

The Effect of ETFs on Intraday Volatility: Evidence from High-Frequency Data in China

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Abstract

Based on 1.5 billion minute-level trading data of Chinese stocks and ETFs from 2012 to 2024, this study finds that ETF ownership reduces the intraday volatility of underlying stocks. Empirical results indicate that ETF arbitrage activity does not exert a statistically significant effect on intraday volatility. Conversely, ETFs enhance pricing efficiency of stocks, facilitating faster incorporation of information into prices. Furthermore, the stabilizing effect on the market is more pronounced for narrow-based ETFs and single-market ETFs, compared to broad-based ETFs and cross-market ETFs. Greater information transparency and liquidity among listed firms enhance the stabilizing role of ETFs in the capital market. Using the 2019 reform of ETF creation and redemption rules on the Shenzhen Stock Exchange as an exogenous shock, the study further confirms that active ETF trading reduces intraday volatility.

Keywords ETFs; Intraday Volatility; Pricing Efficiency; High-Frequency Data

JEL G12; G14

1 Introduction

Exchange-traded funds (ETFs) have been the most significant innovation in global financial markets over the past two decades and represent the fastest-growing equity market product worldwide (Ben-David et al. 2018; Nallareddy 2020). The impact of ETFs on stock markets and their regulatory issues have become prominent topics of interest for regulators and academics alike (Box et al. 2021; Glosten et al. 2021). Although the ETF market in China started relatively late, it has achieved rapid development since 2018 (see Figure 1), supported by national policies as well as its inherent advantages of low costs, flexible trading, and diverse investment attributes. Compared to the overall development of public mutual funds, the proportion of ETFs in both number and scale has continuously increased, reaching a record high of 11.68% of total assets by the end of 2024. The influence of ETFs on China's stock market is bound to deepen gradually.

[Insert Figure 1 about here]

Among the various dimensions of ETF impact on the stock market, such as stock prices (Wurgler 2010; Brown et al. 2021), price synchronicity (Broman 2016; Da and Shive 2018), liquidity (Krause et al. 2014; Pan and Zeng 2017), and informational efficiency (Israeli et al. 2017; Bhojraj et al. 2020; Huang et al. 2021), their effect on price volatility has received particular attention. Representative studies, such as Ben-David et al. (2018), based on U.S. market data, find that stocks with higher ETF ownership exhibit stronger price volatility. The primary mechanism involves arbitrage trading between ETFs and their constituent stocks, which triggers cross-market shock transmission. This process amplifies short-term liquidity shocks between the ETF market and the underlying spot market, thereby increasing the price volatility of the underlying stocks. Related research also points out that the trading structure of ETFs raises trading costs for the underlying securities and reduces the benefits of information acquisition, further reinforcing stock

return synchronicity (Israeli et al. 2017).

However, compared to previous studies that primarily focus on volatility at the daily frequency or lower, intraday volatility holds unique significance in measuring market microstructure stability, liquidity provision, and price discovery efficiency. On one hand, intraday volatility directly reflects trading shocks and the information arrival process, serving as a critical indicator for assessing whether arbitrage activities introduce noise trading. On the other hand, lower intraday volatility generally implies faster information assimilation and higher market operational efficiency, providing important reference value for regulators evaluating the stability impact of financial innovations (Hasbrouck, 2003). With the rapid expansion of ETF assets, systematic high-frequency empirical evidence is still lacking on whether ETFs exacerbate high-frequency price fluctuations through arbitrage trading or act as stabilizers by improving price discovery.

Based on minute-level high-frequency trading data of Chinese stocks and ETFs from 2012 to 2024, we find that ETFs significantly reduce intraday volatility in the stock market. Although ETFs possess characteristics of both open-end and closed-end funds, and bid-ask spreads in the primary and secondary markets inevitably trigger ETF arbitrage activities, the empirical evidence indicates that, under China's unique ETF institutional design and market environment, ETF arbitrage activities do not have a significant impact on intraday volatility. On the contrary, ETFs enable investors to simultaneously purchase large quantities of stocks, facilitating the timely incorporation of information into stock prices, thereby enhancing pricing efficiency and maintaining price stability.

We further document substantial heterogeneity in the effect of ETFs on intraday volatility across ETF types. Broad-based ETFs and narrow-based ETFs exert differential influences on the volatility of their constituent stocks. Because the underlying firms in narrow-based ETFs are more homogeneous, such funds are more conducive to efficient information incorporation. cross-market ETFs, whose creation and redemption processes span multiple trading venues, exhibit lower arbitrage efficiency than single-market ETFs, thereby impeding the timely incorporation of market-wide information. Accordingly, we find that cross-market ETFs exert a weaker effect on intraday volatility. In addition, we show that the impact of ETFs on intraday volatility is significantly stronger for firms with greater information transparency and for stocks with higher liquidity.

In 2019, the Shenzhen Stock Exchange (SZSE) introduced new rules governing ETF creation and redemption aimed at improving the efficiency of the creation-redemption process for Shenzhen-listed ETFs. The 2019 SZSE ETF reform provides a compelling exogenous shock for our analysis. By improving capital utilization and lowering operational frictions in the creation-redemption process, the new rules clearly stimulated ETF ownership and trading activity, while leaving the underlying stocks directly unaffected. Our empirical results show that after the reform, stocks with greater exposure to Shenzhen-listed ETFs experienced significantly larger declines in intraday volatility, lending further support to our central findings. The increase in arbitrage activity induced by the reform did not amplify intraday volatility among constituent stocks. Instead, it accelerated the incorporation of information into prices, enhanced informational efficiency, and ultimately reduced intraday volatility.

First, this study contributes to the literature on ETFs and volatility by disentangling two competing channels, arbitrage-induced noise trading and improvements in price efficiency, through which ETF activity may affect intraday volatility. Existing research offers divergent

interpretations of ETFs' market impact: some studies argue that ETF arbitrage amplifies volatility and return comovement (Israeli et al. 2017), whereas others emphasize that ETFs enhance price discovery and market efficiency (Glosten et al. 2021; Lundholm, 2021; Todorov 2023). Our empirical evidence suggests that, in China's market environment, underlying stock liquidity exceeds that of ETFs. In this setting, ETF trading primarily operates by improving price discovery rather than by intensifying noise-driven fluctuations. These findings provide new empirical support for distinguishing between the competing mechanisms.

Second, this study contributes to the literature by exploiting high-frequency data to examine the economic consequences of ETF activity. Most prior studies on ETFs and volatility rely on daily or lower-frequency observations (Ben-David et al. 2018) and thus do not directly capture intraday price dynamics. Intraday high-frequency data offer a more precise characterization of market microstructure (Goodhart and O'Hara 1997). By employing minute-by-minute data, we are able to trace the short-horizon transmission of arbitrage trading, information arrivals, and trading shocks with greater fidelity, thereby providing sharper identification of whether ETFs exacerbate volatility through noise trading or instead facilitate more rapid incorporation of information into prices (Hasbrouck 2003).

Third, this study contributes to the literature on volatility determinants in emerging markets. As China's capital markets continue to open up, foreign ownership has risen steadily. In this context, stock market volatility is not only central to domestic financial stability but also directly affects cross-border capital flows, international investors' required risk premia, and the global pricing of Chinese assets (Pukthuanthong and Roll 2009). Prior studies document that China's stock market exhibits persistently high volatility and pronounced short-term price fluctuations, which are closely related to investor composition, information asymmetry, and institutional arrangements (Morck et al. 2000; Lee et al. 2001; Bai et al. 2004; Xiong and Yu 2011). However, systematic evidence on the role of financial product innovation, particularly the rapid expansion of ETFs, in shaping market volatility remains limited. Our findings provide new empirical evidence on the formation of volatility in the Chinese equity market. These results offer important implications for financial innovation and risk management in emerging markets.

2 Institutional background

ETFs are investment funds listed and traded on stock exchanges, aiming to track a specific index, combining the redeemability of open-end funds with the continuous trading features of common stocks. Its core operating mechanism includes the primary market's creation-redemption system and the secondary market's trading pricing mechanism: authorized participants exchange a basket of constituent stocks to the fund sponsor, or redeem shares in the reverse direction, thereby engaging in arbitrage whenever discrepancies arise between net asset value and market prices and inducing prices to revert toward fundamental values. Although the development of ETFs in China has drawn on institutional arrangements from mature markets, and trading rules and operating mechanisms share broad similarities with those of foreign ETF markets, distinctive features of China's capital-market system, particularly its settlement procedures, stock-trading rules, and overall market microstructure, have given rise to institutional designs and implementation practices that are specific to the Chinese context.

2.1 Cash-Substitution flags

“In-kind” creation and redemption constitute the fundamental mechanism of ETF operations. However, when investors or fund managers are unable to obtain the required constituent stocks in the secondary market, the in-kind process cannot be implemented as intended. In China’s equity market, price-limit rules and trading suspensions occasionally prevent timely purchases or sales of constituent securities, making it infeasible to create or redeem ETF shares using a full basket of stocks. As a result, China’s ETF market allows cash substitution.

Before the opening of each trading day, fund management companies publish a creation-redemption list specifying, for each constituent stock, whether cash substitution is permitted. Four types of cash-substitution flags are used: permitted, mandatory, prohibited, and adjustment.¹ These flags play a central role in ETF operations. Improper design may generate arbitrage loopholes, impose substantial losses on fund managers and ETF investors, and trigger sharp price fluctuations in constituent stocks.

2.2 Single-market versus cross-market ETFs

Single-market ETFs are those whose constituents are listed exclusively on either the Shanghai Stock Exchange (SSE) or SZSE. For example, all stocks in the SSE 50 Index are listed in Shanghai, whereas all constituents of the ChiNext Index are listed in Shenzhen; accordingly, the SSE 50 ETF and the ChiNext ETF are classified as single-market ETFs. In contrast, cross-market ETFs hold constituents listed on both exchanges. The CSI 300 Index, for instance, includes stocks traded in both Shanghai and Shenzhen, making the CSI 300 ETF a cross-market ETF.

Because securities clearing and settlement for the two exchanges are conducted separately by the Shanghai and Shenzhen branches of China Securities Depository and Clearing Corporation, cross-market ETFs must operate across two independent settlement systems and are therefore more complex than their single-market counterparts. In the early stages of ETF development, single-market ETFs adopted a guaranteed settlement mechanism, allowing real-time creation and redemption, with newly created shares immediately tradable.

Cross-market ETFs, by contrast, require the central clearing house to transmit creation-redemption information separately to the two regional branches and to verify the sufficiency of the delivered consideration on the following trading day. Moreover, cross-market ETFs employ a non-guaranteed settlement system: ETF shares created on day T are not confirmed until T+2 and cannot be redeemed or sold prior to settlement.

2.3 ETFs on SSE and SZSE

In the early stages of ETF development in China, a major institutional difference between ETFs listed on SZSE and those listed on SSE lay in their clearing and settlement arrangements. Single-market ETFs on the SSE operated under a “T+0 pending settlement” regime, under which

¹ Under the “permitted” cash-substitution designation, investors may use either stocks or cash when subscribing to ETF shares, while redemptions are settled in stocks by the fund company. When the designation is “mandatory,” subscriptions must be made in cash and redemptions are settled in cash. Under the “prohibited” designation, subscriptions must be conducted with stocks and redemptions are likewise settled in stocks. The “adjustment” designation applies to non-Shanghai stocks in Shanghai-listed cross-market ETFs and cross-border ETFs. In this case, investors are required to deliver cash when subscribing and receive cash upon redemption.

investors could receive ETF shares on the trade date (T). In contrast, single-market ETFs on the SZSE followed a “T+1 DVP” (delivery-versus-payment) mechanism, meaning that both ETF shares and cash were settled on the following trading day.

The settlement arrangements for cross-market ETFs also differed across the two exchanges. On the SZSE, cross-market ETFs relied on off-exchange in-kind creation and redemption and adopted a “T+1 non-guaranteed settlement on a transaction-by-transaction basis” framework. Under this system, investors who submitted subscription orders on day T would have their creation baskets verified on T+1, and ETF shares could not be used until T+2.

By contrast, SSE-listed cross-market ETFs employed a broker-facilitated trading mechanism for SZSE stocks and introduced a special “cash substitution subject to later adjustment” designation for Shenzhen-listed securities. ETF shares obtained through creation could be sold on the same day; however, if they were not sold on day T, they could only be traded or redeemed on T+2.

2.4 The 2019 SZSE ETF reform

In September 2019, SZSE formally released the revised Implementation Rules for the Trading and Creation-Redemption of Exchange-Traded Funds (2019 Revision) and implemented them on October 21, 2019. The reform contained two major components.

First, the settlement mechanism for single-market ETFs listed on the SZSE was changed from the former “T+1 DVP” system to the standard A-share settlement regime. Following the reform, ETF shares were delivered on the trade date (T), thereby aligning ETF settlement more closely with that of common stocks. Second, the reform modified the creation-redemption mechanism for SZSE-listed cross-market equity ETFs. While maintaining off-exchange in-kind creation and redemption, the SZSE altered the on-exchange creation-redemption process from a “full cash substitution” approach to a hybrid structure in which Shenzhen-listed stocks were delivered in kind and Shanghai-listed stocks were replaced with cash. These transactions were settled on a guaranteed basis by China Securities Depository and Clearing Corporation. As a result, ETF shares created during the day could be sold immediately, and ETF shares purchased in the market could be redeemed on the same day. Settlement for both creation and redemption was effectively advanced from T+2 to T.

3 Research design

3.1 Data

The sample period of this study spans from 2012 to 2024. The ETF sample consists of all equity ETFs listed by 2024. After excluding samples with missing data, the final sample comprises 825 ETFs in total. Among them, 477 ETFs are listed on the Shanghai market, and 348 on the Shenzhen market. Minute-level high-frequency trading data for stocks and ETFs are obtained from the JoinQuant platform. Daily ETF data, including constituent stocks and cash substitution indicators, are manually collected from the daily ETF creation and redemption lists published by SSE and SZSE. Quarterly financial data of listed companies and basic ETF information are obtained from the Wind database. We use minute-level returns to compute half-hour return standard deviations as our primary measure of stock-price volatility and to construct pricing-efficiency proxies based on

intraday return regressions. We exclude ST stocks and stocks hitting price limits, stocks without ETF holdings, and observations with missing relevant variables. Additionally, all continuous variables are winsorized at the 1% and 99% levels. Ultimately, the dataset includes 26,744,812 stock-half-hour observations.

3.2 Variables

3.2.1 ETF ownership

All variables are aggregated to the individual-stock level. We measure ETF ownership (*ETF_Ownership*) as the ratio of the market value of a stock held by ETFs to the stock's total market capitalization. In general, holdings data for active mutual funds are available only at relatively low frequencies.² ETFs are distinct from other funds in this regard. Fund sponsors are required to publish daily creation-redemption lists on both exchange websites and their own platforms. These lists disclose the identities and quantities of the basket securities. Using the reported creation and redemption quantities for each constituent stock, we compute the market value of each stock held by a given ETF. We then aggregate these values across all ETFs to obtain a stock's total ETF-held market value. Dividing this quantity by the stock's total market capitalization yields our ETF ownership measure, *ETF_Ownership*.

Combining minute-level stock price data with the hand-collected daily creation-redemption lists, we construct ETF ownership (*ETF_Ownership*) according to Equation (1):

$$ETF_Ownership_{i,t} = \frac{\sum_{j=1}^J w_{i,j,t} Fundsizes_{j,t}}{MV_{i,t}} \quad (1)$$

In this construction, i , j , and t denote the individual stock, ETF, and half-hour interval, respectively. The denominator on the right-hand side is the stock's total market capitalization, MV , which is computed as the product of the total number of shares outstanding and the stock price at each half-hour interval.

The numerator is the market value of ETF holdings, obtained by first calculating the value of stock i held by each individual ETF and then aggregating across all ETFs. The market value of stock i held by ETF j equals the ETF's total assets under management (*Fundsizes*) multiplied by the weight of stock i in the ETF portfolio (w). The portfolio weight w is computed according to Equation (2):

$$w_{i,j,t} = \frac{Price_{i,j,t} \times Num_{i,j,t}}{\sum_i Price_{i,j,t} \times Num_{i,j,t}} \quad (2)$$

In Equation (2), *Price* denotes the half-hour price of stock i , and *Num* represents the quantity of stock i reported in the creation-redemption basket. The numerator of Equation (2) is the market value of stock i held by ETF j , while the denominator is the total market value of all stocks held by ETF j . Accordingly, w equals the ratio of the value of stock i to the total value of ETF j 's equity

² Fund companies disclose their top ten holdings on a quarterly basis and their complete portfolios annually. As a result, the highest feasible frequency at which mutual-fund stock ownership can be constructed is quarterly. At higher frequencies, detailed portfolio disclosures are typically unavailable, rendering it difficult to compute daily or intraday fund-level stock holdings.

holdings.

3.2.2 ETF Ownership dummy

For out-of-sample robustness tests, we also construct an ETF ownership indicator, *ETF_dummy*. This variable equals one if a stock is included in the holdings of at least one ETF in the sample and zero otherwise.

3.2.3 Intraday volatility

Following Andersen et al. (2001) and Tian and Guo (2007), we measure intraday volatility (*IntraVol*) as the standard deviation of minute-by-minute returns within each half-hour interval.

3.2.4 Stock price crash risk

Following Chen et al. (2001) and Kim et al. (2014), we measure stock price crash risk using two proxies: the negative conditional skewness of returns (*NCSKEW*) and the down-to-up volatility ratio (*DUVOL*). To construct these measures, we first compute firm-specific intraday idiosyncratic returns at the minute level. Specifically, for each stock and within each half-hour interval, minute-level stock returns are regressed on lagged market and industry returns³, as specified in Equation (3):

$$r_{i,t} = \beta_0 + \beta_1 r_{m,t-1} + \beta_2 r_{m,t-2} + \beta_3 r_{ind,t-1} + \beta_4 r_{ind,t-2} + \varepsilon_{i,t} \quad (3)$$

In this Equation, $r_{i,t}$ denotes the minute-level return of stock i , $r_{m,t-1}$ and $r_{m,t-2}$ represent the one- and two-period lagged market returns, and $r_{ind,t-1}$ and $r_{ind,t-2}$ denote the corresponding lagged industry returns. The residuals from Equation (3), denoted by $e_{i,t}$, capture firm-specific return innovations. The idiosyncratic minute-level return is then defined as $R = \ln(1+e_{i,t})$. Based on these idiosyncratic returns, we calculate *NCSKEW* and *DUVOL* following the standard procedures in the literature, as shown in Equations (4) and (5):

$$NCSKEW_{i,t} = -\frac{n(n-1)^{3/2} \sum R_{i,t}^3}{(n-1)(n-2)(\sum R_{i,t}^2)^{3/2}} \quad (4)$$

$$DUVOL_{i,t} = \log \left[\frac{(n_u - 1) \sum_{Down} R_{i,t}^2}{(n_d - 1) \sum_{up} R_{i,t}^2} \right] \quad (5)$$

Here, n denotes the number of minutes within each half-hour trading interval, R represents the firm-specific minute-level return after purging market and industry effects, and n_u and n_d denote the number of observations in which R is above or below its mean, respectively. Higher values of *NCSKEW* and *DUVOL* indicate greater stock price crash risk.

3.2.5 Pricing efficiency

³ We classify firms according to the Shenwan Industry Classification System, which divides listed companies into 28 first-level industries, including banking, non-bank financial institutions, agriculture, forestry and fishing, and utilities. The Shenwan classification is widely adopted in both academic research and industry practice in the Chinese stock market.

We assess stock-level pricing efficiency (*Efficiency*) using the speed with which prices respond to market-wide information. When pricing efficiency is high, market information is incorporated into stock prices immediately. When efficiency is low, prices absorb such information only gradually. Accordingly, faster price responses to market news indicate higher pricing efficiency.

Following Hou and Moskowitz (2005) and Hu et al. (2025), we estimate Equations (6) and (7) to examine the sensitivity of individual stock returns to contemporaneous and up to four lagged market returns:

$$r_{i,t} = \alpha_t + \beta_t R_{m,t} + \varepsilon_{i,t} \quad (6)$$

$$r_{i,t} = \alpha_t + \beta_t R_{m,t} + \sum_{n=1}^4 \delta_{i,n} R_{m,t-n} + \varepsilon_{i,t} \quad (7)$$

In these specifications, i , m , t , and n denote the individual stock, the market, the minute, and the number of lags, respectively. $r_{i,t}$ is the return on stock i at minute t , $R_{m,t}$ is the contemporaneous market return, and for $n=1,2,3$, and 4 , $R_{m,t-n}$ denotes the market return lagged by one through four periods.

Equation (6) includes only the contemporaneous market return as an explanatory variable. Estimating Equation (6) separately for each stock and half-hour interval yields a coefficient of determination, R_i^2 , which captures the extent to which current market movements explain individual stock returns.

Equation (7) augments this specification by including both the contemporaneous market return and its first four lags. The resulting $R_i'^2$ measures the explanatory power of current and past market returns for individual stock returns.

Based on the R_i^2 statistics from Equations (6) and (7), we construct our first proxy for the speed with which stock prices incorporate market information in Equation (8):

$$Efficiency1_i = 1 - \frac{R_i'^2}{R_i^2} \quad (8)$$

In Equation (8), *Efficiency1* captures the proportion of stock returns explained by lagged market returns. A larger value of *Efficiency1* indicates that a greater fraction of stock returns is driven by past market movements, implying that prices take longer to incorporate market-wide information and that pricing efficiency is lower. Conversely, a smaller value of *Efficiency1* reflects faster information incorporation and hence higher pricing efficiency.

In addition to the coefficients of determination, the magnitudes of the estimated regression coefficients in Equations (6) and (7) also convey information about the extent to which market returns explain individual stock returns. Accordingly, we construct a second proxy for the speed with which prices respond to market information, as shown in Equation (9):

$$Efficiency2_i = \frac{\sum_{n=1}^4 |\delta_{i,n}|}{|\beta_i| + \sum_{n=1}^4 |\delta_{i,n}|} \quad (9)$$

In this measure, β denotes the coefficient on the contemporaneous market return, and δ represents the coefficients on lagged market returns. *Efficiency2* similarly captures the proportion of stock returns attributable to lagged market movements: larger values of *Efficiency2* indicate lower pricing efficiency, whereas smaller values correspond to higher efficiency.

3.2.6 Arbitrage activities

ETFs combine features of open-end and closed-end funds in that they allow creation and redemption in the primary market using a basket of securities while ETF shares trade continuously in the secondary market. When the market value of the underlying basket differs from the ETF's secondary-market price, an arbitrage opportunity arises.

The value of the underlying basket is calculated as the sum across constituent securities of the product of each security's quantity and its market price. Constituent quantities are obtained from the daily creation-redemption lists released by fund sponsors, and prices are taken from minute-level trading data. When a constituent security is designated as subject to mandatory cash substitution, investors transact entirely in cash. In such cases, the stock's value is replaced by the reported cash-substitution amount. Moreover, because the basket value may differ from the fund's net asset value, investors are required to pay an additional estimated cash component. Accordingly, the total basket value equals the value of the constituent securities plus the estimated cash component. The corresponding calculation is given in Equation (10):

$$Basket_{f,t} = \left(\sum Num_{i,f,t}^{permit/adjust/prohibit} \times Price_{i,f,t}^{permit/adjust/prohibit} + \sum Sub_{i,f,t}^{Mandatory} + Cash_{f,t} \right) \quad (10)$$

In this expression, $Num_{i,f,t}^{permit/adjust/prohibit}$ denotes the quantity of constituent security i in ETF f at time t whose cash-substitution status is “permitted,” “adjustment,” or “prohibited,” and $Price_{i,f,t}^{permit/adjust/prohibit}$ is the minute-level trading price of that security. $Sub_{i,f,t}^{mandatory}$ represents the cash-substitution amount for securities designated as “mandatory,” and $Cash_{f,t}$ denotes the estimated cash component reported in the creation-redemption list.

Because a creation basket typically corresponds to multiple ETF shares, we divide the basket value by the associated number of fund shares and compute the absolute difference between this per-share basket value and the ETF's secondary-market price. This quantity captures the magnitude of ETF-level arbitrage activities, as shown in Equation (11):

$$Diff_{f,t} = \left| \frac{\left(\sum Num_{i,f,t}^{permit/adjust/prohibit} \times Price_{i,f,t}^{permit/adjust/prohibit} + \sum Sub_{i,f,t}^{Mandatory} + Cash_{f,t} \right)}{Shares_{f,t}} - Price_{f,t}^{ETF} \right| \quad (11)$$

Where $Shares_{f,t}$ is the number of ETF shares in the minimum creation-redemption unit reported in the basket file, and $Price_{f,t}^{ETF}$ is the ETF's minute-level secondary-market trading price. Because $Diff$ in Equation (11) measures the absolute magnitude of the arbitrage gap, we further standardize it by scaling by the ETF price to obtain a relative arbitrage measure in Equation (12):

$$Arbitrage_{f,t} = \left| \frac{\left(\sum Num_{i,f,t}^{permit/adjust/prohibit} \times Price_{i,f,t}^{permit/adjust/prohibit} + \sum Sub_{i,f,t}^{Mandatory} + Cash_{f,t} \right)}{Shares_{f,t} \times Price_{f,t}^{ETF}} - 1 \right| \quad (12)$$

Because our focus is on the effects on constituent stocks, we aggregate ETF-level arbitrage activities to the stock level. Following Ben-David et al. (2018), we compute stock-level arbitrage in Equation (13):

$$Arbitrage_{i,t} = \frac{\sum_{f=1}^F w_{i,f,t} \times MV_{f,t} \times Arbitrage_{f,t}}{MV_{i,t}} \quad (13)$$

Where $w_{i,f,t}$ is the portfolio weight of stock i in ETF f at time t , $MV_{f,t}$ is the total market capitalization of ETF f , and $MV_{i,t}$ is the market capitalization of stock i . Aggregating across all

ETFs holding stock i yields the stock-level arbitrage measure, $Arbitrage_{i,t}$. Larger values of $Arbitrage_{i,t}$ indicate greater arbitrage activities.

3.2.7 ETF constituency style

Based on the nature of their underlying indices, ETFs can be classified as either broad-based or narrow-based. Broad-based ETFs track market-wide indices, such as the CSI 300 or CSI 500 ETFs. Narrow-based ETFs track specific industries or investment themes, such as liquor-industry ETFs or carbon-neutrality-themed ETFs.

Because all variables are aggregated to the stock level, we construct an ETF constituency-style variable, $ETF_constituent$, as the ratio of the total market value of stock i held by narrow-based ETFs to the total market value of stock i held by all ETFs.

The formal definition is given in Equation (14), in which the denominator is the aggregate ETF-held market value of stock i , and the numerator is the portion held by narrow-based ETFs. Larger values of $ETF_constituent$ indicate that a stock is held more intensively by narrow-based ETFs. When $ETF_constituent$ equals one, the stock is held exclusively by narrow-based ETFs; when it equals zero, the stock is held only by broad-based ETFs.

$$ETF_constituent_{i,t} = \frac{\sum_{j=1}^J w_{i,j,t} Fundsize_{j,t}^{narrow-based}}{\sum_{j=1}^J w_{i,j,t} Fundsize_{j,t}} \quad (14)$$

3.2.8 ETF market type

Based on market coverage, ETFs can be classified as either single-market or cross-market funds. Single-market ETFs hold only stocks listed on either SSE or SZSE, whereas cross-market ETFs hold constituents from both venues. Because the two exchanges operate separate trading, clearing, and settlement systems, cross-market ETFs require coordination across platforms, rendering their trading and arbitrage processes more complex.

We measure ETF market type using the variable ETF_cross , defined as the ratio of the market value of stock i held by cross-market ETFs to the total market value of stock i held by all ETFs. The formal definition is provided in Equation (15), where the denominator is the aggregate ETF-held market value of stock i , and the numerator is the portion held by cross-market ETFs.

$$ETF_cross_{i,t} = \frac{\sum_{j=1}^J w_{i,j,t} Fundsize_{j,t}^{cross-market}}{\sum_{j=1}^J w_{i,j,t} Fundsize_{j,t}} \quad (15)$$

Higher values of ETF_cross indicate that a stock is held more intensively by cross-market ETFs. When ETF_cross equals one, the stock is held exclusively by cross-market ETFs; when it equals zero, the stock is held only by single-market ETFs.

3.2.9 2019 SZSE ETF reform

In September 2019, the Shenzhen Stock Exchange formally promulgated the revised Implementation Rules for the Trading and Creation-Redemption of Exchange-Traded Funds (2019 Revision), which came into effect on October 21, 2019. We construct an indicator variable

(*Event2019*) to capture this regulatory change. *Event2019* equals zero for observations prior to October 21, 2019, and one thereafter.

3.2.10 Exchange

Prior to the 2019 SZSE ETF reform, the clearing and settlement arrangements differed substantially between the Shanghai Stock Exchange (SSE) and the SZSE, implying that ETFs listed on the two exchanges could exert heterogeneous effects on market stability. Accordingly, we construct an exchange-level ETF variable (*Exchange*). Because all variables in this study are measured at the firm level, *Exchange* is defined as the ratio of the market value of stock i held by SZSE-listed ETFs to the total market value of stock i held by all ETFs. The detailed computation is provided in Equation (16):

$$Exchange_{i,t} = \frac{\sum_{j=1}^J w_{i,j,t} Fundsizes_{j,t}^{SZSE}}{\sum_{j=1}^J w_{i,j,t} Fundsizes_{j,t}} \quad (16)$$

in Equation (16), the denominator is the aggregate ETF-held market value of stock i , and the numerator is the portion held by SZSE ETFs. The variable *Exchange* ranges from 0 to 1. A value of one indicates that the stock is exclusively held by SZSE ETFs, whereas a value of zero implies that it is entirely held by SSE ETFs. Larger values of *Exchange* therefore reflect greater exposure to SZSE-listed ETFs.

3.2.11 Information transparency

Corporate information transparency, which is often closely related to firms' earnings management behavior, plays a significant role in influencing stock prices (Hirshleifer and Teoh, 2003; Lee and Sung 2021; Chen et al. 2023). Following Dechow et al. (1995) and their modified Jones model, we measure corporate information transparency using discretionary earnings management (*EM*). We estimate Equation (17) by industry and quarter, and treat the regression residuals as firms' discretionary accruals. Because we are concerned with the magnitude rather than the direction of earnings management, we take the absolute value of discretionary accruals to obtain our earnings-management measure.

$$\frac{TA_{i,t}}{A_{i,t-1}} = a_1 \frac{1}{A_{i,t-1}} + a_2 \frac{\Delta REV_{i,t} - \Delta REC_{i,t}}{A_{i,t-1}} + a_3 \frac{PPE_{i,t}}{A_{i,t-1}} + \varepsilon_{i,t} \quad (17)$$

In Equation (17), i and t denote the firm and quarter, respectively. *TA* represents total accruals, defined as operating income minus cash flow from operating activities; *A* denotes total assets; ΔREV is the change in revenues; ΔREC is the change in accounts receivable; and *PPE* is property, plant, and equipment. In general, poorer information environments are associated with greater earnings manipulation. Accordingly, larger values of *EM* indicate lower information transparency.

3.2.12 Liquidity

Although turnover is often used to proxy for stock liquidity, it is closely related to firm size and may therefore overstate liquidity for small-cap stocks. Following Amihud (2002), we instead

employ a price-impact-based illiquidity measure to capture stock-level liquidity in Equation (18):

$$Illiquidity_{i,t} = \frac{1}{M_i} \sum_{m=1}^{M_i} \left(\frac{|r_{i,m}|}{Value_{i,d}} \right) \times 10^7 \quad (18)$$

In this construction, i , t , and m denote the stock, the half-hour interval, and the minute, respectively. $r_{i,m}$ and $Value_{i,m}$ represent the return on stock i and its trading value in minute m . Let M denote the number of minutes within a given half-hour interval. The illiquidity measure reflects the absolute price change per unit of trading volume: smaller price responses to a given trading volume correspond to higher liquidity, whereas larger responses imply lower liquidity. Accordingly, higher values of *Illiquidity* indicate poorer stock liquidity.

3.2.13 Control variables

We include a standard set of firm-level controls: firm size (*Size*), profitability (*ROA*), leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_Ownership*), ownership concentration measured by the top-five shareholders (*Concentration5*), and listing age (*Listyear*). Variable definitions are reported in Table 1.

[Insert table 1 about here]

3.3 Descriptive statistics

Panel A of Table 2 reports summary statistics for ETF management and custodial fees across ETF categories. In China, equity ETFs, cross-border ETFs, and commodity ETFs typically charge management fees of approximately 0.5% and custodial fees of around 0.1%, whereas money-market ETFs and bond ETFs exhibit substantially lower fee levels. The Chinese ETF market is dominated by equity ETFs, which account for 80% of all ETF products.

Panel B compares fee structures between equity ETFs and other equity-oriented mutual funds. Actively managed equity funds and active hybrid funds charge significantly higher management and custodial fees than passive index funds such as equity ETFs. In particular, the average management and custodial fees of active equity funds reach 1.461% and 0.239%, respectively—approximately 3.5 and 2.8 times those of equity ETFs.

Even within index-tracking products, equity ETFs remain substantially cheaper than alternative vehicles. Enhanced index funds and passive index funds charge management fees of 0.927% and 0.576%, respectively, exceeding those of equity ETFs by 0.415%, with both differences statistically significant at the 1% level. Custodial fees for enhanced and passive index funds are likewise significantly higher than those of equity ETFs.

Low fee levels constitute an important driver of the rapid expansion of China's ETF market. According to statistics from the Investment Company Institute (ICI), the average expense ratio of U.S. equity index ETFs has declined by two basis points to 0.14%, indicating that fee levels in China remain substantially higher than those in the United States.

[Insert table 2 about here]

Table 3 reports descriptive statistics for the main variables from 2012 to 2024. The sampling frequency is half-hourly, yielding a total of 26,744,812 observations.

The mean (median) intraday volatility measure, *IntraVol*, equals 0.0016 (0.0011), with a maximum value of 0.0424. The average ETF ownership, *ETF_Ownership* (%), is 0.2943, and its maximum reaches 9.1987, indicating that among stocks held by ETFs, the average ETF ownership amounts to 2.94%, with the highest exceeding 9.20%.

The arbitrage activities measure, *Arbitrage*, has a mean of 0.0040, a median of zero, and a maximum of 0.0919. Although price discrepancies between the primary and secondary ETF markets do occur, once trading costs and price impact are taken into account, economically meaningful arbitrage opportunities appear to be limited for most of the sample period.

[Insert table 3 about here]

4 Empirical results

4.1 ETF ownership and intraday volatility: high-frequency evidence

From a theoretical perspective, the effect of ETF ownership on intraday volatility is ambiguous. On the one hand, higher ETF ownership may reduce intraday volatility. ETFs provide investors with a low-cost and efficient vehicle for simultaneously trading a large basket of securities. As ETF ownership increases, ETF trading can facilitate the rapid incorporation of common information, such as market-wide and industry-level signals, into the prices of constituent stocks. Moreover, ETFs enable informed traders to hedge market-wide risk, which may induce privately informed investors to trade ETF constituent stocks while using ETFs as hedging instruments. In this sense, ETF activity may promote the production and incorporation of private information. The incorporation of both public and private information improves price efficiency and may therefore dampen intraday volatility. On the other hand, ETF ownership may increase volatility. Investors can exploit price discrepancies between ETF shares traded in the secondary market and the underlying basket of securities through arbitrage activity, which is largely unrelated to fundamentals. Frequent trading in ETFs and their constituent stocks may generate non-fundamental shocks, induce temporary price deviations from intrinsic values, and thereby amplify intraday volatility.

Using minute-level data from the Chinese stock market, we examine whether ETF ownership ultimately increases or decreases intraday volatility. Model (19) specifies a panel fixed-effects regression that relates ETF ownership to intraday volatility. The dependent variable, *IntraVol*, measures stock-level intraday volatility, while the main explanatory variable, *ETF_Ownership*, captures ETF ownership. *Controls* denote the set of control variables described in the research design section. *Stock* and *Year* fixed effects are included to absorb time-invariant firm heterogeneity and common yearly shocks, respectively. Table 4 reports the regression results from estimating Model (19). Columns (1) and (2) present specifications without stock and time fixed effects, whereas Columns (3) and (4) incorporate both *stock* and *year* fixed effects. Columns (1) and (3) include only the key explanatory variable, while Columns (2) and (4) further control for firm-level characteristics.

$$IntraVol_{i,t} = a_0 + a_1 ETF_Ownership_{i,t-1} + a_2 Controls_{i,t-1} + Stock_i + Year_t + \varepsilon_{i,t} \quad (19)$$

[Insert table 4 about here]

Table 4 reports the regression results. In Columns (1) and (2), which present ordinary least squares estimates, the coefficient on *ETF_Ownership* equals -0.0026 and -0.0033, respectively, and is statistically significant at the 1% level. Columns (3) and (4), which employ panel specifications with *stock* and *year* fixed effects, yield similar conclusions: the estimated coefficients on *ETF_Ownership* are -0.0031 and -0.0018, respectively, both significant at the 1% level. Taken together, these results indicate that higher ETF ownership is associated with lower intraday volatility.

In addition, the fixed-effects specification in Column (4) reveals that stocks issued by firms with smaller assets (*Size*), weaker profitability (*ROA*), higher leverage (*Leverage*), and stronger growth rate (*Growth*) exhibit significantly higher intraday volatility. Firms with more unstable operations and greater fundamental uncertainty tend to experience larger price fluctuations. The coefficients on the proportion of independent directors (*Independence*) and managerial ownership (*Board_ownership*) are significantly negative, suggesting that stronger corporate governance mitigates intraday volatility, likely by improving information transparency and reducing uncertainty in the firm's fundamentals.

4.2 Mechanism Test

4.2.1 Pricing Efficiency

The preceding analysis shows that ETFs in China significantly reduce intraday volatility. We next examine whether improvements in pricing efficiency constitute the economic mechanism through which ETF ownership affects intraday volatility.

Table 5 reports the results. Columns (1) and (2) use *Efficiency1* as the dependent variable, while Columns (3) and (4) employ *Efficiency2*. In Columns (1) and (2), the estimated coefficients on *ETF_Ownership* are -3.6069 and -3.2066, respectively, both statistically significant at the 1% level. Similarly, in Columns (3) and (4), the coefficients are -2.1810 and -1.9888, again significant at the 1% level. These findings indicate that as ETF ownership increases, both *Efficiency1* and *Efficiency2* decline. Overall, the evidence in Table 5 suggests that ETFs enhance stock-level pricing efficiency, which in turn reduces intraday volatility. Relative to trading a large number of individual stocks separately, ETF trading involves lower transaction costs and facilitates the timely incorporation of market-wide and industry-level information into constituent stock prices, thereby improving informational efficiency.

[Insert table 5 about here]

Our conclusions differ from those of Israeli et al. (2017), who document that rising ETF ownership in the U.S. equity market is associated with reduced private-information production and lower pricing efficiency. Two factors may account for this discrepancy. First, Israeli et al. (2017) rely on annual data over a long horizon, whereas the effects of ETFs on information incorporation are likely to operate at much higher frequencies. Annual measures may therefore fail to capture these short-run dynamics. Second, Israeli et al. (2017) attribute the decline in private information production to wider bid-ask spreads and higher trading costs induced by ETF ownership. In contrast, China's equity market is characterized by heavy retail participation, abundant liquidity, and relatively modest ETF penetration. Investors thus remain actively engaged in acquiring

stock-specific private information. In China, the informational role of ETFs appears to operate primarily through the aggregation and dissemination of market- and industry-level information. By accelerating the incorporation of such common information into prices, ETFs ultimately enhance stock-level pricing efficiency.

4.2.2 Arbitrage activities

Although ETF arbitrage trading may generate non-fundamental shocks to underlying stocks, China's distinctive institutional design and market practices imply that such activities need not exert strong effects on the equity market. For example, Chinese regulators and fund managers employ cash-substitution flags, such as permitted, mandatory, and prohibited, in the ETF creation-redemption process. Fund companies retain discretion over the form of consideration used by investors when creating ETF shares, thereby constraining arbitrage capacity and mitigating the liquidity risks imposed on ETFs and their constituent stocks. Moreover, unlike the U.S. equity market, China's stock market is characterized by high turnover and ample liquidity, which further limits the potential price impact of ETF arbitrage trades. Motivated by these institutional features, we next examine whether ETF ownership generates arbitrage activities in China and whether such activities exert a significant influence on intraday volatility.

[Insert table 6 about here]

In Table 6, columns (1) uses *Arbitrage* as the dependent variable and *ETF_Ownership* as the key explanatory variable. The estimated coefficient on *ETF_Ownership* is significantly positive, indicating that higher ETF ownership is associated with larger arbitrage activities. Mechanically, increases in ETF holdings can generate price discrepancies between the primary and secondary markets, thereby creating potential arbitrage opportunities. Columns (2)-(3) partition the sample into high- and low-arbitrage subsamples based on the median value of *Arbitrage*. In the high-arbitrage group, Columns (2) reports coefficient on *ETF_Ownership* of -0.0019. In the low-arbitrage group, Columns (3) yields coefficients of -0.0015. The magnitude of the coefficients is similar across the two subsamples, suggesting that the volatility-reducing effect of ETF ownership does not differ materially between stocks with high and low arbitrage activity. The results in Table 6 indicate that ETF ownership does not affect intraday volatility through the expansion of arbitrage activities.

4.3 Heterogeneity Analysis

4.3.1 ETF ownership, ETF type, and intraday volatility

We classify ETFs along two dimensions. Based on constituent style, ETFs are divided into broad-based ETFs and narrow-based ETFs. Based on market coverage, ETFs are categorized as single-market ETFs and cross-market ETFs. Table 7 examines how the effect of ETF ownership on intraday volatility varies across these ETF types. Columns (1) and (2) focus on heterogeneity between broad- and narrow-based ETFs, while Columns (3) and (4) compare single-market and cross-market ETFs. The key explanatory variables are the interaction terms $ETF_Ownership \times ETF_constituent$ and $ETF_Ownership \times ETF_cross$, respectively.

[Insert table 7 about here]

In Columns (1) and (2), the coefficients on $ETF_Ownership \times ETF_constituent$ are both -0.0082 and statistically significant at the 1% level, indicating that narrow-based ETFs exert a stronger stabilizing effect on stock prices than broad-based ETFs. Relative to broad-based ETFs, the constituents of narrow-based ETFs share more similar industry exposures or thematic characteristics. When news or corporate announcements affect one constituent firm, other firms in the same narrow-based ETF are more likely to be economically linked. Trading in narrow-based ETFs therefore facilitates the rapid incorporation of firm-relevant information into prices, improves stock-level pricing efficiency, and ultimately reduces intraday volatility.

In Columns (3) and (4), the coefficients on $ETF_Ownership \times ETF_cross$ equal 0.0001 and 0.0009, respectively, both significant at the 1% level. These estimates imply that cross-market ETFs provide a weaker stabilizing effect than single-market ETFs. Because cross-market ETFs operate across two separate clearing and settlement systems, their creation-redemption and capital-usage efficiency is lower than that of single-market ETFs. This institutional friction hampers the timely incorporation of information into prices, causing stock prices to respond more sluggishly to new information.

4.3.2 ETF ownership, firm characteristics, and intraday volatility

Although ETF arbitrage activity may expose constituent stocks to noise trading to some extent, the preceding evidence indicates that the low-cost and rapid trading enabled by ETFs accelerates the incorporation of market- and industry-level information into prices. By improving stock-level pricing efficiency, ETF ownership ultimately reduces intraday volatility. However, the stabilizing role of ETFs may vary across firms with different information environments. On the one hand, noise traders are more likely to concentrate in stocks characterized by greater information asymmetry, in which case ETF-related trading may amplify price fluctuations. On the other hand, investors who rely on private information tend to trade stocks with relatively low information asymmetry while using ETFs to hedge market- or industry-level risk. Such informed trading can further enhance the pricing efficiency of transparent firms.

Stock liquidity is another prerequisite for price formation. Although ETFs allow investors to acquire diversified stock portfolios simultaneously, the execution of trades and the incorporation of information into prices ultimately depend on the liquidity of the underlying securities. When a stock is extremely illiquid, even a high ETF ownership share does not guarantee that fund managers can trade efficiently. Higher liquidity facilitates rapid and low-cost trading by ETF managers, whereas poor liquidity is more likely to generate price discrepancies between the primary and secondary markets, encourage noise trading, and thereby undermine price stability. Motivated by these considerations, we introduce interaction terms between ETF ownership and measures of information transparency and stock liquidity to examine how firm characteristics shape the relation between ETF ownership and intraday volatility.

[Insert table 8 about here]

We proxy for information transparency using discretionary accruals, with larger values indicating poorer transparency. In Table 8, Columns (1) and (2) include the interaction between ETF ownership and information transparency, $ETF_Ownership \times EM$, as the key explanatory

variable. After controlling for *stock* and *Year* fixed effects, the estimated coefficients on this interaction term are 0.0122 and 0.0166, respectively, both statistically significant at the 1% level. The positive coefficients imply that the volatility-reducing effect of ETF ownership becomes stronger as firms' information environments improve.

We measure stock liquidity using the illiquidity index, where higher values correspond to lower liquidity. Columns (3) and (4) incorporate the interaction between ETF ownership and stock illiquidity, $ETF_Ownership \times Illiquidity$. The coefficients on this interaction term are significantly positive, indicating that as *Illiquidity* declines—that is, as stock liquidity improves—the stabilizing effect of ETF ownership on intraday volatility becomes more pronounced.

4.4 Robustness tests

4.4.1 The 2019 SZSE ETF reform as an exogenous shock

In 2019, SZSE officially issued the revised Implementation Rules for the Trading and Creation-Redemption of Exchange-Traded Funds (2019 Revision), which came into effect on October 21, 2019. The reform substantially improved the trading and settlement mechanism for Shenzhen-listed ETFs by aligning it with the A-share settlement system. Specifically, ETF share settlement was accelerated from T+1 to T. The reform also modified the settlement arrangement for cross-market ETFs traded on the SZSE. The on-exchange creation-redemption mechanism was changed from a “full cash substitution” regime to one in which Shenzhen-listed stocks are delivered in kind while Shanghai-listed stocks are substituted with cash, with China Securities Depository and Clearing Corporation providing guaranteed settlement. Under the new rules, ETF shares can be fully settled on day T. These institutional changes enhanced clearing and settlement efficiency for Shenzhen-listed ETFs, increased ETF ownership, and facilitated arbitrage activity.

We exploit this regulatory reform as an exogenous shock and examine whether stocks with greater exposure to Shenzhen-listed ETFs experienced larger changes in intraday volatility relative to those primarily held by Shanghai-listed ETFs. Such a comparison allows us to assess whether increases in ETF ownership causally affect intraday volatility.

[Insert table 9 about here]

In Table 9, the triple interaction term $ETF_Ownership \times Exchange \times Event2019$ is the key explanatory variable. In Columns (1) and (2), which report ordinary least squares estimates, the coefficients on this interaction are -0.0006 and -0.0007, respectively, both significant at least at the 5% level. Columns (3) and (4), which incorporate panel fixed effects, yield coefficients of -0.0120 and -0.0097, each significant at the 1% level. These results indicate that following the SZSE reform, stocks with higher exposure to Shenzhen-listed ETFs experienced larger declines in intraday volatility. This evidence is consistent with our main findings: although the reform increased ETF ownership and facilitated more frequent arbitrage trading, volatility did not rise. Instead, higher ETF participation accelerated information incorporation into prices, ultimately reducing intraday volatility.

4.4.2 Alternative outcome: stock price crash risk

To examine whether the volatility-reducing effect of ETF ownership reflects a broader stabilizing influence on prices, we conduct an additional robustness test by investigating the impact of ETFs on stock price crash risk. Whereas volatility captures continuous price fluctuations, crash risk reflects the accumulation and sudden release of negative information. The two therefore represent distinct dimensions of price risk. Incorporating crash risk as a supplementary outcome provides a more comprehensive assessment of ETFs' role in maintaining capital-market stability.

From a market-wide perspective, stock price crashes pose a serious threat to financial stability. A crash occurs when stock prices experience abrupt and extreme declines, such events may propagate across firms and trigger market-wide turmoil, thereby undermining capital-market stability (Harvey and Siddique 2000). Table 10 reports the regression results examining the relation between ETF ownership and crash risk. One concern is that noise traders may hold substantial short-term ETF positions and liquidate them rapidly when liquidity deteriorates, potentially precipitating sharp price drops.

[Insert table 10 about here]

The results in Table 10 alleviate this concern. Regardless of whether crash risk is measured by negative conditional skewness (*NCSKEW*) or the down-to-up volatility ratio (*DUVOL*), the coefficient on *ETF_Ownership* is significantly negative. These findings indicate that ETF ownership does not increase crash risk. Instead, ETFs appear to facilitate the timely dissemination of information to investors, reduce information asymmetry, and thereby mitigate the likelihood that stock prices deviate sharply from fundamentals, lowering stock-level crash risk.

4.4.3 Out-of-Sample Test

In the baseline analysis, the sample consists only of stocks held by at least one ETF and excludes firms that are not included in any ETF portfolio. We next expand the sample to encompass all A-share stocks to examine whether the effect of ETF ownership on intraday volatility remains robust. For stocks not held by any ETF, *ETF_Ownership* is set to zero.

Table 11 presents the out-of-sample results. In Columns (1) and (2), which report ordinary least squares estimates, the coefficients on *ETF_Ownership* are -0.0021 and -0.0054, respectively. In Columns (3) and (4), which employ panel specifications with fixed effects, the corresponding coefficients are -0.0040 and -0.0030. In all cases, the estimates remain negative and statistically significant at the 1% level. These full-sample results further corroborate the robustness of our main findings, reinforcing the conclusion that ETF ownership significantly reduces intraday volatility in China's equity market.

[Insert table 11 about here]

4.4.4 Alternative measure of ETF ownership

In the out-of-sample analysis, the explanatory variable *ETF_Ownership* contains a large mass of zero observations alongside positive continuous values. To further assess the robustness of our findings, we replace this continuous measure with a binary indicator and examine whether ETF participation per se reduces intraday volatility.

We construct an ETF ownership dummy (*ETF_dummy*) that equals one if a stock is included in

at least one ETF portfolio—that is, if *ETF_Ownership* is greater than zero—and zero otherwise. Table 12 reports the regression results.

Across all specifications in Table 12, the coefficient on *ETF_dummy* is significantly negative at the 1% level, indicating that, relative to stocks not held by any ETF, ETF constituent stocks exhibit substantially lower intraday volatility. These results provide further support for the robustness of our baseline conclusions.

[Insert table 12 about here]

5 Conclusion

Using minute-level high-frequency data on Chinese A-share stocks and ETFs from 2012 to 2024, we investigate the impact of ETFs on intraday volatility. Although the hybrid open-end and closed-end features of ETFs mechanically give rise to arbitrage trading by noise traders and may generate non-fundamental price pressure, our empirical evidence indicates that in China—where stock liquidity is ample and generally exceeds ETF liquidity—ETF arbitrage activity does not exert a significant influence on intraday volatility. Instead, mechanism tests show that ETFs facilitate the rapid incorporation of market-wide and industry-level information into stock prices. By improving stock-level pricing efficiency, ETF ownership ultimately reduces intraday volatility. Our heterogeneity analyses further reveal that narrow-based ETFs play a stronger stabilizing role than broad-based ETFs, and that single-market ETFs are more effective in promoting price stability than cross-market ETFs. Exploiting the 2019 SZSE reform of ETF creation and redemption rules as an exogenous shock, we show that the reform increased ETF ownership among Shenzhen-listed stocks and that the associated rise in ETF holdings continued to be accompanied by declines in intraday volatility. Moreover, the volatility-reducing effect of ETFs is more pronounced for stocks with higher information transparency and greater liquidity.

Our findings suggest that ETFs contribute to capital-market stability in China. At present, China's ETF market remains at an early stage of development, with relatively low ETF penetration and abundant market liquidity, and private information acquisition has not yet diminished. Looking forward, as ETF ownership expands and passive investing becomes more prevalent, alongside ongoing institutional reforms and evolving market conditions, ETFs are likely to exert increasingly profound effects on China's capital markets.

Declarations

Conflict of interest The authors report there are no competing interests to declare.

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Figures

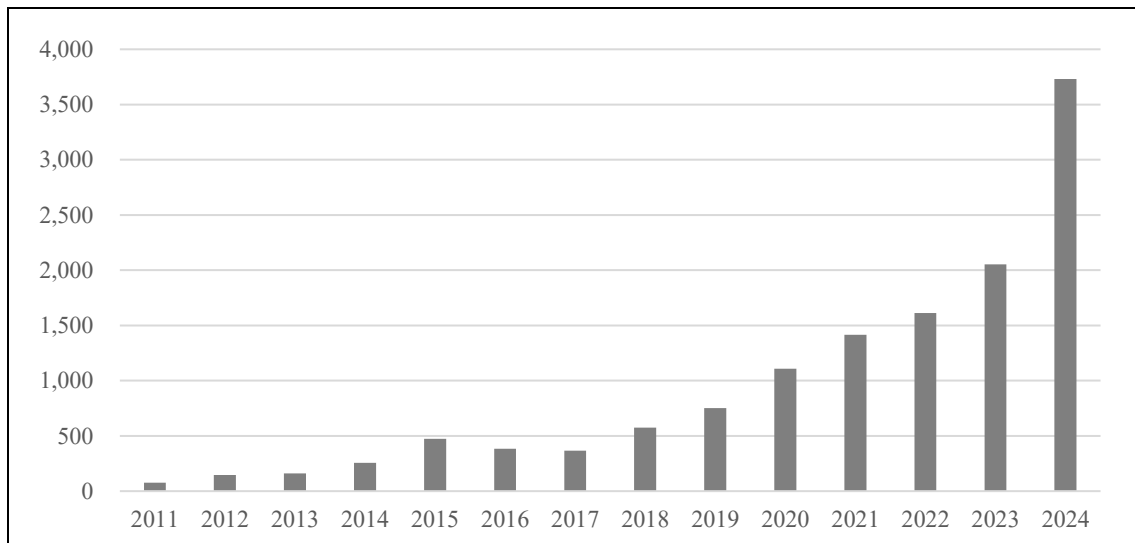


Figure 1 Total net asset value of China's ETF market (RMB billion)

Note: The data in Figure 1 are compiled from the Wind database and include all ETF products listed up to and including 2024. By the end of 2024, the total net asset value of China's ETF market reached RMB 3,732 billion (approximately USD 510 billion, converted using an RMB-USD exchange rate of about 7.3 over 2024-2025).

Tables

Table 1 Variable definitions

Variable	Definition
<i>ETF_Ownership</i>	Ratio of the market value of ETF holdings to the stock's total market capitalization, see Equation (1).
<i>ETF_dummy</i>	Equals one if the stock is included in at least one ETF portfolio and zero otherwise.
<i>IntraVol</i>	Standard deviation of minute-by-minute stock returns within each half-hour interval.
<i>NCSKEW</i>	The negative conditional skewness of returns, see Equation (4).
<i>DUVOL</i>	The down-to-up volatility ratio, see Equation (5).
<i>Efficiency1</i>	Measure of the speed of price adjustment to market information constructed from regression R-squared values, see Equation (8).
<i>Efficiency2</i>	Measure of the speed of price adjustment to market information constructed from regression coefficients, see Equation (9).
<i>Arbitrage</i>	ETF arbitrage activities based on price differentials between the primary and secondary markets, see Equations (10)-(13).
<i>ETF_constituent</i>	Ratio of the market value of stock <i>i</i> held by narrow-based ETFs to the total market value of stock <i>i</i> held by all ETFs, see Equation (14).
<i>ETF_cross</i>	Ratio of the market value of stock <i>i</i> held by cross-market ETFs to the total market value of stock <i>i</i> held by all ETFs, see Equation (15).
<i>Exchange</i>	Ratio of the market value of stock <i>i</i> held by Shenzhen-listed ETFs to the total market value of stock <i>i</i> held by all ETFs, see Equation (16).
<i>Event2019</i>	Equals zero for observations before October 21, 2019, and one thereafter.
<i>EM</i>	Earnings management measured using discretionary accruals, see Equation (17).
<i>Illiquidity</i>	Price change per unit of trading value, following Amihud (2002), see Equation (18).
<i>Size</i>	Natural logarithm of total assets.
<i>ROA</i>	Net income divided by total assets.
<i>Leverage</i>	Total liabilities divided by total assets.
<i>Growth</i>	Growth rate of operating revenue, defined as $(Revenue_t - Revenue_{t-1}) / Revenue_{t-1}$.
<i>Independence</i>	Fraction of independent directors on the board.
<i>Board_ownership</i>	Shares held by executives divided by total shares outstanding.
<i>Concentration5</i>	Sum of squared ownership shares of the five largest shareholders.
<i>Listyear</i>	Firm age, measured as the number of days since listing divided by 365.

Note: ETF basic information and firm-level financial data are obtained from the Wind database. Minute-by-minute high-frequency trading data for stocks and ETFs are sourced from the JoinQuant platform. ETF creation and redemption baskets are manually collected from the official websites of the Shanghai Stock Exchange and the Shenzhen Stock Exchange.

Table 2 ETF fee statistics

Panel A. ETF categories, management fees, and custodial fees					
ETF Category	Management Fee (%)		Custodial Fee (%)		Number
	Mean	Median	Mean	Median	
Equity ETFs	0.4147	0.5000	0.0864	0.1000	825
Cross-border ETFs	0.4748	0.5000	0.1118	0.1000	137
Money-market ETFs	0.2548	0.2800	0.0792	0.0800	27
Bond ETFs	0.1550	0.1500	0.0500	0.0500	20
Commodity ETFs	0.4294	0.5000	0.0882	0.1000	17
Panel B. fee comparison between equity ETFs and other equity funds					
	Active Equity Funds (1)	Active Hybrid Funds (2)	Passive Index Funds (3)	Enhanced Index Funds (4)	Equity ETFs (5)
Management Fee (%)	1.4606 (0.136)	1.1982 (0.393)	0.5763 (0.238)	0.9266 (0.187)	0.4147 (0.137)
Custodial Fee (%)	0.2391 0.210	0.2102 (0.057)	0.1184 (0.048)	0.1627 (0.045)	0.0864 (0.021)
Management Fee Difference (Column – (5))	1.0459***	0.7835***	0.1616***	0.5119***	
Custodial Fee Difference (Column – (5))	0.1236***	0.1238***	0.0320***	0.0763***	
Number	806	6907	2456	485	825

Note: This table reports management fees and custodial fees for Chinese ETFs and other equity-related mutual funds. Fund-level data are obtained from the Wind database, and the sample includes all funds listed up to and including 2024. All fee measures are annualized percentages (%) as disclosed in fund prospectuses. Panel A presents the mean, median, and number of products for management and custodial fees across different ETF categories, including equity ETFs, cross-border ETFs, money market ETFs, bond ETFs, and commodity ETFs. Panel B compares fee levels between equity ETFs and other equity-related fund products, including active equity funds, active Hybrid funds, passive index funds, and enhanced index funds. Standard deviations are reported in parentheses. “Management Fee Difference (Column – (5))” and “Custodial Fee Difference (Column – (5))” denote the average fee differentials relative to equity ETFs. “Number” indicates the number of funds in each category. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively.

Table 3 Descriptive statistics

<i>Variable</i>	<i>N</i>	<i>Mean</i>	<i>SD</i>	<i>Median</i>	<i>Min</i>	<i>Max</i>
<i>ETF_Ownership(%)</i>	26,744,812	0.2943	0.5388	0.0482	0.0000	9.1987
<i>ETF_dummy</i>	41,383,713	0.6460	0.4780	1.0000	0.0000	1.0000
<i>IntraVol</i>	26,744,812	0.0016	0.0011	0.0010	0.0000	0.0424
<i>NCSKEW</i>	26,744,812	-0.1185	2.6609	-0.1316	-5.3181	5.3022
<i>DUVOL</i>	26,744,812	-0.0393	1.3036	-0.0380	-3.4600	3.3876
<i>Efficiency1</i>	26,744,812	0.6952	0.2702	0.7656	0.0000	1.0000
<i>Efficiency2</i>	26,744,812	0.7692	0.1540	0.7911	0.0000	1.0000
<i>Arbitrage</i>	26,744,812	0.0040	0.0135	0.0000	0.0000	0.0919
<i>ETF_constituent</i>	26,744,812	0.3856	0.4187	0.1396	0.0000	1.0000
<i>ETF_cross</i>	26,744,812	0.6893	0.3904	0.9525	0.0000	1.0000
<i>exchange</i>	26,744,812	0.6019	0.4333	0.8860	0.0000	1.0000
<i>Event2019</i>	26,744,812	0.2359	0.4249	0.0000	0.0000	1.0000
<i>EM</i>	26,744,812	0.0265	0.0286	0.0177	0.0003	0.1654
<i>Illiquidity</i>	26,744,812	0.1081	0.1677	0.0495	0.0019	1.0596
<i>Size</i>	26,744,812	22.7103	1.4002	22.4823	19.4974	27.1227
<i>ROA</i>	26,744,812	0.0107	0.0193	0.0092	-0.1031	0.0700
<i>Leverage</i>	26,744,812	0.4420	0.2110	0.4351	0.0515	0.9723
<i>Growth</i>	26,744,812	0.2141	0.7431	0.0963	-1.0630	6.8008
<i>Independence</i>	26,744,812	0.3753	0.0538	0.3571	0.3333	0.5714
<i>Board_ownership</i>	26,744,812	0.1119	0.1737	0.0031	0.0000	0.6744
<i>Concentration5</i>	26,744,812	0.1571	0.1169	0.1236	0.0140	0.5618
<i>Institutions</i>	26,744,812	0.4349	0.2523	0.4605	0.0007	0.9124
<i>Listyear</i>	26,744,812	2.1738	0.7775	2.2566	0.0000	3.4030

Note: This table reports descriptive statistics for the main variables. The sample period spans 2012-2024 and covers all equity ETFs listed up to 2024 and their constituent stocks. The final sample contains 26,744,812 stock-half-hour observations. Minute-level trading data for stocks and ETFs are obtained from the JoinQuant platform; ETF creation and redemption lists are manually collected from the official websites of SSE and SZSE, and financial data as well as fund characteristics are drawn from the Wind database. All continuous variables are winsorized at the 1st and 99th percentiles.

Table 4 ETF ownership and intraday volatility

VARIABLES	<i>IntraVol</i>			
	(1)	(2)	(3)	(4)
<i>ETF_Ownership</i>	-0.0026*** (-54.2889)	-0.0033*** (-65.2221)	-0.0031*** (-64.2084)	-0.0018*** (-37.2248)
<i>Size</i>		-0.0002*** (-224.1120)		-0.0001*** (-181.9843)
<i>ROA</i>		-0.0008*** (-59.6395)		-0.0003*** (-21.7897)
<i>Leverage</i>		0.0005*** (174.7435)		0.0004*** (141.0879)
<i>Growth</i>		-0.0000*** (-13.0388)		0.0000*** (59.1167)
<i>Independence</i>		0.0002*** (24.4935)		-0.0001*** (-14.3635)
<i>Board_ownership</i>		0.0001*** (19.5813)		-0.0001*** (-16.0483)
<i>Concentration5</i>		-0.0007*** (-117.6502)		-0.0007*** (-114.1503)
<i>Institutions</i>		0.0001*** (75.3706)		0.0001*** (44.3528)
<i>Listyear</i>		0.0002*** (197.4933)		0.0000*** (20.9650)
<i>Stock FE</i>	No	No	Yes	Yes
<i>Year FE</i>	No	No	Yes	Yes
<i>Observations</i>	26,744,812	26,744,812	26,744,812	26,744,812
<i>R-squared</i>	0.0001	0.0048	0.2009	0.2028

Notes: This table reports regression results on the relation between ETF ownership and intraday volatility. The dependent variable is *IntraVol*, measured as the standard deviation of minute returns within each half-hour interval. *ETF_Ownership* captures the ratio of the market value of a stock held by ETFs to the stock's total market capitalization. Control variables include firm size (*Size*), return on assets (*ROA*), financial leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). Columns (1) and (2) do not include fixed effects, while Columns (3) and (4) control for *stock* fixed effects and *year* fixed effects, respectively. The sample period is 2012-2024, with a total of 26,744,812 observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.

Table 5 Intraday volatility and pricing efficiency

VARIABLES	Efficiency1		Efficiency2	
	(1)	(2)	(3)	(4)
<i>ETF_Ownership</i>	-3.6069*** (-276.3492)	-3.2066*** (-242.0658)	-2.1810*** (-283.0777)	-1.9888*** (-254.2502)
<i>Size</i>		-0.0346*** (-178.8304)		-0.0163*** (-142.3454)
<i>ROA</i>		-0.1453*** (-43.6589)		-0.0669*** (-34.0466)
<i>Leverage</i>		0.0311*** (43.8292)		0.0141*** (33.6280)
<i>Growth</i>		0.0006*** (8.6942)		-0.0000 (-0.7779)
<i>Independence</i>		-0.0186*** (-10.5107)		-0.0053*** (-5.0557)
<i>Board_ownership</i>		0.0020* (1.8644)		-0.0027*** (-4.4445)
<i>Concentration5</i>		0.0158*** (10.0753)		0.0058*** (6.2544)
<i>Institutions</i>		0.0310*** (53.7686)		0.0043*** (12.5956)
<i>Listyear</i>		-0.0210*** (-62.2351)		-0.0117*** (-58.5564)
<i>Stock FE</i>	Yes	Yes	Yes	Yes
<i>Year FE</i>	Yes	Yes	Yes	Yes
<i>Observations</i>	26,744,812	26,744,812	26,744,812	26,744,812
<i>R-squared</i>	0.0947	0.0962	0.0340	0.0351

Note: This table reports regression results on the relation between ETF ownership and stock price efficiency. The dependent variables are two intraday measures constructed from minute returns. *Efficiency1* captures the extent to which stock returns depend on lagged market returns, with larger values indicating slower price adjustment and lower pricing efficiency. *Efficiency2* is based on regression coefficients on contemporaneous and lagged market returns, where higher values likewise indicate lower pricing efficiency. Columns (1) and (2) correspond to *Efficiency1*, and Columns (3) and (4) correspond to *Efficiency2*. All regressions include *stock* fixed effects and *year* fixed effects. Control variables include firm size (*Size*), return on assets (*ROA*), financial leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). The sample period is 2012-2024, with a total of 26,744,812 observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.

Table 6 ETF ownership, arbitrage activities, and intraday volatility

<i>VARIABLES</i>	<i>Arbitrage</i>	<i>IntraVol</i>	
		high-arbitrage group	low-arbitrage group
	(1)	(2)	(3)
<i>ETF_Ownership</i>	1.3769*** (3052.8746)	-0.0019*** (-33.5084)	-0.0015*** (-33.6073)
<i>Size</i>	0.0013*** (204.4126)	-0.0002*** (-153.6392)	-0.0001*** (-99.0989)
<i>ROA</i>	0.0034*** (30.2528)	-0.0002*** (-10.7347)	-0.0003*** (-15.4200)
<i>Leverage</i>	-0.0031*** (-127.5439)	0.0004*** (103.2211)	0.0003*** (87.9396)
<i>Growth</i>	0.0001*** (44.0255)	0.0000*** (58.2715)	0.0000*** (17.4399)
<i>Independence</i>	0.0030*** (49.9469)	-0.0001*** (-7.2294)	0.0000*** (3.3848)
<i>Board_ownership</i>	0.0019*** (52.2967)	-0.0001*** (-13.9525)	-0.0001*** (-10.2467)
<i>Concentration5</i>	-0.0005*** (-8.6063)	-0.0006*** (-65.0260)	-0.0006*** (-70.7221)
<i>Institutions</i>	0.0015*** (75.3859)	0.0001*** (33.4378)	0.0001*** (33.3379)
<i>Listyear</i>	-0.0050*** (-432.1902)	-0.0000*** (-6.1627)	-0.0000 (-0.2774)
<i>Stock FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Year FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Observations</i>	26,744,812	13,372,406	13,372,406
<i>R-squared</i>	0.5258	0.2250	0.1768

Note: This table examines the relation between ETF ownership (*ETF_Ownership*), arbitrage activity (*Arbitrage*), and intraday stock volatility (*IntraVol*). Column (1) uses *Arbitrage* as the dependent variable to test whether ETF ownership facilitates arbitrage trading. Columns (2) and (3) split stocks into high- and low-arbitrage groups based on the sample median of the arbitrage measure and separately estimate the effect of ETF ownership on intraday volatility. All regressions include stock fixed effects and year fixed effects. Control variables include firm size (*Size*), return on assets (*ROA*), financial leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). The sample period is 2012-2024, with a total of 26,744,812 observations; the high- and low-arbitrage subsamples each contain 13,372,406 observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.

Table 7 ETF ownership, ETF type, and intraday volatility

VARIABLES	IntraVol			
	(1)	(2)	(3)	(4)
<i>ETF_Ownership</i>	0.0010*** (13.4307)	0.0023*** (29.8634)	-0.0029*** (-30.5303)	-0.0022*** (-22.3648)
<i>ETF_Ownership</i> × <i>ETF_constituent</i>	-0.0082*** (-72.1442)	-0.0082*** (-71.3852)		
<i>ETF_constituent</i>	0.0001*** (87.5291)	0.0001*** (62.9082)		
<i>ETF_Ownership</i> × <i>ETF_cross</i>			0.0001*** (3.0917)	0.0009*** (7.7592)
<i>ETF_cross</i>			0.0001*** (114.2908)	0.0001*** (111.9021)
<i>Size</i>		-0.0001*** (-176.4792)		-0.0001*** (-187.2393)
<i>ROA</i>		-0.0003*** (-21.4354)		-0.0002*** (-20.2640)
<i>Leverage</i>		0.0004*** (138.8433)		0.0004*** (140.9940)
<i>Growth</i>		0.0000*** (59.4472)		0.0000*** (57.5226)
<i>Independence</i>		-0.0001*** (-14.4259)		-0.0001*** (-14.9462)
<i>Board_ownership</i>		-0.0001*** (-14.2115)		-0.0000*** (-9.9228)
<i>Concentration5</i>		-0.0007*** (-114.2983)		-0.0007*** (-115.0203)
<i>Institutions</i>		0.0001*** (45.0477)		0.0001*** (49.6245)
<i>Listyear</i>		0.0000*** (14.7174)		0.0000*** (13.4002)
<i>Stock FE</i>	Yes	Yes	Yes	Yes
<i>Year FE</i>	Yes	Yes	Yes	Yes
<i>Observations</i>	26,744,812	26,744,812	26,744,812	26,744,812
<i>R-squared</i>	0.2012	0.2030	0.2014	0.2032

Note: This table examines how the effect of ETF ownership on intraday volatility varies across ETF types. First, based on constituent style, ETFs are divided into broad-based ETFs and narrow-based ETFs. Second, based on market coverage, they are classified as single-market ETFs and cross-market ETFs. Columns (1) and (2) introduce the interaction term *ETF_Ownership* × *ETF_constituent* to test for heterogeneous effects between broad-based and narrow-based ETFs, while columns (3) and (4) use the interaction term *ETF_Ownership* × *ETF_cross* to compare single-market and cross-market ETFs. *ETF_constituent* and *ETF_cross* measure, respectively, the relative share of a stock held by narrow-based ETFs and by cross-market ETFs. All regressions include *stock* fixed effects and *year* fixed effects. Control variables include firm size (*Size*), return

on assets (*ROA*), financial leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). The sample period is 2012-2024, with a total of 26,744,812 observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.

Table 8 ETF ownership, firm characteristics, and intraday volatility

VARIABLES	<i>IntraVol</i>			
	(1)	(2)	(3)	(4)
<i>ETF_Ownership</i>	-0.0034*** (-58.7519)	-0.0022*** (-38.6028)	-0.0042*** (-84.2127)	-0.0030*** (-58.6535)
<i>ETF_Ownership</i> *× <i>EM</i>	0.0122*** (10.0166)	0.0166*** (13.5683)		
<i>EM</i>	0.0002*** (28.8672)	0.0001*** (13.8654)		
<i>ETF_Ownership</i> × <i>Liquidity</i>			0.0253*** (81.0886)	0.0245*** (78.7238)
<i>Liquidity</i>			0.0000 (0.7564)	-0.0000*** (-7.6906)
<i>Size</i>		-0.0001*** (-180.7594)		-0.0001*** (-178.7218)
<i>ROA</i>		-0.0003*** (-22.4477)		-0.0002*** (-19.6309)
<i>Leverage</i>		0.0004*** (139.4495)		0.0004*** (141.0006)
<i>Growth</i>		0.0000*** (58.7964)		0.0000*** (59.0545)
<i>Independence</i>		-0.0001*** (-14.4988)		-0.0001*** (-14.6510)
<i>Board_ownership</i>		-0.0001*** (-15.8550)		-0.0001*** (-15.9385)
<i>Concentration5</i>		-0.0007*** (-114.1893)		-0.0007*** (-113.2349)
<i>Institutions</i>		0.0001*** (44.3217)		0.0001*** (44.0806)
<i>Listyear</i>		0.0000*** (20.8000)		0.0000*** (21.9761)
<i>Stock FE</i>	Yes	Yes	Yes	Yes
<i>Year FE</i>	Yes	Yes	Yes	Yes
<i>Observations</i>	26,744,812	26,744,812	26,744,812	26,744,812
<i>R-squared</i>	0.2010	0.2028	0.2012	0.2030

Note: This table examines how firms' information environments and stock liquidity shape the relation between ETF ownership and intraday stock volatility. Information transparency is proxied by discretionary accruals (*EM*), while stock liquidity is captured by an illiquidity measure (*Liquidity*). All regressions include *stock* fixed effects and *year* fixed effects, and control for firm size (*Size*), return on assets (*ROA*), financial leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). The sample period is 2012-2024, with a total of 26,744,812

observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.

Table 9 The 2019 SZSE ETF reform as an exogenous shock

VARIABLES	<i>IntraVol</i>			
	(1)	(2)	(3)	(4)
<i>ETF_Ownership</i> × <i>Exchange</i> × <i>Event</i> 2019	-0.0006**	0.0007***	-0.0120***	-0.0097***
	(-2.5500)	(3.2365)	(-59.9111)	(-48.0366)
<i>ETF_Ownership</i>	-0.0000	0.0000	-0.0061***	-0.0048***
	(-0.1619)	(0.2207)	(-57.7658)	(-45.7973)
<i>Exchange</i>	0.0001***	0.0002***	0.0000***	0.0000***
	(208.2252)	(216.7580)	(15.0661)	(8.8688)
<i>Period</i>	0.0002***	0.0002***		
	(244.6963)	(228.7990)		
<i>ETF_Ownership</i> × <i>Exchange</i>	-0.0090***	-0.0096***	0.0066***	0.0065***
	(-61.6484)	(-65.6549)	(47.8270)	(46.5275)
<i>ETF_Ownership</i> × <i>Event</i> 2019	-0.0030***	-0.0025***	0.0019***	0.0012***
	(-24.6554)	(-20.7570)	(16.6608)	(10.6612)
<i>Exchange</i> × <i>Event</i> 2019	-0.0001***	-0.0001***	0.0000***	-0.0000***
	(-64.8594)	(-103.4668)	(2.7122)	(-15.7052)
<i>Size</i>		-0.0001***		-0.0001***
		(-212.8079)		(-221.2528)
<i>ROA</i>		-0.0008***		-0.0003***
		(-69.7222)		(-32.6848)
<i>Leverage</i>		0.0004***		0.0003***
		(169.0562)		(155.4030)
<i>Growth</i>		-0.0000***		0.0000***
		(-5.5652)		(65.8088)
<i>Independence</i>		0.0001***		-0.0001***
		(21.2562)		(-20.0319)
<i>Board_ownership</i>		0.0001***		-0.0001***
		(18.0948)		(-16.4936)
<i>Concentration</i> 5		-0.0007***		-0.0006***
		(-142.4026)		(-123.2537)
<i>Institutions</i>		0.0002***		0.0001***
		(127.5804)		(60.8509)
<i>Listyear</i>		0.0002***		0.0000***
		(171.3295)		(8.1792)
<i>Stock FE</i>	<i>No</i>	<i>No</i>	<i>Yes</i>	<i>Yes</i>
<i>Year FE</i>	<i>No</i>	<i>No</i>	<i>Yes</i>	<i>Yes</i>
<i>Observations</i>	26,744,812	26,744,812	26,744,812	26,744,812
<i>R-squared</i>	0.0058	0.0105	0.1638	0.1663

Note: This table exploits the 2019 SZSE reform of ETF trading and creation-redemption mechanisms as an exogenous shock to identify the causal effect of changes in ETF ownership on intraday stock volatility. We implement a triple-difference design in which *Exchange* measures the fraction of stock *i*'s total ETF-held market value that is attributable to SZSE-listed ETFs, and

Event2019 denotes the post-reform period. The key explanatory variable is the triple interaction $ETF_Ownership \times Exchange \times Event2019$, which captures the differential change in intraday volatility for stocks with greater exposure to SZSE ETFs relative to those mainly held by Shanghai-listed ETFs after the reform. Columns (1) and (2) report OLS estimates, while columns (3) and (4) additionally include stock fixed effects and year fixed effects. All specifications control for firm size (*Size*), return on assets (*ROA*), financial leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). The sample period spans 2012-2024, with a total of 26,744,812 observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.

Table 10 ETF ownership and stock price crash risk

<i>VARIABLES</i>	<i>NCSKEW</i>		<i>DUVOL</i>	
	(1)	(2)	(3)	(4)
<i>ETF_Ownership</i>	-0.4023*** (-2.9441)	-0.3234** (-2.3298)	-0.9104*** (-13.8831)	-0.8959*** (-13.4488)
<i>Size</i>		-0.0018 (-0.8943)		0.0006 (0.6277)
<i>ROA</i>		-0.4681*** (-13.4168)		-0.1983*** (-11.8487)
<i>Leverage</i>		-0.0330*** (-4.4322)		-0.0136*** (-3.8144)
<i>Growth</i>		-0.0065*** (-8.3483)		-0.0024*** (-6.4835)
<i>Independence</i>		-0.0591*** (-3.1871)		-0.0287*** (-3.2306)
<i>Board_ownership</i>		-0.0122 (-1.1118)		0.0009 (0.1686)
<i>Concentration5</i>		0.0269 (1.6366)		0.0029 (0.3698)
<i>Institutions</i>		-0.0665*** (-11.0027)		-0.0260*** (-8.9576)
<i>Listyear</i>		-0.0406*** (-11.4595)		-0.0158*** (-9.2915)
<i>Stock FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Year FE</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>	<i>Yes</i>
<i>Observations</i>	26,744,812	26,744,812	26,744,812	26,744,812
<i>R-squared</i>	0.0010	0.0010	0.0018	0.0018

Note: This table examines whether ETF ownership affects stock price crash risk. Stock price crash risk is proxied by negative conditional skewness (*NCSKEW*) and the down-to-up volatility ratio (*DUVOL*). Columns (1) and (2) use *NCSKEW* as the dependent variable, and columns (3) and (4) use *DUVOL* as the dependent variable. All regressions include *stock* fixed effects and *year* fixed effects and control for firm size (*Size*), return on assets (*ROA*), financial leverage (*Leverage*), growth opportunities (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). The sample period spans 2012-2024, with a total of 26,744,812 observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.

Table 11 Out-of-sample test

<i>VARIABLES</i>	<i>IntraVol</i>			
	(1)	(2)	(3)	(4)
<i>ETF_Ownership</i>	-0.0021*** (-43.4187)	-0.0054*** (-105.9793)	-0.0040*** (-86.7905)	-0.0030*** (-63.8502)
<i>Size</i>		-0.0001*** (-157.9729)		-0.0001*** (-159.2594)
<i>ROA</i>		-0.0010*** (-91.5156)		-0.0004*** (-45.2817)
<i>Leverage</i>		0.0003*** (168.5032)		0.0003*** (172.4322)
<i>Growth</i>		-0.0000*** (-16.1428)		0.0000*** (47.2015)
<i>Independence</i>		0.0002*** (32.5677)		-0.0000*** (-7.4794)
<i>Board_ownership</i>		0.0002*** (54.5428)		-0.0000*** (-8.5763)
<i>Concentration5</i>		-0.0006*** (-1.3e+02)		-0.0005*** (-130.4892)
<i>Institutions</i>		0.0002*** (131.8122)		0.0001*** (75.3972)
<i>Listyear</i>		0.0002*** (299.1218)		0.0000*** (33.9583)
<i>Stock FE</i>	No	No	Yes	Yes
<i>Year FE</i>	No	No	Yes	Yes
<i>Observations</i>	41,383,713	41,383,713	41,383,713	41,383,713
<i>R-squared</i>	0.0000	0.0056	0.1930	0.1945

Note: This table extends the analysis beyond the baseline sample to include all A-share listed firms in order to assess the robustness of the effect of ETF ownership on intraday volatility. For stocks not held by any ETF, *ETF_Ownership* is set to zero. Columns (1) and (2) report ordinary least squares estimates, while columns (3) and (4) further incorporate *stock* fixed effects and *year* fixed effects. All regressions control for firm size (*Size*), return on assets (*ROA*), financial leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). The sample period spans 2012-2024, with a total of 41,383,713 observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.

Table 12 ETF ownership dummy and intraday volatility

<i>VARIABLES</i>	<i>IntraVol</i>			
	(1)	(2)	(3)	(4)
<i>ETF_dummy</i>	-0.0000*** (-53.2913)	-0.0000*** (-11.8474)	-0.0001*** (-123.6336)	-0.0000*** (-84.3799)
<i>Size</i>		-0.0001*** (-178.0692)		-0.0001*** (-149.6834)
<i>ROA</i>		-0.0010*** (-89.9817)		-0.0004*** (-44.8314)
<i>Leverage</i>		0.0003*** (175.0271)		0.0003*** (167.2187)
<i>Growth</i>		-0.0000*** (-9.6570)		0.0000*** (44.5906)
<i>Independence</i>		0.0002*** (29.6047)		-0.0001*** (-9.8723)
<i>Board_ownership</i>		0.0002*** (53.6331)		-0.0000*** (-9.3148)
<i>Concentration5</i>		-0.0006*** (-131.0492)		-0.0005*** (-130.0137)
<i>Institutions</i>		0.0002*** (135.5815)		0.0001*** (74.5722)
<i>Listyear</i>		0.0002*** (289.8997)		0.0000*** (33.1526)
<i>Stock FE</i>	<i>No</i>	<i>No</i>	<i>Yes</i>	<i>Yes</i>
<i>Year FE</i>	<i>No</i>	<i>No</i>	<i>Yes</i>	<i>Yes</i>
<i>Observations</i>	41,383,713	41,383,713	41,383,713	41,383,713
<i>R-squared</i>	0.0001	0.0053	0.1932	0.1946

Note: This table uses the ETF ownership indicator (*ETF_dummy*) as the key explanatory variable to examine whether ETF participation per se affects intraday stock volatility. i_i equals one if stock i is held by at least one ETF (i.e., $ETF_Ownership > 0$), and zero otherwise. Columns (1) and (2) report ordinary least squares estimates, while columns (3) and (4) further include *stock* fixed effects and *year* fixed effects. All regressions control for firm size (*Size*), return on assets (*ROA*), financial leverage (*Leverage*), growth rate (*Growth*), board independence (*Independence*), managerial ownership (*Board_ownership*), ownership concentration of the top five shareholders (*Concentration5*), institutional ownership (*Institutions*), and listing age (*Listyear*). The sample period spans 2012-2024, with a total of 41,383,713 observations. *, **, and *** denote statistical significance at the 10%, 5%, and 1% levels, respectively. t-statistics are reported in parentheses.