Do Creation and Redemption Rights Really Matter for ETF Market Maker? *

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Abstract

In the Exchange Traded Fund (ETF) market, in addition to Authorized Participants (APs), there is a type of contractual liquidity provider known as a Lead Market Maker (LMM) that maintains both sides of the order book to provide liquidity. We find that nearly 50% of the LMMs in our sample of ETFs are not APs (LMMNAP), which means that they do not have creation and redemption rights when providing liquidity. The absence of this right, we find, leads to liquidity asymmetries among the ETFs under management. This asymmetry is driven by different LMMs (LMMNAP vs. LMMAP) facing varying creation and redemption uncertainties, which lead to different market making strategies. These strategies, in turn, result in different purposes for creation and redemption, reflected in different inventory positions, prompting agents to seek different compensation amounts, ultimately leading to liquidity asymmetries. However, the uncertainty faced by LMMNAP cannot be resolved by simply increasing the number of active APs. We further prove our inventory management hypothesis by decomposing the effective spreads and showing that different quoted spreads jump during extreme price movements. Our results highlight the potential challenges faced by LMMs when they are unable to freely participate in the primary market and call for a better ETF market structure design.

Keywords: Lead market maker; exchange-trade fund; creation and redemption right.

JEL Codes: G10, G14, G23

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1 Introduction

> "There is often confusion around the usage of AP versus market maker. .... APs are often, but not necessarily, market makers and market makers are not necessarily APs in the ETFs for which they provide liquidity. Some APs act as an agent to create or redeem ETF shares on behalf of a market maker who is not an AP."
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> Thomas A. Wittman NASDAQ Inc. (*Exchange-Traded Funds Rule Proposal*, U.S. Securities and Exchange Commission, September 28, 2018)

With the rapid growth of the Exchange-Traded Fund (ETF) market, its assets now reach over $7.2 trillion[1]. Along with that comes more sound regulation. On June 28, 2018, the U.S. Securities and Exchange Commission (SEC) proposed a new rule under the Investment Company Act of 1940. This rule would allow ETFs that meet specific conditions to operate without the expense and delay of obtaining an exemptive order. Additionally, the SEC proposed several new rules and disclosure requirements aimed at creating a consistent, transparent, and efficient regulatory framework for ETFs, fostering competition and innovation in the industry[2]. Subsequently, the SEC sought comments on this proposal from industry participants and academic researchers. In a comment letter, Thomas A. Wittman, Executive Vice President and Head of Global Trading and Market Services at NASDAQ, clarified the common confusion between Authorized Participants (APs) and Market Makers (MMs). He noted that while APs are sometimes MMs, they are not always[3]. The SEC adopted the new Rule 6c-11 on September 25, 2019, requiring ETFs to disclose additional information on their websites or N-CEN forms[4].

In contrast to Thomas A. Wittman's statement, the literature either acknowledges the differences between APs and MMs but assumes they are the same, or simply treats them as equivalent. This discrepancy is mainly due to the lack of a clear methodology or dataset to accurately identify the role of each entity in the ETF market or consider the functional overlap between APs and MMs. However, it is important to note that APs and LMMs sign different contracts with different parties, thus taking on different obligations. Specifically, APs sign contracts with

[1] The number comes from Investment Company Institute (ICI) Factbook, 2022, https://www.icifactbook.org/pdf/2022_factbook.pdf.

[2] Details of the proposed rule can be found at:https://www.sec.gov/files/rules/proposed/2018/33-10515.pdf.

[3] Details of Thomas A. Wittman's comment letter can be found at:https://www.sec.gov/comments/s7-15-18/s71518-4451170-175713.pdf, and all comment letters can be found at: https://www.sec.gov/comments/s7-15-18/s71518.htm.

[4] Final rule can be found at: https://www.sec.gov/files/rules/final/2019/33-10695.pdf.

ETF issuers, giving them the right but not the obligation to create and redeem ETF shares, while LMMs[5] sign contracts with exchanges, obligating them to provide liquidity. In light of this, it is reasonable to question whether they should be analyzed independently, as well as to examine the implications for the ETFs they manage when the LMM is not serving as the AP.

Imagine a scenario where the AP for ETF A is Company ABC and the LMM is Company XYZ. Since these companies are different entities with distinct contracts, they possess different rights. The interactions and potential frictions between them can lead to unintended consequences for the ETFs they manage. For instance, Company XYZ may wish to contact Company ABC to create or redeem ETF shares due to inventory management needs, mispricing, or buying/selling pressure. However, Company ABC might charge additional fees for immediacy, exclude XYZ from the process to perform end-of-day arbitrage itself or consolidate all client creation/redemption orders periodically[6]. This situation creates uncertainty for Company XYZ, as she lacks creation/redemption rights, potentially prompting her to adjust her market-making strategies strategically. Overall, there is still a lack of clarity regarding whether LMMs face this uncertainty, how they might react, and the impact of their reactions on the ETFs they manage. Therefore, it is crucial to explore whether creation/redemption rights significantly affect ETF LMMs.

We first formalize the above example as a simple trading game to highlight the different choices that LMMAP (LMM has creation/redemption right) and LMMNAP (LMM has no creation/redemption right) make when engaging in market-making activities. Specifically, we use the example of a buy shock to illustrate how creation and redemption uncertainty can lead to different strategies for LMMAP and LMMNAP. In response to buy shocks, since the SEC permits naked short selling for market-making purposes and primary market transaction costs are relatively high, market makers can "operationally short sell" ETFs (Evans et al., 2019). The most crucial consideration for market makers is how quickly they can close out their positions. If there is no reverse order flow, LMMAP can create ETF shares to cover outstanding short positions. However, LMMNAP must rely on its APs to create ETF shares, which may lead LMMNAP to prefer holding inventory to make the market rather than engag-

[5] Due to data limitations, we were only able to obtain the LMM for each ETF rather than the full list of MMs. Therefore the analysis in this paper will be based on LMM.

[6] This can happen between AP and client or between APs. For example, when an AP receives a 1-unit creation order from Client A and a 1-unit redemption order from Client B, the AP may exchange the inventory between the two and charge twice the creation fee instead of paying the creation fee to the ETF issuer. This strategy also applies to different APs.

ing in short selling. Therefore, we hypothesize that LMMNAP's creation and redemption activities are primarily driven by inventory management needs, partly due to operational shorting and mispricing arbitrage. In contrast, LMMAP's creation and redemption activities are mainly for operational shorting, with inventory management and mispricing arbitrage as secondary factors. Overall, given the different levels of inventory, we expect liquidity asymmetries after creation and redemption days between ETFs managed by LMMNAP and LMMAP.

To empirically test the predictions of the trading game, we begin by using Form N-CEN to identify all Authorized Participants (APs), whether active or inactive, for each ETF for each fiscal year. We then use the ETF Global dataset to identify the Lead Market Maker (LMM) for each ETF. Since Form N-CEN and ETF Global may record APs and LMMs at the subsidiary level, potentially leading to incorrect classifications, we aggregate all records to the parent firm level to ensure accuracy. After applying a text-matching algorithm, we determine whether the LMM of each ETF is also an AP. When the LMM and AP are the same, we classify the ETF as managed by LMMAP; when they are different, we classify it as LMMNAP. In our sample of 700 U.S. Equity ETFs, half are managed by LMMNAP. The focus and size of these two groups of ETFs are roughly balanced. Pooled regression results indicate that the effective spread of LMMAP-managed ETFs is higher than that of LMMNAP-managed ETFs by approximately 0.8033 basis points. This finding remains consistent even when additional control variables are included.

What causes the difference in spreads between ETFs managed by LMMAP and LMMNAP? Pooled regression results may suggest that trading with LMMNAP is more cost-effective than trading with LMMAP. However, our trading game indicates that the analysis needs to distinguish between active and inactive days in the primary market. This distinction is crucial because uncertainty can lead LMMNAP to hold inventory rather than operationally shorting like LMMAP. As a result, after creating (redeeming) ETF shares, LMMNAP will increase (decrease) the effective spread to compensate for inventory holding costs. Conversely, on days when the primary market is inactive, LMMAP needs to use hedging instruments to manage its operationally short positions and adjust the effective spread to account for operational costs. To systematically investigate the relationship between inventory and effective spreads for different types of agents, we use the percentage change in shares outstanding as a proxy for changes in the agent's net inventory level, given the difficulty in obtaining precise inventory data[7].

[7] An increase in the number of shares outstanding means that creation activity has occurred in the ETF's primary market or that the number of ETF shares been created is greater than the number of redeemed, and vice versa.

Consistent with our predictions, empirical results show that the effective spread of LMMNAP-managed ETFs is more sensitive to the creation/redemption amount than that of LMMAP-managed ETFs. However, on days when the primary market is inactive, the effective spread of LMMAP-managed ETFs is higher on average than that of LMMNAP-managed ETFs.

However, the varying sensitivities of effective spreads to creation and redemption amounts are not necessarily due to the different inventory levels of LMMNAP and LMMAP. The standard market microstructure approach decomposes effective spread into two components: price impact, which is typically associated with adverse selection, and realized spread, which is associated with liquidity provision. Therefore, differing levels of adverse selection risk faced by LMMNAP or LMMAP could also contribute to the differences in effective spreads. Additionally, these differences could be simultaneously driven by both adverse selection risk and inventory risk, leading to incorrect interpretations. To address this concern, we decomposed the effective spreads and reran the interaction term regressions, replacing the dependent variable with price impact or realized spread. We hypothesize that if different inventory levels between LMMNAP and LMMAP are the primary or sole drivers of the differences in effective spreads, we should observe the same or even stronger results in the realized spread regression compared to the price impact regression. Indeed, our results show statistically significant and economically meaningful findings only in the realized spread regressions, further supporting the different purposes of creation and redemption activities between LMMNAP and LMMAP.

Beyond the different purposes of the creation and redemption activities of LMMNAP and LMMAP, we propose an alternative explanation for the differences in effective spreads. When the number of active APs for an ETF increases, it enhances competition among them, thus improving price efficiency (discount/premium) and liquidity (Gorbatikov & Sikorskaya, 2022; Zurowska, 2022). Furthermore, an increase in active APs reduces the creation and redemption uncertainty faced by LMMNAP, given that LMMNAP can approach various APs to create or redeem ETF shares instead of relying on a single monopoly AP. Consequently, different levels of competition or uncertainty (caused by the number of APs) may also lead to differences in effective spreads. To empirically test this hypothesis, we calculated the logarithm of the number of active APs for each ETF to represent the level of competition or uncertainty faced by LMMAP or LMMNAP and reran the interaction regression. Our findings indicate that the effective spread decreases by 2.3197 basis points for every unit increase in the number of active

APs for LMMAP-managed ETFs. However, for LMMNAP-managed ETFs, a change in the number of active APs results in a non-significant decrease in the effective spread of only 0.7051 basis points. Additionally, the interaction term regression results show that the effective spread of LMMAP-managed ETFs is 1.5015 basis points lower than that of LMMNAP-managed ETFs, given the same number of active APs. For ETFs managed by LMMAP, our empirical results align with predictions that more AP participation in creation and redemption activities leads to heightened competition and, consequently, higher liquidity. However, we do not observe the same empirical results for ETFs managed by LMMNAP, suggesting that changes in the number of active APs do not mitigate the uncertainty faced by LMMNAP.

To gain further insight, we examined the spread dynamics of ETFs managed by LMMNAP and LMMAP before, during and after extreme price movements (EPMs). Our trading game suggests that the absence of creation/redemption rights will cause LMMNAP to hold inventory to make a market. As a result, we expect LMMNAP-managed ETFs to have larger spreads than those managed by LMMAP during EPMs, as they require additional compensation to cover increased inventory risk. We use Brogaard et al.'s (2018) methodology to identify EPMs in 2022 and first visualize the change in spreads across EPM states. We then run a regression that interacts with the EPM stage identification variable with the LMM creation/redemption rights identification variable. The results show that both LMMNAP-managed and LMMAP-managed ETF spreads exhibit jumps during EPMs. However, it is notable that the spreads of LMMNAP-managed ETFs jump more violently than those of LMMAP-managed ETFs, which aligns with our expectation that increasing inventory risk causes LMMNAP to widen spreads in pursuit of additional compensation. Furthermore, for small-cap ETFs managed by LMMNAP, spreads begin to show a widening trend even before the EPM occurs. Additionally, we investigate whether the presence or absence of creation/redemption rights leads to different levels of mispricing. While we find statistically significant results indicating that ETFs managed by LMMAP generally exhibit greater mispricing than those managed by LMMNAP, the economic significance of these findings is extremely low. This is primarily because, in addition to LMMs and APs, many intraday arbitrageurs in the ETF market quickly exploit and eliminate mispricing between ETFs and their underlying assets.

The related literature describes the activities of the main functional players in ETF markets. First and most important, APs correct mispricing between ETFs and their underlying securities through intraday or end-of-day

arbitrage. The first approach, intraday arbitrage, can be performed not only by APs but also by other sophisticated traders. The second approach, however, can only be executed by APs through the creation and redemption mechanism. The consequences of these arbitrage activities have been debated in numerous studies. For instance, liquidity shocks inflicted by short-term investors on ETFs can be transmitted to the underlying securities through the arbitrage channel, potentially increasing the non-fundamental volatility of underlying securities (Ben-David et al., 2018). Using ETF flows as an indicator of non-fundamental demand, Brown et al. (2021) found that such demand for ETFs can lead to investor under performance and incur additional costs. On the other hand, using intraday data for all U.S. equity ETFs, Box et al. (2021) found little evidence that ETF trading affects the underlying securities.

In addition to correcting mispricing through creation and redemption activities, APs can strategically create or redeem ETF shares in response to demand shocks or for inventory management purposes. Evans et al. (2019) argue that, given the high transaction costs in the primary market, APs and market makers (MMs) may choose to "operationally short" ETF shares to respond to demand shocks. They assert that such "operational shorting" facilitates liquidity provision without causing significant fail-to-deliver issues. As a result, APs and MMs may avoid engaging in the primary market as long as they can obtain sufficient reverse order flow to cover their short positions. Moussawi et al. (2022) examines the role that options play in ETF arbitrage, highlighting that APs and MMs are skilled at using complex option strategies to establish fully hedged positions during demand shocks in the ETF market. By providing price incentives to establish these hedged positions, APs and MMs can capture arbitrage profits in addition to bid-ask spreads in both securities. Using bond ETFs, Pan and Zeng (2017) show that as the conflict in the dual role of APs increases, inventory management can distort ETF arbitrage and lead to larger mispricing.

Turning to the literature on ETF liquidity, Bae and Kim (2020) examines the impact of ETF liquidity and finds that illiquid ETFs typically have larger tracking errors and are riskier than their underlying portfolios. Focusing on the relationship between ETF fees and liquidity, Khomyn et al. (2024) theoretically and empirically demonstrate that liquidity-seeking investors are willing to pay higher fees for liquidity, even if alternative ETFs are available. To enhance ETF liquidity, most exchanges worldwide have introduced Designated Market Makers (DMMs) or Lead Market Makers (LMMs) in the ETF market. However, Comerton-Forde et al. (2024) found that in the Australian

ETF market, DMMs have withdrawn liquidity due to toxic arbitrage and even consumed liquidity on creation and redemption days. Our paper shows that APs are not the only institutional players in the ETF market. The lead market maker, who is the primary liquidity provider, may or may not be the same entity as the AP. In the latter case, the lead market maker does not have the right to create or redeem ETF shares and thus prefers to hold inventory to make the ETF market. We demonstrate this argument by showing the different sensitivities of the effective spread to the creation and redemption amount in these two cases. Furthermore, we show that only the realized spread component of the effective spread responds to these factors, further supporting the consideration of LMM inventory management.

Gorbatikov and Sikorskaya (2022) provide the first description of the U.S. ETF-AP network using N-CEN filings. They demonstrate that the level of mispricing is negatively related to the fund's network, with this relationship being stronger during periods of high market volatility. Using the same government filings, Zurowska (2022) shows that most U.S. registered ETFs have an oligopolistic primary market structure. She argues that in a highly concentrated ETF primary market, each additional AP can lead to at least a one basis point decrease in mispricing. Focusing solely on ETF LMMs, Hong et al. (2022) argue that intermediaries' capital constraints cause contagion in the pricing efficiency of assets managed by the same intermediary. They empirically demonstrate comovements in ETF premia for ETFs served by the same LMM, with this effect being stronger for more volatile ETFs and those with more capital-constrained LMMs. Our study distinguishes itself from the aforementioned studies by focusing on the networking between APs and LMMs. APs may act as broker-dealers to create or redeem ETF shares for their clients (LMMs) and receive a service fee. Therefore, APs and MMs can be assumed to be the same entity, both providing liquidity and creating/redeeming ETF shares (Evans et al., 2019; Moussawi et al., 2022). However, in practice, it is not necessary for an MM or LMM to be an AP, and an AP is not required to be an exogenous or endogenous liquidity provider in the secondary market (Comerton-Forde & Marta, 2021; Khomyn et al., 2024). For LMMs that do not have primary market participant rights, they face creation/redemption uncertainty. Our results suggest that when this uncertainty is reduced (as measured by the number of active APs), the ETF's liquidity does not improve.

This paper is organized as follows. Section 2 briefly the ETF system and the role played by AP and LMM. Section 3 introduces a simple trading game to highlight the choice of LMM when facing creation/redemption uncertainty,

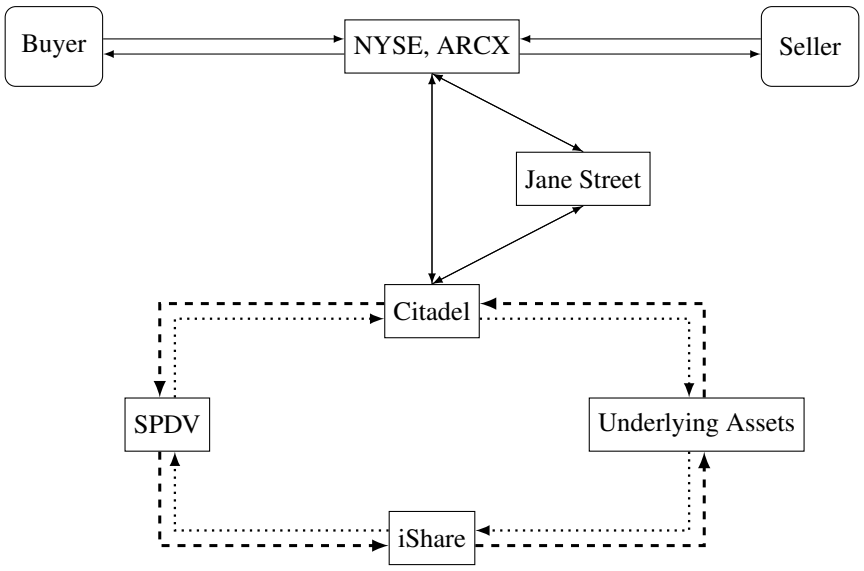

Figure 1: ETF System. This Figure illustrates the ETF system from the ETF issuer to the investor. The lower part of the figure depicts the process of creation (short dotted line clockwise) and redemption (long dotted line counterclockwise) in the primary market for ETFs, as well as the two participants in the process, iShare (the issuer) and Citadel (the authorised participant), respectively. The middle part is the internal market between dealers. This market exists only in some ETFs. The top part is the ETF's secondary market.

and our prediction. Section 4 presents the Data used in this paper, sample construction method, and summary statistics. Section 5 is the empirical results. Section 6 concludes.

2 Institutional Background

The ETF is a basket of securities that are traded intraday and can be created or redeemed based on the net asset value (NAV) after the market closes. In the ETF market, there are typically three primary participants: the ETF issuer, the authorized participant (AP), and the investor, along with an additional key player—the market maker (MM).

2.1 ETF Primary Market and Secondary Market

Figure 1 illustrates the ETF system from the ETF issuer to the investor. In the primary market, there are only two participants: the ETF issuer (e.g., iShares) and the AP (e.g., Citadel). APs deliver underlying securities or ETFs (e.g., SPDV) to the ETF issuer in exchange for ETFs or underlying securities at agreed-upon units and fees. Upon receipt of the ETFs or underlying shares, the AP has two options. One is to deliver the inventory to the

secondary market themselves, acting as a market maker and bearing associated risks such as inventory and information asymmetry. Alternatively, they can deliver the inventory to a specialized market maker (e.g., Jane Street) and let them make the market, at which point the market maker assumes the corresponding risks. Both APs and MMs may hedge their inventory risk, either individually or overall, in the hedge market.

In the most active secondary market, the AP or MM regularly posts and modifies bid and ask prices/volumes in the order book or matches unexecuted orders to provide liquidity. They have an economic incentive to do so, as they can profit from transaction costs and arbitrage between ETFs and underlying assets. In the simplest case, when an ETF trades at a premium or discount, an AP or MM is willing to buy low-value assets, sell high-value assets, and then use the creation/redemption mechanism to manage its inventory position from the primary market, as long as the arbitrage profits exceed the total costs (e.g., transaction costs and creation/redemption fees). However, the Investment Company Institute estimates that $1 of total ETF trading translates into only $0.15 of creation/redemption activity, with the rest being secondary market activity. This is because creation/redemption activity is typically based on the NAV at the end of the trading day, and the fees and units involved are quite high. Evans et al. (2019) point out that a portion of the $0.85 comes from operational shorting. For example, during an extreme buying event in the ETF market, APs or MMs may sell ETF shares to investors that have not yet been created and then create the outstanding ETFs a few days later. This delay allows excess buying to potentially be offset by subsequent selling. On average, operational shorting benefits liquidity provision.

2.2 Authorized Participant and Market Maker

Throughout the analysis of the ETF system, it becomes apparent that APs and MMs play significant roles in inventory delivery. Some ETFs involve entities (e.g. MMs or LMMs) in addition to the AP. Prior studies often either treat the AP as synonymous with the MM or acknowledge the differences but still assume that APs and MMs fulfill the same role.

However, a comment letter from Thomas A. Wittman on Rule 6c-11 of the Investment Company Act of 1940 clarifies the distinction: “There is often confusion around the usage of AP versus market maker. In this comment letter, APs are the firms that are contractually permitted to create and redeem blocks of ETF shares directly with

the ETF issuer. Market makers are firms that are committing capital to provide liquidity directly to ETF investors by buying or selling ETF shares. APs are often, but not necessarily market makers, and market makers are not necessarily APs in the ETFs for which they provide liquidity. Some APs act as an agent to create or redeem ETF shares on behalf of a market maker who is not an AP." The AP is defined in Proposed Rule 6c-11(a) as "a member or participant of a clearing agency registered with the Commission, which has a written agreement with the exchange-traded fund or one of its service providers that allows the authorized participant to place orders for the purchase and redemption of creation units." Moreover, Rule 6c-11 also states, "An authorized participant may act as a principal for its own account when purchasing or redeeming creation units from the ETF. Authorized participants also may act as agents for others, such as market makers, proprietary trading firms, hedge funds, or other institutional investors, and receive fees for processing creation units on their behalf. Market makers, proprietary trading firms, and hedge funds provide additional liquidity to the ETF market through their trading activity." [8]

It is reasonable to believe that there is a cooperative relationship between APs and MMs, meaning that APs will actively create or redeem ETF shares for MMs within a trading day. However, beyond the pre-determined creation and redemption fees, APs may charge MMs additional fees if immediate action is required. Furthermore, if the ETF price is at a discount or premium, the AP may engage in arbitrage activities independently rather than assisting the MM. In both scenarios, MMs face uncertainty regarding creation and redemption and may strategically adjust their market-making methods as a result. In the next section, we formally discuss the considerations and consequences when MMs face such uncertainty through a simple trading game, followed by testable hypotheses.

3 Simple Trading Game

To highlight the impact of creation/redemption rights on LMM, we can consider a simple trading game.

3.1 Multi-Period Trading Game

Suppose there are two identical ETFs, except one's LMM is not an AP, and the other's LMM is also an AP. We refer to the first case as an ETF managed by LMMNAP (LMM not AP) and the second as an ETF managed by

[8] For details, see SEC rule 6c-11: https://www.sec.gov/rules/final/2019/33-10695.pdf

LMMAP (LMM is AP). We assume that both APs and LMMs are risk-averse and profit-seeking agents.

At $t = 0$, when LMMAP receives the ETF inventory, he can hedge the inventory position using the underlying asset or the derivatives market. After establishing his hedge position, he enters the secondary market to maintain both sides of the ETF market and monitors both the ETF and hedging markets. At this point, his costs include establishing the hedging position and being exposed to inventory risk. Alternatively, AP can transfer the ETF inventory to the profit-seeking LMM, thereby shifting all risks and costs to LMMNAP.

Both the ETF and the underlying asset market are traded from $t = 1$ to $t = 2$. The LMMAP submits ETF buy and sell orders based on the ETF's underlying price or the correlated ETF's price. At this point, he can profit from the transaction costs or arbitrage of mispricing between ETF and underlying assets. However, costs and risks include hedging position adjustments, inventory holding risk, and information asymmetry risk. As before, AP can let LMMNAP bear all profits and costs.

At $t = 3$, when LMMAP's or LMMNAP's ETF inventory is close to zero, both expect excess demand in the ETF market. They have two choices. For LMMAP, he can purchase the underlying assets and create ETFs to alleviate the upcoming demand pressure. Alternatively, he can sell the uncreated ETF shares to investors and hedge by buying the underlying assets or entering into derivative contracts. For LMMNAP, she can purchase the underlying assets and approach her AP by paying the creation fee for creating the ETF shares, or she can operationally short the ETF shares to the investor and hedge.

At $t = 4$, as the settlement date approaches, if LMMNAP and LMMAP can receive sufficient reverse order flow to cover the previous short sell amount, they will continue to carry a low inventory position. Alternatively, LMMAP can create ETF shares and deliver them to the previous buyer. As for LMMNAP, she must approach her AP and pay a creation fee to create the ETF shares. However, AP has the right, but not the obligation, to create ETF shares at LMMNAP's request, causing LMMNAP to face creation/redemption uncertainty.

Another possible outcome at $t = 3$ is that when LMMAP's or LMMNAP's ETF inventory is near the upper limit,

both anticipate excessive selling in the ETF market. They can buy all sell orders and retain the inventory for future operational shorting activity or redeem ETF shares at the end of the day.

Overall, operational shorting appears to be a less costly market-making strategy than frequent creation/redemption of ETF shares. However, an important factor for LMMNAPs to consider is how quickly they can unwind their short positions. For example, LMMNAP's AP (agent) may or may not process her creation/redemption orders, introducing uncertainty. Alternatively, she may pay a higher-than-normal creation fee to require the AP to process the creation/redemption order immediately.

3.2 Predictions

This hypothetical trading game suggests that an important consideration for ETF LMMs when making the ETF market is the creation/redemption rights—specifically, whether the AP will create/redeem shares as required by its client (the LMM). If the LMM has the right to create/redeem, they may delay creating ETF shares and wait for reverse order flow (excess selling) to offset outstanding operational short positions. Even if optimal reverse order flow cannot be achieved, the LMM can still create ETF shares and carry any remaining shares as inventory. Conversely, an LMM without creation/redemption rights may be reluctant to engage in short operations due to uncertainty about creation/redemption before the settlement date.

We argue that for LMMs with creation/redemption rights, the primary purpose of creation/redemption is to fulfill outstanding short positions, partially driven by inventory management and mispricing arbitrage. However, for LMMs without these rights, the purpose of creation/redemption is more focused on inventory management, with some consideration for operational shorting and mispricing arbitrage.

Given their different purposes for creation/redemption, we expect liquidity asymmetry in the ETF market. Specifically, for LMMs without creation/redemption rights, we anticipate that the trading costs of these ETFs will increase (decrease) following creation (redemption) activity due to an increase (decrease) in inventory carried by the LMMs, resulting in decreased (increased) liquidity. For LMMs with creation/redemption rights, the increase (decrease) in trading costs after creation (redemption) activity is expected to be lower because the primary purpose

is not inventory management, resulting in a smaller change in liquidity.

Conversely, the trading costs for ETFs managed by LMMs with creation/redemption rights may be higher in the absence of creation/redemption activity because the LMM's operational short-selling activities may incur higher costs, such as establishing a corresponding hedging position. In light of these arguments, we further expect LMMs without creation/redemption rights to widen bid-ask spreads during extreme price movement (EPM) periods, as increased inventory-carrying risk leads to wider spreads that compensate for higher inventory risk.

4 Data, Sample Construction, and Summary Statistics

This section detailed the data used in this study and also the sample construction method and summary statistics.

4.1 Identify ETF's Lead Market Maker and Authorized Participants

Starting in 2019, all U.S.-listed ETFs were required to disclose detailed information on Form N-CEN, covering aspects from ETF style to management structure. Specifically, Item E.2 of Form N-CEN mandates that all ETFs disclose the name of their authorized participants (APs), the Central Registration Depository (CRD) number, the dollar value of creations/redemptions with the ETF's issuer, and other information, even if the AP has not actively created/redeemed ETF shares during that reporting fiscal year. Item E.2 of Form N-CEN provides only the fund ID, so to merge it with other data sources, we used Item E.1—Security Exchange of Form N-CEN—to identify the fund ticker.

Due to these new regulatory filing requirements, some ETFs may need amendments and updates when completing the filing. Consequently, the SEC has made Form N-CEN/A available for updates by ETF managers, resulting in ETFs having multiple records during a reporting period. If an ETF has multiple records during a reporting period, we use the most recent N-CEN/A Form as the final version to identify the ETF's AP list. This data selection method is also used by Gorbatikov and Sikorskaya (2022) and Zurowska (2022). We downloaded all Forms N-CEN and N-CEN/A for the years 2019 to 2022 from the SEC website[9]. After dropping duplicate records, we

[9] Data is available at: https://www.sec.gov/dera/data/form-ncen-data-sets.

identified the full AP list for 3,576 ETFs.

To identify another important player, the Lead Market Maker (LMM) in the ETF market, we utilized the LMM name provided by the ETF Global data set[10]. According to the NYSE Arca Lead Market Maker program description, this program is designed to provide superior liquidity for exchange-traded products (ETPs) listed on NYSE Arca. To become an LMM, a broker-dealer must first register as a market maker with NYSE Arca and then submit an application to become an LMM. NYSE Arca reviews whether an applicant meets the qualifications to be an LMM based on market-making experience, capital adequacy, operational capabilities, and ETF issuer preferences, among other factors. An LMM has an ongoing quoting obligation, such as providing two-sided quotes. In addition, LMMs must meet the minimum performance requirements for major listed ETPs based on various statistical indicators. In return, the exchange provides a rebate for the liquidity provided by the LMM, while penalties are applied if the LMM removes liquidity[11].

After collecting a list of all the APs for each ETF as well as the LMMs, we used both to determine whether the LMM of each ETF is also an AP. If the LMM is an AP, we label it as LMMAP; conversely, if the LMM is not an AP, we label it as LMMNAP. The former implies that the LMM of the ETF has the right to create/redeem ETF shares in the ETF's primary market, while the latter implies that the ETF's LMM does not have that right. As Gorbatikov and Sikorskaya (2022) point out, the APs recorded on N-CEN forms are based on separate legal entities, such as subsidiaries, which could cause our identification strategy to misidentify an LMMAP as an LMMNAP. For example, an LMM recorded in the ETF Global dataset may represent the market maker desk or a subsidiary of a trading firm, whereas the APs recorded on N-CEN forms may refer to the clearing desks or another subsidiary of that trading firm. Therefore, when the market maker's desk (LMM) wants to create and redeem ETF shares, they can approach the clearing desk (AP) to do so. In this case, the previous identification strategy may incorrectly identify an LMMAP as an LMMNAP, leading to incorrect empirical results. To avoid misidentification, we aggregated all APs and LMMs to the parent company level before performing the identification.

[10] ETF Global collects LMM name directly from exchanges and ETF issuers. However, sometimes LMM name is missing. The missing LMM name is reasonable for newly established ETFs because it takes some time for the MM application to become the LMM for those ETFs. We removed those earlier observations in a subsequent data cleaning procedure. Also some ETFs' LMMs change, which can lead to missing LMM name. To ensure the accuracy of the results we also removed the observations with missing LMM name that were due to LMM changes.

[11] Full description of NYSE Arca Lead Market Maker Program can be found at: https://www.nyse.com/publicdocs/nyse/markets/liquidity-programs/arca_lmm_fact_sheet.pdf.

After correctly identifying whether an ETF is managed by LMMAP or LMMNAP, we used the *region*, *asset_class*, *is_levered* and *is_active* fields in the ETF Global dataset to further select sample ETFs. We successfully identified 3,485 ETFs, of which 1,906 were U.S. ETFs. ETFs focused outside the U.S. were excluded from this study due to the different trading hours of non-U.S. ETFs versus their underlying assets, which may affect ETF liquidity. Of those 1,906 U.S. ETFs, we only retained ETFs where the asset class was equities (1,324 ETFs). The different nature of the ETFs and their underlying assets can lead to liquidity mismatches, which is another important factor that LMMs or APs need to consider when making the ETF market (Pan & Zeng, 2017)[12]. In addition, we also excluded leveraged and active ETFs because the liquidity of these ETFs may be driven by the derivatives they use and their management style (Baltussen et al., 2021; Barbon et al., 2022).

4.2 ETF's Liquidity Measure, and Sample Construction

The daily closing prices of ETFs were obtained from the Center for Research in Security Prices (CRSP). To be included in the sample, an ETF must have a closing price above $5 and below $1,000 at the beginning of the month, a market capitalization above $100 million, and at least 100 days of prior trading. We used the Daily TAQ CRSP Link file provided by WRDS to match a TAQ Trading Symbol to a CRSP CUSIP[13]. ETFs that could not be matched were excluded. Observations without a single valid TAQ trade on a given day were also excluded from the sample.

To compute ETF liquidity measures, we used the WRDS TAQ Consolidated Trades and Complete NBBO files, where the timestamp is in nanoseconds[14]. To mitigate the impact of opening and closing periods, all trades and quotes within five minutes after the opening and before the closing are excluded from all liquidity measure calculations. Consistent with Bogousslavsky and Collin-Dufresne (2023), we use the percent effective spread as

[12] Pan and Zeng (2017) study U.S. bond ETFs and argue that liquidity mismatches in the bond ETF market have different impacts on the bond ETF's mispricing under different AP's inventory levels. Furthermore, they pointed out that there was no liquidity mismatch in the equity ETF market.

[13] Since the sample period for this study begins in 2019 and WRDS states that using CUSIP-based matching for data from 2010 onwards will improve the quality of the match. Therefore, we primarily use the CUSIP-based matching method. When CUSIP-based matching fails, we supplement it with Ticker and/or share class matching methods (Level 1 and 2). WRDS Daily TAQ CRSP Link methodology can be found at: https://wrds-www.wharton.upenn.edu/documents/1336/NYSE_Daily_TAQ_to_CRSP_Linking_BPNFjWm.pdf.

[14] We also checked trades and quotes by using the filters suggested by Holden and Jacobsen (2014).

the liquidity measure, which is calculated as follows:

$$ES_{i,t} = 2|\ln P_{i,t} - \ln M_{i,t}|,$$

where $P_{i,t}$ is the trade price and $M_{i,t}$ is the midpoint of the best bid and offer before the trade. To get a daily liquidity measure we aggregate the intraday percentage effective spreads by dollar-volume weight. In addition, to exclude the effects of volume and volatility, we calculate the daily intraday turnover and the realized volatility of one-minute midquote returns. Daily intraday turnover is further scaled by shares outstanding to compare across ETFs. The daily percent effective spread is further decomposed into price impact and realized spread as follows:

$$RS_{i,t} = 2D_{i,t}(\ln M_{i,t+5} - \ln M_{i,t}),$$

$$PI_{i,t} = 2D_{i,t}(\ln P_{i,t} - \ln M_{i,t+5}),$$

where $D_{i,t}$ is the trade direction, identified using the Lee and Ready (1991) algorithm. In detail, we use the last NBBO midpoint quote before each trade in the quote rule to classify the trade direction. If the quote rule fails we compare the current trade price to the price of up to three previous trades to classify the trade direction. $M_{i,t+5}$ is the five-minute NBBO midpoint quote after the trade.

Despite MMs' contractual obligation to continuously provide liquidity, they may withdraw liquidity when several stocks experience EPMs (Bellia et al., 2023; Brogaard et al., 2018). Similarly, ETF-designated MMs also withdraw liquidity when faced with high adverse selection risk posed by ETF arbitrageurs (Comerton-Forde et al., 2024). To further highlight the effects of primary market participation rights, we utilized the EPM identification method proposed by Brogaard et al. (2018) to identify EPMs in 2022 from the sample[15]. We first computed the midpoint quote returns for one-minute intervals. Then, we labeled all intervals with a midpoint return in the 0.01th or 99.9th percentile as negative or positive EPMs, respectively. To minimize the impact of overlapping EPMs on the empirical results, we retained only the first EPM within any ten-minute window. As a result, 39,444 EPMs were used in the empirical analysis, of which 22,236 were positive EPMs and 17,208 were negative EPMs. Meanwhile, small and medium ETFs trade rather infrequently, and there are usually insufficient observations to draw statistically robust conclusions at the intraday level. Therefore, we used the one-minute time-weighted percent

[15] Due to the computational constrain the intraday sample period is between Jan 2022 to Dec 2022 only.

quoted spread as the intraday liquidity measure[16].

4.3 Other Data and Summary Statistics

The ETF's primary market structure is an important factor affecting its liquidity. Compared to a single monopoly AP, increasing the number of active APs implies increased competition, which in turn improves liquidity(Gorbatikov & Sikorskaya, 2022). Additionally, for LMMs that do not have primary market participation rights, having more available APs makes creation/redemption less difficult. Therefore, we calculate the logarithm of the number of active APs in a given reporting year to represent the ETF's primary market structure. We also obtained the ETF's daily net asset value, shares outstanding, age, creation fee, creation size, and expense ratio from the ETF Global dataset. These variables are used to calculate the ETF's daily discount/premium, net creation/redemption amount, and other control variables. Various studies have shown that CRSP and Compustat delay updating the shares outstanding amount, which may result in the net creation and redemption amounts calculated using these two databases being several days before, leading to incorrect conclusions (Ben-David et al., 2018; Evans et al., 2019). However, the data provided by ETF Global is obtained directly from ETF issuers, custodians, administrators, and exchanges at the end of each trading day and is updated without any lag[17].

Table 1 details the summary statistics of the main variables in this study. Overall, the realized spreads of the sample ETFs account for a significant portion of the effective spreads, implying that market makers face a low risk of adverse selection in providing liquidity. This fact still holds when we separate the full sample based on LMMAP/LMMNAP. In addition, Panels B and C show that ETFs managed by LMMAP or LMMNAP share the same characteristics, such as the number of active APs ($e^{1.970} = 7.17$ and $e^{1.898} = 6.67$), creation size and fees, and expense ratios. While we select only U.S. equity ETFs for our sample, these ETFs still fall into different categories (e.g., size and style), which could lead to a concentration of LMMAP or LMMNAP in particular categories. As a result, liquidity differences might be driven by the ETFs' size, sector, and style effects. However, in our sample, LMMAPs and LMMNAPs are broadly distributed across categories, which alleviates these concerns.

[16] We split the 2022's intraday sample at the beginning of each month into small, medium and large samples based on the daily market capitalization of the previous 252 trading days.

[17] Upon receipt of the data ETF Global records the date the data was received (i.e., the trade date, which is recorded as as_of_date in ETF Global) and the date it was reported (which is recorded as $etfg\_date$ in ETF Global). In detail, most ETF issuers provide data to ETF Global with a one-day lag, i.e. $etfg\_date$ is equal to as_of_date. Hence, shares added at time t-1 will be updated to ETF Global at time t, and shares outstanding at time t will reflect the increase/decrease in shares outstanding. We cross checked three ETF shares outstanding amounts provided by ETF Global, Bloomberg, and ishare and confirmed the ETF Global data reliability.

Table 1: Summary Statistics

Variables	N	Mean	Std Dev	p1	p99
Panel A: Full Sample					
Num of Active AP	502,053	1.932	0.525	0.693	3.045
DVPES	502,053	8.794	10.907	0.749	53.855
Realized Vol	502,053	0.972	0.668	0.208	3.705
Turnover	502,053	1.118	2.603	0.003	15.040
C/R Amount	502,053	0.032	1.297	-4.545	5.000
abs(C/R Amount)	502,053	0.408	1.633	0.000	9.091
DVPIP	501,558	1.761	10.381	-29.752	39.701
DVRS	501,558	7.106	14.214	-22.751	62.733
Age	502,053	8.022	0.724	6.084	9.017
Creation Size	500,036	10.711	0.351	9.210	11.513
Creation Fee	501,641	6.344	0.648	5.298	8.006
Expenses Ratio	502,053	0.304	0.179	0.030	0.668
Panel B: LMMAP					
Num of Active AP	238,500	1.970	0.503	0.693	3.045
DVPES	238,500	8.688	10.817	0.793	54.231
Realized Vol	238,500	0.977	0.680	0.197	3.776
Turnover	238,500	1.192	2.636	0.004	14.944
C/R Amount	238,500	0.027	1.305	-4.659	4.940
abs(C/R Amount)	238,500	0.417	1.602	0.000	8.696
DVPIP	238,337	2.047	10.739	-29.752	43.659
DVRS	238,337	6.707	13.996	-23.038	62.034
Age	238,500	7.992	0.656	6.238	9.068
Creation Size	237,892	10.687	0.360	9.210	11.513
Creation Fee	238,500	6.343	0.633	5.298	8.006
Expenses Ratio	238,500	0.296	0.172	0.039	0.806
Panel C: LMMNAP					
Num of Active AP	263,553	1.898	0.542	0.693	3.045
DVPES	263,553	8.890	10.987	0.705	53.383
Realized Vol	263,553	0.967	0.657	0.227	3.632
Turnover	263,553	1.052	2.571	0.003	15.182
C/R Amount	263,553	0.038	1.290	-4.348	5.094
abs(C/R Amount)	263,553	0.399	1.661	0.000	9.677
DVPIP	263,221	1.502	10.039	-29.752	38.085
DVRS	263,221	7.468	14.398	-20.970	63.285
Age	263,553	8.050	0.780	5.971	8.999
Creation Size	262,144	10.732	0.342	9.210	10.820
Creation Fee	263,141	6.345	0.662	5.521	8.006
Expenses Ratio	263,553	0.310	0.184	0.030	0.668

This Table reports the summary statistics of the main variables in this study. Panel A is for the full sample, Panel B is for ETFs managed by LMMAP (Lead Market Maker and Authorized Participant), and Panel C is for ETFs managed by LMMNAP (Lead Market Maker, not the Authorized Participant). Num of Active AP is the logarithm number of active Authorized Participants during a year, DVPES is the daily dollar-volume weighted percentage effective spread, Realized Vol is the realized volatility of one-minute midquote returns, Turnover is the daily intraday turnover scaled by shares outstanding. C/R Amount is the daily net created or redeemed shares scaled by shares outstanding, abs(C/R Amount) is the absolute value of C/R Amount, DVPIP is the daily dollar-volume weighted percentage price impact, DVRS is the daily dollar-volume weighted percentage realized spread, Age is the ETF logarithm of ETF age in days, Creation Size and fee is the logarithm of creation size and fee, and Expenses Ratio is the logarithm of ETF's net expense ratio. Sample period from 01 Jan 2019 to 31 Dec 2022. All variables detailed definitions and calculation methods can be found in Appendix.

5 Empirical Results

5.1 Creation/Redemption Rights and Liquidity

Do the creation/redemption rights of ETF LMMs really matter for liquidity? To answer this question, we examine the impact of this rights on liquidity by using the daily dollar volume-weighted average percentage effective spread (*DVPES*) as a liquidity proxy. Specifically, we estimate the following regression:

$$DVPES_{it} = \alpha_{it} + \beta_1 \times LMM\ C/R\ Right_{it} + \delta \times \mathbf{Z}_{it} + Controls_{it} + Fixed\ Effects_{it} + \varepsilon_{it} \tag{1}$$

The main variable of interest is *LMM C/R Right*, a dummy variable equal to 1 if the ETF's LMM is an AP (LMMAP) and 0 if the ETF's LMM is not an AP (LMMNAP). The estimated coefficients on this variable can answer whether LMM creation/redemption rights affect the ETF's overall liquidity. We have also modified the regression equation by adding several explanatory variables to standout the impact of *LMM C/R Right* in general. As we showed in the trading game, the creation/redemption activities conducted by different types of LMMs may have different effects on liquidity. Therefore, we include the percentage change in ETF shares outstanding (C/R Amount$_t$), the absolute value of the percentage change in ETF shares outstanding (abs(C/R Amount)$_t$), or the positive (Create Amount$_t$) and negative (Redeem Amount$_t$) components of the percentage change in ETF shares outstanding in the regression. Additionally, the degree of competition among APs in the primary market also affects ETF liquidity. A larger number of APs in an ETF compared to a single monopoly AP increases competition and thus liquidity. To capture this effect, we added the logarithm of the number of active APs (Num of Active AP) to the regression. We also control for contemporaneous realized volatility (Realized Vol$_t$), intraday turnover (Turnover$_t$), the previous trading day's closing price (P$_{t-1}$) and market capitalization (Mcap$_{t-1}$), and include ETF fixed effect.

Table 2 details the regression results. Across models (1) to (5), the estimated coefficient of *LMM C/R Right* remains positive and stable, regardless of the inclusion of other explanatory variables. The positive effect suggests that, on average, the *DVPES* of ETFs managed by LMMAP is roughly 0.8 basis points higher compared to ETFs managed by LMMNAP. More importantly, the highly significant additional explanatory variables in models (3)

to (5) emphasize the importance of creation/redemption amounts and AP competition. Specifically, the estimated coefficient on abs(C/R Amount)$_t$ implies that a 1% change in shares outstanding results in a 0.0788 basis point change in $DVPES$. Although this effect is small, it is crucial to understand that creation typically implies an increase in inventory, while redemption implies a decrease, leading to different impacts on liquidity. Therefore, it is necessary to examine the effects of these two primary market activities on secondary market liquidity separately. When the amounts of creation and redemption are split, the magnitude of the estimated coefficients increases to 0.1046 for Create Amount$_t$ and -0.1311 for Redeem Amount$_t$. Additionally, liquidity increases by 1.5378 basis points with each additional Num of Active AP unit.

Overall, the findings suggest that the availability of creation/redemption rights for LMMs can lead to significant changes in liquidity. However, what are the intrinsic mechanisms of this right that lead to liquidity differences? Intuitively, creation/redemption rights imply that the entity holding the right (AP) can create/redeem ETF shares in the primary market, resulting in changes to inventory positions. Typically, changes in inventory also introduce changes in hedging costs and inventory risk, which in turn affect transaction costs and liquidity. As discussed in Section I, the AP can assist the LMM in creating/redeeming ETF shares by charging a fee. In a frictionless market, LMMs can use this feature to manage their inventories, regardless of whether they possess this right. However, the empirical results in Table 2 suggest that, on average, investors face worse liquidity (higher transaction costs) when trading ETFs managed by LMMAPs. To fully understand the mechanisms through which creation/redemption rights affect liquidity, we will examine the drivers of liquidity differences in the next section.

5.2 Drivers of Liquidity Difference

The section sheds light on the driver of liquidity differences caused by creation and redemption rights.

5.2.1 Purpose of Creation and Redemption

What drives the liquidity difference between ETFs managed by LMMNAP and LMMAP? Unlike equities, which have a relatively consistent number of shares outstanding, ETFs experience dramatic changes in shares outstanding due to APs' primary market activities, leading to changes in dealers' inventory positions. Additionally, our trading game suggests that LMMNAP and LMMAP may have different purposes for creation/redemption due to

Table 2: The Effect of ETF Lead Market Maker Creation and Redemption Rights on Liquidity

Dependent Variable:	Intraday Dollar Volume Weighted Average Effective Spread				
	(1)	(2)	(3)	(4)	(5)
LMM C/R Right$_{it}$	0.8033***	0.8030***	0.8042***	0.8040***	0.9242***
	(2.74)	(2.73)	(2.74)	(2.74)	(3.11)
C/R Amount$_{it}$		-0.0073			
		(-0.60)			
abs(C/R Amount)$_{it}$			0.0788***		
			(4.53)		
Create Amount$_{it}$				0.1046***	
				(4.03)	
Redeem Amount$_{it}$				-0.1311***	
				(-5.43)	
Num of Active AP$_{it}$					-1.5378***
					(-3.75)
Realized Vol$_{it}$	5.3930***	5.3928***	5.3963***	5.3950***	5.3995***
	(10.24)	(10.25)	(10.26)	(10.26)	(10.24)
Turnover$_{it}$	0.2555***	0.2557***	0.2369***	0.2339***	0.2595***
	(4.39)	(4.39)	(4.02)	(3.98)	(4.44)
P$_{i,t-1}$	-1.6256***	-1.6243***	-1.6284***	-1.6243***	-1.6778***
	(-3.60)	(-3.60)	(-3.61)	(-3.60)	(-3.71)
Mcap$_{i,t-1}$	-2.0859***	-2.0864***	-2.0896***	-2.0921***	-1.8740***
	(-9.66)	(-9.65)	(-9.67)	(-9.68)	(-8.71)
Constant	50.9063***	50.9108***	50.9767***	51.0052***	49.8097***
	(13.33)	(13.32)	(13.35)	(13.35)	(13.23)
Observations	501,353	501,353	501,353	501,353	501,353
Adj R^2	0.517	0.517	0.517	0.517	0.517
ETF FE	YES	YES	YES	YES	YES

This table reports the effect of ETF LMM creation/redemption rights on liquidity. The dependent variable is the ETF's daily dollar volume-weighted percentage effective spread (*DVPES*). The main independent variable is the ETF's LMM creation and redemption right (LMM C/R Right$_{it}$), which is equal to 1 if the ETF's LMM has creation and redemption rights (LMMAP) and 0 if it does not have such rights (LMMNAP). The control variables include the percentage change in ETF shares outstanding (C/R Amount$_t$), the absolute value of the percentage change in ETF shares outstanding (abs(C/R Amount)$_t$), the positive (Create Amount$_t$) and negative (Redeem Amount$_t$) components of the percentage change in ETF shares outstanding, the logarithm of the number of active APs (Num of Active AP), realized volatility (Realized Vol$_t$) computed using one-minute mid-quote returns, and intraday turnover (Turnover$_t$), which is TAQ intraday trading volume scaled by the total shares outstanding. Additionally, the previous trading day's closing price (P$_{t-1}$) and market capitalization (Mcap$_{t-1}$) are included. All intraday statistics exclude the five minutes after market opening and the five minutes before closing. Except for the dummy variables, all variables are winsorized at the 0.5% and 99.5% percentile each year. Standard errors are double-clustered by date and ETF, and an ETF fixed effect is included in the regression. The sample period is from January 2019 to December 2022.

Figure 2: ETF Share Creation and Redemption

the availability of these rights, resulting in varying levels of inventory position changes. Therefore, we directly test the effect of creation/redemption rights on liquidity following the primary market activities.

To empirically test the hypothesis proposed in the trading game, actual inventory positions of ETF market participants are required. However, these data are proprietary and difficult to obtain. To address this limitation, we use the change in shares outstanding at the end of each day as a proxy for dealers' net inventory position changes resulting from creation/redemption activities. Specifically, since creation/redemption activities occur at the end of each trading day based on the NAV, the change in shares outstanding from t-1 to t represents the change in net inventory position due to these activities. Thus, as shown in Figure 2, the change in shares outstanding at time t reflects the change in the inventory positions of LMMAP and LMMNAP.

We first run regressions on two subsamples split by LMM C/R Right$_{it}$. In both sets of regressions, the estimated coefficients on creation and redemption amounts measure the sensitivity of liquidity to inventory changes. Ideally, β_{11} should be close to β_{21}, and β_{21} should be close to β_{22}. This would indicate that the availability of creation/redemption rights does not result in different purposes for primary market activities, and thus does not lead to different inventory levels.

$$DVPES_{it} = \alpha_{it} + \beta_{11} \times Create\ Amount_{it} + \beta_{12} \times Redeem\ Amount_{it} + Controls_{it} + Fixed\ Effects_{it} + \varepsilon_{it} \quad (2)$$

$$DVPES_{it} = \alpha_{it} + \beta_{21} \times Create\ Amount_{it} + \beta_{22} \times Redeem\ Amount_{it} + Controls_{it} + Fixed\ Effects_{it} + \varepsilon_{it} \quad (3)$$

Surprisingly, the results in Table 3, columns 1 and 3, show that the liquidity of ETFs managed by LMMNAP is more sensitive to the size of creation or redemption (0.1300 and -0.1960) compared to ETFs managed by LMMAP. Moreover, these results still hold, and are even stronger, when we control for discounts/premiums and liquidity mismatches from the previous trading day. These findings suggest that higher sensitivities indicate inconsistencies

in inventories between LMMNAP and LMMAP following the creation and redemption of ETF shares. This results in different levels of inventory risk and hedging costs for LMMNAP or LMMAP and therefore different levels of adjustment strategies for the effective spread.

To further support this argument, we reran the baseline regression on the sample, introducing an interaction term between LMM C/R Right$_{it}$ and the creation and redemption amounts. The estimated coefficient on this interaction term (β_4 and β_5) describes the effect of the availability of creation and redemption rights on ETF liquidity, given the same creation and redemption amounts.

$$\begin{aligned} DVPES_{it} = {} & \alpha_{it} + \beta_1 \times Create\ Amount_{it} + \beta_2 \times Redeem\ Amount_{it} + \beta_3 \times LMM\ C/R\ Right_{it} \\ & + \beta_4 \times Create\ Amount_{it} \times LMM\ C/R\ Right_{it} + \beta_5 \times Redeem\ Amount_{it} \times LMM\ C/R\ Right_{it} \\ & + Controls + Fixed\ Effects + \varepsilon_{it} \end{aligned} \tag{4}$$

The statistically significant coefficients of the interaction terms (β_4 and β_5) in column 6 indicate that the availability of creation and redemption rights results in a liquidity difference of 0.1018 basis points and 0.1765 basis points for the same amount of creations or redemptions, respectively. In other words, if the LMM cannot (can) participate in the ETF primary market, ETF liquidity would decrease by 0.1676 basis points (0.0658 basis points) as 1% of ETF shares are created. Conversely, if the LMM cannot (can) participate in the ETF primary market, ETF liquidity would increase by 0.2124 basis points (0.0359 basis points) as 1% of ETF shares are redeemed.

In these specifications, we highlight the liquidity asymmetry arising from the different purposes of creation/redemption activities. One point to note, however, is that the results in Table 3 are the opposite of those in Table 2. This contrast underscores the importance of the availability of LMMs' creation/redemption rights for liquidity.

The significant liquidity difference when LMMNAP or LMMAP receives or delivers ETF shares suggests that their inventory positions are not aligned. As highlighted in the trading game, the ability of LMMs to participate in the primary market determines the purpose of creation/redemption. Access to the primary market is straightforward for LMMAPs. Simultaneously, "naked short selling" for market-making purposes is permitted. Given the higher transaction costs in the primary market, they prefer to operationally short sell ETF shares that have

not yet been created to investors when facing demand pressure, then wait for the reverse order flow to cover their short positions. However, LMMNAPs are concerned about the uncertainty of creation/redemption. Therefore, they prefer to hold a certain percentage of ETF inventory for market making, but that does not mean they do not engage in operational short selling.

Table 3: The Purpose of Create and Redeem ETF Shares

Dependent Variable:	Intraday Dollar Volume Weighted Average Effective Spread					
	(1) LMMNAP	(2) LMMAP	(3) LMMNAP	(4) LMMAP	(5) All	(6) All
Create Amount$_{it}$	0.1300***	0.0790**	0.1517***	0.0852**	0.1595***	0.1676***
	(3.31)	(2.48)	(3.94)	(2.46)	(4.01)	(4.14)
Redeem Amount$_{it}$	-0.1960***	-0.0652**	-0.1929***	-0.0522*	-0.2252***	-0.2124***
	(-5.26)	(-2.31)	(-5.33)	(-1.71)	(-5.84)	(-5.70)
LMM C/R Right$_{it}$ × Create Amount$_{it}$					-0.1147**	-0.1018*
					(-2.06)	(-1.77)
Redeem Amount$_{it}$					0.1897***	0.1765***
					(3.71)	(3.52)
LMM C/R Right$_{it}$					0.8558***	0.8267***
					(2.91)	(2.69)
Realized Vol$_{it}$	5.6184***	5.2089***	5.5727***	5.5132***	5.3951***	5.5218***
	(9.46)	(10.30)	(10.53)	(11.39)	(10.26)	(11.38)
Turnover$_{it}$	0.3115***	0.1543**	0.2632***	0.1626**	0.2346***	0.2110***
	(3.60)	(2.10)	(3.04)	(2.06)	(4.00)	(3.53)
P$_{i,t-1}$	-1.3582**	-1.9852***	-1.6463***	-1.6808***	-1.6243***	-1.6206***
	(-2.29)	(-3.04)	(-3.56)	(-2.69)	(-3.60)	(-4.13)
Mcap$_{i,t-1}$	-2.2014***	-1.8127***	-1.4822***	-1.2575***	-2.0915***	-1.4843***
	(-7.07)	(-5.98)	(-4.96)	(-4.76)	(-9.68)	(-7.48)
Liquidity Mismatch$_{i,t-1}$			-26.5639***	-27.8753***		-26.9903***
			(-8.95)	(-8.96)		(-11.09)
Discount/Premium$_{i,t-1}$			-0.6555	-0.9768		-0.8639
			(-0.56)	(-1.09)		(-0.92)
Constant	52.2215***	47.4844***	40.2642***	36.0848***	50.9675***	39.8934***
	(9.53)	(8.50)	(7.57)	(7.62)	(13.35)	(11.44)
Observations	263,182	238,171	236,088	205,500	501,353	441,588
Adjusted R-squared	0.519	0.522	0.544	0.539	0.517	0.539
ETF FE	YES	YES	YES	YES	YES	YES

The dependent variable is the ETF's daily dollar volume-weighted percentage effective spread (*DVPES*). The main independent variable is the ETF's LMM creation and redemption right (LMM C/R Right$_{it}$), which is equal to 1 if the ETF's LMM has creation and redemption rights (LMMAP) and 0 if it does not have such rights (LMMNAP). C/R Amount$_t$ is percentage change in ETF shares outstanding, Create Amount$_t$ and Redeem Amount$_t$ is the positive and negative components of the percentage change in ETF shares outstanding. The control variables include realized volatility (Realized Vol$_t$) computed using one-minute mid-quote returns, and intraday turnover (Turnover$_t$), which is TAQ intraday trading volume scaled by the total shares outstanding. Additionally, the previous trading day's closing price (P$_{t-1}$), market capitalization (Mcap$_{t-1}$), liquidity mismatch between ETF and the underlying assets (Liquidity Mismatch$_{t-1}$), and discount/premium (Discount/Premium$_{t-1}$) are included. All intraday statistics exclude the five minutes after market opening and the five minutes before closing. Except for the dummy variables, all variables are winsorized at the 0.5% and 99.5% percentile each year. Standard errors are double-clustered by date and ETF, and an ETF fixed effect is included in the regression. The sample period is from January 2019 to December 2022.

Both operational short selling and holding inventory for market making incur hedging costs. For market makers who primarily use operational short selling (LMMAPs), reverse order flow is uncertain. They are likely to hold relatively large short positions and may be forced to create ETF shares. At this point, hedging costs cannot be ignored, which is why ETFs managed by LMMAPs are more expensive to trade when ETF shares are not created or redeemed.

Turning to the creation date, LMMAPs may find that reverse order flow is insufficient to cover their previous operational short positions. Therefore, a portion of the ETF shares they create is used to cover these positions, while the remaining shares are retained for future market making. Given the small inventory holdings, liquidity is not sensitive to the per-unit creation. In contrast, LMMNAPs create ETF shares primarily due to insufficient inventory. After receiving the created ETF shares from their AP, they face increased inventory risk and seek compensation by widening the bid-ask spread. At this time, liquidity is very sensitive to the per-unit creation.

This argument also applies to the redemption date. Liquidity is not sensitive to per-unit redemptions of ETF shares by LMMAPs because their inventory position is not as high as that of LMMNAPs. For LMMs that hold inventory to make a market (LMMNAPs), the continued accumulation of ETF inventory exposes them to higher inventory risk. Therefore, redeeming per unit of ETF shares reduces their inventory risk, resulting in a tighter bid-ask spread and improved liquidity.

5.2.2 Primary Market Competition and Difficulty of LMM Creation and Redemption

With the introduction of Form N-CEN, several studies have shown that additional APs can help improve the efficiency of the ETF secondary market (Gorbatikov & Sikorskaya, 2022; Zurowska, 2022). However, despite the relatively large number of APs in the ETF primary market, the number of APs actively creating and redeeming ETF shares remains low.

The results of these studies suggest that ETFs still face imperfect competition in the primary market. For ETFs managed by LMMAPs, more active APs imply increased competition intensity in both the primary and secondary markets. As the number of active APs increases, we expect liquidity to benefit from this heightened competitive intensity. However, for ETFs managed by LMMNAPs, since those LMMs do not have creation and redemption rights, more active APs mean that it becomes easier for LMMs to create and redeem shares. If an increase in the number of active APs allows LMMNAPs to create and redeem ETF shares without restrictions, the previously observed difference in liquidity due to the availability of primary market participation rights will diminish as the number of active APs rises.

Table 4: Primary Market Competition and Difficulty of Creation and Redemption.

Dependent Variable:	Intraday Dollar Volume Weighted Average Effective Spread					
	(1) LMMNAP	(2) LMMAP	(3) LMMNAP	(4) LMMAP	(5) All	(6) All
Num of Active AP_{it}	-1.0142*	-2.2380***	-0.7051	-2.3197***	-1.0677**	-0.8327**
	(-1.75)	(-3.60)	(-1.35)	(-4.36)	(-2.39)	(-2.03)
LMM C/R $Right_{it}$ × Num of Active AP_{it}					-1.2071**	-1.5015***
					(-2.13)	(-2.78)
LMM C/R $Right_{it}$					3.2333***	3.6773***
					(2.63)	(3.24)
Realized Vol_{it}	5.6226***	5.2167***	5.5746***	5.5134***	5.4011***	5.5259***
	(9.44)	(10.30)	(10.51)	(11.36)	(10.24)	(11.36)
$Turnover_{it}$	0.3403***	0.1772**	0.2953***	0.1874**	0.2608***	0.2399***
	(3.93)	(2.46)	(3.36)	(2.44)	(4.47)	(4.01)
$P_{i,t-1}$	-1.3775**	-2.0809***	-1.6582***	-1.8186***	-1.6805***	-1.6960***
	(-2.31)	(-3.25)	(-3.58)	(-2.90)	(-3.73)	(-4.32)
$Mcap_{i,t-1}$	-2.0894***	-1.4788***	-1.4017***	-0.8923***	-1.8417***	-1.2299***
	(-6.89)	(-5.08)	(-4.82)	(-3.41)	(-8.56)	(-6.13)
Liquidity $Mismatch_{i,t-1}$			-26.5248***	-27.8364***		-26.9539***
			(-8.96)	(-9.04)		(-11.15)
Discount/$Premium_{i,t-1}$			-0.6452	-0.9348		-0.8375
			(-0.55)	(-1.06)		(-0.89)
Constant	52.0252***	45.6111***	40.0667***	33.8387***	48.2996***	36.7618***
	(9.58)	(8.65)	(7.58)	(7.62)	(12.76)	(10.38)
Observations	263,182	238,171	236,088	205,500	501,353	441,588
Adjusted R^2	0.519	0.523	0.543	0.540	0.518	0.539
ETF FE	YES	YES	YES	YES	YES	YES

The dependent variable is the ETF's daily dollar volume-weighted percentage effective spread (*DVPES*). The main independent variable is the ETF's LMM creation and redemption right (LMM C/R $Right_{it}$), which is equal to 1 if the ETF's LMM has creation and redemption rights (LMMAP) and 0 if it does not have such rights (LMMNAP), and the logarithm of the number of active APs (Num of Active AP). The control variables include realized volatility (Realized Vol_t) computed using one-minute mid-quote returns, and intraday turnover ($Turnover_t$), which is TAQ intraday trading volume scaled by the total shares outstanding. Additionally, the previous trading day's closing price (P_{t-1}), market capitalization ($Mcap_{t-1}$), liquidity mismatch between ETF and the underlying assets (Liquidity $Mismatch_{t-1}$), and discount/premium (Discount/$Premium_{t-1}$) are included. All intraday statistics exclude the five minutes after market opening and the five minutes before closing. Except for the dummy variables, all variables are winsorized at the 0.5% and 99.5% percentile each year. Standard errors are double-clustered by date and ETF, and an ETF fixed effect is included in the regression. The sample period is from January 2019 to December 2022.

Same as Eq 2, 3, and 4, we replace the creation and redemption amounts with the logarithm of the number of active APs in a given year to test the above hypothesis. Table 4 presents the regression results.

For ETFs managed by LMMAPs, a one-unit increase in active APs improves liquidity by 2.2380 basis points, and the inclusion of additional control variables does not change the significance or meaning of the results. However, for ETFs managed by LMMNAPs, a one-unit increase in active APs leads to a negligible change in liquidity, and this effect changes from marginally significant to insignificant with the inclusion of additional control variables. Additionally, the interaction regression results show that the effect of LMM creation and redemption rights on liquidity persists even when the number of APs is the same for different types of LMMs.

These counterintuitive results highlight the issue between APs and LMMs. Without precise knowledge of account-level creation and redemption amounts, we cautiously argue that the creation and redemption uncertainty faced by LMMNAPs cannot be resolved by simply increasing the number of APs. Consequently, they still tend to hold inventory to make the ETF market.

5.3 Adverse Selection or Liquidity Provision

The previous sections highlighted that LMMs without creation and redemption rights prefer to hold inventory to make the ETF market. Consequently, the effect of an inventory increase (due to ETF share creation) or decrease (due to redemption) is directly reflected in the effective spread. A fundamental principle in many classical microstructural models is that trading consists of a permanent price effect associated with information and a temporary component reflecting liquidity provision. Market makers typically set spreads ex ante to account for potential trades with informed traders, with any subsequent change in the security's fundamental value representing the realization of prior private information. The remaining portion of the effective spread—the realized spread—reflects the market maker's liquidity provision profit or, equivalently, the cost to liquidity seekers demanding liquidity(Conrad & Wahal, 2020).

Since inventory effects are not the sole component of the effective spread, there is a possibility that the previous results may reflect differences in the effective spread due to LMMNAP and LMMAP exposure to varying degrees

of adverse selection risk. To address this concern, we will decompose the effective spread into the price impact and the realized spread to further support our inventory management argument. Following the standard effective spread decomposition method, we decompose the effective spread into the realized spread and price impact based on a 5-minute time interval. Then, we replace the dependent variable in Equations 2, 3, and 4 with the realized spread or price impact to validate the inventory management argument.

Table 6 presents the regression results for price impact (specifications 1 to 6) and realized spreads (specifications 7 to 12). Consistent with our expectations, the presence or absence of LMMs' primary market participation rights does not lead to any significant change in the price impact when ETF shares are created and redeemed. Instead, the strong and significant regression results for realized spreads support the inventory management argument.

When the LMM does not have primary market participation rights, each percentage increase in ETF shares created (redeemed) results in a realized spread increase (decrease) of 0.1922 (0.1829) basis points. Conversely, when the LMM has primary market participation rights, each percentage increase in ETF shares created still has a statistically significant effect on the realized spread, but only by 0.0841 basis points. In addition, ETF share redemptions do not result in any statistically significant change in realized spreads. The results of the interaction term regression further support the inventory management argument.

While the effective spread measures transaction costs in many dimensions, the empirical results in this section confirm the previous finding that the liquidity asymmetry between LMMNAP and LMMAP is not due to different adverse selection risks. The realized spread, as compensation for the market maker's liquidity provision, captures the compensation required for the market maker to take on inventory risk. If the market maker holds inventory to make the market, then ETF share creation and redemption represent an increase and decrease in inventory risk, respectively. Changes in inventory are accompanied by changes in inventory risk. Thus, an increase in the realized spread implies that the market maker seeks compensation for high inventory risk and vice versa. As demonstrated earlier, if LMMNAPs face uncertainty about creation and redemption, they will prefer to hold inventory to make the market. Thus, changes in inventory risk due to creation and redemption activity will affect the realized spread portion of the effective spread.

Table 5: Price Impact, Realized Spread, and Lead Market Maker Creation/Redemption Rights

Dependent Variable:	Price Impact						Realized Spread					
	(1) LMMNAP	(2) LMMAP	(3) LMMNAP	(4) LMMAP	(5) All	(6) All	(7) LMMNAP	(8) LMMAP	(9) LMMNAP	(10) LMMAP	(11) All	(12) All
Create Amount$_{it}$	-0.0667**	0.0100	-0.0450	0.0024	-0.0604**	-0.0405	0.1922***	0.0841**	0.1918***	0.0930**	0.2157***	0.2030***
	(-2.32)	(0.34)	(-1.60)	(0.08)	(-2.20)	(-1.49)	(4.03)	(2.29)	(3.87)	(2.24)	(4.34)	(4.00)
Redeem Amount$_{it}$	-0.0140	-0.0576*	-0.0111	-0.0599*	-0.0181	-0.0111	-0.1829***	-0.0297	-0.1829***	-0.0177	-0.2084***	-0.2032***
	(-0.45)	(-1.77)	(-0.33)	(-1.72)	(-0.58)	(-0.33)	(-3.82)	(-0.68)	(-3.68)	(-0.37)	(-4.25)	(-3.99)
LMM C/R Right$_{it}$ × Create Amount$_{it}$					0.0650*	0.0397					-0.1606**	-0.1255*
					(1.69)	(1.00)					(-2.43)	(-1.83)
Redeem Amount$_{it}$					-0.0385	-0.0515					0.2079***	0.2049***
					(-0.88)	(-1.09)					(3.10)	(2.96)
LMM C/R Right$_{it}$					0.0377	0.0070					0.7983***	0.7941***
					(0.26)	(0.04)					(2.86)	(2.81)
Realized Vol$_{it}$	1.4702***	1.9171***	1.4266***	2.0201***	1.6872***	1.7028***	4.2953***	3.3658***	4.2893***	3.5388***	3.8187***	3.9163***
	(10.87)	(12.52)	(11.66)	(13.97)	(14.84)	(16.64)	(8.32)	(7.89)	(9.15)	(8.30)	(8.41)	(9.08)
Turnover$_{it}$	0.0690**	0.0218	0.0558*	0.0179	0.0464**	0.0383*	0.2358***	0.1285**	0.2019**	0.1441**	0.1827***	0.1691***
	(2.22)	(0.76)	(1.92)	(0.59)	(2.17)	(1.80)	(3.13)	(1.97)	(2.57)	(2.02)	(3.58)	(3.16)
P$_{i,t-1}$	-0.0460	-0.0286	-0.2352	0.3344	-0.0465	-0.0010	-1.2591**	-1.9518***	-1.3654***	-2.0531***	-1.5519***	-1.6145***
	(-0.23)	(-0.09)	(-1.29)	(1.03)	(-0.26)	(-0.01)	(-2.38)	(-3.92)	(-3.14)	(-3.85)	(-4.01)	(-4.36)
Mcap$_{i,t-1}$	-0.2132***	-0.5012***	-0.0640	-0.3817**	-0.3387***	-0.2057**	-2.0562***	-1.3483***	-1.4788***	-0.9105***	-1.8041***	-1.3247***
	(-3.24)	(-3.04)	(-0.97)	(-2.12)	(-3.72)	(-2.08)	(-7.03)	(-4.64)	(-5.20)	(-3.51)	(-8.63)	(-6.73)
Liquidity Mismatch$_{i,t-1}$			-4.3660***	-8.4362***		-5.9467***			-22.6522***	-19.4525***		-21.3009***
			(-5.25)	(-5.84)		(-6.44)			(-8.06)	(-6.67)		(-9.42)
Discount/Premium$_{i,t-1}$			-0.0838	-0.5780		-0.3897			-0.5708	-0.2552		-0.3969
			(-0.20)	(-1.38)		(-1.18)			(-0.44)	(-0.31)		(-0.42)
Constant	4.4314***	10.2435***	2.4492**	6.6708**	6.9708***	4.3827**	48.8757***	37.9505***	38.8011***	30.2700***	44.8970***	36.4123***
	(3.64)	(3.57)	(2.00)	(2.12)	(4.39)	(2.53)	(9.27)	(7.16)	(7.50)	(6.51)	(12.03)	(10.35)
Observations	262,850	238,009	235,767	205,343	500,859	441,110	262,850	238,009	235,767	205,343	500,859	441,110
Adjusted R-squared	0.021	0.045	0.021	0.047	0.033	0.034	0.259	0.201	0.271	0.204	0.231	0.238
ETF FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

The dependent variable is the ETF's daily dollar volume-weighted percentage price impact (*DVPIP*) or realized spread (*DVRS*). The main independent variable is the ETF's LMM creation and redemption right (LMM C/R Right$_{it}$), which is equal to 1 if the ETF's LMM has creation and redemption rights (LMMAP) and 0 if it does not have such rights (LMMNAP). C/R Amount$_t$ is percentage change in ETF shares outstanding, Create Amount$_t$ and Redeem Amount$_t$ is the positive and negative components of the percentage change in ETF shares outstanding. The control variables include realized volatility (Realized Vol$_t$) computed using one-minute mid-quote returns, and intraday turnover (Turnover$_t$), which is TAQ intraday trading volume scaled by the total shares outstanding. Additionally, the previous trading day's closing price (P$_{t-1}$), market capitalization (Mcap$_{t-1}$), liquidity mismatch between ETF and the underlying assets (Liquidity Mismatch$_{t-1}$), and discount/premium (Discount/Premium$_{t-1}$) are included. All intraday statistics exclude the five minutes after market opening and the five minutes before closing. Except for the dummy variables, all variables are winsorized at the 0.5% and 99.5% percentile each year. Standard errors are double-clustered by date and ETF, and an ETF fixed effect is included in the regression. The sample period is from January 2019 to December 2022.

5.4 Primary Market Participation Rights, Competition, and Discount/Premium

Previous empirical results highlight that different creation and redemption purposes and the primary market competition or difficulty of creation and redemption are the drivers behind liquidity differences. However, an important question remains: will ETF mispricing, a key measure of market efficiency, also be influenced by the LMM's primary market participation rights? The literature extensively documents the drivers of ETF mispricing. While end-of-day mispricing arbitrage can only be performed by the AP, high-frequency traders and statistical arbitrageurs can engage in intraday arbitrage for any price deviation between the ETF price and its underlying asset price (INAV). Therefore, we hypothesize that the ETF price remains close to the NAV even if the LMM does not have primary market participation rights.

Separating the discounts and premiums due to the absence of primary market participation rights from the total mispricing is challenging. To clarify the results, we interact the LMM's primary market participation rights with the logarithm of the number of active APs. The estimated coefficients of this interaction term will help determine whether the presence or absence of primary market participation rights affects the ETF's mispricing, given the same number of active APs. Intuitively, given the same number of active APs, the presence or absence of the LMM's primary market participation rights should not affect the ETF's mispricing. This is because LMMAPs can arbitrage themselves out of mispricing through the creation and redemption process at will, thereby eliminating mispricing. For ETFs managed by LMMNAPs, the APs of these ETFs may exclude the LMM and conduct end-of-day arbitrage themselves to eliminate mispricing.

Table 6 details the regression results. The dependent variables are absolute discounts and premiums for specifications 1 to 2 and discounts or premiums for specifications 3 to 6. The results show that while the estimated coefficients of the LMM C/R Right$_t$ are statistically significant, the economic significance is extremely low, with only a 0.006 percent difference in absolute discount/premium between LMMNAP and LMMAP. However, the interaction term estimation results show that ETFs managed by LMMAP have smaller discounts and premiums compared to those managed by LMMNAPs, given the same number of active APs. Consistent with the previous section's findings, the interaction term regression results indicate that LMMs face creation and redemption uncertainty when they cannot create and redeem ETFs by themselves. As a result, given the same number of active APs,

ETFs managed by LMMNAPs experience slightly higher mispricing. Although the interaction term is statistically significant, its economic significance remains low, even without accounting for transaction costs.

Table 6: The Effect of ETF Lead Market Maker Creation and Redemption Rights on Discount and Premium

Dependent Variable:	Absolute Discount or Premium		Dicount or Premium			
	(1) All	(2) All	(3) Pre	(4) Dis	(5) Pre	(6) Dis
LMM C/R Right$_{it}$	0.0066***	0.0284***	0.0056**	-0.0076***	0.0241***	-0.0335***
	(2.85)	(3.59)	(2.26)	(-2.76)	(3.00)	(-3.24)
LMM C/R Right$_{it}$ × Num of Active AP$_{it}$		-0.0114***			-0.0096***	0.0136***
		(-3.28)			(-2.75)	(2.89)
Num of Active AP$_{it}$	-0.0045*	-0.0000	-0.0024	0.0055*	0.0013	0.0002
	(-1.78)	(-0.01)	(-0.87)	(1.68)	(0.42)	(0.05)
Turnover$_{it}$	-0.0000	-0.0000	0.0006*	0.0007***	0.0006*	0.0007***
	(-0.16)	(-0.10)	(1.92)	(2.81)	(1.96)	(2.75)
Mcap$_{it}$	-0.0055***	-0.0052***	-0.0055***	0.0066***	-0.0052***	0.0063***
	(-4.53)	(-4.28)	(-4.07)	(4.27)	(-3.87)	(4.05)
Realized Vol$_{it}$	0.0286***	0.0287***	0.0238***	-0.0343***	0.0239***	-0.0344***
	(8.73)	(8.75)	(7.45)	(-8.08)	(7.47)	(-8.10)
Spread$_{it}$	0.0017***	0.0017***	0.0017***	-0.0018***	0.0017***	-0.0018***
	(14.46)	(14.42)	(15.64)	(-9.91)	(15.58)	(-9.89)
Age$_{it}$	-0.0275***	-0.0277***	-0.0220***	0.0325***	-0.0223***	0.0327***
	(-6.02)	(-6.10)	(-4.21)	(5.72)	(-4.29)	(5.77)
Creation Size$_{it}$	0.0248*	0.0241*	0.0199	-0.0233*	0.0195	-0.0220*
	(1.88)	(1.87)	(0.86)	(-1.95)	(0.85)	(-1.89)
Creation Fee$_{it}$	-0.0131	-0.0142*	-0.0096	0.0230***	-0.0106	0.0241***
	(-1.60)	(-1.66)	(-1.12)	(2.61)	(-1.19)	(2.59)
Expenses Ratio$_{it}$	0.0322*	0.0281	0.0372	-0.0163	0.0332	-0.0122
	(1.77)	(1.53)	(1.61)	(-0.68)	(1.44)	(-0.50)
abs D/P$_{i,t-1}$	0.2069***	0.2066***	0.2021***	-0.2017***	0.2018***	-0.2013***
	(18.39)	(18.34)	(15.42)	(-15.03)	(15.36)	(-15.00)
Constant	0.1622	0.1666	0.1516	-0.3066**	0.1538	-0.3125**
	(1.04)	(1.09)	(0.59)	(-2.06)	(0.60)	(-2.12)
Observations	491,471	491,471	254,203	229,040	254,203	229,040
Adjusted R-squared	0.352	0.352	0.351	0.375	0.351	0.376
ETF FE	YES	YES	YES	YES	YES	YES

The dependent variable is the ETF's daily absolute discount/premium ((1) and (2)) or discount/premium ((3) to (6)). The main independent variable is the ETF's LMM creation and redemption right (LMM C/R Right$_{it}$), which is equal to 1 if the ETF's LMM has creation and redemption rights (LMMAP) and 0 if it does not have such rights (LMMNAP), and the logarithm of the number of active APs (Num of Active AP). The control variables include realized volatility (Realized Vol$_t$) computed using one-minute mid-quote returns, intraday turnover (Turnover$_t$), which is TAQ intraday trading volume scaled by the total shares outstanding, currently day's market capitalization (Mcap$_t$), currently day's effective spread ($DVPES$), the age (Age$_t$), the creation size (Creation Size$_t$), the creation fee (Creation Fee$_t$), the expenses ratio (Expenses Ratio$_t$), and previous day's absolute discount/premium (abs D/P$_{t-1}$). All intraday statistics exclude the five minutes after market opening and the five minutes before closing. Except for the dummy variables, all variables are winsorized at the 0.5% and 99.5% percentile each year. Standard errors are double-clustered by date and ETF, and an ETF fixed effect is included in the regression. The sample period is from January 2019 to December 2022.

5.5 Different Inventory Risks Under Extreme Price Movement

Extreme price movements (EPMs) imply that markets are under stress for a short period. During such situations, liquidity providers may exit from liquidity provision or even consume liquidity. This is often true for endogenous liquidity providers, who have no contractual obligation to provide liquidity (Brogaard et al., 2018). Most stock exchanges have market makers who contract with the exchange to continue providing liquidity and receive commissions for liquidity provision or pay penalties for withdrawing liquidity orders. However, Bellia et al. (2023) argue that designated market makers (DMMs) begin to consume liquidity when several stocks experience EPMs

simultaneously.

The findings in the previous section suggest that since LMMNAPs are not free to create or redeem ETF shares, inventory management considerations cause them to hold inventory while making the ETF market. Therefore, we hypothesize that under EPMs, LMMNAPs will face considerably higher inventory risk than LMMAPs, leading LMMNAPs to widen ETF spreads as compensation for holding inventory. To empirically test this hypothesis, we use the method by Brogaard et al. (2018) to identify all intervals labelled as EPM at the 99.9th percentile of the absolute one-minute midquote return for each ETF. Then, we compute the one-minute time-weighted percentage quote spread ($TWPQS$) as the liquidity proxy. Considering that the quote spread is correlated with ETF size, we separate the ETFs according to their market capitalization into small, medium, and large groups in the intraday sample.

Figure 2 visualizes the cross-sectional liquidity measure ($TWPQS$) five minutes before and after the EPM. The cross-sectional $TWPQS$ is averaged across all non-zero 1-minute $TWPQS$. We also plotted the upper and lower 95% confidence intervals for the corresponding average statistics. Figure 2 clearly shows that, regardless of the EPM signal and ETF size, the $TWPQS$ jumps up and then falls during EPM period. Moreover, on average, LMMNAP managed ETFs have large changes in $TWPQS$ between $t-1$ and t, except for medium-sized ETFs during negative EPM. Meanwhile, the changes in the $TWPQS$ of LMMNAP managed ETFs in Panel A of Figure 2 show a gradual increase before EPM and a gradual decrease after EPM, rather than a jump.

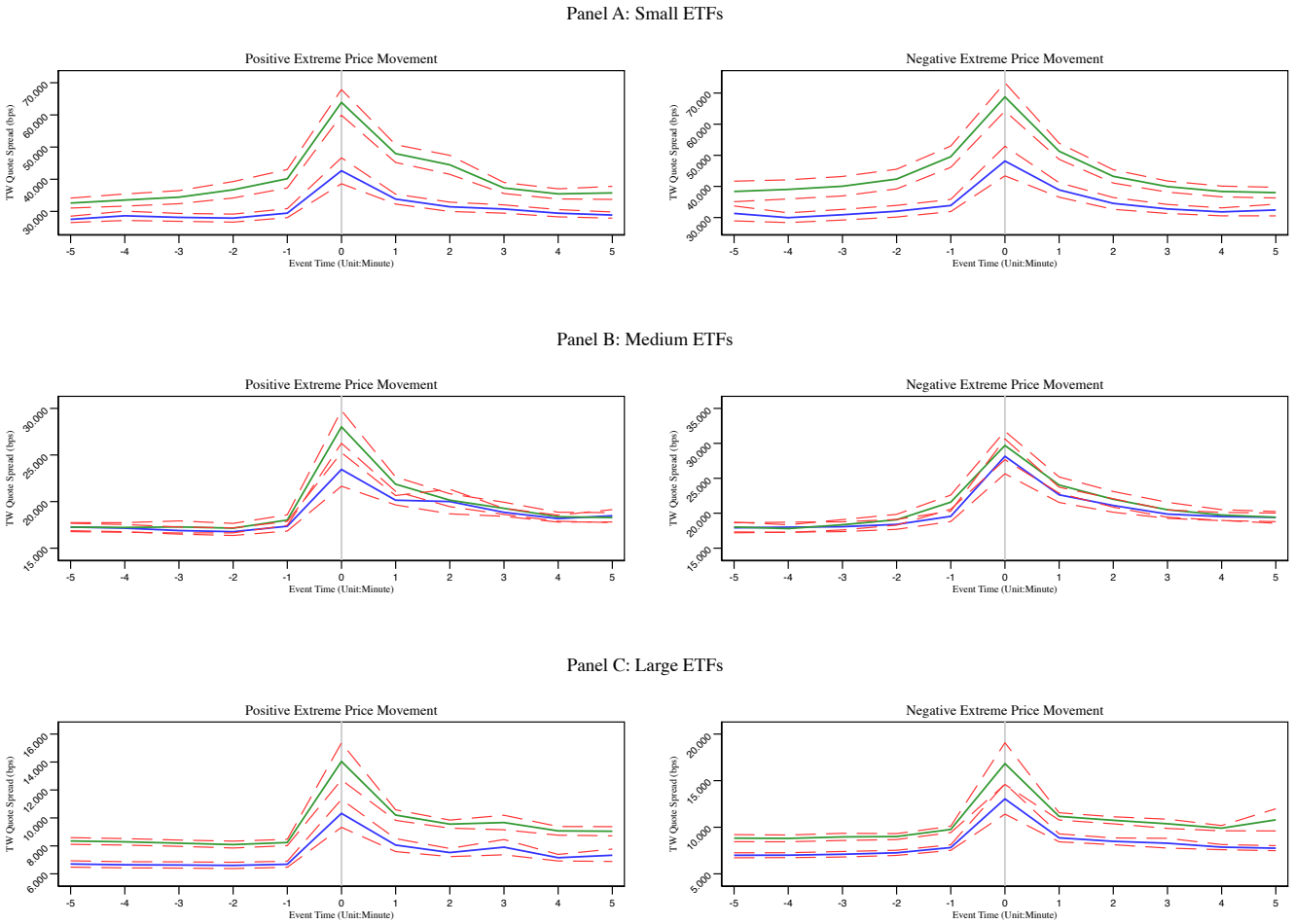

Figure 3: Variation of Quoted Spreads Around Extreme Price Movements Under Different Size Groups. This figure visualises the dynamics of time-weighted quoted spreads during extreme price movement events (EPMs). Panels A, B, and C are for small, mid, and large ETFs, respectively. The green line is the time-weighted quoted spread for LMMNAP, and the blue line is for LMMAP. The red dashed lines are the upper and lower 95% confidence intervals. Time in minutes. t_0 represents EPM, t_{-5} to t_0 is before EPM, and t_0 to t_5 is after EPM. Time-weighted quoted spreads are in basis points

To empirically test whether the LMMNAP face higher inventory risk during the EPM we estimate the following regression:

$$PQSD_{i,t}^{TW} = \alpha_{i,t} + \text{LMM C/R Right}_{it} \times [\gamma \text{ Before-EPM} + \theta \text{ During-EPM} + \lambda \text{ After-EPM}]$$
$$+ \sum_{k=1}^{5} [\beta \times PQSD_{i,t-k}^{TW}] + \beta_6 r_t^{mid} + \beta_7 TAD_t^{TW} + \beta_8 TBD_t^{TW} + \varepsilon_{i,t}$$

where $PQSD_{i,t}^{TW}$ is the time weight percentage quote spread for i ETF at t minute, Before, During, and After EPM are the dummy variables equal to 1 if at the corresponding EPM stage, r_t^{mid} is the one minute midquote return, TAD_t^{TW} and TBD_t^{TW} are the time weighted average best ask and bid depth, respectively.

Table 7 details the regression results. The first six columns are for positive EPMs, and the last six columns are for negative EPMs. The first columns for both positive and negative EPMs are estimated from pooled regressions where the EPM stage variables do not interact with LMM C/R Right$_{it}$, revealing the trend of quoted spreads during EPM events. All EPM stage dummy variables are highly significant at the 1% level, except for the post-EPM dummy variables. Specifically, the quoted spread gradually increases by 0.0815 (0.1105) basis points before the start of the positive (negative) EPM stage and then sharply increases by 0.4868 (0.5255) basis points during the positive (negative) EPM stage. These results suggest that $TWPQS$ begin to increase even before a stochastic-like event and then jumps to very high levels when the event occurs. Moving on to the remaining columns of Table 7, which include an interaction term between the EPM stage and LMM C/R Right$_{it}$, the results indicate that, on average, the ETFs managed by LMMNAPs will have 0.2987 bps (0.042 bps) more to the quoted spread than the ETF managed by LMMAP during (before) a positive EPM. Additionally, these results hold for different-sized ETF groups. The findings imply that LMMNAPs are more likely to widen their quoted spreads during EPMs due to increased inventory risk compared to LMMAPs.

Table 7: The Effects of ETF's Lead Market Maker Creation/Redemption Right on Quoted Spread Around Extreme Price Movements

	Positive Extreme Prive Movement						Negative Extreme Prive Movement					
	All	All	All	Small	Medium	Large	All	All	All	Small	Medium	Large
Before-EPM	0.0815***	0.0815***	0.1001***	0.2040***	0.0835***	0.0467**	0.1150***	0.1150***	0.1484***	0.2913***	0.1149***	0.0801***
	(7.01)	(7.01)	(6.98)	(6.13)	(6.05)	(2.42)	(6.44)	(6.44)	(6.13)	(5.67)	(4.61)	(3.14)
During-EPM	0.4868***	0.4868***	0.6186***	0.9702***	0.5801***	0.3531**	0.5255***	0.5255***	0.5299***	0.8587***	0.4467***	0.3607**
	(3.24)	(3.24)	(3.58)	(4.37)	(3.31)	(2.08)	(3.57)	(3.57)	(3.35)	(3.70)	(3.35)	(2.24)
After-EPM	0.0260	0.0260	0.0192	-0.0266	0.0457*	0.0569*	0.0083	0.0083	-0.0029	-0.0882	0.0401	0.0889*
	(1.61)	(1.61)	(0.96)	(-0.75)	(1.88)	(1.86)	(0.40)	(0.40)	(-0.10)	(-1.64)	(1.29)	(1.83)
LMM C/R Right		-0.0029	-0.0015	-0.0099	0.0009	0.0025		-0.0052	-0.0043	-0.0181	0.0066	0.0064
		(-0.53)	(-0.27)	(-0.74)	(0.10)	(0.53)		(-0.97)	(-0.82)	(-1.62)	(1.28)	(1.08)
LMM C/R Right × Before-EPM			-0.0422***	-0.0916***	-0.0252***	-0.0160**			-0.0759***	-0.1596***	-0.0420***	-0.0294**
			(-3.71)	(-2.61)	(-2.84)	(-2.00)			(-3.97)	(-3.15)	(-2.80)	(-2.46)
LMM C/R Right × During-EPM			-0.2987***	-0.5445***	-0.2228*	-0.1148**			-0.0099	0.1523	-0.0038	-0.1184*
			(-3.78)	(-2.83)	(-1.96)	(-2.00)			(-0.08)	(0.43)	(-0.05)	(-1.92)
LMM C/R Right × After-EPM			0.0156	0.0508	0.0110	-0.0134			0.0253	0.0924**	0.0036	-0.0302
			(1.28)	(1.50)	(1.01)	(-0.87)			(1.52)	(2.22)	(0.25)	(-1.55)
r_{it}^{Mid}	0.0149*	0.0149*	0.0149*	0.0383*	0.0099	-0.0040	0.0121	0.0121	0.0121	0.0486	-0.0073	-0.0072
	(1.78)	(1.78)	(1.77)	(1.83)	(1.16)	(-0.90)	(0.60)	(0.60)	(0.60)	(1.12)	(-0.57)	(-0.68)
TAD_{it}^{TW}	0.0024**	0.0024**	0.0024*	0.0021	0.0064**	0.0013	0.0015	0.0015	0.0014	-0.0092	0.0028	0.0016
	(2.01)	(2.01)	(1.95)	(0.13)	(2.16)	(1.48)	(0.82)	(0.82)	(0.80)	(-0.32)	(1.17)	(1.08)
TBD_{it}^{TW}	0.0017	0.0017	0.0016	-0.0134	0.0060	0.0013	0.0014	0.0014	0.0013	-0.0109	0.0044	0.0014
	(1.23)	(1.22)	(1.18)	(-1.02)	(1.64)	(1.53)	(1.21)	(1.21)	(1.21)	(-0.66)	(1.61)	(1.64)
Constant	-0.0035*	-0.0023	-0.0029	0.1027***	-0.0096*	-0.1210**	-0.0040***	-0.0017	-0.0021	0.0805***	-0.0173***	-0.1659**
	(-1.88)	(-0.71)	(-0.90)	(6.11)	(-1.93)	(-2.02)	(-2.85)	(-0.60)	(-0.72)	(4.91)	(-3.16)	(-2.18)
Observations	6,371,425	6,371,425	6,371,425	1,808,140	2,293,629	2,269,656	4,736,214	4,736,214	4,736,214	1,436,086	1,697,456	1,602,672
Adjusted R^2	0.467	0.467	0.467	0.315	0.417	0.383	0.392	0.392	0.392	0.260	0.369	0.350
ETF FE	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES

This table reports the effect of ETF lead market maker creation and redemption rights on quote spread around extreme price movements. The dependent variable is the ETF's 1-minute time-weighted average quoted spreads. The independent variable is the ETFs Lead Market Maker creation and redemption right, extreme price movements stage dummy. The control variables are contemporaneous 1-minute time-weighted average bid and ask depth and five lagged 1-minute time-weighted average quoted spreads. All intraday statistics exclude five minutes after opening and five minutes before closing. The ETF's Lead Market Maker creation and redemption rights is a dummy variable equal to 1 indicating that the ETF's LMM has creation/redemption rights and 0 indicating that it does not have such rights. Following the microstructure literature, we separately consider large and small ETFs. At the beginning of each month, ETFs are sorted into terciles by their average daily market capitalization over the past 250 trading days. Standard errors are double-clustered by date and ETF. Except for the dummy variables, all variables are normalized by their standard deviation. ETF fixed effect is included in the regression to rule out unobservable ETF characteristics. The Adjusted R^2s reported in the table are regressions that do not control for five lagged 1-minute time-weighted average quoted spreads. Sample period from Jan 2022 to Dec 2022.

6 Concluding Remarks

Overall, our paper sheds light on the consequences of LMM choice in the face of creation/redemption uncertainty, which has been neglected in the previous literature. Although the primary market participation right is seen as the most important for functional participants in ETFs. Yet some LMMs do not have this right when providing liquidity. This would result in them not being able to freely create/redeem ETF shares when needed. Consequently, they choose to carry inventory to make the ETFs market.

We prove this argument by empirically showing the liquidity asymmetry between LMMNAP and LMMAP after the creation/redemption date. We further demonstrate our inventory management argument by showing that only the realised spread, rather than the price impact, capture the liquidity asymmetry between LMMNAP and LMMAP given the same creation and redemption amounts. We also provide an alternative explanation that suggests that this uncertainty cannot be resolved by directly increasing the number of active APs.

Industry participants should gain a more in-depth insight into how to better handle this uncertainty, as some MMs are unwilling or unable to become APs due to their business models or entry barriers. On the other hand, end-investors in the ETF trading cycle should be aware of what type of MMs manage the ETFs that they are currently trading or would like to trade, which relates to the trade-off between immediacy and trading costs. Finally, we call the attention of policymakers and researchers to the growing importance of ETF market structure issues. While the literature suggests that increasing the intensity of competition in the primary market can improve the ETF's secondary market liquidity as well as pricing efficiency. However, our findings call for a more in-depth study of the relationship between AP and LMM.

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7 Appendix

Table 8: Marginal Effect of Create and Redeem Amounts and Number of Active AP

Variable	Create Amount$_t$ (1)	Redeem Amount$_t$ (2)	Num of Active AP (3)
LMM with C/R Right	0.1676***	-0.2124***	-0.83**
	(4.14)	(-5.70)	(-2.03)
LMM Without C/R Right	0.0658*	-0.0359	-2.33***
	(1.74)	(-1.13)	(-4.70)
Absolute Difference	10.18**	17.65***	1.50***

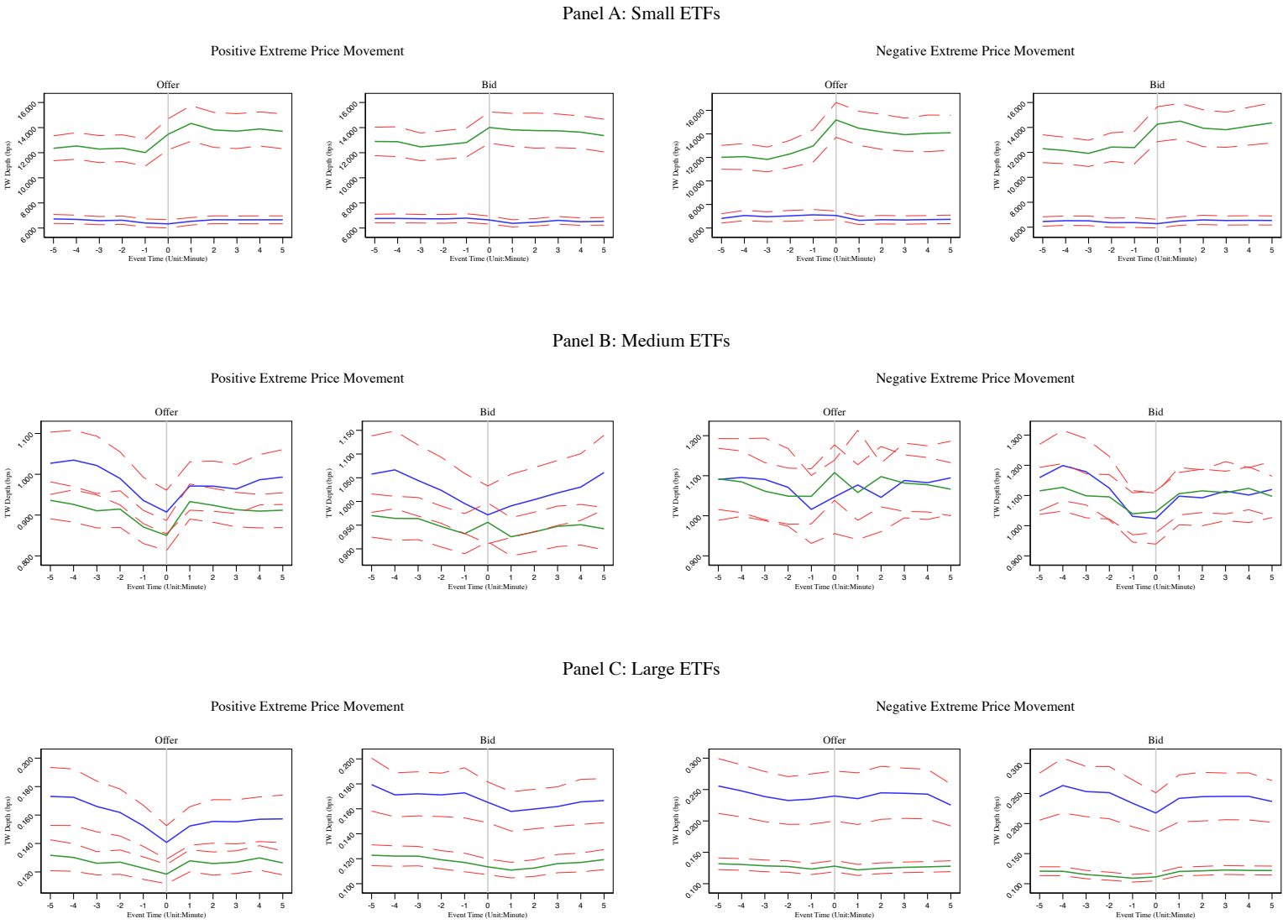
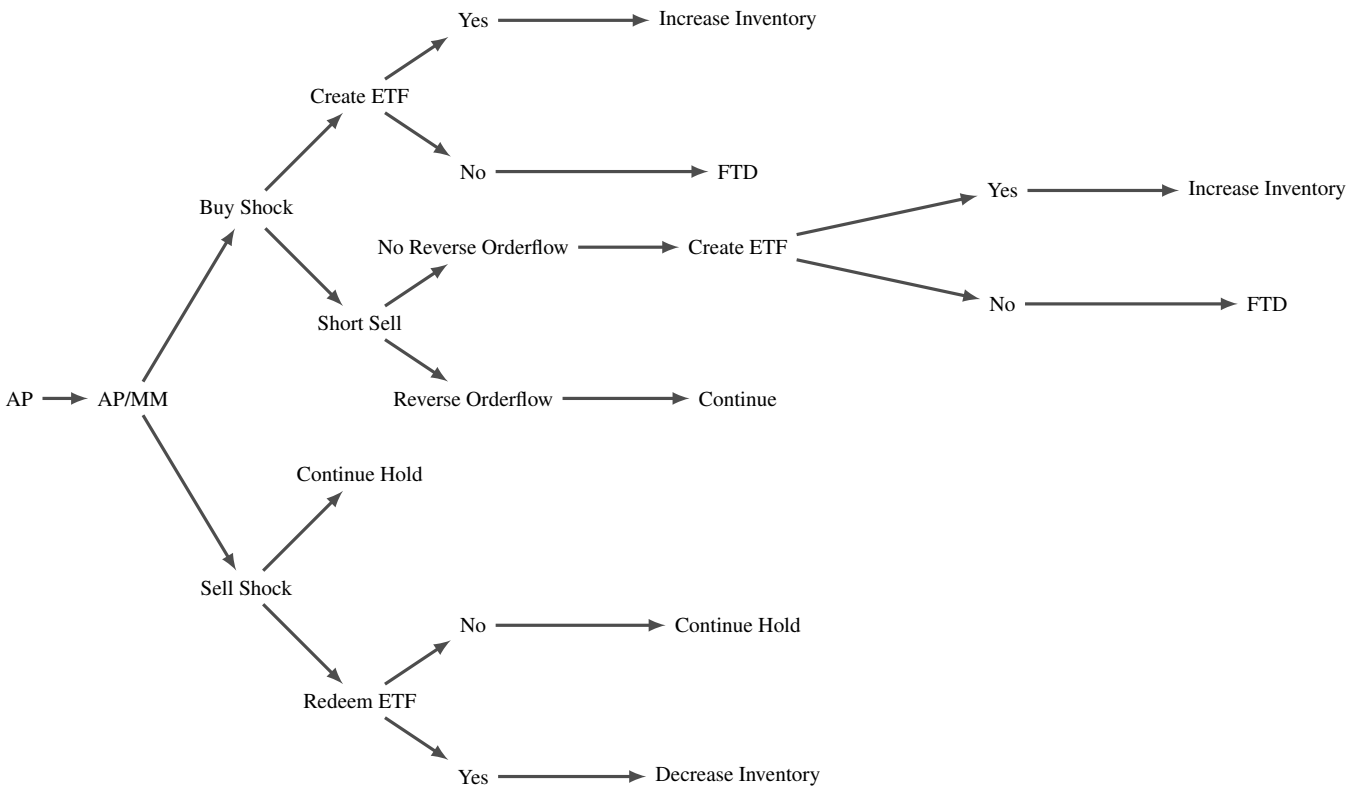


Figure 4: Variation of Depth Around Extreme Price Movements Under Different Size Groups

Table 9: Primary Market Competition and Difficulty of Creation and Redemption.

Dependent Variable:	Creation/Redemption Amount	|Creation/Redemption Amount|	Fail To Delivery
	(1)	(2)	(3)
LMM C/R Right$_{it}$ × D/P$_t$	-0.1846***		
	(-3.11)		
|D/P$_t$|		-0.1898*	
		(-1.92)	
OI$_t$	11.7520***		
	(4.43)		
|OI$_t$|		9.0066***	
		(3.60)	
OI$_{t-3,t-1}$	2.5773***		
	(2.70)		
|OI$_{t-3,t-1}$|		3.4774***	0.6467**
		(2.91)	(2.14)
D/P$_t$	0.4233***		
	(8.28)		
|D/P$_t$|		0.3471***	
		(3.43)	
OI$_t$	3.4108*		
	(1.81)		
|OI$_t$|		1.4612	
		(1.21)	
OI$_{t-3,t-1}$	3.0548***		
	(4.87)		
|OI$_{t-3,t-1}$|		4.9015***	0.7548***
		(6.45)	(5.60)
LMM C/R Right$_{it}$	-0.0363**	-0.0625***	0.0039
	(-2.51)	(-2.76)	(0.35)
Realized Vol$_t$	-0.0261***	-0.0455***	0.0210***
	(-3.56)	(-3.76)	(6.66)
Turnover$_t$	0.0365***	0.1959***	0.0184***
	(7.74)	(10.71)	(13.19)
L_P	0.1421***	0.0618*	0.0767***
	(6.23)	(1.92)	(6.86)
L_{Mcap}	-0.0604***	0.0808***	-0.0441***
	(-5.42)	(6.76)	(-8.81)
L_{DP_w}	0.3524***	0.1312***	0.1860***
	(11.52)	(4.14)	(12.11)
$\ln_{Num_of_Active}$	0.0299*	0.0410*	0.0304***
	(1.77)	(1.88)	(2.90)
$\ln_{Age2}$	0.0026	-0.1431***	-0.0700***
	(0.12)	(-5.06)	(-4.80)
$\ln_{creation_unit_size}$	0.0336	0.0867***	0.0044
	(1.09)	(6.09)	(0.30)
$\ln_{creation_fee}$	0.0221	0.0295	-0.0059
	(0.97)	(1.18)	(-0.99)
$\ln_{net_expenses}$	-0.2516	0.2111	-0.1655**
	(-1.53)	(1.06)	(-2.09)
Constant	0.1699	-1.7939***	1.1410***
	(0.39)	(-5.04)	(4.69)
Observations	490,999	490,999	494,240
Adjusted R-squared	0.043	0.146	0.134
ETF FE	YES	YES	YES


AP
AP/MM
Buy Shock
Create ETF
Yes
Increase Inventory
No
FTD
Short Sell
No Reverse Orderflow
Create ETF
Yes
Increase Inventory
No
FTD
Reverse Orderflow
Continue
Sell Shock
Continue Hold
Redeem ETF
No
Continue Hold
Yes
Decrease Inventory