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IMPORTING INFORMATIONAL EFFICIENCY: EFFICIENCY SPILLOVERS VIA INTERNATIONAL ETFS

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Abstract

This paper investigates the impact of US-traded country equity exchange-traded funds (ETFs) on price discovery, informational efficiency, and liquidity of their foreign constituents. We use index membership to isolate the exogenous variation in US-traded ETF ownership. The paper uses data covering 35 geographies throughout the period from January 2012 to December 2017 inclusive and finds the following results. We find that US-traded country ETFs improve informational efficiency of their foreign constituents by accelerating the speed at which market-wide information gets incorporated into prices of their components. We also provide empirical evidence that US-traded country ETFs improve the liquidity of their foreign constituents. We obtain mixed results with respect to the impact of US-traded country ETFs on price discovery and opening price accuracy of their foreign constituents: equities listed on exchanges whose trading hours do not overlap with those of the US exchanges experience an improvement in opening price accuracy, price discovery shifting towards the non-trading session. Meanwhile, the relationship is reversed for equities listed on exchanges whose trading hours overlap with those of the US market – ETFs having an adverse effect on opening price accuracy of their foreign constituents, with relatively more price discovery occurring throughout the trading session. Altogether, our study makes a significant contribution to the ongoing debate on how ETFs impact their constituents, suggesting that US-traded country ETFs improve market efficiency and liquidity of their foreign constituents while having a significant but mixed effect on the price discovery and opening price accuracy – effects overlooked in research to date.

Keywords: International exchange-traded funds, passive investing, market efficiency, price discovery, price accuracy, market open, liquidity.

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1. Introduction

Traditionally, securities listed on a given exchange could only be traded during the respective market's trading hours. Thus, any information released outside of the trading session (overnight information) could be incorporated in the price of a security only once the market opened (in the morning of the next trading day). As one might expect, large inflows of information often made market openings rather chaotic – illiquid and rather volatile due to price discovery in the morning.

The emergence and proliferation of international exchange-traded funds (ETFs) that track foreign indices (e.g., US-traded ETFs tracking Nikkei 225) allows market participants to trade index components even outside of regular trading hours of the respective market. This allows for overnight price discovery, which is the first potential benefit of US-traded ETFs that hold equities with primary listings in other geographies.

Secondly, since the US markets are relatively liquid, efficient, and populated by sophisticated market participants, another potential benefit of having a US-traded country ETF is that information efficiency of the respective foreign market may improve. Any informed trading in such ETFs may transmit value-relevant information to the respective foreign market via ETF arbitrage mechanism that ensures the absence of mispricing between the ETF and its underlying basket. Therefore, a US-traded international equity ETF may serve as a vehicle through which other countries "import" a higher degree of informational efficiency. What makes this proposition particularly interesting is the fact that in many cases ETFs have been documented to negatively impact informational efficiency of their constituents, previous studies demonstrating signs of excessive volatility, transmission of non-fundamental demand shocks and co-movement patterns, among other adverse effects. Thus, it may turn out that beneficial effects (if any) of US-traded ETFs on market quality of their constituents are offset by the abovementioned negative factors.

With this research we aim to study the effects of US-traded country ETFs on the market quality of underlying foreign constituents – we are primarily concerned with investigating the impact of these investment vehicles on the price discovery, opening price accuracy, informational efficiency, and liquidity of their foreign components. The research questions which we attempt to answer are defined as follows:

1. *To what extent (if any) do US-traded ETFs contribute to overnight price discovery and what is their impact on the accuracy of opening prices of their foreign constituents?*

2. *To what extent (if any) do US-traded ETFs contribute to informational efficiency and liquidity of their foreign constituents?*

The remainder of this paper is organized as follows: Section 2 provides a comprehensive overview of relevant academic literature and sets forward hypotheses to be tested in the course of our work. Section 3 describes the data types used in the study and their respective sources. Section 4 presents the methodology of the paper. Section 5 presents the empirical results of the research and proceeds with the discussion. Section 6 examines the robustness of the obtained results to alternative model specifications and sampling choices. Section 7 concludes and provides suggestions for future research.

2. Literature Review and Hypotheses

Literature review begins with the overview of academic studies examining the impact of ETF ownership on markets and individual securities. We then proceed with analyzing existing research on the price discovery and its driving factors. We then hypothesize that an introduction of a US-traded country ETF can be effectively treated as cross-listing a basket of foreign shares in the US. Thus, we focus our attention on documented effects of cross-listing – in particular, its effect on price discovery and informational efficiency. The section concludes with the overview of the literature on after-hours trading and its impact on price discovery.

2.1. Effects of ETFs on the market and individual securities

To understand how ETFs may influence their foreign constituents' price discovery and informational efficiency, we will start with the review of existing literature on ETFs, which studied empirically the effects on the market and single stocks. Numerous academic papers study the effects of ETFs on their constituents, documenting both positive and negative effects.

Glosten, Nallareddy, and Zou (2016) argue that ETFs may contribute to informational efficiency of stocks with weak information environment. Without ETFs investors would have to evaluate each security separately as new information arrived to the market, thus their coverage would be limited. However, since ETFs enable one to trade a portfolio of securities, this may result in a more timely incorporation of information. The authors provide empirical evidence that increased ETF ownership and index inclusion increases informational efficiency of constituents. However, the effect is limited to small firms with low analyst coverage, as well as stocks that are traded on illiquid markets. Ivanov, Jones, and Zaima (2013) study the effect of ETFs on the price discovery process. The authors argue that, although informed investors are incentivized to trade in the futures market, with the introduction of ETFs price discovery shifts from the futures market towards the spot market, as ETFs are tied to the latter via the no-arbitrage mechanism.

Da and Shive (2018), on the other hand, are among researchers to document negative effects of ETFs on their constituents. More specifically, the study reveals that ETFs lead to excessive return co-movement among their component stocks and the extent of co-movement increases with ETF trading volume. The authors argue that ETFs' components are subject to extensive non-fundamental shocks transmitted via the no-arbitrage mechanism. Tse and Martinez (2007) analyze the impact of international ETFs on the price discovery process, concluding that there is more noise trading in ETFs as compared to their components. If investors indeed learn from ETFs, noise trading may be transmitted into the market of underlying components. The effect of noise trading and volatility transmission was studied by Ben-David, Franzoni & Moussawi (2018), who find that higher ETF ownership increases the volatility of underlying assets. The additional layer of volatility is undiversifiable and exposes investors to a greater degree of systematic risk. These findings contradict the notion that ETFs can contribute to informational efficiency of their components or can make market open more orderly.

The idea that US-listed ETFs may affect liquidity and informational efficiency of foreign stocks was proposed by several researchers, including Boehmer and Zhang (2015). More specifically, the authors argue that due to a lack of information about underlying assets and high transaction costs, US investors avoid investing heavily in foreign equity markets. With the emergence US-traded ETFs tracking foreign indices, investors can access foreign equities, even though not directly investing in them. One of the additional incentives for US investors to trade US-listed ETFs, rather than foreign equities directly, is the possibility to avoid some specific regulations (e.g., short-selling constraints). Boehmer and Zhang (2015) study return predictability of equities included in US-listed country ETFs – the authors' results suggest that returns and market quality of US-traded ETFs are transmitted to their foreign constituents, the effect being stronger for underlying stocks with higher variation of returns and/or when ETF ownership is lower. At first, the idea might appear rather similar to the one investigated in our research. Nevertheless, after careful examination, we conclude that the above-mentioned study is primary concerned with investigating the ETF-stock return relationship and impact of US-traded ETFs on their foreign components' liquidity. The research though neglects potential impact of ETFs on price discovery, opening price accuracy and informational efficiency of their foreign components.

2.2. Price discovery and its determinants

Price discovery is referred to as the process of impounding information into securities' prices so that they converge towards their "true" values. One of the simplest models that explains the price formation mechanism described in many studies is that developed by Glosten and Milgrom (1985). The model features three types of market participants – liquidity providers, informed and uninformed traders. Liquidity providers set different bid and ask quotes for a security to avoid costs of adverse selection that arise from informed trading. Other market participants may engage in trades at quoted bid and ask prices. Liquidity providers may freely adjust their prices by observing the order flow and correctly interpreting behavior of traders. If a set quote is lower than the fundamental value and informed traders receive private information, the liquidity provider will observe buy-order imbalance and adjust quotes so that they are higher, and vice versa. With this mechanism, the price converges towards its fundamental value. Illiquidity, however, may negatively influence the price discovery process. The lack of liquidity may prevent arbitrageurs from engaging in trade and correcting prices towards their fundamental values (Boehmer & Wu, 2013). Trading volume also plays a significant role in price discovery, as it was empirically tested and concluded that stocks with higher trading volume react more quickly to new information and incorporate it into the price, compared with thinly traded stocks (Chordia & Swaminathan, 2000).

Another determinant that influences price discovery is the ability to short sell the security. Given that informed traders contribute to price discovery, the fact of short-selling influence on price discovery stems from the findings of Boehmer, Jones, and Zhang (2008), who show that short-sellers are typically informed traders. The authors suggest that it is superior information about the asset that incentivizes market participants to bear substantial costs associated with short-selling, including inability to freely use proceeds from short-selling. They check it empirically using data from NYSE and conclude that short-sellers are typically well-informed, as heavily-shorted stocks show underperformance compared with slightly shorted ones. Boehmer and Wu (2013) further discover the effects of short-selling on price discovery. Using different measures of informational efficiency, the authors find empirical evidence that short-selling positively contributes to short-term efficiency of prices by reducing deviations from the random walk, which is the essence of efficient prices.

2.3. Cross-listing and its impact on price discovery

To understand the potential effects of US-traded ETFs on the foreign market with both overlapping and non-overlapping trading hours, we turn to academic literature examining the economic implications of cross-listing. US-traded ETFs can be effectively treated as cross-listed baskets of securities – hence, we expect the documented effects of cross-listing observed on individual-stock level to hold on the basket level as well. Although cross-listing via American Depositary Receipts (ADRs) is distinctly different from "direct" cross-listing, for the sake of the forthcoming discussion we do not differentiate between different cross-listing options.

Karolyi (1998) provides a comprehensive overview and critical analysis of the literature on international cross-listings. The evidence suggests that among other benefits cross-listed companies enjoy higher valuations in the month around the cross-listing and greater stock liquidity, with post-listing trading volume increasing in the home market. Exposure to domestic market risk is reduced after cross-listing, which results in a lower cost of equity. For a sample of Canadian stocks, Foerster and Karolyi (1993) find that cross-listing on the US market is associated with improved liquidity. Lang, Lins, and Miller (2003) document that cross-listing in the US improves the stock's information environment, leading to greater analyst coverage and better forecast accuracy. The research on the benefits of cross-listing includes but is not limited to Alexander, Eun, and Janakiramanan (1987, 1988); Damodaran, Liu, and Van Harlow (1993); Jayaraman, Shastri, and Tandon. (1993); Lau, Diltz, and Apilado (1994); Domowitz, Glen, and Madhavan (1998).

Since our research is primarily concerned with the impact of US-traded ETFs on price discovery of their foreign components, studies examining the link between cross-listings and price discovery are of particular interest to us. The question of whether cross-listings contribute to price discovery remains open, previous studies arriving at contradictory conclusions. Per Karolyi (1998), the principal matter of debate is which of the two factors drives in the price discovery process: market quality or location? Coffee (2002) demonstrates that stringent disclosure requirements and higher enforcement standards make information more reliable. In terms of market quality, US markets are perceived to be superior to many other markets because of their efficient market microstructure (Ghadhab and Hellara, 2016) and stringent disclosure requirements imposed by the Sarbanes-Oxley Act (Chen, Li, and Wu, 2010). Meanwhile, most of the company-specific information originates in the country where the company is headquartered. If the 'market quality' effect dominates the 'location' effect, one can expect price discovery to happen on the US exchanges, the no-arbitrage condition assuring that prices in the foreign market react accordingly. On the other hand, if the 'location' effect dominates the 'market quality' effect, a reverse process is to be observed with US market participants learning from foreign markets.

Most of the studies on international cross-listings confirm the home country bias hypothesis – the home market leading in terms of price discovery, with the foreign market having no significant contribution to price discovery and information flowing unidirectionally from the home to the host market. Lieberman, Ben-Zion, and Hauser (1999) study six Israeli firms cross-listed in the US and find that price discovery for these firms occurs predominantly in Israel. Chen et al. (2010) examine nine Chinese companies cross-listed on NYSE and the Stock Exchange of Hong Kong, confirming the dominant role of the 'location' effect. In the same vein, the conclusions of von Furstenberg and Tabora (2004) support the home bias hypothesis: for two major Mexican stocks, the home market dominates NYSE in price discovery. A sample of atypical cross-listing cases is examined by Alhaj-Yaseen, Lam, and Barkoulas (2014) with Israeli companies performing IPOs in the host (US) market and subsequently listing their shares in the home (Israeli) market - a dominating role of the home market is confirmed, in spite of IPOs in the host market. The abovementioned studies are notable in that they cast doubt on the generally-accepted assertion that prices of emerging markets' stocks originate in a more established exchange, such as the NYSE. The universe of studies confirming the home bias hypothesis includes but is not limited to Grammig, Melvin, and Schlag (2005), Kutan and Zhou (2006), Pascual, Pascual-Fuster, and Climent (2006).

The second strand of literature on international cross-listings features studies supporting the global center hypothesis, which suggests that prices originate in the more liquid market, with information then flowing unidirectionally to the less liquid market. Such reasoning is consistent with studies of Fleming, Ostdiek, and Whaley (1996), and Frino and West (2003) who show that markets with lower trading costs attract more informed investors, who in turn drive price discovery. If the host market is more liquid than the home market, unidirectional return and volatility transmission from the former to the latter can be expected. The host market is then said to dominate the price discovery process, contrary to the prediction of the home bias hypothesis.

Recent research by Ghadhab and Hellara (2016) provides support for the assertion that the host market contributes to price discovery, the contribution being greater for multiple-listed firms than for cross-listed ones. Kim, Szakmary, and Mathur (2000) document that the US market dominates the home market in price discovery of ADRs. Alaganar and Bhar (2002) report a unidirectional flow of information from ADRs to their underlying Australian stocks. Along the same line, Jaiswal-Dale and Jithendranathan (2009), and Otsubo (2014), among others, provide evidence that trading in the host market provides important information for pricing of cross-listed stocks.

The third category of studies posits that a two-way, bidirectional price discovery process exists between the home and the host market, both markets being important for information origination and transmission. For a sample of 62 Canadian stocks cross-listed on the TSE and on the NYSE, AMEX, or Nasdaq Eun and Sabherwal (2003) provide evidence for significant price discovery in both markets. Studies by Lau and Diltz (1994), and Werner and Kleidon (1996) document a similar two-way price discovery process for a sample of British firms listed on NYSE and AMEX.

In addition to the link between cross-listing and price discovery, some authors have analyzed the impact of cross-listing on informational efficiency. Domowitz et al. (1998) were among the first to hypothesize that information production in the host market should be transmitted to the home market, improving the stock's informational efficiency. Using a set of intraday microstructure informational efficiency measures, Dodd and Gilbert (2016) provide empirical support for the notion that cross-listing in the US indeed brings such benefits. Moreover, the authors find that cross-listings that took place after the adoption of Sarbanes-Oxley Act are associated with a greater improvement in a firm's information environment and informational efficiency – a finding consistent with the notion that stricter disclosure requirements have a substantial impact on informational efficiency. Some recent evidence suggests that stocks cross-listed in the US become dependent on the US exchanges for information generation – Dodd and Frijns (2018) document that stocks cross-listed on NYSE experience reduction in liquidity and informational efficiency following NYSE closures (e.g., during public holidays).

In a similar vein, Korczak and Bohl (2005) arrive at the conclusion that cross-listing on the US exchanges improves informational efficiency of Central and Eastern European companies – for a sample of 33 companies the authors find that return autocorrelations decrease following cross-listings. Moreover, since liquidity of a company's stock improves in the home market after a cross-listing, the authors suggest that cross-listings attract foreign traders and encourage them to trade in both foreign (US) and home (CEE) market. Lowengrub and Melvin (2001) document for a sample of German firms that cross-listing in the US causes intraday volume and volatility flatten. The authors suggest that ADRs effectively extend trading hours of German stocks: trading hours in the US and Germany are partially overlapping – hence, once the German market closes an investor can continue trading in respective ADRs. Similarly, volatility in the morning drops since trading in ADRs allows for price discovery even before the German market opens.

However, as argued in Fernandes and Ferreira (2008), cross-listing in the US improves informational efficiency of firms with a primary listing in a developed stock market, whereas it has a negative effect on informational efficiency of firms listed in emerging markets. The authors argue that the added analyst coverage from cross-listing primarily contributes to the generation of market-wide information rather than stock-specific information. This finding implies that the impact of US-traded ETFs might also depend on the level of stock market development in the home country. Moreover, if the introduction of a US-traded ETF is associated with greater production of market-level (and not stock-level) information, we can expect that informational efficiency of stocks not tracked by the respective ETF also increases because of greater market-wide information production (this could probably be more pronounced for country ETFs). Hence, stocks which are not part of the stock market index may also benefit from the introduction of a US-traded ETF.

2.4. The impact of after-hours trading on price discovery

We now turn our attention to literature investigating the impact of after-hours/overnight trading on price discovery and efficiency. A US-traded ETF which tracks stocks in a foreign market can potentially allow for better price discovery in the morning before the respective foreign market opens (similar to Lowengrub and Melvin (2001)). This analysis allows us to evaluate the potential effects of US-traded ETFs on markets with non-overlapping or partially overlapping trading hours.

Prior research posits that trading outside of regular trading hours (RTH) brings a significant contribution to informational efficiency of opening prices. In a seminal paper Barclay and Hendershott (2003) evaluate the impact of after-hours trading (AHT) on the amount and timing of price discovery throughout the trading day, concluding that, although prices are more efficient during RTH, AHT plays an important role in price discovery. After-hours trades contain more information per trade than trades made during RTH, indicating greater proportion of informed traders. Barclay and Hendershott (2008) evaluate the role of the Nasdaq pre-open electronic communication network in price discovery: the authors' findings indicate that the increase in pre-open trading on Nasdaq has had a positive impact on informational efficiency during market open, opening prices becoming less noisy. With the increase of pre-trading volume, price discovery shifted to the pre-open period, thus indicating that pre-open trading on Nasdaq contributes to the price discovery process. Nevertheless, in the sample of 250 equities price discovery shifted to the pre-open period only for the 50 most liquid stocks – indicating that substantial trading volumes are required for price discovery to shift to the pre-open.

The contribution of AHT period to establishing efficient opening prices has also been noted by Moshirian, Nguyen, and Pham (2012): the authors suggest that in the presence of AHT, opening prices incorporate overnight earnings announcement information in a timely and efficient manner, whereas intraday price reaction to announcements made within RTH is not instantaneous. These findings support the importance of AHT and pre-open period in establishing efficient opening prices.

Price discovery benefits of AHT are not confined to equities: He, Lin, and Wu (2009) study price discovery in the US Treasury market over a 24-hour day. The authors confirm the significant contribution of AHT to price discovery in the US Treasury market despite low trading volume and high transaction costs in the post-close period – consistent with Barclay and Hendershott (2003).

Based on existing academic research we define the following hypotheses:

Hypothesis 1: US-traded country ETFs have a positive impact on their foreign constituents' opening price accuracy by increasing the amount of overnight price discovery as a fraction of total price discovery, the effect being more pronounced when a foreign market and the US market have noncurrent trading hours.

Hypothesis 2: US-traded country ETFs have a positive impact on informational efficiency and liquidity of their foreign constituents.

3. Data and sample description

To obtain the data necessary for performing the empirical analysis we adhere to a number of secondary data sources. First and foremost, we rely on the Datastream database to obtain the vast majority of variables. The following data have been retrieved at daily frequency: opening and closing prices (USD and in local currency); volume-weighted average prices (USD and in local currency); daily trading volume (USD thousands); market capitalization (USD millions); assets under management of ETFs tracking indices listed in Appendix A. The initial sample covers the period from January 1, 2012 to December 31, 2017 inclusive for a total of 30,137 non-US equities listed in 42 different geographies.

Although the database does not provide readily calculated US-traded ETF ownership figures, one can arrive at ETF ownership figures himself in the following manner. For every equity index to which a given stock belongs one can retrieve historical constituents of the index, their respective weights within the index – $w_{j,i,t}$, and historical market capitalization figures - $Mcap_{i,t}$. One can then obtain historical assets under management figures of all ETFs tracking the index - $\sum_{j=1}^{J} AUM_{j,t}$. The ETF ownership variable is then constructed in the following manner:

$$ETF_{i,t} = \frac{\sum_{j=1}^{J} w_{j,i,t} \cdot AUM_{j,t}}{Mcap_{i,t}} \quad (1)$$

J represents the set of US-traded ETFs holding stock i at the end of month t. $w_{j,i,t}$ represents the weight of stock i in the portfolio of ETF j. $AUM_{j,t}$ stands for assets under management of ETF j at the end of month t. $Mcap_{i,t}$ is the dollar market capitalization of stock i at the end of month *t*.

The abovementioned approach effectively assumes that at any given point in time an ETF which is supposed to track the performance of a given index does so without exhibiting any substantial deviations from the index portfolio.

Another key variable of our interest is *Index* dummy variable. The variable takes the value of 1 if the stock was among the members of a particular index at the of a month and 0 otherwise. The variable is to be applied in the first stage of the 2SLS procedure, as described in Section 4. We reconstruct index membership for all stocks within our sample, with *Index* indicating whether at a given point in time a stock belonged to an index of our interest (Appendix A presents the list of indices for which we obtain membership data). As the data for MSCI index constituents are not available within the Datastream database, we derive the variable using the data provided at iShares.com website. The data source presents historical holdings of iShares ETFs on a monthly basis – the data on MSCI index constituents, however, is lacking. We thus proceed with an assumption that if an ETF replicates the respective MSCI index, the list of ETF constituents should be identical to constituents of the index. With some countries in our sample having more than one major stock market index tracked by US-traded ETFs, for the first stage regression we select the index based on its US-traded country ETF coverage. Thus, for each country, we select an index with the highest US-traded country ETF AUM. Appendix A features the list of indices applied in the analysis as well as the sample of geographies within the scope of our research.

Finally, a variable that represents the percentage of a selected index' market capitalization owned by US-traded ETFs is needed for the subsequent analysis (included in the set of control variables). We calculate market capitalization of each country index as presented in Appendix A by taking the sum of market capitalizations of index constituents at the end of every month. We then arrive to $AUM\%_{c,t}$, a variable that represents the percentage of a respective country index held by US-traded ETFs:

$$AUM\%_{c,t} = \frac{AUM_{c,t}}{IndexMCap_{c,t}} \quad (2)$$

$AUM_{c,t}$ represents assets under management of a respective US-listed country ETF at the end of month t. $IndexMCap_{c,t}$ represents the market capitalization of country index c at the end of month t.

3.1. Overnight price discovery and opening price accuracy metrics

To measure overnight price discovery, we employ a metric developed by French and Roll (1986). The authors analyze the amount of information that enters prices during the trading session in the following manner: first, for their sample of stocks, the authors measure daily open-to-close and close-to-open returns during the sample period. The authors proceed by calculating the variance of open-to-close and close-to-open returns and dividing the close-to-open variance by the sum of open-to-close and close-to-open variances. Thus, one obtains the "variance ratio" – a measure which indicates the contribution of the non-trading session to price discovery as a fraction of total (trading + non-trading session) price discovery. Thus, higher values of the variance ratio imply that more information enters during the non-trading session and vice-versa.

In our tests we employ a slight modification of variance ratio, calculating the variable for each stock-month in the following manner:

$$IntradayPriceDiscovery_{i,m} = \frac{\sigma^2_{T\ i,m}}{\sigma^2_{T\ i,m} + \sigma^2_{N\ i,m}} \quad (3)$$

$\sigma^2_{T\ i,m}$ represents the trading hours (open-close) return variance of stock i during month m. $\sigma^2_{N\ i,m}$ represents the non-trading hours (close-open) return variance of stock i during month m.

Under such specification, the variable measures the amount of information entering a foreign stock's price during the trading session relative to the amount of information entering the price throughout the 24-hour period. Decrease in this variable would thus suggest that price discovery shifts from the trading session towards the non-trading session and vice-versa.

The second metric that we use is *Inaccuracy* of opening price at the beginning of the trading session. We measure opening price inaccuracy as the absolute difference between opening price of a given stock and its volume-weighted average price (VWAP) during day k scaled by VWAP during day k, subsequently arriving to a single stock-month estimate of opening price accuracy by computing the average of n stock-day observations, where n represents the number of trading days in a given stock-month (thus, we obtain a single measure of *Inaccuracy* for each stock-month). Furthermore, we employ prices expressed in local currencies to calculate the *Inaccuracy* measure in order to avoid having *Inaccuracy* driven by exchange rate fluctuations:

$$Inaccuracy_{i,t} = \frac{1}{n} \cdot \sum_{k=1}^{n} \frac{|Opening\ Price_{k,t} - VWAP_{k,t}|}{VWAP_{k,t}} \tag{4}$$

Assuming that the price of a security during a trading day is representative of the security's fundamental value, VWAP of a stock can be applied as the proxy for the fundamental value of a stock during a given trading day. The relative difference between VWAP and the opening price of a stock thus measures by how much the market was off at the beginning of the trading session, be it under- or overpricing. Higher absolute values of the variable indicate greater degree of opening price inaccuracy. Since the price of a security evolves during the trading day as newly discovered information gets incorporated into the price – opening price of a security rarely equals its VWAP. Hence, our measure of opening price accuracy is expected to be significantly different from zero regardless of US-listed ETF ownership. However, if US-traded ETFs provide a price stabilizing mechanism during the market open and contain price-relevant information about their foreign constituents, the opening price for a given stock is expected to be closer to the daily VWAP day for stocks with higher US-listed ETF ownership.

3.2. Informational efficiency and liquidity metrics

To measure informational efficiency for a given stock-month, we resort to such metrics as first-order return autocorrelation, variance ratio, and delay, stock-month estimates derived from daily USD closing prices.

First-order return autocorrelation: Non-zero first-order log-return autocorrelation indicates that the price of a given security deviates from a random walk process, thus exhibiting return predictability and violating random walk hypothesis (RWH). Positive (negative) autocorrelation implies market under– (over)reaction to newly arriving information, indicating partial price adjustment, which is inconsistent with markets being informationally efficient. We calculate absolute first-order return autocorrelation for each stock-month, hence greater values of the measure indicate a greater degree of inefficiency, be it under- or overreaction. For each stock-month within the sample the measure is derived as follows:

$$Autocorrelation_{i,t} = \left|Corr(r_{i,k}\ , r_{i,k-1})\right| = \left|\frac{\sum_{k=1}^{n}(r_{i,k} - \overline{r_{i,k}}) \cdot (r_{i,k-1} - \overline{r_{i,k-1}})}{\sqrt{\sum_{k=1}^{n}(r_{i,k} - \overline{r_{i,k}})^2 \cdot \sum_{k=1}^{n}(r_{i,k-1} - \overline{r_{i,k-1}})^2}}\right| \quad (5)$$

Variance ratio: If the price of a security follows a random walk, the sample variance of the security's n-period returns is *n* times the sample variance of the security's one-period returns:

$$\sigma^2_{n-PeriodReturns} = n \cdot \sigma^2_{1-PeriodReturns} \quad (6)$$

For each stock-month within our sample we construct the *Variance Ratio* measure as follows:

$$Variance\ Ratio_{i,t,n} = \left|\frac{\sigma^2_{i,t,n}}{n\sigma^2_{i,t,1}} - 1\right| \quad (7)$$

Therefore, *Variance Ratio* measures the degree to which return variance deviates from the pattern suggested by the random walk hypothesis (Lo and MacKinlay, 1988). Hence, for RWH to hold the estimated *Variance ratio* should be equal to zero. 3-day and 1-day log-returns have been used in constructing *Variance ratios* applied throughout the forthcoming empirical analysis.

Delay in impounding public information: We employ a modification of the *Delay* measure proposed by Hou and Moskowitz (2005). The measure represents the degree to which a stock's returns can be predicted using lagged market returns. For each stock-month we estimate a regression of a stock's daily log-returns on the market portfolio returns and five lags:

$$r_{i,k} = \alpha_i + \beta_i \cdot r_{m,k} + \sum_{n=1}^{5} \delta_{i,n} \cdot r_{m,k-n} + \varepsilon_{i,k} \quad (8)$$

Subsequently, we save the R^2 ($R^2_{Unconstrained}$) of the estimated regression and re-estimate the relationship with coefficients on lagged market portfolio returns constrained to zero, saving the R^2 coefficient of the constrained regression *(*$R^2_{Constrained}$*)*. We then proceed by calculating *Delay* for each stock-month as follows:

$$Delay_{i,t} = 1 - \frac{R^2_{Constrained}}{R^2_{Unconstrained}} \tag{9}$$

The measure takes values from 0 to 1 – larger values indicating that more variation in daily returns of a stock can be explained by lagged market returns, implying that it takes longer for the stock's price to incorporate market-wide information – hence a lower degree of informational efficiency. We calculate daily log-returns on market portfolio by weighing daily log-returns of all stocks in a given market by their respective market capitalizations.

Stock liquidity: To measure the liquidity of a stock, we employ Amihud's (2002) illiquidity measure that represents the ratio of a stock's absolute return to its dollar trading volume throughout the period. Higher *ILLIQ* measure thus represents a lower degree of liquidity. The measure is constructed in the following manner:

$$ILLIQ_{i,t} = \frac{1}{D}\sum_{t=1}^{D}\frac{|r_{i,t}|}{V_{i,t}} \tag{10}$$

$|r_{i,t}|$ represents the absolute daily return of stock i on day t. $V_{i,t}$ represents the dollar trading volume in stock i during day t. D represents the number of days in a month.

3.3. Final dataset and summary statistics

The metrics described in sub-sections 3.1 and 3.2 are calculated on daily data for each stock-year-month. Once the metrics of our interest are calculated, we compress the dataset by obtaining stock-month averages of all variables (dependent and explanatory)[1]. Since the distribution of the *ETF* variable is severely concentrated around 0, we perform log normalization procedure. Furthermore, for normalization purposes, we exclude all observations where *ETF* is equal to 0. All of the regressions described herein employ the normalized *ETF* variable.

We acknowledge that our dataset could potentially be subject to outliers – therefore, we manually check the data and perform winsorization of variables when needed. Firstly, we filter the data by market capitalization and average daily trading volume at 1st and 99th percentiles to exclude potential outliers as well as the most illiquid stocks. We then winsorize ETF ownership and $AUM\%$ variables at 2.5 percentile from the right tail both. Dependent variables were winsorized at 1st and

[1] *Inaccuracy* has been calculated for each stock-day separately based on the procedure described in equation (4) with monthly average *Inaccuracy* for each stock-month computed subsequently. Thus, *Inaccuracy* as presented in the dataset and employed in subsequent regression analysis, represents average opening price inaccuracy during a month. Similarly, ILLIQ represents average daily ILLIQ throughout a given month.

99th percentiles. Our final sample represents an unbalanced panel consisting of 330,621 stock-month observations:

Table 1: Summary statistics

The table reports summary statistics for the filtered and winsorized variables used in regressions, as well as descriptive statistics on the observations included in the final dataset.

Variable	Obs	Mean	Std. Dev.	Min	Max
Panel A: General descriptive statistics					
ETF	330,621	0.0213	0.0472	0.0000	0.2635
Index	327,919	0.2615	0.4395	0	1
Mcap	330,621	3043	4915	5	33747
AUM%	299,891	0.0031	0.0027	0.0000	0.0151
Panel B: Overnight price discovery and opening price accuracy metrics					
IntradayPriceDiscovery	330,008	0.7547	0.1563	0.2767	0.9750
Inaccuracy	330,598	0.0103	0.0049	0.0029	0.0286
Panel C: Informational efficiency and liquidity metrics					
Autocorrelation	330,621	0.1802	0.1308	0.0029	0.5540
Variance ratio	330,621	0.2692	0.1870	0.0048	0.8363
Delay	330,621	0.5149	0.3046	0.0282	0.9995
ILLIQ	330,621	0.0003	0.0010	0.0000	0.0075

4. Methodology

This section discusses methods applied in the forthcoming empirical analysis which assesses the impact of US-traded country ETFs on price discovery, opening price accuracy, informational efficiency and liquidity of the underlying foreign stocks.

4.1. 2SLS estimation: first stage procedure

The main challenge to drawing statistical inferences regarding the causal relationship between the respective characteristic of a given stock and its US-traded ETF ownership is that of isolating exogenous variation in US-traded ETF holdings. To account for the fact that ownership of a given stock by US-traded ETFs can be correlated with the error term of the regression, we apply two-stage least squares (2SLS) analysis, an approach similar to that proposed in Appel, Gormley, and Keim (2016). We exploit exogenous variation in ETF ownership in an instrumental variable estimation, applying index membership as the instrument and controlling for stocks' market capitalization alongside time and industry fixed effects. The instrument is meant to exploit discontinuity around the edges of indices: given two stocks, where one is just in the index (at the bottom of the index based on market capitalization), and the other is almost in the index (at the top of non-members list based on market capitalization), it can be expected that the former stock enjoys significantly higher ETF ownership compared to the latter stock. One may rightly notice that there is more than one equity market index available for the vast majority of countries. Thus, for each country, we select an index with the highest US-traded country ETF AUM. Appendix A features the list of indices applied throughout the forthcoming analysis.

Our first stage estimation procedure rests on the assumption that after controlling for a stock's market capitalization at a given point in time, index mambership does not directly interact with independent variables of our interest, except through ETF ownership. For the purposes of our research we deem such assumption plausible: after we control for daily market capitalization – one of the main determinants of index membership, index membership *per se* should have no impact on liquidity, price discovery and informational efficiency characteristics of a given stock, stocks "just in the index" and those "almost in the index" sharing similar characteristics except for index membership. In line with Appel et al. (2016), our set of explanatory variables does not include firm fixed effects, the reasoning being that controlling for firm fixed effects will remove a significant portion of sustained variation in ETF ownership. Since the composition of indices remains relatively unchanged during our sample period (i.e., not many companies during the sample period change index membership), controlling for firm fixed effects will restrict our ability to capture relevant variation in ETF ownership. As suggested in McKinnish (2008); and subsequently emphasized in Gormley and Matsa (2014), this can result in misleading statistical inferences. Instead, industry fixed effects are included in the set of control variables.[2]

To account for the fact that index membership may affect the level of ETF holdings differently across countries, we estimate the first stage separately for each country – doing otherwise would result in ETF ownership being over-estimated for markets with comparatively low ETF coverage and under-estimated ETF ownership for markets with comparatively high ETF coverage. Similarly, one may reasonably expect that the magnitude of the index membership – ETF ownership relationship varies over time: back in the days when the ETF market was not as developed as it is now, index membership had little to no effect on ETF ownership. As AUM of ETFs tracking a specific index increases, so does the magnitude of the ETF membership effect. In other words, the effect of index membership on ETF ownership depends on the fraction of the index' aggregate market capitalization held by ETFs tracking the index. Our proposed method

[2] We would like to bring it to the reader's attention that our results, nevertheless, are robust to the introduction of stock fixed effects, as indicated in Table 6 – Specification (5)

accounts for the potential time-varying nature of the relationship by including the amount of a given stock market index held by US-traded country ETFs ($AUM\%$) and interacting the variable with *Index* dummy variable. We expect to observe a positive coefficient on the interaction term, suggesting that the impact of index membership on ETF ownership is greater when a larger fraction of a given stock market index is held by US-traded ETFs. Thus, the following relationship is examined in the first stage:

$$lnETF_{i,t} = \beta_0 + \beta_1 \; Index_{i,t} + \beta_2 \; AUM\%_{c,t} + \beta_3 \; AUM\%_{c,t} * \; Index_{i,t} + \sum_{n=1}^{2} \beta_{n+3}\left(\ln\left(Mcap_{i,t}\right)\right)^n + \tau_t + \gamma_i + \varepsilon_{i,t} \quad (11)$$

$ETF_{i,t}$ represents the percentage of a given company's stock owned by US-traded ETFs at the end of month t. $Index_{i,t}$ is a dummy variable that takes the value of 1 if the stock belongs to the stock market index (as specified in Appendix A) at the end of month t and 0 otherwise. $AUM_{c,t}$ represents the percentage of a given stock market index held by US-traded ETFs. $Mcap_{i,t}$ is a firm's average dollar market capitalization throughout month t. τ_t represents monthly time fixed effects; γ_i represents industry fixed effects. $\varepsilon_{i,t}$ represents error term of the regression.

4.2. Impact on overnight price discovery of foreign constituents

We hypothesize that the introduction of a US-traded country ETF leads to greater non-trading-session price discovery for their foreign constituents. French and Roll (1986) suggest that higher trading session volatility is caused by private information being incorporated into prices. An informed trader cannot act on his private information if the exchange is closed, therefore, any private information acquired outside of trading hours can be incorporated into the price of a security only once the respective exchange opens (or so it would in the absence of cross-listed securities). Hence, higher trading-hours volatility can be partially attributed to informed investors acting on newly acquired information.

With the arrival of a US-traded ETF tracking securities in foreign markets, an informed trader can act on his information while foreign markets are closed by trading in the respective US-listed ETF. Therefore, the relative contribution of non-trading hours to price discovery of foreign constituents is expected to increase, the greater is the fraction of a foreign constituent's stock held by US-traded ETFs. Hence, our hypothesis implies that stocks with higher US-traded ETF ownership have lower variance ratios since less information enters during the trading session, market participants acting on the newly-arriving information by trading ETFs instead of waiting for the foreign market open. We proceed with the 2SLS analysis, estimating the following regression in the 2nd stage:

$$Y_{i,t} = \beta_0 + \beta_1 \cdot ln\widehat{ETF_{i,t}} + \sum_{n=1}^{2} \beta_{n+1}\left(ln\left(Mcap_{i,t}\right)\right)^n + \tau_t + \gamma_i + \varepsilon_{i,t} \qquad (12)$$

$Y_{i,t}$ represents a respective price discovery metric during month *t* for stock i. $ln\widehat{ETF_{i,m}}$ represents the natural logarithm of the percentage of a given company's stock owned by US-listed ETFs at the end of month m as estimated in the first stage (see equation (11)). $Mcap_{i,t}$ is a firm's average dollar market capitalization during month t. τ_t represents monthly time fixed effects; γ_i represents industry fixed effects. $\varepsilon_{i,t}$ is the error term of the regression.

The regression is estimated separately for 3 different groups of countries based on the extent of their trading session overlap with the US trading session: i) markets where trading hours almost fully overlap with the US trading hours; ii) markets where there is no overlap of local trading hours with the US trading hours; iii) markets where trading hours overlap partially with the US trading hours. Thus, we estimate specification (12) for three different sub-samples.

Consistent with our hypothesis we expect to observe a negative relationship between $IntradayPriceDiscovery_{i,t}$ and $\widehat{ETF_{i,t}}$ variables for the group of countries that have noncurrent trading hours with the US market (i.e. less information entering the price of a stock during the trading session for stocks with higher US-traded ETF ownership). It is not clear what could be the potential effect on price discovery for stocks within the *Full Overlap* group: on the one hand, since trading hours in markets where such stocks are listed almost fully overlap with those in the US, there could be little to no relationship. Market participants willing to trade on their information after the respective market closes would have no choice but to wait for either of the markets to open – hence, US-traded ETFs should not lead to a shift in price discovery towards the non-trading/pre-open session. On the other hand, if US market participants who would otherwise be reluctant to trade in foreign equities decided to trade in such equities via ETFs listed on the US exchanges, this would have a positive impact on the amount of price discovery happening during the trading session – and a positive relationship for such countries would be observed. At this stage we abstain from hypothesizing further, our expectation being that if US-traded ETFs do have an impact on price discovery in foreign equities listed in markets whose trading hours overlap almost fully with the US trading hours, the observed effect must be positive. Overall, the probability that market participants can act on their value-relevant information outside of the trading session should be higher the longer a respective ETF trades while a foreign market is closed.

If there is indeed a negative relationship between $IntradayPriceDiscovery_{i,t}$ and $\widehat{ETF_{i,t}}$ for the groups with noncurrent trading hours, meaning that more price discovery occurs outside of the trading session, we suspect that there is a price stabilization mechanism that could potentially make opening prices more accurate. If opening price inaccuracy is primarily due to excessive volatility at the beginning of the trading session, having price discovery shift towards the overnight/pre-open period should make opening prices less volatile and thus more informative. To evaluate this relationship, we explain the inaccuracy of opening prices as captured by the variable $Inaccuracy_{i,t}$ by re-estimating equation (12), with $Inaccuracy_{i,t}$ in the role of the dependent variable.

As described in Section 3, since the price of a stock evolves during the trading session, the opening price will rarely be equal to VWAP during the day (which would mean perfect accuracy). However, if US-traded ETFs provide price stabilization mechanism, inaccuracy of opening prices should decrease. Thus, we expect to observe a negative relationship between US-listed country ETF ownership and $Inaccuracy_{i,t}$, the effect being more pronounced the lower the extent of trading session overlap between a respective country and the US.

4.3. Impact on informational efficiency and liquidity of foreign constituents

To evaluate the relationship between US-traded ETFs and informational efficiency of their foreign constituents, we adopt a method similar to that described in the previous sub-section. In the first stage of the 2SLS regression analysis (equation (11)) we explain ETF ownership with index membership, controlling for market capitalization, the percentage of country index market capitalization held by US-traded country ETFs as well as industry and time fixed effects. In the second stage we select the following variables that describe informational efficiency/liquidity of stocks, respectively, and regress them on ETF ownership and a set of control variables as indicated in equation (12):

Variable ($Y_{i,t}$)	Measure of:	Description
$Autocorrelation_{i,t}$	Informational efficiency	Absolute value of first-order log-return autocorrelation. A measure of return predictability, higher values indicating a greater degree of informational inefficiency
$Variance\ Ratio_{i,t}$	Informational efficiency	A measure of weak-form information efficiency representing the degree to which price series deviate from the pattern expected under the random

		walk hypothesis. 1-day and 3-day log returns have been used in constructing the metric
$Delay_{i,t}$	Informational efficiency	A measure of return predictability representing the extent to which lagged market returns can predict returns of a security. Five lags of log returns on local market portfolio have been used to compute the metric
$ILLIQ_{i,t}$	Liquidity	The ratio of a stock's absolute log return to its trading volume throughout the period of interest. Represents price response of a security associated with one thousand US dollar trading volume

5. Results and discussion

In line with the approach present in the Methodology section, to isolate exogenous variation in ETF ownership, we instrument ETF ownership on index membership, controlling for two powers of log market capitalization, time- and industry fixed effects. We should also note that all the regressions are estimated using two-way cluster-robust standard errors to account for potential cross-sectional and time-series correlation in the dataset (the errors are thus clustered across individual stocks and year-months).

Results of the first stage regression for the pooled sample are presented in Table 2 and, in line with our expectations, indicate a statistically-significant positive relationship between index membership and ETF ownership. We also observe a statistically significant relationship between ETF ownership and interaction of *AUM%* and *Index* variables, which provide the evidence that the effect of index membership on ETF ownership is greater when a larger portion of a given stock market index is held by ETFs.

The table reports the coefficients of the following regression:

$$lnETF_{i,t} = \beta_0 + \beta_1 \cdot Index_{i,t} + \sum_{n=1}^{2} \beta_{n+1}\left(\ln(Mcap_{i,t})\right)^n + \beta_4 \cdot AUM\%_{c,t} + \beta_5 \cdot Index_{i,t} \cdot AUM\%_{c,t} + \tau_t + \gamma_i + \varepsilon_{i,t}$$

ln(ETF) $_{i,t}$ represents natural logarithm of the percentage of a given company's stock owned by US-listed country ETFs at the end of month t. *Index* $_{i,t}$ is a dummy variable that takes the value of 1 if the stock belongs to the respective stock market index (as specified in Appendix 1) at the end of month t and 0 otherwise. *Mcap* $_{i,t}$ is a firm's average dollar market capitalization throughout month t. *ln(AUM%)* $_{i,t}$ represents the percentage of the respective country index' market capitalization held by the largest US-traded country ETF tracking the index. τ_t represents monthly time fixed effects; γ_i represents industry fixed effects. $\varepsilon_{i,t}$ represents error term of the regression.

ln(ETF)	**Coef.**	
Index	**2.370**	***
	(5.52)	
ln(Mcap)	0.627	***
	(4.03)	
ln(Mcap) ^{2}	-0.043	***
	(-4.22)	
ln(AUM%)	0.011	
	(0.16)	
*Index*ln(AUM%)*	0.136	**
	(2.19)	
Constant	-7.669	***
	(-18.55)	
No. of observations	299,891	
R^2	0.342	

t statistics reported in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

We acknowledge the fact that the magnitude the effect of index membership may differ based on the stock market where the respective stock is traded. Therefore, we perform the first stage of the 2SLS procedure country-by-country and report regression coefficients in Appendix B The working variable in all subsequent regressions is instrumented natural logarithm of ETF ownership, as predicted in the first-stage regression. The set of control variables applied in all second-stage regressions includes two powers of log market capitalization, time- and industry-fixed effects.

We proceed to examine the effect of ETF ownership on the amount of overnight price discovery and opening price accuracy. Table 3 reports regression coefficients of the second stage of 2SLS analysis.

Table 3: Impact of ETFs on price discovery and opening price accuracy

The table reports the coefficients of the following regression by *Overlap* groups:

$$Y_{i,t} = \beta_0 + \beta_1 \cdot ln\widehat{ETF}_{i,t} + \sum_{n=1}^{2} \beta_{n+1}\left(\ln\left(Mcap_{i,t}\right)\right)^n + \tau_t + \gamma_i + \varepsilon_{i,t}$$

$Y_{i,t}$ represents intraday price discovery or opening price inaccuracy metric for a given stock i during month t. $ln\widehat{ETF}_{i,t}$ is the natural logarithm of the percentage of a given company's stock owned by US-listed ETFs at the end of month t as estimated in the first stage of the regression. $Mcap_{i,t}$ is a firm's average dollar market capitalization throughout month t. τ_t represents monthly time fixed effects; γ_i represents industry fixed effects. $\varepsilon_{i,t}$ represents error term of the regression.

Panel A: IntradayPriceDiscovery	***Full Overlap***	***No Overlap***	***Partial Overlap***
ln(ETF)	0.0119 ***	-0.0276 ***	-0.0014
	(3.22)	*(-12.43)*	*(-0.63)*
ln(Mcap)	0.0435 ***	0.0896 ***	0.1040 ***
	(3.65)	*(10.77)*	*(9.85)*
ln(Mcap) ^{2}	-0.0032 ***	-0.0063 ***	-0.0062 ***
	(-3.78)	*(-10.61)*	*(-9.00)*
Constant	0.7260 ***	0.2780 ***	0.3350 ***
	(14.02)	*(8.61)*	*(7.48)*
No. of observations	27,835	196,814	74,629
R^2	0.120	0.120	0.106

Panel B: Inaccuracy	***Full Overlap***	***No Overlap***	***Partial Overlap***
ln(ETF)	0.0009 ***	-0.0011 ***	0.0004 ***
	(6.45)	*(-10.09)*	*(4.94)*
ln(Mcap)	-0.0041 ***	0.0001	-0.0021 ***
	(-7.27)	*(0.26)*	*(-4.48)*
ln(Mcap) ^{2}	0.0002 ***	-0.0000	0.0001 **
	(4.22)	*(-0.63)*	*(2.11)*
Constant	0.0363 ***	0.0052 ***	0.0243 ***
	(15.94)	*(3.23)*	*(12.05)*
No. of observations	28,442	196,819	74,630
R^2	0.516	0.246	0.311

t statistics reported in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

One can observe that ETFs lead to price discovery shifting towards the trading session for the *Full Overlap* group of stocks, while the relationship is reversed for the *No Overlap* group. We document no effect on stocks within the *Partial Overlap* group. More specifically, 1% increase in ETF ownership leads to an increase in *IntradayPriceDiscovery* of 0.0119% for the *Full Overlap* group (i.e., the amount of price discovery during the trading session as a fraction of total price discovery increases by 0.0119%). Meanwhile, for stocks within the *No Overlap* group, the amount of price discovery during the non-trading session as a fraction of total price discovery decreases by 0.0276%. We interpret this finding as follows: ETFs make price discovery of their constituents shift towards the part of the day when these ETFs are traded. Thus, for the group with fully-overlapping trading hours price discovery shifts towards the trading session because the US trading hours are concurrent to trading hours in these geographies. Meanwhile, the *No Overlap* group experiences a shift in price discovery towards the non-trading session (when local stock markets are closed and ETFs are being traded on the US exchanges). The sign of the coefficient for the *Partial Overlap* group appears to be in line with our hypothesis, however, we abstain from drawing any strong conclusions for this group of stocks as the regression coefficient appears insignificant.

In a similar vein, we test for the effects of US-traded ETFs on opening price accuracy of their constituents. Table 3 presents evidence on opening prices becoming more accurate for the *No Overlap* group: 100% percent increase in ETF ownership leading to opening prices being closer to their VWAPs by 0.1 percentage points. On the other hand, the *Full Overlap* group suffers from more inaccurate opening prices – 100% increase in ETF ownership resulting in 0.09 percentage point increase in *Inaccuracy* metric. A potential explanation for this observation could lie in the fact that price discovery, as measured by the *IntradayPriceDiscovery* metric, shifts towards the trading session for stocks within this group. Since price discovery shifts towards the trading session, less information gets impounded into the price of a stock throughout the overnight/pre-open period. Thus, prices as of the market open are not as accurate as they would have been in the absence of US-traded ETFs, and "true prices" are yet to be revealed as the trading session evolves.

Interestingly, for the *Partial Overlap* group, the test reveals a deterioration of opening price accuracy – *Inaccuracy* metric increasing by 0.04 percentage points as a result of ETF ownership doubling. This result might appear rather puzzling when one reminds himself of the fact that the *IntradayPriceDiscovery* tests revealed no relationship between ETF ownership and intraday price discovery patterns. We direct the reader's attention to the fact that the beginning of the trading session in the US overlaps with the end of the trading session in these markets (see Appendix C). Therefore, it could well be the case that US-traded ETFs make trading session price discovery shift towards the end of the trading day (i.e. there is relatively more trading activity at the end of the trading session as compared to its beginning). This explanation is consistent with the observation that US-traded ETFs have no impact on *IntradayPriceDiscovery* for the *Partial Overlap* group: price discovery does not shift from the trading session towards the non-trading session – instead, it shifts within the trading session, with relatively more price discovery occurring at the end of the trading day. Put simply, opening prices become less accurate because price discovery shifts from the morning trading period (local market open) towards the evening trading period (US market open). Such an interpretation effectively implies that the US ETFs may impact not only opening prices of their foreign constituents, but also their VWAPs – thus, there may be no effect on market open – instead, it is "market close" which is affected. To some extent these findings are supportive of the hypothesis set forward by Boehmer and Zhang (2015), who suggest that US investors might avoid investing heavily in foreign equity markets due to the lack of information and high transactions costs. Through ETFs, however, investors can access these markets indirectly, and hence contribute to greater price discovery process throughout the period when these ETFs are traded. Since for the *Full Overlap* group this period coincides with the trading session in ETFs' components, relatively more price discovery occurs through the trading session. The opposite is true for the *No Overlap* group – the period of ETF trading coincides with the non-trading session in ETFs' components, hence price discovery during the non-trading session becomes more intensive.

We now turn our attention to the relationship between ETF ownership and informational efficiency of their constituent stocks. Table 4 summarizes the effect of ETF ownership on three metrics of informational efficiency – *Autocorrelation*, *Variance Ratio,* and *Delay:*

$$Y_{i,t} = \beta_0 + \beta_1 \cdot \widehat{lnETF}_{i,t} + \sum_{n=1}^{2} \beta_{n+1}\left(\ln\left(Mcap_{i,t}\right)\right)^n + \tau_t + \gamma_i + \varepsilon_{i,t}$$

$Y_{i,t}$ represents a a respective informational efficiency metric for a given stock i during month t. $\widehat{lnETF}_{i,t}$ is the natural logarithm of the percentage of a given company's stock owned by US-listed ETFs at the end of month t as estimated in the first stage of the regression. $Mcap_{i,t}$ is a firm's average dollar market capitalization throughout month t. τ_t represents monthly time fixed effects; γ_i represents industry fixed effects. $\varepsilon_{i,t}$ represents error term of the regression.

Panel A: Autocorrelation	***Full Overlap***	***No Overlap***	***Partial Overlap***
ln(ETF)	-0.0002	-0.0002	-0.0013
	(-0.13)	*(-0.10)*	*(-1.43)*
ln(Mcap)	-0.0204 ***	-0.0192 ***	-0.0201 ***
	(-3.78)	*(-6.56)*	*(-3.86)*
ln(Mcap) ^{2}	0.0012 ***	0.0010 ***	0.0009 ***
	(3.00)	*(5.23)*	*(2.68)*
Constant	0.2640 ***	0.2620 ***	0.2750 ***
	(12.49)	*(15.52)*	*(12.60)*
No. of observations	28,442	196,819	74,630
R^2	0.018	0.018	0.019

Panel B: Variance ratio	***Full Overlap***	***No Overlap***	***Partial Overlap***
ln(ETF)	-0.0002	0.0028 *	-0.0009
	(-0.10)	*(1.69)*	*(-0.60)*
ln(Mcap)	-0.0237 ***	-0.0309 ***	-0.0283 ***
	(-3.14)	*(-7.79)*	*(-3.72)*
ln(Mcap) ^{2}	0.0013 **	0.0017 ***	0.0013 ***
	(2.46)	*(5.97)*	*(2.77)*
Constant	0.3700 ***	0.4160 ***	0.4050 ***
	(12.32)	*(22.60)*	*(12.15)*
No. of observations	28,442	196,819	74,630
R^2	0.014	0.017	0.023

Panel C: Delay	***Full Overlap***	***No Overlap***	***Partial Overlap***
ln(ETF)	-0.0274 ***	0.0043	-0.0283 ***
	(-4.64)	*(0.92)*	*(-6.03)*
ln(Mcap)	0.0233	0.0088	-0.0408 *
	(1.19)	*(0.63)*	*(-1.92)*
ln(Mcap) ^{2}	-0.0047 ***	-0.0042 ***	-0.0025 *
	(-3.42)	*(-4.43)*	*(-1.85)*
Constant	0.5250 ***	0.6780 ***	0.8370 ***
	(6.32)	*(10.71)*	*(9.22)*
No. of observations	28,442	196,819	74,630
R^2	0.210	0.202	0.288

t statistics reported in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

Presented in Panel A, results for *Autocorrelation* tests suggest that there is a negative but statistically insignificant relationship between ETF ownership and first-order return autocorrelation. *Variance Ratio* tests (Panel B) yield similar results for *Full Overlap* and *Partial Overlap* groups, implying a negative but insignificant relationship between the two variables. At the same time, *Variance Ratio* tests for the *No Overlap* group indicate that ETFs have a negative impact on informational efficiency of the stocks within the group: if ETF ownership doubled (100% increase), one would expect *Variance Ratio*s to increase by 0.0028 units (equivalent to 0.015 standard deviations). – the effect is significant at 10% significance level. Contrary to Ben-David et al. (2018), who find that stocks with higher ETF ownership tend to exhibit negative autocorrelation, we document no impact of ETFs on return autocorrelation of their components.

We proceed by examining the extent to which US-traded ETFs impact the speed with which prices of individual component stocks incorporate local market-wide information. The results are reported in Panel C of Table 4. In line with our expectations, the estimated relationship indicates that prices of individual component stocks incorporate local market-wide information faster the greater is their US-traded ETF ownership. A doubling of ETF ownership (100% increase) would lead to a decrease in *Delay* by 0.0274 and 0.0283 units, respectively (which is equivalent to a decrease of 0.090 and 0.093 standard deviations, accordingly). Meanwhile, there appears to be no effect on stocks listed in markets with trading hours not overlapping with the US market – for the *No Overlap* group we document no statistically significant effect of ETF ownership on the *Delay* metric. It appears that concurrent/overlapping trading hours are a prerequisite for faster incorporation of market-wide information.

One might question the results of the three tests in terms of their consistency: ETFs appear to not affect informational efficiency of their components when *Autocorrelation* and *Variance Ratio* metrics are used as proxies – meanwhile, the tests on *Delay* indicate improvement in informational efficiency. The three metrics, however, capture different dimensions of informational efficiency: *Autocorrelation* and *Variance Ratio* capture deviations of stock prices from RWH – such deviations could be attributable to the quality of incorporation of any information, be it private, public or market-wide. *Delay*, on the other hand, reflects how quickly the price of a given security incorporates market-wide information. Thus, ETFs' component stocks enjoy faster incorporation of market-wide information, while the effect on overall price efficiency appears indistinguishable from zero. After all, this explanation seems rather compelling given that prices of US-traded ETFs aggregate information of the whole underlying foreign portfolio (e.g., foreign market-wide information), whereas any stock-specific information is hardly incorporated (unless the stock in question represents a sizeable fraction of the market portfolio). Overall, the finding supports the claim of Glosten et al. (2016), who argue that increased ETF ownership leads to a faster incorporation of information – in the absence of ETFs investors would have to evaluate the impact of market-wide information on each security separately. With the introduction of ETFs, market participants can trade the whole basket of constituents instead of trading individual components one at a time – thus allowing for faster incorporation of such information.

We finally turn our attention to analyzing the impact of US-traded ETFs on the liquidity of their foreign components. Table 5 reports the results.

Table 5: Impact of ETFs on liquidity

The table reports the coefficients of the following regression by *Overlap* groups:

$$ILLIQ_{i,t} = \beta_0 + \beta_1 \cdot \widehat{lnETF}_{i,t} + \sum_{n=1}^{2} \beta_{n+1}\left(\ln\left(Mcap_{i,t}\right)\right)^n + \tau_t + \gamma_i + \varepsilon_{i,t}$$

$ILLIQ_{i,t}$ represents Amihud's illiquidity measure for a given stock i during month t. $\widehat{lnETF}_{i,t}$ is the natural logarithm of the percentage of a given company's stock owned by US-listed ETFs at the end of month t as estimated in the first stage of the regression. $Mcap_{i,t}$ is a firm's average dollar market capitalization throughout month t. τ_t represents monthly time fixed effects; γ_i represents industry fixed effects. $\varepsilon_{i,t}$ represents error term of the regression.

ILLIQ	***Full Overlap***	***No Overlap***	***Partial Overlap***
ln(ETF)	-0.00015 ***	-0.00001 *	-0.00029 ***
	(-3.58)	*(-1.84)*	*(-8.75)*
ln(Mcap)	-0.00064 ***	-0.00023 ***	-0.00039 *
	(-4.14)	*(-4.04)*	*(-1.96)*
ln(Mcap) ^{2}	0.00004 ***	0.00001 **	0.00002
	(4.12)	*(2.40)*	*(1.37)*
Constant	0.00189 ***	0.00138 ***	0.00103
	(2.73)	*(6.25)*	*(1.21)*
No. of observations	28,442	196,819	74,630
R^2	0.183	0.190	0.162

t statistics reported in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

Overall, we observe a negative and statistically significant relationship between US-traded ETF ownership and the *ILLIQ* measure. A 100% increase in ETF ownership leads to a decrease in *ILLIQ* of 0.015 and 0.029 units for *Full Overlap* and *Partial Overlap* groups respectively. The effect is equivalent to 0.148 and 0.296 standard deviations decrease, accordingly, and is significant at 10% significance level. Our tests also document improvement in liquidity for the *No Overlap* group – *ILLIQ* decreasing by 0.0001 units (0.009 standard deviations) as a result of ETF ownership doubling. The latter effect is significant at 10% significance level. The finding is in line with our hypothesis and is consistent with prior research on international cross listings – academic documenting positive effect on liquidity of stocks post cross-listings. Our tests thus support the effect documented by Boehmer and Zhang (2015), although the authors apply a different metric of liquidity (i.e., bid-ask spreads instead of *ILLIQ*). Thus, we conclude that US-traded ETFs indeed improve market quality of their components by making them more liquid. Referring to the literature on the cross-listings and stock liquidity, our findings are supportive of these studies (see Karolyi (2006) for the comprehensive summary of the literature on international cross-listings and its effects on the stock).

6. Robustness to alternative model specifications and sampling choices

To evaluate the robustness of our findings we employ a number of alternative model specifications as well as perform the analysis for different sub-samples. A total of 7 alternative tests are performed. Table 6 displays the coefficients before instrumented ETF ownership ($\widehat{lnETF}_{i,t}$) as estimated in the respective alternative specification. Each column from (1) to (8) corresponds to a different test or model specification.

Specification (1) is the base specification that has been added for comparative purposes. Specifications (2) and (3) employ the same model as that in (1) and estimate the relationship for the smallest and largest stocks in the sample respectively. For each country we select bottom and top quartile of stocks based on their average monthly market capitalization and rebalance the two portfolios on a monthly basis. Thus, (2) and (3) estimate the previously described relationship for the smallest and largest stocks within the sample, respectively.

Specifications (4), (5) and (6) are estimated for the full sample, but the model specification differs from that outlined previously. To be more precise, we test the robustness of our results to alternative first stage 2SLS specifications. Thus, coefficients reported under (4) are estimated by running the first stage country-by-country without controlling for the stocks' market capitalization. Specification (5) is similar to (1), except that it implements stock- rather than industry fixed effects in the first stage. Finally, specification (6) estimates instrumented ETF ownership over the whole sample of stocks rather than country-by-country, and includes industry-, market- and time fixed effects.

Since we apply multiple filters to the dataset and perform winsorization of the variables, we also check whether the obtained results are driven by specific data filtering or winsorization procedures. Specification (7) is estimated in the same manner as (1), except observations are not filtered by either volume or market capitalization. Specification (8) resembles (7), but in addition no filtering of dependent variables is performed. Robustness tests indicate that our results are consistent across different samples and model specifications. Increase in US-traded ETF ownership leads to the price discovery shifting from the overnight period towards the trading session for the *Full Overlap* group, while the effect is reversed for the *No Overlap* group. We observe no effect for the *Partial Overlap* group. Similarly, our results for tests on opening price accuracy are robust to alternative regression specifications - ETFs have a positive effect on opening price accuracy of stocks within the *No Overlap* group. Meanwhile, opening prices of stocks within the other two groups become less accurate when ETF ownership increases. Most of the alternative tests indicate that the relationship is significant.

Consistent with base results, we observe that ETF ownership has no effect on such price efficiency measures as *Variance ratio* and *Autocorrelation*. Nevertheless, even under alternative specifications, market-wide information is incorporated faster for groups of countries whose trading sessions at least partially overlap with the US trading hours. As before, for the *No Overlap* group the tests document no significant relationship between ETF ownership and the *Delay* measure, except for specification (6). This leads us to the conclusion that US-traded country ETFs have no effect on *Delay* for stocks within the *No Overlap* group.

As for liquidity, as before, ETF ownership is associated with improvement in liquidity of stocks within *Full Overlap* and *Partial Overlap* groups. We obtained mixed results for the *No Overlap* group – half of the specifications (i.e., (2), (4), (5), (6)) document no significant relationship between ETF ownership and *ILLIQ*. The other half (i.e., (1), (3), (7), (8)) indicates a negative and statistically significant relationship – ETFs having a positive impact on liquidity of their underlying stocks.

Table 6: Robustness checks

The table reports the results of robustness checks using different samples and estimation methods. The table reports the coefficient on the instrumented ETF ownership $(\widehat{lnETF_{i,t}})$ for different regression specifications. Specification (1) is the base specification used for analysis and has been included for the sake of comparison. Specifications (2) and (3) estimate the model in the same manner as in (1), but are run over bottom (2) and top (3) quartile observations according to market capitalization. Specification (4) is identical to (1), except the first stage is estimated without controlling for market capitalization of sample stocks. Specification (5) is identical to (1), except first stage is estimated using stock fixed effects instead of industry fixed effects. Specification 6 is identical to (1), except first stage is estimated over the whole (pooled) sample rather than coutry-by-country. Specification (7) is identical to (1), except using sample without volume and market cap filters. Specification (8) is identical to (7), except the variables do not undergo any winsorization in addition to the absence of filtering.

		(1)	*(2)*	*(3)*	*(4)*	*(5)*	*(6)*	*(7)*	*(8)*
	Full Overlap	0.0119 ***	0.0078	0.0085	0.0101 ***	0.0126 ***	0.0198 ***	0.0139 ***	0.0142 ***
IntradayPriceDiscovery	*No Overlap*	-0.0276 ***	-0.0171 ***	-0.0249 ***	-0.0274 ***	-0.0275 ***	-0.0177 ***	-0.0276 ***	-0.0276 ***
	Partial Overlap	-0.0014	-0.0015	0.0047 *	-0.0022	-0.0014	0.0031	-0.0014	-0.0011
	Full Overlap	0.0009 ***	0.0005 *	0.0004 **	0.0008 ***	0.0007 ***	0.0010 ***	0.0008 ***	0.0009 ***
Inaccuracy	*No Overlap*	-0.0011 ***	-0.0012 ***	-0.0008 ***	-0.0011 ***	-0.0012 ***	-0.0009 ***	-0.0011 ***	-0.0011 ***
	Partial Overlap	0.0004 ***	0.0005 ***	0.0000	0.0004 ***	0.0004 ***	-0.0006	0.0004 ***	0.0004 ***
	Full Overlap	-0.0002	0.0013	-0.0022	-0.0004	0.0000	-0.0001	0.0000	-0.0000
Autocorrelation	*No Overlap*	-0.0002	-0.0016	-0.0002	-0.0002	-0.0003	-0.0008	-0.0004	-0.0004
	Partial Overlap	-0.0013	-0.0026 *	-0.0028 *	-0.0014	-0.0010	-0.0006	-0.0012	-0.0012
	Full Overlap	-0.0002	0.0052	-0.0053	-0.0011	0.0005	0.0003	-0.0004	-0.0005
Variance ratio	*No Overlap*	0.0028 *	0.0004	0.0035 *	0.0026	0.0026	-0.0018	0.0028 *	0.0032 **
	Partial Overlap	-0.0009	-0.0049 **	-0.0012	-0.0014	-0.0008	-0.0018	-0.0006	-0.0072
	Full Overlap	-0.0274 ***	-0.0196 **	-0.0017	-0.0286 ***	-0.0208 ***	-0.0386 ***	-0.0279 ***	-0.0275 ***
Delay	*No Overlap*	0.0043	0.0038	-0.0060	0.0023	0.0032	-0.0450 ***	0.0036	0.0031
	Partial Overlap	-0.0283 ***	-0.0111 **	-0.0157 ***	-0.0235 ***	-0.0159 ***	-0.0232 ***	-0.0289 ***	-0.0287 ***
	Full Overlap	-0.0001 ***	-0.0002 *	-0.0000 **	-0.0001 ***	-0.0001 ***	-0.0002 ***	-0.0002 ***	-0.0002 **
ILLIQ	*No Overlap*	-0.0000 *	0.0000	-0.0000 **	-0.0000	-0.0000	-0.0000	-0.0000 **	-0.0000 **
	Partial Overlap	-0.0003 ***	-0.0003 ***	-0.0001 ***	-0.0003 ***	-0.0002 ***	-0.0002 ***	-0.0003 ***	-0.0006 ***

t statistics reported in parentheses

* p < 0.1, ** p < 0.05, *** p < 0.01

7. Conclusions

This study seeks to investigate the impact of US-traded ETFs on their foreign constituents. Our research comes at a crucial time given the growing popularity of passive investing and ETFs in particular and, to the best of our knowledge, is the first one of its kind.

In the present paper we have studied the effects of ETFs traded on the US market on overnight price discovery, opening price accuracy, informational efficiency and liquidity of their foreign constituents. We find that US-traded ETFs contribute to the price discovery process of their foreign constituents, price discovery partially shifting towards that period of the day when the respective ETF is traded. We further provide evidence that such ETFs lead to improvement in opening price accuracy of constituents listed in markets whose trading hours are noncurrent to those of the US market. At the same time, we document less accurate opening prices for stocks whose trading hours overlap with the US trading hours. Taken together, these findings suggest that ETFs have a sizeable impact on opening price accuracy and price discovery of their foreign constituents – effects overlook in research to date.

Furthermore, we provide empirical evidence that US-traded ETFs improve informational efficiency of their foreign components by increasing the speed at which market-wide information is incorporated into the prices. At the same time, ETFs appear to have no significant impact on informational efficiency of foreign components as measured by return autocorrelations and variance ratios. As expected, these findings imply that ETFs do poor job in incorporating information on individual securities. Instead, ETFs aggregate market-wide information, and hence trading in ETFs results in faster incorporation of market-wide information. The effect, however, appears to be significant only for those stocks that have concurrent trading hours with the US market. Finally, we find that US-traded ETFs improve the liquidity of their foreign constituents.

Even though our results are consistent across a number of alternative model specifications, we acknowledge a number of limitations in our analysis. Our research finds that increased ETF ownership is associated with faster incorporation of market-wide information, as captured by the *Delay* measure. At the same time, ETFs appear to have no significant effect on the other two metrics of price efficiency – autocorrelations and variance ratios. Our research design, coupled with the unavailability of more granular (intraday) data, does not allow us to determine the channels through which US-traded ETFs impact informational efficiency of their foreign components. The second limitation lies in the fact that the 2SLS procedure may be not the most appropriate research design for answering the research questions of our interest. Undoubtedly, other index-linked products and passive mutual funds specifically could potentially impact index members. Hence, the magnitude of the ETF effect (if any) may be less pronounced than that presented in our research. Finally, the lack of access to intraday data precludes us from constructing high-frequency informational efficiency measures and investigating the impact of US-traded ETFs on their foreign constituents throughout the trading day. It would be particularly interesting to investigate whether US-traded ETFs lead to intraday shifts in price discovery process, and whether there are any improvements to the liquidity of foreign components at market open specifically.

We believe that, despite the above-mentioned limitations, our study brings sizeable benefits to those considering investing in ETFs or their component securities, as well as policy makers and academics. Our study puts the ground for further research on the effects of ETFs on price discovery and market quality of their components. Firstly, it would be beneficial to discover the channels through which US-traded ETFs improve informational efficiency of their foreign constituents. Secondly, with more granular (intraday) data available, a deeper investigation of price evolvement throughout the day and the effect of ETFs on intraday price discovery can be performed. We believe that such research would deepen the understanding of academics and practitioners about ETFs, including the benefits and adverse effects that these securities have on markets.

8. References

Alaganar, V. T., & Bhar, R. (2002). Information and Volatility Linkage Under External Shocks: Evidence from Dually Listed Australian Stocks. *International Review of Financial Analysis*, *11*(1), 59–71.

Alexander, G. J., Eun, C. S., & Janakiramanan, S. (1987). Asset Pricing and Dual Listing on Foreign Capital Markets: A Note. *Journal of Finance*, *42*(1), 151–158.

Alexander, G. J., Eun, C. S., & Janakiramanan, S. (1988). International Listings and Stock Returns: Some Empirical Evidence. *Journal of Financial & Quantitative Analysis*, *23*(2), 135–151.

Alhaj-Yaseen, Y. S., Lam, E., & Barkoulas, J. T. (2014). Price Discovery for Cross-Listed Firms with Foreign IPOs. *International Review of Financial Analysis*, *31*, 80–87.

Amihud, Y. (2002). Illiquidity and Stock Returns: Cross-section and Time-series Effects. *Journal of Financial Markets*, *5*, 31-56.

Appel, I. R., Gormley, T. A., & Keim, D. B. (2016). Passive Investors, Not Passive Owners. *Journal of Financial Economics*, *121*(1), 111–141.

Barclay, M. J., & Hendershott, T. (2003). Price Discovery and Trading After Hours. *Review of Financial Studies*, *16*(4), 1041–1073.

Barclay, M. J., & Hendershott, T. (2008). A Comparison of Trading and Non-trading Mechanisms for Price Discovery. *Journal of Empirical Finance*, *15*(5), 839–849.

Ben-David, I., Franzoni, F., & Moussawi, R. (2018). Do ETFs Increase Volatility? Fischer College of Business Working Paper No. 2011-03-20.

Boehmer, E., Jones, C. M., & Zhang, X. (2008). Which Shorts Are Informed? *The Journal of Finance*, *63*(2), 491-527.

Boehmer, E., Wu, J. (2013). Short Selling and the Price Discovery Process. *The Review of Financial Studies*, *26*(2), 287-322.

Boehmer, E., Zhang, X. (2015). *Cross-country Trading Without Leaving Home: Country ETFs and their Impact on Local Stock Markets.* Retrieved from https://www.lyxoretf.de/pdfDocuments/4HOW-DOES-ETF-TRADING-AFFECT-LOCAL-MARKETSWP-2518394519353541536.pdf

Chen, K. C., Guangzhong Li, & Lifan Wu. (2010). Price Discovery for Segmented US-Listed Chinese Stocks: Location or Market Quality? *Journal of Business Finance & Accounting*, *37*(1/2), 242–269.

Chordia, T., Swaminathan, B. (2000). Trading Volume and Cross-Autocorrelations in Stock Returns. *The Journal of Finance*, *55*(2), 913-935.

Coffee Jr., J. C. (2002). Racing Towards the Top?: The Impact of Cross-Listings and Stock Market Competition on International Corporate Governance. *Columbia Law Review*, *102*(7), 1757.

Da, Z., Shive, S. (2018). Exchange Traded Funds and Asset Return Correlations. *European Financial Management*, *24*(1), 136-168.

Damodaran, A., Liu, C., & Van Harlow, W. (1993). The Effects of International Dual Listings on Stock Price Behavior. New York University working paper.

Dodd, O., & Frijns, B. (2018). NYSE Closure and Global Equity Trading: The Case of Cross-Listed Stocks. *International Review of Financial Analysis*, *60*, 138–150.

Dodd, O., & Gilbert, A. (2016). The Impact of Cross-Listing on the Home Market's Information Environment and Stock Price Efficiency. *Financial Review*, *51*(3), 299–328.

Domowitz, I., Glen, J., Madhavan, A. (1998). International Cross-Listing and Order Flow Migration: Evidence from an Emerging Market. *Journal of Finance*, *53*(6), 2001-2027.

Eun, C. S., & Sabherwal, S. (2003). Cross-Border Listings and Price Discovery: Evidence from U.S.-Listed Canadian Stocks. *Journal of Finance*, *58*(2), 549–575.

Fernandes, N., & Ferreira, M. A. (2008). Does International Cross-Listing Improve the Information Environment. *Journal of Financial Economics*, *88*(2), 216–244.

Fleming, J., Ostdiek, B., & Whaley, R. E. (1996). Trading Costs and the Relative Rates of Price Discovery in Stock, Futures, and Option Markets. *Journal of Futures Markets*, *16*, 353–387.

Foerster, S. R., & Karolyi, G. A. (1993). International Listings of Stocks: The Case of Canada and the U.S. *Journal of International Business Studies*, *24*(4), 763–784.

French, K. R., & Roll, R. (1986). Stock Return Variances: The Arrival of Information and the Reaction of Traders. *Journal of Financial Economics*, *17*(1), 5–26.

Frino, A., & West, A. (2003). The Impact of Transaction Costs on Price Discovery: Evidence from Cross-Listed Stock Index Futures Contracts. *Pacific-Basin Finance Journal*, *11*(2), 139–151.

Ghadhab, I., & Hellara, S. (2016). Price Discovery of Cross-Listed Firms. *International Review of Financial Analysis*, *44*, 177–188.

Glosten, L., Milgrom, P. (1985). Bid, Ask, and Transaction Prices in a Specialist Market with Heterogenously Informed Traders. *Journal of Financial Economics*, 14, 71-100.

Glosten, L., Nallareddy, S., Zou, Y. (2016). *ETF Activity and Informational Efficiency of Underlying Constituents*. Columbia Business School Research Paper No. 16-71.

Gormley, T., Matsa, D. (2014). Common Errors: How to (and not to) Control for Unobserved Heterogeneity. *Review of Financial Studies*, 27, 617–661.

Grammig, J., Melvin, M., & Schlag, C. (2005). Internationally Cross-Listed Stock Prices During Overlapping Trading Hours: Price Discovery and Exchange Rate Effects. *Journal of Empirical Finance*, *12*(1), 139–164.

He, Y., Lin, H., Wang, J., & Wu, C. (2009). Price Discovery in the Round-the-Clock U.S. Treasury Market. *Journal of Financial Intermediation*, *18*(3), 464–490.

Ivanov, S. I., Jones, F. J., Zaima, J. K. (2013). Analysis of DJIA, S&P 500, S&P 400, NASDAQ 100 and Russell 2000 ETFs and Their Influence on Price Discovery. *Global Finance Journal*, *24*(3), 171-187.

Jaiswal-Dale, A., & Jithendranathan, T. (2009). Transmission of Shocks from Cross-Listed Markets to the Return and Volatility of Domestic Stocks. *Journal of Multinational Financial Management*, *19*(5), 395–408.

Jayaraman, N., Shastri, K., Tandon, K. (1993). The Impact of International Cross Listings on Risk and Return: Evidence from American Depositary Receipts. *Journal of Banking and Finance*, *17*, 91–103.

Karolyi, G. A. (1998). Why Do Companies List Shares Abroad?: A Survey of the Evidence and Its Managerial Implications. *Financial Markets, Institutions and Instruments*, *7*(1), 1–60.

Kewei Hou, & Moskowitz, T. J. (2005). Market Frictions, Price Delay, and the Cross-Section of Expected Returns. *Review of Financial Studies*, *18*(3), 981–1020.

Kim, M., Szakmary, A. C., & Mathur, I. (2000). Price Transmission Dynamics Between ADRs and Their Underlying Foreign Securities. *Journal of Banking and Finance*, *24*(8), 1359–1382.

Korczak, P., & Bohl, M. T. (2005). Empirical Evidence on Cross-Listed Stocks of Central and Eastern European Companies. *Emerging Markets Review*, *6*(2), 121–137.

Kutan, A. M., & Zhou, H. (2006). Determinants of Returns and Volatility of Chinese ADRs at NYSE. *Journal of Multinational Financial Management*, *16*(1), 1–15.

Lang, M. H., Lins, K. V., & Miller, D. P. (2003). ADRs, Analysts, and Accuracy: Does Cross Listing in the United States Improve a Firm's Information Environment and Increase Market Value? *Journal of Accounting Research*, *41*(2), 317–345.

Lau, S. T., & Diltz, J. D. (1994). Stock Returns and the Transfer of Information Between the New York and Tokyo Stock Exchanges. *Journal of International Money and Finance*, *13*(2), 211–222.

Lau, S., Diltz D., Apilado, V. (1994). Valuation Effects of International Stock Exchange Listings. *Journal of Banking and Finance*, *18*, 743–755.

Lieberman, O., Ben-Zion, U., Hauser, S. (1999). A Characterization of the Price Behavior of International Dual Stocks: An Error Correction Approach. *Journal of International Money and Finance*, *18*, 289-304.

Lo, A., MacKinlay, A.C. (1988). Stock Market Prices Do Not Follow Random Walks: Evidence From a Simple Specification Test. *Review of Financial Studies*, *1*(1).

Lowengrub, P., & Melvin, M. (2002). Before and After International Cross-Listing: An Intraday Examination of Volume and Volatility. *Journal of International Financial Markets*, Institutions and Money, *12*(2), 139–155.

McKinnish, T. (2008). Panel Data Models and Transitory Fluctuations in the Explanatory Variable. In: Millimet, D., Smith, J., Vytlacil, E. (Eds.), Modeling and Evaluating Treatment Effects in Econometrics. Elsevier, Amsterdam, pp. 334–358.

Moshirian, F., Nguyen, H. G., & Pham, P. K. (2012). Overnight Public Information, Order Placement, and Price Discovery During the Pre-opening Period. *Journal of Banking and Finance*, *36*(10), 2837–2851.

Otsubo, Y. (2014). International Cross-Listing and Price Discovery Under Trading Concentration in the Domestic Market: Evidence from Japanese Shares. *Journal of Empirical Finance*, *25*, 36–51.

Pascual, R., Pascual-Fuster, B., & Climent, F. (2006). Cross-Listing, Price Discovery and the Informativeness of the Trading Process. *Journal of Financial Markets*, *9*(2), 144–161.

Tse, Y., Martinez, V. (2007). Price Discovery and Informational Efficiency of International iShares Funds. *Global Finance Journal*, *18*(1), 1-15.

von Furstenberg, G. M., & Tabora, C. B. (2004). Bolsa or NYSE: Price Discovery for Mexican Shares. *Journal of International Financial Markets, Institutions and Money*, *14*(4), 295–311.

Werner, I., & Kleidon, A. (1996). U.K. and U.S. Trading of British Cross-Listed Stocks: An Intraday Analysis of Market Integration. *Review of Financial Studies*, *9*(2), 619.

9. Appendices

Appendix A. Stock Market Indices Applied in the Role of Instrumental Variables.

Country	Index
Brazil	MSCI Brazil 25/50 Index
Canada	MSCI Canada Index
Chile	MSCI Chile Investable Market Index
Mexico	MSCI Mexico IMI 25/50 Index
Austria	MSCI Austria Investable Market Index
Belgium	MSCI Belgium Investable Market Index
Denmark	MSCI Denmark IMI 25/50 Index
Finland	MSCI Finland IMI 25/50 Index
France	MSCI France Index
Germany	MSCI Germany Index
Ireland	MSCI Ireland Investable Market 25/50 Index
Italy	MSCI Italy Index
Netherlands	MSCI Netherlands Investable Market Index
Norway	MSCI Norway IMI 25/50 Index
Poland	MSCI Poland Investable Market Index
Russia	MSCI Russia 25/50 Index
South Africa	MSCI South Africa Index
Spain	MSCI Spain Index
Sweden	MSCI Sweden Index
Switzerland	MSCI Switzerland Index
Turkey	MSCI Turkey Investable Market Index
United Kingdom	MSCI United Kingdom Index
Australia	MSCI Australia Index
China	MSCI China Index
Hong Kong	MSCI Hong Kong Index
India	MSCI India Index
Indonesia	MSCI Indonesia Investable Market Index
Japan	MSCI Japan Index
Malaysia	MSCI Malaysia Index
New Zealand	MSCI New Zealand Investable Market Index
Philippines	MSCI Philippines Investable Market Index
Singapore	MSCI Singapore Index
South Korea	MSCI Korea Index
Taiwan	MSCI Taiwan Index
Thailand	MSCI Thailand Investable Market Index

Appendix B. First stage regression estimation.

Country	*Index*	*Index*ln(AUM%)*	R^2
Australia	7.345 ***	0.986 ***	0.293
Austria	6.393 **	0.746	0.568
Belgium	-3.869 *	-0.761 ***	0.660
Brazil	4.016 **	0.523	0.490
Canada	11.100 ***	1.695 ***	0.415
Chile	2.479	-0.057	0.641
China	3.401 *	0.000	0.409
Colombia	n/a	n/a	n/a
Czech	n/a	n/a	n/a
Denmark	2.264	0.084	0.707
Finland	-0.448	-0.126	0.655
France	3.538	0.302	0.553
Germany	2.639 *	0.198	0.529
Greece	n/a	n/a	n/a
Hong Kong	2.753 **	0.109	0.455
India	-0.850 ***	-0.345 ***	0.592
Indonesia	3.391	0.307	0.379
Ireland	1.836	-0.145	0.606
Italy	0.444	-0.143	0.598
Japan	-3.501 ***	-0.752 ***	0.684
Malaysia	8.030 ***	1.021 ***	0.404
Mexico	1.852	-0.123	0.671
Netherlands	7.387	0.658	0.726
New Zealand	1.031	-0.270	0.714
Norway	9.752	0.931 *	0.509
Philippines	-5.678	-1.040	0.768
Poland	16.760 ***	2.121 **	0.743
Portugal	n/a	n/a	n/a
Russia	29.630 ***	3.807 ***	0.710
Singapore	-5.725 *	-1.148 **	0.490
South Africa	1.156	0.033	0.561
South Korea	-10.350 **	-2.227 ***	0.566
Spain	0.860	-0.046	0.556
Sweden	-1.903	-0.342	0.577
Switzerland	-5.251 *	-0.883 **	0.467
Taiwan	2.950	0.417	0.513
Thailand	0.816 *	0.000	0.232
Turkey	-6.667	-1.252	0.451
United Kingdom	0.321	-0.073	0.428

Appendix C. Trading Hours for Markets Within the Sample.

Country	Local Time	
United States	*09:30*	*16:00*
Brazil	10:00	17:30
Canada	09:30	16:00
Chile	09:30	16:00
Mexico	08:30	15:00
Austria	08:55	17:35
Belgium	09:00	17:00
Denmark	09:00	17:00
Finland	10:00	18:30
France	09:00	17:30
Germany	08:30	17:00
Ireland	08:00	16:30
Italy	09:00	17:35
Netherlands	09:00	17:40
Norway	09:00	16:30
Poland	09:00	17:00
Russia	10:00	18:45
South Africa	09:00	17:00
Spain	09:00	17:30
Sweden	09:00	17:30
Switzerland	09:00	17:30
Turkey	10:00	18:00
United Kingdom	08:00	16:30
Australia	10:00	16:00
China	09:30	15:00
Hong Kong	09:30	16:00
India	09:15	15:30
Indonesia	09:00	16:00
Japan	09:00	15:00
Malaysia	09:00	17:00
New Zealand	10:00	16:45
Philippines	09:30	15:30
Singapore	09:00	17:00
South Korea	09:00	15:30
Taiwan	09:00	13:30
Thailand	10:00	16:30