Effects of Weekly Option Introduction on Market Participant Behavior and Volatility Expectations

Siddhesh Dalvi and Henry LaFond*

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1 Abstract

We examine how the introduction of weekly-expiring options on three major equity indexes has affected options market microstructure, including maturity allocation, trading behavior, and participant composition and volatility expectations. We find that the expansion of daily expirations is associated with a significant increase in ultra-short-dated (0–1DTE) trading, accompanied by evidence of maturity substitution away from both short-term (2–5DTE) and medium-term (6–30DTE) options. This shift is associated with a marked increase in directional trading intensity, particularly following Tuesday and Thursday expirations, as well as a rise in small trade activity consistent with increased retail participation. We also document a reflexive relationship between ultra-short-dated trading and directional behavior, suggesting that the growth of 0DTE options both reflects and reinforces speculative trading dynamics. We also find that the expansion of short-dated trading is associated with increased market maker intermediation, indicating greater hedging and liquidity provision demands in these markets. Additionally, we use ordinary least squares and instrumental variables

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regression strategies to estimate the relationship between expected volatility and increased trading volume in short-term (0–6DTE) options relative to long-term (≥7DTE) options. We find evidence that a higher percentage of short-term options volume is associated with a higher level of volatility expectations at a 30-day time horizon over our data period (2012–2024). We also find evidence that a higher percentage of short-term options volume is associated with a flatter volatility expectations term structure and lower 7-day volatility expectations relative to 30-day volatility expectations.

2 Introduction

Historically, Cboe has offered options on indexes that expire on the third Friday of each month. Beginning in 2016, Cboe began to offer exchange-traded options expiring on other weekdays with a time-to-expiration of one week at issuance with certain equity indexes as the underlying asset. **Exhibit 1** lays out the timeline of weekly option introductions for options on three different underlying indexes: the State Street SPDR S&P 500 ETF Trust ("SPY"), the iShares Russell 2000 ETF ("IWM"), and the Invesco QQQ Trust ("QQQ").

Exhibit 1: Timeline of Weekly Option Introductions

Index	Monday	Tuesday	Wednesday	Thursday	Friday
SPY	2/16/2018	11/14/2022	8/30/2016	11/16/2022	6/11/2010
IWM	10/8/2021	4/16/2024	10/5/2021	4/18/2024	6/11/2010
QQQ	4/23/2021	11/14/2022	4/27/2021	11/16/2022	6/11/2010

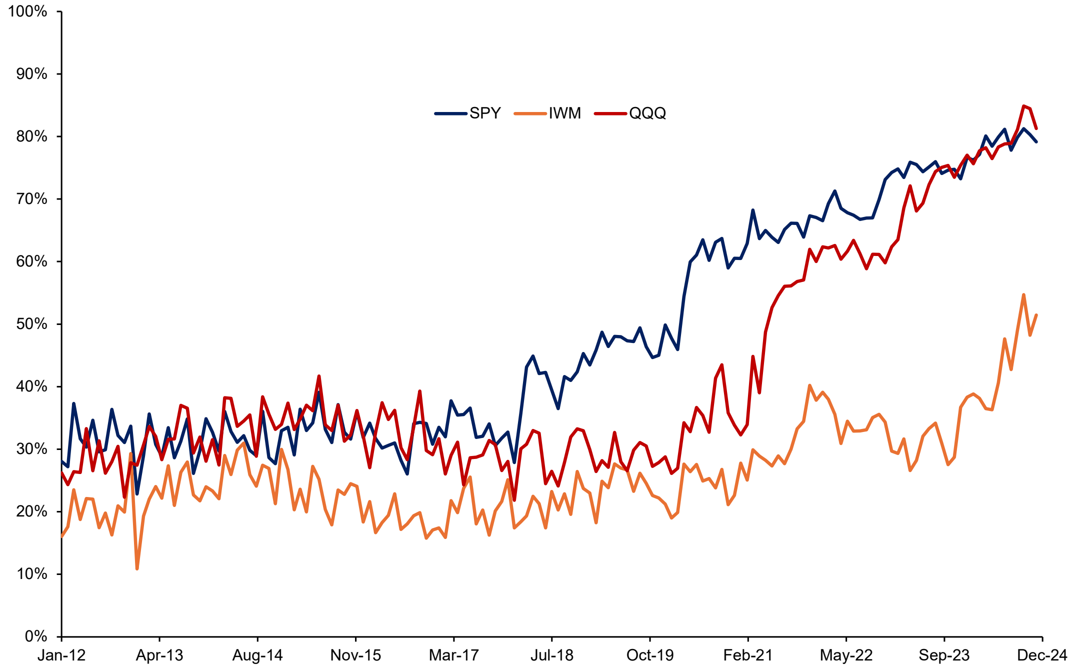
Source: Cboe Press Releases

The development of 0DTE options is best understood as the culmination of a multi-decade process of innovation in expiration structures. In the early years of listed options trading, contracts were limited to quarterly expirations, which were later supplemented by monthly cycles. This structure concentrated trading activity around a small number of expiration dates, resulting in pronounced volatility and liquidity effects during those periods. The introduction of weekly options in 2005 represented a critical turning point. By allowing contracts to expire at the end of each week, exchanges provided traders with the ability to more precisely align option maturities with anticipated events, such as earnings announcements or macroeconomic releases. The success of weekly options demonstrated strong latent demand for shorter-duration instruments and set the stage for further experimentation. Subsequent expansions included the addition of mid-week expirations and, eventually, the introduction of contracts expiring on every trading day. This progression was driven by both competitive dynamics among exchanges and evolving user needs. Market participants increasingly sought instruments that could isolate specific temporal risks, such as weekend gaps or intraday volatility spikes, which were not adequately addressed by longer-dated options. By the early 2020s, daily expirations had been implemented across major index and ETF options, effectively enabling continuous short-term trading. This transformation not only increased trading frequency but also fundamentally altered the temporal structure of risk in the options market. Instead of being concentrated around discrete expiration events, risk could now be transferred and resolved on a daily basis, leading to a more granular and dynamic market environment.

Over the same time period, a higher proportion of options trading volume has been concentrated in options that expire in fewer than seven days. **Exhibit 2** illustrates this change over time. Short-dated volume in SPY options as risen the fastest, followed by short-dated volume for QQQ options. The rise in volume for IWM options lags the rise in volume for SPY and QQQ options because of the differential timing of weekly option introductions shown in **Exhibit 1**.

The rise in short-dated options volume could be attributable to many factors besides the introduction of weekly options, such as increased levels of retail participation in options markets or option market maker hedging activity. We observe, however, that the percentage of short-dated options volume rises after the introduction of weekly options in each index. **Exhibit 3** shows, for each index, the change in the weekly percentage of short-dated options

Exhibit 2: Monthly Percentage of Options Volume with Fewer than 7 Days to Expiration: January 2012 – December 2024

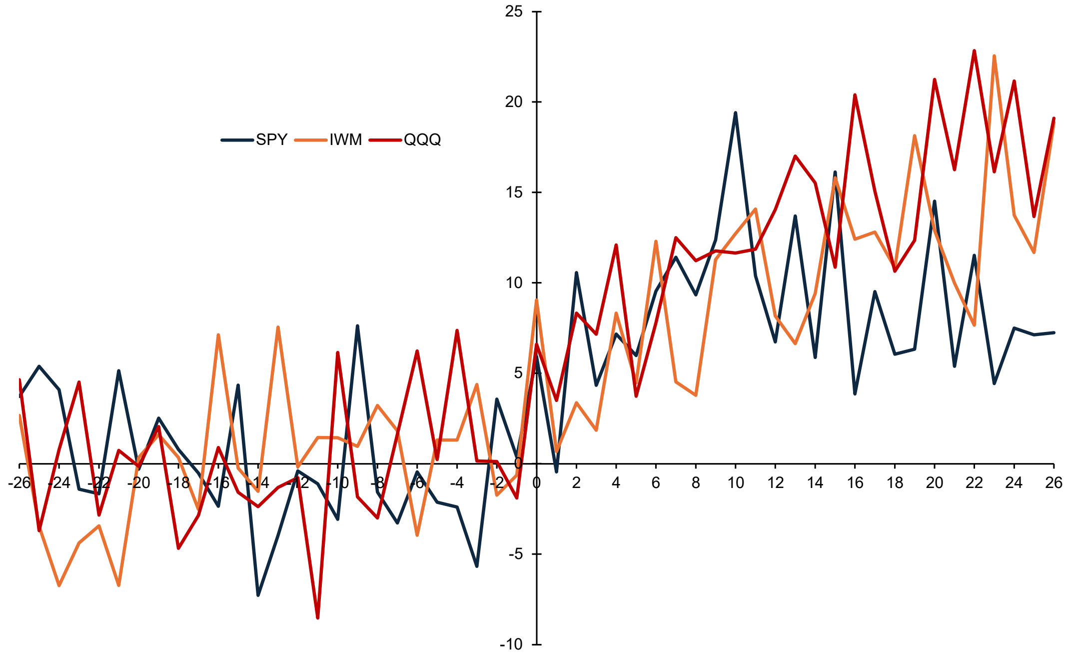


Source: Cboe Options Data
Note: Volumes are aggregated at the monthly level.

volume relative to the average percentage during the six months prior to weekly option introduction. Each data point represents the average over the four weekly option introductions on Monday through Thursday for each index N weeks before or after the introduction. We document an increase in the percentage of short-dated option volume after the introduction of weekly options. That increase occurs over a similar timeframe and at a similar magnitude for each of the three indexes.

We examine the market microstructure effects of weekly option introductions using a panel regression framework that exploits the staggered expansion of weekday expirations. We find that increased availability of ultra-short-dated options leads to a significant reallocation of trading toward the 0–1DTE segment, accompanied by declines in longer maturities and increases in directional trading intensity and small trade activity, consistent with greater retail participation. We also document a positive relationship between ultra-short-dated trading and directional behavior, along with increased market maker intermediation, suggesting that the growth of 0DTE options both reflects and reinforces more short-horizon,

Exhibit 3: Change in Weekly Percentage of Options Volume with Fewer than 7 Days to Expiration: 6 Months Before and After Weekly Option Introductions



Source: Cboe Options Data
Note: Weekly options are introduced in Week 0 in the chart. Percentages are computed relative to the average weekly percentage of options volume with less than 7 days to expiration during the 26 weeks prior to weekly option introduction.

flow-driven market dynamics.

Another one of our key research questions is how this increase in short-dated options volume relative to long-dated options volume has changed volatility expectations. One standard measure of of volatility expectations over a 30-day time horizon is the Cboe Volatility Index ("VIX"), which is calculated using S&P 500 Index option bid and ask quotes [2]. To analyze how the increase-in short-dated options volume has changed volatility expectations, we construct an analogous measure at a 7-day and 30-day time horizon using Cboe options trade data for SPY, IWM, and QQQ options, which we call the "Volatility Index". This Volatility Index differs from VIX because it is calculated based on executed trade prices rather than bid and ask quotes and because VIX is based on S&P 500 (SPX) options data rather than SPY, IWM, or QQQ options data. Nevertheless, the level of the Volatility Index at the 30-day time horizon correlates tightly with the VIX measure. We use our calculated Volatility Index to analyze how increases in short-dated options volume from weekly option introductions have affected both the level of volatility expectations at the 7-day and 30-day time horizons and the slope between them.

We analyze the term structure of the Volatility Index using a combination of ordinary least squares ("OLS") regression and instrumental variables ("IV") specifications. Our OLS regression analysis gives evidence that an increased proportion of short-dated options volume is associated with increased volatility at both the 7-day and 30-day time horizons while the slope of the Volatility Index curve flattens. We also analyze two IV specifications with separate instruments: (1) an indicator for the introduction of weekly options and (2) a five-week-lagged proportion of short-dated options volume. We find weaker evidence of increases in Volatility Index level at the 7-day horizon, but consistent evidence of increases at the 30-day horizon and that the Volatility Index term structure flattens with an increase in the proportion of short-dated options volume.

3 Related Literature

Our analysis of volatility primarily follows work by Brogaard et al. (2023) [5] and Khalil (2024) [6]. Brogaard et al. examine how the increase in 0DTE options volume has affected volatility for the options' underlying asset and finds that an increase in the proportion of 0DTE options trading increases the level of volatility in the underlying asset. They argue that this increase is caused by increase retail investor participation. Brogaard et al. use an instrumental variables regression methodology with an indicator variable for the introduction of weekly options as an instrument. We take a similar approach in our first instrumental variables specification. Khalil examines how the increase in 0DTE options volume has affected the variance risk premium (calculated as realized variance minus implied variance) for the underlying asset. Khalil finds that an increased percentage of 0DTE options volume relative to total options volume is associated with a more negative variance risk premium. Mechanically, this effect could occur due to a decrease in realized variance with constant implied variance, an increase in implied variance with constant realized variance, or some partially offsetting combination of the two. Given that Brogaard et al. find that underlying volatility rises with increased 0DTE options volume, we would expect implied variance to rise for the behavior to be consistent with Khalil's findings.

In terms of our analysis, we would thus expect the Volatility Index level to rise with an increased percentage of short-dated options trading. Our analysis differs from Brogaard et al. and Khalil because we used a longer time horizon (one week rather than one day) for identifying short-dated options. Additionally, we consider the impact of increased short-dated options trading on the relative levels of volatility expectations at different time horizons, which neither Brogaard et al. nor Khalil analyze.

4 Market Microstructure Analysis

4.1 Data Structure

In this section, we describe the construction of variables and the econometric framework used to analyze how the expansion of weekday option expirations affects market microstructure outcomes. The objective of the empirical design is to measure the relationship between increased availability of ultra-short-dated options and trading behavior, maturity allocation, and participant composition. The analysis is conducted using the Cboe Option Sentiment dataset, which provides daily aggregated measures at the underlying index level. Each observation corresponds to a given underlying index $i \in \{\text{SPY}, \text{QQQ}, \text{IWM}\}$ on trading day t, allowing us to exploit both cross-sectional variation across indices and time-series variation associated with structural changes in option expiration availability.

4.2 Regression Variable Construction

The central explanatory variables in the analysis are indicator variables that capture the introduction of weekday expirations. For each weekday d, excluding Friday, we construct an indicator variable $PostDay_t^{(d)}$ that takes the value one for all dates following the introduction of that weekday's expiration and zero otherwise. Using the staggered timing of these introductions, we can examine the effect of expanded expiration availability while controlling for broader time trends.

In addition to the discrete *PostDay* indicators, we construct a continuous measure of participation in ultra-short maturities, denoted $share_{0dte,i,t}$. This variable is defined as the fraction of total options trading volume accounted for by contracts with one or fewer days to expiration. While the measure includes both 0DTE and 1DTE contracts due to daily aggregation, it serves as a robust proxy for activity in the shortest segment of the maturity distribution and captures the concentration of trading in ultra-short horizons.

The dependent variables are constructed to capture multiple dimensions of market microstructure. To analyze maturity allocation, we construct the share of volume in the 0–1DTE ($share_{0dte}$), 2–5DTE ($share_{2\_5}$), and 6–30DTE ($share_{6\_30}$) buckets. These measures allow us to test whether the expansion of daily expirations leads to a reallocation of trading activity across maturities. In particular, declines in longer-dated shares following expiration expansions provide evidence of substitution toward ultra-short maturities rather than purely incremental demand.

To capture trading behavior, we use $directional\_pct_{i,t}$, which measures the fraction of trading volume classified as directional. Directional trades exclude complex multi-leg strategies and serve as a proxy for outright speculative or directional positioning. Changes in this variable allow us to assess whether increased availability of ultra-short maturities is associated with a shift toward more aggressive trading behavior.

We also construct a proxy for retail participation using $small\_share_{i,t}$, defined as the share of volume in the smallest trade size buckets. While trader identity is not directly observable, small trade size is widely used as a proxy for retail activity. In addition, we include measures of positioning and moneyness, specifically the shares of out-of-the-money call and put volume ($call\_otm\_share_{i,t}$ and $put\_otm\_share_{i,t}$), to capture how traders express views through payoff structures. Finally, we examine participant composition using clearing-category shares (market maker, firm, and customer), which allow us to analyze how intermediation changes as trading becomes more concentrated in short maturities.

To isolate the effect of expiration expansions, we include a set of control variables capturing time-varying market conditions. These include the logarithm of total trading volume, implied volatility ($iv30$), historical volatility ($hv20$), and contemporaneous underlying returns ($spot\_chg$). All specifications include underlying fixed effects and Year-Month fixed effects to control for persistent cross-sectional differences and common time trends.

We describe the calculation of the key variables listed in **Exhibit 4**. Our regression dataset includes observations at the trading date-underlying index level.

Exhibit 4: Variable Definitions

Exhibit 4: Variable Definitions

Variable		Definition
Outcome variables:		
0–1DTE Share	share_0dte	Share of volume in options with 0–1 calendar days to expiration
2–5DTE Share	share_2_5	Share of volume in options with 2–5 calendar days to expiration
6–30DTE Share	share_6_30	Share of volume in options with 6–30 calendar days to expiration
Directional Trading	directional_pct	Fraction of trading volume classified as directional
Retail Proxy	small_share	Share of volume in the smallest trade size buckets
Call OTM Share	call_otm_share	Share of out-of-the-money call volume
Put OTM Share	put_otm_share	Share of out-of-the-money put volume
Market Maker Share	mkt_mkr_share	Share of total volume attributable to market makers
Independent variables:		
Post Expiration Indicator	PostDay	Indicator equal to 1 for dates after introduction of a weekday expiration
Ultra-short Maturity Share	share_0dte	Fraction of total options volume in contracts with one or fewer days to expiration
Control variables:		
Underlying Index FE	α_i	Indicator variables for SPY, IWM, and QQQ underlyings
Year-Month FE	γ_YM	Year-Month fixed effects
Log Total Volume	log(total_volume)	Logarithm of total options trading volume
Implied Volatility	iv30	30-day implied volatility
Historical Volatility	hv20	20-day historical volatility
Spot Return	spot_chg	Contemporaneous return of the underlying index

4.3 Regression Construction

The baseline regression specification is given by:

$$Y_{i,t} = \beta \cdot PostDay_t + \Gamma X_{i,t} + \alpha_i + \gamma_{YM} + \varepsilon_{i,t}, \tag{1}$$

where $Y_{i,t}$ represents the outcome variable of interest, $PostDay_t$ captures expiration availability, $X_{i,t}$ denotes the vector of control variables, and α_i and γ_{YM} represent underlying and Year-Month fixed effects. Standard errors are clustered by time to account for cross-sectional correlation across underlyings.

We extend this framework to examine specific mechanisms. To test for maturity substitution, we replace the dependent variable with alternative maturity shares. To analyze reflexivity, we estimate specifications in which directional trading intensity is regressed on $share_{0dte}$, controlling for expiration indicators and other covariates. To study event-driven behavior, we estimate interaction models incorporating both $PostDay$ indicators and event dummies, such as FOMC days, allowing us to distinguish between general effects of expiration availability and event-specific responses.

All coefficients are interpreted in percentage point terms. Coefficients on indicator variables capture the average change in the dependent variable following the introduction of a new expiration day, while coefficients on continuous variables represent the effect of a one percentage point increase in ultra-short-dated participation. Economic significance is evaluated relative to the distribution of the dependent variables and the magnitude of observed shifts following expiration expansions.

A causal interpretation of the impact of expanded expiration availability on market microstructure outcomes would require that the timing of weekday expiration introductions be exogenous to short-term trading behavior. Future research is needed to verify the extent to which expiration expansion is driven by exogenous exchange-level design decisions. Our current analysis provides an initial estimate of the association between expanded expiration availability and market microstructure outcomes.

4.4 Results, Interpretation, and Market Implications

4.4.1 Effects of Expiration Expansion on Ultra-Short-Dated Trading

We begin by examining the direct effect of weekday expiration expansions on the share of ultra-short-dated options trading. The results provide strong evidence that increasing the availability of expirations is association with a statistically significant increase in participation in the 0–1 days-to-expiration segment. However, the magnitude of this effect varies meaningfully across weekdays, revealing important heterogeneity in the economic role of different expiration days.

Specifically, the introduction of Monday and Wednesday expirations is associated with large increases in ultra-short-dated trading share, on the order of approximately 3.3 to 3.6 percentage points, whereas Tuesday and Thursday expansions generate more modest increases of roughly 1 percentage point. While all coefficients are statistically significant, the economic magnitude differs substantially, indicating that not all expansions contribute equally to market activity.

This asymmetry suggests that the growth of ultra-short-dated trading is not driven purely by mechanical increases in supply, but rather by the interaction between product availability and underlying demand for specific risk horizons. Monday expirations likely capture demand for hedging weekend risk, which is otherwise difficult to isolate with traditional expiration structures. Wednesday expirations align closely with macroeconomic announcement cycles, particularly Federal Open Market Committee (FOMC) meetings, which are often scheduled midweek. In contrast, Tuesday and Thursday expirations primarily serve to fill gaps in the expiration calendar, providing incremental flexibility but not fundamentally unlocking new sources of demand.

Taken together, these results imply that the expansion of expiration days does not uniformly increase trading activity, but instead reveals a demand structure that is sensitive to the timing of risk. The large effects observed for Monday and Wednesday highlight the importance of aligning expiration availability with economically meaningful risk events, whereas the smaller effects for Tuesday and Thursday suggest diminishing marginal returns to additional expiration granularity.

Summary statistics for the key regression variables are computed in **Exhibit 5**. The summary statistics are computed with all underlying indexes pooled together.

Exhibit 5: Regression Outputs for Short Dated Trading

	Outcome Variable			
	PostMon	PostTue	PostWed	PostWed
Coef	0.0359	0.0103	0.0329	0.0105
t-Stat	8.9203	2.0531	8.8172	2.0942
p-value	0.0000	0.0401	0.0000	0.0362
Sig	***	**	***	**

4.4.2 Maturity Substitution and Compression of Risk Horizons

A central question in evaluating the impact of 0DTE options is whether their growth represents new demand or a reallocation of existing trading activity. The results provide strong evidence in favor of the latter, indicating that the expansion of ultra-short-dated trading is accompanied by substantial declines in longer-dated maturities.

Following the introduction of Tuesday and Thursday expirations, the share of volume in the 2–5 days-to-expiration bucket declines by approximately 4.3 percentage points, while the share in the 6–30 days-to-expiration bucket declines by approximately 8.6 percentage points. These effects are both economically large and highly statistically significant, suggesting a pronounced shift in the maturity distribution of options trading.

The magnitude of these declines, particularly in the 6–30 day segment, indicates that the growth of ultra-short-dated options is not simply displacing very near-term contracts, but is instead drawing activity away from even medium-term positioning. This represents a fundamental change in how market participants choose to express and manage risk. Rather than holding positions over multiple days or weeks, traders increasingly concentrate exposure within a single trading day, effectively compressing the time horizon of risk-taking.

This compression has important implications for market dynamics. Shorter maturities are associated with higher gamma and faster time decay, which in turn amplify the sensitivity of option prices to underlying price movements. As a result, a shift toward ultra-short maturities increases the responsiveness of trading activity to short-term price fluctuations and may contribute to more pronounced intraday dynamics. In this sense, the rise of 0DTE options represents not only a change in the level of activity, but also a transformation in the temporal structure of risk in the market.

Summary statistics for the key regression variables are computed in **Exhibit 6**. The summary statistics are computed with all underlying indexes pooled together.

Exhibit 6: Regression Outputs for Maturity Substitution

	Outcome Variable			
	PostTue		PostThu	
	share_2_5	share_6_30	share_2_5	share_6_30
Coef	-0.0425	-0.0866	-0.0436	-0.0859
t-Stat	-9.3779	-13.6851	-9.6592	-13.5515
p-value	0.0000	0.0000	0.0000	0.0000
Sig	***	***	***	***

4.4.3 Directional Execution and Behavioral Shifts

In addition to changes in maturity allocation, the expansion of daily expirations is associated with significant shifts in trading behavior. We observe large increases in directional execution intensity, particularly following the introduction of Tuesday and Thursday expirations, where directional share rises by approximately 13 percentage points. This effect is economically meaningful and indicates a substantial increase in the share of trading volume classified as directional.

Directional trades exclude complex multi-leg strategies and serve as a proxy for outright speculative or directional positioning. The increase in directional intensity suggests a shift in how options are used, with trading moving away from structured strategies toward more direct exposure to underlying price movements. This change can be understood through the payoff characteristics of ultra-short-dated options. As time to expiration decreases, options exhibit higher gamma, making their value more sensitive to small price changes. Combined with rapid time decay, this creates strong incentives for short-horizon, high-convexity trading. As a result, options increasingly function as instruments for expressing intraday views rather than longer-horizon hedging.

Summary statistics for the key regression variables are computed in **Exhibit 7**. The summary statistics are computed with all underlying indexes pooled together.

Exhibit 7: Regression Outputs for Directional Execution

	Outcome Variable			
	PostMon	PostTue	PostWed	PostThu
Coef	2.6009	13.2984	1.4777	13.2996
t-Stat	6.2982	31.5042	3.7766	31.5794
p-value	0.0000	0.0000	0.0002	0.0000
Sig	***	***	***	***

4.4.4 Participation Effects and the Role of Retail Traders

The expansion of daily expirations is also associated with a significant increase in small trade activity, which serves as a proxy for retail participation [1]. Following the introduction of Tuesday and Thursday expirations, small trade share increases by approximately 5.9 percentage points, indicating a broadening of participation in options markets.

Ultra-short-dated options are particularly attractive to retail traders due to their low premiums, defined risk, and potential for large percentage returns over short horizons. The short feedback cycle inherent in same-day expiration further enhances their appeal. Increased retail participation may alter order flow composition, as retail trading tends to exhibit greater sensitivity to recent price movements and a higher propensity for directional positioning, potentially amplifying short-term price dynamics.

Summary statistics for the key regression variables are computed in **Exhibit 8**. The summary statistics are computed with all underlying indexes pooled together.

Exhibit 8: Regression Outputs for Retail Trading

	Outcome Variable			
	PostMon	PostTue	PostWed	PostThu
Coef	0.0212	0.0590	0.0081	0.0592
t-Stat	15.3900	40.9347	6.4286	41.0583
p-value	0.0000	0.0000	0.0000	0.0000
Sig	***	***	***	***

4.4.5 Reflexivity and Endogenous Market Dynamics

We next examine the relationship between ultra-short-dated trading and directional execution intensity. The results indicate that higher participation in the 0–1DTE segment is associated with increased directional trading, even after controlling for expiration indicators and other covariates. This provides evidence of a reflexive relationship between maturity choice and trading behavior.

The positive relationship suggests that increased use of short-dated options reinforces speculative activity, creating feedback effects between market structure and trading behavior. As directional trading rises, demand for ultra-short-dated options increases, which may further amplify short-term price movements. Such reflexivity implies that markets become more sensitive to shocks, with trading behavior and price dynamics evolving jointly.

Summary statistics for the key regression variables are computed in **Exhibit 9**. The summary statistics are computed with all underlying indexes pooled together.

Exhibit 9: Regression Outputs for Reflexivity

	Outcome Variable				
	Mon	Tue	Wed	Thur	Fri
Coef	2.7152	2.5909	2.9021	2.5840	3.0862
t-Stat	2.2931	2.2447	2.4488	2.2389	2.6128
p-value	0.0218	0.0248	0.0143	0.0252	0.0090
Sig	**	**	**	**	***

4.4.6 Event-Driven Trading and FOMC Interactions

We examine whether the introduction of Wednesday expirations alters trading behavior around macroeconomic events, specifically FOMC announcements. The results show no significant increase in ultra-short-dated participation on event days following expansion, suggesting that short maturities were already used for event-driven trading prior to the introduction of Wednesday expirations.

However, we observe changes in trade composition. In particular, the share of out-of-the-money call options increases, while directional execution intensity declines on FOMC days. This pattern indicates that expiration expansion affects how traders express views rather than the level of participation. Event-driven trading appears to operate primarily through adjustments in payoff structure rather than maturity selection.

Summary statistics for the key regression variables are computed in **Exhibit 10**. The summary statistics are computed with all underlying indexes pooled together.

Exhibit 10: Regression Outputs for Event-Driven Trading

Outcome Variable	Coef	t-Stat	p-value	Sig
share_0DTE	0.0011	0.1549	0.8769	
directional_pct	-3.5252	-2.6328	0.0085	***
call_otm_share	0.064	2.721	0.0065	***
put_otm_share	-0.0219	-0.6977	0.4854	
small_share_proxy	0.0033	0.6233	0.5331	

4.4.7 Market Maker Intermediation and Structural Implications

Finally, we examine changes in participant composition. The results indicate a substantial increase in market maker participation following the introduction of Tuesday and Thursday expirations, with market maker share rising by approximately 10 percentage points. Firm share declines, while customer share increases modestly.

These patterns suggest that the growth of ultra-short-dated trading increases intermediation demands. Short-dated options generate higher turnover and rapidly changing risk exposures, requiring continuous hedging and rebalancing by market makers. While increased intermediation may support liquidity under normal conditions, it may also amplify price movements through hedging activity, particularly in environments with strong directional flows.

Taken together, these results indicate that the expansion of daily expirations is associated with a shift toward more directional trading, increased retail participation, and greater reliance on market maker intermediation. These changes reflect a broader transition toward shorter-horizon, flow-driven market dynamics.

Summary statistics for the key regression variables are computed in **Exhibit 11**. The summary statistics are computed with all underlying indexes pooled together.

Exhibit 11: Regression Outputs for Market Maker Intermediation

	Outcome Variable					
	mkt_mkr_share		firm_share		cust_share	
	PostTue	PostThu	PostTue	PostThu	PostTue	PostThu
Coef	0.1004	0.0995	-0.1175	-0.1175	0.0096	0.0104
t-Stat	20.1695	19.9050	-25.1974	-25.0630	2.6826	2.9188
p-value	0.0000	0.0000	0.0000	0.0000	0.0073	0.0035
Sig	***	***	***	***	***	***

4.4.8 Synthesis and Broader Implications

Taken together, the results provide a comprehensive picture of how the expansion of daily expirations has transformed options market microstructure. The evidence points to a shift toward shorter maturities, more directional trading, increased retail participation, and greater reliance on market maker intermediation. These changes are interconnected and reflect a broader transition toward a market environment characterized by shorter time horizons and more flow-driven dynamics.

Importantly, the results suggest that the rise of 0DTE options is not merely a quantitative increase in trading activity, but a qualitative transformation in how markets operate. By compressing the time horizon of risk and increasing the responsiveness of trading to short-term price movements, ultra-short-dated options have altered the fundamental nature of options markets. Understanding these changes is essential for assessing their implications for volatility, liquidity, and market stability.

5 Volatility Expectations Analysis

5.1 Data

We use several datasets from Cboe, the Federal Reserve, and other vendors to construct our volatility regression dataset. In this section, we describe the data sources, our variable construction methodology, and provide summary statistics for the key regression variables.

5.1.1 Data Sources

The primary data source consists of trade-level options data from Cboe for the time period from January 3, 2012 to July 7, 2025 ("Cboe Options Data"). The Cboe Options Data includes trades data for options on the SPY, IWM, and QQQ equity indexes. SPY tracks a broad market-cap weighted index covering large-cap companies in multiple sectors. IWM tracks a broad market-cap weighted index covering small-cap companies in multiple sectors. QQQ tracks a market-cap weighted index covering large-cap technology companies. For each options trade, the Cboe Options Data include information about the date and time of the trade, the underlying asset, strike, time to expiration, type (put or call), trade size, and trade price.

For construction of our regression variables, we also obtained additional Cboe, Federal Reserve, and other vendor data. We obtained VIX closing levels, measured at 4:15pm ET, from Cboe at the daily level [4]. We obtained daily yield data for short-term Treasury bonds from the Federal Reserve. We obtained daily price, volume, and returns data for the SPY, IWM, and QQQ indexes from Refinitiv.

5.1.2 Regression Variable Construction

We describe the calculation of the key variables listed in **Exhibit 12**. Our regression dataset includes observations at the trading date-underlying index level.

Exhibit 12: Variable Definitions

Variable		Definition
Outcome variables:		
7-day Volatility Index	VI^{7}_{it}	Level of VIX-like volatility index with 7 calendar days to expiration
30-day Volatility Index	VI^{30}_{it}	Level of VIX-like volatility index with 30 calendar days to expiration
Volatility Index Slope	RR_{it}	Slope of VIX-like volatility index, calculated as VI^{7}_{it} - VI^{30}_{it}
Independent variable:		
%<7DTE Contract Volume	$Pct7_{it}$	Daily percentage of options volume by index with fewer than 7 calendar days to expiration; in percentage points
Control variables:		
Underlying Index FE	α_i	Indicator variables for IWM and QQQ indexes
Weekday FE	δ_t	Indicator variables for Mondays, Tuesdays, Wednesdays, and Thursdays
Previous Index Return	$Return_{t-1}$	Percentage return for the underlying index on the previous trading day; standardized by subtracting mean and scaling by standard deviation
Previous Index Volume	$Volume_{t-1}$	Log trading volume for the underlying index on the previous trading day; standardized by subtracting mean and scaling by standard deviation
Realized Volatility (prior 30 days)	$RealizedVol30_{it}$	Realized volatility over the prior 30 days, annualized
Instrumental variables:		
Weekly Option Introduction Indicator	$Weeklys_{it}$	Indicator variable for weekly option availability for each index-day of week combination
Five-week Lagged %<7DTE Contract Volume	$LagPct7_{it}$	$Pct7_{it}$ from 35 calendar days prior; in percentage points

The independent variable of interest is the daily fraction of options trading that occurs in contracts with fewer than seven calendar days to expiration. This fraction is calculated separately for each trading day and underlying index and multiplied by 100 to express the quantity in percentage points. We denote this percentage as $Pct7_{it}$, where the i subscript indicates the index and the t subscript indicates the trading day.

We construct indicator variables for each underlying index (α_i) and day of the week (δ_t) to use as fixed effect controls. SPY is the reference level for the underlying index indicator variables and Friday is the reference level for the day of the week indicator variables.

To adjust for underlying index price movement and volume patterns in our analyses, we include controls for underlying index return and volume variables from the previous trading day. The previous day's close-to-close total return for the underlying index is standardized by subtracting the mean value over the period of the Cboe Options Data and dividing by the standard deviation over the period of the Cboe Options Data. We denote this standardized return as $Return_{it}$. The logarithm of the previous day's underlying index volume is similarly standardized and denoted as $Volume_{it}$. The effect of a unit change in these variables is the same as a one-standard deviation change in the raw underlying return or log underlying trading volume.

To adjust for volatility persistence, we include the realized volatility of the underlying asset for the prior 22 trading days (approximately one month of data). The variable is standardized in the regression specifications by subtracting its mean level over the period of the Cboe Options Data and is denoted by $RealizedVol30_{it}$.

We compute two quantities for use as instrumental variables. First, we construct an indicator variable for weekly option availability for each index-day of the week combination. The indicator variable is 0 for days prior to weekly option introduction and 1 for days on or after weekly option introduction. Thus, for example, the indicator is 1 for Monday SPY observations on or after February 16, 2018, and is 0 for earlier Monday SPY observations. The indicator variable is always 1 on Fridays in the regression dataset and is denoted $Weeklys_{it}$. The dates of option introductions for each index and weekday are detailed in **Exhibit 1**. Second, we construct a lagged volume measurement, $LagPct7_{it}$, which measures the level of $Pct7_{it}$ thirty-five calendar days prior to day t. This measures the penetration of short-dated options approximately one month before the date under consideration. By choosing a long lag, we avoid any potential confounding between this instrument and our adjustment for volatility persistence.

Finally, we construct three outcome variables, VI^7_{it}, VI^{30}_{it}, and RR_{it} to measure the level and slope of the Volatility Index. We describe the construction of the Volatility Index in detail below. VI^7_{it} measures the level of the Volatility Index at a time horizon of seven days. VI^{30}_{it} measures the level of the Volatility Index at a time horizon of 30 days. RR_{it} measures the slope of the Volatility Index term structure between these two points as the difference in levels, $RR_{it} = VI^7_{it} - VI^{30}_{it}$. Positive values of RR_{it} indicate that short-term expected volatility is higher than longer-term expected volatility, while negative values indicate the opposite.

5.1.3 Volatility Index Construction

The VIX index measures the expected volatility of the S&P 500 Index over a 30-day time horizon using quotes data for options on the S&P 500 Index. Our analogous Volatility Index extends a similar construction to a 7-day time horizon as well as the 30-day time horizon using the Cboe Option Trades Data. The Volatility Index is calculated separately for each underlying index i, date t, and time to expiration T. We follow a similar approach to the Cboe's VIX construction [3].

Step 1: We calculate the volume-weighted average price across all trades for each day, grouped by underlying index, time to expiration, strike price K, and option type (call or put). This price is denoted as $vwap^{call}_{itTK}$ or $vwap^{put}_{itTK}$ for calls and puts respectively.

Step 2: For each strike, we calculate the magnitude of the difference between the call and put prices:

$$\Delta_{itTK} = |vwap^{call}_{itTK} - vwap^{put}_{itTK}|.$$

We identify the at-the-money (ATM) strike K^{ATM} for each index and date (subscripts suppressed) as the strike for which Δ_{itTK} is minimized. If there are multiple minima, we pick the smallest strike price as K^{ATM}.

Step 3: We calculate the forward price

$$F_{itT} = K^{ATM} + e^{r_t T/365}(vwap^{call}_{itTK^{ATM}} - vwap^{put}_{itTK^{ATM}}),$$

where r_t denotes the applicable interest rate for the day. The interest rate is calculated using the one-month Treasury yield data from the Federal Reserve and converting that yield to a continuously compounded rate equivalent to semi-annual compounding for the listed yield. For dates where no yield data are available, we use the rate from the closest prior day with available yield data.

Step 4: We identify a reference strike K^0 for each index and date (subscripts suppressed) as the largest strike price that is no greater than the forward price F_{itT}.

Step 5: We calculate the contribution V_{itTK} for each strike price K as

$$V_{itTK} = \frac{2}{T/365} e^{r_t T/365} \cdot Q_{itTK} \cdot \frac{\Delta K}{K^2},$$

where

$$Q_{itTK} = \begin{cases} vwap^{put}_{itTK}, & K < K_0 \\ \frac{1}{2}(vwap^{call}_{itTK} + vwap^{put}_{itTK}), & K = K_0 \\ vwap^{call}_{itTK}, & K > K_0 \end{cases},$$

and the weighting factor ΔK is defined as the difference between adjacent strikes if K is the highest or lowest strike. Otherwise, ΔK is calculated as the average difference between strikes adjacent to K.

Step 6: Calculate the squared Volatility Index $(VI_{itT})^2$ as:

$$(VI_{itT})^2 = \sum_K V_{itTK} - \frac{1}{T/365} \left(\frac{F_{itT}}{K^0} - 1 \right)^2.$$

Exclude observations for which $(VI_{itT})^2$ is negative.

Step 7: Options with exactly 7 or 30 days to expiration did not necessarily trade on each day. To compute the level of $(VI_{itT})^2$ at the 7 or 30-day horizons when there is no option with exactly 7 or 30 days to expiration, identify the nearest maturities with data before and after the desired maturity. Linearly interpolate $(VI_{itT})^2$ to obtain the level of $(VI_{itT})^2$ at the 7 or 30-day maturity.

Step 8: The Volatility Index VI_{itT} is then calculated as $VI_{itT} = 100 \times \sqrt{(VI_{itT})^2}$.

5.1.4 Regression Variable Summary Statistics

Summary statistics for the key regression variables are computed in **Exhibit 13**. The summary statistics are computed with all underlying indexes pooled together. Summary statistics for standardized control variables are calculated prior to standardization.

Exhibit 13: Regression Dataset Summary Statistics

Variable	Minimum	25th Percentile	Median	Mean	75th Percentile	Maximum	Standard Deviation	Observations	Missing
Outcome variables:									
VI^{7}_{it}	7.2	15.2	18.9	21.1	24.5	122.2	9.4	9,520	143
VI^{30}_{it}	8.4	15.3	18.5	20.3	23.6	84.7	7.4	9,662	1
RR_{it}	-35.5	-1.0	0.4	0.8	2.0	104.9	3.5	9,520	143
Independent variable:									
$Pct7_{it}$	4.8%	24.6%	33.6%	38.8%	50.3%	90.4%	19.3%	9,662	1
Control variables:									
$Return_{t-1}$	-13.3%	-0.5%	0.1%	0.1%	0.7%	9.1%	1.2%	9,657	6
$Volume_{t-1}$	6.8	27.2	42.5	56.1	71.3	507.2	42.2	9,660	3
$RealizedVol30_{it}$	3.2%	11.2%	15.0%	17.0%	20.4%	99.7%	9.5%	9,597	66
Instrumental variables:									
$Weeklys_{it}$	0.0%	0.0%	0.0%	39.9%	100.0%	100.0%	49.0%	9,663	0
$LagPct7_{it}$	5.1%	24.5%	33.3%	38.5%	49.9%	90.4%	19.1%	9,125	538

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Yield Data
Note: Statistics are computed across all underlying indexes. Statistics for control variables are calculated prior to standardization.

The independent variable $Pct7_{it}$ exhibits significant variation, with short-term option volume comprising between 5% and 90% of options trading volume at the minimum and maximum of the period.

The level outcome variables exhibit skewness, with the maximum significantly greater than the 75th percentile and the 25th percentile less than one standard deviation below the median. The distribution of the level outcomes is similar to the distribution of the lagged realized volatility variable, which has a slightly narrower range, lower mean, and similar standard deviation. Additionally, options on SPY have lower levels of VI^{7}_{it} and VI^{30}_{it} on average than options on IWM and QQQ, as shown in **Exhibit 14** below, which shows that the coefficients on the IWM and QQQ index indicator variables is positive and statistically significant in regressions of the level outcome variables against the contemporaneous level of VIX. The slope outcome variable exhibits a tight distribution in the center, as the 25th percentile and 75th percentile are less than one standard deviation apart, with wide tails. The Volatility Index curve usually exhibits a downward slope from the short-term 7-day maturity to the longer-term 30-day maturity, as shown by the positive median and mean levels of RR_{it}.

In **Exhibit 14** we examine the relationship between the outcome variables and the contemporaneous level of VIX to confirm that the Volatility Index construction is measuring similar expectations to the VIX. At the 30-day horizon, we find that VI_{it}^{30} varies nearly one-for-one with VIX after adjusting for level differences between underlying indexes. Variation in VIX alone accounts for over 90% of the variation in VI_{it}^{30}. Similar results hold for VI_{it}^{7}, though the short-term Volatility Index measurement rises by 1.25, more than the longer-term Volatility Index measurement, when VIX rises by 1.0. Mechanically, this causes the slope RR_{it} to vary positively with VIX (coefficient of 0.24), though variation in VIX alone only explains less than a quarter of variation in the slope. Additionally, we find that IWM and QQQ options exhibit higher average Volatility Index levels and somewhat steeper slopes.

Exhibit 14: OLS Regression of Outcome Variables vs. Contemporaneous VIX

	VI^{7}_{it}	VI^{30}_{it}	RR_{it}
VIX	1.25 ***	1.01 ***	0.24 ***
	(0.04)	(0.03)	(0.03)
Intercept	17.62 ***	17.55 ***	0.07
	(0.22)	(0.04)	(0.16)
IWM indicator	6.24 ***	4.99 ***	1.25 ***
	(0.36)	(0.30)	(0.21)
QQQ indicator	4.17 ***	3.32 ***	0.83 ***
	(0.33)	(0.28)	(0.22)
Day of Week FE	No	No	No
Adjusted R^2	86.5%	90.4%	23.4%
Observations	9,520	9,662	9,520
F-statistic	20,314.59 ***	30,282.04 ***	971.38 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data
Note: Ordinary least squares regression with index fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001.

5.2 Empirical Analysis

5.2.1 OLS Regression Analysis

We first analyze the relationship between the three outcome variables and the percentage of trading volume in short-dated options using ordinary least squares (OLS) regression. For each outcome variable, we examine two specifications. Both specifications include controls for index and weekday fixed effects, but one specification also includes standardized controls for the return and log trading volume in the underlying index and the realized volatility over the past month, to account for the persistence of volatility. Coefficients and Newey-West standard errors are displayed in **Exhibit 15**. Letting Y_{it} denote the outcome variable, the specifications are as follows:

$$Y_{it} = \alpha_i + \delta_t + \beta \cdot Pct7_{it} + \Gamma \cdot X_{it} + \varepsilon_{it},$$

where X_{it} represents a matrix, possibly empty, of control variables, and ε_{it} is the regression error term. The coefficient β is the key coefficient of interest and represents the effect of a one percentage point increase in the percentage of options volume that is short dated on each outcome variable, holding other covariates constant.

The level outcome variables are positively and significantly associated with $Pct7_{it}$, while the slope variable is negatively and significantly associated with $Pct7_{it}$. Notably, the association between VI^7_{it} and $Pct7_{it}$ is weaker after adding additional control variables. A 10-percentage point increase in $Pct7_{it}$ is associated with an increase of only 0.19 in VI^7_{it} with controls, which is small compared to the standard deviation of 9.4 and mean value of 21.1. This suggests that the effect of additional short-term option volume share on 7-day volatility expectations is economically small. A 10-percentage point increase in $Pct7_{it}$ is associated with an increase of 0.56 in V^{30}_{it}, which is somewhat larger in comparison that variables standard deviation of 7.4 and mean value of 20.3. Overall, the magnitude is not large compared to the effect of changes in realized volatility. A 10-percentage point increase in $Pct7_{it}$ is

Exhibit 15: OLS Regression of Outcome Variables vs. Short-term Share of Trading Volume

	VI^{7}_{it}		VI^{30}_{it}		RR_{it}	
$Pct7_{it}$	0.080 ***	0.019 *	0.106 ***	0.056 ***	-0.026 ***	-0.037 ***
	(0.017)	(0.009)	(0.013)	(0.008)	(0.005)	(0.004)
$Return_{t-1}$		-1.100 ***		-0.632 ***		-0.460 ***
		(0.083)		(0.047)		(0.055)
$Volume_{t-1}$		2.076 ***		1.140 ***		0.932 ***
		(0.214)		(0.146)		(0.096)
$RealizedVol30_{it}$		0.682 ***		0.567 ***		0.116 ***
		(0.040)		(0.032)		(0.020)
Index FE	Yes	Yes	Yes	Yes	Yes	Yes
Day of Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	9.7%	71.6%	13.9%	74.7%	3.9%	28.3%
Observations	9,520	9,457	9,662	9,596	9,520	9,457
F-statistic	146.8 ***	2,383.4 ***	224.0 ***	2,834.5 ***	56.1 ***	375.0 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data

Note: Ordinary least squares regression with index fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001.

associated with an decrease of 0.37 in the slope of the Volatility Index. This is small relative to the standard deviation of 3.5, but large in percentage terms compared to the mean value of 0.8. The $Return_{t-1}$ and $Volume_{t-1}$ variables are standardized so that the coefficients represent the effect of a one standard deviation change in those variables. Higher prior-day returns are associated with lower volatility expectation levels looking forward and a flatter Volatility Index. Higher prior-day volumes are associated with higher volatility expectations looking forward and a steeper Volatility Index.

We use a 10-percentage point increase in $Pct7_{it}$ as a baseline measurement for determining economic relevance based on **Exhibit 3** above, which shows an increase of approximately 10 percentage points in the six months after the introduction of weekly options relative to the average before the introduction of new weekly options.

The OLS regression estimates suffer from several potential sources of error. First, the outcome variables themselves may drive trading behavior. For example, higher levels of expected volatility might lead to additional trading activity as market participants seek to hedge volatility exposure or speculate on future volatility movements. Similarly, changes in the slope of the Volatility Index term structure could cause market participants to prefer trading in shorter-term or longer-term options to take advantage of the relative expected volatility. A second potential source of error is omitted variables bias. There may be other sources of variation that affect both the outcome variables and $Pct7_{it}$. For example, the COVID-19 pandemic drove up the level of expected volatility and could have had a causal effect on the trading of short-dated options if it encouraged significant levels of retail participation during lockdown. A third concern is the persistent nature of volatility. Realized volatility is significantly correlated with the outcome variables, as shown in **Exhibit 16**, and the level of realized volatility over the prior month might influence trading behavior in the current week. This potential influence raises concerns about the bias of the OLS regression estimates.

Exhibit 16: OLS Regression of Outcome Variables vs. Realized Volatility

	VI^7_{it}	VI^{30}_{it}	RR_{it}
$RealizedVol30_{it}$	0.77 ***	0.63 ***	0.14 ***
	(0.10)	(0.06)	(0.04)
Intercept	17.24 ***	17.35 ***	-0.15
	(0.32)	(0.32)	(0.16)
IWM indicator	6.22 ***	4.98 ***	1.25 ***
	(0.50)	(0.46)	(0.21)
QQQ indicator	4.16 ***	3.33 ***	0.82 ***
	(0.44)	(0.50)	(0.21)
Day of Week FE	Yes	Yes	Yes
Adjusted R^2	65.3%	70.3%	15.8%
Observations	9,457	9,596	9,457
F-statistic	2,537.86 ***	3,238.11 ***	254.73 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data

Note: Ordinary least squares regression with index fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

5.2.2 IV Regression Analysis

To supplement the OLS analysis, we perform two instrumental variables (IV) regression analyses to analyze the relationship between changes in short-term options volume and the level and slope of the Volatility Index curve. We perform our analysis using two distinct instrumental variables: $Weeklys_{it}$, an indicator for days on which weekly options are available for that day of the week and index combination, and $LagPct7_{it}$, which measures the level of $Pct7_{it}$ thirty-five calendar days prior to the date under consideration. We implement the IV regression strategy using two-stage least squares (2SLS). For the IV regression strategy to give rise to a valid causal interpretation, the instrumental variables must be (1) relevant, (2) exogenous, and (3) obey the exclusion restriction. While we document relevance, there are potential exogeneity and exclusion concerns that prevent a causal interpretation of our estimates. Instead, our findings give further evidence of association between changes in the Volatility Index curve and short-term options volume.

For the relevance condition, we evaluate the first-stage regressions for both potential instrumental variables. We expect $Weeklys_{it}$ to strongly influence $Pct7_{it}$ because the introduction of new weekly options increases the set of short-dated options that could be traded in any given week. If, for example, one compares a Monday where only Wednesday and Friday weekly expirations are available for SPY options to one where Monday weekly expirations are also available, one would expect a higher $Pct7_{it}$ in the latter case. **Exhibit 17** shows the first-stage regression of $Pct7_{it}$ against the $Weeklys_{it}$ instrumental variable, controlling for the same index and weekday fixed effects and control variables as in the original OLS specifications. The regression confirms the intuition above, as the instrumental variable has a large and significant coefficient and significant regression F-statistic in both specifications.

We expect $LagPct7_{it}$ to strongly influence $Pct7_{it}$ because of the time trend of options trading volume in **Exhibit 2**. The exhibit shows that higher proportions of trading in short-dated options are followed by higher proportions of trading in short-dated options over time as there is more market penetration. **Exhibit 18** shows the first-stage regression of $Pct7_{it}$

Exhibit 17: First Stage: Weeklys Available Instrument

	$Pct7_{it}$	
$Weeklys_{it}$	14.233 ***	13.815 ***
	(0.737)	(0.783)
$Return_{t-1}$		-0.304
		(0.083)
$Volume_{t-1}$		-1.062 *
		(0.214)
$RealizedVol30_{it}$		0.250 ***
		(0.042)
Index FE	Yes	Yes
Day of Week FE	Yes	Yes
Adjusted R^2	9.1%	71.2%
Observations	9,520	9,457
F-statistic	117.4 ***	2,348.8 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data

Note: Ordinary least squares regression with index and day-of-week fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001.

against the $LagPct7_{it}$ instrumental variable, controlling for the same index and weekday fixed effects and control variables as in the original OLS specifications. The regression confirms this intuition, as the instrumental variable has a large and significant coefficient and significant regression F-statistic across both specifications.

To satisfy the exogeneity requirement, the instrumental variables much each be uncorrelated with the error term in the second-stage regression. In the case of the $Weeklys_{it}$ instrumental variable, the introduction of weekly options would need to be unrelated to the level or slope of the Volatility Index curve. As a heuristic indication, **Exhibit 19** illustrates the average level of VIX over the four weeks prior to each weekly option introduction. The bottom panel of the exhibit shows the same data in terms of standard deviations away from the mean VIX level over the length of the dataset. There is no consistent pattern. In other words, based on this metric, Cboe does not appear to have systematically introduced new options during periods of especially high or low VIX level. However, this analysis is merely

Exhibit 18: First Stage: Lagged Trading Volume Share Instrument

	$Pct7_{it}$	
$LagPct7_{it}$	0.787 ***	0.776 ***
	(0.021)	(0.022)
$Return_{t-1}$		-0.261 *
		(0.089)
$Volume_{t-1}$		-0.275
		(0.227)
$RealizedVol30_{it}$		0.134 ***
		(0.039)
Index FE	Yes	Yes
Day of Week FE	Yes	Yes
Adjusted R^2	9.9%	72.3%
Observations	8,999	8,999
F-statistic	126.8 ***	2,347.6 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data

Note: Ordinary least squares regression with index and day-of-week fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses.
* p < 0.05, ** p < 0.01, *** p < 0.001.

indicative and cannot fully support the assertion that the timing of weekly option introductions is exogenous to the shape of the Volatility Index Curve. Similarly, further analysis would be required to support the assumption that the $LagPct7_{it}$ instrumental variable is exogenous.

Finally, both $Weeklys_{it}$ and $LagPct7_{it}$ must only affect the outcome variables VI_{it}^7, VI_{it}^{30}, and RR_{it} through their effect on the proportion of short-dated trading volume, $Pct7_{it}$. Both instrumental variables might affect short-dated trading volume through other channels like liquidity driven by changing market participant behavior (e.g., market maker hedging). A causal interpretation of our estimates would require that the $Weeklys_{it}$ indicator have an effect only by increasing the range of options available to traders (i.e., a volume effect) rather than by changing liquidity. When calculating the level of the Volatility Index curve at the 7-day and 30-day horizons, most of the relevant options trades occur in options expiring more than one week away. Specifically, VI_{it}^7 is usually computed based on the average of

Exhibit 19: Average VIX over 4 Weeks before Weekly Option Introductions

Index	Weekday: Monday	Tuesday	Wednesday	Thursday
VIX level				
SPY	25.59	27.58	12.64	26.55
IWM	21.70	14.16	19.89	14.30
QQQ	18.21	27.58	17.76	26.55
Standard deviations away from mean VIX level				
SPY	1.20	1.50	-0.75	1.35
IWM	0.62	-0.52	0.34	-0.50
QQQ	0.09	1.50	0.02	1.35

Source: Cboe

Note: Averages are computed over the four weeks before the introduction of weekly options for each index-day of the week combination. Standard deviations are computed relative to the mean VIX level over the entire period of available data.

the weekly option with the longest remaining time to expiration and the monthly option with the shortest remaining time to expiration that is longer than one week, while VI^{30}_{it} is usually computed based on the average of two monthly options. While alternative channels, such as a liquidity channel, might have a smaller effect on these longer-dated options, we cannot rule such effects out. Alternative channels could also still affect short-dated options used in the computation of VI^{7}_{it} and RR_{it}. Similarly, variation in $LagPct7_{it}$ may still affect volatility expectations both through the time-series trend of trading volume and through other channels like the liquidity channel for similar reasons.

Without stronger evidence that the exogeneity and exclusion conditions hold, we cannot draw causal conclusions from the estimates below. Instead, these regressions provide further evidence of association between increased short-term options volume related to market penetration (as proxied by $Weeklys_{it}$ and $LagPct7_{it}$) and the shape of the Volatility Index curve.

5.2.3 IV Regression Analysis: Weekly Options Introduction Indicator

The schedule of weekly options introductions is listed in **Exhibit 1** above. **Exhibit 20** shows the results of the IV specification using $Weeklys_{it}$ as the instrumental variable. The regression findings vary by outcome variable. In general, the relevant coefficients for the level variable VI^{7}_{it} are not statistically significant, while the coefficients for VI^{30}_{it} and RR_{it} are.

Exhibit 20: IV Analysis: Weekly Option Availability Instrument

	VI^{7}_{it}		VI^{30}_{it}		RR_{it}	
$Pct7_{it}$	0.037	-0.017	0.093 ***	0.049 ***	-0.056 ***	-0.065 ***
	(0.024)	(0.010)	(0.024)	(0.010)	(0.005)	(0.005)
$Return_{t-1}$		-1.119 ***		-0.636 ***		-0.475 ***
		(0.083)		(0.046)		(0.054)
$Volume_{t-1}$		2.007 ***		1.125 ***		0.877 ***
		(0.214)		(0.151)		(0.102)
$RealizedVol30_{it}$		0.696 ***		0.570 ***		0.127 ***
		(0.042)		(0.032)		(0.019)
Index FE	Yes	Yes	Yes	Yes	Yes	Yes
Day of Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	9.1%	71.2%	13.8%	74.7%	1.8%	26.6%
Observations	9,520	9,457	9,662	9,596	9,520	9,457
F-statistic	117.4 ***	2,348.8 ***	156.2 ***	2,789.0 ***	72.6 ***	373.6 ***
Wu-Hausman	41.3 ***	81.1 ***	6.8 **	6.1 *	134.7 ***	147.0 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data

Note: Two-stage least squares regression with index and day-of-week fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Compared to the original OLS specification, the coefficient on $Pct7_{it}$ with VI^{7}_{it} is no longer statistically significant and remains economically small. This finding suggests that an increased short-dated share of options trading volume is not associated with higher near-term volatility expectations. The coefficients in the VI^{30}_{it} specifications remain statistically significant and are only slightly smaller than in the OLS regressions. The lack of movement at the short end of the Volatility Index curve plus the rise at the 30-day time horizon lead to a flattening of the Volatility Index curve as the short-dated share of options trading volume rises, consistent with the negative, statistically significant coefficients in the RR_{it}

specifications of **Exhibit 20**.

5.2.4 IV Regression Analysis: Lagged Short-Dated Options Volume

Exhibit 21 shows the results of the IV specification using $LagPct7_{it}$ as the instrumental variable. Similarly to the findings for the $Weekys_{it}$ variable specifications, the findings vary by outcome variable. Again, the relevant coefficient on $Pct7_{it}$ for the level variables is consistently significant only for VI^{30}_{it} while the relevant coefficient for the slope variable is consistently negative.

Exhibit 21: IV Analysis: Lagged Short-Dated Options Volume Share Instrument

	VI^7_{it}		VI^{30}_{it}		RR_{it}	
$Pct7_{it}$	0.073 ***	0.017	0.117 ***	0.067 ***	-0.043 ***	-0.051 ***
	(0.019)	(0.011)	(0.016)	(0.011)	(0.006)	(0.005)
$Return_{t-1}$		-1.114 ***		-0.646 ***		-0.459 ***
		(0.089)		(0.048)		(0.056)
$Volume_{t-1}$		2.083 ***		1.174 ***		0.905 ***
		(0.227)		(0.158)		(0.106)
$RealizedVol30_{it}$		0.679 ***		0.561 ***		0.118 ***
		(0.039)		(0.029)		(0.019)
Index FE	Yes	Yes	Yes	Yes	Yes	Yes
Day of Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	9.9%	72.3%	13.9%	74.5%	3.7%	30.0%
Observations	8,999	8,999	9,124	9,124	8,999	8,999
F-statistic	126.8 ***	2,347.6 ***	185.7 ***	2,663.7 ***	73.5 ***	399.4 ***
Wu-Hausman	2.9	0.8	6.7 **	36.8 ***	97.3 ***	95.9 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data

Note: Two-stage least squares regression with index and day-of-week fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

Compared to the original OLS specification, the coefficient on $Pct7_{it}$ with VI^7_{it} is significant only in the specification with no additional controls and remains economically small after controlling for the underlying asset's behavior. The lack of significance in the Wu-Hausman test also suggests that IV analysis may not be appropriate with this instrument for this outcome variable. This finding suggests that an increased short-dated share of options trading volume does not raise near-term volatility expectations and corroborates the findings from the previous IV analysis. The coefficients in the VI^{30}_{it} specifications remain statistically significant. However, in this case they are slightly larger than in the OLS specifications. Consistent with the first IV analysis, we again find that the Volatility Index flattens with additional short-dated options volume share. The magnitudes of the $Pct7_{it}$ coefficients in the VI_{it}^{30} and RR_{it} regressions of **Exhibit 21** are consistent with the $Weeklys_{it}$ IV specification in **Exhibit 20**. This consistency supports the findings.

5.3 Robustness to Contracts vs. Dollar Percentage Volume

We perform the same analysis using the percentage of option trading volume in short-dated options, weighted by the dollar value of the contracts (measured as price of contract times number of contracts). Our findings are robust to this choice, as shown in **Exhibits 22** and **23**. Relative to the equal weighting considered in the main specifications, this weighting choice generally adds weight to options that are at-the-money or in-the-money and under-weights options that are out of the money.

Directionally, the results of the OLS specifications agree with the findings in the main specifications. The level variable VI_{it}^{7} remains flat, VI_{it}^{30} and the slope RR_{it} decreases as $PctDollar7_{it}$ increases.

Using the same instruments with the new weighting for the independent variable, we find the same qualitative results as in the main specification with the $Weeklys_{it}$ instrumental variable, as shown in **Exhibit 22**. There is evidence of a statistically significant increase in VI_{it}^{30} associated with a higher proportion of trading in short-term options, but no statistically significant effect for the 7-day volatility expectation. There is somewhat stronger evidence of a statistically significant decrease in slope. We find the same qualitative results as in the main specification with the $LagPctDollar7$ instrumental variable, as shown in **Exhibit 23**. Again, the magnitudes of the Pct_{it} coefficients are similar across VI_{it}^{30} and RR_{it} specifications.

Exhibit 22: IV Analysis: Weekly Option Availability Instrument

	VI^{7}_{it}		VI^{30}_{it}		RR_{it}	
$PctDollar7_{it}$	0.075	-0.034	0.189 ***	0.098 ***	-0.114 ***	-0.132 ***
	(0.050)	(0.021)	(0.051)	(0.018)	(0.013)	(0.013)
$Return_{t-1}$		-1.123 ***		-0.623 ***		-0.492 ***
		(0.090)		(0.050)		(0.055)
$Volume_{t-1}$		2.020 ***		1.091 ***		0.925 ***
		(0.196)		(0.131)		(0.106)
$RealizedVol30_{it}$		0.696 ***		0.569 ***		0.127 ***
		(0.047)		(0.036)		(0.019)
Index FE	Yes	Yes	Yes	Yes	Yes	Yes
Day of Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	9.5%	71.0%	12.0%	73.9%	-7.7%	16.1%
Observations	9,520	9,457	9,662	9,596	9,520	9,457
F-statistic	117.9 ***	2,330.7 ***	153.0 ***	2,711.1 ***	66.2 ***	326.8 ***
Wu-Hausman	14.7 ***	70.3 ***	14.2 ***	19.3 ***	311.4 ***	385.6 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data

Note: Two-stage least squares regression with index and day-of-week fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001.

Exhibit 23: IV Analysis: Lagged Short-Dated Options Volume Share Instrument

	VI^{7}_{it}		VI^{30}_{it}		RR_{it}	
$PctDollar7_{it}$	0.104 **	0.007	0.188 ***	0.101 ***	-0.082 ***	-0.094 ***
	(0.040)	(0.020)	(0.039)	(0.019)	(0.012)	(0.011)
$Return_{t-1}$		-1.119 ***		-0.641 ***		-0.471 ***
		(0.089)		(0.049)		(0.057)
$Volume_{t-1}$		2.056 ***		1.106 ***		0.946 ***
		(0.222)		(0.154)		(0.110)
$RealizedVol30_{it}$		0.684 ***		0.567 ***		0.117 ***
		(0.039)		(0.031)		(0.019)
Index FE	Yes	Yes	Yes	Yes	Yes	Yes
Day of Week FE	Yes	Yes	Yes	Yes	Yes	Yes
Adjusted R^2	10.1%	72.3%	12.0%	73.8%	-2.6%	23.4%
Observations	8,999	8,999	9,124	9,124	8,999	8,999
F-statistic	117.9 ***	2,342.4 ***	150.0 ***	2,564.6 ***	59.0 ***	351.0 ***
Wu-Hausman	4.9 *	20.2 ***	16.7 ***	30.6 ***	204.1 ***	227.8 ***

Source: Cboe Options Data; Cboe VIX Data; Federal Reserve Interest Rate Data

Note: Two-stage least squares regression with index and day-of-week fixed effects and heteroskedasticity-robust standard errors. Newey-West standard errors in parentheses. * p < 0.05, ** p < 0.01, *** p < 0.001.

5.4 Conclusion

As discussed above, we find mixed evidence that higher volume of trading in short-dated options following the introduction of weekly options by Cboe is associated with a higher expected level of volatility at the 7-day and 30-day time horizons, with more evidence of a consistent relationship at the 30-day horizon and little at the 7-day horizon. However, we document a robust decrease in the steepness of the expected volatility curve. As the proportion of options trading volume in short-dated options increases, expected volatility at the 7-day maturity does not rise by as much as expected volatility at the 30-day maturity rises.

This result is striking in contrast to the effect of shifts in the level of volatility expectations in general. Increases in VIX five trading days prior are associated with positive increases in the level of the Volatility Index curve at the 7-day and 30-day maturities, but VIX increases are also associated with a steeper slope for the Volatility Index curve. Based on the analysis above, changes in short-dated options volume appear to have a weak effect in the same direction on levels of expected volatility, but a stronger effect in the opposite direction on slope. This finding suggests that increased options volume might affect the Volatility Index curve through different mechanisms than the general level of VIX does. While this paper has focused on identifying the empirical effect of increased short-term options volume relative to total options volume, it may be helpful for future research to identify what features of the options market contribute to this flattening effect.

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