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Performance Dynamics of International Exchange-Traded Funds

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Abstract: Asynchronous trading hours between the markets of Exchange-Traded Funds (ETFs) and their benchmarks not only make it difficult to apply a *full replication strategy* but also make the *creation/redemption process* ineffective and consequently distress the performance of international ETFs. Despite the exponential growth of the ETF industry in general and international ETFs in particular, the performance of international ETFs is under-researched. Therefore, this study evaluates the performance of US-listed international ETFs by analyzing the returns, volatilities, tracking ability and pricing efficiency. The study findings are useful for investors interested in understanding the performance dynamics of international ETFs.

Keywords: ETFs; return and volatility; tracking error; premium and discount

1. Introduction

Despite persistent economic and political volatility, the Exchange-Traded Fund (ETF) industry continues to experience popularity and growth since the invention of the first ETF. In the process, it broke new records in terms of numbers of ETFs and assets under management (AuM), Strong growth in exchange-traded fund (ETF) assets is expected to continue with assets under management (AuM) on track to reach US $7 trillion by 2021 (PwC 2016). However, by the end of 1997, there were only two ETFs with an AuM value of US$ 6.2 billion (Ferri 2011).

This growth of the ETF industry is not just in scale but in sophistication as well. There is now a variety of ETFs catering different investment needs of the global investors, and international ETFs are one of these sophisticated types of ETFs. International ETFs were first introduced in 1996 by Black Rock Inc., the world's largest ETF provider (Chen and Nicholas 2020). The objective of international ETFs is to facilitate every investor, including institutional and retail investors, to directly invest and obtain exposure to promising global capital market indices from their home country stock exchanges (Levy and Lieberman 2013). Previously it was difficult for investors to directly invest in certain foreign markets due to a number of restrictions on international capital flow such as capital market, exchange rules and regulations, extreme transaction costs and higher costs of information (Chang et al. 1995). For example, international investors need QFII (qualified foreign institutional investor) license to trade in the Chinese "A-share" market, which comprises of the 75% of the total market capitalization of over 2000 Chinese firms (Mistry 2013). These barriers have stimulated the innovation of many investment products to facilitate international investment. These products include International Mutual Funds, American Depository Receipts (ADRs), Closed-End Country Funds (CECFs) and International ETFs, which are the most popular of all. This is because of their unique hybrid structure, which simultaneously possesses the characteristics of stocks and mutual funds.

In addition, international ETFs bear some very distinguishing features such as continuous trading, higher international diversification, lower management fee and higher tax efficiency (Rompotis 2015) but at the same time, they may suffer from the issues of great importance such as pricing inefficiency and tracking error. According to Engle and Sarkar (2006), international ETFs trade at a larger premium or discount and more persistent compared to the domestic ETFs. This is because of the difference in trading hours between the markets of international ETFs and benchmark indices. Hughen and Mathew (2009) argue that asynchronous trading hours causes information asymmetry in ETFs' market, which does not let international ETFs fully replicate the performance of their underlying indices.

The motivation of this study is twofold. The first is to employ the type of 'replication strategies' used by international ETFs to mirror the performance of their underlying indices. Generally, passively-managed ETFs use physical (either full or optimized) strategies and actively-managed ETFs employ synthetic replication strategies to mirror the performance of their benchmarks. The physical replication strategies are relatively expensive in terms of transaction costs (which refers to the buying and selling of underlying securities. It is not included in the expense ratio (or management fee) charged by the ETF issuers), especially for broad indices that are composed of hundreds of securities or indices which consist of volatile and illiquid securities (Maurer and Williams 2015). According to Dickson et al. (2013), the ETFs (whether domestic or international), following any physical replication strategy, are less likely to consistently track their benchmark indices and expose investors to the risk of tracking error. Svetina (2010) compares the tracking performance of domestic ETFs to international ETFs and confirms that the tracking error of international ETFs is more than double that of domestic ETFs.

The second is to assess the unique *Creation/Redemption process* of ETFs, which takes place in the primary market between the authorized market makers and the ETF issuer. Thus, the Creation/Redemption of ETF shares immediately arbitrages away the price discrepancies of ETFs in the secondary market (i.e., the stock exchange). Ma (2015) argues that the Creation/Redemption process is effective only if the ETF shares and underlying securities are traded synchronically, as in the case of domestic ETFs; however, for International ETFs there are asynchronous trading hours between the markets of international ETFs and benchmark indices. For instance, Asian-Pacific markets have completely asynchronous trading hours with the US market, while the European markets only have partially synchronous trading hours with the US market (Levy and Lieberman 2013). In such cases, the arbitrage mechanism becomes ineffective (Campbell et al. 1997). Consequently, the trading prices of international ETFs fluctuate during the US trading day while their net asset values (NAVs) remain stale and thus make international ETFs to trade at large premiums or discounts compared to their underlying foreign stale NAVs (Shum 2010).

This study empirically examines the performance of US-listed international ETFs offering exposure to the Asia-Pacific and the European markets. Our particular interest is to evaluate the trading performance of the US-listed international ETFs in terms of return and volatility, tracking efficiency and pricing efficiency. This study has several distinct contributions to the extant literature on international ETFs. First, the study examines the distinguishing behavior of returns and volatility estimated in trading prices and NAVs of international ETFs. Second, it provides intraday and overnight return and volatility analyses of international ETFs. Third, the study investigates how well the international ETFs track the performance of their benchmark indices using three different measures of tracking error; also, in case there is any tracking error, the study also determines the persistence of tracking error using the second-order autoregressive AR (2) model. Finally, we evaluate the pricing efficiency of international ETFs in terms of premiums or discounts and test whether premiums or discounts persist over time using the second-order autoregressive AR (2) model.

The remaining of the paper is organized as follows. Section 2 discusses the previous empirical literature on the performance of international ETFs. Section 3 presents the methodology, Section 4 is about the sample of the study while Section 5 discusses results and conclude the study.

2. Literature Review

Ever since the introduction of the first international ETF in 1996, several studies have endeavored to analyze the performance and efficiency of international ETFs by considering their daily, intraday and overnight returns and volatilities, tracking efficiency (Purohit et al. 2014; Ramos 2015) and pricing efficiency (Delcoure and Zhong 2007; Engle and Sarkar 2006).

The returns and volatilities of international ETFs are calculated in terms of their trading prices or their NAV. Previous studies (e.g., (Rompotis 2015; Tse and Martinez 2007)) compare returns and return volatilities estimated using trading prices and NAV. Rompotis (2015) reports that the mean NAV return is higher than the closing price return, whereas the closing price return variance is found to be higher than the NAV return variance. Moreover, Tse and Martinez (2007) perform return variance analyses and report that the closing price return variance is higher than the NAV return variance. Tse and Matinez further argue that the higher differences between price return variance and the NAV return variance indicate the existence of more *noise trading* of international ETFs.

For a more precise understanding of the return and volatility behavior of international ETFs, many previous studies (Gutierrez et al. 2009; Kang and Babbs 2012; Tse and Martinez 2007) separately measure and compare the intraday and overnight returns and the volatilities of international ETFs. Some studies find that the overnight mean returns are greater than the intraday mean returns; other studies find contrary results that mean returns during the trading hours are greater compared to during non-trading hours. According to Tse and Martinez (2007), the intraday and overnight mean return variances of international ETFs are 62% and 77%, respectively. In another study by Gutierrez et al. (2009) the overnight return volatility is also found to be higher than the intraday return volatility for the case of ETFs tracking Asian indices; the authors attributed their findings to the release of public information during the trading session of the underlying markets. In addition, Kang and Babbs (2012) examine fifteen equity ETFs and find that overnight returns on the funds have higher means, lower variances and distributions with fatter tails than intraday returns.

Engle and Sarkar (2006) emphasize the importance of another important performance metric (i.e., pricing efficiency) of the international ETFs. They argue that the pricing inefficiencies in international ETFs are relatively more persistent and difficult to eliminate through the creation/redemption process. Several previous studies (Ackert and Tian 2008; Delcoure and Zhong 2007; Levy and Lieberman 2013) endorse that the deviations of the trading price of international ETFs from their NAVs are more material, frequent and persistent compared to other ETF types. Engle and Sarkar (2006) compare the pricing efficiency of 21 domestic and 16 international ETFs on a daily and intra-day basis. They find that domestic ETFs have very small premiums that last for few minutes while international ETFs have larger and more persistent premiums that last for three hours or take longer to adjust. The findings of Ackert and Tian (2008) are also consistent with the findings of Engle and Sarkar (2006). Ackert and Tian (2008) examine the pricing efficiency of 7 domestic and 21 international ETFs and conclude that international ETFs trade at a larger premium compared to the domestic ETFs. However, Delcoure and Zhong (2007) exclusively sample 20 international ETFs and find that these ETFs trade at significant premiums which usually persist for one or two days. Moreover, Levy and Lieberman (2013) study 17 US-listed international ETFs and find that the prices of these ETFs are mainly driven by their NAVs during the synchronized trading hours while during the asynchronous trading hours, the S&P 500 Index has the dominant effect on the pricing of international ETFs.

Tracking ability is another important performance metric of the international ETFs. The tracking ability is the ability of international ETFs to replicate the performance of their foreign tracking indices. A number of studies (Blitz and Huij 2012; Shin and Soydemir 2010; Svetina 2010) report the tracking error of international ETFs. Blitz and Huij (2012) compare the tracking efficiency of international ETFs tracking of developed and developing market indices and report that the tracking errors of international ETFs with developing markets' benchmark indices are greater than the tracking errors indices of developed markets. However, Svetina (2010) notes a higher tracking error for international ETFs compared to for domestic ETFs, suggesting transaction costs as the possible reason for this.

Moreover, Shin and Soydemir (2010) find that ETFs tracking foreign indices are exposed directly to the exchange rate risk, unlike those that track the U.S. indices. This is why the tracking error of international ETFs is relatively higher than that of domestic ETFs.

3. Data and Research Design

The sample of this study comprises of 56 US-listed international ETFs offering Asia-Pacific and European market exposure to investors. All constituents of the sample have following characteristics in common: (1) they are created by Black Rock with the iShares brand; (2) they all are listed on US exchanges; (3) they either track single-country or broad-market indices of Asia-Pacific and Europe; (4) they all are passively-managed ETFs; and (5) the underlying indices of all sample ETFs are equity focused; as different asset classes have different dynamics, we limited the scope of this study to only select international ETFs which track the performance of equity-based tracking indices. Daily historical data of sample ETFs were downloaded from the Bloomberg database for a 10 years' time span from 1 January 2010 to 31 December 2019. The profiles of sample international ETFs are given in Appendix A.

The scope of this study is to evaluate the performance of international ETFs by analyzing the (1) daily, intraday (trading hours) and overnight (non-trading hours) performance, (2) the tracking performance and persistence of tracking error and (3) the pricing inefficiency and persistence of premiums or discounts. More detail is given in Table 1.

Table 1. Research design.

Performance Metrics		Method
(1)	Return and risk analyses of international ETFs	Analyze daily return and volatility of international ETFs Analyze intraday and overnight return and volatility of international ETFs
(2)	Tracking performance of international ETFs	Measure tracking error in international ETFs Examine the persistence of tracking error in international ETFs over time.
(3)	Pricing inefficiency of international ETFs	Measure pricing inefficiency of international ETFs Examine the persistence of pricing inefficiency of international ETFs over time.

Note: This table explains the complete research design of the study.

4. Empirical Results

4.1. Return and Volatility Analyses of International ETFs

4.1.1. Does the Measurement of Daily Return and Volatility of International ETFs in Terms of Trading Price and NAV Matter?

ETF investors receive the NAV returns (Rompotis 2015) and the associated cash flows e.g., dividend payments of the underlying can flow to the ETF shares, as a percentage of NAV on their investments while most of the retail investors calculate returns in trading price which are more frequently and easily available compared to the NAVs. We, therefore, compute the returns of international ETFs both in trading prices and in NAVs to determine if there is any significant difference in the two returns series. Likewise, the study also examined the differences in volatilities of the trading price return and the NAV return.

Our findings in Table 2 suggest that the mean NAV return (volatility) is higher (lower) than the mean trading price return (volatility) of both Asia-Pacific and European ETFs. These results are consistent with the findings of Pontiff (1997) on close-end funds and Rompotis (2015) on country ETFs; both reports suggest that the trading prices are more volatile than their NAVs. On the basis of benchmarks, the returns ratio ($R_{ETF}/R_{NAV} = 0.8367$) and the volatilities ratio ($\sigma_{ETF}/\sigma_{NAV} = 1.0732$)

for European ETFs are closer to one, reflecting that European ETFs are better than the Asia-Pacific ETFs, which is consistent with the findings of Shin and Soydemir (2010).

Table 2. Daily return and volatility analyses of International Exchange-Traded Funds (ETFs).

	Asia-Pacific ETFs			European ETFs		
	Price-Based	**NAV-Based**	**Ratio**	**Price-Based**	**NAV-Based**	**Ratio**
	(a)	**(b)**	**(a/b)**	**(c)**	**(d)**	**(c/d)**
Return	0.0054	0.0080	0.6750	0.0041	0.0049	0.8367
Volatility	1.6445	1.4143	1.1627	1.6511	1.5384	1.0732

Note: This table reports daily mean values of the trading price return (R_{ETF}), the NAV return (R_{NAV}), trading price return volatility (σ_{ETF}), the NAV return volatility (σ_{NAV}); the table also reports two corresponding ratios: first between the trading price and the NAV returns (R_{ETF}/R_{NAV}) and second between the trading prices and the NAV return volatilities $(\sigma_{ETF}/\sigma_{NAV})$ for the sample Asia-Pacific and European ETFs. If the ratio (R_{ETF}/R_{NAV}) is greater than one, it implies that the trading price return is higher than the NAV return and vice versa. On the other hand, if the ratio $(\sigma_{ETF}/\sigma_{NAV})$ is greater than unity, it means that the volatility in trading price return is higher than the NAV return volatility.

4.1.2. What Is the Difference between Intraday and Overnight Performance of International ETFs?

In order to determine the difference between the volatilities during the trading and non-trading hours and to identify the cause of that difference, we compared the standard deviations of intraday and overnight returns of international ETFs. In previous literature (Chan et al. 2000; Rompotis 2015; Tse and Martinez 2007), the volatility in the assets traded on the stock markets was ascribed to one of three factors: the release of accumulated public information, more noise trading during the trading hours or the release of more private information. To be more specific, the return volatility is either linked to the trading activity (e.g., the noise trading or the release of private information) or the information flow (e.g., the release of accumulated public information). The possible reason for the earlier relationship is the synchronous trading hours, while the reason for the latter is due to the asynchronous trading hours between ETFs and their benchmark.

Therefore, if volatility is caused by the release of accumulated public information, then overnight return volatility is greater than the intraday return volatility of ETFs, which are asynchronous in trading hours compared to their benchmarks indices; otherwise, for the case of synchronous trading hours between ETFs and their benchmarks, intraday return volatility is greater than overnight return volatility. If noise trading or release of private information causes the volatility, then intraday return volatility is seen to be greater than the overnight return volatility of ETFs.

Our findings show that intraday return (volatility) is lower (higher) than the overnight return (volatility), irrespective of the benchmark market (see Table 3). Based on our findings, we can conclude that the release of accumulated public information during the trading hours is the reason for higher overnight return volatility compared to the intraday return volatility of international ETFs with asynchronous trading hours as their underlying indices. On the bases of benchmarks, the returns ratio $\left(R_{day}/R_{night} = 0.8108\right)$ and the volatilities ratio $\left(\sigma_{day}/\sigma_{night} = 0.8635\right)$ for European ETFs are closer to one, reflecting that European ETFs are better than the Asia-Pacific ETFs. Our findings, that the overnight return volatility among European ETFs is relatively lower than the overnight return volatility of Asia-Pacific ETFs, support the argument that European markets are relatively more matured and developed, even though they only have partial synchronous trading hours with the US market while the Asia-Pacific market has full synchronous trading hours with the US market (Levy and Lieberman 2013).

Table 3. Intraday and overnight return and risk analyses.

	Asia-Pacific ETFs			European ETFs		
	Intraday	**Overnight**	**Ratio**	**Intraday**	**Overnight**	**Ratio**
	(a)	**(b)**	**(a/b)**	**(c)**	**(d)**	**(c/d)**
Return	0.0080	0.0149	0.5369	0.0090	0.0111	0.8108
Volatility	1.0270	1.3137	0.7817	1.0368	1.2006	0.8635

Note: This table reports the mean values of the intraday return $\left(R_{day}\right)$, overnight return $\left(R_{night}\right)$, intraday return volatility $\left(\sigma_{day}\right)$, overnight return volatility $\left(\sigma_{night}\right)$; the table also reports a pair of corresponding ratios: first between the intraday and overnight returns $\left(R_{day}/R_{night}\right)$ and second between the intraday and overnight return volatilities $\left(\sigma_{day}/\sigma_{night}\right)$. If the ratio $\left(R_{day}/R_{night}\right)$ is greater than one, it implies that intraday return is higher than the overnight return and vice versa. However, if the ratio $\left(\sigma_{day}/\sigma_{night}\right)$ is greater than unity, it means that intraday return volatility is higher than overnight return volatility.

4.2. Tracking Ability of International ETFs

4.2.1. Do International ETFs Exactly Mimic the Underlying Benchmarks?

The term 'tracking error' refers to the deviation in returns of passively managed investment products and their benchmarks, whose performance they try to imitate (Pope and Yadav 1994). The literature (Frino and Gallagher 2001; Pope and Yadav 1994; Roll 1992) on the index funds suggests several methods to measure tracking error such as the average raw return difference between the passive funds and the indexes. Following Frino and Gallagher (2001), we used two methods to estimate tracking error. The first method estimates tracking error as the average term of the absolute differences in ETF and their benchmark returns. The second method computes tracking error as the standard deviation of the daily differences in ETF and their benchmark returns. Finally, we calculated the average of the tracking errors estimated using the two aforementioned methods.

Once the estimation tracking errors were obtained using the trading price returns, we repeated the method to estimate NAV returns. The purpose of calculating the tracking errors in trading price and NAV returns is to compare and determine which one of the two is superior in tracking their underlying indices.

Our results, as reported in Table 4, show that the average tracking errors based on NAV returns are lower than the average tracking errors based on trading prices return, regardless of the benchmark market. This implies that NAV is more efficient in tracking the performance of underlying indices than the trading prices. The tracking errors in terms of trading price returns are inflated, indicating that the trading price provides an unreliable ETF performance measure relative to the NAV. We also note that European ETFs are superior in tracking efficiency compared to the Asia-Pacific ETFs. For the European ETFs, the mean TE in terms of trading price returns and NAV returns are 0.7359% and 0.0850%, which are significantly lower compared to the mean values of the Asia-Pacific ETFs which are 1.0246% and 0.1178%, respectively. Our findings, on the superior tracking abilities of the European ETFs over the Asia-Pacific ETFs, are consistent with the results of Shin and Soydemir (2010).

Table 4. Tracking errors of International ETFs.

	Asia-Pacific ETFs		European ETFs	
	Tracking Error between R_{ETF} and R_{Ind}	**Tracking Error between R_{NAV} and R_{Ind}**	**Tracking Error between R_{ETF} and R_{Ind}**	**Tracking Error between R_{NAV} and R_{Ind}**
TE_1	0.9270	0.1034	0.6593	0.0764
TE_2	1.1222	0.1323	0.8125	0.0937
Mean TE	1.0246	0.1178	0.7359	0.0850

Note: This table presents the tracking errors of Asia-Pacific and European ETFs estimated in both trading price return and NAV return. We used two methods to estimate tracking error: (1) the absolute difference in trading price (or NAV) returns and its benchmark returns, and (2) the standard deviation of the difference in trading price (or NAV) returns and its benchmark returns. The mean TE of the two both methods are also reported in this table.

4.2.2. Does the Tracking Error in International ETFs Persist over Time?

Having computed the tracking error, we next investigated the persistence of tracking error in international ETFs. To examine the persistence, we estimated the second-order autoregressive model AR (2) by regressing the tracking error on the values of two lagged day as follows:

$$TE1_{ETF,t} = \alpha + \beta_1 TE1_{ETF,t-1} + \beta_2 TE1_{ETF,t-2} + \varepsilon_t \tag{1}$$

$$TE1_{NAV,t} = \alpha + \beta_1 TE1_{NAV,t-1} + \beta_2 TE1_{NAV,t-2} + \varepsilon_t \tag{2}$$

where $TE1_{ETF,t}$ is the average absolute difference between trading price return of ETFs and their corresponding benchmark returns and $TE1_{NAV,t}$ is the average absolute difference between NAV return of ETFs and their corresponding benchmark returns. The positive and significant β_1 and β_2 coefficients imply that the tracking error persists for one and two days, respectively; the negatively significant estimates mean that the tracking error exhibits mean-reverting behavior. Finally, non-significant β_1 and β_2 coefficients show the lack of persistence and significant *alpha* (α) indicates that a constant portion of replication inefficiency remains unexplained by the lagged values of tracking error.

The results of autoregressive modes reveal that *alpha* (α) coefficients are statistically significant irrespective of the underlying markets (i.e., Asia-Pacific and European markets) and the types of tracking errors (i.e., $TE1_{ETF,1}$ and $TE1_{NAV,1}$). These results imply that a significant portion of tracking errors remain unexplained by their lagged values. For both Asia-Pacific and European ETFs, the *alpha* (α) coefficients are higher for tracking errors based on trading price returns compared to the NAV return based tracking errors, which shows that tracking errors based on NAV returns is relatively more efficient and can be mainly explained by their lagged values.

In terms of the impact of past values, the β_1 and β_2 coefficients are positive and significant for both Asia-Pacific and European ETFs, implying that the tracking errors persist in almost all international ETFs for two days but it diminishes over time, as $\beta_2 < \beta_1$. We also note that tracking errors are less persistent in European ETFs and quickly fade away compared to for the Asia-Pacific ETFs, since the magnitude of β_1 and β_2 coefficients for European ETFs (see Column 3 and 4 in Table 5) are less than that of Asia-Pacific ETFs (see Column 1 and 2 in Table 5). In addition, we also found that the tracking efficiency in terms of NAV returns is higher relative to the trading price return, meaning that tracking errors more quickly diminish if they are measured using the NAV. The magnitude of β_1 and β_2 coefficients for NAV based tracking errors (see Column 2 and 4 in Table 5) are less than that of trading price return based tracking errors (see Column 1 and 3 in Table 5) in both Asia-Pacific and European ETFs. These results are consistent with our baseline results indicating that NAV is the better performance indicator and that European ETFs are more efficient. For the robustness of our results, we re-ran our analyses with a maximum of four lagged values of tracking error but our results (unreported) remain unchanged, which confirms the significant persistence of the tracking error for two days.

Table 5. Persistence of tracking errors in international ETFs.

	Asia-Pacific ETFs		European ETFs	
	$TE1_{ETF,t}$	$TE1_{NAV,t}$	$TE1_{ETF,t}$	$TE1_{NAV,t}$
	(1)	**(2)**	**(3)**	**(4)**
α	0.5861 *** (0.1243)	0.0343 *** (0.0189)	0.2751 *** (0.0987)	0.0656 *** (0.0325)
β_1	0.5657 *** (0.2570)	0.4999 *** (0.2578)	0.4306 *** (0.2450)	0.2217 *** (0.0781)
β_2	0.2534 *** (0.0370)	0.1494 *** (0.0250)	0.137 *** (0.0283)	0.0855 *** (0.0480)
$Number\ of\ ETFs$	28	28	28	28
$Number\ of\ Observations$	2120	2120	2250	2250
$F-Stat\ (p-value)$	0.000	0.000	0.000	0.000
R^2	0.2728	0.2542	0.3034	0.0827

Note: This table reports the results of model (1): $TE1_{ETF,t} = \alpha + \beta_1 TE1_{ETF,t-1} + \beta_2 TE1_{ETF,t-2} + \varepsilon_t$ and model (2): $TE1_{NAV,t} = \alpha + \beta_1 TE1_{NAV,t-1} + \beta_2 TE1_{NAV,t-2} + \varepsilon_t$. Prior to applying autoregressive models, we examined the random walk characteristics of the tracking errors measured in trading price and NAV using Lo and MacKinlay's (1988) individual variance ratio and Chow and Denning's (1993) multiple variance ratio with homoscedastic and heteroscedastic test estimates. Also in unreported results, we found that the tracking errors of both Asia-Pacific and European ETFs do not follow the random walk and can be predictable based on the historical values. The standard errors for the estimated coefficients are heteroscedasticity and autocorrelation consistent standard errors (Newey and West 1987). "***" represents the significance at the 1% level.

4.3. Pricing Inefficiency of International ETFs

4.3.1. Do International ETFs Suffer from Pricing Inefficiency?

The trading prices of international ETFs generally deviate from their NAVs (Delcoure and Zhong 2007) and ETFs either trade at a premium or a discount to their NAVs. To measure the pricing efficiency in terms of the premium and discount, we used two methods. First, we calculated the difference between the closing price of ETF on day t and the closing NAV of ETF on day t and scaled this by the closing NAV of ETF on day t.

We then regressed the trading price of ETF on its NAV using the ordinary least square (OLS) method, which is a method for measuring the pricing discrepancies in international ETFs.

$$CP_{ETF,t} = \alpha + \beta_1 CP_{NAV,t} + \varepsilon_t \tag{3}$$

International ETFs are efficiently priced if the β_1 coefficient is statistically significant and equals to one; however, if the coefficient is statistically significant but different from unity, then this indicates the pricing discrepancies in international ETFs. In particular, the significant and greater than one β_1 coefficient indicates that international ETFs trade at a discount to their NAVs; the significant but less than one β_1 coefficient suggests that international ETFs trade at a premium to their NAVs.

With regard to pricing inefficiency, the fact that our results of percentage estimates and OLS regression were not different, as reported in Table 6; both measures confirm that Asia-Pacific and European ETFs trade at a premium and that European ETFs are relatively more price efficient. We specifically found that the β_1 coefficient for Asia-Pacific and European ETFs is not equal to one and trades at a premium of 2.10 bps and 0.99 bps to its Asia-Pacific and European NAV, respectively. However, the percentage estimates of Asia-Pacific and European ETFs premium were higher but consistent with OLS results. Overall, we found that international ETFs are not efficiently priced and trade at a premium. Also, European ETFs are relatively more price efficient compared to the Asia-Pacific ETFs because of their lower premium whether they are estimated by percentage or OLS regression approaches.

Table 6. Pricing inefficiency of international ETFs.

	Asia-Pacific ETFs	**European ETFs**
Premium (in %)	0.0905	0.0312
OLS Regression:		
α	0.0451 *** (0.0251)	0.0027 *** (0.0008)
β_1	0.9790 *** (0.5514)	0.9901 *** (0.4215)
Number of ETFs	28	28
Number of Observations	2120	2250
$F-Stat\ (p-value)$	0.0000	0.0000
R^2	0.9966	0.9985
$Premium = \lvert\beta_1 - 1\rvert$	0.0210	0.0099

Note: This table reports the percentage premium and the estimates of model (3): $CP_{ETF,t} = \alpha + \beta_1 CP_{NAV,t} + \varepsilon_t$ for Asia-Pacific and European ETFs. Prior to running the OLS regression, we tested for the stationarity of trading prices and NAVs series using variance ratio tests. Also, in unreported results, we found that both the trading price and NAV series are stationary by nature. The standard errors for the estimates are heteroscedasticity and autocorrelation consistent standard errors (Newey and West 1987). "***" represents the significance at the 1% level.

4.3.2. Does the Pricing Inefficiency Persist over Time in International ETFs?

Finally, in order to examine that how persistent is the pricing deviation in international ETFs, we regressed the $Premium_t$ on its two day lagged values using the second-order autoregressive model AR (2)

$$Premium_t = \alpha + \beta_1 Premium_{t-1} + \beta_2 Premium_{t-2} + \varepsilon_t \tag{4}$$

where $Premium_t$ represents the magnitude of premium or discount at which international ETFs trade on day t.

Table 7 reports the results on persistence of pricing inefficiency in international ETFs. we found that the *alpha* (α) coefficients are statistically significant for Asia-Pacific and European ETFs, though economically they are below 05 bps and have no material contribution to the premium or discount of international ETFs. This implies that intrinsic frictions in the pricing induce the deviation between the trade prices and NAVs of international ETFs. Also, similarly to the persistence of tracking error, pricing inefficiency in the international ETFs also persisted for two days but it faded away as the tracked time moved from one to two lagged days, as $\beta_2 < \beta_1$. We concluded that there exist significant arbitrage opportunities in international ETFs, which remain available for two days in most of the cases. For the robustness of our results, we re-ran our analyses with a maximum of four lagged values of premium but our results (unreported) remained unchanged and confirmed the significant persistence of pricing inefficiency for two days.

Table 7. Persistence of pricing inefficiency in international ETFs.

	Asia-Pacific ETFs	**European ETFs**
α	0.0458 *** (0.0247)	0.0319 *** (0.0124)
β_1	0.3450 *** (0.1234)	0.1145 *** (0.0654)
β_2	0.1018 *** (0.0600)	0.0984 *** (0.0551)
Number of ETFs	28	28
Number of Observations	2120	2250
$F-Stat\ (p-value)$	0.000	0.000
R^2	0.3033	0.3897

Note: This table reports the estimates of model (4): $Premium_t = \alpha + \beta_1 Premium_{t-1} + \beta_2 Premium_{t-2} + \varepsilon_t$. The standard errors for the estimates are heteroscedasticity and autocorrelation consistent standard errors (Newey and West 1987). "***" represents the significance at the 1% level.

5. Conclusions

This study evaluates the performance of international ETFs by analyzing their (1) daily, intraday (trading hours) and overnight (non-trading hours) returns and return volatilities, (2) tracking performance and persistence of tracking error and (3) pricing efficiency and persistence of premiums or discounts. Our study sample comprised of 56 US-listed international ETFs, offering exposure to the Asia-Pacific and European markets. Daily historical data was downloaded from Bloomberg for a 10 years' time span from 1 January 2010 to 31 December 2019.

We found that the NAV returns (volatilities) are superior in performance relative to the trading price returns (volatilities) of Asia-Pacific and European ETFs. Next, the comparison of intraday returns (volatilities) and overnight returns (volatilities) revealed that the overnight performance of both Asia-Pacific and European ETFs is relatively better than the intraday performance. Furthermore, our findings indicated that both Asia-Pacific and European ETFs suffer from tracking and pricing errors which persist for two days and fade away the tracked time moves from one to two lagged days. Finally, our results show that European ETFs perform relatively better than the Asia-Pacific ETFs in terms of daily, intraday, overnight, tracking and pricing performance.

The results of this study have several important implications for investors and practitioners. First, the findings provide an understanding of distinguishing behavior of returns and volatilities estimated in trading prices and NAVs of international ETFs. Second, the results related to the intraday and overnight comparison of returns and return volatilities of international ETFs enable investors and practitioners to choose the optimal investment strategy. Third, the larger tracking errors have a material effect on ETF returns and are, therefore, a major concern for investors. They (as large tracking errors) make ETFs ineffective and unattractive by undermining their ability to offer exposure to the benchmark indices. Our findings on the magnitude and persistence of tracking errors, help investors to ensure they have a higher tracking ability prior to investing in international ETFs. Fourth, the pricing inefficiency provides an arbitrage opportunity for large investors. In this respect, our results provide an understanding of the dynamics of pricing inefficiency of international ETFs, which enable investors to implement an idle investment strategy for earning an abnormal return from potential arbitrage opportunities (as and when they occur). Thus, by analyzing the return and return volatility, tracking ability and pricing efficiency of international ETFs, this study equips investors and practitioners with the substantial performance-related information that is useful for making better-informed investment decisions.

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Appendix A. Profiles of International ETFs Tracking Asia-Pacific and European Indices

Table A1. Profiles of International ETFs Tracking Asia-Pacific Indices.

S#	ETF Ticker	Name	Benchmark	Inception Date	Expense Ratio	Volume	Assets	Intraday Volatility	Trading Frequency
1	AAXJ	iShares MSCI All Country Asia ex Japan ETF	NDUECAXJ Index	13/08/2008	0.72	621,171	4,204,400,916	1.61%	93.12%
2	AIA	iShares Asia 50 ETF	SPAS50NT Index	13/11/2007	0.50	32,803	468,681,113	1.49%	91.19%
3	AXJV	iShares Edge MSCI Min Vol Asia ex Japan ETF	M1APJVO Index	3/06/2014	0.35	5270	6,982,865	0.19%	86.11%
4	DVYA	iShares Asia/Pacific Dividend ETF	DJAPSDT Index	23/02/2012	0.49	11,187	41,268,658	0.65%	96.98%
5	ECNS	iShares MSCI China Small-Cap ETF	MSLUCHNN Index	28/09/2010	0.64	10,028	23,007,626	1.31%	89.46%
6	EEMA	iShares MSCI Emerging Markets Asia ETF	NDUEEGFA Index	8/02/2012	0.49	29,020	507,817,486	0.86%	97.78%
7	EIDO	iShares MSCI Indonesia ETF	MIMUINON Index	5/05/2010	0.63	478,651	489,193,848	1.56%	95.12%
8	ENZL	iShares MSCI New Zealand Capped ETF	M1CXBLRK Index	1/09/2010	0.48	45,082	172,199,717	1.07%	90.48%
9	EPHE	iShares MSCI Philippines ETF	MIMUPHIN Index	28/09/2010	0.64	215,159	175,456,225	1.23%	89.40%
10	EPP	iShares MSCI Pacific ex Japan ETF	NDDUPFXJ Index	25/10/2001	0.49	899,051	3,092,809,942	1.45%	99.92%
11	EWA	iShares MSCI Australia ETF	NDDUAS Index	12/03/1996	0.48	2,889,905	1,733,576,223	1.59%	99.96%
12	EWH	iShares MSCI Hong Kong ETF	NDDUHK Index	12/03/1996	0.48	4,673,897	1,848,097,337	1.42%	99.92%
13	EWJ	iShares MSCI Japan ETF	NDDUJN Index	12/03/1996	0.48	7,268,228	15,998,310,005	1.14%	99.92%
14	EWM	iShares MSCI Malaysia ETF	NDDUMAF Index	12/03/1996	0.48	521,496	439,561,297	1.41%	99.92%
15	EWS	iShares MSCI Singapore Capped ETF	M1CXBLY Index	12/03/1996	0.48	1,221,571	575,266,118	1.38%	99.92%
16	EWT	iShares MSCI Taiwan Capped ETF	M1CXBLZ Index	20/06/2000	0.64	4,719,238	3,652,582,226	1.45%	99.96%
17	EWY	iShares MSCI South Korea Capped ETF	M1CXKR5I Index	9/05/2000	0.64	2,909,692	3,739,590,053	1.53%	99.92%
18	FXI	iShares China Large-Cap ETF	TXIN0UNU Index	5/10/2004	0.74	21,230,847	3,434,027,411	1.83%	99.96%
19	HEWJ	iShares Currency Hedged MSCI Japan ETF	M0JPHUSD Index	31/01/2014	1.02	559,512	1,248,128,836	0.89%	97.35%
20	INDA	iShares MSCI India ETF	NDEUSIA Index	2/02/2012	0.71	991,824	4,969,106,604	1.03%	98.17%
21	INDY	iShares India 50 ETF	BXTRNIF$ Index	18/11/2009	0.93	165,657	1,114,897,457	1.12%	88.89%
22	IPAC	iShares Core MSCI Pacific ETF	M1PCIME Index	10/06/2014	0.10	71,536	1,131,429,121	0.76%	85.58%
23	JPMV	iShares Edge MSCI Min Vol Japan ETF	M1JPMVOE Index	3/06/2014	0.30	7248	32,071,990	0.36%	86.11%
24	JPXN	iShares JPX-Nikkei 400 ETF	JPNKNTR Index	23/10/2001	0.48	23,246	90,492,360	1.00%	99.92%
25	MCHI	iShares MSCI China ETF	NDEUCHF Index	29/03/2011	0.64	585,249	2,531,987,300	1.09%	95.90%
26	SCJ	iShares MSCI Japan Small-Cap ETF	NCUAJN Index	20/12/2007	0.48	19,299	199,583,535	0.97%	90.20%
27	SMIN	iShares MSCI India Small-Cap ETF	MSLUINDN Index	8/02/2012	0.80	14,031	210,863,316	1.37%	97.78%
28	THD	iShares MSCI Thailand Capped ETF	M1CXTH5I Index	26/03/2008	0.63	208,539	381,076,869	1.54%	97.44%

Table A2. Profiles of International ETFs tracking European Indices.

S#	ETF Ticker	Name	Benchmark	Inception Date	Expense Ratio	Volume	Assets	Intraday Volatility	Trading Frequency
29	EDEN	iShares MSCI Denmark Capped ETF	M1DK5IM Index	25/01/2012	0.53	21,667	67,454,790	0.78%	98.73%
30	EFNL	iShares MSCI Finland Capped ETF	M1FI5IM Index	25/01/2012	0.53	12,290	46,299,454	0.76%	98.65%
31	EIRL	iShares MSCI Ireland Capped ETF	M1CXIEAC Index	5/05/2010	0.48	29,498	71,790,441	1.24%	95.24%
32	EIS	iShares MSCI Israel Capped ETF	MISCNU Index	26/03/2008	0.64	48,263	92,458,364	1.38%	97.40%
33	ENOR	iShares MSCI Norway Capped ETF	M1NO5IM Index	23/01/2012	0.53	16,388	33,714,329	0.93%	98.81%
34	EPOL	iShares MSCI Poland Capped ETF	M1CXPL5I Index	25/05/2010	0.64	186,410	356,139,805	1.45%	94.39%
35	ERUS	iShares MSCI Russia Capped ETF	MSEURU$N Index	9/11/2010	0.64	169,008	612,767,266	1.70%	87.81%
36	EUFN	iShares MSCI Europe Financials ETF	NDRUFNCL Index	20/01/2010	0.48	175,247	1,905,790,798	1.33%	99.26%
37	EUMV	iShares Edge MSCI Min Vol Europe ETF	M00IER$O Index	3/06/2014	0.25	16,448	35,392,866	0.51%	86.11%
38	EWD	iShares MSCI Sweden Capped ETF	M1CXBLV Index	12/03/1996	0.48	257,130	479,030,207	1.68%	99.92%
39	EWG	iShares MSCI Germany ETF	NDDUGR Index	12/03/1996	0.48	3,339,165	4,705,640,819	1.54%	99.92%
40	EWGS	iShares MSCI Germany Small-Cap ETF	NCUDGR Index	25/01/2012	0.59	7727	51,310,779	0.72%	98.73%
41	EWI	iShares MSCI Italy Capped ETF	M1CXBLRM Index	12/03/1996	0.48	569,897	887,541,157	1.69%	99.92%
42	EWK	iShares MSCI Belgium Capped ETF	M1CXBLRJ Index	12/03/1996	0.48	173,845	67,755,695	1.37%	99.92%
43	EWL	iShares MSCI Switzerland Capped ETF	M1CXBLRO Index	12/03/1996	0.48	399,918	1,243,064,689	1.23%	99.96%
44	EWN	iShares MSCI Netherlands ETF	M1CXNIC Index	12/03/1996	0.48	160,552	202,399,765	1.36%	99.96%
45	EWO	iShares MSCI Austria Capped ETF	M1CXBLRQ Index	12/03/1996	0.48	151,219	240,539,136	1.55%	99.96%
46	EWP	iShares MSCI Spain Capped ETF	M1CXBLRP Index	12/03/1996	0.48	662,447	1,534,713,122	1.66%	99.92%
47	EWQ	iShares MSCI France ETF	NDDUFR Index	12/03/1996	0.48	529,990	636,626,394	1.51%	99.96%
48	EWU	iShares MSCI United Kingdom ETF	NDDUUK Index	12/03/1996	0.48	1,009,349	2,656,216,756	1.43%	99.92%
49	EWUS	iShares MSCI United Kingdom Small-Cap ETF	NCUDUK Index	25/01/2012	0.59	7553	35,632,245	0.69%	98.65%
50	EZU	iShares MSCI Eurozone ETF	NDDUEMU Index	25/07/2000	0.48	2,529,517	13,931,762,827	1.49%	99.96%
51	HEWG	iShares Currency Hedged MSCI Germany ETF	M0DEHUSD Index	31/01/2014	1.01	699,196	685,330,286	1.00%	97.35%
52	HEZU	iShares Currency Hedged MSCI Eurozone ETF	M0EMHUSR Index	9/07/2014	1.10	941,674	1,881,111,305	0.99%	82.94%
53	IEUR	iShares Core MSCI Europe ETF	MIMUEURN Index	10/06/2014	0.10	120,351	3,208,069,017	0.96%	85.58%
54	IEUS	iShares MSCI Europe Small-Cap ETF	M1EUSC Index	12/11/2007	0.40	7369	173,865,041	1.29%	91.31%
55	IEV	iShares Europe ETF	SPE35CUN Index	25/07/2000	0.60	630,513	3,213,215,541	1.37%	99.92%
56	TUR	iShares MSCI Turkey ETF	MIMUTURN Index	26/03/2008	0.64	289,726	375,926,396	2.14%	97.44%

Note: Appendix A reports the profile of international ETFs offering exposure to Asia-Pacific (in Table A1) and European (in Table A2) markets. Each panel has 28 ETFs and provides important information such as Bloomberg ticker for ETFs and their benchmark indices; name and inception date of ETFs; their expense ratio, trading volume, assets, intraday volatility and trading frequency of each ETFs.

Appendix B. Measurement of Variables

Table A3. Variables Measured in Trading price and NAV.

Variables	In Terms of Trading Price	In Terms of NAV
Daily return	$R_{ETF,t} = \log(CP_{ETF,t}) - \log(CP_{ETF,t-1})$	$R_{NAV,t} = \log(CP_{NAV,t}) - \log(CP_{NAV,t-1})$
Daily return volatility	$\sigma_{ETF} = \sqrt{\frac{\sum_{t=1}^{n}(R_{ETF,t}-\overline{R_{ETF}})^2}{n-1}}$	$\sigma_{NAV} = \sqrt{\frac{\sum_{t=1}^{n}(R_{NAV,t}-\overline{R_{NAV}})^2}{n-1}}$
Tracking error (First Measure)	$TE1_{ETF,t} = \frac{\sum_{t=1}^{n}\lvert R_{ETF}-R_{Ind}\rvert}{n}$	$TE1_{NAV,t} = \frac{\sum_{t=1}^{n}\lvert R_{NAV}-R_{Ind}\rvert}{n}$
Tracking error (Second Measure)	$TE2_{ETF,t} = \sqrt{\frac{\sum_{t=1}^{n}[(R_{ETF}-R_{Ind})-\overline{(R_{ETF}-R_{Ind})}]^2}{n-1}}$	$TE2_{NAV,t} = \sqrt{\frac{\sum_{t=1}^{n}[(R_{NAV}-R_{Ind})-\overline{(R_{NAV}-R_{Ind})}]^2}{n-1}}$

Table A4. Variables Measured for Intraday and Overnight Periods.

Variables	Intraday	Overnight
Return	$R_{day} = \log(CP_{ETF,t}) - \log(OP_{ETF,t})$	$R_{night} = \log(OP_{ETF,t}) - \log(CP_{ETF,t-1})$
Return volatility	$\sigma_{day} = \sqrt{\frac{\sum_{t=1}^{n}(R_{day,t}-\overline{R_{day}})^2}{n-1}}$	$\sigma_{night} = \sqrt{\frac{\sum_{t=1}^{n}(R_{night,t}-\overline{R_{night}})^2}{n-1}}$

Note: Appendix B reports the measurement of variables in Tables A3 and A4. Table A3 is for variables measured in trading price and NAV while Table A4 is for variables measured for intraday and overnight periods.

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