The Fed and the Wall Street Put*

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Abstract

We study the trading behavior of financial intermediaries around Federal Open Market Committee (FOMC) announcements in the S&P 500 index options market using intraday data. Proprietary trading firms are net sellers of options on FOMC days, in contrast to other days, with their trading activity concentrated in the morning, well before the announcement. Larger option sales by proprietary trading firms in the morning predict both a more accommodative monetary policy shock later in the day and a subsequent decline in option prices after the policy announcement, rendering morning trades profitable. Notably, this predictive power is driven by announcements that include the Summary of Economic Projections and dot plots, which detail FOMC participants' policy rate forecasts. These findings suggest that some financial institutions may have preferential access to information about the Fed's projected future policy actions.

Keywords: monetary policy, intermediaries, equity options, Federal Reserve, informed trading.

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1 Introduction

After their scheduled meeting on March 18, 2015, the Federal Open Market Committee (FOMC) issued a statement that financial markets perceived as unexpectedly dovish.[1] Despite no change to the federal funds rate, the Fed's accommodative stance regarding the path of future interest rates led to a decline in market interest rates following the announcement.[2] The dovish monetary policy news spurred a rally in the stock market: S&P 500 futures rose by 1.56% in the announcement window, and the index closed 1.21% higher on the day. The *VIX* index, reflecting investors' risk perceptions and equity option prices, dropped from 16.26 to 14.02 during the FOMC announcement window.

Meanwhile, proprietary trading firms, which are financial institutions without a market-making mandate and trade for profit using their own capital, were net sellers of 127,519 S&P 500 index option contracts to other investor categories.[3] This behavior may indicate a greater appetite for risk in response to the Fed's more accommodative stance. Strikingly, however, these trades occurred entirely within the first 10 minutes after the options exchange opened (9:30 a.m. to 9:40 a.m.), well before the FOMC announcement at 2:00 p.m. This suggests that proprietary traders may have anticipated the market's reaction to the announcement, including the drop in option prices, and capitalized on this expectation for profit.

In this paper, we investigate whether this pattern holds more broadly using daily and intraday trade volume data from the S&P 500 index options market. Specifically, we study how monetary policy shocks affect trading behavior of financial intermediaries in the options market, such as proprietary trading firms, and other investor types, around FOMC announcements, and whether their trading behavior reflects changes in risk-taking or some

[1] "U.S. Stocks and Bonds Gain as Fed Signals Caution," *The Wall Street Journal*, March 18, 2015.

[2] For example, the 1-year Eurodollar futures fell by 10 basis points in the 30-minute window around the announcement, and the 5-year U.S. Treasury yield fell by 15 basis points throughout the day.

[3] From 2011 to 2023, March 18, 2015, had the fifth-largest negative option demand by proprietary trading firms among 3,268 trading days.

investors' informational advantage regarding the Fed's influence on financial markets.

We assess both the unconditional impact of scheduled FOMC announcements and the effects of unexpected monetary policy shocks, measured by high-frequency market interest rate movements (Gürkaynak, Sack, and Swanson (2005), Nakamura and Steinsson (2018), Bauer and Swanson (2023a)). Our findings reveal that proprietary trading firms without market-making mandate are net sellers of options on FOMC announcement days. These institutions provide significantly more liquidity to other investors when monetary policy is unexpectedly accommodative. Strikingly, option trades by proprietary trading firms occur shortly after the market opens and predict monetary policy shocks as well as subsequent option price movements later in the day, which suggests that some financial institutions may have gained an informational advantage about the forthcoming FOMC statement prior to trading hours. This pattern is driven by FOMC announcements when the Fed releases the Summary of Economic Projections and dot plots, which detail participants' interest rate projections. On the demand side, the primary buyers of options sold by firms are public customers, including retail investors, and professional customers, such as hedge funds, with residual supply absorbed by market makers.[4]

Our analysis leverages a novel dataset that reports buy and sell trade volumes by investor category at both the daily and intraday 10-minute level, allowing us to pinpoint the timing of option trades around FOMC announcements. Firms in the options trading volume data are institutions engaged in proprietary trading for profit (Pan and Poteshman (2006)). Their activities typically include selling hedging instruments to capture risk premiums or speculative trading based on informed views of future market movements. Unlike designated market makers, firms are not obligated to balance the market by adjusting to exogenous demand and can set the size of options holdings at their own discretion.

During our sample period from 2011 to 2023, there were 103 scheduled FOMC announce-

[4]Throughout the paper, we use "firms" and "proprietary trading firms" interchangeably.

ments, typically held at 2:00 p.m., with some exceptions that occurred at 2:15 p.m. or 11:30 a.m. The FOMC meets over two days, with the Federal Funds Rate decision and the committee's statement released on the second day. Following Gürkaynak, Sack, and Swanson (2005) and Bauer and Swanson (2023a), we measure monetary policy shocks using changes in Eurodollar futures within a 30-minute window, from 10 minutes before to 20 minutes after the announcement. These shocks reflect the unexpected component of monetary policy news as interpreted by the Eurodollar futures market.

We find that monetary policy shocks have the greatest impact on firm trades in S&P 500 options expiring before the next FOMC announcement rather than those maturing afterward. The demand response is highly nonlinear: accommodative monetary shocks lead to significantly larger option sales, whereas monetary tightening induces comparatively smaller purchases. Additionally, the effects of FOMC day trades in response to monetary shocks persist, influencing firms' option inventories for more than seven trading days.

Absent any informed trading in the options market, we would expect firm option trades to respond to monetary policy shocks primarily during or after the announcement, as traders adjust their positions based on the implications of the monetary policy news for market interest rates, expectations, and risk appetite. Our high-frequency volume analysis reveals a striking indication of informed trading: firms' responses to monetary policy shocks are entirely concentrated in their morning trades between 9:30 a.m. and 9:40 a.m. The relationship between option demand and monetary policy shocks is negligible for the rest of the day, yet the morning trades strongly predict these monetary policy shocks occurring later in the day. Specifically, FOMC meeting days with high firm sell volumes in S&P 500 index options at 9:40 a.m. are significantly more likely to coincide with declines in market interest rates around the FOMC announcements, typically held at 2:00 p.m.

We find that firms' morning trades not only predict monetary policy shocks but also

their impact on option prices. Specifically, firms' option demand between 9:30 a.m. and 9:40 a.m. predicts the rate of change in the squared *VIX*—a proxy for the price of a portfolio of S&P 500 options with one month to maturity—from 9:41 a.m. to market close, with a much stronger effect on FOMC announcement days compared to non-FOMC days. That is, when firms sell options in the morning, monetary policy tends to be accommodative, leading to cheaper options later in the day and rendering these trades profitable. Importantly, this predictive ability for option prices is unique to proprietary trading firms and is not observed for other investor types including customers or market makers.

We also examine whether the predictability of monetary policy shocks using proprietary firms' morning option demand is driven by other drivers of asset price response to monetary policy shocks studied in the literature. In the data, firms' morning demand provides predictive power for the magnitude of interest rate shocks, beyond the information contained in the option-implied monetary policy uncertainty measure proposed by Bauer, Lakdawala, and Mueller (2022). Additionally, the predictability of firm option demand is distinct from the predictive role of interest rate skewness for monetary policy shocks, as documented by Bauer and Chernov (2024), and it is robust to using orthogonalized monetary policy shocks constructed by Bauer and Swanson (2023b). Finally, the predictability is driven by FOMC announcements that do not coincide with other macroeconomic announcements such as employment and inflation distinguishing it from other announcement effects such as Lucca and Moench (2015)'s pre-FOMC drift which is driven by FOMC announcements preceded by other announcements (Alam (2023)).

Through additional analyses, we explore the mechanisms underlying the informational advantage of proprietary trading firms prior to FOMC announcements. First, we find that the predictability is driven by FOMC announcements where the news about interest rate itself dominates over the news about the Fed's economic outlook giving rise to the information

effect (Nakamura and Steinsson (2018), Cieslak and Schrimpf (2019), Jarociński and Karadi (2020)), suggesting firms' information advantages likely about the former. Second, our findings are entirely concentrated in FOMC announcements where the target policy rate remains unchanged, and monetary policy shocks stem from changes in the expected path of future interest rates. This suggests that firms' informational advantage is likely related to the Fed's forward guidance communicated through its statements (Gürkaynak, Sack, and Swanson (2005)). Third, we observe that pre-announcement option trading activity is pronounced exclusively on FOMC days that include the release of the Summary of Economic Projections (SEP) and dot plots. These releases provide explicit forecasts from FOMC participants on key macroeconomic variables—such as employment and inflation—and the projected future trajectory of policy rates. We interpret these findings as evidence that proprietary trading firms may have advance access to easily interpretable information from the Fed such as participants' policy rate forecasts, which has a clear and direct impact on asset prices. This informational advantage may facilitate their profitable trading in the morning of FOMC days. Indeed, such monetary policy shocks are accompanied by significant movements in the *VIX* index and large morning trades by proprietary trading firms, which prove profitable as subsequent news unfolds and option prices adjust throughout the day.

Monetary policy decisions are among the most influential forces shaping financial markets, affecting risk pricing, capital allocation, and investor strategies. The stock market reacts immediately to unexpected monetary policy shocks, highlighting the financial market's unique role in understanding the transmission of monetary policy before its effects on macroeconomic aggregates are observable (Bernanke and Kuttner (2005)). While much research has focused on equity and fixed-income markets, our analysis using the equity index options market offers a unique setting to study the interplay between policy, investor behavior, and asset prices. The options market not only facilitates hedging against diverse future

scenarios but also provides insights into investors' information and speculation about market fluctuations.

The predictive power of firms' morning trades for monetary policy shocks points to the possibility of informal communication of Federal Reserve decisions to financial intermediaries, consistent with evidence from Finer (2018), Cieslak, Morse, and Vissing-Jorgensen (2019), Vissing-Jorgensen (2019), and Ehrmann, Gnan, and Rieder (2023). Specifically, our findings suggest that certain financial institutions may gain preferential access to information from FOMC meetings. This interpretation is further supported by the two-day structure of FOMC meetings, during which the content of the Fed's statement, finalized on the first day for release on the second day, could be conveyed overnight to select market participants, allowing them to act on this information in the options market immediately after trading begins the following day.

Lastly, proprietary trading firms and market makers play critical roles in liquidity provision and risk transfer within the options market. Garleanu, Pedersen, and Poteshman (2009) demonstrate how these intermediaries manage risks and influence option prices, while Chen, Joslin, and Ni (2019) examine the impact of their exposure to market crash risk on pricing. Additionally, Fournier and Jacobs (2020) offer a quantitative model of constrained market makers and their influence on equilibrium option prices. Our analysis reveals significant differences in behavior between proprietary trading firms and market makers on FOMC days. While firms pursue profit-driven strategies, market makers adhere to liquidity provision mandates. These distinctions are essential for understanding how various intermediary types respond to monetary policy shocks.

The paper is organized as follows. Section 2 introduces the data and examines the impact of monetary policy on daily option demand across investor types. Section 3 presents high-frequency trading evidence, focusing on morning trades by proprietary traders on FOMC

days, which suggest an informational advantage. Section 4 shows that morning trades by proprietary trading firms predict option price movements, highlighting their profitability. Section 5 investigates the interaction between other drivers of asset price responses to monetary policy and option trading on FOMC announcement days. Section 6 analyzes key features of FOMC announcements that drive our results including Fed's communication about the future path of monetary policy. Section 7 concludes the paper.

2 Evidence using daily option demand

2.1 Option trade volume data

Our option trade volume dataset is from the Chicago Board Options Exchange (CBOE) Open-Close Interval Volume data.[5] We use all options with trading symbols SPX and SPXW which are the major options with the S&P 500 index as the underlying. For each day, starting from the market open at 9:30 a.m., the dataset provides the cumulative intraday number of contracts bought and sold for each option by investor category at 10-minute intervals. For each investor category, we calculate option demand as the difference between buy and sell volumes. Both open and close trading volumes are included, capturing trades that increase or decrease an option's open interest, respectively. Thus, option demand reflects the net effect of all buy and sell transactions, equal to the change in inventory for each investor category.[6] Finally, we aggregate demand across all options within each investor group to construct a daily dataset. This means that our demand metrics represent the collective trading activities of all investors within a given category, rather than at the individual investor level. For example, a positive firm demand for an option indicates that firms, as

[5]See Appendix B for details on data sources and construction.

[6]That is, $\text{Demand}_t^j = \sum_i (\text{All buys})_{i,t}^j - (\text{All sells})_{i,t}^j$ for each option chain i and investor type j. Throughout the paper, "demand" and "net demand" are used interchangeably.

a group, have bought more contracts than they have sold. This surplus in firm demand must be offset by a corresponding surplus in sell volume from all other investor categories combined. Since options are in zero net supply, the total demand and inventory for each option sum to zero, both daily and at each 10-minute interval. Trades between investors within the same category do not affect the aggregated demand measures.

The dataset categorizes investors into five groups: firms, broker-dealers, customers, professional customers, and market makers. Firms consist of proprietary traders affiliated with Options Clearing Corporation (OCC) clearing members, typically engaging in in-house institutional trading strategies. Broker-dealers execute client orders, which may include those from other institutions or hedge funds. Customers encompass retail traders, hedge funds, or other individual accounts. Professional customers represent hedge funds and high-frequency traders whose daily minimum trading volumes qualify them as institutional participants. Market makers, tasked with providing liquidity, profit from option bid-ask spreads while managing risk exposure through strategies such as delta hedging. Facing an exogenous demand curve, market makers set prices to determine the quantity of options supplied. In contrast, firms, without a liquidity provision mandate, base their trading decisions on internal financial conditions, such as leverage costs, and seek profits through informed or speculative trading and risk taking.

S&P 500 index options span a broad range of expiration dates and moneyness levels for both call and put options. Each contract has a notional value equal to 100 times the S&P 500 index in USD. Aggregating the net demand for all options for each investor category at the daily level yields a dataset with 3,268 observations, spanning from January 2011 to December 2023. During our sample period, there are 103 scheduled FOMC announcements, typically occurring eight times per year.[7] A common method for measuring

[7]One scheduled announcement was canceled in 2020 due to the frequent unscheduled FOMC meetings during the COVID-19 crisis.

unexpected monetary policy shocks is to analyze high-frequency changes in yields around FOMC announcements (Gürkaynak, Sack, and Swanson (2007), Nakamura and Steinsson (2018), Bauer and Swanson (2023a)). This approach assumes that interest rate movements within a 30-minute window—from 10 minutes before to 20 minutes after a scheduled announcement—are driven by the unexpected component of monetary policy news. In our analysis, we use monetary policy shocks (MPS) from Bauer and Swanson (2023a), which are constructed based on high-frequency movements in Eurodollar futures with maturities of up to four quarters, available on the San Francisco Fed's Center for Monetary Research website.

Appendix Table A.1 presents summary statistics for daily option demand by investor type and normalized monetary policy shocks (MPS). On non-FOMC days, all investor types except market makers exhibit positive net demand on average, indicating that their buy volume, measured in number of contracts across all options, exceeds their sell volume. Market makers, in turn, absorb this demand and act as net sellers, consistent with Garleanu, Pedersen, and Poteshman (2009) and Fournier and Jacobs (2020). Among the investor types, broker-dealers and professional customers display less variation in their option demand compared to others.

Average option demand varies significantly on FOMC days: firms switch from net buyers to net sellers, with an average net sale of 3,629 contracts, compared to a net purchase of 5,036 contracts on non-FOMC days. Meanwhile, average customer demand nearly doubles. These figures indicate imbalances among investor types; for example, a sale from firms to customers decreases firm demand and increases customer demand. However, trades between two firms do not influence these metrics. For ease of interpretation, we normalize the MPS variable to have zero mean and unit standard deviation on FOMC days, and set it to zero on non-FOMC days.

Table 1
Daily option demand and monetary policy

	Firm	Broker-Dealer	Customer	Prof-Customer	Market-Maker
			Panel A: All days		
FOMC	-8664.78***	-809.41**	8962.91***	-578.29	1089.88
	[-2.93]	[-2.00]	[2.90]	[-0.34]	[0.34]
MPS	9840.37**	407.76	-2593.07	-3298.46	-4356.60
	[2.45]	[1.00]	[-0.68]	[-1.24]	[-1.08]
Cons.	5036.16***	2613.12***	9859.95***	734.65***	-18244.19***
	[10.05]	[23.36]	[19.49]	[4.38]	[-37.32]
R^2	0.0066	0.0007	0.0033	0.0037	0.0008
Obs.	3268	3268	3268	3268	3268
			Panel B: FOMC days		
MPS	9840.37**	407.76	-2593.07	-3298.46	-4356.60
	[2.45]	[1.00]	[-0.68]	[-1.24]	[-1.08]
Cons.	-3628.62	1803.71***	18822.86***	156.36	-17154.31***
	[-1.24]	[4.65]	[6.17]	[0.09]	[-5.46]
R^2	0.0986	0.0105	0.0069	0.0355	0.0182
Obs.	103	103	103	103	103

Notes. Panel A reports results from regressing daily net option demand aggregated by investor type on a dummy variable for FOMC days and the monetary policy shock (MPS). Panel B runs the regression using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

2.2 Daily option demand and monetary policy

We begin our analysis by regressing daily option demand for each investor category on a dummy variable for scheduled FOMC announcement days and monetary policy shocks (MPS). A negative MPS indicates that the FOMC announcement is perceived as more accommodative than expected by the market, such as through an unanticipated interest rate cut or forward guidance signaling a declining interest rate path.

Panel A of Table 1 shows that firm net demand decreases significantly on FOMC days

by 8,665 contracts, turning the average non-FOMC net demand of 5,036 contracts negative. This additional supply of options from firms is largely absorbed by customers, whose net demand increases significantly on FOMC days.

The coefficient on MPS in Panel A of Table 1 indicates that firm option demand on FOMC days is significantly influenced by the unexpected monetary policy shock. Specifically, unexpected monetary easing (lower MPS) leads to larger net sales of options by firms. A one standard deviation decrease in MPS corresponds to an additional net sale of 9,840 contracts by firms to other investor types. Over half of this increased supply is absorbed by higher demand from customers and professional customers, while the remainder is offset by a reduction in supply from market makers.

Panel B of Table 1 replicates the analysis using data exclusively from FOMC days. Firm option demand exhibits the strongest and statistically significant correlation with MPS, indicating that proprietary traders are the most responsive to monetary policy shocks. While their average option demand on FOMC days is not significantly different from zero (as reflected in the constant term of this regression), the magnitude of MPS has a substantial impact on firm demand, with an R^2 of 9.9%.[8]

2.3 The role of option time to maturity

When firms act as net option sellers on days with looser than expected monetary policy, they can provide liquidity to other investors for options with maturities extending up to or beyond the next scheduled FOMC day. This distinction is important for understanding which segment of the options market the proprietary traders are active in. For instance, options expiring before the next FOMC announcement can be utilized to hedge against or leverage stock market risk during the intermediate period, rather than addressing interest

[8]Appendix Table A.2 shows that the results in Table 1 are robust to using orthogonalized MPS from Bauer and Swanson (2023b).

rate risk associated with future monetary policy shocks.

We divide the sample of options on FOMC days into two groups: those expiring before the next scheduled announcement (Exp < next FOMC) and those expiring after it (Exp > next FOMC). During our sample period (2011–2023), the number of calendar days between scheduled FOMC meetings ranges from 41 to 56, with one exception: a 91-day interval caused by a canceled announcement in 2020 during the COVID-19 crisis. On non-FOMC days, we restrict the (Exp < next FOMC) sample to options with less than 56 days to maturity.

Another question is whether firms' trading on FOMC days is concentrated in short-dated options –potentially to capitalize on predictable short-term market movements– or whether their activity is driven by options with maturities extending beyond the immediate impact of the monetary policy announcement. To explore this, we further divide the (Exp < next FOMC) sample into short-term options and the rest. Among options that expire before and closest to the next FOMC day, the shortest time to maturity is 16 days (and typically longer). Therefore, we focus on options with maturities of at least 16 days but expiring before the next FOMC announcement (16 < Exp < next FOMC).

Appendix Table A.3 presents summary statistics for options in the (Exp < next FOMC) and (16 < Exp < next FOMC) groups. Similar to the broader set of options, net demand for these subsets is positive on non-FOMC days for all investor types except market makers. Additionally, the significant shift in firm demand –from positive to negative– on FOMC days is evident in both samples.

Does the response of firm option demand to monetary policy stem from options expiring before or after the next FOMC announcement? The first two columns of Table 2 reveal that both the larger net sales by firms on FOMC days and their strong response to unexpected monetary policy shocks are entirely driven by options expiring before the next monetary policy announcement. Longer-dated options have no significant role in firm behavior on

Table 2
Firm option demand by time to maturity and monetary policy

	Exp < next-FOMC	Exp > next-FOMC	16 < Exp < next-FOMC	Exp < 16
		Panel A: All days		
FOMC	-7826.96**	-837.82	-6141.49**	-1685.47
	[-2.57]	[-1.04]	[-2.10]	[-1.17]
MPS	10211.18**	-370.82	10327.92**	-116.73
	[2.35]	[-0.42]	[2.44]	[-0.08]
Cons.	6503.80***	-1467.64***	804.49**	5699.31***
	[13.35]	[-9.55]	[2.27]	[15.51]
R^2	0.0067	0.0003	0.0107	0.0002
Obs.	3268	3268	3268	3268
		Panel B: FOMC days		
MPS	10211.18**	-370.82	10327.92**	-116.73
	[2.35]	[-0.42]	[2.44]	[-0.08]
Cons.	-1323.17	-2305.46***	-5337.00*	4013.83***
	[-0.44]	[-2.92]	[-1.84]	[2.87]
R^2	0.0998	0.0021	0.1082	0.0001
Obs.	103	103	103	103

Notes. Panel A reports results from regressing daily firm net option demand on a dummy variable for FOMC days and the monetary policy shock (MPS). Panel B runs the regression using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. Results are reported separately for the (Exp < next FOMC), (Exp > next FOMC), (16 < Exp < next FOMC), and (Exp < 16) options (defined in the text) separately. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

FOMC days.

This evidence suggests that proprietary trading firms' liquidity provision during periods of monetary easing supports the market in sharing stock market risks up to the next FOMC announcement. These trades may result from increased risk-taking by firms as financial conditions loosen or from profit-seeking behavior if firms are better able to predict price movements around and after FOMC announcements compared to other investor groups. In either case, the trading activity is concentrated in options that are not exposed to interest

rate risks associated with future monetary policy shocks.

We next examine whether firms' liquidity provision following accommodative monetary policy is driven by options with maturities between 16 days and the next scheduled FOMC meeting, or those with maturities less than 16 days. The last two columns of Table 2 show that firms' response to monetary policy shocks is entirely driven by options in the (16 < Exp < next FOMC) category. This suggests that, on average, monetary policy easing leads firms to provide liquidity in options with the longest possible maturities up to the next FOMC announcement.

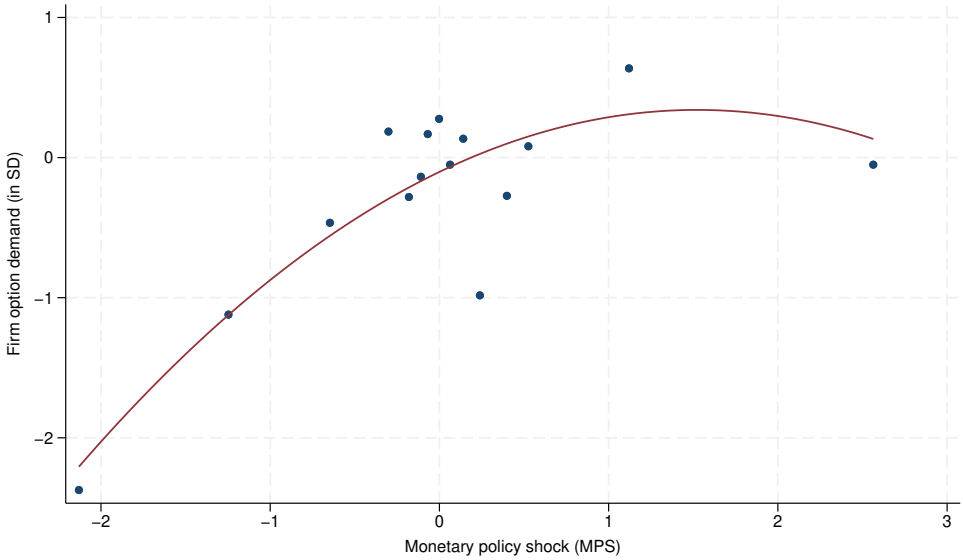
Panel B further indicates that firm option demand in the (16 < Exp < next FOMC) group not only exhibits a strong positive correlation with MPS but is also significantly negative on average on FOMC days. Based on these results, we restrict the sample to (16 < Exp < next FOMC) options for the remainder of our analysis.

2.4 Nonlinear option demand response to monetary policy shocks

We next explore potential nonlinearities in the response of option demand to monetary policy shocks. Specifically, we examine whether the results are driven symmetrically by both positive and negative shocks or are primarily influenced by monetary easing (lower MPS) or tightening (higher MPS).

Figure 1 presents a binscatter of normalized firm option demand on FOMC announcement days as a function of the monetary policy shock (MPS). Firm option demand is lower on FOMC days than on non-FOMC days, resulting in a negative average. The pattern suggests that the positive coefficient of firm option demand on MPS in Tables 1 and 2 is predominantly driven by negative monetary policy shocks, which reflect announcements of accommodative policy. In contrast, the effect is relatively flat for near-zero (MPS $\approx$ 0) and tightening shocks (higher MPS), resulting in an overall concave relationship between firm option demand and

Figure 1. Firm option demand and monetary policy shocks



Notes. This figure plots a binscatter of daily firm demand for (16 < Exp < next FOMC) options against monetary policy shocks (MPS) on FOMC announcement days. Each dot represents approximately 7 of the 103 FOMC days in our sample period from January 3, 2011 to December 29, 2023. The red line plots the quadratic fit. Firm option demand is normalized to have mean zero and unit standard deviation in the entire sample including FOMC and non-FOMC days.

MPS.

Table 3 formalizes the nonlinear response by regressing FOMC day option demand for each investor category on dummies for the lowest (MPS Low), highest (MPS High), and intermediate (MPS Med) quintiles of MPS. These regressions do not include an intercept, so the coefficient estimates reflect the average demand within each MPS category.

In the lowest MPS quintile, firms sell an average of 26,357 option contracts, while their demand is statistically indistinguishable from zero in the other MPS ranges. This negative firm demand is primarily absorbed by customers and market makers. Notably, MPS Low is the only category where customer demand is significantly positive, and market maker demand is also positive. Broker-dealer demand in the MPS Low range is significantly positive but

Table 3
Nonlinear demand response to monetary policy shocks

	Firm	Broker-Dealer	Customer	Prof-Customer	Market-Maker
MPS Low	-26357.38***	1517.19***	11142.10**	2392.19	11305.90
	[-2.58]	[3.17]	[2.00]	[0.48]	[1.50]
MPS Med	-1692.58	612.24***	2553.69	2352.29***	-3825.65*
	[-0.69]	[2.67]	[1.47]	[2.75]	[-1.81]
MPS High	5436.70	-370.00	1889.65	-279.65	-6676.70
	[0.79]	[-1.36]	[0.30]	[-0.05]	[-0.85]
R^2	0.1236	0.0987	0.0302	0.0045	0.0605
Obs.	103	103	103	103	103

Notes. This table reports results from regressing daily net option demand on FOMC days aggregated by investor type on dummy variables for the lowest (MPS Low) and highest (MPS High) quintiles of MPS as well as for the range in between the two (MPS Med). The units are number of contracts. Net option demand is computed as buy minus sell volume. All regressions suppress the constant. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

relatively small, averaging 1,517 contracts, compared to the magnitude of firm demand.[9]

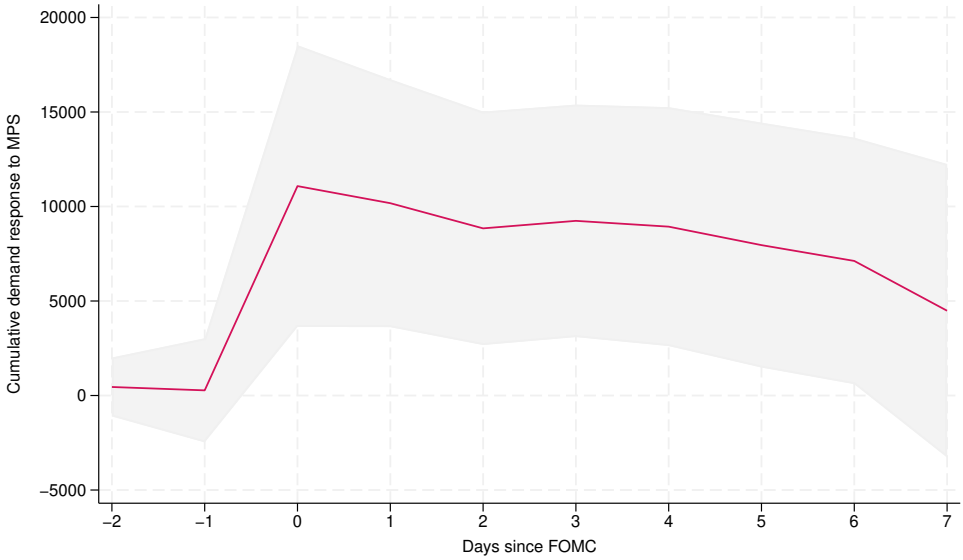
2.5 Persistence of firm demand response to monetary policy

To assess the persistence of the effect of monetary policy shocks on firms' option inventory, we calculate the cumulative net firm demand from two trading days before to seven trading days after the FOMC day for each option in the (16 < Exp < next-FOMC) category on an FOMC day. Importantly, each option is included in this category only once across the 103 FOMC days in our sample period. We then regress the cumulative demand on the MPS and plot the resulting coefficients in Figure 2.

The coefficient is effectively zero on days -2 and -1, indicating that firm option demand

[9]The zero lower bound (ZLB) for interest rates is binding during a large part of our sample period. However, the ZLB does not mechanically influence the direction of MPS because MPS represents changes in the market interest rate relative to expectations formed prior to FOMC announcements. For instance, FOMC members consistently anticipated the tightening to happen sooner than it actually did from 2012 to 2015, generating negative MPS when Fed policy remained unchanged (Cieslak (2018)).

Figure 2. Firm cumulative option demand response to monetary policy shocks



Notes. This figure plots the cumulative firm option demand's response to monetary policy shocks (MPS) from 2 trading days before to 7 trading days after the FOMC announcement. The red line plots the coefficient β_τ for $\tau \in \{-2, -1, ..., 7\}$ from the regression $\sum_{i=-2}^{\tau} \text{demand}_{t,i} = \alpha_\tau + \beta_\tau \text{MPS}_t + \epsilon_{t,\tau}$ where $\text{demand}_{t,i}$ is the firm demand on day $t+i$ for all options in our sample on FOMC day t. The units are number of contracts. Net option demand is computed as buy minus sell volume. The shaded area represents the 90% confidence interval of estimated coefficients.

during the two trading days before FOMC announcements do not predict the monetary policy shock on day 0. On the FOMC day itself (day 0), cumulative demand responds sharply to MPS, consistent with the findings in the third column of Table 2. For example, a one standard deviation negative MPS shock reduces net demand by over 10,000 option contracts.

If firms were to quickly repurchase the options sold on day 0, the cumulative demand response would revert to zero by day 1. However, Figure 2 shows that this is not the case. The impact of FOMC day trades in response to MPS persists, affecting firms' option inventory for up to seven trading days. This persistence suggests that, even if proprietary trading firms' option sales during monetary easing are driven by profit-seeking rather than increased

risk appetite, their new positions are maintained well beyond the FOMC day, extending to the end of next week.

In Appendix C, we show that firm demand for both calls and puts moves in the same direction in response to monetary policy shocks. Looser than expected monetary policy leads firms to adjust their positions, increasing their exposure to the risk of significant stock market movements, regardless of the direction.

2.6 Summary of evidence from daily data

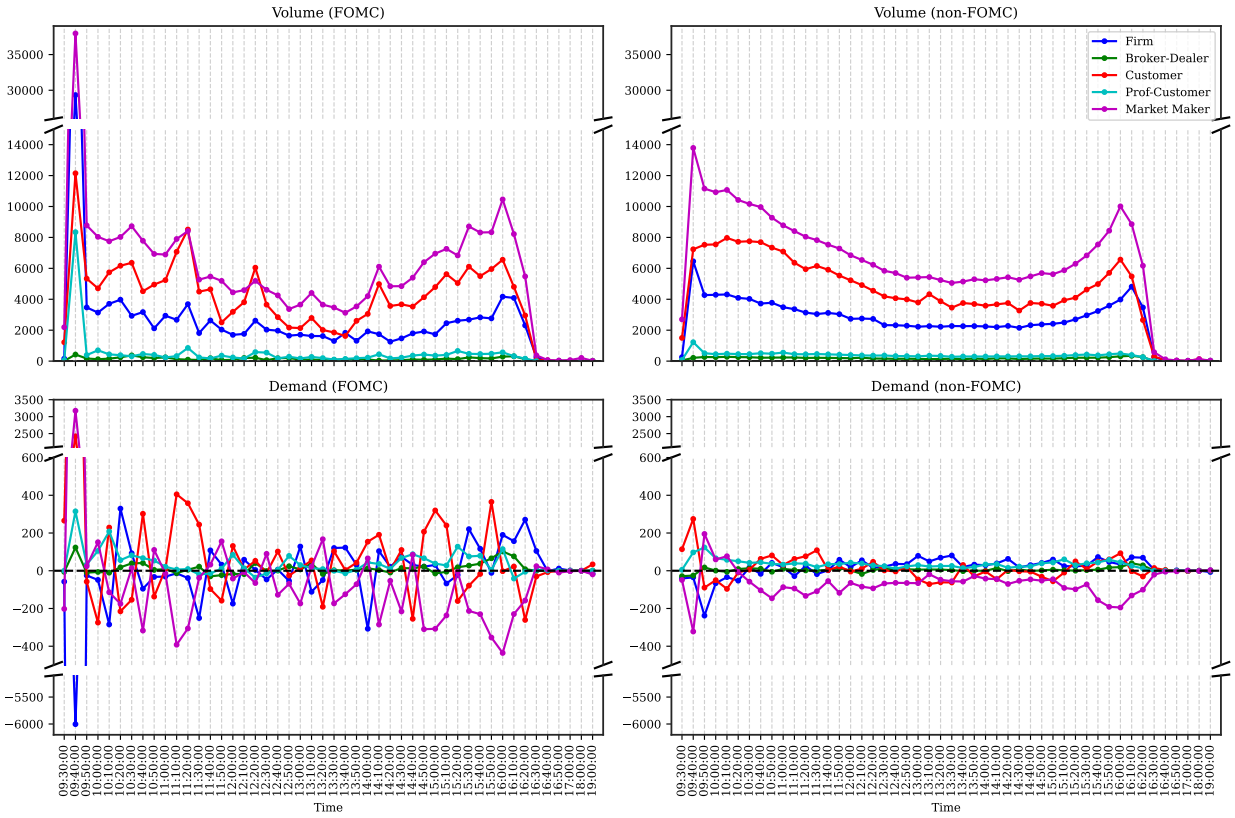
In summary, proprietary trading firms provide liquidity in the S&P 500 options market on FOMC days, particularly by acting as net sellers of S&P 500 index options maturing before next FOMC announcement. Accommodative monetary policy shocks further amplify this liquidity provision.

Our findings suggest that these dynamics may reflect increased risk-taking or informed trading around FOMC announcements. From a risk-taking perspective, looser monetary policy may enhance the willingness of financial intermediaries to take on more risk, consistent with Kashyap and Stein (2023). This could result in larger negative positions in S&P 500 options, as lower leverage costs increase intermediary wealth, reducing effective risk aversion (He and Krishnamurthy (2013), Kekre and Lenel (2022), Kilic, Zhang, and Zotov (2024)).

Alternatively, some proprietary trading firms may possess superior information about the impact of FOMC announcements on interest rates, as captured by Bauer and Swanson (2023a)'s MPS, or on other asset prices. Such information could arise from informal communication (Finer (2018), Vissing-Jorgensen (2019), Cieslak, Morse, and Vissing-Jorgensen (2019)), enabling firms to adjust their option positions in advance of the announcement in a way that is both profitable and predictive of its market impact.

These channels are not mutually exclusive; firm option demand could be driven by both

Figure 3. Average option demand and volume throughout the trading day



Notes. The figure plots the average trading volume (upper panels) and net demand (lower panels) at the 10-minute frequency for FOMC (left panels) and non-FOMC (right panels) days for options expiring after 16 days but before the next FOMCs (16 < Exp < next FOMC). The units are number of contracts. Net option demand is computed as buy minus sell volume. The sample period is from January 3, 2011 to December 29, 2023 out of which 103 are FOMC days and 3,165 are non-FOMC days.

informational advantages and changes in risk-taking behavior. High-frequency trade data is critical for assessing these effects, as it allows us to examine how option demand evolves throughout the FOMC day and whether trades correlated with MPS occur before or after the public release of the announcement. To this end, we next analyze intraday trading by proprietary firms and other investor types.

3 Intraday options trading and monetary policy

3.1 High frequency option demand and volume

We analyze intraday trading behavior by investor type on FOMC and non-FOMC days using intraday option trading volume data from CBOE. Figure 3 shows the average trading volume and net demand by investor type in 10-minute intervals throughout the trading day, beginning at 9:30 a.m. For instance, the values at 13:10:00 represent average trading volume and net demand from 1:00 p.m. to 1:10 p.m., across FOMC days (left panels) and non-FOMC days (right panels). Trades recorded at 9:30 a.m. reflect overnight activity from the previous day's market close to the current day's market open. As options are in zero net supply, net demand across all investor types sums to zero in each 10-minute interval.

Figure 3 reveals several patterns common to both non-FOMC and FOMC days. Option trading volume by firms, customers, and market makers dominates the overall trading activity in the S&P 500 options market on both types of days.[10] Trading volume for firms, customers, and market makers exhibits a U-shaped pattern throughout the trading day, similar to the documented stock market patterns in the literature (Jain and Joh (1988), Foster and Viswanathan (1993)). The absolute value of net demand is significantly smaller than trading volume across all investor categories. This difference arises because trading volume includes transactions where the buyer and seller are within the same investor category, while net demand reflects only cases where cumulative buys exceed sells or vice versa. Additionally, high-frequency trades involving the same option contract within a 10-minute interval increase trading volume but do not affect net demand.

Figure 3 also highlights striking differences in options trading patterns between FOMC

[10]Market makers typically exhibit negative net demand, consistent with their role as liquidity providers (Garleanu, Pedersen, and Poteshman (2009), Chen, Joslin, and Ni (2019), Fournier and Jacobs (2020)). Their net sales tend to increase toward the end of the trading day, beginning around 3:30 p.m. Professional customers show a brief spike in trading volume at 9:40 a.m. but contribute only a small fraction of the total trading volume for the rest of the day.

days and non-FOMC days. Trading volume in the first 10 minutes of the trading day (9:30 a.m. to 9:40 a.m., henceforth "morning") is significantly higher on FOMC days. For instance, the average trading volume of firms, representing proprietary traders, is four to five times greater on FOMC days than on non-FOMC days, while their trading volume patterns for the rest of the day are similar. Customers, professional customers, and market makers exhibit similarly large spikes in morning trading volume on FOMC days relative to non-FOMC days.

Net option demand also shows distinct spikes at 9:40 a.m. on FOMC days, while average net demand at the same time on non-FOMC days is relatively muted. Notably, average firm option demand in the morning on FOMC days is highly negative, while all other investor types exhibit larger positive morning demand compared to non-FOMC days. This significant morning spike in firm demand on FOMC days accounts for nearly all of the average negative firm demand observed on FOMC days, documented in Section 2.

In contrast, on non-FOMC days, firms' morning net demand is close to zero, with the only notable pattern being positive net demand from customers, which is offset by market makers. Firms become net sellers around 9:50 a.m. on non-FOMC days, but their net sales are relatively small (approximately 200 contracts) compared to the morning net sales on FOMC days, which average around 6,000 contracts.[11]

Appendix Table A.4 provides detailed insights into firm option demand during the morning period (9:30 a.m. to 9:40 a.m.) and the rest of the trading day on FOMC and non-FOMC days. Consistent with Figure 3, Panel A of Appendix Table A.4 reveals that the first 10 minutes account for 14% of firm trading volume on FOMC days, compared with 3% on non-FOMC days. Panel B shows that the difference in firm option demand between FOMC and non-FOMC days is strikingly similar when comparing daily data (804 vs. -5,337) and the

[11] Using transaction level data from CBOE's OPRA as an alternative, we calculate intraday option trading volume and show that the patterns are very similar across data sources (Appendix Figure A.1). Appendix Figure A.2 shows that intraday median effective spreads for options in our sample, calculated using OPRA data, spike at the market open on FOMC days compared to non-FOMC days. This indicates that trading at the market open on FOMC days does not provide a liquidity advantage.

Table 4

The response of firm demand to monetary policy in the morning and the rest of the day

	Morning			Rest		
	All options	Puts	Calls	All options	Puts	Calls
			Panel A: All days			
FOMC	−5968.16**	−5047.45**	−920.70**	−173.34	−648.32	474.99
	[−2.13]	[−2.12]	[−2.06]	[−0.18]	[−0.72]	[0.89]
MPS	9815.04**	8300.52**	1514.52**	512.88	503.71	9.17
	[2.26]	[2.23]	[2.36]	[0.73]	[0.72]	[0.02]
Cons.	−34.99	−58.40	23.41	839.48**	67.56	771.93***
	[−0.14]	[−0.27]	[0.53]	[2.07]	[0.18]	[5.56]
R^2	0.0184	0.0183	0.0156	0.0000	0.0001	0.0002
Obs.	3268	3268	3268	3268	3268	3268
			Panel B: FOMC days			
MPS	9815.04**	8300.52**	1514.52**	512.88	503.71	9.17
	[2.26]	[2.23]	[2.36]	[0.73]	[0.72]	[0.02]
Cons.	−6003.15**	−5105.85**	−897.29**	666.15	−580.77	1246.91**
	[−2.14]	[−2.14]	[−2.00]	[0.71]	[−0.66]	[2.40]
R^2	0.1053	0.1046	0.0990	0.0029	0.0032	0.0000
Obs.	103	103	103	103	103	103

Notes. Panel A reports results from regressing daily firm net option demand for all options, puts, and calls on a dummy variable for FOMC days and the monetary policy shock (MPS) using data at 10-minute frequency. Morning refers to 9:30 a.m.–9:40 a.m. Rest of day refers to 9:40 a.m.–4:15 p.m. Panel B runs the regression using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

morning period from 9:30 a.m. to 9:40 a.m. (-35 vs. -6,003). In contrast, the difference is much smaller during the rest of the trading day (839 vs. 666). This pattern holds for both puts and calls, as shown in Panels C and D of Appendix Table A.4. In summary, on FOMC days, negative firm demand is larger and more pronounced in the morning compared to the rest of the day or to non-FOMC days.

3.2 Monetary policy shocks and morning trades

Our intraday trading evidence thus far highlights distinctive patterns on FOMC days compared to non-FOMC days. The concentration of trading volume and the pronounced negative firm demand during the morning of FOMC days raise an important question: are these morning trades related to monetary policy shocks that will be revealed later in the day?

In our sample period, most scheduled FOMC announcements (86 out of 103) occurred at 2:00 p.m., while announcements in 2011 and 2012 alternated between 11:30 a.m. and 2:15 p.m. The monetary policy shocks (MPS) used in our analysis are derived from 30-minute Eurodollar futures movements, measured from 10 minutes before to 20 minutes after the announcement. These shocks capture unexpected changes in interest rates driven by FOMC announcements (Bauer and Swanson (2023a)). Noteably, this high frequency change should be unknown to the public as of 9:40 a.m., when firms' option trades on FOMC days are concentrated.

Table 4 examines the relationship between firm option demand during the morning period (9:30 a.m. to 9:40 a.m.) and the rest of the trading day with monetary policy shocks. Panel A shows that all significant effects of monetary policy documented in Section 2 are driven by morning trades. The loading of firm option demand, for both puts and calls, on the FOMC dummy is significantly negative for morning trades and statistically indistinguishable from zero for the rest of the day. This finding aligns with the evidence presented in Figure 3 and Appendix Table A.4. Panel B of Table 4 focuses exclusively on FOMC days. The results in the first column reveal that firm option demand in the morning of FOMC announcement days predicts monetary policy shocks, with an R^2 of 10.5%. Firms are more likely to sell options, both puts and calls, in the morning if the Eurodollar futures market later interprets the FOMC announcement as more accommodative than expected. In contrast, trades during

the rest of the day show no significant relationship with monetary policy shocks.[12]

The observation that firms sell both puts and calls ahead of accommodative monetary policy shocks suggests that their trades are primarily driven by expectations of an upcoming decline in volatility, rather than a directional bet on an S&P 500 index spike in response to the accommodative monetary policy shock. In other words, the overall trading position has no clear directional exposure to the underlying index because the opposing sensitivities (deltas) of puts and calls to the index cancel each other out. Instead, firms appear to trade with the intent to profit from the positive correlation between monetary policy shocks (MPS) and changes in the *VIX* (Bauer, Bernanke, and Milstein (2023), Kilic, Zhang, and Zotov (2024)). When monetary policy shocks are accommodative, volatility typically declines significantly. This benefits the short positions established in the morning, as falling put and call prices, both of which are positively exposed to underlying volatility due to options' vega, result in gains.

Finally, we examine the role of option inventory prior to FOMC days in Appendix D.2. The results show that firms end the day prior to FOMC announcements with higher inventory levels, but these levels do not predict their morning option demand on FOMC days and do not relate significantly to monetary policy shocks. These findings suggest that the information driving firms' morning trades on FOMC days becomes available to proprietary traders between the market close on the prior day and the market open on the FOMC day.

4 Option prices and option demand on FOMC days

Given that monetary policy shocks are measured using Eurodollar futures in the tight window around the announcement, firms have the capability to predict the high frequency response

[12]This result is robust to using orthogonalized MPS measures from Bauer and Swanson (2023b) (see Appendix Table A.5).

of market interest rates to FOMC news. However, for option traders, the relevant asset prices are option prices, and their profits from utilizing superior information should be reflected in the returns derived from option trades. Therefore, we next investigate whether morning option trades on FOMC days predict option price fluctuations in the rest of the day. We first use the intraday movements in the squared *VIX* index which is a portfolio of S&P 500 index options with close to one-month to maturity similar to our option sample.

Appendix Table A.6 shows the summary statistics for the percentage change in VIX^2 from prior day's close to current day's 9:41 a.m. (on), from current day's 9:41 a.m. to market close (day), and in the 30-minute window around FOMC announcements ($fomc$):[13]

$$\Delta VIX^2_{t,on} = VIX^2_{t,9:41} / VIX^2_{t-1,close} - 1$$
$$\Delta VIX^2_{t,day} = VIX^2_{t,close} / VIX^2_{t,9:41} - 1$$
$$\Delta VIX^2_{t,fomc} = VIX^2_{t,+20min} / VIX^2_{t,-10min} - 1$$

On average, VIX^2 drops 3% in the FOMC announcement window reflecting the resolution of monetary policy uncertainty. In other words, options become cheaper around the announcement on average. VIX^2 also drops overnight and during the rest of the trading hours on FOMC days after 9:41 a.m. We include the price movement until 9:41 a.m. in the overnight return to use it as a proxy for the period of potential price impact from morning trades.

Table 5 shows the relation between ΔVIX^2 and firm option demand on FOMC announcement days. Panel A shows that a one standard deviation increase in firms' morning option demand is associated with a 66 basis point higher overnight return. This result may reflect the price impact of firm trades on FOMC days. Since the *VIX* index is based on quotes rather than transaction prices, firm trades between 9:30 a.m. and 9:40 a.m. might already

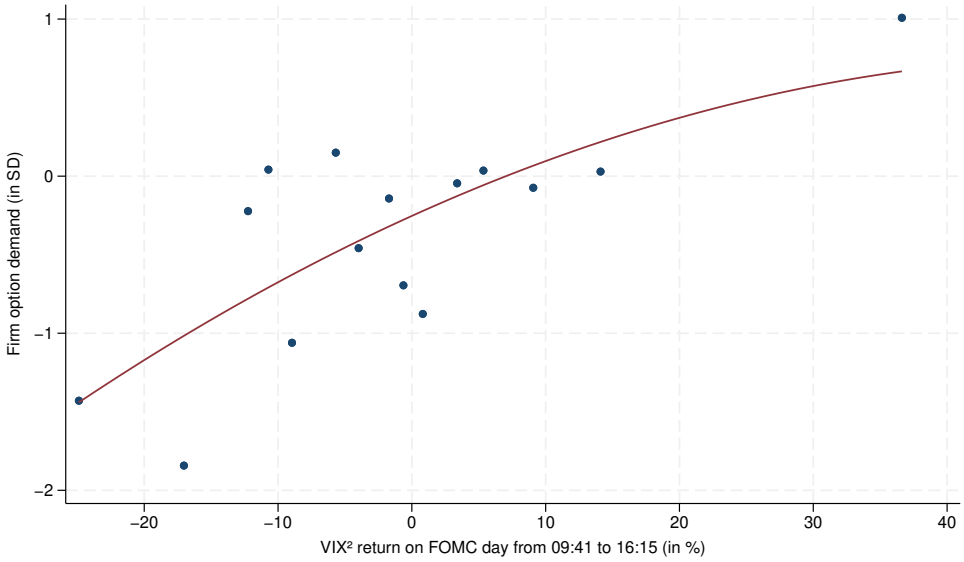
[13] Assuming that the set of options in the *VIX* calculation remain largely the same, the percentage changes in VIX^2 can be interpreted as the return on an option portfolio that mimics a 1-month S&P 500 variance swap. Therefore, we occasionally refer to ΔVIX^2 as a return.

Table 5
Firm option demand in the morning and VIX^2 returns on FOMC days

	ΔVIX^2_{on}	ΔVIX^2_{on}	ΔVIX^2_{fomc}	ΔVIX^2_{fomc}	ΔVIX^2_{day}	ΔVIX^2_{day}
Panel A: Only demand						
Firm demand	0.66*		0.80**		1.58***	
	[1.91]		[2.00]		[2.85]	
Demand Low		-2.73		-5.30***		-8.00***
		[-1.57]		[-3.32]		[-3.87]
Demand Med		-0.06		-2.25***		0.39
		[-0.04]		[-3.42]		[0.19]
Demand High		-1.38		-2.96*		-0.31
		[-1.03]		[-1.88]		[-0.12]
Cons.	-0.60		-2.70***		-0.84	
	[-0.65]		[-4.42]		[-0.57]	
R^2	0.0201	0.0130	0.0687	0.0374	0.0482	0.0520
Obs.	103	103	103	103	103	103
Panel B: Including MPS						
MPS	-0.61	-0.18	1.94***	2.20***	-0.17	0.70
	[-1.12]	[-0.34]	[3.25]	[3.47]	[-0.14]	[0.55]
Firm demand	0.76**		0.49		1.61***	
	[2.07]		[1.24]		[2.75]	
Demand Low		-2.75		-5.06***		-7.92***
		[-1.58]		[-4.05]		[-4.02]
Demand Med		-0.05		-2.36***		0.35
		[-0.04]		[-3.62]		[0.17]
Demand High		-1.39		-2.86*		-0.28
		[-1.03]		[-1.83]		[-0.11]
Cons.	-0.57		-2.82***		-0.83	
	[-0.61]		[-4.80]		[-0.56]	
R^2	0.0238	0.0133	0.1563	0.1624	0.0483	0.0543
Obs.	103	103	103	103	103	103

Notes. This table reports results from predictive regressions of ΔVIX^2_{on}, ΔVIX^2_{fomc}, and ΔVIX^2_{day} on firm option demand in the morning (9:30 a.m.–9:40 a.m.) and on dummies for lowest (Demand Low), highest (Demand High) quintiles of firm demand in the morning as well as a dummy for intermediate values of demand (Demand Med) on FOMC days. Firm option morning demand is normalized to have mean zero and unit standard deviation in the entire sample including FOMC and non-FOMC days. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Figure 4. Firm option demand in the morning and VIX^2 return in the rest of the day



Notes. This figure plots a binscatter of morning firm option demand on FOMC days (9:30 a.m. to 9:40 a.m.) against the rate of change in VIX^2 from 9:41 a.m. to market close at 4:15 p.m. Each dot represents approximately 7 of the 103 FOMC days in our sample period from January 3, 2011 to December 29, 2023. The red line plots the quadratic fit. Firm option demand is normalized to have mean zero and unit standard deviation in the entire sample including FOMC and non-FOMC days.

influence quotes starting at 9:30 a.m. However, this relationship is statistically weaker compared to the predictive relationship between morning trades and changes in option prices discussed below. This weaker relationship is expected because firm net demand, even if informative about the upcoming shock, remains quite small relative to overall trading volume as can be seen in Figure 3, making a large price impact unlikely.

Strikingly, firm morning trades predict the change in VIX^2 in the FOMC announcement window (80 basis points) and in the rest of the trading day from 9:41 a.m. to market close (158 basis points). The results also show that the effects are primarily driven by large and negative firm option trades in the morning. Panel B controls for the MPS and repeats the regressions in Panel A of Table 5. MPS and the contemporaneous change in VIX^2 in the FOMC announcement window leave no room for predictability by firms' morning demand.

However, firms' morning demand can predict option price changes throughout the day, even after accounting for MPS, indicating that proprietary trades anticipate the market's reaction to FOMC news beyond what MPS captures. This pattern suggests that firms have the ability to predict option market movements in the rest of the day and change their option positions accordingly in the morning on FOMC days. When they predict monetary easing and sell options, option prices depreciate and firms benefit from their sales before the decline.

Figure 4 illustrates the nonlinearity in the relation between the rate of change in VIX^2 in the rest of the day and firms' morning trades. Negative returns on the S&P 500 option portfolio correspond to particularly negative firm option demand in the morning, explaining our finding in Section 2 that large option sales by firms are concentrated in cases of most accommodative monetary policy announcements. Such announcements lower option prices significantly consistent with Bauer, Bernanke, and Milstein (2023) and firms are able to identify the right time to sell options in their inventory before they lose value in the rest of the day.

5 Firm option demand and determinants of asset price response to monetary policy

In this section, we examine whether the predictability of monetary policy shocks using proprietary firms' morning option demand is driven by other drivers of asset price response to monetary policy shocks studied in the literature.

5.1 Monetary policy uncertainty from interest rate options

We investigate whether the information in firms' morning option demand on FOMC days prevails when monetary policy uncertainty (MPU) is high, using the option implied MPU

by Bauer, Lakdawala, and Mueller (2022). These authors apply CBOE's *VIX* methodology to Eurodollar futures to obtain market-based measures of MPU at the daily frequency. [14]

For each scheduled FOMC meeting, we analyze the MPU on the day preceding the announcement to assess the market's uncertainty about the Fed's upcoming decision. Across 103 FOMC days in our sample period, the average MPU on the day before the announcement is 21.0%. Furthermore, MPU is highly right-skewed before FOMC days, with a skewness of 3.21. The median MPU of 7.1% is notably lower than the mean, indicating significant asymmetry.[15] We verify MPU's ability to predict large unexpected monetary policy shocks by regressing the absolute value of the normalized MPS, |MPS|, on MPU (Column 1 of of Appendix Table A.7), validating its use as a conditional volatility measure for Eurodollar futures rates.

Next, we investigate the information content of MPU and firms' option demand for positive and negative MPS. To do so, we compute $|\text{MPS}|^+ = |\text{MPS}| \text{ x } (\text{MPS} > 0)$ and $|\text{MPS}|^- = |\text{MPS}| \text{ x } (\text{MPS} < 0)$, which are equal to |MPS| if MPS is positive and negative, respectively, and zero otherwise. Column 1 of Table 6 shows that MPU predicts the size of positive MPS but |Demand| does not, where Demand is the firms' normalized morning option demand on the FOMC day. However, |Demand| has strong predictive power for negative MPS shocks controlling for MPU. Hence, the predictive abilities of MPU and |Demand| for |MPS| are distinct. While both higher option-implied MPU and greater firm option trading activity predict larger movements in MPS, MPU is more effective at predicting tightening shocks, whereas the large firm option demand regardless of its sign is associated with upcoming

[14]Updated data is available from the San Francisco Fed's Center for Monetary Research website. The underlying for the options is the 3-month LIBOR rate until September 2022 and the SOFR rate starting in October 2022. We opt for the interest rate *VIX* that is computed for the 6-month maturity which is obtained by linearly interpolating conditional variances as in CBOE's computation method for the *VIX* index.

[15]The average *VIX* index on the same set of days is 18.3%, with a skewness of 1.56.

Table 6
Predicting absolute positive/negative MPS shocks on FOMC days

	$\|\text{MPS}\|^+$	$\|\text{MPS}\|^-$
	(1)	(2)
MPU	0.23*	0.16**
	[1.82]	[2.16]
|Demand|	−0.01	0.27***
	[−0.16]	[3.25]
Cons.	0.35***	0.29***
	[5.86]	[5.53]
R^2	0.1263	0.2352
Obs.	103	103

Notes. This table reports results from regressing absolute value of normalized monetary policy shock (|MPS|) multiplied by a dummy for MPS > 0 in column (1) or MPS < 0 in column (2) on monetary policy uncertainty (MPU) from Bauer, Lakdawala, and Mueller (2022), and the absolute value of firm option demand between 9:30 a.m. and 9:40 a.m. (|Demand|). Both independent variables are normalized to have zero mean and unit standard deviation on FOMC announcement days. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

monetary easing shocks beyond the predictive ability of MPU.[16]

5.2 Interest rate skewness

Section 3 demonstrates that firms' morning option demand can predict monetary policy shocks, raising the question of whether firms have an informational advantage over other market participants regarding the upcoming interest rate shock induced by the Fed. Measures of forward-looking volatility are not intended to capture asymmetry in interest rate shocks. To quantify this asymmetry, Bauer and Chernov (2024) compute option-implied interest rate skewness (ISK) using options on 10-year Treasury Note futures. In addition to their findings

[16]In Appendix E, we further show that firms' option demand in the morning of FOMC days is significantly related to the degree of MPU resolution on those days. We also confirm that all results remain robust when using the 15th-85th percentile range of interest rates from Mertens and Williams (2021) as the MPU measure.

Table 7
Predicting MPS using interest rate skewness and firm option demand

	(1)	(2)	(3)	(4)
ISK	0.77***		0.61***	
	[3.59]		[2.83]	
Demand		0.32***	0.27***	0.25***
		[3.46]	[3.01]	[3.06]
Cons.	-0.05	-0.00	-0.04	0.00
	[-0.56]	[-0.00]	[-0.46]	[0.00]
R^2	0.0900	0.1053	0.1583	0.0710
Obs.	103	103	103	103

Notes. This Table reports results from regressing monetary policy shocks (MPS) on interest rate skewness (ISK) on the day before the FOMC announcement and firm option demand between 9:30 a.m. and 9:40 a.m. (Demand) normalized to have zero mean and unit standard deviation on FOMC announcement days. Demand in Column 4 is the orthogonal component of firm demand with respect to ISK. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

on the role of conditional skewness for bond risk premia and forecast errors, they show that ISK measured on days prior to FOMC announcements predicts MPS. They argue that some variation in MPS is predictable, raising questions about its suitability as a shock measure. We investigate whether the predictive abilities of firm option demand and ISK for MPS are distinct.

Column 1 of Table 7 shows that lagged ISK predicts MPS during our sample period from 2011 to 2023, consistent with the findings of Bauer and Chernov (2024) in a longer sample. While firms' morning option demand also predicts MPS (Column 2), ISK and demand capture distinct variations in MPS (Column 3), with only minor differences in predictive coefficients between the univariate and bivariate regressions. Moreover, firm option demand orthogonalized by ISK remains a significant predictor (Column 4). This finding is notable because Bauer and Chernov (2024) demonstrate that ISK's predictive power for MPS is largely driven by loosening monetary policy shocks, similar to firms' option demand. Our

Table 8
Predicting MPS using firm option demand: FOMCs with other macro announcements

	Daily	Morning	Rest
Panel A: No macro announcement (1 day)			
Demand	0.34***	0.32***	0.08
	[3.54]	[3.51]	[1.08]
Cons.	0.05	0.05	0.05
	[0.49]	[0.50]	[0.47]
R^2	0.1199	0.1079	0.0069
Obs.	80	80	80
Panel B: No macro announcement (2 days)			
Demand	0.39***	0.37***	0.09
	[5.02]	[4.94]	[1.15]
Cons.	-0.07	-0.07	-0.07
	[-0.75]	[-0.72]	[-0.68]
R^2	0.2125	0.1915	0.0109
Obs.	65	65	65

Notes. This table reports results from regressing monetary policy shocks (MPS) on firm option demand (Demand) normalized to have zero mean and unit standard deviation on FOMC announcement days. We condition on FOMC announcements if there was no other macroeconomic announcement on the FOMC day (1 day) and the preceding day (2 days). Morning refers to 9:30 a.m.–9:40 a.m. Rest of day refers to 9:40 a.m.–4:15 p.m. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

results indicate that, although both predict loosening shocks, firms' demand predicts variations in MPS not captured by ISK. Thus, the informational advantage of firms regarding the direction and magnitude of upcoming interest rate shocks is not fully reflected in the information priced into Treasury Note options.

5.3 Other macroeconomic news

The asset pricing literature has documented several distinct patterns around FOMC and other macroeconomic announcements such as inflation and employment. In particular, stock

market returns are significantly higher on announcement days relative to other days and the stock market index drifts upward prior to FOMC announcements (Savor and Wilson (2014), Lucca and Moench (2015)). Furthermore, Hillenbrand (2023) shows that the secular decline in long-term interest rates is also attributable to bond price movements around FOMC announcements. In recent work, Alam (2023) documents that these patterns about the stock market's response are driven by a small subset of FOMC announcements that are preceded by other macroeconomic announcements. This finding is particularly relevant for our work because most macroeconomic announcements occur prior to trading hours, raising the question whether morning option trades by firms which predict MPS are informed by other relevant announcements such as inflation and GDP.

Following Alam (2023), we compile a dataset of releases on employment, consumer price index (CPI), industrial production and capacity utilization, producer price index (PPI), and gross domestic product (GDP) including revisions. Out of 3,268 trading days in our sample period, 731 days include at least one macroeconomic announcement excluding FOMC announcements. Furthermore, 23 out of 103 FOMC announcement days in our sample period feature another macroeconomic announcement, and 38 FOMC days feature at least one other macroeconomic announcement either on the FOMC day or the preceding day. Appendix Table A.8 shows that our results from the daily analysis (Table 1) remain largely unchanged when we omit all trading days that are paired with a macroeconomic data release.

Importantly, the predictive power of firm option demand in the morning for MPS holds when the sample is restricted to FOMC days without another macroeconomic data release as shown in Table 8. A one standard deviation increase in firms' morning demand for options predicts a 0.32 standard deviations higher MPS on FOMC days with no other macro announcement on the same day, and a 0.37 standard deviation when there is also no other data release on the previous day. Hence, we conclude that our results are driven by FOMC

announcements themselves rather than other macroeconomic announcements.

6 Inspecting the mechanism

In this section, we investigate the content of proprietary trading firms' informational advantage prior to FOMC meetings.

6.1 Monetary shocks and information shocks

Does the predictive power of firm option demand stem from information advantages regarding the Fed's monetary policy decisions as an exogenous shock to the economy, or the Fed's economic outlook? The interpretation of monetary policy shocks in New Keynesian models operates through the real effects of interest rate shocks in an economy with nominal rigidities (e.g., Christiano, Eichenbaum, and Evans (2005)). In this framework, upon an expansionary monetary policy shock, prices do not adjust quickly, leading to lower real interest rates which can stimulate economic activity. Monetary policy announcements also reveal several other pieces of information that can impact the stock market. For instance, information from the Fed resulting in lower market interest rates may be related to Fed's lower growth expectations and the market's accompanying expectation of low interest rates going forward (Nakamura and Steinsson (2018)). In this case, the monetary policy announcement's role as an information shock may dominate the policy news, leading to lower stock prices despite the accommodating stance of monetary policy.

High frequency comovement between interest rates and stock market returns are informative about whether the financial market response to the announcement is dominated by the Keynesian or the information channel (Cieslak and Schrimpf (2019), Jarociński and Karadi (2020)). For example, a negative MPS may lead to a negative S&P 500 response if the accommodative policy news is seen as signaling lower growth expectations. However, the stock

market may react positively to a negative MPS if the accommodative news is perceived as improving financial conditions, boosting growth expectations, and lowering discount rates for listed firms.

We investigate whether firm option demand's predictive power for MPS is driven by Keynes or information shocks. To do so, we label announcements where the change in S&P 500 E-Mini futures and orthogonalized MPS from Bauer, Bernanke, and Milstein (2023) in the 30-minute announcement window have opposite signs as "Keynesian shocks", and announcements with the same sign are "information shocks". Out of 103 scheduled FOMC announcements in our sample period, 57 are classified as Keynesian shocks and 46 as information shocks. We observe that MPS is more volatile among Keynesian shocks compared to information shocks.[17]

Table 9 presents results from regressions of firm option demand on MPS interacted with a dummy for Keynesian shocks (KEYN). The first column shows that daily option demand has an insignificant negative correlation with MPS on FOMC days classified as an information shock. The positive average relation between firm demand and MPS documented in Section 2 is entirely driven by Keynesian shocks. Furthermore, consistent with our results in Section 3, the effect is entirely driven by morning trades.

We further examine the behavior of firm option demand in cases of Keynesian and information shocks in Appendix F. In particular, we show that the predictive power of firm option demand in the morning for MPS is driven by Keynesian shocks. Hence, proprietary trading firms engage in more option selling in the morning when MPS later in the day will be accommodative and it will spur a positive stock market response. Interestingly, firms' morning trades' ability to predict the change in VIX^2 in the announcement window and in the rest of the day holds with both types of MPS. This result can again be understood with

[17] In the Keynesian subsample, the standard deviation of normalized orthogonalized MPS is 1.25 compared to 0.57 among information shocks.

Table 9
Firm option demand and monetary policy: Keynesian vs. information shocks

	Daily	Morning	Rest
KEYN	-5115.71	-5817.75	702.04
	[-0.93]	[-1.12]	[0.37]
$MPS^{\perp}$	-7960.08	-8723.34	763.25
	[-1.20]	[-1.57]	[0.36]
KEYN x $MPS^{\perp}$	19559.79**	20055.82***	-496.03
	[2.46]	[2.81]	[-0.22]
Cons.	-2281.39	-2553.33	271.94
	[-0.69]	[-0.93]	[0.19]
R^2	0.1328	0.1414	0.0028
Obs.	103	103	103

Notes. This table reports results from regressing firm option demand on orthogonalized monetary policy shocks $MPS^{\perp}$ interacted with a dummy for Keynesian shocks (KEYN). We label announcements where the change in S&P 500 E-Mini futures and $MPS^{\perp}$ from Bauer and Swanson (2023b) in the 30-minute announcement window have opposite signs as "Keynesian shocks", and "Information shocks" otherwise. Out of 103 scheduled FOMC announcements in our sample period, 57 are classified as Keynesian shocks and 46 as information shocks. Morning refers to 9:30 a.m.–9:40 a.m. Rest of day refers to 9:40 a.m.–4:15 p.m. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

the example of a large negative MPS. If the shock is Keynesian, firms tend to sell options in the morning and, upon the announcement, *VIX* drops and the S&P 500 index rises. Before information shocks, firms do not engage in option sales in the morning and *VIX* tends to rise while the S&P 500 index declines as we show in Appendix F. In sum, firms appear to predict market movements well in both cases while the effects are quantitatively stronger in case of Keynesian shocks. The fact that our results are driven by Keynesian shocks suggests that the superior information held by proprietary traders is likely about the Fed's influence on interest rates rather than the Fed's economic outlook.

6.2 Federal funds rate changes and forward guidance

Which information that induce monetary policy shocks are predictable using firms' option trades in the morning of FOMC days? The commonly known policy tool of the Fed is the Federal Funds Rate (FFR) which determines the overnight lending rate in the financial sector. Out of 103 FOMC announcements in our sample period, the Fed changed the target policy rate in 23 cases while the other 80 meetings did not result in a policy rate change. In Table 10, we show that FOMC days with no change in FFR drive our results. Daily firm option demand is positively correlated with MPS only on these days (Panel A) while the correlation is essentially zero on other FOMC days (Panel B).

MPS captures not only shocks to the current FFR rate, but also shocks to the future path of policy actions (Gürkaynak, Sack, and Swanson (2005)). Panel B of Appendix Table A.9 shows that firm morning demand indeed predicts the path component rather than the target rate component of MPS based on updated data from Acosta, Brennan, and Jacobson (2024) that uses the decomposition in Gürkaynak, Sack, and Swanson (2005).

Taken together, these results suggest that the information in MPS predicted by proprietary trading firms is about the Fed's policy communication about future actions rather than the imminent changes in the policy rate. A concrete policy tool that has been used since 2012 is the release of dot plots as part of the Summary of Economic Projections (SEP) published along with the FOMC statement. The SEP includes FOMC meeting participants' expectations about macroeconomic variables such as GDP growth and inflation as well as the dot plot that refers to forecasts of the FFR in the short and the long run.

We collect data from 2012 to 2023 on which of the 95 FOMC statements have an SEP and dot plot release from the Fed's website, since 2012 is the first year that the Fed introduced dot plots. On average, the net option demand of proprietary firms in this period in the morning of FOMC days is -7,440 contracts. Strikingly, almost all of the variation in option demand

Table 10

Predicting monetary policy shocks using firm option demand conditional on FFR change

	Daily	Morning	Rest
Panel A: No rate change			
Demand	0.35***	0.34***	0.05
	[3.58]	[3.76]	[0.81]
Cons.	-0.11	-0.11	-0.12
	[-1.41]	[-1.42]	[-1.29]
R^2	0.2200	0.2119	0.0048
Obs.	80	80	80
Panel B: Rate change			
Demand	-0.14	-0.27	0.01
	[-0.47]	[-0.60]	[0.06]
Cons.	0.42	0.42	0.41
	[1.50]	[1.52]	[1.45]
R^2	0.0024	0.0053	0.0001
Obs.	23	23	23

Notes. This table reports results from regressing monetary policy shocks (MPS) on firm option demand (Demand) normalized to have zero mean and unit standard deviation on FOMC announcement days. We report the results in two subsamples: FOMCs without Federal Funds Rate (FFR) changes (Panel A) and with rate changes (Panel B). Morning refers to 9:30 a.m.–9:40 a.m. Rest of day refers to 9:40 a.m.–4:15 p.m. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

stems from the 48 FOMC days with an SEP and dotplot release. Panel A of Table 11 shows that the average option demand is -164 with a standard deviation of 1604 on FOMC days without SEP, while the average is -14,650 with a standard deviation of 40,922 on FOMC days with SEP. Hence, firm net demand is typically close to zero in the morning of FOMC days where no release about concrete projections for macroeconomic variables and the FFR rate path are expected.

Panel B of Table 11 reports results from predictive regressions of the MPS on firms' option demand in the morning on FOMC days with and without an SEP release. The analysis

Table 11

Predicting monetary policy shocks on FOMC days with Summary of Economic Projections

	All	SEP Yes	SEP No
Panel A: Summary statistics			
Mean	-7440.17	-14650.23	-164.13
SD	29868.37	40922.09	1603.77
Min	-129947	-129947	-5151
Max	86344	86344	4904
Panel B: Predicting MPS shocks			
Demand	0.31***	0.34***	0.87
	[2.94]	[2.92]	[0.59]
Cons.	0.00	0.15	−0.24
	[0.00]	[0.79]	[−0.80]
R^2	0.0870	0.1178	0.0088
Obs.	95	48	53

Notes. Panel A reports summary statistics for firm morning option demand. Panel B reports results from regressing monetary policy shocks (MPS) on firm option demand (Demand) normalized to have zero mean and unit standard deviation on FOMC announcement days. Morning refers to 9:30 a.m.–9:40 a.m. Summary of Economic Projections (SEP) Yes refers to the publication of a dot plot, which is published together with the FOMC statement, while SEP No means no such release. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2012 to December 29, 2023.

reveals that all of the predictability comes from FOMC announcements with an SEP. While the predictive coefficient is large on days without SEP, it is not statistically significant and economically negligible given that there is very little variation in firm demand on these days to start with as shown in Panel A.

In summary, the predictive power of firm trades in the first minutes of FOMC days for MPS suggests that certain financial intermediaries may have access to information about upcoming FOMC announcements and can anticipate the market's reaction to Fed news. Despite the existence of a blackout period, the two-day structure of FOMC meetings introduces vulnerabilities to informal communication of policy overnight, consistent with evidence of

leaks in Cieslak, Morse, and Vissing-Jorgensen (2019). These patterns could be driven by intentional informal communication from the Fed (Vissing-Jorgensen (2019)) or increased interactions between policymakers and traders in financial institutions (Finer (2018)). Notably, our results are driven by FOMC days where there was no actual change in the policy rate, and market interest rates responded solely to Fed communication. As a result, the predictability stems from the path component of MPS. In particular, firm option trading activity is concentrated among FOMC days with an SEP release that communicates the FOMC members' forecasts about future interest rates. Advance access to this easily interpretable information prior to trading hours on the second day of the FOMC meeting might create profitable trading opportunities, questioning the costs of dot plots as a forward guidance tool used by the Fed (e.g., Cieslak, Malamud, and Schrimpf (2020)).[18]

6.3 Discussion of FOMC day examples

In this section, we discuss representative FOMC days that align with the patterns documented in our empirical analysis. The first example is March 18, 2015. Referring to the dot plot released with the FOMC statement, the Fed chair mentioned in the press conference that "Compared with the projections made in December, most participants lowered their path for the federal funds rate, consistent with the downward revisions made to the projections for GDP growth and inflation as well as somewhat lower estimates of the longer-run normal unemployment rate." Following the announcement, The Wall Street Journal (WSJ) reported that the announcement "boosted confidence that zero interest rate policy will stay in place for longer." This announcement represented a -1.94 standard deviation monetary policy shock, and the S&P 500 rose by 1.2% over the course of the day. Additionally, ΔVIX^2_{day}

[18] According to the Fed's website, initial projections (SEP) are due by the end of the day on the Friday before the FOMC meeting. Policymakers may revise their projections at any time until the morning of the second day of the meeting. Once the projections are finalized, the charts and figures are assembled for public release.

was 19.2%, indicating a significant decline in option prices from 9:41 a.m. to 4:15 p.m. On this day, firm net demand for options was -129,447 contracts between 9:30 a.m. and 9:40 a.m., despite firm inventory from the previous day being just 57 contracts. Firms' sales were absorbed by customers (73,135 contracts) and market makers (41,558 contracts), resulting in substantial gains for firms as option prices fell throughout the day.

Next, we examine the numbers for March 16, 2016 which also featured an SEP. The press conference minutes refer to interest rate projections mentioning that "In other words, most Committee participants now expect that achieving economic outcomes similar to those anticipated in December will likely require a somewhat lower path for policy interest rates than foreseen at that time". Following the release of the Federal Reserve's statement, WSJ reported that "the Federal Reserve laid out a more cautious plan for interest-rate increases," after deciding to keep the policy rate unchanged. This announcement resulted in a -2.34 standard deviation monetary policy shock, driven by changes in market participants' interest rate expectations. The S&P 500 rose by 0.6% over the day, while ΔVIX^2_{day} was 9.4%, indicating a significant decline in the market's risk perception and option prices. Consistent with the previous example, firm net demand for options was -107,794 contracts between 9:30 a.m. and 9:40 a.m., representing the sale of nearly all options in inventory from the previous day (111,549 contracts). Customers (53,736 contracts) and market makers (54,038 contracts) were the primary buyers of these trades.

The final example of accommodative monetary policy is June 19, 2019, which features a -2.31 standard deviation MPS. The dot plot in the corresponding SEP included predictions of declining rates which the Fed chair referred to in the press conference: "So, generally, as I mentioned, many on the Committee do see a strengthened case—eight of those, a strengthened case for cutting rates. Eight actually wrote down rate cuts. A number of others see that the case has strengthened." Bond yields fell significantly and WSJ reported

that the "Federal Reserve hinted that it could cut interest rates in the coming months if the central bank's economic outlook weakens." Driven by expectations of future rate cuts, the S&P 500 rose by 0.3%, while ΔVIX^2_{day} was 12.3%, again reflecting a notable decline in market risk perception and option prices. Proprietary trading firms positioned themselves profitably in the morning, with a net demand of -113,459 contracts, further adding to their already negative inventory of -84,226 contracts. In this instance, professional customers (37,893 contracts) and market makers (87,532 contracts) were the primary counterparties for firm sales.

While most of firms' ability to predict Fed outcomes and option price movements on FOMC days is concentrated around loosening monetary policy shocks, there are notable exceptions. For example, September 21, 2011, represents a +1.59 standard deviation monetary policy shock. On this day, the S&P 500 fell by 2.9%, driven by the announcement of "Operation Twist", which aimed to increase the share of long-term Treasuries on the Federal Reserve's balance sheet. WSJ reported that investors were skeptical about the operation's potential to meaningfully impact economic growth, employment, or consumer demand for mortgages. Consistent with this skepticism, ΔVIX^2_{day} was 29.1%, indicating a significant increase in option prices. During the morning trading period (9:30 a.m. to 9:40 a.m.), firms exhibited large positive demand, buying 88,784 contracts and nearly closing their previous short inventory of -81,167 contracts. By closing their short positions before the public learned of and reacted to the Fed's policy announcement, firms positioned themselves ahead of the significant rise in option prices.

In summary, these examples show that firm proprietary traders in S&P 500 index options markets correctly anticipate the direction of monetary policy shifts and option prices, especially when the Fed is scheduled to communicate information about the updated policy rate projections of FOMC members.

7 Conclusion

This paper examines the trading behavior of proprietary trading firms in the S&P 500 options market around Federal Open Market Committee (FOMC) announcements. Notably, proprietary trading firms act as net sellers of options on announcement days, in contrast to their behavior on other days. This liquidity provision is concentrated during morning trading and is particularly pronounced when the FOMC announcement later in the day is perceived as unexpectedly dovish and leads to a decline in market interest rates. Such rate declines are typically accompanied by falling option prices and a lower *VIX*, indicating that proprietary trading firms may possess information about the market impact of upcoming FOMC announcements, enabling them to trade profitably.

In further analysis, we explore the specific content of proprietary trading firms' informational advantage. We find that firms' morning trades predict the path component of monetary policy shocks, reflecting the impact of the Fed's communication on expected future policy rates. Additionally, larger net option positions by firms before FOMC announcements are concentrated on days when the Fed releases the Summary of Economic Projections, including dot plots that display FOMC participants' policy rate forecasts. These findings suggest that some financial institutions may have preferential access to the Fed's forthcoming information, such as FOMC members' policy rate projections, which are submitted prior to and released on the second day of the two-day meeting.

While our data are aggregated at the investor-type level rather than at the institution level, the high-frequency nature of our dataset allows us to precisely identify the timing of trading activity on FOMC days. Despite this limitation, our findings emphasize how monetary policy announcements provide proprietary trading firms with a trading edge driven by their informational advantage.

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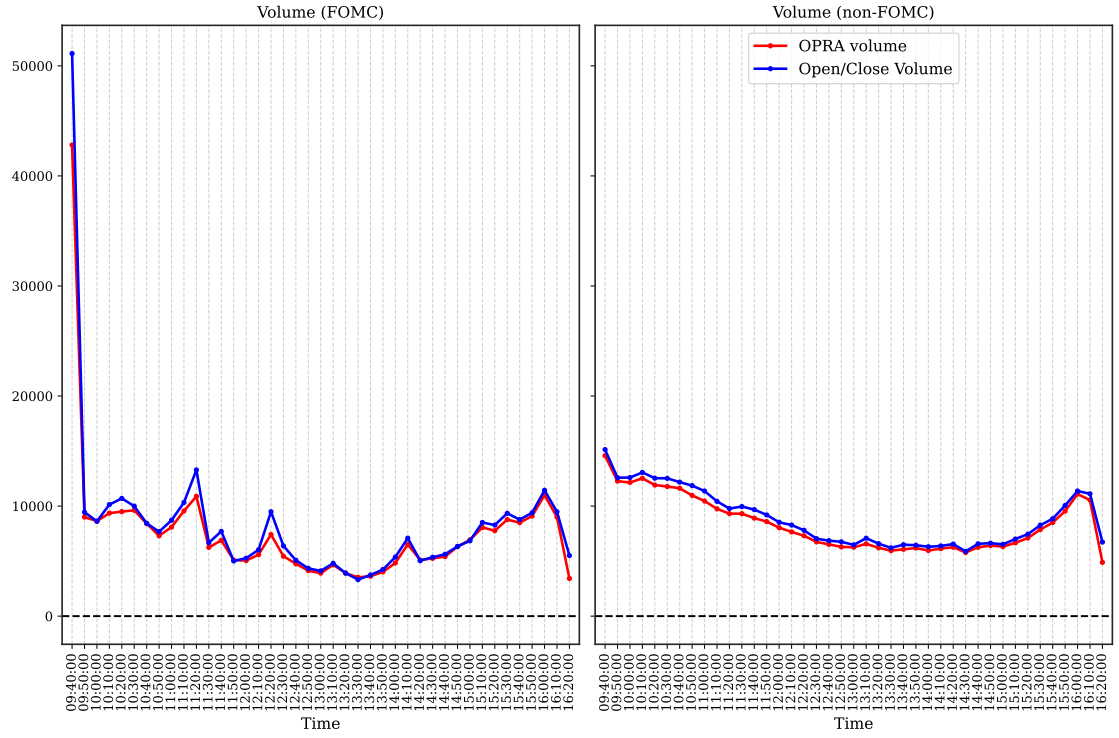
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Appendix

A Additional tables and figures

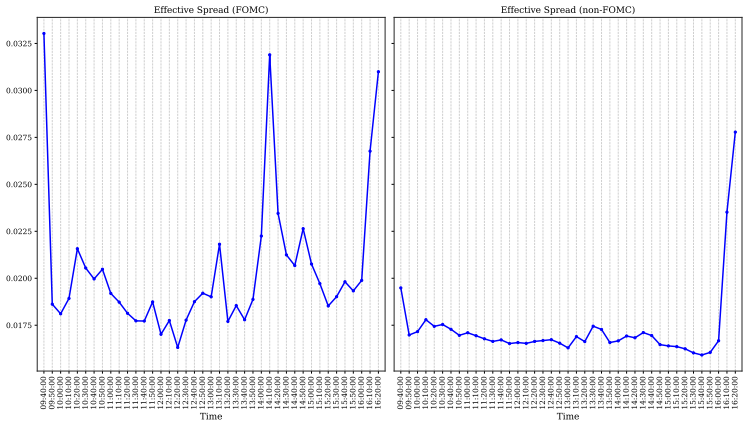
This section includes tables and figures mentioned in the main text.

Figure A.1. OPRA vs. CBOE Open/Close volume data throughout the day



Notes. The figure plots the average trading volume using transaction-level data from OPRA vs. CBOE's Open/Close database at the 10-minute frequency on FOMC (left panel) and non-FOMC (right panel) days for (16 < Exp < next FOMC) options. The sample period is from January 3, 2011 to September 29, 2023, out of which 101 are FOMC days and 3,106 are non-FOMC days.

Figure A.2. OPRA effective median spreads



Notes. This figure plots median effective spreads, calculated from OPRA transaction-level trade data for the subsample of (16 < Exp < Next FOMC) options for FOMC and non-FOMC dates. For each trade k, we calculate $ES_k^O = (2|O_k^P - O_k^M|)/O_k^M$, where O_k^P is the trade price and O_k^M the mid-price of the k^{th} trade. On each day for each 10-minute interval and each option chain O, we calculate $ES^O = \sum_k \text{Vol}_k ES_k^O / \sum_k \text{Vol}_k$, where VOL_k is the trade size of the k^{th} trade. We take the median ES^O for each datetime and compute the mean per time. The sample period is from January 3, 2011 to September 29, 2023 out of which 101 are FOMC days and 3,106 are non-FOMC days.

Table A.1
Summary statistics for daily option demand and monetary policy shocks

		Mean	Std.	5%	95%	Obs.
Firm	non-FOMC	5036.2	28232.1	-34033.4	50565.8	3165
	FOMC	-3628.6	31338.5	-58643.8	25618.2	103
Broker-Dealer	non-FOMC	2613.1	6269.2	-4465.4	14360.8	3165
	FOMC	1803.7	3973.3	-3954.2	8750.0	103
Customer	non-FOMC	9859.9	28296.9	-34837.4	56460.4	3165
	FOMC	18822.9	31218.1	-22235.3	72249.1	103
Prof. Customer	non-FOMC	734.6	9396.6	-12189.2	14524.4	3165
	FOMC	156.4	17509.2	-15291.4	32003.0	103
Market-Maker	non-FOMC	-18244.2	27343.2	-63602.8	17495.6	3165
	FOMC	-17154.3	32317.1	-62864.9	26487.2	103
MPS	FOMC	0.0000	1.0000	-1.8036	1.9937	103

Notes. This table reports summary statistics for daily net option demand aggregated by investor type on non-FOMC and FOMC days. The units are number of contracts. Net option demand is computed as buy minus sell volume. MPS is the standardized monetary policy shock. The sample period is from January 3, 2011 to December 29, 2023.

Table A.2
Daily option demand and orthogonalized monetary policy shocks

	Firm	Broker-Dealer	Customer	Prof-Customer	Market Maker
			Panel A: All days		
FOMC	-6141.49**	398.78**	3684.86*	297.04	1761.17
	[-2.07]	[2.11]	[1.86]	[0.20]	[0.69]
$MPS^{\perp}$	8841.61**	-455.96**	-3313.47	-767.70	-4304.48
	[2.21]	[-2.47]	[-1.24]	[-0.31]	[-1.22]
Cons.	804.49	207.23***	490.92	1552.33***	-3055.34***
	[1.61]	[3.29]	[1.12]	[6.57]	[-8.23]
R^2	0.0086	0.0013	0.0028	0.0004	0.0020
Obs.	3268	3268	3268	3268	3268
			Panel B: FOMC days		
$MPS^{\perp}$	8841.61**	-455.96**	-3313.47	-767.70	-4304.48
	[2.21]	[-2.47]	[-1.24]	[-0.31]	[-1.22]
Cons.	-5337.00*	606.02***	4175.79**	1849.37	-1294.17
	[-1.81]	[3.34]	[2.11]	[1.20]	[-0.51]
R^2	0.0793	0.0574	0.0262	0.0024	0.0265
Obs.	103	103	103	103	103

Notes. Panel A reports results from regressing daily net option demand aggregated by investor type on a dummy variable for FOMC days and the orthogonalized monetary policy shock ($MPS^{\perp}$) from Bauer and Swanson (2023b). Panel B reports results using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.3
Summary statistics for daily option demand by maturity group

			Mean	Std.	5%	95%	Obs.
Firm	Exp < next FOMC	non-FOMC	6503.8	27413.1	-31789.4	51691.4	3165
		FOMC	-1323.2	32322.0	-51352.9	31563.5	103
	16 < Exp < next FOMC	non-FOMC	804.5	19957.9	-19637.8	19456.6	3165
		FOMC	-5337.0	31396.8	-75360.6	15203.8	103
Broker Dealer	Exp < next FOMC	non-FOMC	2790.5	5963.8	-3490.8	14147.0	3165
		FOMC	2313.4	3548.0	-2195.7	8728.0	103
	16 < Exp < next FOMC	non-FOMC	207.2	2969.6	-3018.0	3836.8	3165
		FOMC	606.0	1903.4	-1309.1	4220.5	103
Customer	Exp < next FOMC	non-FOMC	6330.9	27829.2	-37719.6	52342.6	3165
		FOMC	13703.2	27542.1	-22996.2	54457.9	103
	16 < Exp < next FOMC	non-FOMC	490.9	16346.1	-23691.0	25372.4	3165
		FOMC	4175.8	20453.5	-22106.3	35464.2	103
Prof. Customer	Exp < next FOMC	non-FOMC	658.0	9347.1	-12070.0	14508.4	3165
		FOMC	-328.0	17258.9	-15725.6	31753.6	103
	16 < Exp < next FOMC	non-FOMC	1552.3	6917.2	-4309.0	10040.2	3165
		FOMC	1849.4	15711.3	-10611.4	21133.3	103
Market Maker	Exp < next FOMC	non-FOMC	-16283.4	26648.3	-59915.0	17528.0	3165
		FOMC	-14365.4	32125.0	-63167.9	40562.6	103
	16 < Exp < next FOMC	non-FOMC	-3055.3	17792.9	-24875.4	18615.8	3165
		FOMC	-1294.2	26428.0	-35366.7	38945.5	103

Notes. This table reports summary statistics for daily net option demand aggregated by investor type on non-FOMC and FOMC days. The units are number of contracts. Net option demand is computed as buy minus sell volume. Results are reported for the (Exp < next FOMC) and (16 < Exp < next FOMC) options (defined in the text) separately. The sample period is from January 3, 2011 to December 29, 2023.

Table A.4

Summary statistics for firm demand in the morning and the rest of the day

		Mean	Std.	5%	95%	Obs.
Panel A: Share						
Morning volume share	non-FOMC	0.0325	0.0883	0.0000	0.1041	3165
	FOMC	0.1393	0.2311	0.0000	0.7366	103
Panel B: All options						
Morning demand	non-FOMC	-35.0	14097.4	-2269.2	1663.4	3165
	FOMC	-6003.1	30243.5	-75850.6	13148.0	103
Rest of day demand	non-FOMC	839.5	13975.6	-16583.0	17866.8	3165
	FOMC	666.1	9576.8	-14045.0	13193.9	103
Panel C: Puts						
Morning demand	non-FOMC	-58.4	11957.6	-1766.6	1367.4	3165
	FOMC	-5105.9	25668.6	-60743.9	9884.1	103
Rest of day demand	non-FOMC	67.6	12662.1	-15856.2	15127.6	3165
	FOMC	-580.8	8923.8	-15780.5	11434.7	103
Panel D: Calls						
Morning demand	non-FOMC	23.4	2379.6	-1082.2	897.0	3165
	FOMC	-897.3	4812.3	-15248.0	2204.7	103
Rest of day demand	non-FOMC	771.9	6178.6	-8483.4	11046.4	3165
	FOMC	1246.9	5304.4	-7305.1	11146.6	103

Notes. This table reports summary statistics for firm net option demand (buy minus sell) aggregated by investor type on non-FOMC and FOMC days using data at 10-minute frequency. Morning refers to 9:30 a.m. – 9:40 a.m. Rest of day refers to 9:40am–4:15pm. The units are number of contracts. Net option demand is computed as buy minus sell volume. Results are reported for Put and Call options separately and the sample is restricted to (16 < Exp < next FOMC) options. The sample period is from January 3, 2011 to December 29, 2023.

Table A.5

Morning vs. rest-of-day option demand and orthogonalized monetary policy shocks

	Morning	Rest
Panel A: All days		
FOMC	-5968.16**	-173.34
	[-2.10]	[-0.18]
$MPS^{\perp}$	8511.08**	330.53
	[2.09]	[0.46]
Cons.	-34.99	839.48**
	[-0.14]	[2.11]
R^2	0.0151	0.0000
Obs.	3268	3268
Panel B: FOMC days		
$MPS^{\perp}$	8511.08**	330.53
	[2.09]	[0.46]
Cons.	-6003.15**	666.15
	[-2.11]	[0.71]
R^2	0.0792	0.0012
Obs.	103	103

Notes. Panel A reports results from regressing firm option demand on a dummy variable for FOMC days and the orthogonal monetary policy shock ($MPS^{\perp}$) from Bauer and Swanson (2023b). Panel B runs the regression using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. Morning refers to 9:30 a.m.–9:40 a.m. Rest of day refers to 9:40 a.m.–4:15 p.m. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.6
Summary statistics for VIX^2 returns

		Mean	Std.	5%	95%	Obs.
ΔVIX^2_{on}	non-FOMC	1.78	10.71	-13.13	19.96	3165
	FOMC	-0.86	9.48	-14.38	9.48	103
ΔVIX^2_{day}	non-FOMC	-0.39	13.53	-15.93	21.00	3165
	FOMC	-1.46	14.62	-19.74	18.32	103
ΔVIX^2_{fomc}	FOMC	-3.01	6.20	-13.33	5.99	103

Notes. This table reports summary statistics from the rate of change in VIX^2 in percent on each day computed from changes in squared VIX index using intraday VIX data. ΔVIX^2_{on} is based on the change of VIX^2 from last day's close to current day's 9:41 a.m. ΔVIX^2_{day} is based on the change of VIX^2 from current day's 9:41 a.m. to market close. ΔVIX^2_{fomc} is based on the change of VIX^2 from 10 minutes before to 20 minutes after the FOMC announcement. The sample period is from January 3, 2011 to December 29, 2023.

Table A.7
Monetary policy uncertainty, firm option demand, and MPS magnitude

	(1)	(2)	(3)	(4)	(5)
MPU	0.35***	0.39***			0.38***
	[3.53]	[3.64]			[3.93]
MPS		-0.16		0.18	0.02
		[-1.23]		[1.07]	[0.11]
MPU x MPS		0.19***			0.10*
		[2.87]			[1.75]
|Demand|			0.22***	0.11	0.16**
			[3.03]	[1.22]	[2.02]
|Demand| x MPS				-0.18**	-0.12*
				[-2.46]	[-1.76]
Cons.	0.64***	0.61***	0.64***	0.59***	0.59***
	[9.53]	[10.22]	[8.85]	[8.00]	[9.70]
R^2	0.2108	0.3201	0.0837	0.1990	0.4418
Obs.	103	103	103	103	103

Notes. This tables reports results from regressing the absolute value of monetary policy shocks, |MPS|, on lagged monetary policy uncertainty, MPU, the absolute value of firm option demand between 9:30 a.m. and 9:40 a.m., |Demand|, and interaction terms on FOMC announcement days. MPU, MPS, and |Demand| are normalized to have zero mean and unit standard deviation. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.8

Daily option demand, monetary policy, and other macroeconomic announcements

	Firm	Broker-Dealer	Customer	Prof-Customer	Market Maker
Panel A: All days without macro announcement					
FOMC	-5973.12*	519.11***	2720.63	626.35	2107.50
	[-1.78]	[2.76]	[1.19]	[0.32]	[0.75]
MPS	11127.91**	-697.79***	-3439.26	-2755.60	-4235.26
	[2.35]	[-3.36]	[-1.26]	[-0.88]	[-0.99]
Cons.	269.63	205.02***	807.49*	1573.72***	-2856.33***
	[0.54]	[2.92]	[1.76]	[6.41]	[-7.19]
R^2	0.0135	0.0025	0.0021	0.0040	0.0022
Obs.	2537	2537	2537	2537	2537
Panel B: FOMC days without macro announcement					
MPS	11127.91**	-697.79***	-3439.26	-2755.60	-4235.26
	[2.35]	[-3.36]	[-1.26]	[-0.88]	[-0.99]
Cons.	-5703.49*	724.12***	3528.12	2200.07	-748.83
	[-1.71]	[4.05]	[1.54]	[1.11]	[-0.27]
R^2	0.1199	0.1599	0.0260	0.0234	0.0254
Obs.	80	80	80	80	80

Notes. Panel A reports results from regressing daily net option demand aggregated by investor type on a dummy variable for FOMC days and the monetary policy shock (MPS) for days where no other macroeconomic announcement took place. We focus on other macro announcements including unemployment, non-farm payroll, consumer price index, GDP, and industrial production. Panel B runs the regression using data from FOMC days when there were no other macroeconomic announcements. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.9
Predicting alternative MPS measures using firm option demand

Panel A: Eurodollar futures				
	ED1	ED2	ED3	ED4
Demand	0.32***	0.33***	0.31***	0.30***
	[3.39]	[3.51]	[3.40]	[3.40]
R^2	0.1033	0.1108	0.0970	0.0888
Obs.	103	103	103	103
Panel B: Other MPS				
	NS	Target	Path	TNOTE5
Demand	0.32***	0.02	0.30***	0.24**
	[3.43]	[0.17]	[3.02]	[2.55]
R^2	0.1042	0.0004	0.0925	0.0564
Obs.	103	103	103	103

Notes. Panel A reports results from regressing Eurodollar futures (ED), with maturities of 1 to 4 quarters, on firm morning option demand (Demand) normalized to have zero mean and unit standard deviation on FOMC announcement days. Panel B reports results from regressing other monetary policy shocks on firm morning option demand. NS is themonetary policy shocks based on Nakamura and Steinsson (2018). Target and Path is the decomposition of NS following Gürkaynak, Sack, and Swanson (2005). TNOTE5 is the 5-year Treasury note future yield responses around FOMC. Morning refers to 9:30 a.m.–9:40 a.m. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

B Data

B.1 Data sources

This section details the data sources and sample periods used in our analysis.

CBOE 10-minute volume. We focus on S&P 500 index options traded exclusively on the CBOE, with data provided by CBOE. Specifically, we analyze SPX and SPXW options, excluding FLEX, SPXQ, and SPXPM options. The open/close data offers detailed 10-minute information on buy and sell trading activity that either increases (opening) or decreases (closing) open interest, broken down by five investor types: firms, broker-dealers, customers, professional customers, and market makers. The sample spans from January 3, 2011, to December 29, 2023. For each day, we compute net demand by summing up buys minus sells for each investor type. As SPX/SPXW options are European, we calculate high-frequency inventory for each contract and participant by aggregating net demand over time, starting from the contract's first trade. A contract exits the inventory upon expiration.

Intraday CBOE *VIX*. We obtain intraday *VIX* index prices from the CBOE for the period spanning January 3, 2011, to December 29, 2023. Data is transmitted at approximately 15-second intervals. Beginning April 15, 2016, *VIX* is also quoted overnight, starting at 3:15 a.m. and continuing until 9:15 a.m. Regular trading resumes at 9:30 a.m. and concludes at 4:15 p.m., aligning with the *VIX* closing price.

B.2 Open/Close 10-minute interval data

Trading intervals. The raw data from CBOE (Link to Cboe website) consists of 41 files covering 10-minute intervals between 9:30 a.m. and 4:20 p.m. U.S. Eastern Time, corresponding to Regular Trading Hours (RTH), which span from 9:30 a.m. to 4:15 p.m. The 9:30 a.m. timestamp exclusively reflects overnight trading activity during Global Trading

Hours (GTH), which run from 8:15 p.m. to 9:25 a.m. Therefore, the 9:40 a.m. timestamp captures trading activity from the first 10 minutes of the RTH session.

CBOE began collecting GTH 10-minute interval data on December 11, 2023. After RTH, the Curb session runs from 4:30 p.m. to 5:00 p.m., with CBOE providing data in four additional 10-minute interval files. Additionally, there are two single files recorded at 6:00 p.m. and 7:00 p.m., respectively.

Aggregation method. Trade count and volume (number of contracts traded) are aggregated by investor types and time intervals throughout the day. For each option traded, CBOE provides the cumulative trade volume data at 10-minute intervals throughout the trading day. To calculate the traded volume for each option chain, we first record the initial trade for each option on a given day. Then, we compute the difference in cumulative volume across intervals to determine traded volume. Finally, the first trade is added back to the option chain to ensure completeness.

C Demand for put and call options

Appendix Table A.10 presents summary statistics for put and call demand. On non-FOMC days, market makers are net suppliers of puts, while other investor types exhibit positive net demand. For calls, market makers display a positive net demand on average, while customers sell more calls than they purchase. Across all investor types, average call demand tends to have smaller magnitudes and standard deviations compared to put demand. On FOMC days, firms shift to being net suppliers of puts, while their call demand decreases but remains positive.

Appendix Table A.11 reports the response of put demand to monetary policy announcements for all investor types. On non-FOMC days, net firm demand for puts is effectively zero, but this changes drastically on FOMC days. Panel B shows that firms exhibit signif-

icantly negative net demand for puts on FOMC days, averaging -5,687 contracts, which is offset by significant positive put demand from customers.

Moreover, firm put sales increase sharply in response to loosening monetary policy shocks (MPS < 0). A one standard deviation decrease in MPS more than doubles the new short positions that firms take in S&P 500 puts. Over half of these short positions are offset by customers and professional customers, with the remainder taken on by market makers. Overall, net firm demand for puts shows a stronger correlation with MPS compared to any other investor type, including market makers.

We also find a significant response of firm call demand to MPS, though smaller than the response for puts in terms of the number of contracts, as shown in Appendix Table A.12. On non-FOMC days, firms, professional customers, and market makers are net buyers of calls, while customers are net sellers, as indicated by the regression intercept in Panel A. In contrast, on FOMC days, average call demand is not significantly different from zero for any investor type, as shown by the regression intercept in Panel B. Firms engage in significant call sales in response to negative interest rate shocks, with most of these sales absorbed by professional customers and market makers.

Appendix D.1 provides additional details on firms' put option demand. Specifically, we demonstrate that the results in Appendix Table A.11 are primarily driven by out-of-the-money (OTM) put options. Furthermore, demand for deep OTM puts with moneyness below 90% exhibits a stronger reaction to MPS compared to moderately OTM options, as measured by the number of contracts.

D Additional results on option demand on FOMC days

D.1 Firm demand for OTM and deep OTM puts

Appendix Table A.13 reports the response of firm option demand to monetary policy shocks for out-of-the-money (OTM) and in-the-money (ITM) puts. On non-FOMC days, firm net demand for OTM puts is close to zero, indicating balanced average trading in these options. However, all average option sales by firms, as well as the expansion of short positions in response to negative MPS shocks, are concentrated in OTM puts. Firms are net sellers of ITM puts, but their positions in these options remain unaffected by monetary policy announcements.

Another important consideration is whether firms dynamically hedge the risks associated with their short positions in OTM puts on the S&P 500 index induced by negative MPS shocks. While options are theoretically redundant securities whose risks can be eliminated through delta hedging in the Black and Scholes (1973) and Merton (1973) no-arbitrage framework, transaction costs, limits to arbitrage and higher-order risks constrain investors' ability to fully hedge the risks associated with liquidity provision (Figlewski (1989)).

The inherently unhedgeable portion of option inventory risk has prompted a growing literature on market makers' roles in the option market, highlighting the residual risks of dynamically delta-hedged positions (Garleanu, Pedersen, and Poteshman (2009), Fournier and Jacobs (2020), Tian and Wu (2023)). In particular, Chen, Joslin, and Ni (2019) demonstrate that the effectiveness of dynamic hedging is significantly weaker for deep OTM index put options compared to moderately OTM or ITM options.

We divide the sample into deep OTM options (Moneyness < 0.9) and moderately OTM options ($0.9 <$ Moneyness < 1) and report the results in Appendix Table A.14. The findings indicate that firms are net sellers of deep OTM options and net buyers of moderately OTM

options on non-FOMC days. This behavior suggests that firms sell insurance against extreme tail risks while hedging themselves by purchasing insurance against moderate downside risks. Given the downward-sloping implied volatility curve, this strategy can be profitable as it captures the tail risk premium in the S&P 500 index option market documented by Bollerslev and Todorov (2011). Importantly, left tail risk is not fully captured by traditional risk factors in the options market, such as volatility risk (Andersen, Fusari, and Todorov (2015)).

D.2 Option inventory around FOMC announcements

Panel A of Appendix Table A.15 indicates that, while firms generally hold negative average option inventory, they accumulate positive inventory on the day prior to FOMC announcements. This increase in firm inventory corresponds to a decrease in customer inventory, consistent with the findings of Beckmeyer, Branger, and Gruenthaler (2021), who argue that option prices—particularly for options providing tail risk insurance—rise before FOMC days due to reduced option supply. The results in Panel A suggest that the reduced supply to customers is driven by higher firm inventory rather than changes in market maker inventory. Panel B further shows that option inventory for any investor category does not significantly predict monetary policy shocks. This finding suggests an absence of superior information prior to FOMC days.

We also examine whether morning trades on FOMC days can be attributed to mean reversion of inventory from the previous day or if they are instead driven by the upcoming MPS. Appendix Table A.16 shows that morning FOMC demand is not significantly related to lagged inventory. Furthermore, the significant positive relationship between firm morning demand and MPS remains robust after controlling for inventory from the previous day. This suggests that while firms tend to increase inventory prior to FOMC days, the magnitude of this inventory does not explain the relationship between firm morning demand and

MPS. Similarly, other investor categories also show no significant relationship between their morning demand and lagged inventory on FOMC days.

Similarly, Appendix Table A.17 demonstrates that firm inventory does not improve the prediction of monetary policy shocks beyond the information contained in firm morning trades. The only significant predictors of MPS are broker-dealer demand, market maker demand, and firm demand. Among these, firm demand has by far the greatest predictive power, explaining 11% of the variation in MPS (R^2).

E Additional analyses on monetary policy uncertainty and option demand

Bauer, Lakdawala, and Mueller (2022) emphasize that daily changes in MPU are significantly lower on FOMC announcement days consistent with the resolution of monetary policy uncertainty. We compute the daily change in MPU by computing the rate of change in conditional interest rate variance: $\Delta\text{MPU}_t = \text{MPU}_t^2/\text{MPU}_{t-1}^2 - 1$. Consistent with Bauer, Lakdawala, and Mueller (2022), the average ΔMPU_t is lower by 6.1 percentage points on FOMC announcement days compared to other days in our sample period from January 2011 to December 2023.

Columns 1 and 2 in Panel A of Appendix Table A.18 shows that firm option demand in the morning of FOMC announcement days is positively correlated with MPU resolution, also controlling for the level of MPU. This relation is not necessarily predictive given that ΔMPU is measured as the change of MPU^2 from the last day's close to the FOMC day's close while firm demand takes place between 9:30 a.m. and 9:40 a.m. of the FOMC day. However, as a proxy for uncertainty resolution overnight and the rest of the day, we control for $\Delta\, VIX_{on}^2$ and $\Delta\, VIX_{day}^2$ and observe that demand still positively correlated with MPU

resolution (Columns 3 and 4 in Panel A of Appendix Table A.18). In sum, firms engage in option sales when a larger fraction of MPU is expected to be resolved, consistent with predicting option selling at a higher price in a case where they are expected to lose value. In addition, Panel B of Appendix Table A.18 shows that the predictability of ΔVIX^2_{day} using firm option demand in the morning of FOMC days is unaffected by controlling for MPU, ΔVIX^2_{on}, and the level of VIX^2 at 09:41 a.m. on FOMC days. Finally, Appendix Table A.19 shows that lagged MPU does not predict MPS and does not interfere with the firm option demand's ability to predict MPS.

As an alternative proxy for monetary policy uncertainty, we compute the difference between the 85^{th} and 15^{th} percentiles (IRRANGE) of the conditional 2-year interest rate distribution using data from Mertens and Williams (2021), where they compute option-implied conditional distributions of interest rates taking the zero lower bound into account.

Appendix Table A.20 shows that IRRANGE, similar to MPU, predicts the absolute value of MPS shocks and that this predictability is stronger for the upside realizations of MPS. Furthermore, Appendix Table A.21 shows that lagged IRRANGE does not predict MPS and does not interfere with the firm option demand's ability to predict MPS.

F Keynesian vs. information shocks

In this section, we examine the relation between MPS, option prices, and firm option demand on FOMC days featuring Keynesian and information shocks as defined in Section 6.1.

Appendix Table A.22 presents results from firm's morning option demand's predictive ability for MPS, changes in VIX^2 and S&P 500 on FOMC days.[19] As shown in Appendix

[19]The dummy variable KEYN for Keynesian shocks can be calculated after the announcement window. As a result, the regressions are not meant to predict whether the shock will be Keynesian or information, but documents differences in predictability after shocks is retrospectively classified into Keynesian and information.

Table A.22, the predictive power of morning option demand for orthogonalized MPS with a positive sign is driven by Keynesian shocks. The predictive relation is negative, albeit statistically insignificant, on FOMC days with information shocks. However, firm option demand predicts ΔVIX^2_{fomc} and the high frequency response of S&P 500 during the announcement window regardless of whether the shock is Keynesian or information. This result holds for ΔVIX^2_{fomc} as well.

What explains the result that firms' morning demand on FOMC days go in the right direction of option price changes regardless of the MPS type, even though demand predicts MPS with opposite signs in cases of Keynesian and information shocks? The answer lies in the differential response of option prices to MPS that we document in Appendix Table A.23. There is no significant difference between ΔVIX^2_{fomc} between FOMC announcement with Keynesian and information shocks, and MPS is significantly positively correlated with ΔVIX^2_{fomc} on average (the first two columns in Table A.23). However, accommodating MPS which are accompanied by an increase in the S&P 500 index by construction during Keynesian shocks also lead to a decline in VIX^2 in the announcement window. In contrast, lower MPS are associated with a drop in S&P 500 and an increase in VIX^2 in case of information shocks. This result suggests that the negative correlation between the S&P 500 return and ΔVIX^2_{fomc} holds regardless of the MPS type. Consequently, firm option demand predicts the change in option prices around the announcement with a positive sign regardless of the MPS type as well. When the shock will be Keynesian, firms tend to sell before an accommodative announcement and VIX drops after the announcement. In case of information shocks, an accommodative announcement leads to an increase in VIX and firms' morning demand is higher in these cases.

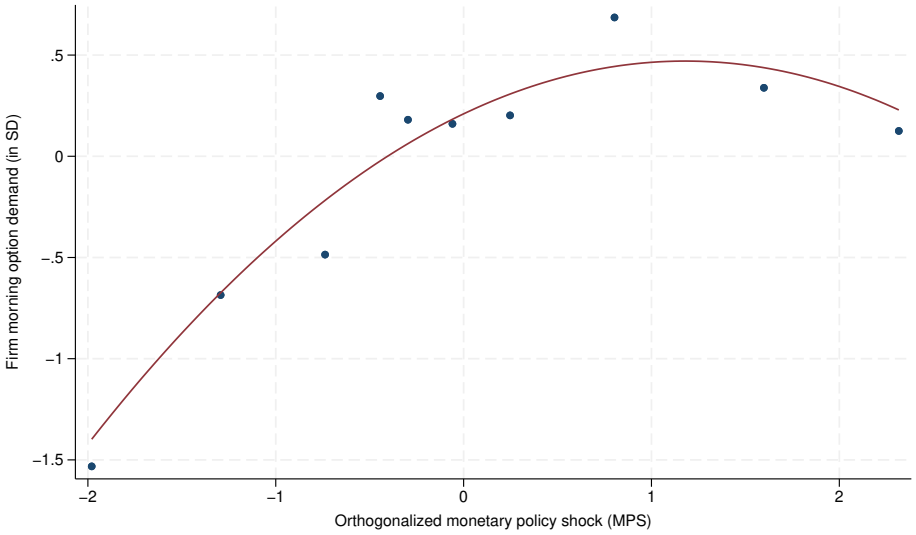
Finally, Appendix Figure A.3 illustrates the relation between firms' morning option demand and ortgonalized MPS. MPS exhibit higher dispersion during Keynesian shocks ex-

hibiting a positive and concave relation between MPS and demand. However, information shocks are smaller and have a negative relation with firms' morning demand for options on FOMC days.

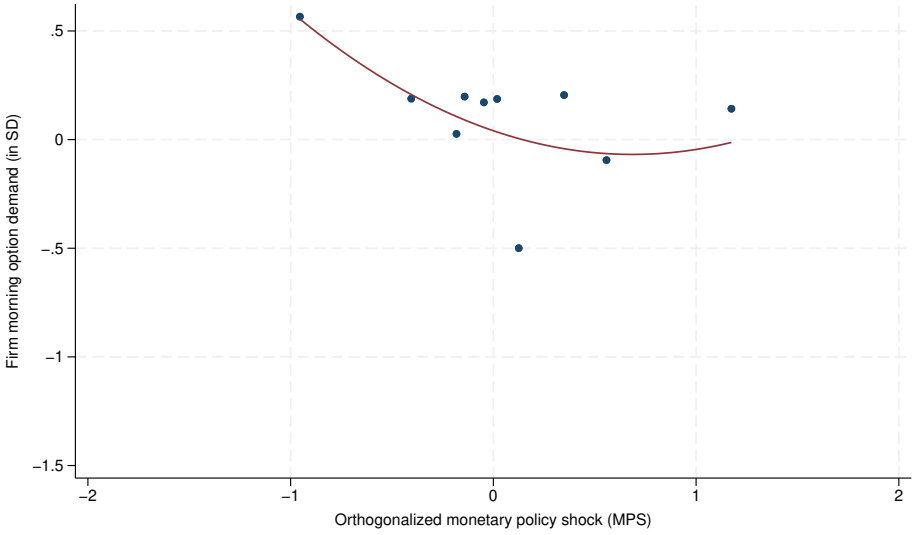
G Appendix tables and figures

This section includes tables and figures mentioned in the Appendix sections.

Figure A.3. Firm Morning Demand as a Function of Orthogonalized MPS Shocks



(a) Keynes channel



(b) Info channel

Notes. This figure shows a binscatter plot of standardized firm morning demand against orthogonalized MPS shocks for the Keynes (Panel A) and Info (Panel B) channels. We label announcements where the change in S&P 500 E-Mini futures and $MPS^{\perp}$ from Bauer and Swanson (2023b) in the 30-minute announcement window have opposite signs as "Keynesian shocks", and "Info shocks" otherwise. Out of 103 scheduled FOMC announcements in our sample period, 57 are classified as Keynesian shocks and 46 as information shocks. The sample period is from January 3, 2011 to December 29, 2023.

Table A.10
Summary statistics for daily put and call demand

		Mean	Std.	5%	95%	Obs.
Panel A: Puts						
Firm	non-FOMC	9.2	17320.2	-17956.6	16314.0	3165
	FOMC	-5686.6	26675.9	-58520.9	15526.9	103
Broker Dealer	non-FOMC	109.6	3091.6	-3499.6	3862.0	3165
	FOMC	363.7	2458.3	-2467.5	4205.0	103
Customer	non-FOMC	2259.1	13879.6	-17321.0	23768.6	3165
	FOMC	4659.3	18831.0	-15982.9	34518.4	103
Prof. Customer	non-FOMC	1363.9	6490.4	-3759.4	8918.4	3165
	FOMC	1970.2	14087.4	-9605.4	18917.8	103
Market-Maker	non-FOMC	-3742.2	15137.7	-23581.4	13234.6	3165
	FOMC	-1306.5	23017.6	-39731.5	30640.8	103
Panel B: Calls						
Firm	non-FOMC	795.3	6728.0	-9018.6	11348.0	3165
	FOMC	349.6	7437.5	-13050.1	11999.8	103
Broker Dealer	non-FOMC	97.6	2140.2	-2238.0	2969.8	3165
	FOMC	242.3	1893.5	-1770.9	2814.0	103
Customer	non-FOMC	-1768.2	8282.2	-14641.8	10406.2	3165
	FOMC	-483.5	7613.2	-11700.8	10014.1	103
Prof. Customer	non-FOMC	188.5	1686.4	-2231.4	2921.4	3165
	FOMC	-120.8	2258.5	-3408.6	2577.7	103
Market-Maker	non-FOMC	686.9	7884.5	-11951.6	12405.0	3165
	FOMC	12.3	8095.6	-12014.1	14185.9	103

Notes. This table reports summary statistics for daily net option demand aggregated by investor type on non-FOMC and FOMC days. The units are number of contracts. Net option demand is computed as buy minus sell volume. Results are reported for Put and Call options separately and the sample is restricted to (16 < Exp < next FOMC) options. The sample period is from January 3, 2011 to December 29, 2023.

Table A.11
Daily put demand and monetary policy

	Firm	Broker-Dealer	Customer	Prof-Customer	Market-Maker
			Panel A: All days		
FOMC	-5695.78**	254.07	2400.18	606.28	2435.67
	[-2.29]	[1.04]	[1.31]	[0.44]	[1.08]
MPS	8804.23**	-282.84*	-3155.42	-1767.68	-3598.29
	[2.42]	[-1.76]	[-1.35]	[-0.85]	[-1.13]
Cons.	9.15	109.60**	2259.14***	1363.88***	-3742.20***
	[0.03]	[1.98]	[9.13]	[11.82]	[-13.87]
R^2	0.0109	0.0005	0.0025	0.0023	0.0025
Obs.	3268	3268	3268	3268	3268
			Panel B: FOMC days		
MPS	8804.23**	-282.84*	-3155.42	-1767.68	-3598.29
	[2.42]	[-1.76]	[-1.35]	[-0.85]	[-1.13]
Cons.	-5686.62**	363.67	4659.32**	1970.16	-1306.52
	[-2.30]	[1.52]	[2.56]	[1.44]	[-0.59]
R^2	0.1089	0.0132	0.0281	0.0157	0.0244
Obs.	103	103	103	103	103

Notes. Panel A reports results from regressing daily net put option demand aggregated by investor type on a dummy variable for FOMC days and the monetary policy shock (MPS). Panel B runs the regression using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.12
Daily call demand and monetary policy

	Firm	Broker-Dealer	Customer	Prof-Customer	Market-Maker
			Panel A: All days		
FOMC	-445.72	144.72	1284.69*	-309.24	-674.51
	[-0.62]	[0.77]	[1.69]	[-1.41]	[-0.84]
MPS	1523.69**	-272.74**	-153.04	-401.08	-696.83
	[2.05]	[-2.04]	[-0.27]	[-1.14]	[-0.80]
Cons.	795.34***	97.63**	-1768.22***	188.45***	686.85***
	[6.67]	[2.56]	[-12.02]	[6.27]	[4.90]
R^2	0.0017	0.0007	0.0007	0.0027	0.0005
Obs.	3268	3268	3268	3268	3268
			Panel B: FOMC days		
MPS	1523.69**	-272.74**	-153.04	-401.08	-696.83
	[2.05]	[-2.04]	[-0.27]	[-1.14]	[-0.80]
Cons.	349.62	242.35	-483.53	-120.79	12.35
	[0.49]	[1.32]	[-0.65]	[-0.55]	[0.02]
R^2	0.0420	0.0207	0.0004	0.0315	0.0074
Obs.	103	103	103	103	103

Notes. Panel A reports results from regressing daily net call option demand aggregated by investor type on a dummy variable for FOMC days and the monetary policy shock (MPS). Panel B runs the regression using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.13
Firm option demand and monetary policy shocks by moneyness

	Moneyness < 1	Moneyness > 1
	Panel A: All days	
FOMC	-5638.34**	-57.44
	[-2.24]	[-0.24]
MPS	8960.26**	-156.03
	[2.40]	[-0.76]
Cons.	401.76	-392.61***
	[1.30]	[-7.65]
R^2	0.0111	0.0001
Obs.	3268	3268
	Panel B: FOMC days	
MPS	8960.26**	-156.03
	[2.40]	[-0.76]
Cons.	-5236.57**	-450.05*
	[-2.10]	[-1.90]
R^2	0.1104	0.0041
Obs.	103	103

Notes. Panel A reports results from regressing daily firm net put option demand for out-of-the-money (Moneyness<1) and in-the-money (Moneyness>1) options on a dummy variable for FOMC days and the monetary policy shock (MPS). Panel B runs the regression using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.14

Out-of-the-money and deep out-of-the-money put demand and monetary policy shocks

	Mnes < 0.9	0.9 < Mnes < 1
	Panel A: All days	
FOMC	-4171.63*	-1466.70**
	[-1.89]	[-1.99]
MPS	7702.16**	1258.10**
	[2.32]	[2.04]
Cons.	-1596.02***	1997.78***
	[-5.86]	[15.58]
R^2	0.0097	0.0022
Obs.	3268	3268
	Panel B: FOMC days	
MPS	7702.16**	1258.10**
	[2.32]	[2.04]
Cons.	-5767.65***	531.08
	[-2.64]	[0.73]
R^2	0.1066	0.0280
Obs.	103	103

Notes. Panel A reports results from regressing daily firm net put option demand for deep OTM (Mnes<0.9) and moderately OTM (0.9<Mnes<1) options on a dummy variable for FOMC days and the monetary policy shock (MPS). Panel B runs the regression using data from FOMC days only. The units are number of contracts. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.15
Lagged inventory, FOMC days, and monetary policy shocks

	Firm		Broker-Dealer		Customer		Prof-Customer		Market-Maker	
					Panel A: All days					
FOMC		20192.17***		230.70		−17929.31**		3034.02		−5528.72
		[3.31]		[0.23]		[−2.19]		[1.51]		[−0.83]
Cons.	−11010.76***	−11647.17***	−3037.84***	−3045.12***	54723.34***	55288.43***	9424.68***	9329.05***	−50109.48***	−49935.23***
	[−2.59]	[−2.70]	[−3.67]	[−3.64]	[8.20]	[8.16]	[5.37]	[5.28]	[−8.70]	[−8.57]
R^2	0.0000	0.0024	0.0000	0.0000	0.0000	0.0009	0.0000	0.0004	0.0000	0.0001
Obs.	3268	3268	3268	3268	3268	3268	3268	3268	3268	3268
					Panel B: FOMC days					
MPS		−2691.01		−1341.02		3852.43		1297.21		−1111.28
		[−0.43]		[−1.19]		[0.46]		[0.53]		[−0.15]
Cons.	8545.00	8545.00	−2814.42**	−2814.42**	37359.12***	37359.12***	12363.08***	12363.08***	−55463.94***	−55463.94***
	[1.38]	[1.38]	[−2.50]	[−2.51]	[4.53]	[4.51]	[5.13]	[5.12]	[−7.60]	[−7.57]
R^2	0.0000	0.0018	0.0000	0.0138	0.0000	0.0021	0.0000	0.0028	0.0000	0.0002
Obs.	103	103	103	103	103	103	103	103	103	103

Notes. This table presents results from regressing daily option inventory at the prior day's close on an FOMC dummy (Panel A) on all days and on MPS on FOMC days (Panel B) for all investor categories. The units are number of contracts. Inventory is computed as cumulative buy minus sell volume. The dependent variable in regressions is inventory at the close of the last trading day. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.16
Morning demand, lagged inventory, and MPS on FOMC days

	Firm	Broker-Dealer	Customer	Prof-Customer	Market-Maker
Inventory	-0.13	-0.03	-0.05	0.22	-0.06
	[-0.59]	[-0.72]	[-0.26]	[0.36]	[-0.46]
MPS	0.65**	-0.18	-0.21	-0.51	-0.44
	[2.25]	[-1.25]	[-0.72]	[-1.00]	[-1.53]
Cons.	-0.35*	0.17	0.26	0.02	0.25
	[-1.68]	[1.54]	[1.33]	[0.09]	[1.41]
R^2	0.1086	0.0229	0.0116	0.0274	0.0565
Obs.	103	103	103	103	103

Notes. This table presents results from regressing option demand between 9:30 a.m. and 9:40 a.m. on FOMC days on lagged inventory and MPS. Inventory is from the close of the last trading day. All variables are normalized to have zero mean and unit standard deviation. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.17
Predicting MPS using morning demand and lagged inventory

	Firm	Broker-Dealer	Customer	Prof-Customer	Market-Maker
Inventory	-0.02	-0.14*	0.05	0.07	-0.02
	[-0.27]	[-1.84]	[0.66]	[0.49]	[-0.30]
Demand	0.16***	-0.13*	-0.05	-0.05	-0.13*
	[3.43]	[-1.89]	[-0.65]	[-0.85]	[-1.95]
Cons.	0.07	0.02	0.02	-0.01	0.03
	[0.73]	[0.25]	[0.23]	[-0.05]	[0.35]
R^2	0.1057	0.0364	0.0131	0.0276	0.0562
Obs.	103	103	103	103	103

Notes. This table presents results from regressing MPS on option demand between 9:30 a.m. and 9:40 a.m. for each investor category on FOMC days and lagged inventory. Inventory is from the close of the last trading day. All variables are normalized to have zero mean and unit standard deviation. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.18
Resolution of monetary policy uncertainty and option demand

	(1)	(2)	(3)	(4)
Panel A: Predicting MPU resolution				
Demand	1.68***	1.79***	1.74***	1.62**
	[2.68]	[2.81]	[2.74]	[2.49]
MPU		-1.63***	-1.60***	-1.59***
		[-2.74]	[-2.64]	[-2.62]
$\Delta\, VIX^2_{on}$			0.03	0.01
			[0.37]	[0.15]
$\Delta\, VIX^2_{day}$				0.04
				[0.87]
Cons.	-5.43***	-5.43***	-5.40***	-5.35***
	[-7.22]	[-7.39]	[-7.60]	[-7.37]
R^2	0.0458	0.0890	0.0903	0.0966
Obs.	103	103	103	103
Panel B: Predicting ΔVIX^2_{day}				
Demand	3.21***	3.26***	2.71**	2.92**
	[2.85]	[2.85]	[2.20]	[2.18]
MPU		-0.68	-0.28	-0.00
		[-0.51]	[-0.23]	[-0.00]
$\Delta\, VIX^2_{on}$			0.39	0.38
			[1.12]	[1.02]
VIX^2_{0941}				-0.00
				[-0.60]
Cons.	-1.46	-1.46	-1.12	0.49
	[-1.04]	[-1.04]	[-0.76]	[0.21]
R^2	0.0482	0.0504	0.1113	0.1178
Obs.	103	103	103	103

Notes. Panel A reports results from regressing the daily change in MPU ($\Delta\text{MPU}_t = \text{MPU}_t^2/\text{MPU}_{t-1}^2 - 1$) on firm option demand between 9:30 a.m. and 9:40 a.m., lagged MPU (MPU_{t-1}), the rate of change in VIX^2 from last day's close to 9:40 a.m. ($\Delta\, VIX^2_{on}$), and the rate of change in VIX^2 from 9:40 a.m. to current day's close ($\Delta\, VIX^2_{day}$) on FOMC days. Panel B reports results from regressing the change in VIX^2 from 09:41 a.m. to trading close on the FOMC day on firm morning demand, MPU, $\Delta\, VIX^2_{on}$, and the level of VIX^2 at 09:41 a.m. Demand and MPU are normalized to have zero mean and unit standard deviation. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.19
Predicting MPS using MPU and firm option demand

	(1)	(2)
MPU	0.13	0.11
	[0.70]	[0.58]
Demand		0.32***
		[3.39]
R^2	0.0163	0.1166
Obs.	103	103

Notes. This table reports results from regressing MPS on lagged daily MPU and firm option demand between 9:30 a.m. and 9:40 a.m. on FOMC announcement days. Option demand and MPU are normalized to have zero mean and unit standard deviation. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.20
Interest rate range, firm option demand, and MPS magnitude

	(1)	(2)
IRRANGE	0.38***	0.35***
	[4.81]	[4.39]
MPS		-0.71**
		[-2.47]
IRRANGE x MPS		0.20**
		[2.51]
Cons.	-0.23	-0.20
	[-1.56]	[-1.29]
R^2	0.3025	0.4029
Obs.	103	103

Notes. This tables reports results from regressing the absolute value of monetary policy shocks, |MPS|, on lagged interest rate range, IRRANGE, MPS, and interaction terms on FOMC announcement days. IRRANGE and MPS are normalized to have zero mean and unit standard deviation. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.21
Predicting MPS using IRRANGE and firm option demand

	(1)	(2)
IRRANGE	0.14	0.15
	[1.01]	[1.08]
Demand		0.33***
		[3.51]
Cons.	-0.31	-0.34
	[-1.23]	[-1.33]
R^2	0.0232	0.1326
Obs.	103	103

Notes. This table reports results from regressing MPS on lagged daily IRRANGE and firm option demand between 9:30 a.m. and 9:40 a.m. on FOMC announcement days. Option demand and IRRANGE are normalized to have zero mean and unit standard deviation. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.22

Firm morning option demand and asset price changes: Keynesian vs. information shocks

	$\text{MPS}^{\perp}$	$\Delta\, VIX^2_{fomc}$	ΔS&P	$\Delta\, VIX^2_{day}$
KEYN	-0.04	0.28	-0.06	2.36
	[-0.21]	[0.25]	[-0.78]	[0.86]
Demand	-0.23	2.30***	-0.10***	3.49***
	[-1.45]	[3.77]	[-4.51]	[3.22]
KEYN x Demand	0.63***	-0.81	-0.01	-0.20
	[3.60]	[-0.69]	[-0.15]	[-0.11]
Cons.	0.05	-3.21***	0.08**	-2.78
	[0.62]	[-5.39]	[2.10]	[-1.63]
R^2	0.1370	0.0716	0.0693	0.0546
Obs.	103	103	103	103

Notes. This table reports results from regressing several outcome variables on firm morning option demand, a dummy for Keynesian shocks (KEYN), and its interaction. The outcome variables are orthogonal monetary policy shocks $\text{MPS}^{\perp}$, the rate of change in VIX^2 from 10 minute before to 20 minutes after the announcement ($\Delta\, VIX^2_{fomc}$), the change in S&P 500 from 10 minute before to 20 minute after the announcement, and the rate of change in VIX^2 from 9:40 a.m. to current day's close ($\Delta\, VIX^2_{day}$) on FOMC days. We label announcements where the change in S&P 500 E-Mini futures and $\text{MPS}^{\perp}$ from Bauer and Swanson (2023b) in the 30-minute announcement window have opposite signs as "Keynesian shocks", and "Information shocks" otherwise. Out of 103 scheduled FOMC announcements in our sample period, 57 are classified as Keynesian shocks and 46 as information shocks. Morning demand refers to 9:30 a.m.–9:40 a.m. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.

Table A.23

Monetary policy shocks and asset price changes: Keynesian vs. information shocks

	$\Delta\, VIX^2_{fomc}$	$\Delta\, VIX^2_{fomc}$	$\Delta\, VIX^2_{fomc}$	ΔS&P
KEYN	-0.09	0.01	-0.14	-0.04
	[-0.08]	[0.01]	[-0.15]	[-0.67]
$MPS^{\perp}$		2.09***	-4.58***	0.25***
		[3.20]	[-4.11]	[4.15]
KEYN x $MPS^{\perp}$			7.78***	-0.56***
			[6.00]	[-7.69]
Cons.	-2.96***	-3.01***	-2.84***	0.06*
	[-4.65]	[-4.00]	[-5.50]	[1.80]
R^2	0.0001	0.1132	0.3071	0.5192
Obs.	103	103	103	103

Notes. This table reports results from regressing several outcome variables on orthogonal monetary policy shocks ($MPS^{\perp}$), a dummy for Keynesian shocks (KEYN), and its interaction. The outcome variables are the rate of change in VIX^2 from 10 minute before to 20 minutes after the announcement ($\Delta\, VIX^2_{fomc}$), and the change in S&P 500 from 10 minute before to 20 minute after the announcement (ΔS&P). We label announcements where the change in S&P 500 E-Mini futures and $MPS^{\perp}$ from Bauer and Swanson (2023b) in the 30-minute announcement window have opposite signs as "Keynesian shocks", and "Information shocks" otherwise. Out of 103 scheduled FOMC announcements in our sample period, 57 are classified as Keynesian shocks and 46 as information shocks. Morning demand refers to 9:30 a.m.–9:40 a.m. Net option demand is computed as buy minus sell volume. t-statistics in brackets are based on Newey-West standard errors. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively. The sample period is from January 3, 2011 to December 29, 2023.