Half the Signal: Retail Attention and the Price of Volatility *

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Abstract

Retail investors reveal in public which stocks they are crowding into, and those stocks become more volatile the following week. Option prices, the market's forecast of that volatility, absorb only about half the signal. Measured from 86.7 million Reddit comments, attention keeps half its predictive power after the full implied volatility surface is observed, and nonlinear readings do not close the gap. The absorbed half runs through the at-the-money term structure, not the smile, which attention nonetheless reshapes. It is also transitory: the implied volatility that attention raises reverses within a week while the stock's volatility is still being realized, and buyers of that volatility lose. The unabsorbed half improves volatility forecasts out of sample. Controlling for implied volatility does not control for what retail attention predicts.

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1 Introduction

Retail investors on Reddit say in public, every day, which stocks they are crowding into. Those stocks go on to be more volatile the following week. Option traders can read the same posts in real time, and implied volatility is the market's forecast of exactly that volatility, so the surface should already reflect whatever public attention foretells. It reflects about half of it. After conditioning on the full surface of implied volatilities across maturities and moneyness, attention keeps half of its power to predict a stock's own volatility in the week ahead.

The distinction matters because implied volatility is routinely used as a summary of what the option market already knows, and as a control for it. A visible price response shows that a signal reaches the market. It does not show that the price makes the signal redundant. Those are different properties, and only the second one justifies the way implied volatility is used.

The answer is not obvious. Complete encompassing is plausible because options are direct claims on volatility, option traders can observe public discussion in real time, and the surface provides many prices across maturities and moneyness. A sufficiently rich surface could aggregate the signal even if no single volatility level does. Partial encompassing is also plausible. The signal is noisy, the relevant volatility episode may be short lived, and a market maker can adjust average volatility levels without perfectly reallocating prices across names. Demand related to attention can also move quotes without revealing how much of the response reflects information. The same observed price response is consistent with very different degrees of predictive redundancy.

I measure attention by counting how many different people mention a stock on r/wallstreetbets each day, as a lagged trailing score of log distinct comment authors. Counting people rather than posts matters because a handful of accounts can dominate message volume, and breadth of participation is the object of interest. The score is known before the forward volatility window begins, and the main specifications compare stocks on the same day after absorbing persistent differences across names. The active population is fixed by the archived posts record rather than selected using future outcomes. The measure does not identify investors, trades, or signed option demand. Its role is to provide a public signal whose relation with future realized volatility can be read against contemporaneous option prices.

The empirical object is a reduced-form spanning share. I first estimate the attention slope in a forecast of forward realized volatility. I then estimate the same slope after conditioning on an option-price benchmark, always on identical observations. The share $\phi = 1 - \beta_P/\beta_0$ records how much of the original attention relation disappears when that benchmark enters. A larger share means that the benchmark makes more of the signal predictively redundant. The share is not a cardinal fraction of information, and it does not identify why the remaining slope survives.

Five findings organize the evidence. First, public retail attention predicts a stock's firm-specific volatility over the following week. Second, the option surface responds to attention but leaves a positive conditional relation with future volatility. Third, almost all measurable spanning comes from at-the-money volatility across maturities, even though smile shape responds and its call-versus-put tilt lines up with the direction of public option discussion. Fourth, the response is transitory and expensive: the implied volatility that attention raises reverses within a week while the stock's volatility is still elevated and then falls below its starting level, so a buyer of volatility on the signal day loses more on the repricing than the arriving volatility earns. Finally, the remaining relation survives recent-price controls, appears across high-frequency physical-volatility components, and adds a small forecast improvement in recursive tests. Together they describe a price that responds to a public signal, gives the response back, and still does not encompass the signal.

The first finding is economically and statistically clear. Across 93,350 active name-days from 2020 through 2024, a one standard deviation increase in attention predicts 0.0320 higher annualized realized volatility over the following five trading days after trailing volatility, size, ticker fixed effects, and date fixed effects are included. The relation is primarily firm specific and declines at longer horizons. Replacing date fixed effects with industry-by-date fixed effects changes the comparable active-sample coefficient only from 0.0318 to 0.0307. The result is not an aggregate volatility episode or a same-industry daily shock attached to popular names. It is a cross-sectional relation between public attention and subsequent volatility.

The option surface contains important but incomplete parts of that relation. On the fixed 61,434-row common grid, where the attention slope is 0.0263 rather than the 0.0320 headline, the thirty-day at-the-money level spans 0.345 of the attention slope. The full standardized twelve-node surface spans 0.466 and leaves a positive coefficient of 0.0140. The three at-the-money maturity levels alone deliver essentially the same share. Adding call-put asymmetries and the observed wings changes little. Fixed quadratic representations raise the share to 0.488 and 0.497, while a shallow tree leaves it at 0.469. The conditional coefficient and the share remain bounded away from full encompassing under separate date and ticker resampling. The full surface is more informative than a conventional level, but the added information is concentrated in the level term structure and still does not encompass attention.

The response extends to surface shape even though shape adds little spanning. Conditional on the same-maturity at-the-money level, a one standard deviation increase in attention is associated with about 0.0008 higher wing convexity at both ten and thirty days. The corresponding call-minus-put wing tilt rises by 0.0030 and 0.0018. Both maturity-specific vectors are distinguishable from zero under date and ticker resampling, while the sixty-day vector remains unresolved. These estimates use the complete surface grid, which covers 538 of the 841 names with a thirty-day node and disproportionately excludes smaller, higher-implied-volatility firms. Surface response reaches shape margins that add almost no predictive span beyond the at-the-money curve.

The direction of public option discussion sharpens this shape result. I classify comments that explicitly describe long-call or long-put positions and construct a daily call-minus-put author score, while keeping the amount of directional discussion as a separate control. A one standard deviation shift toward call language is associated with a 0.0017 larger average call-minus-put wing tilt across the three maturities, with a double-clustered t-statistic of 2.57. The estimate is positive at every maturity and survives a bounded share score, short discussion windows, signed stock-return controls, and the exclusion of familiar meme and mega-cap names. This same-sample exploratory result concerns stated public positions, not executed trades or price pressure.

Attention raises at-the-money implied volatility at each maturity, most at the short end of the curve. The measured response is of a similar average scale to a matched physical benchmark, although the ratio estimates are not precise enough to establish exact calibration. At the same time, the spanning share falls as option maturity lengthens for the short-horizon volatility outcome. The short end therefore contains more of the near-term signal, while the back of the curve contains less. This combination is the paper's central fact. The surface moves in the direction implied by the signal, yet the cross section of those movements does not make the signal redundant. The response also has a payoff consequence. Higher attention predicts lower subsequent delta-hedged straddle gains under conventional option-return controls.

The response does not last. On the common sample of 53,976 name-days, a one standard deviation increase in attention raises ten-day at-the-money implied volatility by 0.0108 on the signal day and thirty-day implied volatility by 0.0056. Over the next five sessions the same nodes fall by 0.0093 and 0.0052, and they keep falling in the second week, after realized volatility, 0.0139 higher in the first week, has returned to its normal level. A delta-hedged straddle bought on the signal day loses 0.0035 of its entry vega per standard deviation of attention: it earns 0.0033 on the volatility that arrives and loses 0.0069 on the repricing of the contracts it holds. The response sits at the short end of the term structure and is nearly flat across strikes, which is also where retail names its contracts and, in 2025 customer records, where net opening buys concentrate. Discussion about the firm's options is priced more and realized less than discussion about the firm, and the pattern holds outside earnings windows, in every year of the sample, and most strongly in small names.

Recent price history is the strongest alternative explanation, and the evidence contains an adverse fact that should be stated directly. With thirty-day at-the-money implied volatility as the only price control, trailing absolute five-day return and attention each have a spanning share of 0.427. In the fixed joint horse race, attention falls from 0.0151 to 0.0076 after the full surface enters, for a conditional share of 0.500. Absolute return remains independently predictive and has a share of 0.399. Both conditional coefficients remain positive under date and ticker resampling. A strict recursive benchmark that already contains HAR dynamics, size, and all twelve surface nodes gains 0.293 percentage points in cross-sectional out-of-sample fit when attention is added. Attention is related to recent price history, but its conditional forecast content is not reducible to that history. In 2024 TAQ data, the same residual appears in continuous and jump variation, in upside and downside variation, and in both intraday and overnight moves. The surface absorbs 0.431 of the overnight relation against 0.287 of the intraday relation; their paired difference is 0.143.

Public data on option trades bearing the single-leg auction non-ISO (SLAN) marker, the internalized-auction marker used as a retail proxy by Bryzgalova et al. (2023), narrow this boundary. Attention predicts greater same-day internalized option activity, but the proxy does not resolve direction or detectably account for the surface-conditioned residual. Because SLAN is not customer-origin signed flow and has no maturity dimension, information aggregation, demand related to attention, omitted public news, and quote noise remain admissible.

The results have two implications. First, a single implied volatility level can materially understate what the option market contains because the maturity curve carries additional forecast content. Researchers who use implied volatility as a sufficient market forecast should therefore distinguish one node from the broader surface. Second, even the full observed surface can respond to a public signal without encompassing it. That distinction matters for empirical tests of information aggregation, because response, predictive redundancy, forecast improvement, and implementable value are separate objects. It also matters for forecasting practice, where a market price can remain an excellent predictor while an external public signal still adds conditional information.

The closest paper is Eaton et al. (2026). They use brokerage outages to show that retail option trading affects the level and shape of the implied volatility surface. Their design identifies a contemporaneous retail demand effect on option prices and provides a benchmark for how retail buying and writing appear across contracts. I begin instead with a public attention signal and ask whether the surface makes its relation with future realized volatility redundant. The contribution is a full-surface encompassing result and its maturity allocation, not another estimate of retail demand's causal price effect. Without historical signed flow, I cannot attribute the residual to the retail demand channel they identify.

The paper also relates to research on retail option trading and demand-based option prices. Retail investors account for an important share of option activity, concentrate in short-dated contracts, and can affect both option and underlying markets (Bryzgalova et al., 2023; Eaton et al., 2022; de Silva et al., 2026; Bogousslavsky and Muravyev, 2024). Demand pressure can move implied volatility away from a frictionless information benchmark (Gârleanu et al., 2009; Bollen and Whaley, 2004). This work explains why a price response need not be a pure measure of information. I do not add a new measure of signed retail flow, estimate dealer inventories, or identify price pressure. I show instead that the observed surface's response to a public retail attention signal is not the same as encompassing that signal's future volatility relation.

A second strand studies attention and social interaction in asset prices. Attention shapes what investors trade and what they earn (Barber and Odean, 2008; Da et al., 2011), and search activity and other attention measures predict volatility (Andrei and Hasler, 2015; Vlastakis and Markellos, 2012; Hamid and Heiden, 2015; Dimpfl and Jank, 2016; Audrino et al., 2020), while retail platforms and social networks shape trading and returns (Barber et al., 2022; Welch, 2022; Cookson et al., 2023; Bradley et al., 2024; Pedersen, 2022; Hu et al., 2024). Earlier work also links social media activity to option prices (Wei et al., 2016), though implied volatility has itself been shown to predict subsequent Twitter activity (Frino et al., 2022). I do not claim the first relation between attention and volatility or the first response of options to social media. The contribution is to use the relation between attention and volatility as a public signal and measure how it is distributed across the full surface, how much remains after the surface, and whether the residual survives a direct comparison with recent prices.

A third strand studies volatility forecasts and the information content of options. Realized-volatility dynamics provide demanding forecasting benchmarks (Andersen et al., 2003; Corsi, 2009; Bollerslev et al., 2016), and implied volatility adds predictive content beyond realized volatility dynamics (Kambouroudis et al., 2021). Classic studies evaluate the relation between implied and realized volatility (Canina and Figlewski, 1993; Christensen and Prabhala, 1998; Jiang and Tian, 2005). Related work studies option-price underreaction and return predictability from volatility signals (Poteshman, 2001; Goyal and Saretto, 2009; Heston et al., 2026). My result is narrower than a structural efficiency or return predictability claim. It shows that a fixed linear and nonlinear reading of the equity option surface does not make a public attention signal redundant for forecasting the cross section of near-term realized volatility.

The broader stake is how market prices are interpreted. A price can acknowledge a public signal, move by an economically plausible amount, and still leave the signal useful for predicting which assets experience the outcome. Reading response as full incorporation would miss that distinction, while reading any residual as mispricing would go too far. The equity option surface provides an unusually rich setting in which to measure both objects because it offers prices across names, maturities, and moneyness before realized volatility is observed. For retail attention, the maturity curve contains much more than a conventional volatility level, but the full observed surface still stops short of encompassing the public forecast.

2 Measuring response scale and spanning

A single response coefficient cannot say whether a price vector encompasses a public signal. Response scale asks how much the price moves with the signal on average. Spanning asks whether the signal retains conditional predictive content after the price vector is observed. These objects can differ. A price can respond at a scale close to a physical benchmark while leaving a positive conditional forecasting coefficient. The distinction is about linear redundancy, not necessarily a change in the daily rank ordering of securities.

The central object is the spanning share. Write β_0 for the slope of future realized volatility on attention and β_P for the same slope after a vector of option prices P enters. Then $\phi(P) = 1 - \beta_P/\beta_0$. By Frisch–Waugh–Lovell, $\beta_0 - \beta_P$ is the portion of the original linear attention slope spanned by P. This identity is unconditional on a structural model. In a general covariance system, $\phi(P)$ need not lie between zero and one, and adding prices need not move it monotonically. I therefore report the remaining coefficient, the absorbed slope, and the share, without clipping the ratio or calling it a literal fraction of information.

A vector benchmark supplies a precision comparison under explicit assumptions. After removing the paper's controls and fixed effects, let attention and the realized outcome be $z_i = S_i + \eta_i$ and $RV_i = S_i + u_i$. Collect K observed option nodes in

$$P_i = gS_i + \nu_i, \tag{1}$$

where g contains the nodes' loadings on the attention-linked variance state and ν_i contains option-specific components that do not forecast the realized outcome. If ν_i is orthogonal to (S_i, η_i, u_i) with covariance Σ_ν, the entire surface is equivalent for forecasting S_i to the scalar $g'\Sigma_\nu^{-1}P_i$. Its precision about the state is $\mathcal{I}_P = g'\Sigma_\nu^{-1}g$. Under this benchmark, $\phi(P)$ rises with $\mathcal{I}_P$ and is invariant to any invertible rotation or rescaling of the price vector. It is still a spanning share, not a cardinal fraction of information, because its level also depends on noise in the attention proxy. Outside the benchmark, only the nested-projection identity applies.

For maturity m, write the observed quote as $P_{m,i} = a_m Q_{m,i}$, where $Q_{m,i} = G_m S_i + B_{m,i} + \widetilde{\xi}_{m,i}$ and $a_m \neq 0$ rescales the entire observed quote. This pure rescaling divides out of ϕ, but an additive error left outside a_m would not, and the loading G_m does not divide out relative to background variation. A smaller long-maturity response is therefore not by itself lower spanning, and the full curve can recover content that no single node contains. The realized-horizon by option-maturity matrix is an empirical fact that generally requires multiple variance states. The scalar benchmark does not derive its shape, and it yields three empirical restrictions.

1. Response scale can be near its physical benchmark while the spanning share remains below one.

2. Under orthogonal node noise, the joint curve spans weakly more than any one node. Outside that benchmark, nesting alone does not guarantee a monotone ratio.

3. If surface shape identifies which attention episodes become extreme moves, tail-sensitive nodes should add to the tail-outcome spanning share.

Attention-related option demand can either raise the loading on S_i or add price noise. The same observed share can therefore reflect incomplete information aggregation or demand-contaminated prices. Signed maturity-specific flow would be needed to separate them. The benchmark organizes the evidence rather than its cause, and Appendix A gives the vector derivation and the demand extension.

Two qualifications keep the benchmark in its proper register. The observed vector is an interpolated representation of option quotes rather than the latent market state, so correlated quote noise, risk-premium variation, or demand can break the precision ordering. The attention score is also measured with error. A common rescaling of the score cancels from the ratio, but a change in measurement precision generally does not. Under the orthogonal benchmark, noisier attention can even raise the measured share because conditioning on prices increases attenuation of the residual signal. The selected author construction is therefore chosen for a cleaner first stage and stable inference, not because the share is invariant to proxy quality. These restrictions make the framework an organizing map rather than a structural information decomposition.

3 Data and measurement

The sample comprises U.S. stocks matched to Reddit attention between January 2020 and December 2024 at the daily frequency. The active sample contains 93,350 name-days across 938 CRSP-matched tickers. The dense covered universe, which retains quiet dates after a ticker enters the observable risk set, contains 1,046,140 ticker-days across 946 names.

The latter is not the full CRSP universe because the source panel uses a lifetime mention screen.[1]

Attention. The source archive covers r/wallstreetbets posts and comments from December 2019 through December 2025. For each ticker and day, I count distinct comment authors, apply $\log(1+x)$, and compare the result with the ticker's trailing 30-day history. I lag the score by one calendar day, so attention dated t uses comments only through $t-1$. The lagged posts-mention count, rather than the comment count, continues to determine whether a name-day enters the active sample. This population-fixed design changes the signal without changing the paper's active estimation population. I refer to the lagged log-author score as attention throughout. Tables label whether its one standard deviation scaling is inherited from the fixed dense covered panel or recomputed for an explicit common-population comparison.

The source corpus contains 86.7 million comments. Ticker extraction admits both plain strings and dollar-prefixed cashtags after removing common-word aliases and requiring a valid security mapping. Distinct authors are platform accounts, not verified individuals, so the score measures participation breadth on Reddit rather than a count of unique investors.[2] The selected construction combines a strong response with lower tail leverage while preserving the fixed active population inherited from the posts count.

Sample construction proceeds in layers so that changing a price control does not silently change the attention population. The 93,350-row active panel carries the headline volatility regression, and the 81,809-row paired- ATM panel asks what a conventional 30-day level spans. The 61,434-row grid requires all twelve standardized nodes and is the common population for every linear and nonlinear surface comparison. The grid retains 538 names and 65.8 percent of active name-days, and relative to excluded rows it is larger

[1]The established risk set begins strictly after a ticker's first positive lagged mention. The first active date is excluded from dense active-quiet regressions but retained in the separate all-active confirmation.

[2]A cashtag-only version produces a similar first stage and spanning pattern, and the online supplement compares the posts score, comment volume, author breadth, and intensity-given-breadth variants.

and less volatile. I therefore treat the surface result as a statement about Reddit-active, option-covered names with complete standardized grids, not about the full stock market. Forecast models and paired spanning comparisons never mix these populations.

Prices and volatility targets. CRSP daily returns for every attention ticker mapping to a common share produce forward and trailing realized volatility. Forward five-day realized volatility for name i at day t is the annualized standard deviation of daily log returns over $t+1$ to $t+5$. Trailing 21-day volatility and log market capitalization are the baseline controls. The panel mean of forward five-day volatility is 66.7 percent annualized with median market capitalization of $7.9 billion. This is a large-cap-tilted but high-volatility universe.[3]

Options and earnings. ATM implied volatility is the arithmetic mean of exact OptionMetrics standardized thirty-day call-delta 50 and put-delta minus-50 nodes, with both sides required on the same effective ticker-security-date link. The corrected active regression sample covers 841 names. For the term structure I add the standardized ten- and sixty-day nodes and the 25-delta wings on the same names, so that the same signal can be read against the front, middle, and back of the maturity curve. The ten-day node exists for 538 of the covered names, and the rebuilt thirty-day node reproduces the paired series exactly. Earnings announcement dates are Compustat quarterly report dates, covering 90.3 percent of active name-days. Appendix C gives the exact timing and matching rules.[4]

Standard errors are double-clustered by ticker and day in all panel specifications. The inference leans on neither dimension and on no influential unit. A cluster bootstrap over

[3] The tail indicator equals one when the absolute cumulative return over the same forward window reaches ten percent. Appendix C gives the timing and units of every variable.

[4] A separate strike-level cache is used only for validation. A few further sources support single exhibits and enter nowhere else. To check that the forecast is not specific to one community, I rebuild attention from the r/stocks and r/options posting archives using the identical construction. To ask whether attention recruits option demand or supply, I use Cboe open-close data, which reports customer opening volume split into buys and sells, over its 2025-03 to 2025-08 public window; that exhibit relates attention to order flow rather than to realized or implied volatility, and so sits outside the main sample. For the full-surface tail exhibit I draw the per-contract OptionMetrics option chain near the ten-day maturity, from which a model-free tail variance is integrated across all out-of-the-money strikes, and it serves the single tail-spanning table alone.

tickers alone returns narrower bands on every headline object, and deleting any single name or any single month leaves the spanning share inside its reported band in every case.[5] Appendix Table A2 reports summary statistics and sample coverage.

4 Attention and future realized volatility

The central fact is cross-sectional. After persistent name differences and common daily shocks are absorbed, attention predicts next week's realized volatility across names on the same day. I estimate

$$RV_{i,t}^{t+1,t+5} \;=\; \beta\, z_{i,t} \;+\; \kappa\, RV_{i,t}^{\text{trail}} \;+\; \delta \log MktCap_{i,t} \;+\; \alpha_i \;+\; \lambda_t \;+\; \varepsilon_{i,t}, \tag{2}$$

where $z_{i,t}$ is attention as of $t-1$, $RV_{i,t}^{\text{trail}}$ is trailing 21-day realized volatility, α_i and λ_t are ticker and day fixed effects, and $\varepsilon_{i,t}$ is the residual. The attention slope β is estimated on the full active sample. Its option-covered counterpart, written β_0 in the share exercise of Section 5, is the same slope on the names that carry an implied-volatility node. Table 1 reports the specification path.

Table 1. Public retail attention and forward realized volatility. The dependent variable is annualized realized volatility over days $t+1$ to $t+5$. Attention is the lagged trailing z-score of log distinct comment authors, standardized on the fixed dense covered panel. Controls are trailing 21-day realized volatility and log market capitalization, and standard errors are double-clustered by ticker and day. The sample contains 93,350 active name-days across 938 names from 2020 to 2024.

Specification	Coef (annualized RV / 1σ)	t (two-way cl.)	N
Entity FE only	0.0380	11.29	93,350
+ Trailing RV + size	0.0329	10.77	93,350
+ Date FE (absorbs market-wide vol)	**0.0320**	**11.48**	93,350

[5] For the full grid, no single ticker deletion and no single month deletion moves the share outside its conservative band. Fama– MacBeth slopes carry Newey–West standard errors with ten lags, and in the two-part models attention intensity is standardized among active observations in the relevant estimation sample and set to zero on quiet observations.

Entity fixed effects alone give 0.0380, adding trailing volatility and size lowers the coefficient to 0.0329, and adding date fixed effects leaves it at 0.0320 ($t = 11.48$). The relation is cross-sectional within day rather than an artifact of the day's aggregate volatility environment. On a given day, the names receiving more attention realize more volatility over the following week. Per standard deviation of attention on the fixed dense covered panel, the coefficient is 0.0320 higher annualized realized volatility, or 3.20 annualized-volatility percentage points. On the same 80,218 FF12-classifiable rows, replacing date fixed effects with industry-by-date fixed effects changes the coefficient from 0.0318 to 0.0307. On classifiable full grid rows, the corresponding spanning share changes from 0.461 to 0.482, and the surface-conditioned attention coefficient remains 0.0134. Appendix Table A3 reports the detailed comparisons. Table 2 collects the corresponding estimates discussed in the main text.[6]

Table 2. Industry controls and recent price history. The table reports the industry-by-date comparison, the full grid industry-date conditional estimate, and a joint regression of attention and recent absolute return on common samples.

Comparison	Specification	Coef.	t	ϕ	N
Industry controls	Active, ticker + date	0.0318	10.79	–	80,218
Industry controls	Active, ticker + FF12×date	0.0307	10.19	–	80,218
Industry controls	Full grid, ticker + FF12×date	0.0134	5.16	0.482	55,251
Recent prices	Attention + full grid	0.0076	3.82	0.500	61,429
Recent prices	|5-day return| + full grid	0.0419	3.74	0.399	61,429

Notes: Industry rows use identical FF12-classifiable rows within each sample. The full-grid industry row reports the coefficient after the complete 12-node surface enters and its reduced-form spanning share. Freshness rows enter attention and trailing absolute five-day return jointly with standardized 1-, 5-, and 21-day realized volatility, log market capitalization, and the full 12-node surface. All freshness variables end at $t - 1$. Standard errors are clustered by ticker and original calendar date. Paired date-block and ticker-pairs 95% bands are, respectively: active FF12×date β, [0.0231, 0.0366] / [0.0255, 0.0365]; full-grid FF12×date conditioned β, [0.0064, 0.0208] / [0.0093, 0.0183], and ϕ, [0.393, 0.635] / [0.404, 0.568]; freshness attention β, [0.0035, 0.0116] / [0.0042, 0.0112], and ϕ, [0.381, 0.678] / [0.375, 0.655]; |5-day return| β, [0.0119, 0.0751] / [0.0217, 0.0605], and ϕ, [0.288, 0.667] / [0.309, 0.564].

[6] The relation is also not confined to entry into discussion: under the posts-based measure, both entry and intensity among already discussed names predict forward volatility, and the intensity estimate remains positive after current ATM implied volatility enters. Independent StockTwits attention also predicts volatility and is only partially spanned on matched option-covered rows. The online supplement reports these results separately because they use posts rather than distinct comment authors.

Breadth and intensity are not interchangeable. An intensity-given-breadth score also forecasts volatility, while the log-author score remains the headline because it combines a strong first stage with stability rather than maximizing the spanning share.

4.1 Freshness and trading-session timing

The signal's response level is sensitive to freshness, while its spanning share is not. On the paper panel, replacing lagged intraday authors with same-day intraday authors raises the first-stage coefficient from 0.0448 to 0.0678, about one half, but leaves the full grid share at 0.456 versus 0.457. The paired same-day-minus-lagged share is -0.002 and is not distinguishable from zero, and overnight and all-day comparisons are similarly unresolved. Repeating the paired tests on the separately admitted 210,228-row comment panel yields tighter bands that also span zero. Thus freshness changes how much subsequent volatility the score predicts, not the fraction spanned by the contemporaneous surface.

Intraday shares exceed overnight shares in all four author/mention by lagged/same-day cells and in both panels. Three of the four individual bands include zero, so no cell is singled out. The pooled contrast places all eight signals on the same date-block draw and in one fixed-effect demeaning. It is 0.031 on the paper panel and 0.025 on the extended panel, with both bands excluding zero. The surface therefore spans a modestly larger share of attention that arrives while the market is open than while it is shut. The result is a pooled session-timing difference, distinct from the unresolved freshness comparisons.[7]

The online supplement reports the full timing and session comparisons.

The volatility that attention forecasts is the name's own, and it is transient. Decomposing daily returns with a trailing sixty-day market beta, attention forecasts the idiosyncratic component at 0.0322, while the systematic coefficient is small and unresolved. The forecast

[7] It also reports a distinct pre-open posts-count measure, fixed before any of the day's trading, that forecasts same-day open-to-close and high-low volatility. This supports timing for public retail attention generally, though it is not a direct timing test of the selected score.

declines along the comparable horizons, from 0.0320 over five days to 0.0137 over 21 days, with a one-day absolute-return analogue of 0.0382, the decay of a transient episode whose volatility footprint fades as opinions settle, consistent with the social-network dynamics in Pedersen (2022). It remains 0.0304 outside observed earnings windows and 0.0167 inside them, so observed earnings timing does not subsume it (de Silva et al., 2026). These are properties of the signal itself, established before any option price enters (Table 3). Appendix Figure A1 plots the four coefficients and their date-block intervals.

Table 3. Anatomy of the volatility relation. Panel A reports the horizon profile, Panel B decomposes forward five-day volatility using a trailing market beta, and Panel C splits observations by whether the forecast window contains an observed earnings announcement. All specifications include ticker and date fixed effects. Standard errors are double-clustered by ticker and day.

Outcome	Coef / 1σ	t	N
Panel A. Forward volatility by horizon:			
1-day absolute return	0.0382	13.02	93,350
5 days (headline)	0.0320	11.48	93,350
10 days	0.0221	10.22	92,930
21 days	0.0137	8.07	92,067
Panel B. Forward 5d RV decomposition:			
Idiosyncratic	0.0322	12.43	92,310
Systematic	-0.0007	-1.03	92,310
Panel C. Observed earnings window:			
No observed earnings in fwd window	0.0304	9.61	74,852
Observed earnings in fwd window	0.0167	2.37	9,479

5 What the option surface encompasses

The forecast is established. The question is how much of it option prices already hold. On stocks with option coverage, the attention slope on forward realized volatility falls from 0.0297 to 0.0195 once thirty-day at-the-money implied volatility enters the regression, so implied volatility already carries a share $\phi = 0.342$ of the attention relation. The score here is standardized on the fixed dense covered panel, and a positive conditional relation remains after the thirty-day price is observed.

The share is a third for a specific reason, and the reason matters for how to read it. The drop from β_0 to β_{IV} equals $\gamma_{IV}\,\pi_{IV}$, where π_{IV} is how much the implied-volatility level moves with attention and γ_{IV} is how well that level forecasts realized volatility. Here γ_{IV} is 0.749, so the level strongly forecasts realized volatility. What is smaller is π_{IV}, since the thirty-day level moves with attention by only 0.0136 in volatility units. The price responds to attention, but the response does not make attention redundant.

A share of one-third needs a yardstick. Measured against the thirty-day level as the sole control, so that every signal is scored the same way, a stock's trailing realized volatility sits at 0.85 and its size at 0.91, while retail attention sits at 0.43 against 0.342 under the paper's full controls. The appendix reports this benchmark ladder. Recent absolute return is the adverse exception, and Section 6 treats it directly rather than using the simple ladder to claim that attention is uniquely unspanned.

The missing content belongs partly to maturity. On the roughly five hundred names for which a ten-day node exists, implied volatility responds most at the front and least at the back, and the spanning share is higher at ten days than at thirty days. The price therefore responds in the direction of the near-term signal, while longer maturities contain less of it. The detailed response-scale and price-unit translations remain in the submission appendix.

The maturity pattern raises the encompassing question directly. Table 4 places the 30-day node, the ATM curve, and the full standardized grid on the same 61,434 name-days. The 30-day share on this population is 0.345, and the 0.342 reported above is the same object measured on the 81,809 option-covered rows. Combining the three ATM maturities raises the share to 0.466. The full grid leaves a coefficient of 0.0140, with a conservative date-and-ticker band of $[0.0083, 0.0199]$. Relative to 30-day ATM alone, it adds 0.122 to the share, and every ticker and month deletion preserves the positive residual. Adding their call-minus-put differences contributes 0.007, a small increment whose separate date and ticker bands exclude zero. Adding the wings then contributes −0.007, with both bands spanning zero. Thus the level term structure, not the wings, accounts for essentially all of the full surface's span.[8] The observed grid contains more of the relation than a single conventional node, but it does not encompass attention.

Table 4. Joint spanning by the standardized option grid. Panel A adds the 30-day ATM level, the 10/30/60-day ATM curve, ATM call-put asymmetries, and the full 12-node invertible basis in a fixed order. Panel B compares the full grid with 30-day ATM. Every specification uses the same 61,434 name-days, 538 names, controls, and stock and day fixed effects. Analytic standard errors are double-clustered, date bands use 2,000 paired 10-day-block draws, and ticker bands use 2,000 paired ticker draws. All 9,999 null-imposed ticker wild draws are valid, and no ratio is clipped. Separate ticker and date bands and full single-ticker and single-month deletion censuses accompany the analytic inference.

Specification or object	Estimate	Analytic SE	Date band	Ticker band
Panel A: Remaining attention coefficient and spanning share				
Controls only, β_0	0.02632	0.00320		
+ 30-day ATM, β_1	0.01725	0.00241		
Spanning share, ϕ_1	0.3447			
+ 10/30/60-day ATM curve, β_2	0.01405	0.00232		
Spanning share, ϕ_2	0.4661			
+ ATM call-put asymmetry, β_3	0.01386	0.00229		
Spanning share, ϕ_3	0.4734			
Full 12-node grid, β_4	0.01405	0.00227	[0.00825, 0.01991]	[0.01066, 0.01806]
Spanning share, ϕ_4	0.4663		[0.3935, 0.5811]	[0.4035, 0.5377]
Panel B: Full grid relative to 30-day ATM				
Additional absorbed coefficient, $\beta_1 - \beta_4$	0.00320		[0.00235, 0.00399]	[0.00225, 0.00411]
Additional spanning share, $\phi_4 - \phi_1$	0.1216		[0.0830, 0.1808]	[0.0864, 0.1561]

Little added span from the wings does not mean that smile shape is unresponsive. On the same complete grid, attention is positively associated with wing convexity and call-minus-put tilt at ten and thirty days after conditioning on the corresponding at-the-money level. Both two-dimensional vectors are distinguishable from zero under date and ticker resampling, while the sixty-day vector remains unresolved. The complete grid covers 538 of the 841 names with a thirty-day node and disproportionately excludes smaller, higher-implied-volatility firms. Appendix Table A10 reports the six estimates

[8] The framework permits small nonmonotonic steps because the share is a covariance ratio rather than a variance decomposition.

and simultaneous bands. The pattern does not identify why the smile changes, but it establishes that response is broader than encompassing.

The direction of option discussion matches this price response. I classify explicit descriptions of long-call and long-put positions and define direction as log call-author breadth minus log put-author breadth. Gross directional breadth enters separately, and all zero-direction rows remain in the sample. A one standard deviation shift toward calls predicts a 0.0019 larger ten-day call-minus-put tilt and a 0.0017 larger average tilt across maturities. The estimates are positive at all three maturities under ticker and date fixed effects and standard errors clustered by ticker and day. Bounded share scores, three- and seven-day text windows, signed-return controls, and broader ticker attachment preserve the relation. The separate-wing estimates locate the direct-text result primarily in a rising call wing. Table 5 reports these comparisons. The measure captures disclosed discussion rather than executed orders, so the result links discussion direction to smile shape but does not establish an option-flow mechanism.

Who participates and when participation arrives provide two additional behavioral facts. Holding directional breadth fixed, wing convexity responds less to discussion by authors with longer or more active WallStreetBets histories: the average-maturity experience interaction is -0.0005. The relation appears in 2020–2021 but is unresolved in 2022–2024. Separately, after a two-year history burn-in, fresh stock discussion follows a 0.0103 larger five-session rise in at-the-money implied volatility and coincides with a 0.0089 larger reversal on the attention date. There is no detectable fresh-minus-recent difference over the next one or five sessions. These patterns locate attention around changes in the option surface; they do not identify author skill, executed trades, or price pressure (Appendix Table A11).

What authors discuss also matters. When four text-only narrative measures enter jointly with total attention, volatility and position-mechanics discussion have average

Table 5. Directional option discussion and call-minus-put wing tilt

	10 day	30 day	60 day	Average
Panel A. Direct long-call versus long-put language				
Directional score	0.0019	0.0014	0.0017	0.0017
	(2.97)	(2.20)	(2.11)	(2.57)
Panel B. Alternative constructions, average tilt				
Bounded call-put share				0.0016 (3.00)
Prior and same-day signed returns				0.0018 (2.86)
Three-day discussion window				0.0028 (3.10)
Seven-day discussion window				0.0033 (2.65)
Direct plus root-confirmed tickers				0.0027 (3.14)
Including short-option language				0.0017 (2.72)
Panel C. Separate wing responses				
Call wing relative to ATM	0.0014 (2.77)	0.0012 (2.37)	0.0014 (2.82)	
Put wing relative to ATM	-0.0006 (-1.62)	-0.0003 (-0.76)	-0.0003 (-0.72)	

Notes: The sample contains 61,434 ticker days from 2020 through 2024. The directional score is positive for explicit long-call language and negative for explicit long-put language, and is standardized over the estimation sample. All specifications retain zero-direction days and include ticker and date fixed effects, selected unsigned attention, trailing realized volatility, log market capitalization, same-maturity ATM implied volatility, and gross directional breadth. The signed-return row also controls for the prior one- and five-day returns and the market-day return. Parentheses report t-statistics from standard errors clustered by ticker and date. The evidence concerns stated public positions, not executed order flow.

ATM-level coefficients of 0.0095 and 0.0098, compared with 0.0030 for fundamentals. The differences between each of the first two and fundamentals are 0.0065 ($t = 2.62$) and 0.0068 ($t = 2.85$). Volatility discussion is also associated with a 0.0027 larger average call-minus-put wing tilt, exceeding the mechanics coefficient by 0.0039. The level results survive cashtag-only attachment, return controls, and the 2022–2024 sample. The tilt result survives return controls but weakens with cashtag-only attachment and in the later sample. Narrative composition therefore provides a stable level result and a more tentative shape result (Appendix Table A12).

The linear result does not depend on treating the surface as an additive set of nodes. I consider three nonlinear readings. The first adds all unique squares and interactions of the three ATM maturity levels. The second adds quadratic terms in five principal components of the standardized surface. The third compresses the surface with a depth-two boosted tree whose tuning is confined to 2020–2021. Table 6 compares each reading with the same linear grid on the same observations. The ATM quadratic raises the share from 0.466 to 0.488, and the five-component quadratic raises it to 0.497. For both, the paired increment bands exclude zero by date and by ticker, while the tree adds little and leaves the share at 0.469. More important, every benchmark leaves a positive attention coefficient. It ranges from 0.0132 under the five-component quadratic to 0.0140 under the linear grid, precisely estimated in each. These tests rule out the particular concern that the linear grid misses simple curvature or low-order interactions. They do not establish non-encompassing against every measurable function of a latent surface.

Table 6. Linear and nonlinear surface encompassing. The specifications use the full linear 12-node grid, quadratic terms in the three ATM levels, quadratic terms in five surface principal components, or a depth-two boosted-tree index tuned on 2020–2021. Every row uses the same 61,434 name-days, controls, and fixed effects. Date and ticker columns report separate paired-bootstrap bands.

Benchmark	β	t	Spanning share	Date / ticker bands
linear grid	0.0140	6.20	0.466	[0.397,0.574] / [0.401,0.534]
quadratic ATM	0.0135	6.17	0.488	[0.423,0.595] / [0.426,0.559]
quadratic PCs	0.0132	6.04	0.497	[0.431,0.611] / [0.435,0.570]
shallow tree	0.0140	6.21	0.469	[0.401,0.574] / [0.405,0.539]

Figure 1 collects the nested surface readings on the fixed complete grid. The attention coefficient falls as the benchmark expands from the thirty-day level to the maturity curve and then to the full surface, but it remains positive under every fixed linear and nonlinear reading. The figure makes the separation between response and encompassing visible across benchmarks.

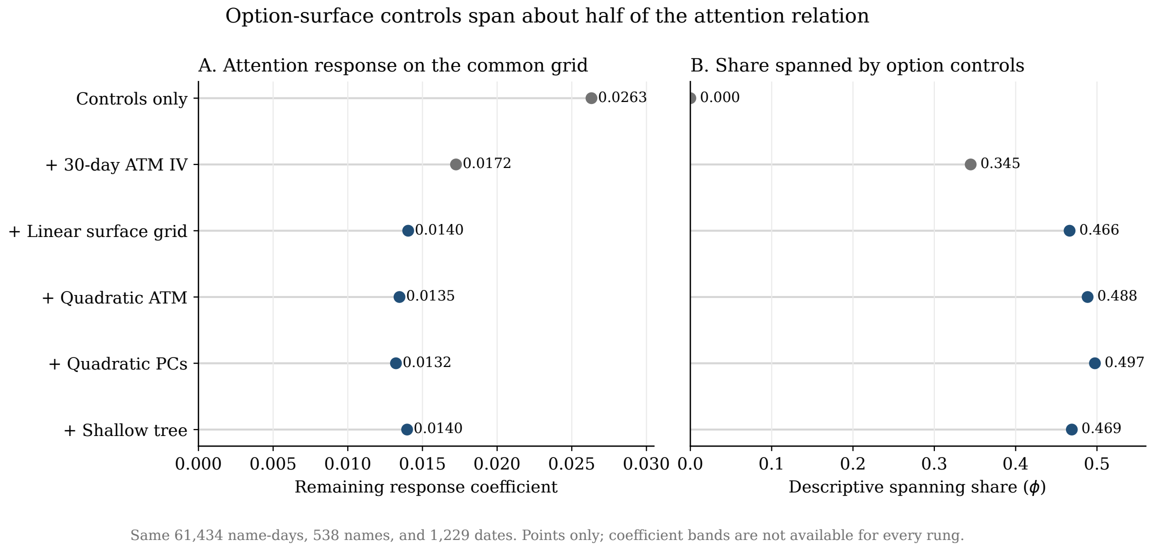
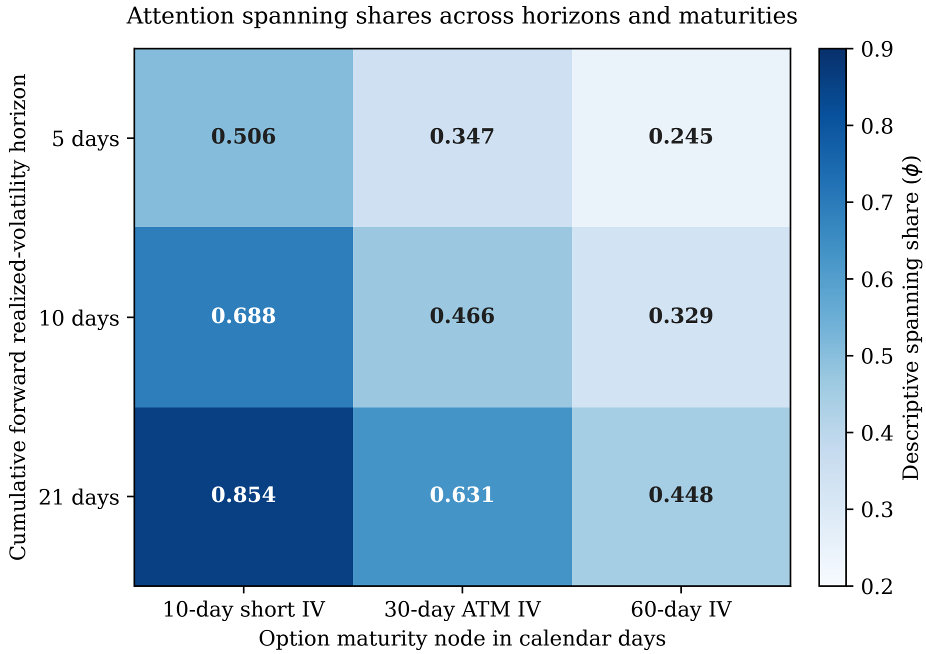


Figure 1. Attention coefficients under increasingly rich option-surface benchmarks. Every point uses the same 61,434 name-days on the complete 12-node grid. The leftmost coefficient is therefore 0.0263, the common-grid baseline, rather than the 0.0320 headline estimate on the broader 93,350-row active sample. Tables 4 and 6 report the corresponding inference.

The realized-horizon by option-maturity matrix gives the sharpest view of where the span sits. The share ranges from 0.245 when sixty-day implied volatility is asked to span five-day realized volatility to 0.854 when ten-day implied volatility is asked to span twenty-one-day realized volatility. Thus the short option node contains more of the attention signal, and more of a longer-horizon volatility outcome is already reflected in the price. The nine cells are not globally monotone toward a matched-horizon diagonal, while under the same procedure trailing volatility is almost fully spanned in every cell.



61,434 name-days and 538 names. Rows are trading-day outcome windows; columns are calendar-day IV nodes.

Figure 2. Spanning shares by realized volatility horizon and option maturity. Each cell reports $1 - \beta_{IV}/\beta_0$ on the common 61,434-row surface grid. Darker cells indicate that the option node makes more of the attention forecast redundant. Appendix Table A5 reports the underlying estimates.

5.1 Response scale, tails, and regime boundaries

A two-thirds shortfall in the thirty-day price invites a reading it does not deserve. Part of the gap is horizon. A thirty-day option should not move much for a burst of volatility that lasts a week. The right comparison holds the horizon fixed. Under a matched physical benchmark, in which a maturity's implied variance equals the expected realized variance over its life, the implied-volatility response that would fully price the signal is computable from how attention forecasts realized volatility at the matching horizon. Table A6 sets the measured response beside that matched physical benchmark.

Measured in volatility units and matched to the horizon, the response ratios run from 0.80 at the short node to 1.13 at the long node. The point estimates are consistent with a similar average response, but their intervals also admit meaningful underreaction and overreaction. Variance-space ratios run from 0.63 to 0.90, with broad and overlapping intervals. Their difference from the volatility-space ratios is descriptive rather than a structural tail test. Even at matched horizons, point spanning shares run from 0.52 to 0.62 and remain below one. The remaining slope is not eliminated by matching horizons and is identified in the within-day, cross-name dimension.[9]

Figure 3 states the two halves of the result together. The measured implied-volatility response tracks its matched physical benchmark point estimate across maturities, while the spanning share stays far below the trailing-volatility placebo. The response scale and the cross-name span are distinct empirical objects.

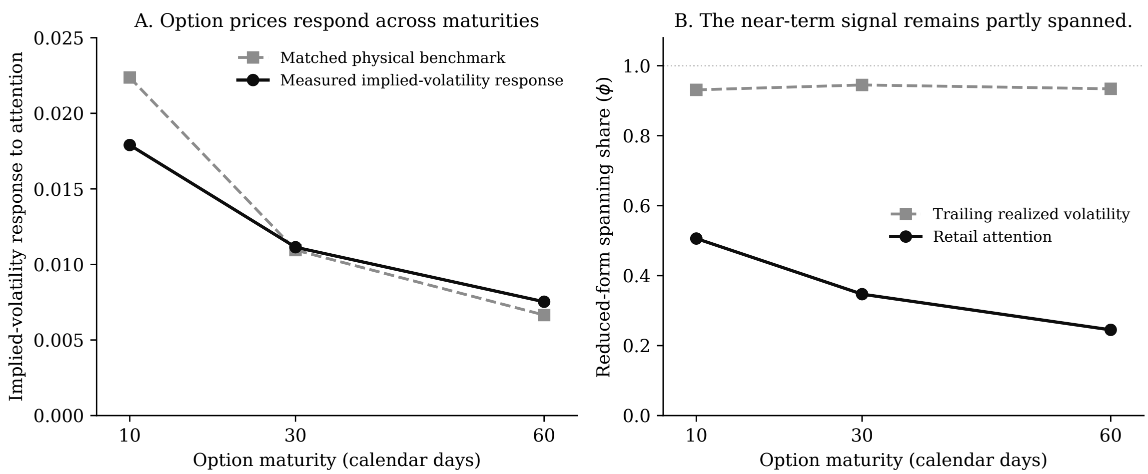


Figure 3. Response scale and cross-name spanning. Panel A plots the measured implied-volatility response to a one standard deviation increase in attention against its matched physical benchmark value, across the ten-, thirty-, and sixty-day maturities. The point estimates converge at the back of the curve, although the ratio estimates are imprecise. Panel B plots the spanning share by maturity, which sits far below the same share for a stock's trailing volatility, a signal the market has long known that lies near one throughout. Panel A is in annualized volatility units per one standard deviation of attention, with the measured response and the matched physical benchmark value plotted as the two labeled series. Panel B is a unit-free share, with attention and trailing volatility as the two labeled series. Values are the vol-space responses of Table A6 and the five-day row of Table A5.

[9]The shortfall is not an artifact of scheduled news. Splitting the covered panel on whether an observed earnings announcement falls in the forward five-day window, the share is essentially the same inside and outside, 0.30 against 0.32, so the spanning shortfall is broad-based rather than concentrated on unscheduled episodes. It is therefore not the scheduled earnings event risk the option surface is known to price through pre-announcement concavity (Alexiou et al., 2025).

A separate state split asks where the surface absorbs more. For prior-week moves of average magnitude, adding the full option surface reduces the predicted future volatility response to a one standard deviation attention increase by 0.35 annualized volatility points more after negative weeks than after positive weeks. The date- and ticker-resampled bands both exclude zero, and every ticker and month deletion retains the sign (Appendix Table A13, Panel A).

Appendix B asks whether the remaining span sits in features omitted by the at-the-money curve. The observed wings add little in the fixed standardized grid and only a small increment in the broader tail sample. Call-put differences are jointly detectable but remain secondary to the common maturity-level response. These decompositions support the main allocation result without identifying whether the remaining relation reflects information or demand.

6 What remains after the surface

A demanding alternative is that attention merely repackages recent price history. The adverse fact is that trailing absolute five-day return and attention each have a standalone spanning share of 0.427 when thirty-day at-the-money implied volatility is the only price control. The joint test therefore places both signals in the same fixed basis of recent returns, realized volatility histories, and size, with every price-history window ending at $t-1$. Attention falls from 0.0151 to 0.0076 after the full twelve-node grid enters, for a conditional spanning share of 0.500. Absolute return remains separately predictive and has a share of 0.399. Both conditional coefficients remain positive under date and ticker resampling. Table 2 reports this horse race together with the industry-by-date comparison.

The result does not make attention uniquely unspanned. It shows instead that the attention relation is not reducible to recent price history. The separate forecast test asks whether this conditional relation survives a stricter recursive setting rather than only an in-sample projection.

The stricter forecast check conditions on the full grid rather than one implied-volatility level. Table 7 reports 36 monthly expanding fits from 2022 through 2024. Attention raises cross-sectional out-of-sample R^2 by 0.293 percentage points, and the loss improvement is positive in every year. The daily rank-IC increment is 0.0009. The Clark–West improvement (Clark and West, 2007) is also positive in every residual-spread tercile, so the gain is not confined to illiquid names and is difficult to attribute solely to stale quotes. A distinct-author measure therefore identifies forecasting value in the unspanned residual. The gain is statistically unambiguous but economically small, and it supports rather than replaces the paper's spanning result.

The same forecast protocol applied to the nonlinear benchmarks leaves the result intact. Across the linear grid, ATM quadratic, principal-component quadratic, and shallow-tree specifications, attention raises cross-sectional out-of-sample R^2 by 0.293 to 0.312 percentage points, with rank increments from 0.0008 to 0.0014. Table 7 therefore evaluates the residual against the same fixed linear, quadratic, principal-component, and tree surface readings used in sample. The forecast evidence shows that the residual contains incremental predictive content under these representations. It does not reveal whether the content reflects a noisy public state, omitted public news, demand related to attention, or some mixture of them.

Table 7. Recursive forecasts after linear and nonlinear surface benchmarks. Models are estimated at 36 monthly origins over 2022–2024. Benchmark and attention-augmented models use identical observations, and all training outcomes end before the forecast month. Evaluation removes date means from outcomes and forecasts and gives dates equal weight.

Benchmark	CS OOS R^2 (%)	Loss t	CW t	Δ rank IC	Rank t
Linear grid	0.293	4.66	7.41	0.0009	3.50
Quadratic ATM	0.312	4.73	7.66	0.0009	3.11
Quadratic PCs	0.301	4.49	7.49	0.0008	3.13
Shallow tree	0.303	3.86	6.24	0.0014	4.35

6.1 The physical form of the residual

High-frequency returns make it possible to ask where the residual is realized. I construct five-minute return paths over days $t + 1$ through $t + 5$ for every 2024 observation on the complete option-surface grid. Synchronized SPY returns are removed with a market beta estimated over the prior 126 trading days, and the resulting firm-specific variation is split into continuous and jump components and into upside and downside components. Close-to-open returns provide a separate overnight measure. The preferred sample requires all five forward sessions and near-complete five-minute coverage in every session, leaving 10,548 observations across 406 stocks and 232 signal dates.

Table 8 shows a common pattern across these outcomes. A one standard deviation increase in attention predicts 0.0153 higher annualized firm-specific intraday volatility. The coefficient remains 0.0109 after the full option surface enters, so the surface absorbs a share of 0.287. The corresponding overnight share is 0.431, so the overnight-minus-intraday difference is 0.143 ($t = 3.60$). Thus the signal-date surface contains more of attention's relation with subsequent close-to-open repricing than with regular-session variation, but it does not encompass either one.

The intraday residual is broad. Continuous and jump volatility remain positive after the surface enters, as do upside and downside volatility. Their surface shares range from 0.283 to 0.316, and neither the jump-minus-continuous contrast nor the downside-minus-upside contrast is distinguishable from zero. The unspanned relation therefore does not arise only from rare discontinuities or negative-tail moves.[10] This decomposition sharpens the economic object while preserving the paper's reduced-form boundary: it locates the subsequent price variation but does not identify why option prices leave it unspanned.

[10] Averaging the same decomposition across two offset ten-minute grids leaves the intraday component shares essentially unchanged and every full-surface coefficient precisely estimated, so the pattern is not a five-minute microstructure artifact.

Table 8. The physical form of the surface-conditioned volatility relation. Panel A decomposes firm-specific volatility over days $t+1$ through $t+5$ on the 2024 complete-surface sample. Panel B reports paired differences in the surface shares.

	Attention coefficient		Surface
Outcome	No surface	Full surface	share
Panel A: Physical volatility components			
Intraday total	0.0153	0.0109	0.287
	(9.12)	(9.05)	[0.217, 0.358]
Continuous	0.0147	0.0105	0.284
	(9.08)	(9.07)	[0.214, 0.353]
Jump	0.0039	0.0027	0.316
	(7.33)	(6.03)	[0.222, 0.410]
Upside	0.0103	0.0074	0.283
	(8.85)	(8.61)	[0.213, 0.353]
Downside	0.0112	0.0080	0.290
	(9.14)	(9.18)	[0.219, 0.361]
Overnight	0.0169	0.0096	0.431
	(8.25)	(5.94)	[0.327, 0.534]
Panel B: Paired differences in surface shares			
Contrast	Difference	t-statistic	p-value
Overnight minus intraday	0.143	3.60	0.0003
Jump minus continuous	0.033	1.04	0.2976
Downside minus upside	0.007	0.59	0.5539

Notes: Panel A reports coefficients on the standardized attention score before and after the full 12-coordinate option surface enters. Outcomes aggregate five-minute returns over trading days $t+1$ through $t+5$ and are expressed as annualized volatility. Intraday components remove synchronized SPY returns using a market beta estimated over the prior 126 trading days; overnight variation removes the corresponding close-to-open market component. The sample requires all five sessions, at least 60 observed five-minute bins, and at least 55 synchronized return intervals in each session. Outcomes are winsorized at the first and ninety-ninth percentiles. All specifications include trailing realized volatility, size, ticker fixed effects, and date fixed effects. The sample contains 10,548 observations, 406 tickers, and 232 dates in 2024. Parentheses contain double-clustered t-statistics. Brackets contain delta-method 95 percent intervals from the joint ticker-and-date clustered covariance matrix. Panel B uses that same joint covariance matrix.

7 A transitory and expensive response

7.1 The payoff to buying volatility

Greater subsequent stock volatility coexists with lower gains to option buyers. I follow a same-strike, same-expiration at-the-money straddle for five trading days, rebalance the stock hedge daily, and scale its gain by entry vega. With conventional option-return controls, ticker and date fixed effects, and 1/99 winsorization, the attention coefficient is -0.001899 on 57,095 name-days, with a double-clustered t-statistic of -3.35. The negative relation holds across the conventional specification set rather than resting on a single specification, including the unwinsorized outcome and a version charging the full quoted spread at entry and exit. A spread-adjusted variant estimated without winsorization is negative but not statistically resolved. Higher attention is therefore followed by a lower delta-hedged gain to the option buyer, consistent with options being priced more richly relative to their ensuing hedged payoffs. The raw outcome, Fama–MacBeth estimates, residual-attention portfolios, quote-quality screens, and separate call and put positions preserve the negative relation. Adding the three ATM maturity levels attenuates the coefficient to -0.001208, and the full surface leaves -0.001172. This is a conditional pricing relation rather than evidence that Reddit users made the trades or that an executable arbitrage remains.

Table 9. Retail attention and subsequent delta-hedged option gains. The position combines same-strike, same-expiration at-the-money calls and puts, rebalances the stock hedge daily for five trading days, and scales the midpoint-priced gain by entry vega.

Specification	Estimate	t-statistic	Observations
Panel A. Midpoint-priced delta-hedged straddle gain			
Realized volatility and size	-0.003853	-5.88	57,095
Add 30-day ATM implied volatility	-0.002154	-3.75	57,095
Literature controls	-0.001899	-3.35	57,095
ATM implied-volatility term structure	-0.001208	-2.08	57,095
Full implied-volatility surface	-0.001172	-2.02	57,095
Panel B. Conventional sensitivities with literature controls			
Raw outcome	-0.002018	-2.99	57,095
Full quoted-spread charge	-0.002603	-3.99	57,095
Fama–MacBeth	-0.001456	-2.25	57,095
Residual-attention quintile H–L	-0.007059	-2.44	57,095
Quote-quality proxy	-0.001944	-3.29	47,839
Strict ATM and quote-quality proxy	-0.001013	-2.08	39,576
Panel C. Separate option legs			
Delta-hedged call gain	-0.000412	-3.73	57,095
Delta-hedged put gain	-0.000235	-2.96	57,095

Notes: The sample contains attention-active name-days from January 2020 through December 2024. The selected score dated t uses comment authors through calendar day t-1. The position combines same-strike, same-expiration call and put contracts and rebalances the stock hedge daily over five trading days. Except for the raw row, outcomes are winsorized at the 1st and 99th percentiles. Panel A scales the midpoint-priced gain by entry vega. Literature controls include 30-day ATM implied volatility, the historical-minus-implied volatility gap, log market capitalization, relative quoted spread, log dollar option volume, and an indicator for two-sided quoting. Regressions include ticker and date fixed effects, with standard errors clustered by ticker and date. The Fama–MacBeth row uses Newey–West standard errors with 10 lags. The H–L row is the mean daily difference between the highest and lowest residual-attention quintiles, also with Newey–West standard errors. The full-spread row charges the complete quoted spread at entry and exit. The quote-quality proxy requires positive bids, positive quoted spreads, a minimum $0.125 midpoint, and fresh entry and exit last-trade dates. The strict ATM band is 0.975 to 1.025. Contract-level volume and risk-free financing are unavailable in the saved pull. Panel C scales each leg by its securities-value denominator. Coefficients describe conditional associations, not identified trade direction or causal effects.

7.2 Price, quantity, and payoff on one sample

The response does not last. Implied volatility rises on the signal day, gives the rise back within a week while the stock's volatility is still elevated, and keeps falling after realized volatility has returned to normal. Table 10 places the price, the quantity, and the payoff on the same 53,976 name-days across 527 names, the common sample on which the straddle, the surface, and the realized outcomes are all observed, with the paper's controls and fixed effects throughout.[11]

A one standard deviation increase in attention raises ten-day at-the-money implied volatility by 0.0108 on the signal day, thirty-day implied volatility by 0.0056, and sixty-day implied volatility by 0.0030. Over the next five sessions the same three nodes fall by 0.0093, 0.0052, and 0.0032. The reversal matches the response at every maturity within a week. It then continues. In the second week the thirty-day node falls a further 0.0011 and the ten-day node a further 0.0020, and the thirty-day node is still falling in the third and fourth weeks. Realized volatility follows a different path. It is 0.0139 higher in the first week and indistinguishable from its normal level in the second week and after. By the end of the second week, implied volatility sits below where it started relative to the cross section, while the volatility the signal foretold has already been realized. A price that had risen only to reflect a week of higher volatility would return to its starting point. This one goes through it.

The buyer of that volatility pays for the round trip. A delta-hedged straddle entered on the signal day and held five sessions loses 0.0035 of its entry vega per standard deviation of attention. The same-contract decomposition of that loss follows both legs through the holding period. The first-order contribution of implied volatility changes, entry vega times the subsequent change in each contract's own implied volatility, is -0.0069. The remainder, which collects stock-price curvature, time decay, and higher-order terms, is $+0.0033$. Buyers earn on the volatility that arrives and lose twice as much on the repricing of the contracts they hold. The loss is a repricing loss, not a shortfall in realized volatility.

[11] The common sample requires every outcome, including the market-residual variance used in the appendix, so the index fund and a small number of name-days with incomplete return histories are absent. The attention coefficient on five-day realized volatility is 0.0139 on this sample against 0.0263 on the surface grid and 0.0320 on the active panel.

Table 10. Price, quantity, and payoff per standard deviation of attention. Every row uses the common sample of 53,976 name-days across 527 names from 2020 through 2024, the paper's controls, ticker and date fixed effects, and standard errors clustered by ticker and date. Implied volatility nodes are constant-maturity at-the-money values on the exact trading dates; window changes are the node at the window's close less the node at the previous window's close. Realized volatility is the annualized standard deviation of daily log returns over each window. The payoff decomposition uses the 52,574 name-days with complete same-contract implied volatility paths.

	Coefficient	SE	t	N
Panel A. Signal-day implied volatility level				
10-day ATM IV, signal day	0.0108	0.0011	10.07	53,976
30-day ATM IV, signal day	0.0056	0.0009	6.47	53,976
60-day ATM IV, signal day	0.0030	0.0008	3.66	53,976
Panel B. Subsequent implied volatility change				
10-day ATM IV change, t+1 to t+5	-0.0093	0.0008	-12.41	53,973
30-day ATM IV change, t+1 to t+5	-0.0052	0.0005	-9.77	53,976
60-day ATM IV change, t+1 to t+5	-0.0032	0.0004	-7.63	53,976
10-day ATM IV change, t+6 to t+10	-0.0020	0.0006	-3.22	53,361
30-day ATM IV change, t+6 to t+10	-0.0011	0.0005	-2.33	53,378
60-day ATM IV change, t+6 to t+10	-0.0008	0.0004	-1.91	53,378
10-day ATM IV change, t+11 to t+21	-0.0008	0.0008	-0.98	52,213
30-day ATM IV change, t+11 to t+21	-0.0014	0.0006	-2.27	52,253
60-day ATM IV change, t+11 to t+21	-0.0005	0.0005	-0.99	52,253
Panel C. Subsequent realized volatility				
Realized volatility, t+1 to t+5	0.0139	0.0016	8.82	53,976
Realized volatility, t+6 to t+10	0.0004	0.0016	0.26	53,722
Realized volatility, t+11 to t+21	-0.0010	0.0012	-0.83	53,185
Panel D. Delta-hedged straddle gain and its parts				
Straddle gain per entry vega (winsorized)	-0.0031	0.0007	-4.74	53,976
Straddle gain per entry vega (raw)	-0.0035	0.0008	-4.64	52,574
same-contract IV repricing	-0.0069	0.0006	-12.22	52,574
remainder (curvature, decay, error)	0.0033	0.0006	5.75	52,574

Each row is a separate regression of the stated outcome on retail attention with firm and date fixed effects and standard errors clustered by firm and date. Controls throughout are trailing 21-day volatility, log market capitalization, and mean absolute five-day returns, all measured through the preceding trading day. Attention is the selected lagged score in standard-deviation units, so each coefficient is the response to a one standard deviation rise. Panels A to C use the common risk-price-payoff sample; N falls at longer horizons because the constant-maturity nodes and returns needed for the window must fall on or before 31 December 2024. Implied volatility is the average of the +50-delta call and the −50-delta put at the stated constant maturity, read on exact trading dates: $t + k$ is the kth later date on the CRSP trading calendar of the price panel, and each window change is the node at its closing date minus the node at the previous window's closing date. Realized volatility is the annualized sample standard deviation of daily log returns over the window. The straddle rows hold the entry pair for five sessions and scale by entry vega; the IV-repricing row is the same-contract first-order vega contribution and the remainder carries curvature, time decay, and approximation error. The decomposition rows use the 52,574 paths with a complete same-contract implied volatility record.

Figure 4 shows the same sequence in event time. Attention onsets are days on which the lagged score crosses two after ten sessions below it, at least 21 sessions apart; 2,155 onsets across 507 names have balanced option coverage. Implied volatility at every maturity peaks the session before the score is observable, alongside the realized jump that generates the discussion, and falls through its pre-episode level within ten sessions. Realized volatility is back near its baseline by the third session. Option volume stays elevated for the whole window. A straddle bought on the first day the score is usable has lost 0.034 of its entry vega five sessions later. The surface responds to the episode itself, on the day of the jump; the attention score records the episode with a one-day lag; and what the score then predicts, conditional on that surface, is a week of elevated volatility and a month of declining implied volatility.

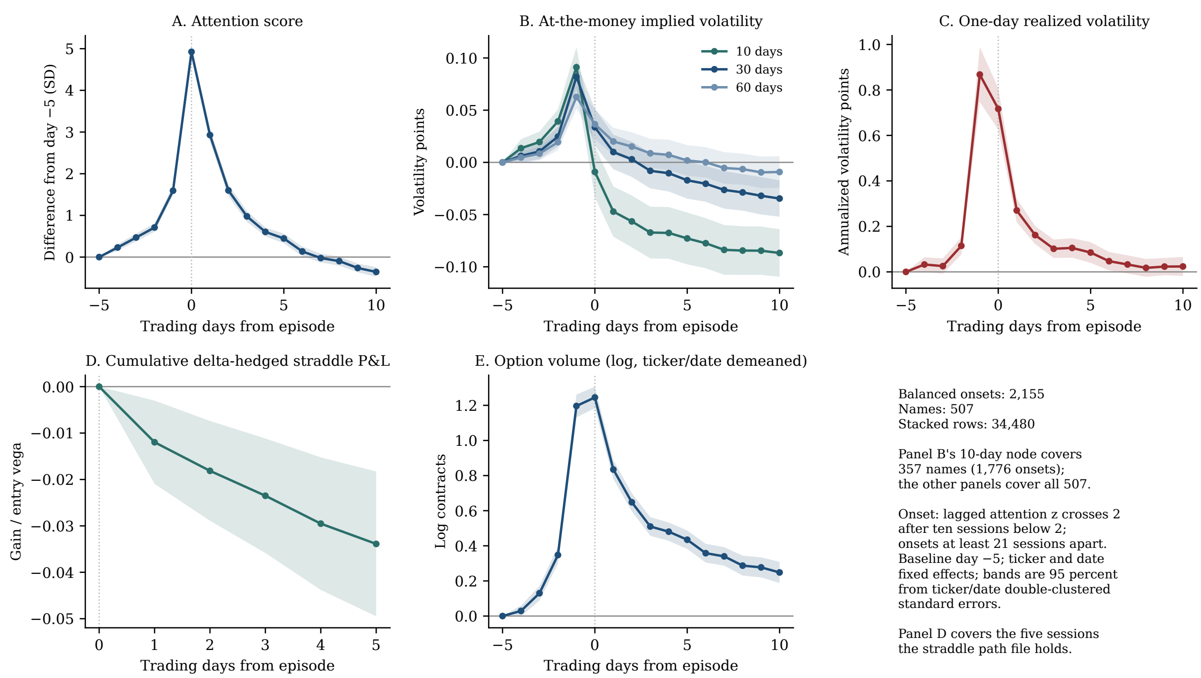


Figure 4. The anatomy of an attention episode. Onsets are days on which the lagged attention score crosses two after ten sessions below two, at least 21 sessions apart; the sample contains 2,155 balanced onsets across 507 names from 2020 through 2024. Each panel plots coefficients on event-time indicators relative to day −5 with ticker and date fixed effects; bands are 95 percent from standard errors clustered by ticker and date. Panel D covers the five sessions of the straddle path file and 1,595 onsets with a complete path. The ten-day node in Panel B covers 357 of the 507 names.

7.3 Where the response sits

The response and its reversal sit at the short end of the term structure and are nearly flat across strikes. Figure 5 maps both across the twelve surface nodes in volatility points. At ten days, every node rises between 0.92 and 1.20 points per standard deviation of attention and gives back between 0.84 and 1.00 points over the next five sessions. At sixty days the response is between 0.22 and 0.34 points and the reversal matches it. Within a maturity the out-of-the-money call moves most and reverses most, but the differences across strikes are a fraction of the differences across maturities.

The lower panels place retail discussion and retail trading on the same grid. I parse every comment in the corpus for a stated contract, a strike with a call or put marker and, where given, an expiration, and assign each mention to a moneyness bucket from the prior close and a maturity bucket from the stated date.[12] Calls expiring within thirty days at or out of the money are the most stated contracts, and among contracts with a stated expiration, out-of-the-money calls at eight to thirty days are the largest cell. In the 2025 customer records described below, the same cell carries the largest net opening buys, 0.0115 of gross opening volume per standard deviation of attention on the C1 exchange. The maturities retail names, and buys when its trading can be observed, are the maturities where the surface moves most and reverses most. Across strikes, the surface is flatter than a call-specific demand story would predict.

[12]The parser recovers 302,011 priced mentions from 262,135 comments and finds a stated contract on 35.6 percent of the grid ticker-days. In an independent read of 300 randomly drawn mentions, 99 percent refer to a real contract, the strike is correct in 99 percent, and the call or put side is never wrong on a real mention. Calls are 71 percent of mentions. The share of mentions with a stated expiration falls from 0.75 in 2020 to 0.48 in 2024.

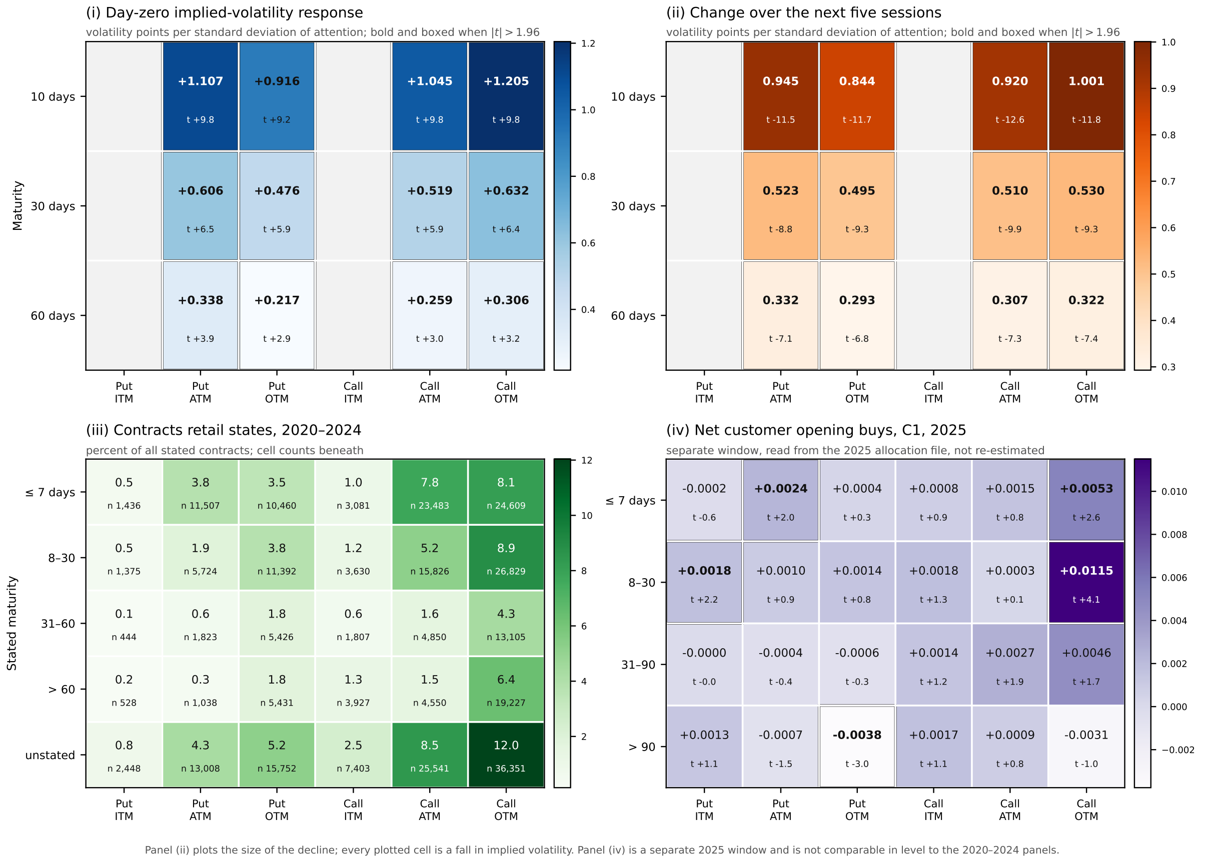


Figure 5. The response, the reversal, stated contracts, and customer opening buys on one grid. Panels (i) and (ii) report the signal-day response and the five-session change of each surface node in volatility points per standard deviation of attention on the common sample, with the paper's controls and fixed effects; bold cells have $|t| > 1.96$. Panel (iii) is the share of all stated contracts in r/wallstreetbets comments from 2020 through 2024 by call or put, moneyness from the prior close, and stated maturity. Panel (iv) is the Cboe C1 net customer opening-buy share by contract cell per standard deviation of attention from March through August 2025, a separate window that is not comparable in level to the historical panels.

Discussion about the firm's options is priced more and realized less than discussion about the firm. Table 11 splits daily distinct authors into two disjoint groups: authors who state a contract or describe an option position, and authors who mention the stock without any option language. Each count receives the paper's trailing surprise transformation. Entered jointly, firm discussion predicts 0.0186 higher realized volatility over the following week and raises thirty-day implied volatility by 0.0038; option discussion predicts 0.0095 higher realized volatility and raises implied volatility by 0.0094. The difference in the realized coefficient is -0.0091 and in the implied coefficient 0.0056, each about two standard errors from zero. Per unit of the volatility it forecasts, option discussion moves the price more than twice as much. The two channels share the reversal and the loss: their five-session implied changes are -0.0055 and -0.0041 and their straddle coefficients -0.0029 and -0.0032, with neither difference resolved. The spanning share of the option-discussion slope is 0.533 on the surface grid against 0.460 for firm discussion, in line with a price that co-moves most with the discussion that is about the price.[13]

[13] The broad dictionary measures of an earlier draft, which counted words such as "call" and "contract" in any context and overlapped one another, are reported in the online supplement as a sensitivity. The disjoint construction here is what makes the joint regression interpretable.

Table 11. Firm discussion and option discussion. Daily distinct authors are split into those who state a contract or describe an option position and those who mention the stock without any option language, and each count receives the paper's trailing surprise transformation. Panels A through D use the common sample of 53,976 name-days with the paper's controls, ticker and date fixed effects, and standard errors clustered by ticker and date in parentheses. Panel E reports each measure's realized-volatility slope before and after the thirty-day level and the twelve-node surface enter on the 61,434-row grid, with 95 percent date-block bands for the shares.

	Realized volatility	Entry ATM implied vol.	Change in implied vol.	Hedged straddle gain
Panel A. Entered jointly				
Firm discussion	0.0186	0.0038	-0.0055	-0.0029
	(0.0029)	(0.0015)	(0.0010)	(0.0013)
Option discussion	0.0095	0.0094	-0.0041	-0.0032
	(0.0024)	(0.0017)	(0.0009)	(0.0014)
Option − firm	-0.0091	0.0056	0.0014	-0.0003
	(0.0041)	(0.0025)	(0.0016)	(0.0022)
Panel B. Entered separately				
Firm discussion	0.0241	0.0093	-0.0079	-0.0048
	(0.0029)	(0.0016)	(0.0010)	(0.0012)
Option discussion	0.0196	0.0115	-0.0071	-0.0048
	(0.0026)	(0.0017)	(0.0009)	(0.0013)
Panel C. Each alongside total attention				
Total attention	0.0139	0.0069	-0.0080	-0.0048
	(0.0022)	(0.0013)	(0.0008)	(0.0011)
Firm discussion	0.0001	-0.0027	0.0060	0.0035
	(0.0037)	(0.0021)	(0.0014)	(0.0018)
Total attention	0.0118	0.0029	-0.0045	-0.0024
	(0.0017)	(0.0009)	(0.0006)	(0.0007)
Option discussion	0.0064	0.0082	-0.0021	-0.0021
	(0.0026)	(0.0018)	(0.0010)	(0.0014)
Panel D. All three jointly				
Total attention	0.0120	0.0044	-0.0074	-0.0041
	(0.0024)	(0.0013)	(0.0008)	(0.0011)
Firm discussion	-0.0003	-0.0032	0.0061	0.0036
	(0.0036)	(0.0021)	(0.0014)	(0.0018)
Option discussion	0.0064	0.0083	-0.0022	-0.0022
	(0.0026)	(0.0018)	(0.0010)	(0.0014)
Observations		53,976		

Panel E. Spanning share of the realized-volatility slope, grid sample

	β_0	β | 30d ATM	φ_{30}	β | 12 nodes	φ_{grid}
Total attention	0.02632	0.01725	0.345	0.01405	0.466
			[0.274, 0.421]		[0.391, 0.562]
Firm discussion	0.04715	0.03068	0.349	0.02547	0.460
			[0.276, 0.431]		[0.379, 0.571]
Option discussion	0.04201	0.02446	0.418	0.01961	0.533
			[0.323, 0.534]		[0.420, 0.673]

7.4 General, not announcement

Earnings announcements do not carry the pattern. On the 48,914 common name-days with earnings coverage, 7,249 have an announcement between the signal day and the option's exit. Outside those windows, attention predicts 0.0111 higher realized volatility, raises thirty-day implied volatility by 0.0059, is followed by a 0.0022 decline, and predicts a 0.0019 lower straddle gain. Inside them the relation with realized volatility is absent, the implied level is lower rather than higher, and the straddle loss is present but imprecise. Appendix Table A20 reports the split with a placebo window that closes before the signal day: the placebo removes the realized-volatility split but not the price-side splits, so the realized relation is about the coming announcement while the price-side relations track proximity to any announcement. The transitory response and the loss are objects of ordinary days.

7.5 Scope

The response and the reversal are present in every year of the sample with stable signs. What changes over time is the share of the volatility signal the surface prices. On the selected measure, the thirty-day level spans 0.404 of the attention slope in 2020 and 2021 and 0.280 from 2022 through 2024, a difference whose band excludes zero; the full surface spans 0.519 and then 0.458, a difference whose band does not. The level lost span after the meme years and the curve kept most of it, so the surface's incremental span beyond the thirty-day level widens from 0.091 to 0.158. Appendix Figure A4 reports the annual and rolling estimates with the 2025 holdout as a labeled point.

Across names, the response, the reversal, and the loss are all larger in small names, and so is the realized-volatility relation, so the cross section of the response follows the cross section of the signal. Neither option bid-ask spreads nor open interest relative to stock trading moves any of the three, and neither the level of the VIX nor a dealer gamma proxy built from index options does either (Appendix Tables A18 and A17). The evidence does not locate the response in hedging costs.

The magnitude is modest against the option-return literature's own benchmarks. A weekly sort of straddles on residual attention loses 0.0081 of entry vega more in the top quintile than in the bottom, or 0.0115 after charging the full quoted spread, against an average loss of 0.035 for every straddle in the sample (Appendix Table A19). The spread widens with the spread charge because attention names carry wider quotes, and the relation survives the two-way fixed-effect ladder but not a Fama–MacBeth version with the full surface. It is a statement about a transitory response, not a strategy, and the net-of-cost test reported earlier remains a null.

Customer records for 2025 show what the trading looks like. Daily contract records for Cboe C1 and C2 identify customer-origin opening buys, opening sells, closing buys, and closing sells from March through August 2025, a window after the estimation sample that describes trading composition rather than the historical mechanism. Conditional on discussion content, a standard deviation of attention predicts 0.194 higher log gross customer opening volume on C1 and 0.243 on C2. Net opening buys rise by 3.2 percentage points of gross opening volume on C1. Including closing transactions reduces the coefficient to 0.2 percentage points, indistinguishable from zero, and neither signed relation is resolved on C2 (Appendix Table A21). Attention brings customers to the open on both exchanges; the day's net position is a smaller and less certain object.

The incremental forecast content above is a week-one object, covering $t+1$ through $t+5$, and does not extend to week two, $t+6$ through $t+10$, under the appendix design. At that later horizon, the premise attention coefficient is already near zero and negative before the later surface enters, and the estimated difference has the opposite sign from absorption (Appendix Table A14, Panel B).

A signed decomposition of later variation gives a different limit. Attention predicts capped variation on both positive-return and negative-return days after full-surface conditioning, while their difference is unresolved and the raw comparison is tail sensitive (Appendix Table A13, Panel B).

On the public SLAN sample, a one standard deviation increase in attention predicts a 0.138-standard-deviation increase in same-day internalized option activity. Neither calls nor puts show a coherent same-sign directional response. Adding the contract-based signed-level proxy leaves the surface-conditioned attention coefficient unchanged, and the sample can resolve attenuation only above 0.0015. SLAN is a public internalized-flow proxy rather than customer-origin signed flow, and its sample runs from January 2020 through June 2021. The public proxy therefore cannot resolve direction (Appendix Table A14, Panel A, and Appendix Figure A2). The 2025 customer-origin records distinguish opening from closing transactions and locate the C1 opening-buy association across contracts. Their later window and exchange coverage still leave the historical connection between demand and repricing unidentified. The evidence supports conditional forecasting and option-gain relations, while an implementable trading strategy requires a separate assessment of prices, costs, and financing.

The selected measure also carries to 2025, a calendar year outside the estimation sample. The response is 0.0315, against 0.0320 in sample, and the ten-day less thirty-day spanning difference is 0.156 in both periods. Both forecast comparisons remain positive at smaller magnitudes. The thirty-day share, timing contrast, and rank increment are imprecise. Appendix Table A16 reports all seven quantities.

8 Conclusion

Public retail attention predicts which stocks become more volatile over the following week. The equity option surface responds to that signal but does not make it redundant. A conventional thirty-day level captures only part of the relation, and the full observed surface spans about 0.47 while leaving a positive conditional attention slope, and fixed nonlinear readings yield the same conclusion. Response and predictive encompassing are different empirical objects.

Nearly all additional span comes from the at-the-money maturity curve. Smile shape also responds, and call-versus-put discussion predicts the matching wing tilt, but these shape margins add little span. Attention remains separately predictive after recent price history. In high-frequency data, the residual appears in continuous and jump variation, on both sides of the return distribution, and in both intraday and overnight moves. The surface contains more of the overnight relation than of the intraday relation, but it encompasses neither. Attention also modestly improves recursive forecasts and predicts lower subsequent delta-hedged option-buyer gains under conventional controls. Together, the results make the residual economically relevant without turning it into a large forecasting or trading claim.

The design identifies the shape of the response, not its cause. Implied volatility rises with attention, gives the rise back within a week while the volatility is still being realized, and ends below its starting point, so the priced half is priced through a movement that does not persist and a buyer of volatility on the signal day pays for it. The movement sits at the short end of the surface, where retail names its contracts and where customer opening buys concentrate, and discussion of the options is priced more and realized less than discussion of the firm. A spanning share counts any co-movement between prices and attention as priced, so the half is an upper bound on what the surface aggregates as information. Signed customer flow over the estimation sample would be needed to say how much of the movement is demand. The contribution is that an option surface can respond to a public signal, reverse, and still stop short of encompassing what the signal predicts.

A The vector spanning benchmark

This appendix derives the spanning share in the vector benchmark of Section 2. Let S, attention noise η, outcome noise u, and price noise ν be mutually independent and mean zero. Attention is $z = S + \eta$, the outcome is $RV = S + u$, and the K observed price nodes satisfy $P = gS + \nu$, with $\mathrm{Var}(\nu) = \Sigma_\nu$ positive definite.

The univariate attention slope is

$$\beta_0 \;=\; \frac{\mathrm{Cov}(RV, z)}{\mathrm{Var}(z)} \;=\; \frac{\sigma_S^2}{\sigma_S^2 + \sigma_\eta^2}. \tag{3}$$

The best linear surface signal is proportional to $Q = g'\Sigma_\nu^{-1}P$. After normalization, Q is equivalent to observing $S + w$, where

$$\sigma_w^2 = \left(g'\Sigma_\nu^{-1}g\right)^{-1}. \tag{4}$$

Conditioning on P is therefore equivalent to conditioning on $S + w$. Solving the normal equations gives

$$\beta_P \;=\; \frac{\sigma_S^2\,\sigma_w^2}{\sigma_S^2\,\sigma_w^2 + \sigma_\eta^2\,\sigma_S^2 + \sigma_\eta^2\,\sigma_w^2}, \tag{5}$$

and the share follows,

$$\phi(P) \;=\; 1 - \frac{\beta_P}{\beta_0} \;=\; \frac{\sigma_S^2\,\sigma_\eta^2}{\sigma_S^2\,\sigma_w^2 + \sigma_S^2\,\sigma_\eta^2 + \sigma_\eta^2\,\sigma_w^2}. \tag{6}$$

The surface precision is $\mathcal{I}_P = g'\Sigma_\nu^{-1}g = \sigma_w^{-2}$. Thus $\phi(P)$ rises with precision. Adding an informative node weakly raises precision under the orthogonal-noise benchmark, and an invertible transformation of P leaves both its span and $\phi(P)$ unchanged. A common response scale applied to the entire observed vector also leaves the share unchanged. These precision-monotonicity statements require the benchmark's covariance restrictions. The regression identity defining the spanning share does not. Even here, ϕ is not a cardinal information fraction because it depends on σ_η^2 as well as surface precision.

Maturity coordinates. For each maturity, write $P_m = a_m Q_m$ with $Q_m = G_m S + B_m + \widetilde{\xi}_m$ and $a_m \neq 0$. Because a_m rescales the entire observed quote, it is an invertible transformation and leaves the span unchanged. This conclusion would be false for $P_m = a_m(G_m S + B_m) + \xi_m$ with an additive ξ_m that does not co-scale. The loading G_m matters relative to the covariance of the background components. Stacking maturities can therefore span more than any single maturity, but the scalar state supplies no restriction on the full matrix of realized horizons and option maturities. The matrix in the paper is evidence for a richer variance-state model, not a prediction derived here.

Attention-related demand. A reduced-form extension writes $P = gS + \Lambda D + \nu$, where $D = bS + e$ is option demand related to attention. The predictable component bS changes the price loading on the state, while e adds price variation. Depending on their covariances, demand can raise or lower the measured spanning share. Call-put responses are consequently descriptive coordinates, not a structural pressure instrument. Signed maturity-specific flow is needed to distinguish information aggregation from demand contamination.

Noise in the signal raises the measured share

A natural reading of a low share is that the signal is simply noisy. The benchmark says the opposite. Write the share as $\phi = \sigma_S^2\sigma_\eta^2/(\sigma_S^2\sigma_w^2 + \sigma_S^2\sigma_\eta^2 + \sigma_\eta^2\sigma_w^2)$. As a function of σ_η^2 this is $cx/(b + ax)$ with $c = \sigma_S^2$, $a = \sigma_S^2 + \sigma_w^2$ and $b = \sigma_S^2\sigma_w^2$, whose derivative $cb/(b + ax)^2$ is positive, so the measured share rises with the signal's own noise. As $\sigma_w \to 0$ the share tends to one at any noise level, and as $\sigma_\eta \to 0$ it tends to zero for any imperfect price. The price's error about the state, σ_w, is what lowers the share. The signal's own noise does not.

The same ordering can hold beyond the parametric benchmark under stable signs. Let the observed signal be $z = z^* + e$ with classical e. In any least-squares regression the probability limit of z's coefficient is its true value times $\lambda = \mathrm{Var}(z_\perp^*)/(\mathrm{Var}(z_\perp^*) + \sigma_e^2)$, where $z_\perp^*$ is the true signal residualized on the remaining regressors. Adding implied volatility, a variable correlated with z^*, weakly reduces $\mathrm{Var}(z_\perp^*)$ and therefore λ, so the controlled slope is attenuated by more than the uncontrolled one, their ratio falls, and the measured share weakly exceeds the true one, provided the uncontrolled and controlled true attention coefficients are both positive and the added projection does not reverse their signs.

Under those conditions, classical signal noise makes attention appear better spanned, not less spanned. The paired selected-measure gaps can then be read as conservative. The bound does not apply when either coefficient changes sign, when measurement error is correlated with the volatility state, or when the added price vector changes the underlying estimand.

A rejected transient-persistent calibration

Table A1 compares the seven selected-measure moments with the specified two-component benchmark. The fitted transient and persistent half-lives are 2.91 and 44.06 trading days, but the model understates the one- and five-day realized-volatility responses and overstates the short-maturity spanning share. The centered date-block-bootstrap specification p-value is 0.001. The common orthogonal two-state benchmark is therefore rejected and is not used to interpret the spanning share structurally.

B Supporting empirical evidence

This appendix reports the sample description, robustness comparisons, and the source tables needed to interpret the principal figures. The online supplement reports additional construction, timing, portability, subsample, and estimator checks.

Table A1. Transient-persistent calibration. Parameter bands refit the specified minimum-distance model to the paired date-block moment draws. The overidentification p-value uses the centered block bootstrap.

Object	Estimate	95% bootstrap band	Economic unit
Transient loading	0.0195	[0.0156,0.0246]	annualized volatility
Persistent loading	0.0109	[0.0054,0.0139]	annualized volatility
Transient persistence	0.788	[0.644,0.877]	daily AR coefficient
Persistent persistence	0.984	[0.972,1.000]	daily AR coefficient
Overidentification p	0.001		centered block bootstrap

Table A2. Summary statistics. The main sample contains 93,350 active name-days across 938 names from 2020 through 2024. Realized and implied volatility are annualized decimals, returns are decimals, and market capitalization is in billions of dollars. Implied-volatility variables use the OptionMetrics-covered subset.

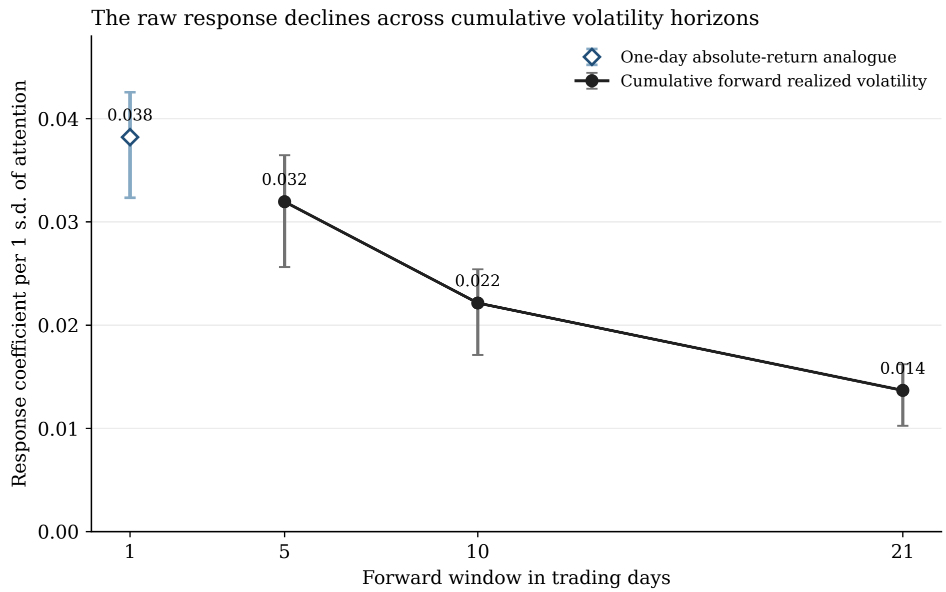
Variable	N	Mean	SD	P25	Median	P75
Retail attention (lagged z-score)	93,350	0.422	0.869	-0.129	0.320	0.864
Ticker mentions	93,350	6.0	147.9	1.0	1.0	3.0
Forward RV, 5 days	93,350	0.667	0.685	0.275	0.488	0.824
Trailing RV, 21 days	93,350	0.761	0.702	0.345	0.581	0.939
Absolute forward return, 5 days	93,350	0.084	0.198	0.020	0.049	0.103
Tail move indicator	93,350	0.258	0.437	0.000	0.000	1.000
Market capitalization ($ billions)	93,350	131.9	393.5	1.5	7.9	69.5
Positioning intensity	8,114	1.490	1.213	0.527	1.195	2.301
ATM implied volatility	81,809	0.741	0.492	0.366	0.617	0.990
Forward ATM IV change, 5 days	81,245	-0.0141	0.1596	-0.0520	-0.0055	0.0299

Table A3. Industry controls and recent price history. Panel A compares date and FF12-by-date fixed effects on identical classifiable rows. Panel B includes attention and trailing absolute five-day return jointly with the fixed recent-price basis, then adds the complete 12-node option surface.

Panel A. Industry-by-date fixed effects					
Sample	Fixed effects	Attention coefficient		ϕ	N
		Unconditioned	Conditioned		
Active	Ticker + date	0.0318 (10.79)	–	–	80,218
Active	Ticker + FF12×date	0.0307 (10.19)	–	–	80,218
30-day ATM	Ticker + date	0.0301 (10.04)	0.0198 (8.55)	0.343	74,408
30-day ATM	Ticker + FF12×date	0.0293 (9.50)	0.0188 (7.89)	0.359	74,408
Full grid	Ticker + date	0.0268 (8.07)	0.0145 (6.14)	0.461	55,251
Full grid	Ticker + FF12×date	0.0260 (7.36)	0.0134 (5.16)	0.482	55,251
Panel B. Joint freshness horse race					
Model	Conditioning set	Attention	|5-day return|	ϕ_A / $\phi_{\|r\|}$	N
Recent-price basis	Without option surface	0.0151 (7.28)	0.0698 (5.33)	–	61,429
Full-grid model	Add complete option surface	0.0076 (3.82)	0.0419 (3.74)	0.500 / 0.399	61,429

Paired bootstrap 95% bands for decisive rows			
Object	Date block	Ticker pairs	Valid draws (D/T)
Active, industry-date attention coefficient	[0.0231, 0.0366]	[0.0255, 0.0365]	2,000 / 2,000
Full grid, conditioned attention coefficient	[0.0064, 0.0208]	[0.0093, 0.0183]	2,000 / 2,000
Full grid, industry-date ϕ	[0.393, 0.635]	[0.404, 0.568]	2,000 / 2,000
Attention, full-grid model	[0.0035, 0.0116]	[0.0042, 0.0112]	2,000 / 2,000
Attention, ϕ_A	[0.381, 0.678]	[0.375, 0.655]	2,000 / 2,000
|5-day return|, full-grid model	[0.0119, 0.0751]	[0.0217, 0.0605]	2,000 / 2,000
|5-day return|, $\phi_{\|r\|}$	[0.288, 0.667]	[0.309, 0.564]	2,000 / 2,000

Notes: Panel A uses identical FF12-classifiable rows within each sample. The unconditioned specifications include trailing 21-day realized volatility and log market capitalization. The conditioned specifications add the 30-day at-the-money level or the complete 12-node option surface. Panel B jointly includes attention and standardized 1-, 5-, and 21-day realized volatility and absolute five-day return, with log market capitalization. The second specification adds the complete 12-node surface. All freshness windows end at $t-1$. Parentheses report Cameron–Gelbach–Miller t-statistics clustered by ticker and original calendar date. The final block reports paired date-block and ticker-pairs 95% bands. D/T denotes date/ticker valid draws. For each reported ϕ row, denominator counts are date draws (2,000 positive, 0 nonpositive, 2,000 finite) and ticker draws (2,000 positive, 0 nonpositive, 2,000 finite). The reduced-form spanning share is $\phi = 1 - \beta_{\text{conditioned}}/\beta_{\text{unconditioned}}$.



Points and 95% paired 10-day date-block bootstrap intervals. The one-day outcome is an absolute-return analogue, not cumulative RV.

Figure A1. Raw horizon profile. The one-day point uses an absolute-return analogue and is distinct from the cumulative forward realized volatility outcomes measured over five, ten, and twenty-one trading days. Points are attention coefficients under the paper's controls and fixed effects; bars are paired date-block intervals.

Table A4. The share of a signal already in the price, for retail attention and benchmark signals. The share is $1 - \beta_{IV}/\beta_0$ from a forecast of forward five-day realized volatility, with 30-day at-the-money implied volatility as the only control. Bands and paired differences use common ten-day date-block draws. The sample contains 81,809 active option-covered name-days across 841 names from 2020 to 2024.

Signal	Share in price	95% band	Difference from attention	
Retail attention	0.427	[0.374, 0.496]	—	
Trailing |5-day return|	0.427	[0.353, 0.533]	0.001	[−0.067, 0.104]
Trailing realized volatility	0.846	[0.714, 1.015]	0.419*	[0.271, 0.594]
Size (log market cap)	0.911	[0.682, 1.286]	0.484*	[0.238, 0.863]

Table A5. The share of the volatility signal already in the price, by realized volatility horizon and option maturity. Each entry is $1 - \beta_{IV}/\beta_0$ under the paper's controls, within stock and within day. The sample contains 61,434 name-days across 538 names.

Realized-vol horizon	10-day option	30-day option	60-day option
5-day	0.506	0.347	0.245
10-day	0.688	0.466	0.329
21-day	0.854	0.631	0.448

Table A6. Decomposing the 30-day shortfall. The magnitude and tail ratios compare the measured implied-volatility response with its matched physical benchmark. The matched-horizon share is the portion of the corresponding realized volatility slope spanned by the price. Brackets are 95 percent paired ten-day date-block intervals. The sample contains 61,434 name-days across 538 names.

Option maturity	Magnitude ratio (vol)	Tail ratio (variance)	Matched-horizon share
10-day	0.80 [0.64, 1.05]	0.63 [0.39, 1.25]	0.61 [0.45, 1.06]
30-day	1.02 [0.78, 1.40]	0.84 [0.57, 1.39]	0.62 [0.43, 0.98]
60-day	1.13 [0.74, 1.94]	0.90 [0.57, 1.71]	0.52 [0.33, 0.90]

Table A7. The full out-of-the-money surface and the tail. On a common ten-day-node sample, ϕ^{tail} is the share of a realized five-day tail already in the price under nested conditioning sets that add observed wing measures and model-free tail variance to the at-the-money level. The sample contains 71,760 name-days across 822 names.

Conditioning set	ϕ^{tail}
ATM level only	0.608
ATM + 25-delta shape	0.629
ATM + shape + model-free tail variance	0.632
Addition beyond ATM	+0.024 [+0.014, +0.039]

Table A8. Common and asymmetric at-the-money responses. At maturity m, L_m is the average of the call-delta 50 and put-delta minus-50 implied-volatility nodes and D_m is their difference. $\Delta\phi_D$ is the change in the spanning share when asymmetry enters. All specifications use the same 61,434 name-days.

Maturity	L_m response	D_m response	Wild p_D	$\Delta\phi_D$	Date band	Ticker band
10 days	0.01789	−0.00029	0.666	0.0075	[0.0000, 0.0181]	[−0.0010, 0.0171]
30 days	0.01133	−0.00087	0.207	0.0009	[−0.0014, 0.0061]	[−0.0033, 0.0065]
60 days	0.00750	−0.00095	0.158	0.0009	[−0.0014, 0.0061]	[−0.0030, 0.0068]
Joint ATM curve				0.0074	[0.0020, 0.0156]	[0.0003, 0.0145]

Table A9. Tail and call-put contributions beyond ATM levels. Panel A reports spanning shares for a five-day realized-tail indicator on the broad full-surface sample. Panel B decomposes the historical ATM response into the paired call-put common component and the call-minus-put difference on the fixed common grid. Tail increment bands are 95 percent. The joint call-put increment reports separate date and ticker bands.

	ATM object	Expanded object	Increment	Paired 95% band
Panel A. Full-surface tail spanning				
ATM level	0.608			
ATM plus observed wings		0.629	0.021	
ATM plus full surface		0.632	0.024	[0.014, 0.039]
Panel B. Common and asymmetric ATM responses				
10-day maturity	0.01789	−0.00029	0.0075	individual band includes zero
30-day maturity	0.01133	−0.00087	0.0009	individual band includes zero
60-day maturity	0.00750	−0.00095	0.0009	individual band includes zero
Joint ATM curve			0.0074	date [0.0020, 0.0156]; ticker [0.0003, 0.0145]

Table A10. Attention and smile shape on the complete surface grid. Wing convexity is the average of the call and put wings relative to at-the-money volatility. Call-minus-put tilt is their difference. Each estimate conditions on the same-maturity at-the-money level, the paper's controls, and stock and day fixed effects. Bands control the six reported shape coefficients jointly within each resampling dimension. The sample contains 61,434 name-days across 538 names.

Maturity	Estimate	Date-family 95%	Ticker-family 95%	Inference
Panel A. Wing convexity relative to ATM				
10-day	0.000755	[0.000198, 0.001312]	[0.000067, 0.001443]	Both bands exclude zero
30-day	0.000781	[0.000180, 0.001382]	[0.000184, 0.001379]	Both bands exclude zero
60-day	0.000291	[-0.000183, 0.000765]	[-0.000221, 0.000803]	Bands include zero
Panel B. Call-minus-put wing tilt				
10-day	0.002952	[0.001265, 0.004638]	[0.001129, 0.004774]	Both bands exclude zero
30-day	0.001766	[0.000191, 0.003340]	[0.000174, 0.003357]	Both bands exclude zero
60-day	0.001205	[-0.000437, 0.002848]	[-0.000312, 0.002723]	Bands include zero

Notes: Coefficients are selected-attention slopes in raw implied-volatility units, conditional on same-maturity ATM implied volatility, the paper's controls, ticker effects, and date effects. Date-family and ticker-family bands are simultaneous 95% bands across the six coefficients and retain 2,000 draws each. The common sample contains 61,434 name-days, 538 names, and 1,229 dates from January 2020 through December 2024. Requiring the complete cross-maturity grid excludes 303 of the 841 names with 30-day ATM support. The 60-day margins are unresolved.

Table A11. Who generates attention and when the option surface adjusts. Panel A interacts directional option breadth with authors' lagged WallStreetBets experience. Panel B compares the implied-volatility path associated with fresh stock discussion and recent-author discussion.

	10 day	30 day	60 day	Average
Panel A. Author experience and wing convexity				
Directional option breadth	0.0007	0.0008	0.0004	0.0006
	(1.63)	(1.85)	(1.44)	(1.83)
Breadth × author experience	-0.0006	-0.0006	-0.0002	-0.0005
	(-2.26)	(-2.83)	(-0.97)	(-2.47)
Three-day discussion, experience interaction				-0.0006 (-2.07)
Prior and same-day return controls				-0.0005 (-2.43)
2020–2021				-0.0005 (-2.24)
2022–2024				-0.0002 (-0.81)
Panel B. Fresh-minus-recent ATM implied-volatility path				
Five-session change before attention	0.0172 (3.14)	0.0096 (2.38)	0.0042 (1.40)	0.0103 (2.55)
Prior session to attention date	-0.0140 (-4.49)	-0.0081 (-3.58)	-0.0047 (-2.73)	-0.0089 (-3.97)
Change over next session	-0.0023 (-1.25)	-0.0016 (-1.01)	-0.0014 (-1.02)	-0.0018 (-1.22)
Change over next five sessions	-0.0027 (-0.83)	-0.0006 (-0.23)	-0.0001 (-0.04)	-0.0011 (-0.45)
Fama–MacBeth: five-session change before				0.0100 (3.37)
Fama–MacBeth: attention-date change				-0.0096 (-5.35)

Notes: Author experience uses only platform history observed through the calendar day before each directional comment and combines prior activity with tenure in within-quarter ranks. Fresh authors either discuss a stock for the first observed time or return after more than 90 days; recent authors discussed it within the preceding 90 days. Panel B uses 2022–2024 after a two-year history burn-in. Market-day variables use discussion through the prior calendar day, and surface changes join exact adjacent trading sessions. Specifications include ticker and date fixed effects and the controls described in Section 5; parentheses report t-statistics from standard errors clustered by ticker and date, except the Fama–MacBeth rows, which use Newey–West(10) inference. Experience is an observed platform-history measure, not investor sophistication, and neither panel identifies executed trades or price pressure.

Table A12. Narrative composition and the option surface. The four text-only narrative measures enter jointly with selected unsigned attention. Panel A reports average-maturity coefficients, Panel B reports cross-narrative differences, and Panel C varies ticker attachment, the discussion window, return controls, and the sample period.

	ATM level	Wing convexity	Wing tilt
Panel A. Joint daily narrative coefficients, maturity average			
Volatility and risk	0.0095 (3.42)	0.0003 (0.84)	0.0027 (2.33)
Corporate catalysts	0.0073 (3.96)	0.0006 (1.74)	0.0018 (2.18)
Fundamentals and valuation	0.0030 (1.79)	0.0003 (1.02)	-0.0001 (-0.11)
Position mechanics	0.0098 (5.59)	0.0000 (0.06)	-0.0013 (-0.85)
Panel B. Primary cross-narrative contrasts, maturity average			
Volatility minus fundamentals, ATM level	0.0065 (2.62)		
Mechanics minus fundamentals, ATM level	0.0068 (2.85)		
Volatility minus fundamentals, wing tilt			0.0028 (1.97)
Volatility minus mechanics, wing tilt			0.0039 (2.11)
Panel C. Average-maturity specification checks			
	Volatility, level	Mechanics, level	Volatility, tilt
Cashtag-only ticker attachment	0.0057 (2.25)	0.0063 (4.04)	-0.0001 (-0.05)
Three-day discussion window	0.0100 (3.86)	0.0031 (1.84)	0.0021 (1.89)
Signed and lagged return controls	0.0079 (3.31)	0.0086 (4.93)	0.0026 (2.41)
2022–2024	0.0058 (2.15)	0.0080 (3.66)	0.0021 (1.50)

Notes: Volatility and risk, corporate catalysts, fundamentals and valuation, and position mechanics are assigned from comment text without using market outcomes. Labels can overlap. The main construction counts distinct authors by ticker and UTC date, applies the paper's trailing surprise transformation, and shifts the signal so market-day outcomes use discussion through the prior calendar day. All four narrative surprises enter jointly with selected unsigned attention, trailing realized volatility, log market capitalization, ticker fixed effects, and date fixed effects. Shape regressions also condition on same-maturity ATM implied volatility, and parentheses report t-statistics from standard errors clustered by ticker and date. The full sample contains 61,434 name-days across 538 names. Narrative coefficients are reduced-form associations and do not identify trading or price pressure.

Table A13. State-dependent absorption and signed realized variation. Panel A compares the amount of the attention coefficient absorbed by the full option surface after run-ups and drawdowns. Panel B splits five-day realized quadratic variation between nonnegative- and negative-return days under capped and raw constructions.

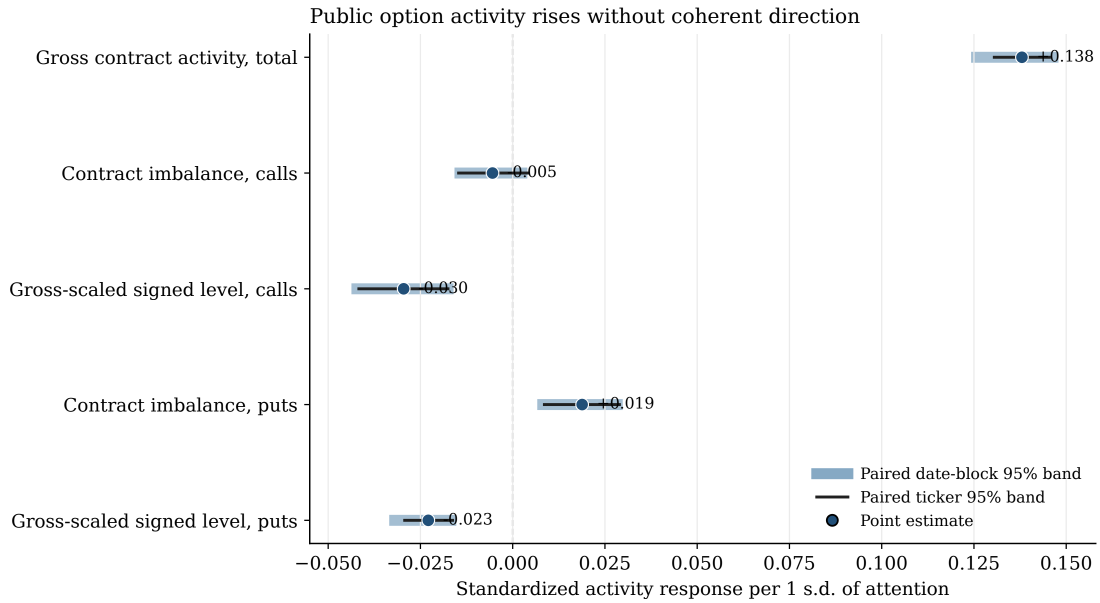
Outcome	Estimate	Date 95%	Ticker 95%	Inference
Panel A. State-dependent amount absorbed by the option surface				
Run-up amount absorbed	0.003517	—	—	Point estimate
Drawdown amount absorbed	0.007025	—	—	Point estimate
Drawdown minus run-up	0.003508	[0.000521, 0.006257]	[0.000423, 0.006721]	Both bands exclude zero
Spanning-share difference	0.196091	[-0.046155, 0.462489]	[-0.069697, 0.497990]	Bands include zero
Panel B. Signed five-day realized quadratic variation				
Capped positive-return-day variation	0.014430	[0.007055, 0.021805]	[0.007860, 0.021000]	Both bands exclude zero
Capped negative-return-day variation	0.013080	[0.005212, 0.020947]	[0.008050, 0.018109]	Both bands exclude zero
Capped positive minus negative	0.001350	[-0.005245, 0.007945]	[-0.005570, 0.008270]	Bands include zero
Raw positive-return-day variation	0.063867	[-0.020253, 0.147987]	[-0.017768, 0.145502]	Bands include zero
Raw negative-return-day variation	0.014310	[0.000916, 0.027705]	[0.004739, 0.023882]	Both bands exclude zero
Raw positive minus negative	0.049557	[-0.022641, 0.121755]	[-0.027818, 0.126932]	Bands include zero

Notes: The common sample contains 61,434 name-days, 538 names, and 1,229 dates from January 2020 through December 2024. Panel A defines drawdowns and run-ups from the sign of the trailing $t-5$ through $t-1$ return and evaluates state-specific coefficients at mean standardized return magnitude. The amount absorbed is the attention coefficient without the surface minus its coefficient with the full surface. Its date and ticker bands use 2,000 paired draws each. All 538 ticker deletions and all 60 month deletions retain the signs of both Panel A differences. The spanning-share difference is imprecisely estimated. Panel B splits five-day realized quadratic variation between nonnegative- and negative-return days. Capped outcomes use one common 99.5th-percentile cap; raw outcomes are uncapped. Panel B reports attention slopes conditional on the full twelve-node surface, trailing realized volatility, log market capitalization, and ticker and date effects. Date and ticker bands are simultaneous 95 percent bands across the three outcomes and retain 2,000 draws each. The raw signed difference has limited effective-cluster support and is therefore interpreted cautiously. Deleting BBBY changes the capped positive-minus-negative estimate from 0.001350 to -0.000045. No month deletion reverses it, and neither ticker nor month deletion reverses the raw difference. These reduced-form decompositions do not identify trading direction or causality.

Table A14. Public option activity and later surface updating. Panel A separates gross activity, direction, and gross-scaled signed levels in the public SLAN sample, then tests whether the signed proxy attenuates the surface-conditioned attention coefficient. Panel B evaluates whether week-one changes in the option surface forecast volatility in the following week.

Object	Estimate	t	Date-block 95% band	Ticker-pair 95% band
Panel A. Public internalized option activity				
Gross contract activity, total	0.13800	27.99	[0.12422, 0.14791]	[0.13012, 0.14584]
Contract imbalance, calls	-0.00547	-1.01	[-0.01578, 0.00397]	[-0.01505, 0.00467]
Gross-scaled signed level, calls	-0.02955	-4.31	[-0.04370, -0.01603]	[-0.04208, -0.01714]
Contract imbalance, puts	0.01882	3.24	[0.00666, 0.02982]	[0.00820, 0.02932]
Gross-scaled signed level, puts	-0.02287	-5.78	[-0.03346, -0.01528]	[-0.02966, -0.01589]
Surface-conditioned forward realized volatility				
Attention coefficient without signed proxy	0.03138	3.66	[0.00948, 0.05314]	[0.01837, 0.04610]
Attention coefficient with signed proxy	0.03079	3.74	[0.00952, 0.05172]	[0.01822, 0.04424]
Attenuation, without minus with signed proxy	0.00059	n.a.	[-0.00018, 0.00161]	[-0.00002, 0.00227]
Panel B. Week-two surface updating				
Attention coefficient, surface at t	-0.00252	-1.49	n.a.	n.a.
Attention coefficient, adding surface change through $t+5$	0.00032	0.19	[-0.00291, 0.00371]	[-0.00237, 0.00329]
Difference, first minus second	-0.00284	-6.08	[-0.00386, -0.00180]	[-0.00367, -0.00204]

Notes: Panel A reports standardized activity outcomes per one-standard-deviation increase in the lagged attention score. Its activity sample contains 37,711 name-days, 747 names, and 370 dates from January 2020 through June 2021. Gross contract activity is log one plus the sum of reported call and put contract volume. Direction is reported contract imbalance. Signed level is volume times imbalance, a gross-scaled proxy rather than signed vega demand. Call direction is unresolved and put direction is positive, while both signed levels are negative, so neither side has a coherent same-sign directional response. The final three Panel A rows use 24,220 name-days, 371 names, and 353 dates and condition on the complete day-t 12-node option surface. Attenuation is the attention coefficient without the signed proxy minus the coefficient with it. The signed-arm null-imposed MDEs are 0.00150 for date blocks and 0.00123 for ticker pairs. A dollar-weighted gross-activity specification gives attenuation 0.00806, with date-block [0.00277, 0.01260] and ticker-pair [0.00445, 0.01217]. Panel B forecasts week-two realized volatility over $t+6$ through $t+10$. The first specification includes the full surface at t; the second adds its change through $t+5$. The sample contains 60,718 name-days, 536 names, and 1,219 origin dates. The paper's headline incremental forecast content concerns week one, $t+1$ through $t+5$. A spanning share is not reported because only 9.70% of date draws and 4.95% of ticker draws have positive first-specification denominators. Panel A uses paired ten-trading-day date blocks; Panel B uses paired 20-origin-day blocks. Ticker-pair bands use common paired draws. Every band retains 2,000 draws. At week two, the premise attention coefficient is near zero and negative before the later surface enters. The estimated difference has the opposite sign from absorption, so there is no continuing relation for the later surface to absorb. SLAN is a public internalized-flow proxy, not customer-origin signed flow by maturity. Neither panel identifies retail demand, information aggregation, or why the surface changes.



Public internalized option activity, 37,711 name-days from 2020-01-13 through 2021-06-30. Signed levels are gross-scaled proxies.

Figure A2. Public internalized-activity proxy and directional measures. The sample covers January 2020 through June 2021. Attention is associated with gross activity, while the call and put directional proxies do not deliver a coherent same-sign pattern. SLAN is not customer-origin signed flow and has no maturity dimension.

Table A15. Economic-scale and payoff boundaries. The reallocation is a mean-preserving forecast-space adjustment to standardized nodes, and the half- spread comparison uses a fixed nearest-contract call-put proxy and is noncausal. Payoff rows come from disclosed r/thetagang short-put positions and report controlled attention slopes.

Object	Estimate	t-statistic	Interpretation
Reallocation, 95th percentile	0.261 vol. points		synthetic standardized node
Nearest-contract proxy half-spread, median	0.985 vol. points		noncausal scale comparison
Cells with adjustment no larger than proxy	95.4%		90,390 name-maturity-days
Disclosed short-put gross-loss slope	0.0095	1.37	statistically unresolved
Approximate net-payoff slope	0.0028	0.62	statistically unresolved

Table A16. Selected-measure evidence on 2025, a calendar year outside the estimation sample. The seven reported quantities correspond to the in-sample objects of the main text. The headline panel contains 7,310 name-days; the common-node and full-surface panels contain 6,353. Forecast tests cover 160 dates, except rank IC, which covers 150 dates with at least 20 names. Coefficient and spanning rows report 95 percent intervals or paired bootstrap bands; forecast rows report Clark–West intervals.

Outcome	Estimate	95% interval or band
Headline β	+0.0315 ($t = 4.01$)	[+0.0160, +0.0471]
30-day share ϕ	+0.232	[+0.125, +0.463]
10-day less 30-day ϕ	+0.156	[+0.083, +0.228]
HAR+IV CS OOS R^2	+0.098%	CW [+0.00126, +0.00301]
Pooled timing gap	+0.061	[-0.043, +0.164]
Full-surface rank IC increment	+0.0017	[+0.0002, +0.0032]
Full-panel HAR CS OOS R^2	+0.144%	CW [+0.00153, +0.00983]

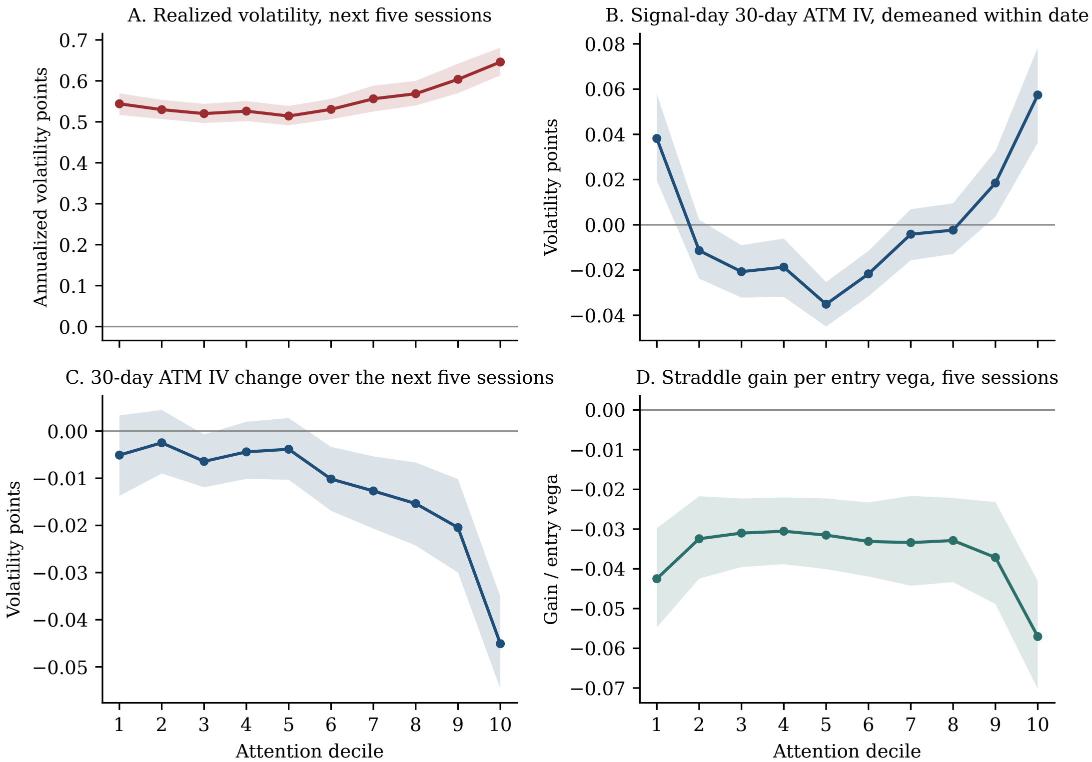
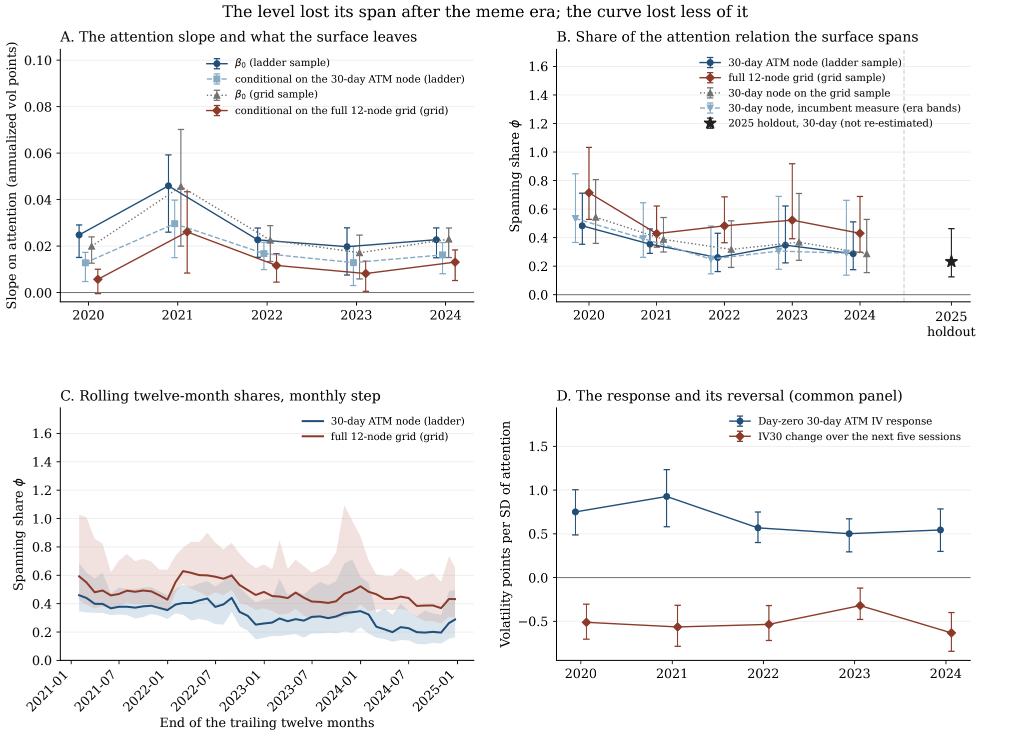


Figure A3. Attention deciles and the four outcomes. Deciles of the attention score are formed on the common sample of 53,976 name-days across 527 names from 2020 through 2024. Each panel plots the raw decile mean of one outcome: forward five-day realized volatility, the thirty-day at-the-money implied volatility demeaned within date, the change in that node over the following five sessions, and the five-day delta-hedged straddle gain per entry vega. Bands are 95 percent from a ten-day date-block bootstrap with 2,000 draws. Decile means carry no controls and no fixed effects, so they are not the controlled responses of Table 10.



Panels A to C use the paper's selected attention measure, log distinct comment authors, on the posts-defined active population; the light dashed series in panel B is the incumbent column behind results/era_bands.txt. Ladder sample 81,809 name-days and 841 names with a 30-day ATM node; grid sample 61,434 name-days and 538 names with all twelve nodes; common panel 53,976 name-days and 527 names. Ticker and date fixed effects, trailing realized volatility and log market capitalization, 10-day date-block percentile bands. The 2025 point is read from the holdout file and is not re-estimated.

Figure A4. Time variation in the slope, the conditional slope, and the spanning share. All estimates use the paper's selected comment-author measure. The ladder sample contains 81,809 option-covered name-days and the common-grid sample 61,434 name-days, both from 2020 through 2024. Panels report the attention slope on forward five-day realized volatility, the slope after conditioning on the thirty-day at-the-money node and after conditioning on the full twelve-node surface, and the implied spanning shares, by calendar year and over rolling twelve-month windows. Bands are 95 percent from a ten-day date-block bootstrap, 2,000 draws for the annual and era estimates and 500 for the 48 rolling windows. The 2025 point is the thirty-day share read from the holdout evaluation and is not re-estimated here.

Table A17. The response, the reversal, and the hedged gain by aggregate market state. Attention is interacted with terciles of a predetermined date-level state on the common sample of 53,976 name-days across 527 names from 2020 through 2024. The state indicators are absorbed by the date fixed effect, so each panel reports state-specific attention slopes and their high-minus-low difference. The spanning share is not split by state.

	Day-zero IV30	IV30 change t+1 to t+5	Hedged straddle gain	Realized vol t+1 to t+5
Pooled				
All name-days	+0.0056	-0.0052	-0.0031	+0.0139
	(0.0009)	(0.0005)	(0.0007)	(0.0016)
Panel A: prior-day VIX tercile				
Low VIX	+0.0055	-0.0057	-0.0021	+0.0151
	(0.0013)	(0.0009)	(0.0009)	(0.0023)
Middle VIX	+0.0066	-0.0054	-0.0047	+0.0132
	(0.0014)	(0.0007)	(0.0011)	(0.0024)
High VIX	+0.0049	-0.0044	-0.0027	+0.0134
	(0.0014)	(0.0010)	(0.0011)	(0.0025)
High − low	-0.0007	+0.0013	-0.0005	-0.0017
	[t -0.35]	[t +0.97]	[t -0.40]	[t -0.58]
	[-0.0038, +0.0030]	[-0.0014, +0.0035]	[-0.0036, +0.0026]	[-0.0089, +0.0060]
Panel B: prior-day index dealer-gamma tercile				
Low gamma (dealers short)	+0.0050	-0.0046	-0.0022	+0.0136
	(0.0013)	(0.0008)	(0.0010)	(0.0024)
Middle gamma	+0.0052	-0.0044	-0.0040	+0.0135
	(0.0013)	(0.0008)	(0.0010)	(0.0026)
High gamma (dealers long)	+0.0067	-0.0066	-0.0032	+0.0147
	(0.0014)	(0.0009)	(0.0011)	(0.0022)
High − low	+0.0017	-0.0019	-0.0010	+0.0012
	[t +0.88]	[t -1.90]	[t -0.72]	[t +0.38]
	[-0.0015, +0.0047]	[-0.0044, +0.0005]	[-0.0042, +0.0021]	[-0.0051, +0.0074]
Observations	53,976 name-days, 527 firms, 1,192 dates			

Sample: the common risk-price-payoff panel, one row per firm-day, on which every outcome is observed. Attention is the standardized daily Reddit measure, lagged so that a value labelled t uses posts through $t-1$. Each panel interacts attention with three indicators for the terciles of a predetermined, market-wide state variable and reports the three state-specific slopes; the state indicators themselves are date-level and are absorbed by the date fixed effect. All columns carry firm and date fixed effects and the panel's predetermined controls (trailing 21-day realized volatility, log market capitalization, and mean absolute five-day return, all measured through $t-1$). Standard errors clustered by firm and by date are in parentheses. The high-minus-low row reports the difference, its two-way clustered t in square brackets, and below it a 95 percent percentile band from a 10-day date-block bootstrap with 2,000 resamples.

Panel A splits on the prior trading day's CBOE VIX close, with tercile cutpoints at 17.61 and 23.13. Panel B splits on a prior-day index dealer-gamma state built from OptionMetrics index option records for the S&P 500 and Nasdaq-100 exchange-traded funds: for each date, $\mathrm{GEX}_t = \sum_i \gamma_{i,t}\,\mathrm{OI}_{i,t}\,s_i$ over all listed contracts, with $s_i = +1$ for calls and $s_i = -1$ for puts, standardized over the estimation sample and cut at its terciles, at -0.35 and +0.57 standard deviations. The measure nets call gamma against put gamma in open interest. Under the standard convention that dealers hold the call open interest long and the put open interest short, a high value is a long-gamma, stabilizing dealer state and a low value is a short-gamma one. Open interest does not identify which side a dealer holds, so the sign is an assumption about market structure rather than observed inventory, and the state is an index-level condition rather than firm-level dealer positioning.

Day-zero IV30 and its five-session change are in decimal annualized units; the hedged straddle gain is the five-day midpoint straddle gain per unit of entry vega, winsorized at the historical sample's first and ninety-ninth percentiles; realized volatility is the annualized standard deviation of log returns over the five option holding sessions. No observation after 2024-12-31 enters any estimate. The spanning share is not split by state: the VIX split of the share is unresolved (`results/vix_diff_bootstrap.txt`). Estimates are conditional associations.

Table A18. Capacity sorts and the transitory response. Panels A to C sort on the previous trading day's market capitalization, vega-weighted relative option bid-ask spread, and open interest in contracts with 6 to 20 days to expiry scaled by prior-month dollar stock volume, on the common sample of 53,976 name-days across 527 names; Panel C covers the 53,957 rows with a prior-day open-interest value. Panel D reports the size gradient of the attention slope on the active forecasting sample of 93,350 name-days across 938 names. The sorts are cross-sectional and the spanning share is not examined here.

	Day-zero ATM IV	IV change $t+1..t+5$	Straddle gain per entry vega	Realized vol $t+1..t+5$
Panel A. Market capitalization tercile, previous trading day				
Small	0.0112	-0.0079	-0.0063	0.0223
	(0.0017)	(0.0011)	(0.0014)	(0.0030)
Middle	0.0030	-0.0047	-0.0024	0.0110
	(0.0012)	(0.0007)	(0.0008)	(0.0017)
Large	0.0029	-0.0029	-0.0007	0.0087
	(0.0008)	(0.0004)	(0.0007)	(0.0016)
Large minus small	-0.0083	0.0050	0.0056	-0.0137
t	[-4.35]	[4.52]	[3.56]	[-4.34]
95% block band	[-0.0121, -0.0047]	[0.0030, 0.0071]	[0.0031, 0.0083]	[-0.0208, -0.0068]
N per tercile	18,378 / 17,999 / 17,599			
Panel B. Option relative bid-ask spread tercile, previous trading day				
Narrow	0.0072	-0.0054	-0.0023	0.0164
	(0.0015)	(0.0007)	(0.0009)	(0.0023)
Middle	0.0047	-0.0049	-0.0033	0.0123
	(0.0012)	(0.0006)	(0.0009)	(0.0021)
Wide	0.0056	-0.0053	-0.0038	0.0138
	(0.0014)	(0.0008)	(0.0010)	(0.0024)
Wide minus narrow	-0.0016	0.0001	-0.0015	-0.0025
t	[-0.87]	[0.12]	[-1.11]	[-0.82]
95% block band	[-0.0051, 0.0016]	[-0.0020, 0.0022]	[-0.0040, 0.0009]	[-0.0075, 0.0019]
N per tercile	18,378 / 17,999 / 17,599			
Panel C. Open interest over prior-month dollar volume tercile				
Low	0.0076	-0.0061	-0.0043	0.0164
	(0.0017)	(0.0010)	(0.0013)	(0.0027)
Middle	0.0045	-0.0049	-0.0028	0.0126
	(0.0012)	(0.0006)	(0.0008)	(0.0018)
High	0.0050	-0.0044	-0.0023	0.0132
	(0.0012)	(0.0006)	(0.0009)	(0.0020)
High minus low	-0.0026	0.0017	0.0019	-0.0032
t	[-1.19]	[1.42]	[1.27]	[-1.06]
95% block band	[-0.0055, 0.0002]	[-0.0003, 0.0038]	[-0.0007, 0.0046]	[-0.0086, 0.0023]
N per tercile	18,372 / 17,995 / 17,590			
Panel D. Attention slope by firm size, active forecasting sample				
Outcome: forward five-day realized volatility. Coefficient, (standard error), [t], N.				
One SD smaller firm	0.0503	(0.0045)	[11.28]	93,350
Mean size	0.0325	(0.0026)	[12.45]	93,350
One SD larger firm	0.0147	(0.0024)	[6.14]	93,350
Attention × smaller-firm rank	0.0178	(0.0025)	[7.27]	93,350

Panels A to C use the common risk-price-payoff sample of 53,976 stock-days and 527 firms. Every column in a panel uses the same stock-days. Each panel regresses the outcome on attention interacted with within-date tercile indicators of a predetermined sort variable, together with the tercile indicators, trailing 21-day volatility, log market capitalization, and mean absolute five-day returns, all measured through the preceding trading day, and firm and date fixed effects. Parentheses report standard errors clustered by firm and date, square brackets the corresponding t-statistic. Sort variables are the previous trading day's market capitalization, the previous trading day's vega-weighted relative option bid-ask spread, and the previous trading day's open interest in contracts with 6 to 20 days to expiry, valued at the previous close and divided by the prior month's average daily dollar stock volume. The 95% band resamples 10-day date blocks with relabelled pseudo-dates, 2,000 draws. Demand-based pricing predicts a larger day-zero response, a more negative IV change, and a more negative straddle gain where hedging is costlier, that is in small firms, wide-spread firms, and high open-interest firms. Panel D reproduces the market-depth heterogeneity test on the

Table A19. Attention-sorted delta-hedged straddle gains against known determinants. The panel contains 57,095 name-days across 529 names and 1,229 signal dates from January 2020 through December 2024. Panel A forms quintiles within each week on attention purged of ticker and date fixed effects and of the literature controls, with Newey–West(10) inference on the 256 weekly high-minus-low observations. Panels B and C add characteristics cumulatively on the 54,148 name-days across 526 names where every characteristic exists, by Fama–MacBeth with Newey–West(10) and by ticker and date fixed effects with standard errors clustered by ticker and date. Gross is the five-day midpoint delta-hedged straddle gain per entry vega, winsorized at the first and ninety-ninth percentiles; net charges the full quoted spread on each leg at entry and at exit. Panel A quintile means are residual deviations that average to zero by construction and are not portfolio returns.

Panel A. Weekly quintile sorts on residual attention						
	Q1	Q2	Q3	Q4	Q5	H−L
Gross	0.002313	0.003145	0.002250	-0.001845	-0.005829	-0.008141
						(-2.95)
Net of quoted spread	0.004186	0.004012	0.002287	-0.003181	-0.007276	-0.011462
						(-3.82)
Weeks	256					
Name-days	57,095					

Panel B. Fama–MacBeth, Newey–West(10)						
	Gross		Net		*N*	Names
	Coef.	*t*	Coef.	*t*		
(1) RV, size	-0.002868	(-4.28)	-0.003410	(-4.63)	54,148	526
(2) + IV30, IV - RV	-0.001728	(-2.70)	-0.001790	(-2.67)	54,148	526
(3) + idiosyncratic vol	-0.001855	(-2.83)	-0.001994	(-2.93)	54,148	526
(4) + 12-node surface	-0.000619	(-0.98)	-0.000533	(-0.77)	54,148	526

Panel C. Ticker and date fixed effects, two-way clustered						
	Gross		Net		*N*	Names
	Coef.	*t*	Coef.	*t*		
(1) RV, size	-0.003932	(-5.85)	-0.005233	(-6.39)	54,148	526
(2) + IV30, IV - RV	-0.002306	(-3.98)	-0.002936	(-4.30)	54,148	526
(3) + idiosyncratic vol	-0.002474	(-4.28)	-0.003049	(-4.52)	54,148	526
(4) + 12-node surface	-0.001539	(-2.61)	-0.001698	(-2.56)	54,148	526

Table A20. The earnings-window split of the response, the reversal, and the gain. The sample is the 48,914 common name-days across 466 firms with earnings coverage, of which 7,249 carry a Compustat report date between the calendar day before the signal date and the option exit date; the two gain components use the 47,643 rows with a complete same-contract implied-volatility path. The placebo column repeats the split with a window of the same calendar length that closes before the live window opens. Report dates are realized rather than expected schedules, so the split conditions on an announcement having occurred.

	Attention slope		Earnings-window split			Placebo
	(1)	(2)	Outside	Inside	Difference	difference
Realized volatility	0.0143	0.0056	0.0111	-0.0116	-0.0227	-0.0040
	(0.0016)	(0.0019)	(0.0018)	(0.0029)	(0.0028)	(0.0030)
					t -8.24	t -1.30
					[-0.0283,-0.0172]	[-0.0089,0.0013]
Signal-day ATM IV	0.0057	0.0033	0.0059	-0.0049	-0.0107	-0.0098
	(0.0009)	(0.0010)	(0.0011)	(0.0012)	(0.0014)	(0.0022)
					t -7.54	t -4.51
					[-0.0137,-0.0079]	[-0.0135,-0.0066]
Change in ATM IV	-0.0054	-0.0013	-0.0022	0.0015	0.0037	0.0056
	(0.0006)	(0.0005)	(0.0006)	(0.0010)	(0.0010)	(0.0012)
					t 3.52	t 4.68
					[0.0017,0.0059]	[0.0034,0.0078]
Hedged straddle gain	-0.0033	-0.0017	-0.0019	-0.0009	0.0009	0.0049
	(0.0007)	(0.0007)	(0.0008)	(0.0013)	(0.0014)	(0.0014)
					t 0.66	t 3.44
					[-0.0019,0.0041]	[0.0020,0.0077]
IV repricing	-0.0070	-0.0023	-0.0026	-0.0016	0.0009	0.0042
	(0.0005)	(0.0006)	(0.0006)	(0.0012)	(0.0012)	(0.0011)
					t 0.79	t 3.96
					[-0.0012,0.0034]	[0.0019,0.0064]
Remainder	0.0035	0.0006	0.0006	0.0006	-0.0000	0.0010
	(0.0005)	(0.0006)	(0.0006)	(0.0011)	(0.0011)	(0.0010)
					t -0.02	t 0.99
					[-0.0020,0.0019]	[-0.0010,0.0031]
Observations	48,914 (top four rows), 47,643 (gain components)					
Inside the window	0.148 of observations (earnings), 0.116 (placebo)					

Total attention enters alone; no topic dictionary is conditioned on. All columns use the earnings-covered common observations behind Table 10 (48,914 stock-days, 466 firms), except the two gain components, which additionally require a complete same-contract implied-volatility path (47,643 stock-days). Every specification carries firm and date fixed effects, trailing 21-day volatility, log market capitalization, and mean absolute five-day returns through the preceding trading day, and standard errors clustered by firm and by date (in parentheses). Column (1) omits any earnings variable. Column (2) adds the earnings-window indicator, which equals one when a Compustat report date falls between the calendar day before the signal date and the option exit date. The split columns interact attention with that indicator: Outside and Inside are the implied slopes and Difference is the interaction coefficient. The placebo indicator uses a window of the same calendar length that closes the day before the live window opens, so the announcement it flags precedes the option holding period. For the two difference columns the third line reports the two-way clustered t statistic and the fourth a 10-day date-block bootstrap 95 percent interval (2,000 draws, relabelled pseudo-dates, paired across outcomes). Implied volatilities are decimal annualized; gains are per unit of entry vega. Report dates are realized, not as-of expected, schedules. The estimates are conditional associations.

Table A21. Attention and customer option trading

	Log gross opening	Net opening share	Net trading share
C1			
Total attention	0.1943	0.0321	0.0020
	(0.0238)	(0.0082)	(0.0061)
Catalyst	0.0579	-0.0095	-0.0002
	(0.0189)	(0.0053)	(0.0036)
Position mechanics	0.0412	0.0099	0.0052
	(0.0207)	(0.0082)	(0.0060)
Observations / firms		4,852 / 454	
C2			
Total attention	0.2427	0.0114	-0.0145
	(0.0269)	(0.0122)	(0.0103)
Catalyst	0.0495	-0.0037	0.0069
	(0.0218)	(0.0055)	(0.0045)
Position mechanics	0.0257	0.0168	0.0140
	(0.0268)	(0.0116)	(0.0082)
Observations / firms		4,674 / 432	

Daily Cboe C1 and C2 customer-origin records, March 3–August 29, 2025 (126 sessions), restricted to standard equity contracts. Gross opening is customer opening buys plus opening sells. Net opening subtracts opening sells from opening buys and divides by gross opening. Net trading also includes closing buys and sells and divides by gross trading. Every column includes total attention, all four topics, the three predetermined controls, and firm and date fixed effects. Signals are standardized on the 5,895-observation 2025 base sample before venue matching. Parentheses report standard errors clustered by firm and date. Customer origin does not identify households or Reddit users; signed flows are venue transactions, not investor inventories.

C Variable definitions and sample conventions

Table A22 fixes the timing and unit of every empirical object. The selected attention score is built from log distinct comment authors on a dense calendar grid, standardized against the prior 30 calendar days and then lagged one day. The posts count is lagged on the same calendar and defines entry into the fixed active population. The date on an attention observation is therefore the first trading day on which it is usable, and forward outcomes begin after that date.

Table A22. Variable definitions. Volatility variables are annualized decimals. Returns are decimals. All rolling constructions are computed within ticker.

Variable	Definition
Attention, $z_{i,t}$	Distinct r/wallstreetbets comment authors naming ticker i on calendar day $t-1$, transformed by $\log(1+x)$ and standardized against the ticker's trailing 30-day calendar history using at least ten observations. The resulting score is standardized across the fixed dense covered panel before any active, ATM, or full-grid sample restriction. Explicit measure-comparison exhibits instead standardize each score on their stated common population.
Posts-based attention	Daily ticker mentions in r/wallstreetbets posts divided by all collected posts, converted to a trailing 30-day z-score and shifted one day. Used only in supplementary comparisons.
Entry into discussion	Indicator that lagged post mentions are positive. In the posts-based two-part model, it captures entry into discussion at mean active intensity.
Positioning intensity	$\log(1 + \text{sold puts} \times \log(1 + \text{engagement}))$ on r/thetagang disclosure days, standardized before estimation.
Sold-put wall	Modal disclosed sold-put strike for a ticker-day. Used only in the open-interest validation and the pin and breach tests.
Forward RV, five days	Annualized standard deviation of daily log returns over trading days $t+1$ through $t+5$.
Other RV horizons	One-day annualized absolute log return, or annualized standard deviation over the next 10 or 21 trading days.
Trailing RV	Annualized standard deviation of daily log returns over the 21 trading days ending at t.
Tail move	Indicator that the absolute cumulative return over $t+1$ through $t+5$ is at least ten percent.
Market capitalization	Absolute CRSP price times shares outstanding. The regressions use its natural logarithm.
ATM implied volatility	Arithmetic mean of the exact OptionMetrics thirty-day call-delta 50 and put-delta minus-50 implied-volatility nodes, with both required on the same effective security-date link.
Forward IV change	ATM implied volatility on the exact fifth next CRSP trading day minus ATM implied volatility at t.
Earnings window	Indicator, on Compustat-covered tickers, that an observed quarterly report date falls from measurement day t through the exact fifth next CRSP trading day. Measurement-day reports are included because Compustat lacks announcement times.

Data availability

CRSP, OptionMetrics, and Compustat data are licensed through Wharton Research Data Services and cannot be redistributed. Reddit posts and comments and StockTwits records are drawn from public platform archives, and their construction is described in Section 3 and Appendix C. The public SLIM file is obtained from the authors' public data page and is not redistributed. Code and constructed series are available from me on request, subject to the licensing restrictions above.

No signed customer-flow data covering the 2020–2024 spanning sample are used. The customer-trading analysis uses daily Cboe C1 and C2 contract records from March 3 through August 29, 2025, separating opening and closing purchases and sales. Option sensitivities are available for a smaller subset of those contracts. This later, exchange-specific sample does not identify the historical information-versus-demand mechanism. Redistribution of the exchange records is subject to their applicable data terms.

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