.66 | −3.83** |
| IYY | 332 | 44.0 | 422 | 55.9 | 1 | 755 | −5.48 | −3.75** |
| NYC | 328 | 43.4 | 427 | 56.6 | 0 | 755 | −6.92 | −3.59** |
| *Average* | 332.7 | 44.1 | 421.2 | 55.8 | 1.0 | 754.8 | −5.75 | −3.48 |

Table reports the sum of simple tracking errors – return on the ETF less return on the benchmark – and number of positive and negative errors. Numbers in each column are (A) Number of positive errors; (B) Percentage of positive errors; (C) Number of negative errors; (D) Percentage of negative errors; (E) Number of zero errors; and (F) Sum of daily errors (%).

* Significant at 10%.

** Significant at 5%.

are significant. In the 1-day lag, all ETFs in Asian markets exhibit positive and significant serial coefficients, which are larger than two standard errors, while only two out of six ETFs in the U.S. markets have positive and significant serial correlation coefficients. Furthermore, the significant relationships are maintained, on average, for 5.6 days in Asian markets and 4.7 days in European markets, while the U.S. markets maintain only 1.4 days when NYC is excluded, which has low liquidity with small number of outstanding shares.

Table 8 reports the results of runs test including the actual and expected number of runs and standardized variables. The finding that all of ETFs have larger 'expected' number of runs is consistent with the positive serial correlation coefficient findings. However, we note that the differences between actual and expected number of runs in the U.S. markets are much smaller in magnitude than those in Asian markets. The actual number of runs occurs significantly less than the expected (fitted) number of runs both in the U.S. and in the Asian markets. However, the difference (actual minus expected) between the actual and expected number of runs in the Asian market is much greater exhibiting less success in predicting the actual number of runs and more prone to error. This finding is consistent with the view that the Asian market is noisier in the dissemination of information.

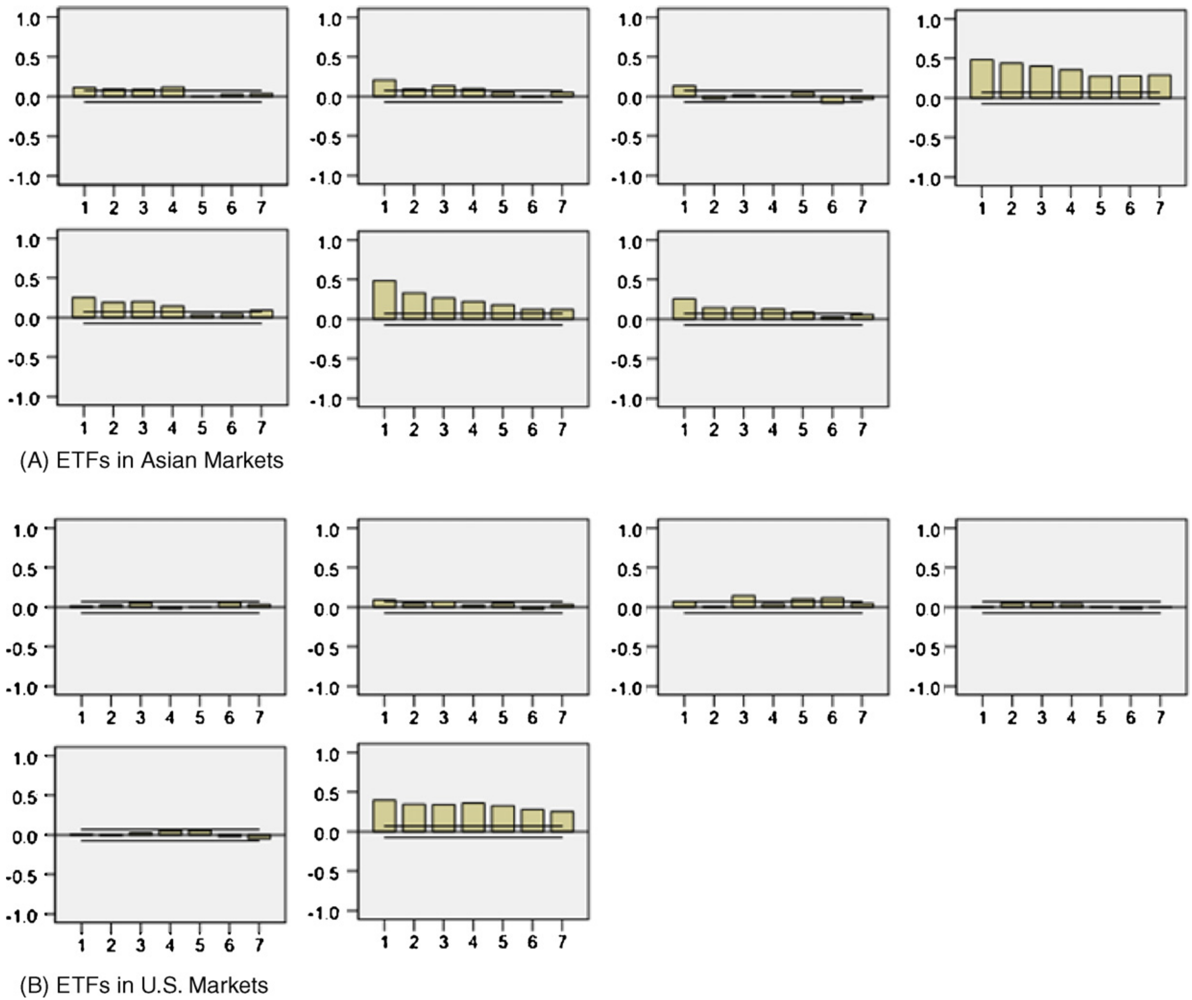


**Fig. 2.** Correlograms of the serial correlation on ETFs in Asian and the U.S. markets.

**Table 7**
Results of the serial correlation tests using the differences between market value and NAV of ETF.

| Area | Ticker | Lags | | | | | | | Std. error |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | |
| Asia | EWA | 0.115* | 0.095* | 0.088* | 0.119* | −0.001 | 0.028 | 0.039 | 0.036 |
| | EWH | 0.206* | 0.090* | 0.133* | 0.096* | 0.045 | −0.007 | 0.048 | 0.036 |
| | EWJ | 0.134* | −0.036 | 0.017 | −0.006 | 0.046 | −0.085 | −0.040 | 0.036 |
| | EWM | 0.483* | 0.438* | 0.400* | 0.356* | 0.274* | 0.277* | 0.290* | 0.036 |
| | EWS | 0.254* | 0.190* | 0.198* | 0.141* | 0.036 | 0.037 | 0.091 | 0.036 |
| | EWT | 0.485* | 0.332* | 0.267* | 0.220* | 0.182* | 0.121* | 0.120* | 0.036 |
| | EWY | 0.256* | 0.142* | 0.144* | 0.127* | 0.088* | 0.029 | 0.054 | 0.036 |
| Europe | EWD | 0.245* | 0.131* | 0.252* | 0.243* | 0.148* | 0.201* | 0.144* | 0.036 |
| | EWG | 0.048 | 0.039 | 0.137 | 0.123 | 0.029 | 0.060 | 0.048 | 0.036 |
| | EWI | 0.049 | 0.067 | 0.106 | 0.101 | 0.003 | 0.050 | 0.066 | 0.036 |
| | EWK | 0.337* | 0.318* | 0.341* | 0.287* | 0.233* | 0.240* | 0.217* | 0.036 |
| | EWL | 0.205* | 0.163* | 0.183* | 0.207* | 0.109* | 0.116* | 0.127* | 0.036 |
| | EWN | 0.147* | 0.137* | 0.203* | 0.200* | 0.136* | 0.143* | 0.133* | 0.036 |
| | EWO | 0.260* | 0.167* | 0.215* | 0.232* | 0.159* | 0.139* | 0.181* | 0.036 |
| | EWP | 0.107 | 0.074* | 0.179 | 0.162 | 0.095 | 0.086 | 0.114 | 0.036 |
| | EWQ | −0.034 | 0.027 | 0.090 | 0.054 | −0.002 | 0.019 | 0.014 | 0.036 |
| | EWU | 0.322* | 0.281* | 0.375* | 0.339* | 0.277* | 0.298* | 0.275* | 0.036 |
| America | EWC | 0.240* | 0.170* | 0.120* | 0.066 | 0.124 | 0.055 | 0.165 | 0.036 |
| | EWW | 0.139* | 0.067 | 0.129 | 0.109 | 0.022 | 0.057 | 0.096 | 0.036 |
| | EWZ | 0.102* | 0.045 | −0.017 | 0.112 | 0.097 | 0.024 | 0.013 | 0.036 |
| US | ISI | 0.014 | 0.028 | 0.048 | −0.025 | 0.000 | 0.058 | 0.033 | 0.036 |
| | IWV | 0.091* | 0.047 | 0.069 | 0.025 | 0.043 | −0.028 | 0.032 | 0.036 |
| | IWW | 0.071 | 0.008 | 0.144 | 0.039 | 0.099 | 0.115 | 0.043 | 0.036 |
| | IWZ | 0.001 | 0.049 | 0.052 | 0.038 | 0.001 | −0.025 | −0.004 | 0.036 |
| | IYY | 0.007 | −0.012 | 0.027 | 0.050 | 0.056 | −0.023 | −0.049 | 0.036 |
| | NYC | 0.397* | 0.344* | 0.340* | 0.359* | 0.326* | 0.279* | 0.254* | 0.036 |

Table reports the results of serial correlation tests by testing dependence of future price changes on historical price changes. Numbers in the column in 1–7 are the serial correlation coefficients, $\rho_\tau$, measuring the relationship between the value of a random variable in $t$ and its value in $t-\tau$ and is estimated by: $\rho_\tau = \mathrm{cov}(d_t, d_{t-\tau})/\mathrm{var}(d_t)$, where $d_t$ is the difference between NAV and market value of ETF in dollar at the close of day $t$, and length of lag $\tau = 1, 2, \ldots, 7$ is used. Since the sample size, $N$, for each ETF is large, the standard error of serial correlation coefficient is given by: $\sigma_\rho = (N-\tau)^{-1/2}$.

* Significant at 5%.

## 5.5. Determinants of ETF premiums/discounts

Table 9 reports the results of panel regression analyses using five variables that are postulated to affect ETF premiums/discounts. The results in column (A) are from the test of equation (14) using all 26 ETFs premiums/discounts. We see that with an exception of the changes in exchange rates, all variables have significant impacts on the ETF premiums/discounts. The positive coefficient of bid-ask price spread as a proxy for transaction costs perhaps implies that arbitrage activities are impeded by high transaction costs leading to high premiums/discounts. We also employ the trading volume as a measure of investors' beliefs for the fundamental value. The positive coefficient of trading volume supports the view that high level of trading volume indicates greater difference in beliefs. For the momentum variables, we have significant and positive coefficients for both 1- and 2-day lagged variables, suggesting that past information is not fully reflected in the current prices.

Column (B) reports the results of panel regression analysis using sample of the six of the U.S. and seven of Asian ETFs. Dummy variables are introduced to investigate what factors may cause ETFs to have discrepancy in the dissemination of information. We see that there are significant differences in bid-ask price spread, trading volume, 2-day lagged momentum, and funds capitalization between the U.S. and Asian ETFs. Most notably, the positive and statistically significant coefficient of the 2-day lagged momentum variable for Asian ETFs provides further evidence in favor of the Asian market being noisier in the dissemination of information than the U.S. market.

**Table 8**
Results of runs test.

| Area | Ticker | Total run | | | Run analysis | |
|---|---|---|---|---|---|---|
| | | $R$ | $m$ | $R-m$ | $K$ | $(R-m)/m$ |
| Asia | EWA | 309 | 368.37 | −59.37 | −4.913 | −0.161 |
| | EWH | 345 | 402.53 | −57.53 | −4.488 | −0.143 |
| | EWJ | 354 | 385.80 | −31.80 | −2.474 | −0.082 |
| | EWM | 213 | 409.58 | −196.58 | −15.086 | −0.480 |
| | EWS | 285 | 363.13 | −78.13 | −7.066 | −0.215 |
| | EWT | 283 | 391.70 | −108.70 | −8.027 | −0.278 |
| | EWY | 302 | 378.92 | −76.92 | −5.782 | −0.203 |
| Europe | EWD | 292 | 355.53 | −63.53 | −5.222 | −0.179 |
| | EWG | 380 | 397.88 | −17.88 | −1.373 | −0.045 |
| | EWI | 351 | 386.01 | −35.01 | −2.629 | −0.091 |
| | EWK | 291 | 354.85 | −63.85 | −5.427 | −0.180 |
| | EWL | 283 | 310.03 | −27.03 | −2.660 | −0.087 |
| | EWN | 322 | 369.03 | −47.03 | −3.833 | −0.127 |
| | EWO | 294 | 378.79 | −84.79 | −6.675 | −0.224 |
| | EWP | 320 | 382.61 | −62.61 | −4.830 | −0.164 |
| | EWQ | 391 | 401.21 | −10.21 | −0.755 | −0.025 |
| | EWU | 207 | 280.70 | −73.70 | −7.899 | −0.263 |
| America | EWC | 339 | 387.51 | −48.51 | −3.957 | −0.125 |
| | EWW | 335 | 395.81 | −60.81 | −4.554 | −0.154 |
| | EWZ | 303 | 393.39 | −90.39 | −6.736 | −0.230 |
| US | ISI | 378 | 397.79 | −19.79 | −1.453 | −0.050 |
| | IWV | 408 | 410.50 | −2.50 | −0.155 | −0.006 |
| | IWW | 374 | 409.80 | −35.80 | −2.731 | −0.087 |
| | IWZ | 414 | 414.29 | −0.29 | 0.017 | −0.001 |
| | IYY | 424 | 424.64 | −0.64 | −0.011 | −0.002 |
| | NYC | 355 | 366.61 | −11.61 | −0.911 | −0.032 |

Table reports the results of runs test including the actual and expected number of runs and standardized variables. 'Run' is defined as a sequence of price changes of the same sign. $R$ denotes the actual number of runs; $m$ is the total expected number of runs computed as $m=[N(N+1)-\sum_{i=1}^{3}n_i^2]/N$, where $N$ is the total number of price changes and $n_i$ is the number of price changes of each sign; $(R-m)$ is the difference between actual and expected runs; $K$ is the standard variable testing the significance of the difference between actual and expected number of runs and computed as $K=(R+1/2)-m/\sigma_m$ and $\sigma_m=[(\sum_{i=1}^{3}n_i^2(\sum_{i=1}^{3}n_i^2+N(N+1))-2N\sum_{i=1}^{3}n_i^3)-N^3/N^2(N-1)]^{1/2}$, where $R$ is the actual number of runs and $\sigma_m$ is the standard error of $m$; and $(R-m)/m$ is the standardized difference between actual and expected number of runs.

**Table 9**
Results of panel regression analyses.

| | (A) All ETFs | (B) U.S and Asian ETFs |
|---|---|---|
| SPRD | 0.0574 (0.0045)** | 0.0084 (0.0079) |
| DM × SPRD | | 0.1737 (0.0133)** |
| LnVolume | 0.0082 (0.0013)** | −0.0024 (0.0026) |
| DM × LnVolume | | 0.0100 (0.0042)* |
| Exchange Rate | 0.0011 (0.0023) | −0.0004 (0.0031) |
| Mom(−1) | 0.8017 (0.0082)** | 0.5334 (0.3418) |
| DM*Mom(−1) | | −0.2701 (0.4037) |
| Mom(−2) | 0.9751 (0.1146)** | 0.1610 (0.3413) |
| DM × Mom(−2) | | 1.2782 (0.4015)** |
| Cap | −0.0138 (0.0022)** | −0.0398 (0.0051)** |
| DM × Cap | | 0.0348 (0.0077)** |
| Constant | 0.1239 (0.0228)** | 0.2603 (0.0414)** |
| $R$-squared | 0.0398 | 0.0610 |

Table reports the results of panel regression analyses using five variables that may affect ETF premiums/discounts. Numbers in the column (A) are the coefficients (standard errors) from panel regression and the model can be expressed as: $d_{i,t}=b_0+b_1\cdot Sprd_{i,t}+b_2\cdot LnVol_{i,t}+b_3\cdot ExchRate_{i,t}+b_4\cdot Mom_{i,t-1}+b_5\cdot Mom_{i,t-2}+b_6\cdot Cap_{i,t}+\varepsilon_{i,t}$, where $d_{i,t}$ is the premiums/discounts of ETF $i$ in the day $t$; $Sprd_{i,t}$ is the difference between the highest bid and the lowest ask prices; $LnVol_{i,t}$ is the natural logarithm of daily trading volume; $ExchRate_{i,t}$ is the changes in exchange rates; $Mom_{i,t-j}$ is the momentum in the NAVs in the day $t-1$ and $t-2$; and $Cap_{i,t}$ is the natural logarithm of the ETF's market capitalization. Numbers in the column (B) are the coefficients (standard errors) from panel regression. The model in the column (B) is tested using the sample of the U.S. and Asian ETFs with dummy variable and the model can be expressed as: $d_{i,t}=c_0+c_1\cdot Sprd_{i,t}+c_2\cdot DM_i*Sprd_{i,t}+c_3\cdot LnVol_{i,t}+c_4\cdot DM_i*LnVol_{i,t}+c_5\cdot Exchrate_{i,t}+c_6\cdot DM_i*Exchrate_{i,t}+c_7\cdot Mom_{i,t-1}+c_8\cdot DM_i*Mom_{i,t-1}+c_9\cdot Mom_{i,t-2}+c_{10}\cdot DM_i*Mom_{i,t-2}+c_{11}\cdot Cap_{i,t}+c_{12}\cdot DM_i*Cap_{i,t}+\varepsilon_{i,t}$, where $DM_i$ denotes the dummy variable that is 1 if ETF $i$ mimics Asian market or 0 if ETF $i$ mimics the U.S. market.

* Significant at 5%.
** Significant at 1%.

## 6. Conclusion

In this study, we estimate tracking errors and relative performance of 26 exchange-traded funds (ETFs) over their benchmark indexes. We find tracking errors to be statistically significant and negative. Further, statistically significant alpha values from testing the relative performance of ETFs support the existence of tracking errors. With regard to the factors affecting tracking errors, the change in the exchange rate is found to be an important factor impacting tracking errors. Naturally, ETFs benchmarking foreign markets are exposed directly to the exchange rate risk unlike those benchmarking the U.S. markets. Therefore it seems reasonable to find exchange rate changes significantly affecting tracking errors.

The examination of market reaction to the premiums/discounts in different countries reveals that on average, ETFs in Asian markets take about 4 days or more of positive autocorrelation coefficients than those belonging to the U.S. markets. The results of runs test also show substantially larger gaps between actual and expected number of runs from ETFs in Asian markets than those from ETFs in the U.S. markets. The results of the two tests consistently indicate that Asian markets are more likely to depend on past performance. Furthermore, the results from panel regression analysis exhibit that premiums/discounts of Asian ETFs have a significant and positive relationship with the 2 days lagged momentum variable while those of the U.S. ETFs have no relationship. In all, Asian markets when compared with the U.S. markets, display relatively greater persistence. Therefore Asian markets appear to be less efficient in disseminating information and noisier in filtering of information contained in returns.

Through these empirical results, we identify the following contributions to the international financial management literature. The finding of negative Jensen's alphas implies that investing in ETFs does not provide a significant benefit compared to their benchmark returns. Authorized participants provide liquidity of the ETF shares and ensure that market price approximates to the NAV of the underlying assets. Our findings indicate that there appears to be a greater divergence between market price and NAV of ETFs for the Asian markets relative to the U.S. Therefore, the liquidity risk appears to be relatively higher for Asian ETFs. A noisy market may result in prolonged periods of mispricing due to momentum trading and speculative behavior away from fundamental value. When only ETFs from different regions are compared, a relatively active ETF investment strategy may be more appropriate for Asian markets which are found to be noisier than the U.S. markets. Lastly, with exchange rate positively related to the tracking errors, a depreciation of the U.S. dollar causes tracking errors to be greater. Therefore, the findings are consistent with the view that investors may benefit from a depreciating dollar by investing in ETFs from Asian markets that have greater tracking errors than the U.S. markets.

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