Arbitrage, Liquidity, and the Valuation of Exchange Traded Funds

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This paper investigates the performance of U.S. and country exchange traded funds currently traded in the United States and provides new insight into their pricing. While the U.S. funds are priced closely to their net asset values, the country funds are not and can exhibit large, positive autocorrelations in fund premium. The mispricing of country funds is related to momentum, illiquidity, and size effects. We also find an inverted U-shaped relationship between fund premium and market liquidity, which suggests that more active trading does lead to lower mispricing but only after a certain level of liquidity is reached.

I. INTRODUCTION

This paper examines the pricing of exchange traded index funds (ETFs) relative to the value of their underlying equities. Index ETFs differ from traditional index equity mutual funds in that they trade just like shares of stock on organized stock exchanges, including the American, NASDAQ, and New York stock exchanges. Also unlike mutual funds, an index ETF is organized as an investment trust and new shares are created when an institutional investor deposits securities into the trust. Although ETFs are a relatively recent financial innovation, their trusts hold billions of dollars in assets. Unlike many traditional funds, each ETF has a very specific investment objective, such as replicating an industry sector or country stock index. Because ETFs have clearly defined objectives to track a sector or index, their prices should closely track fundamentals.

In a liquid market with no limits to arbitrage, we would not observe deviations in ETF fund prices from their fundamental net asset values (NAVs). The concept of arbitrage is a central principle in financial economics because it suggests that markets will price assets efficiently. However, arbitrage is limited to the extent that market frictions and impediments to information diffusion are present. Thus, the existence of these limits is likely to be reflected in deviations in ETF prices from NAV.

The goal of this paper is to provide new evidence on the ability to arbitrage mispricing in ETFs. Recent research argues that pricing efficiency is associated with liquidity. Although the meaning of liquidity in an economic sense is abstract, it is generally regarded as having a positive influence on efficiency. In a liquid

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market, trades are effected at low cost with little impact on price. In an illiquid market, on the other hand, the market's valuation is depressed because owners of the asset face uncertain selling prices. Thus, the liquidity hypothesis predicts that asset returns are higher in an illiquid market. For a sample of 28 U.S. and country ETFs currently traded in the U.S., we examine how liquidity of the ETF in the U.S. market and the liquidity of the underlying stocks in the home market impact the premium (or discount) in the funds' prices above (or below) NAVs.[1] All of these funds trade under the same sponsor and advisor, Barclays Global Investors, so that management fees and style are comparable.

Previous research provides evidence that U.S. ETF prices are very close to NAVs, but the redemption feature is critical (Ackert and Tian (2000) and Elton, Gruber, Comer, and Li (2002)). Outstanding units of an ETF can be redeemed for the underlying stock by qualified investors, a feature that facilitates arbitrage and promotes efficient pricing. Investors can take advantage of mispricing by redeeming an ETF that is selling at a discount. Similarly, when an ETF is selling at a premium, the trust can create additional units. Together, the abilities to redeem and create units of a fund are critical in enhancing the pricing efficiency of ETFs.

The evidence also suggests that although the premiums for U.S. ETFs are small, mispricing for international ETFs is more significant (Jares and Lavin (2004) and Engle and Sarkar (2006)). Jares and Lavin (2004) consider trading strategies based on mispricing in two country ETFs (Japan and Hong Kong). Engle and Sarkar (2006) use daily and intra-day data and focus on whether mispricing in the short-term can be explained by errors in reported prices and net asset values. For U.S. ETFs Engel and Sarkar report that mispricing is very small and usually lasts only a few minutes. For country funds, mispricing is more persistent. With its focus on liquidity and the longer-term development of ETF markets, this paper provides new insight into the pricing of country funds.

No prior study has examined cross-market liquidity effects for country ETFs. A potential caveat of this type of investigation is the fact that the underlying asset is a portfolio, rather than a single stock. Although ETF managers have explicit objectives, the underlying asset does not always perfectly replicate the goal. In fact, for country funds investors are warned that the fund may not replicate the benchmark because of illiquidity and foreign ownership restrictions.[2] Nonetheless, the redemption feature of ETFs helps keep fund prices close to NAVs, as studies of U.S. ETFs document (Ackert and Tian (2000) and Elton, Gruber, Comer and Li (2002)). In addition, all of the MSCI country indexes we analyze are constructed based on the float of their constituent stocks rather than their outstanding shares. A reformulation of the MSCI indexes as of May 31, 2002 makes it possible for the country ETFs to track the underlying MSCI indexes closely.[3] Furthermore,

[1] Though as many as 175 ETFs currently trade in the United States, our sample is constrained at 28 funds due to data availability, as further described later in the paper. Many funds have short trading histories and home market data is unavailable for some international funds.
[2] See, for example, http://www.etfconnect.com/select/etf/global.
[3] As discussed later in the paper, our sample begins in 2002 because of the index reformulation. However, the results are similar when we extend the series back in time to the beginning of 2000.

our investigation of efficiency and liquidity effects in ETF pricing is particularly insightful because we investigate whether these assets track their fundamental values for a broad sample of U.S. and country ETFs while including home and cross-market liquidity effects.

Our empirical analysis indicates that while the fund premium is on average quite small, the variation in the premium can be quite large especially for country funds. In addition, many country ETFs exhibit large, positive autocorrelation in fund premium while U.S. ETFs typically do not. The average first-order autocorrelation is 3.4% for U.S. ETFs and 21.0% and 40.7% for open economy and emerging market ETFs, respectively. Time zone differences only partially explain the observed autocorrelation in fund premium of the country ETFs. We also find that mispricing is related to momentum, illiquidity, and size effects, which may reflect capital controls and other market frictions. These results are generally consistent with previous research that U.S. ETFs are priced very close to NAVs (Ackert and Tian (2000) and Elton, Gruber, Comer, and Li (2002)) while country ETFs are not (Jares and Lavin (2004) and Engle and Sarkar (2006)). Although the redemption and creation features of ETFs encourage efficient pricing, our evidence indicates that there are significant, persistent fund premiums for country ETFs. This finding for country funds may be the product of taxes and other impediments to trade, which hinder the creation and redemption process (Engle and Sarkar (2006)).[4]

More importantly, our empirical results suggest an interesting relationship between fund premium and market liquidity. For the more actively traded U.S. ETFs, we find some evidence of a *negative* relationship between fund premium and market liquidity. This is consistent with the expectation that higher liquidity is associated with lower mispricing. The negative relationship is generally statistically insignificant, however, providing further support for efficiency in the market for U.S. ETFs. These funds are closely priced to their NAVs. In contrast, we find a *positive* (and often statistically significant) relationship between fund premium and market liquidity for the less liquid country funds. This appears counterintuitive as it suggests that more active trading actually drives fund prices away from fundamental values. These findings are robust to alternative measures of liquidity (or illiquidity) including dollar trading volume, Amihud's (2002) illiquidity measure, the turnover ratio defined as total market value divided by dollar traded volume, and the percentage of stocks that had no change in price each day.[5]

There are two possible explanations for the positive premium-liquidity relationship for the country funds. First, the relationship between fund premium and market liquidity is nonlinear and should not be simply characterized by a positive or negative relationship. Indeed, further analysis of country ETFs identifies a

[4] Data on creations and redemptions of units is at this time available only on a quarterly basis. If more frequent reporting is later implemented, future research could empirically examine how the creation/redemption process impacts flows in ETF markets.

[5] The first three measures are calculated for both the ETF and the home market while the last measure is calculated for the home market only.

nonlinear relationship, with the fund premium positively related to liquidity but negatively related to squared liquidity. This indicates an inverted U-shaped relationship between fund premium and market liquidity for country ETFs. At lower levels of market liquidity, more active trading leads to a larger fund premium, perhaps due to noise trading. At higher levels of market liquidity, the reverse is true with more active trading leading to a smaller fund premium. This finding is consistent with the conjecture that informed trading dominates after a certain level of trading volume is reached and the impact of noise trading diminishes.[6] Secondly, the fund premium is likely influenced by the liquidity of both the ETFs and home markets (where the underlying stocks trade). Predictions of the signs of cross-market effects are unclear when markets are not fully segmented. Indeed, we find that the fund premium for the country ETFs is positively related to *both* ETF *and* home market liquidity. Full segmentation is not supported as measures of liquidity in the two markets are highly positively correlated, suggesting some degree of integration among these markets. Our results contrast with Chan, Hong, and Subrahmanyam (2005) and Chan, Jain, and Xia (2006) who find that American depositary receipts (ADRs) and closed-end country funds (CEFs) premiums are lower in an illiquid host market and higher in an illiquid home market. We also point out a unique type of liquidity spillover effect in the market for ETFs that is not present in the markets for ADRs or CEFs. This research thus provides new evidence on the complex relationship between market liquidity and pricing efficiency.

This paper is organized as follows. In section II we review the evidence supporting a relationship between mispricing and liquidity. In section III, we present our research method, including the testable hypotheses and research design. In Section IV, we describe our data and provide summary information. In Section V, we present the empirical results. Finally, we provide concluding remarks in Section VI.

II. LIQUIDITY AND ASSET PRICING

The literature reports that liquidity affects pricing. Empirical evidence supports the hypothesis that illiquidity results in lower asset prices and higher returns (Brennan and Subrahmanyam (1996), Amihud and Mendelson (1986), and Amihud (2002)). In addition, the effect of liquidity differs in developed and emerging markets with liquidity's influence being smaller in open economies with fewer regulatory barriers (Allen and Gale (1994)).

The impact of liquidity on pricing has been examined for various asset types. Chan, Jain, and Xia (2006) provide a model of segmented markets and empirically examine the predictions of the model for CEFs.[7] Their model predicts that the

[6] Tkac (1999) provides evidence that abnormal trading volume is lower for firms that are large, have high institutional ownership, and with option availability. Noise trading is likely to be less influential for such firms.

[7] Closed-end funds differ from ETFs in that ETFs are not closed-end and their trusts commonly issue new units each year. Furthermore, ETFs can be redeemed for the underlying assets.

fund premium will be lower in an illiquid host market (where the CEF trades), whereas the fund premium will be higher in an illiquid home market (where the underlying assets trade). Chan, Jain, and Xia find strong evidence in support of their predictions and conclude that the relationships are even stronger in emerging markets because of higher market segmentation.

Another recent study by Chan, Hong, and Subrahmanyam (2005) examines the relationship between ADRs and liquidity.[8] If liquidity effects are important, higher ADR illiquidity in the U.S. will lead to a lower premium because traders will be willing to pay less for the ADR. However, higher illiquidity for the underlying stock in the home market will lead to a higher ADR premium, in this case because traders will be willing to pay less for the stock. Their results are consistent with the hypothesis that the premium will increase with ADR *liquidity* and home market *illiquidity*. In addition, Chan, Hong, and Subrahmanyam find that the liquidity effects are stronger for ADRs of companies from developed markets and weaker, and somewhat ambiguous, for ADRs of companies from emerging markets. This is surprising since the ADR market is expected to have a higher degree of integration with the developed markets (hence weaker liquidity effects) than with the emerging markets (hence stronger liquidity effects).

In the following section we describe the research method used to examine pricing and cross-market liquidity effects for country ETFs. ETFs are financial products that differ significantly from CEFs and ADRs in their design. Thus, further investigation of pricing in the large, yet still rapidly growing, ETF market is warranted.

III. RESEARCH METHOD

Empirical Hypotheses

The objective of this paper is to gain insight into the pricing of ETFs. Previous empirical investigations indicate that U.S. equity index ETFs are priced closely with fundamentals, with greater mispricing for international ETFs. We hypothesize that if information is immediately disseminated, changes in the value of an ETFs' underlying stocks are fully reflected in prices. However, because of asynchronous trading across international time zones, the prices of country ETFs may respond with some delay.

This paper also examines the relationship between premiums in ETF prices and liquidity in the ETF and its underlying equity market. The premium is defined as the difference between the ETF price and its NAV. In completely segmented markets, illiquidity in the ETF market will drive down the price of the ETF, resulting in a lower premium. At the same time, illiquidity in the home market

[8] ADRs are certificates issued by a U.S. depository bank and represent foreign shares held by the bank. An ADR represents ownership in a foreign corporation and an ADR holder receives the same cash flows (in U.S. dollars) as shareholders in the foreign country. ADRs are the most common method of cross-listing in the U.S. (Gagnon and Karolyi (2004)).

in which the underlying shares trade will drive down the NAV, giving a higher ETF premium. With segmentation, we expect a negative (positive) relationship between ETF premium and illiquidity in the ETF (home) market.

Of course, today's markets reflect some degree of integration. In markets that are integrated, the predictions are not as clear because of liquidity spillover effects (Chan, Jain, and Xia (2006)). For example, if liquidity is easily transferred between markets, increased illiquidity in one market can be transferred to another so that the price of the ETF and its NAV both decline in which case the directional impact on the premium is not clear. The relationship between the premium and liquidity is thus expected to be weakened in integrated markets, and could even be zero.

Empirical Design

To examine efficiency and liquidity effects in the pricing of ETFs, we regress the daily fund premium on changes in NAV and measures of liquidity, as follows:

$$\begin{aligned} PR_{f,t} = \alpha_{f,0} &+ \sum_{i=0}^{2} \alpha_{f,t-i}^{MOM} MOM_{f,t-i} + \sum_{i=0}^{2} \alpha_{f,t-i}^{AIM,\,ETF} AIM_{f,t-i}^{ETF} \\ &+ \sum_{i=0}^{2} \alpha_{f,t-i}^{AIM,\,Home} AIM_{f,t-i}^{Home} + \sum_{i=0}^{2} \alpha_{f,t-i}^{VOL,\,ETF} VOL_{f,t-i}^{ETF} \\ &+ \sum_{i=0}^{2} \alpha_{f,t-i}^{VOL,\,Home} VOL_{f,t-i}^{Home} + \alpha_{f}^{MV} MV_{f,t} + e_{f,t} \end{aligned} \tag{1}$$

where *PR* is the fund premium defined as the natural logarithm of the ratio of the ETF price over the fund's NAV (i.e., $\ln(\text{ETF}_{f,t}/\text{NAV}_{f,t-1})$), *MOM* is momentum in the fund's NAVs measured by the natural logarithm of the ratio of the fund's closing NAV on day t over the fund's closing NAV on day $t-1$ (i.e., $\ln(\text{NAV}_{f,t}/\text{NAV}_{f,t-1})$), *AIM* is Amihud's square root illiquidity measure, *VOL* is the natural logarithm of dollar trading volume, and *MV* is the natural logarithm of the ETF's market capitalization.[9] *AIM* is defined here as the square root of the ratio of daily return and dollar volume. In our regression model (1) we include current and two lags of *MOM*, *AIM*, and *VOL* because information may be disseminated slowly and trading periods are asynchronous across international borders.[10] Note that the premium can be negative, so that the ETF trades at a discount.

[9] Chan, Jain, and Xia (2006) use de-trended data in their examination of closed-end fund discounts. We do not de-trend because examination of time series plots fails to indicate clear trends in our data.

[10] We also estimated the regressions reported subsequently with one day lags *and leads* and inferences were unchanged. Gagnon and Karolyi (2004) suggest lags and leads as a conservative approach. In addition, we re-estimated the regressions using ETF opening prices and NAV closing values. This approach to control for time zone differences is particularly clean for Asian ETFs because there is no overlap in trading hours. Again the results are similar to those reported later in the paper.

The first independent variable included in our regression analysis is the percentage change in the fund's NAV (*MOM*). Current and past information concerning momentum in the fund should be reflected in its market price. If the fund's price reacts slowly to an increase in the fund's value, the premium will be positively related to past momentum. In this case, past increases in NAV are reflected in current ETF prices. In addition, asynchronous data across international markets may result in a positive relationship between the premium and lagged momentum, as current data reflects information with a lag.

The remaining independent variables measure the degree of liquidity in the markets for the ETF and its underlying equities. The theoretical literature provides alternative definitions of liquidity. With data at the daily frequency, we clearly want a measure of liquidity that is highly correlated with microstructure estimates. Amihud (2002) provides a measure of illiquidity that is based simply on daily returns and volume, yet is correlated with price impact measures of liquidity using intra-day data. We use the square root transformation of Amihud's measure because Hasbrouck (2005) provides evidence that the square root measure is a good proxy for the effective cost and trade impact when measuring illiquidity with daily data. In our regression (1), we include Amihud's measure, computed as the square root of the ratio of daily return and dollar trading volume, for each ETF (AIM^{ETF}) and its underlying stocks traded in the home market (AIM^{Home}).[11]

Next the regression includes the dollar value of trading volume for the ETF (VOL^{ETF}) and its underlying stocks (VOL^{Home}). Trading volume is highly correlated with quoted bid-ask spreads, which are microstructure measures of the liquidity of a market (Chordia, Roll, and Subrahmanyam (2000)).

Finally, the regression includes the market value of the ETF (*MV*). Firm size and liquidity are positively correlated (Pastor and Stambaugh (2003)). Chan, Hong, and Subrahmanyam (2005) show that liquidity effects on ADR premiums do not disappear when size is included as an independent variable. They conclude that size has a negative effect on the premium because arbitrage forces are stronger for larger ADRs.

We estimate (1) following Peterson (2007), who builds on the method proposed by Fama and MacBeth (1973).[12] The Fama-MacBeth standard errors are adjusted for time and ETF effects. In the following section we describe our sample.

[11] We re-estimated the regressions using two alternative measures of illiquidity: the turnover ratio defined as total market value divided by traded volume and the percentage of stocks that had no change in price each day. The results are similar to those reported subsequently.

[12] We also estimated the simple regression model separately for each of the 28 ETFs in our sample, rather than using the panel data approach. Because the speed of information dissemination and liquidity effects may be quite different across economies depending on their degree of openness and development, a cross-sectional analysis could mask significant relationships for each particular fund. The results of the individual regressions are similar to those reported subsequently for the panel data model and are available from the authors upon request.

IV. DATA AND DESCRIPTIVE INFORMATION

Data Sources and Sample Selection

We obtain daily price, volume, shares outstanding, and underlying index data for our sample of ETFs from Datastream and ETF NAVs from Nuveen Investments.[13] For our country funds, we obtain home market trading volume from Reuters. Index values are computed using the latest available closing prices from each market. Market capitalization is the share price times the number of shares in issue, adjusted for any capital changes. Though more than one hundred index ETFs currently trade, our sample includes 28 funds due to data availability. As noted previously, all of our sample funds are traded under the same sponsor and advisor, Barclays Global Investors, so that management fees and style are comparable. We begin with the universe of funds and include all that have complete information for closing price, NAV, ETF trading volume, home market trading volume, underlying index value, and market capitalization for a minimum of one year.

Our time series begin June 1, 2002 because prior to that date MSCI equity indexes were not constructed on a consistent basis.[14] As of May 31, 2002 all MSCI equity indexes are adjusted for float and extended market capitalization coverage. Prior to that date, MSCI equity indexes were constructed based on outstanding shares of the constituent stocks. Because many of the outstanding shares are privately held, it is difficult for a country ETF to replicate the performance of the underlying index. MSCI equity indexes were subsequently reformulated based on float instead of outstanding shares, which enhances the ability of ETFs to track their underlying indexes. The reformulation was phased in over time and completed on May 31, 2002. By excluding the earlier time period, we ensure that the fund premium is not due to the inherent problem associated with the measurement of the index.

Volume is the dollar value of shares traded each day, always reported in thousands and adjusted for capital changes. For the U.S. ETFs, home market dollar trading volume is the total number of shares of the index's constituent stocks traded multiplied by the closing value of the index. For the country ETFs, a corresponding home market dollar trading volume is not available for the underlying MSCI country index. As a close proxy, we use the total dollar value of shares traded in the country on a particular day. Although it is not a precise measure of the dollar trading volume for the constituent stocks of the underlying MSCI country index, the difference is relatively small. On average the dollar trading volume of the MSCI country index is 83% of the entire domestic market in that country. For many markets the coverage of the MSCI country index is over 90% and for some, including Spain, the coverage is 100%. Thus while our measure of home market trading volume is not perfect for the country ETFs, it is a good proxy with high coverage.

[13] See http://www.etfconnect.com/ for a complete listing of traded index ETFs, as well as information on pricing and underlying net asset values.
[14] We re-estimated the regressions reported in Table II after adding back data from 2000 through June 2002, when available. The results are similar to those reported in the paper.

Table 1: Sample of Exchange Traded Funds

The table provides information on the sample of ETFs including the underlying index fund, the starting and ending dates for the sample data, the number of observations, and whether the home economy is the United States, another developed or open economy, or an emerging market.

Number	Fund Ticker	Fund Index	Data Starting Date	Data Ending Date	Number of Observations	Home Economy
1	IVV	S&P 500	6/3/2002	1/13/2005	592	
2	IJH	S&P MidCap 400	6/3/2002	1/13/2005	592	
3	IJR	S&P SmallCap 600	6/3/2002	1/13/2005	588	
4	IWB	Russell 1000	6/3/2002	1/13/2005	592	
5	IWM	Russell 2000	6/3/2002	1/13/2005	592	U.S.
6	IWV	Russell 3000	6/3/2002	1/13/2005	588	
7	IWR	Russell MidCap	6/16/2003	1/13/2005	354	
8	EWA	Australia	6/3/2002	1/13/2005	570	
9	EWO	Austria	6/3/2002	1/13/2005	514	
10	EWK	Belgium	6/3/2002	1/13/2005	480	
11	EWC	Canada	6/3/2002	1/13/2005	556	
12	EWQ	France	6/3/2002	1/13/2005	589	
13	EWG	Germany	6/3/2002	1/13/2005	582	
14	EWI	Italy	6/3/2002	1/13/2005	546	Developed or Open
15	EWJ	Japan	6/3/2002	1/13/2005	502	
16	EWN	Netherlands	6/3/2002	1/13/2005	537	
17	EWS	Singapore	6/3/2002	1/13/2005	551	
18	EWP	Spain	6/4/2002	1/13/2005	518	
19	EWD	Sweden	6/3/2002	1/13/2005	551	
20	EWL	Switzerland	6/3/2002	1/13/2005	571	
21	EWU	United Kingdom	6/6/2002	1/13/2005	570	
22	EWZ	Brazil	6/3/2002	1/13/2005	548	
23	EWH	Hong Kong	6/3/2002	1/13/2005	539	
24	EWM	Malaysia	6/3/2002	1/13/2005	538	
25	EWW	Mexico	6/3/2002	1/13/2005	557	Emerging
26	EZA	South Africa	2/20/2003	1/13/2005	334	
27	EWY	South Korea	6/3/2002	1/13/2005	512	
28	EWT	Taiwan	6/3/2002	1/13/2005	546	

Summary Statistics

Table 1 lists the funds included in our analysis, as well as the observation interval, number of observations, and whether the home economy is the United States, another developed or open economy, or an emerging market. The number of observations per fund ranges from 334 to 592. Our sample includes 7 domestic U.S. ETFs, 14 whose underlying stocks trade in another developed or open economy, and 7 ETFs tracking emerging markets.

Table 2 provides additional information on our sample of ETFs. For each fund, the table reports the mean, median, 5th and 95th percentile values, standard deviation, first-order autocorrelation, and percentage positive for each fund premium. The premium is computed as the difference between the ETF price and the fund's NAV, divided by the NAV. In addition, the table reports the average market value of each fund.

For nineteen of twenty-eight funds, the average deviation in price from NAV is positive (a premium), whereas for 9 funds a discount is observed, on average. The largest premium on any day in our sample was 9.46% for the Sweden ETF and the largest discount observed was 8.50% for the Taiwan fund. We observe that the average price deviation is more often a premium, as opposed to a discount, which may result from the redemption and creation process. An ETF that trades at a discount can be redeemed by a qualified investor with relatively low cost, whereas creating new units is more costly for the trust and may be implemented with a greater time lag. Thus, it is not surprising that we see fewer discounts. However, the observed discounts and premiums are small relative to those reported for ADRs and CEFs.

The final rows of Table 2 report summary information on the premium for funds classified by the type of home economy. As might be expected, the deviation in price from NAV for the U.S. funds is very small (0.0154%). However, somewhat surprisingly, the average premium for funds with underlying assets in emerging markets is smaller (0.0135%) than those for developed or open economies (0.1689%). A closer look at the fund premium figures reveals that three of the seven emerging market funds have large discounts, another three have large premiums, while the remaining fund has a small discount.[15] The large discounts and premiums mostly offset one another, resulting in a smaller average premium for emerging market funds. In contrast, 11 of the 14 funds for developed or open economies show a premium and most of them are quite large. The remaining three funds have discounts, not enough to have much impact on the average premium for developed or open economy funds.

Further investigation of the observed distributions of the fund premiums confirms that the mean premium provides an incomplete picture. Not only is the median premium higher for funds tied to emerging markets, but the distribution is wider. The 5th (95th) percentile premiums are lower (higher) for the emerging market funds and the standard deviation of the fund premium is also the highest.

Figures 1 through 3 provide insight into differences across markets and over time. Figure 1 plots the premium for the S&P 500 ETF. Consistent with our

[15] The complete set of figures of fund premiums over time is available upon request from the authors. As discussed subsequently, three figures are included in the paper for illustrative purposes.

Table 2: Summary Statistics for Exchange Traded Funds

The table provides summary information on the sample of ETFs. The fund premium is defined as the difference between the ETF price and the fund's net asset value, divided by the net asset value. The table reports the mean, median, 5% and 95% percentile premium, standard deviation, and first-order autocorrelation, as well as the proportion of positive premiums for the percentage fund premium. In addition, the table reports the average market capitalization of each fund in millions of dollars. The final rows of the table report summary information for ETFs classified by the home economy: United States, another developed or open economy, or an emerging market.

		Premium							
				Percentile (%)					
Number	Fund Index	Mean (%)	Median (%)	5%	95%	Standard Deviation (%)	Autocorrelation	Positive (%)	Average Market Value (millions)
1	S&P 500	0.0282	0.0300	−0.2502	0.2792	0.1665	0.0752	59.9662	4959.54
2	S&P MidCap 400	0.0328	0.0478	−0.2486	0.2746	0.1585	0.0046	61.1486	827.24
3	S&P SmallCap 600	−0.0297	−0.0306	−0.3445	0.2687	0.1870	0.0844	41.6667	1486.14
4	Russell 1000	0.0297	0.0395	−0.2065	0.2373	0.1479	−0.0031	61.9932	934.39
5	Russell 2000	−0.0448	−0.0413	−0.3834	0.3041	0.2328	0.0137	40.7095	2707.18
6	Russell 3000	0.0263	0.0390	−0.1969	0.2045	0.1347	0.0420	62.0748	904.49
7	Russell MidCap	0.0652	0.0625	−0.1300	0.2772	0.1533	0.0227	70.6215	325.30
8	Australia	0.2426	0.3622	−1.5436	1.6168	0.9385	0.3745	63.6842	114.55
9	Austria	0.1048	0.2286	−1.4528	1.4664	0.9000	0.4570	57.3930	33.31
10	Belgium	0.2391	0.2881	−1.3770	1.7501	0.9380	0.3001	60.6250	19.57
11	Canada	0.2776	0.1828	−0.8403	1.6998	0.7658	0.3104	61.3309	195.55
12	France	−0.0617	0.0000	−1.1728	0.9452	0.7029	0.0602	47.5382	57.54
13	Germany	−0.0256	0.0000	−1.3216	1.0907	0.7689	0.1212	47.4227	98.96
14	Italy	0.0043	0.0552	−1.0906	0.9709	0.6528	0.0585	51.2821	33.69
15	Japan	0.2006	0.1998	−1.3245	1.6319	0.9033	0.1095	57.1713	3723.59

(Continued)

Table 2: (*Continued*)

		Premium							
				Percentile (%)		Standard			Average Market
Number	Fund Index	Mean (%)	Median (%)	5%	95%	Deviation (%)	Autocorrelation	Positive (%)	Value (millions)
16	Netherlands	0.0907	0.1497	−1.2206	1.2461	0.7949	0.0463	57.3557	27.70
17	Singapore	−0.1357	0.1542	−3.0637	2.0315	1.6029	0.6214	50.4537	113.35
18	Spain	0.0558	0.0555	−1.0317	1.0257	0.6926	0.0614	52.5097	50.94
19	Sweden	0.3583	0.4008	−1.4269	2.0801	1.1779	0.0203	65.8802	20.00
20	Switzerland	0.3656	0.3971	−1.1994	1.8036	0.9137	0.2137	65.8494	34.28
21	United Kingdom	0.6481	0.6929	−0.8016	1.9586	0.8399	0.1779	80.0000	204.10
22	Brazil	−0.2228	0.0000	−2.9431	1.4158	1.3744	0.4394	47.8102	217.76
23	Hong Kong	−0.0527	0.1157	−2.3690	1.5666	1.2049	0.4621	52.1336	255.15
24	Malaysia	−0.0858	0.0000	−2.2924	2.0849	1.3953	0.7229	47.5836	110.52
25	Mexico	−0.1779	−0.0800	−1.5546	1.0695	0.7888	0.2608	42.5494	72.99
26	South Africa	0.2298	0.1950	−0.7038	1.1024	0.5636	0.2843	67.3653	92.50
27	South Korea	0.1545	0.2687	−2.0777	2.2528	1.3244	0.2229	58.7891	172.91
28	Taiwan	0.2492	0.3791	−3.0142	3.1198	1.8590	0.4588	57.5092	266.57
U.S.		0.0154	0.0210	−0.2514	0.2637	0.1687	0.0342	56.8829	1734.90
Developed or open economies		0.1689	0.2262	−1.3477	1.5227	0.8994	0.2095	58.4640	337.65
Emerging economies		0.0135	0.1255	−2.1364	1.8017	1.2158	0.4073	53.3915	169.77
All funds		0.0917	0.1497	−1.2708	1.2777	0.7958	0.2151	56.8006	644.99

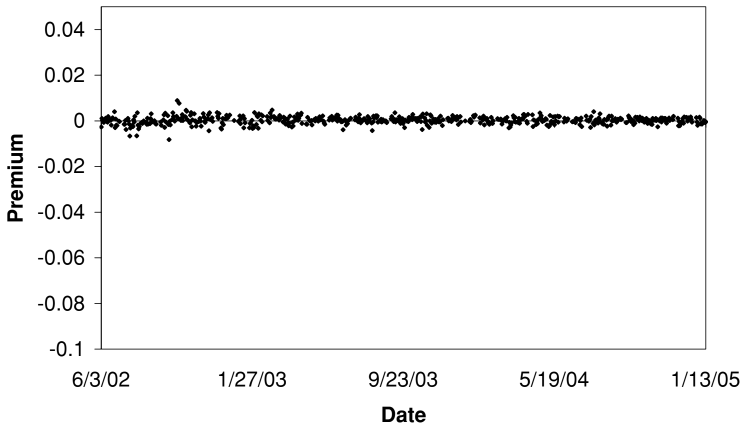

Figure 1: S&P 500 ETF Premium.

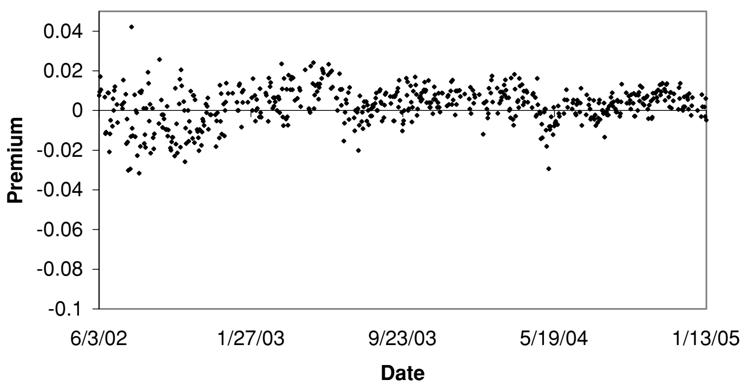

Figure 2: Australia ETF Premium.

expectations, the fund price closely tracks fundamental value and the premium does not vary far from zero over time. Figure 2 shows the premium for the Australia fund, chosen as illustrative of the set of other developed markets. As compared to the S&P 500, the premium deviates more from zero, though the distribution appears to have become more concentrated around zero in recent years. Figure 3 plots the premium for the Brazil fund, to demonstrate the experience of the emerging markets ETFs. The behavior of the premium is quite erratic over the early sample period, with what appear to be large and persistent deviations from zero. As with the developed markets ETFs, the distribution seems to converge toward fundamental pricing over time.

Table 2 also reports the first-order autocorrelation coefficient to provide information on correlation in premiums over time. As the figures suggest, there is

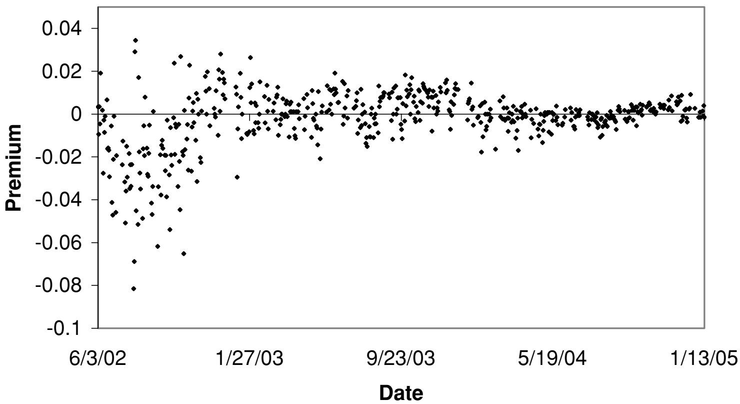

Figure 3: Brazil ETF Premium.

greater serial dependence in the emerging markets funds, with less in the developed markets, particularly the U.S. Nearly all first-order autocorrelations are positive (except for the Russell 1000), suggesting the possible existence of momentum in fund premiums. The average first-order autocorrelation for U.S. ETFs (3.4%) is much smaller than for emerging markets (40.7%) or other developed economies (20.1%). For all 7 of the emerging markets ETFs, the autocorrelation is significantly positive ($p < 0.01$), whereas 9 of 14 (2 of 7) autocorrelations are significant for the other developed economies (U.S.). For some funds, asynchronous trading due to time zone differences may at least partially explain correlation in premiums. However, different time zones cannot fully explain observed correlations, as some are large even though the home and U.S. markets are in the same hemispheres (e.g., Brazil). In addition, untabulated partial autocorrelation coefficients suggest that serial dependence remains significant (greater than 10%) for three to five lags for many country ETFs, particularly so for the emerging market funds. Time zones differences alone cannot explain serial dependence beyond the first lag.

Finally, Table 2 also reports the percentage of days with positive premiums and the average market value of each fund in millions of U.S. dollars. For 21 of the 28 funds premiums are observed more often than discounts. The average capitalization in our sample is $645 million, with the Belgium (S&P 500) ETF having the smallest (largest) capitalization of nearly $20 ($4,960) million. The average ETF capitalization exceeds that of CEFs and ADRs.[16]

We observe wide variation in the distribution of premiums, both over time and across funds. Summary information in Table 3 suggests that trading activity and liquidity also vary widely in our sample. The table reports trading volume (in millions of dollars) for ETFs and their underlying assets, as well as Amihud's

[16] Chan, Jain, and Xia (2006) report an average capitalization of $106.88 million for their sample of closed ends funds and Chan, Hong and Subrahmanyam (2005) report an average capitalization of $46 million for their sample of American depositary receipts.

Table 3: Liquidity of Exchange Traded Funds and their Underlying Assets

The table provides summary information on the sample of ETFs. The trading volume is the average daily dollar volume, in millions of dollars, and Amihud's square root illiquidity measure is the root of the ratio of daily return and dollar volume. The final rows of the table report volume and Amihud's illiquidity measure (AIM) for ETFs classified by the home economy: United States, another developed or open economy, or an emerging market.

		Trading Volume		AIM	
Number	Fund Index	ETF	Home Market	ETF	Home Market
1	S&P 500	51.20	18595.23	0.015616	0.000620
2	S&P MidCap 400	10.03	1570.44	0.036382	0.002258
3	S&P SmallCap 600	31.74	378.97	0.020867	0.004864
4	Russell 1000	11.84	1253.65	0.034028	0.002395
5	Russell 2000	413.49	316.12	0.006401	0.005643
6	Russell 3000	19.42	1690.90	0.031365	0.002091
7	Russell MidCap	6.42	730.66	0.037749	0.002774
8	Australia	1.41	1450.56	0.149960	0.002280
9	Austria	0.82	59.75	0.305062	0.012486
10	Belgium	0.42	208.04	0.518618	0.006629
11	Canada	2.64	1771.20	0.138373	0.002000
12	France	0.42	4170.56	0.252863	0.001520
13	Germany	1.51	104.54	0.124076	0.010567
14	Italy	0.31	2783.34	0.364810	0.001695
15	Japan	41.87	8273.24	0.022966	0.001093
16	Netherlands	0.24	2058.98	0.490199	0.002202
17	Singapore	0.87	281.71	0.199078	0.005362
18	Spain	0.48	1717.36	0.345066	0.002346
19	Sweden	0.40	1210.57	0.466358	0.003106
20	Switzerland	0.26	1928.96	0.304012	0.002054
21	United Kingdom	3.16	11803.25	0.083073	0.000836
22	Brazil	6.87	238.42	0.096889	0.008485
23	Hong Kong	4.43	868.92	0.089937	0.002989
24	Malaysia	1.65	89.43	0.115609	0.007827
25	Mexico	3.43	126.55	0.099463	0.008735
26	South Africa	0.92	346.80	0.218832	0.004946
27	South Korea	4.63	1503.25	0.084742	0.002941
28	Taiwan	4.73	1478.71	0.108810	0.002797
U.S.		77.73	3505.14	0.026058	0.002949
Developed or open economies		3.92	2701.58	0.268894	0.003870
Emerging economies		3.81	664.58	0.116326	0.005531
All funds		22.34	2393.22	0.170043	0.004055

Table 4: Correlations

The table reports the correlations among the ETF premium, the natural logarithm of market value, the natural of logarithm ETF and home market trading volume, ETF and home market illiquidity (AIM), and momentum. The fund premium is defined as the difference between the ETF price and the fund's net asset value, divided by the net asset value. Amihud's illiquidity measure (AIM) is the square root of the ratio of daily return and dollar volume and momentum is measured by the continuous growth in the fund's NAV.

	Market Value	ETF Volume	Home Market Volume	ETF AIM	Home Market AIM	Momentum
Premium	0.1143	0.0884	0.0800	−0.0991	−0.0907	0.0136
Market Value	1.0	0.4477	0.5136	−0.4153	−0.3847	0.0523
ETF Volume	-	1.0	0.4221	−0.6847	−0.1678	0.0227
Home market volume	-	-	1.0	−0.3052	−0.3202	0.0666
ETF AIM	-	-	-	1.0	0.4326	−0.0466
Home market AIM	-	-	-	-	1.0	−0.0577

square root illiquidity measure (AIM). The final rows of the table report averages for the U.S., developed or open economies, and emerging markets. The volume of trade varies considerably in the sample across ETFs and their associated home markets. The Netherlands ETF has the lowest trade value, while the Russell 2000 has the largest dollar trade for our sample. Not surprisingly, we also observe divergence in volume for the home markets, with trade in the United States and United Kingdom at very high levels. As also is expected, trading volume is lower in emerging markets, as compared to developed or open economies.

Table 3 reports Amihud's illiquidity measure (AIM) in the final two columns. AIM is calculated as the square root of the ratio of daily return to dollar volume. As with the trading volume, we observe considerable variation in the AIM across ETFs and home markets. Average AIMs in the final rows are consistent with the volume measures of liquidity. Among the ETFs, the U.S. ETFs have the highest average volume of trade and the lowest illiquidity as reflected in Amihud's measure. The ETFs for developed economies have lower trading volume and a higher Amihud measure. For the home markets, the emerging markets have the lowest trading volume and the highest average AIM.

As the statistics in Table 3 suggest, our measures of ETF and home liquidity are not perfectly correlated and each may reflect unique information. To more precisely examine the relationships between the liquidity measures we report correlations in Table 4. The table includes the correlations among the ETF premium, the natural logarithm of market value, the natural logarithm of ETF and home market trading volume, ETF and home market illiquidity (AIM), and momentum. Contrary to expectations, ETFs with higher market value are associated with a higher premium, ETF and home market volume are positively correlated to the premium, and ETF and home market illiquidity are negatively related to the premium. The table also indicates that the various measures may capture distinct aspects of liquidity, though the correlation between the liquidity measures is high. For example, although the correlation between the ETF AIM and volume is relatively strong (−0.6847), the correlation between home market AIM and volume is much lower (−0.3202). The multivariate analysis, reported subsequently, will better isolate the effects of interest.

Summary information reported in Tables 1 through 3 indicates that ETF pricing is closely related to fundamental values in the U.S. ETFs, with more mispricing evident for international funds. In addition, the markets are characterized by active trading. The data also suggest relationships between liquidity and market development that are consistent with expectations. As Figures 1 through 3 indicate, mispricing in ETFs has declined over time. At the same time, the liquidity of these markets has improved. Dividing our sample into three periods of equal length, average dollar trading volume in millions in the ETF (home) markets has increased from 9.62 (2,023.88), to 18.34 (2,449.11), to 39.21 (2,749.56) in the most recent sub-sample. Similar improvements in liquidity are observed using AIM. Formal statistical tests of the relationship between pricing and liquidity follow.

V. FUND PREMIUMS AND LIMITS TO ARBITRAGE

In order to more formally examine the relationship between ETF premiums, information dissemination, and liquidity, we estimate (1) and regress fund premium on several explanatory variables. Panels A, B, C, and D of Table 5 include estimates for the full sample, U.S. ETFs, other developed or open economies ETFs, and emerging markets ETFs, respectively. As Table 4 previously documents, ETF and home market measures of liquidity (AIM and VOL) are correlated and, thus, Table 5 includes five versions of the fixed effects regression model (1). In the first four specifications we include only one measure of liquidity (or illiquidity), whereas in the final column all measures are included. In general, the estimates across models are very similar and indicate that multicollinearity is not a problem. Below each coefficient estimate, we report *t*-statistics in parentheses. These *t*-statistics are computed following Peterson (2007), who builds on the method proposed by Fama and MacBeth (1973), and adjust for time and ETF effects.[17] The final rows of each column report the adjusted R^2 and an F-statistic for a test of the null hypothesis that all slope coefficients equal zero.

We first examine the hypothesis that if information is immediately disseminated, changes in the value of an ETF's underlying stock are fully reflected in prices. We find past price changes in NAVs (momentum) have significant effects on premiums for many regressions, suggesting that past information is not

[17] The results are unchanged when we use the the Newey-West (1987) autocorrelation consistent covariance estimator or the White (1980) heteroscedasticity consistent estimator.

Table 5: Cross-Sectional Regressions

The table reports estimates of a cross-sectional regression of the fixed effects regression model (1) for ETFs in our sample with t-statistics reported in parentheses below coefficient estimates. The dependent variable (PR) is the fund premium defined as the difference between the ETF price and the fund's net asset value (NAV), divided by the NAV. The independent variables include momentum (MOM), Amihud's square root illiquidity measure (AIM), the natural logarithm of trading volume (VOL) for the fund (ETF) and its underlying home market stocks (Home), and the natural logarithm of market value of the fund (MV). The final rows of each column report adjusted R^2 and the F-statistic for a test of the null hypothesis that the intercept and all slope coefficients equal zero. Panels A-D include estimates for all ETFs in our sample and those traded in the United States, other developed or open economies, and emerging markets, respectively. *,** indicates significance at the 5%, 1% level.

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel A: All ETFs in the Sample					
$MOM_{f,t-2}$	0.0213*	0.0167*	0.0228*	0.0198*	0.0174*
	[2.59]	[2.26]	[2.70]	[2.60]	[2.35]
$MOM_{f,t-1}$	0.0313**	0.0268**	0.0326**	0.0292**	0.0267**
	[3.89]	[3.22]	[4.06]	[3.57]	[3.16]
$MOM_{f,t}$	0.0278	0.0235	0.0276	0.0252	0.0254
	[1.73]	[1.45]	[1.72]	[1.57]	[1.58]
$AIM^{ETF}_{f,t-2}$	−0.001				0.0002
	[1.17]				[0.32]
$AIM^{ETF}_{f,t-1}$	−0.0018**				−0.0004
	[3.97]				[1.29]
$AIM^{ETF}_{f,t}$	−0.0014*				0.0003
	[2.19]				[0.50]
$AIM^{Home}_{f,t-2}$		−0.1835**			−0.1239**
		[3.18]			[3.03]
$AIM^{Home}_{f,t-1}$		−0.2436**			−0.1555*
		[3.84]			[2.69]
$AIM^{Home}_{f,t}$		−0.2245**			−0.1502*
		[3.26]			[2.59]
$VOL^{ETF}_{f,t-2}$			0.0004*		0.0002
			[2.49]		[1.76]
$VOL^{ETF}_{f,t-1}$			0.0005**		0.0002*
			[3.81]		[2.22]
$VOL^{ETF}_{f,t}$			0.0005**		0.0004**
			[5.30]		[4.60]

(*Continued*)

Table 5: (*Continued*)

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel A: All ETFs in the Sample					
$VOL^{Home}_{f,t-2}$				0.0015*	0.0007
				[2.54]	[1.38]
$VOL^{Home}_{f,t-1}$				0.0024**	0.0017**
				[4.83]	[3.86]
$VOL^{Home}_{f,t}$				0.0010*	0.0003
				[2.06]	[0.74]
MV_f	0.0008	0.0005	0.0002	−0.0001	−0.0006
	[1.53]	[0.98]	[0.37]	[0.25]	[1.54]
Adj. R^2	0.0604	0.0687	0.0704	0.0747	0.0853
F-statistic	27.47**	31.21**	32.31**	34.13**	31.20**
Panel B: U.S. ETFs					
$MOM_{f,t-2}$	0.0036	0.0035	0.0033	0.0036	0.0035
	[0.94]	[0.93]	[0.92]	[0.96]	[0.90]
$MOM_{f,t-1}$	0.0106**	0.0103**	0.0104**	0.0097**	0.0094**
	[7.78]	[6.61]	[7.40]	[6.73]	[6.43]
$MOM_{f,t}$	−0.0005	−0.0004	−0.0005	0.0011	0.0005
	[0.11]	[0.10]	[0.11]	[0.22]	[0.10]
$AIM^{ETF}_{f,t-2}$	0.0022				0.0016
	[2.19]				[1.03]
$AIM^{ETF}_{f,t-1}$	0.0008				0.0014
	[0.45]				[0.50]
$AIM^{ETF}_{f,t}$	0.0018				−0.0013
	[1.37]				[0.50]
$AIM^{Home}_{f,t-2}$		0.0254			0.0088
		[1.75]			[0.46]
$AIM^{Home}_{f,t-1}$		0.0047			−0.0043
		[0.44]			[0.19]
$AIM^{Home}_{f,t}$		−0.0045			0.0009
		[0.34]			[0.06]
$VOL^{ETF}_{f,t-2}$			0.0000		0.0000
			[0.30]		[0.38]
$VOL^{ETF}_{f,t-1}$			0.0000		0.0000
			[0.26]		[0.30]
$VOL^{ETF}_{f,t}$			−0.0002**		−0.0002*
			[7.56]		[3.01]
$VOL^{Home}_{f,t-2}$				−0.0001	−0.0001
				[0.64]	[0.52]

(*Continued*)

Table 5: (*Continued*)

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel B: U.S. ETFs					
$VOL^{Home}_{f,t-1}$				0.0005	0.0005
				[1.21]	[1.07]
$VOL^{Home}_{f,t}$				−0.0008*	−0.0006
				[3.15]	[2.13]
MV_f	0.0000	0.0000	0.0000	0.0000	0.0000
	[0.32]	[0.91]	[0.54]	[0.52]	[1.37]
Adj. R^2	0.0433	0.0426	0.0473	0.0463	0.0475
F-statistic	13.55**	13.33**	14.81**	14.51**	9.19**
Panel C: Developed or Open Economy ETFs					
$MOM_{f,t-2}$	0.0188	0.0161	0.0197	0.0202	0.0173
	[1.58]	[1.43]	[1.63]	[1.83]	[1.59]
$MOM_{f,t-1}$	0.0208	0.0174	0.0224	0.0198	0.0179
	[2.04]	[1.87]	[2.16]	[2.03]	[1.84]
$MOM_{f,t}$	−0.0035	−0.0086	−0.0042	−0.0068	−0.0064
	[0.25]	[0.66]	[0.30]	[0.54]	[0.47]
$AIM^{ETF}_{f,t-2}$	−0.0007				0.0004
	[0.80]				[0.47]
$AIM^{ETF}_{f,t-1}$	−0.0013**				−0.0001
	[3.04]				[0.27]
$AIM^{ETF}_{f,t}$	−0.0009				0.0007
	[1.50]				[1.50]
$AIM^{Home}_{f,t-2}$		−0.1501			−0.1094
		[1.83]			[1.90]
$AIM^{Home}_{f,t-1}$		−0.2332**			−0.1537**
		[3.10]			[3.14]
$AIM^{Home}_{f,t}$		−0.1838			−0.1338
		[1.97]			[1.74]
$VOL^{ETF}_{f,t-2}$			0.0004		0.0003
			[1.68]		[1.71]
$VOL^{ETF}_{f,t-1}$			0.0004**		0.0003**
			[3.28]		[3.04]
$VOL^{ETF}_{f,t}$			0.0005**		0.0005**
			[4.17]		[6.39]
$VOL^{Home}_{f,t-2}$				0.001	0.0003
				[1.25]	[0.40]
$VOL^{Home}_{f,t-1}$				0.0025**	0.0017*
				[3.73]	[2.77]
$VOL^{Home}_{f,t}$				0.0009	0.0002
				[1.27]	[0.35]

(*Continued*)

Table 5: (*Continued*)

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel C: Developed or Open Economy ETFs					
MV_f	0.0013	0.0011	0.0005	0.0004	−0.0002
	[0.79]	[0.74]	[0.40]	[0.26]	[0.16]
Adj. R^2	0.0655	0.0722	0.0766	0.0766	0.0881
F-statistic	25.81**	28.45**	30.48**	30.29**	24.36**
Panel D: Emerging Market ETFs					
$MOM_{f,t-2}$	0.0349	0.0269	0.0394	0.027	0.0237
	[1.94]	[1.51]	[2.00]	[1.43]	[1.29]
$MOM_{f,t-1}$	0.0507	0.0482	0.0552*	0.0501	0.045
	[2.42]	[1.85]	[2.53]	[2.01]	[1.71]
$MOM_{f,t}$	0.0901*	0.0863*	0.0924*	0.0899*	0.0868*
	[3.13]	[2.60]	[3.16]	[2.77]	[2.82]
$AIM^{ETF}_{f,t-2}$	−0.0026				0.0000
	[0.86]				[0.00]
$AIM^{ETF}_{f,t-1}$	−0.0071				−0.0048
	[2.30]				[1.47]
$AIM^{ETF}_{f,t}$	−0.0091				−0.0056
	[1.89]				[0.93]
$AIM^{Home}_{f,t-2}$		−0.2438			−0.1696
		[2.04]			[1.78]
$AIM^{Home}_{f,t-1}$		−0.2867			−0.1546
		[2.31]			[1.22]
$AIM^{Home}_{f,t}$		−0.2924*			−0.1493
		[2.49]			[1.56]
$VOL^{ETF}_{f,t-2}$			0.0003		0.0001
			[1.25]		[0.24]
$VOL^{ETF}_{f,t-1}$			0.0005		−0.0001
			[1.54]		[0.19]
$VOL^{ETF}_{f,t}$			0.0007*		0.0001
			[2.57]		[0.15]
$VOL^{Home}_{f,t-2}$				0.0027	0.0018
				[2.35]	[1.76]
$VOL^{Home}_{f,t-1}$				0.0026*	0.002
				[2.48]	[1.85]
$VOL^{Home}_{f,t}$				0.0009	0.0005
				[1.01]	[0.50]
MV_f	0.0014	0.0015*	0.0008	0.0007	−0.0001
	[1.61]	[3.68]	[0.71]	[1.35]	[0.15]
Adj. R^2	0.0709	0.0733	0.0692	0.0814	0.0906
F-statistic	20.62**	20.82**	20.09**	23.26**	15.79**

fully reflected in current ETF prices. When the effect of momentum is significant, the sign is positive and indicates that past price changes (up or down) are persistent. For the U.S. ETFs reported in Panel B of Table 5, the effect of lagged momentum is consistently positive and significant. The magnitude of the mispricing is unlikely to be economically significant, however, because the fund premium is quite small for these funds. Arbitrage trade may not be profitable once transaction costs (such as bid-ask spreads and commission fees) are factored in (Ackert and Tian (2000) and Elton, Gruber, Comer, and Li (2002)). For country funds reported in Panels C and D, the effects of momentum are similar but weaker.

In addition to the effects of momentum, our results provide further support for predictability in ETF premiums. For the U.S. ETFs, current (lag 0) ETF and home trading volume have negative (and statistically significant) effects on the premium. The negative relationship between fund premium and liquidity in the ETF markets is expected (Brennan and Subrahmanyam (1996), Amihud and Mendelson (1986), and Amihud (2002)) since more liquidity leads to higher fund prices and thus lower fund premium. In contrast, the negative relationship between fund premium and liquidity in the U.S. stock markets is not expected if the ETF market and the market for the underlying stocks are segmented. Of course, ETF and home markets are likely highly integrated since both operate inside the U.S. The relationship between fund premium and market liquidity may be ambiguous in this case.

For the country funds, the picture is different. There appears to be a positive relationship between fund premium and liquidity. As shown in Panels C and D in Table 5, the coefficients for ETF and home trading volume are positive (with one exception) while the coefficients for ETF and home market AIM are negative (with two exceptions). When liquidity effects are significant (and many of them are), liquidity (illiquidity) is associated with *higher* (*lower*) premiums. This seems counterintuitive as it suggests that more active trading is associated with larger mispricing. One possible explanation is that the relationship between fund premium and market liquidity is nonlinear and cannot simply be characterized by a positive or negative relationship.

To further investigate the liquidity-premium relationship, we included squared values of current and lagged AIM in our empirical model of fund premiums. Panels A, B, C, and D of Table 6 report estimates for the full sample, U.S. ETFs, other developed or open economies ETFs, and emerging markets ETFs, respectively.[18] Recall that when liquidity effects are significant for the country funds, illiquidity (i.e., AIM) is negatively related to fund premiums as previously reported in Table 5. After adding the squared illiquidity terms, we find that fund premium is still negatively related to illiquidity but positively related to squared illiquidity (with one exception). These relationships are often statistically significant, more so for the country funds than for the U.S. funds as reported in Table 6.

[18] In the interest of space, the estimated effects of volume are not tabulated.

Table 6: Cross-Sectional Regressions with Nonlinear Effects

The table reports estimates of a cross-sectional regression of the fixed effects regression model (1) for ETFs in our sample with additional independent variables to measure nonlinearities with t-statistics reported in parentheses below coefficient estimates. The dependent variable (PR) is the fund premium defined as the difference between the ETF price and the fund's net asset value (NAV), divided by the NAV. The independent variables include momentum (MOM), Amihud's square root illiquidity measure (AIM), the natural logarithm of trading volume (VOL) for the fund (ETF) and its underlying home market stocks (Home), and the natural logarithm of market value of the fund (MV). The final rows of each column report adjusted R^2 and the F-statistic for a test of the null hypothesis that the intercept and all slope coefficients equal zero. Panels A–D include estimates for all ETFs in our sample and those traded in the United States, other developed or open economies, and emerging markets, respectively. *, ** indicates significance at the 5%, 1% level.

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel A: All ETFs in the sample					
$MOM_{f,t-2}$	0.0195*	0.0166*	0.0225*	0.0201*	0.0170*
	[2.52]	[2.16]	[2.68]	[2.65]	[2.30]
$MOM_{f,t-1}$	0.0299**	0.0263**	0.0324**	0.0296**	0.0267**
	[3.86]	[3.23]	[4.04]	[3.57]	[3.21]
$MOM_{f,t}$	0.026	0.0235	0.0277	0.0253	0.0249
	[1.64]	[1.45]	[1.74]	[1.59]	[1.59]
$AIM^{ETF}_{f,t-2}$	−0.0033*				−0.0004
	[2.69]				[0.37]
$(AIM^{ETF}_{f,t-2})^2$	0.0009**				0.0004
	[2.95]				[1.81]
$AIM^{ETF}_{f,t-1}$	−0.0030**				0.0007
	[2.87]				[0.80]
$(AIM^{ETF}_{f,t-1})^2$	0.0006*				0.0000
	[2.09]				[0.19]
$AIM^{ETF}_{f,t}$	−0.0051**				−0.0019*
	[3.92]				[2.06]
$(AIM^{ETF}_{f,t})^2$	0.0013**				0.0008**
	[4.07]				[3.16]
$AIM^{Home}_{f,t-2}$		−0.2611*			−0.2042
		[2.08]			[1.86]
$(AIM^{Home}_{f,t-2})^2$		3.5763			4.5692
		[0.64]			[0.82]
$AIM^{Home}_{f,t-1}$		−0.1928			−0.1507
		[1.79]			[1.54]

(*Continued*)

Table 6: (*Continued*)

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel A: All ETFs in the sample					
$(AIM^{Home}_{f,t-1})^2$		−2.955			0.3598
		[0.58]			[0.06]
$AIM^{Home}_{f,t}$		−0.3841**			−0.2752**
		[3.31]			[3.20]
$(AIM^{Home}_{f,t})^2$		7.5285			7.4140
		[1.90]			[1.93]
$VOL^{ETF}_{f,t-2}$			0.0003*		0.0001
			[2.57]		[1.29]
$VOL^{ETF}_{f,t-1}$			0.0004**		0.0003*
			[3.55]		[2.46]
$VOL^{ETF}_{f,t}$			0.0005**		0.0003**
			[5.32]		[2.90]
$VOL^{Home}_{f,t-2}$				0.0052*	0.004
				[2.29]	[1.61]
$VOL^{Home}_{f,t-1}$				0.0063**	0.0040*
				[3.82]	[2.64]
$VOL^{Home}_{f,t}$				0.0001	−0.0006
				[0.04]	[0.45]
MV_f	0.0005	0.0004	0.0003	0.0000	−0.0004
	[1.14]	[0.92]	[0.58]	[0.08]	[1.23]
Adj. R^2	0.0908	0.0689	0.0692	0.0718	0.0784
F-statistic	29.13**	29.00**	30.44**	33.14**	26.30**
Panel B: U.S. ETFs					
$MOM_{f,t-2}$	0.0038	0.0035	0.0032	0.0035	0.0034
	[1.01]	[0.91]	[0.90]	[0.94]	[0.89]
$MOM_{f,t-1}$	0.0109**	0.0105**	0.0104**	0.0095**	0.0096**
	[8.64]	[6.49]	[7.49]	[6.59]	[6.60]
$MOM_{f,t}$	−0.0003	−0.0005	−0.0005	0.0012	0.0007
	[0.06]	[0.13]	[0.12]	[0.24]	[0.15]
$AIM^{ETF}_{f,t-2}$	0.0043				−0.0017
	[2.03]				[0.51]
$(AIM^{ETF}_{f,t-2})^2$	−0.0225				0.0039
	[0.94]				[0.15]
$AIM^{ETF}_{f,t-1}$	0.0069				0.011
	[2.32]				[1.82]
$(AIM^{ETF}_{f,t-1})^2$	−0.0668				−0.0818
	[1.70]				[1.57]

(*Continued*)

Table 6: (*Continued*)

	Model				
	(1)	(2)	(3)	(4)	(5)
	Panel B: U.S. ETFs				
$AIM^{ETF}_{f,t}$	0.0044				−0.0062
	[1.10]				[1.18]
$(AIM^{ETF}_{f,t})^2$	−0.0289				0.0238
	[0.68]				[0.58]
$AIM^{Home}_{f,t-2}$		0.0719*			0.0938*
		[2.48]			[2.73]
$(AIM^{Home}_{f,t-2})^2$		−4.5029			−6.3892
		[1.33]			[1.52]
$AIM^{Home}_{f,t-1}$		−0.038			−0.0899*
		[1.57]			[2.77]
$(AIM^{Home}_{f,t-1})^2$		4.3477			6.9619*
		[1.82]			[2.59]
$AIM^{Home}_{f,t}$		0.0216			0.0882
		[0.49]			[1.41]
$(AIM^{Home}_{f,t})^2$		−2.3607			−6.062
		[0.57]			[1.25]
$VOL^{ETF}_{f,t-2}$			−0.0001		−0.0001
			[0.64]		[0.96]
$VOL^{ETF}_{f,t-1}$			0.0000		0.0000
			[0.28]		[0.39]
$VOL^{ETF}_{f,t}$			−0.0001		−0.0002
			[1.53]		[1.36]
$VOL^{Home}_{f,t-2}$				−0.0020	−0.002
				[2.23]	[1.78]
$VOL^{Home}_{f,t-1}$				0.0035	0.0035
				[2.01]	[1.76]
$VOL^{Home}_{f,t}$				−0.0012	−0.0009
				[0.95]	[0.77]
MV_f	0.0000	0.0000	0.0000	0.0000	0.0001
	[0.09]	[0.76]	[0.49]	[0.57]	[1.56]
Adj. R^2	0.0434	0.0426	0.0467	0.0474	0.0486
F-statistic	11.23**	11.01**	12.07**	12.25**	6.43**
	Panel C: Developed or Open Economy ETFs				
$MOM_{f,t-2}$	0.0162	0.0153	0.0196	0.0202	0.0162
	[1.48]	[1.33]	[1.62]	[1.86]	[1.53]
$MOM_{f,t-1}$	0.0194	0.0165	0.0223*	0.0201	0.0178
	[1.95]	[1.80]	[2.16]	[2.11]	[1.85]

(*Continued*)

Table 6: (*Continued*)

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel C: Developed or Open Economy ETFs					
$MOM_{f,t}$	−0.0058	−0.0085	−0.0036	−0.0061	−0.0059
	[0.44]	[0.66]	[0.26]	[0.49]	[0.44]
$AIM^{ETF}_{f,t-2}$	−0.0030				−0.0011
	[2.12]				[1.16]
$(AIM^{ETF}_{f,t-2})^2$	0.0008*				0.0005*
	[2.65]				[2.71]
$AIM^{ETF}_{f,t-1}$	−0.0020				0.001
	[2.03]				[1.56]
$(AIM^{ETF}_{f,t-1})^2$	0.0003				−0.0002
	[1.35]				[1.16]
$AIM^{ETF}_{f,t}$	−0.0039**				−0.0020**
	[3.45]				[3.86]
$(AIM^{ETF}_{f,t})^2$	0.0010**				0.0007**
	[3.65]				[3.26]
$AIM^{Home}_{f,t-2}$		−0.1985			−0.1349
		[1.01]			[0.76]
$(AIM^{Home}_{f,t-2})^2$		1.5929			2.3936
		[0.22]			[0.29]
$AIM^{Home}_{f,t-1}$		−0.3759			−0.3449*
		[2.11]			[2.38]
$(AIM^{Home}_{f,t-1})^2$		5.437			9.3662
		[1.11]			[1.51]
$AIM^{Home}_{f,t}$		−0.4475			−0.3411
		[2.01]			[1.64]
$(AIM^{Home}_{f,t})^2$		10.5345			10.9911
		[1.67]			[1.44]
$VOL^{ETF}_{f,t-2}$			0.0003		0.0001
			[1.74]		[0.80]
$VOL^{ETF}_{f,t-1}$			0.0003		0.0003*
			[1.84]		[2.86]
$VOL^{ETF}_{f,t}$			0.0007**		0.0005**
			[8.14]		[3.43]
$VOL^{Home}_{f,t-2}$				0.0051	0.0047
				[1.73]	[1.24]
$VOL^{Home}_{f,t-1}$				0.0056*	0.0045
				[2.26]	[1.67]
$VOL^{Home}_{f,t}$				0.001	0.0009
				[0.58]	[0.68]

(*Continued*)

Table 6: (*Continued*)

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel C: Developed or Open Economy ETFs					
MV_f	0.0008	0.0009	0.0005	0.0004	−0.0003
	[0.58]	[0.67]	[0.40]	[0.30]	[0.30]
Adj. R^2	0.0745	0.0739	0.0768	0.0818	0.0958
F-statistic	25.85**	25.50**	26.72**	28.42**	19.16**
Panel D: Emerging Market ETFs					
$MOM_{f,t-2}$	0.0346	0.0283	0.0384	0.0272	0.0229
	[2.03]	[1.52]	[1.94]	[1.40]	[1.28]
$MOM_{f,t-1}$	0.0502	0.0486	0.0544*	0.0508	0.0452
	[2.34]	[1.97]	[2.51]	[1.99]	[1.72]
$MOM_{f,t}$	0.0887*	0.0870*	0.0918*	0.0883*	0.0842*
	[3.08]	[2.63]	[3.19]	[2.82]	[2.86]
$AIM^{ETF}_{f,t-2}$	−0.0075				−0.0017
	[1.45]				[0.24]
$(AIM^{ETF}_{f,t-2})^2$	0.0059				0.0039
	[1.76]				[1.10]
$AIM^{ETF}_{f,t-1}$	−0.009				−0.006
	[1.32]				[0.84]
$(AIM^{ETF}_{f,t-1})^2$	0.0027				0.0025
	[0.54]				[0.54]
$AIM^{ETF}_{f,t}$	−0.0174**				−0.0115
	[4.81]				[1.88]
$(AIM^{ETF}_{f,t})^2$	0.0086*				0.0060
	[3.35]				[2.11]
$AIM^{Home}_{f,t-2}$		−0.6384*			−0.5202*
		[2.70]			[2.92]
$(AIM^{Home}_{f,t-2})^2$		22.1479			19.8435*
		[1.80]			[2.59]
$AIM^{Home}_{f,t-1}$		0.239			0.4101
		[0.69]			[1.15]
$(AIM^{Home}_{f,t-1})^2$		−29.8649			−31.8017
		[1.47]			[1.54]
$AIM^{Home}_{f,t}$		−0.4142			−0.1612
		[1.26]			[0.59]
$(AIM^{Home}_{f,t})^2$		6.9547			1.133
		[0.35]			[0.07]
$VOL^{ETF}_{f,t-2}$			0.0003		0.0001
			[1.30]		[0.36]

(*Continued*)

Table 6: (*Continued*)

	Model				
	(1)	(2)	(3)	(4)	(5)
Panel D: Emerging Market ETFs					
$VOL^{ETF}_{f,t-1}$			0.0005		−0.0001
			[1.58]		[0.14]
$VOL^{ETF}_{f,t}$			0.0007*		0.0000
			[2.67]		[0.12]
$VOL^{Home}_{f,t-2}$				0.0031	0.0001
				[0.54]	[0.02]
$VOL^{Home}_{f,t-1}$				0.0101*	0.0066
				[2.77]	[1.93]
$VOL^{Home}_{f,t}$				−0.0053	−0.0067
				[1.17]	[1.75]
MV_f	0.0008	0.0015*	0.0011	0.0008	−0.0001
	[1.08]	[2.77]	[0.98]	[1.36]	[0.13]
Adj. R^2	0.0744	0.0766	0.0704	0.0818	0.0956
F-statistic	17.80**	17.89**	16.81**	19.18**	11.16**

This finding suggests a U-shaped relationship between *illiquidity* and fund premium or equivalently an inverted U-shaped relationship between *liquidity* and fund premium. Perhaps, informed trading dominates only after a certain level of trading is reached. With high illiquidity, trading appears to add noise and lead to higher mispricing. Liquidity moves price toward the NAV once a critical level of trading is achieved. This finding is consistent with the conjecture that informed trading dominates after a certain level of trading volume is reached and the impact of noise trading diminishes (Tkac (1999)).

For the country funds, the liquidity estimates also suggest a second interesting result: the directional effects of ETF and home market liquidity take the same sign. For example, the fund premium is negatively related to the AIM illiquidity measures in both the ETF and home markets (see Panel A of Table 5). These results are robust and not due to a particular measure of illiquidity. Inferences do not change when we use alternative measures of liquidity (illiquidity), including the turnover ratio defined as total market value divided by dollar trading volume and the percentage of stocks that had no change in price each day. This finding contrasts with Chan, Hong, and Subrahmanyam (2005) and Chan, Jain, and Xia (2006) who predict that the fund premium will be higher in a liquid host market (where the ETF trades), whereas the fund premium will be lower in a liquid home market (where the underlying assets trade).

However, recall that when markets are somewhat integrated, directional predictions regarding the effects of host and home market liquidity are unclear because of liquidity spillover effects. As Table 4 documents, liquidity measures across host and home markets are highly positively correlated, indicating that there is some degree of integration across the markets. In addition, ETFs are also inherently different from ADRs or closed-end funds studied by Chan, Hong, and Subrahmanyam (2005) and Chan, Jain, and Xia (2006). While ADRs and closed-end funds are typically sold to investors via an IPO process and closed to new investors afterwards, ETFs have a more flexible structure and do create new units whenever the need arises (Ackert and Tian (2000)). This is likely to happen when liquidity is high in the ETF market (due to high demand for the ETF). As the fund sponsor must purchase the underlying stocks in order to create new units of the ETF, this in turn creates more demand/liquidity in the market for the underlying stocks. This type of liquidity spillover effect is not present in the market for ADRs or closed-end funds. Taken together, our results indicate that the relationship between liquidity and market efficiency is potentially complex and may vary from markets (e.g., ADRs/closed-end funds) to markets (ETFs).

In summary, while prior research argues that the pricing of U.S. ETFs is very efficient (Ackert and Tian (2000), Elton, Gruber, Comer, and Li (2002)), our results indicate that for country funds, significant mispricing is evident. For every regression reported in Tables 5 and 6, the F-statistic rejects the null hypothesis that all regression coefficients are zero. Our results indicate that there is persistent mispricing, especially for country funds.

VI. DISCUSSION AND CONCLUDING REMARKS

This paper reports the results of an examination of the pricing of ETFs in relation to their fundamental values. If arbitrage forces are unlimited, we should see little deviation from NAV. The 28 U.S. and country ETFs in our sample are priced inefficiently, consistent with significant limits to arbitrage. Particularly for country funds and during the initial years in which the ETFs markets were developing, we observe large and persistent deviations in fund prices from their fundamental values. While the fund premium is on average quite small, the variation in the premium can be quite large especially for country funds. The average fund premium is less than 2 basis points for the U.S. funds, whereas the average premium for the country funds is more than 10 basis points. Country ETFs exhibit significant autocorrelation in fund premium while U.S. ETFs typically do not. Time zone differences only partially explain the observed autocorrelation in fund premium of the country ETFs. In contrast to the efficient pricing hypothesis, we report persistent mispricing that is related to momentum, illiquidity, and size effects.

The results reported in this paper indicate that liquidity in the markets in which the ETFs and their underlying shares trade impact fund premiums. For the U.S. funds, higher liquidity is associated with a lower premium. The results are quite different for the country funds in our sample. Others, including Allen and Gale (1994), show that the effect of liquidity differs in developed and emerging markets. This paper documents lower liquidity for country funds and their home markets, relative to U.S. funds and markets. The lower liquidity for country funds leads to larger mispricing for these ETFs, perhaps because the creation and redemption process for country funds is more complex than for U.S. funds due to taxes and impediments to trade (Engle and Sarkar (2006)).

Future research might examine the extent to which increased liquidity in one, less active market displaces trading in another. The current research focuses on the pricing of relatively liquid assets with large market values and the added option of redemption. Future research might also directly compare ADR, CEF, and ETF markets to provide insight into how the redemption feature of ETFs and liquidity interact to promote market efficiency.

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