0DTE Trading Rules*

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The accompanying data will be updated on a regular basis and the analysis will be extended to conditional trading rules.

Abstract

This empirical study is the first in a series documenting empirical properties of 0DTE options on the S&P500 index (SPX) and popular strategies built from these options for the sample period from 09/2016 to January 11, 2024. We focus on strategies established every trading day and held to expiry (i.e., unconditional and static trading rules). 0DTEs deliver significant variance risk premium for the whole sample period. Realized returns of individual options are highly volatile and skewed, though at the median, buying deep in-the-money calls and selling out-the-money calls and puts can be statistically profitable. The realized return distribution of most strategies is extensive, rendering mean returns insignificant. The realized PNL of most strategies can be explained well by the realized skewness of the underlying index return, and its prediction is essential for building conditional trading rules.

Keywords: 0DTE, ultra-short options, variance risk premium, volatility trading, option strategies, option trading

*Parts of the data processing methodology in this article were developed while writing Dim, Eraker, and Vilkov (2023). The data for producing statistics in this paper and additional analysis is available online at https://osf.io/7q86u/. The update history is provided in Table A1.

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1 Introduction

The trading volumes in zero-days to expiry options (0DTEs) have exploded in the past several years, and due to relatively easy access to brokerage platforms, abundance of various learning resources, and low option premiums for ultra-short maturity options, retail investors increasingly use 0DTEs to make directional and volatility bets. While plenty of internet sites offer free and paid recipes on making money on options markets and explaining when and how a particular strategy should work, little is known about the performance of naked 0DTE call and put options and various strategies combining several call and put positions.

We aim to fill the information gap and provide simple yet detailed performance statistics for naked 0DTE options on the S&P500 market index and for several popular strategies from these options. The first part of the analysis covers unconditional static trading rules, in which positions are taken every day at some fixed time point during the day (we use 10:00 in the main analysis and also include data and performance numbers for 16:00 of the previous day and 13:00 and 15:00 of the current day in the additional figures and data files) and held until expiry of all options at 16:00. The second part makes the first attempt to explore conditional trading rules, looking for variables that can explain and predict the performance of selected strategies. The sample period is from 09/2016 to January 11, 2024, i.e., starting from the month with at least three weekly expiration days. The data will be regularly updated to more recent periods.

For the analysis, at a given point in time on each day, we interpolate prices of available 0DTE options with moneyness (defined as strike to underlying level ratio) between 0.98 and 1.02 (e.g., 3920 to 4080 for the SPX level of 4000) to fill in the available range with step 0.001 (i.e., a 4-dollar step for the SPX of 4000), and then use these standardized options to compute performance statistics for standalone positions and selected option strategies. As such option strategies, we use an at-the-money (ATM) straddle and strangles with several moneyness levels, iron condors and iron butterflies, bull call and bear put spreads, call and put ratio spreads, and risk reversals, each (except for a straddle) for several combinations of strikes, from in-the-money (ITM) to out-the-money (OTM). Figure A1 provides their sample payoff profiles. We also document the realized variance risk premium, computed as the implied variance of SPX options until settlement time minus realized variance for the same period.

The rest of the paper is structured as follows: Section 2 analyzes the average variance risk premiums, prices, and returns of individual options and option-based strategies. Section 3 (unfinished so far) attempts to figure out conditional trading rules. Section **??** will analyze dynamic trading rules. Section 4 discusses input data and its processing. Section 5 briefly overviews relevant academic literature. Section 6 concludes. Appendix A contains additional materials such as tables and figures for variations in the analysis.

2 Unconditional Static Trading Rules

Suppose we establish an options position daily without considering any possible conditioning variables (a.k.a. managing parameters) defining when and how many contracts to open. In that case, we pursue an unconditional and static trading strategy. We calculate holding period returns and profits and loss (PNL) to expiry for the considered options and their combinations and then present the statistics for these returns.

2.1 Variance Risk Premium

Over the whole sample period from 09/2016 to January 11, 2024, the 0DTEs deliver a positive and statistically significant variance risk premium, i.e., their implied variance is significantly higher than the realized variance to expiry, see Figure 1, Panel B. To trade variance, we need to sell options with different moneyness levels, with proportions depending on the method used to compute the variance. For example, Cboe computes a well-known volatility index VIX as

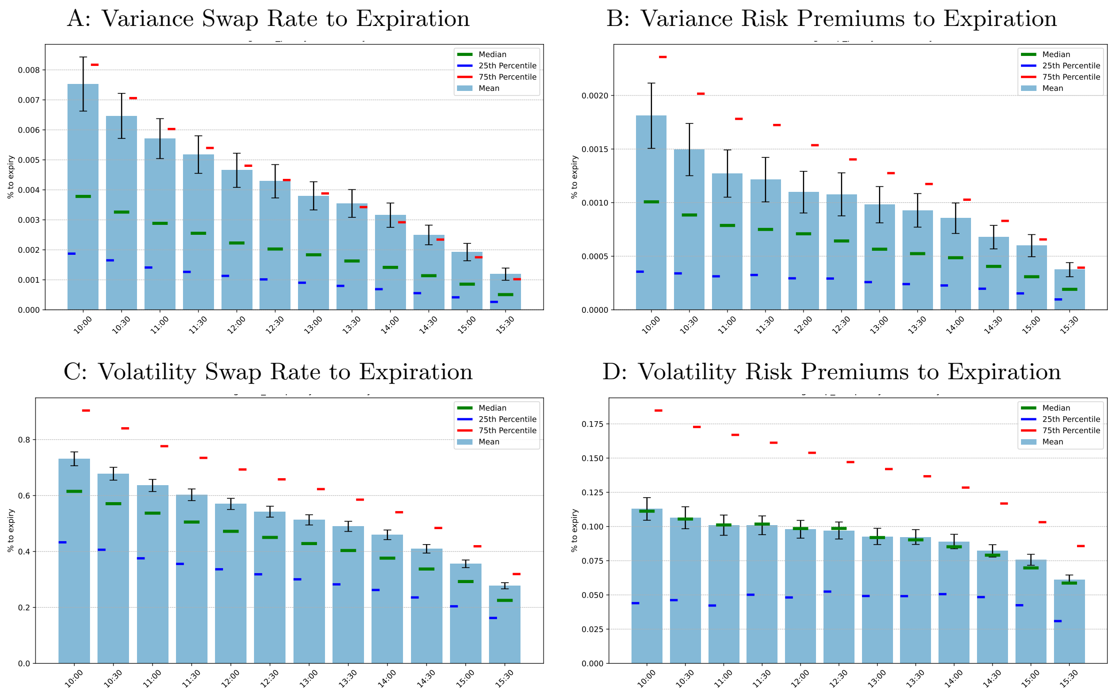

Figure 1: Variance Risk Premiums. The figure shows average variance and its risk premiums (VRP) to expiration for 0DTE SPXW options by intraday 30-minute bars. VRP is computed as implied minus realized variances from a given bar to expiration at 16:00 ET. Panels C and D are based on average volatility and differences in volatilities, respectively. We average variables measured at the end of each bar to expiration at 16:00 that day (with 95% confidence bounds based on Newey and West (1987) errors with three lags). Bars show mean values; each bar is accompanied by median, 25th, and 75th percentiles. X-axis labels show the endpoints of intraday bars. The sample period is from 09/2016 to January 11, 2024.

the risk-neutral variance of log returns, weighting prices of out-the-money options according to the formula in equation 4. Essentially, the variance swap rate is a weighted sum of time values of the out-the-money call and put options, with weights proportional to the reciprocal of the moneyness (for both stock price and strikes normalized by stock price) and empirically adding up to a number between one and two. For 0DTEs, the variance swap rate to expiration is shown in Figure 1, Panel A. The realized variance risk premium can be thought of as the remaining time value from selling a portfolio of OTM options after paying off the options that were exercised. Indeed, the higher the realized variance, the further away from the ATM point the final price realization can be, and the more we need to pay out on exercised options. In the limiting case of the zero realized variance, the underlying price does not change, and we keep all the collected time values.

The numbers in Panel B of Figure 1 indicate that selling 0DTE variance can, on average, be profitable; however, because the time values of the OTM options with just hours to expiry are minimal (see Figure 2), the variance swap rates are also very low, and even having realized variance of zero during the day and collecting two times average time value of all the OTM calls and puts would earn us only $\approx 0.20\%$ of the underlying price. Thus, the magnitude of the variance risk premium is tiny due to the very short period to expiry, and realistic transaction costs would hardly make it tradable for retail investors. Figure 1, Panel B puts the median realized VRP from 10:00 to expiry to about 0.0011%, which confirms the above point (in volatility points 0.12% looks larger, but not very tradable as well).

2.2 Individual Options

We compute individual option returns for calls and puts relative to the mid-prices and the PNL of the option positions at expiry relative to the underlying price (i.e., $(payoff - mid\, price)/underlying\, price \times 100\%$) at the time the option position is established (10:00 ET for the figures and tables in the

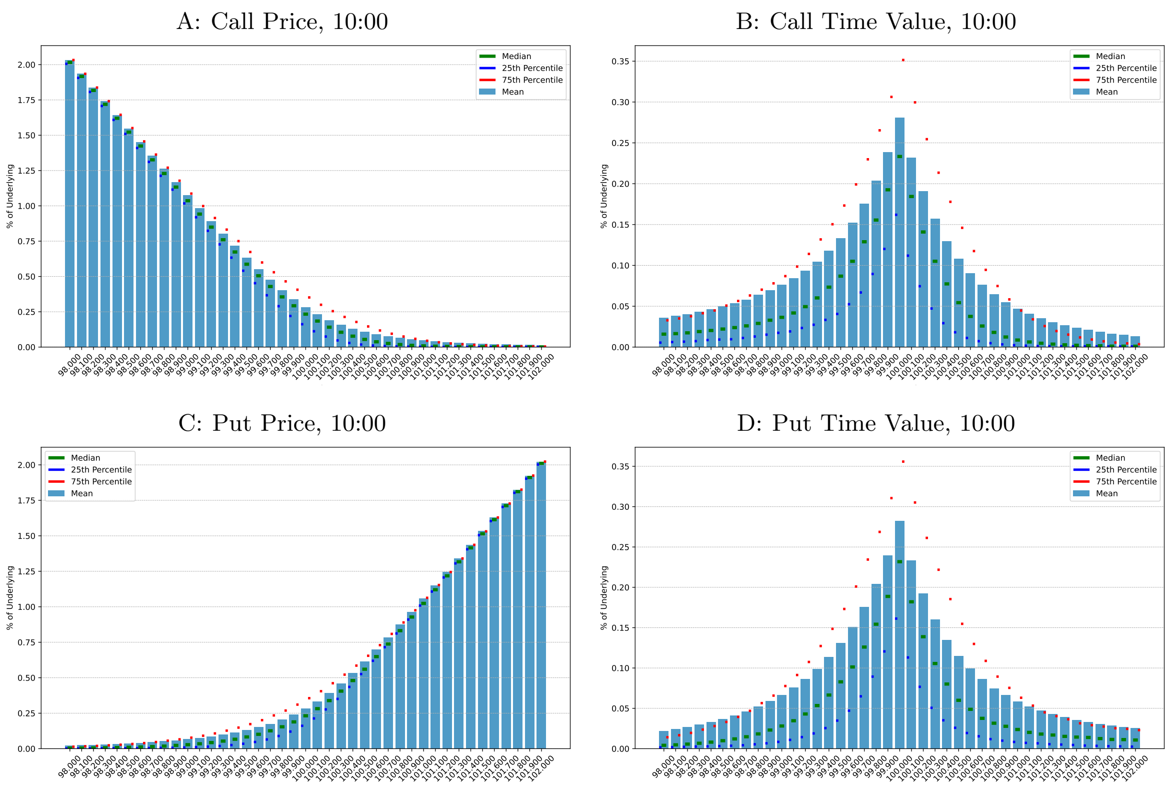

Figure 2: 0DTE Option Prices and Time Value. The figure provides statistics on prices of 0DTE call and put options at 10:00 ET. Panels on the left show option mid-price relative to the underlying price in %. Panels on the right show time value relative to underlying, also in %. Bars show mean values, and each bar is accompanied by median, 25th, and 75th percentiles. X-axis labels show the moneyness of the analyzed options. The sample period is from 09/2016 to January 11, 2024.

main text). The results are presented in Figure 3. Individual call and put option returns are highly volatile, especially out-the-money ones, and mean returns are typically not significantly different from zero. However, statistical inference in this case can be flawed due to skewed distributions of realized returns. Computing rather option realized PNL relative to the underlying price produces a less asymmetric (i.e., a more normal) distribution and shows that at- and out-the-money calls and all puts are losing money on average, and out-the-money option realized PNL is typically more compact in terms of the distribution. Selling slightly OTM calls and puts delivers in up to 75 percent of observations positive returns; for more ITM options, the realized PNL is far more volatile, with the difference between 75th and 25th percentile of 0.7-0.8% of underlying price.

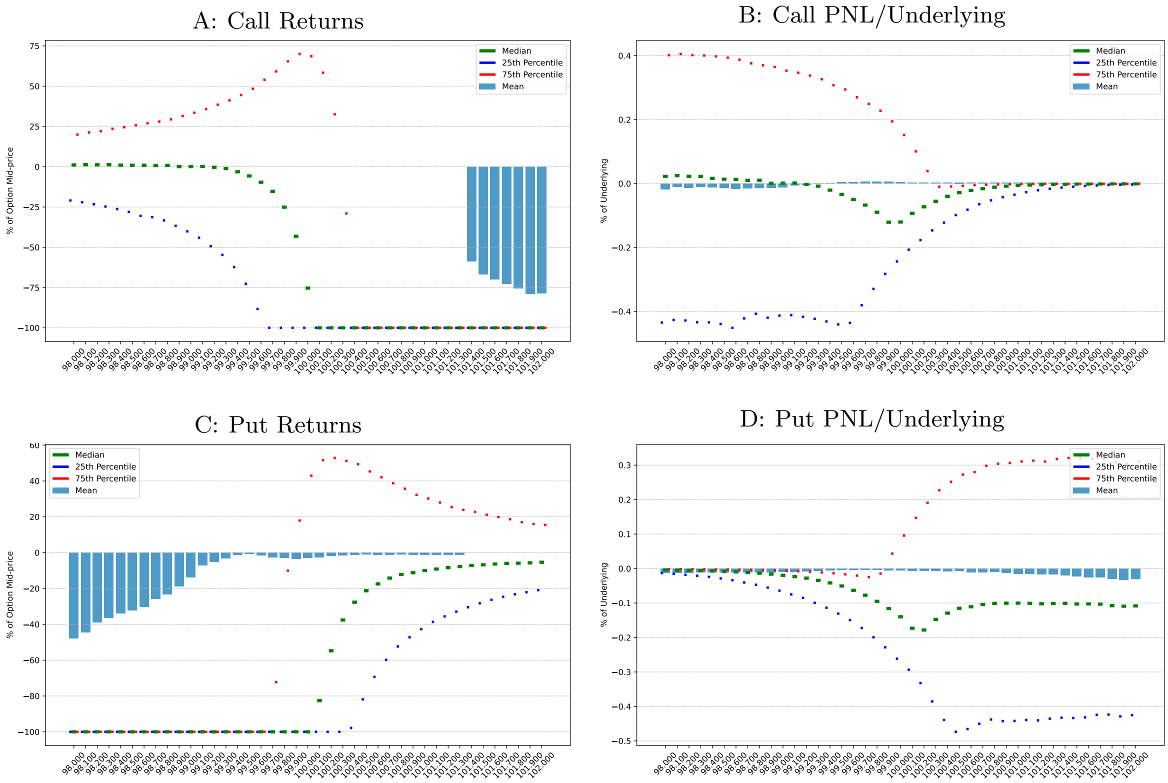

Figure 3: 0DTE Option Returns. The figure provides statistics on the profitability of naked 0DTE call and put option buying at 10:00 ET and holding to expiry at 16:00 ET. Panels on the left show realized return in % relative to option mid-price. Panels on the right show the realized profit per one unit of underlying relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. Bars show mean values, and each bar is accompanied by median, 25th, and 75th percentiles. X-axis labels show the moneyness of the analyzed options. The sample period is from 09/2016 to January 11, 2024.

The options performance from 16:00 on previous day and 13:00 and 15:00 on the current day to expiry is shown in Figures A2, A3 and A4. The general message does not change for these position opening times.

2.3 Option Strategies

Individual option positions are bets on both volatility and the direction of underlying, and the specific option structures allow us to bet on more specific views, benefiting from their realizations. We build and analyze (i) an ATM straddle and strangles, which at initiation are approximately delta-neutral and are close to a pure volatility play; (ii) iron butterfly and iron condor combinations, which are short volatility with limited downside; (iii) risk reversals that benefit from a positive skewness risk premium (i.e., realized skewness being larger than the implied one); (iv) bull call spreads and bear put spreads, which are bets on a moderate to a significant move in underlying, positive for the bull and negative for the bear spreads; and (v) call and put ratio spreads (1×2), which are cheap bets on zero to a moderate move in underlying, again positive for the call and negative for the put ratio spreads.

Considered strategies have very distinct risk-return profiles (see Figure A1): the straddle and strangles have limited downside and unlimited upside, iron butterfly and condor have limited upside and limited downside and do not depend on direction, bull, and bear spreads have limited both downside and upside, but are built upon directional risk, ratio spreads have limited upside and unlimited downside, and risk reversal has both upside and downside unlimited. It is reflected in the initial cost: Risk reversals and ratio spreads with a narrow strike range are typically credit strategies, resulting in net premium receipt at initiation, while the others are debit ones, with the straddle and strangles being the most expensive ones, and we need to pay a premium at the start.

Because of the low or even negative cost of some of the option combinations, the realized returns computed relative to the cost either do not make sense or demonstrate a very skewed and unstable distribution. Instead, we again analyze the realized PNL of the strategies relative to the underlying price. The results in Figure 4 and Table 1 for several moneyness combinations used for the combos construction contain mostly negative news: the spreads and ratio spreads' return distributions are very volatile and, in general, show realizations all around the place, with 25th and 75th percentiles being close to symmetric around zero. The median returns for spreads with long positions being ATM are all negative, so shorting them could make more sense; long sides ITM produce close to symmetric distributions with literally zero means and medians slightly above zero for calls and below zero for puts. This result seems to be an artifact of a mostly bullish market in 2017-2023. Buying strangles with both OTM strikes would result in relatively

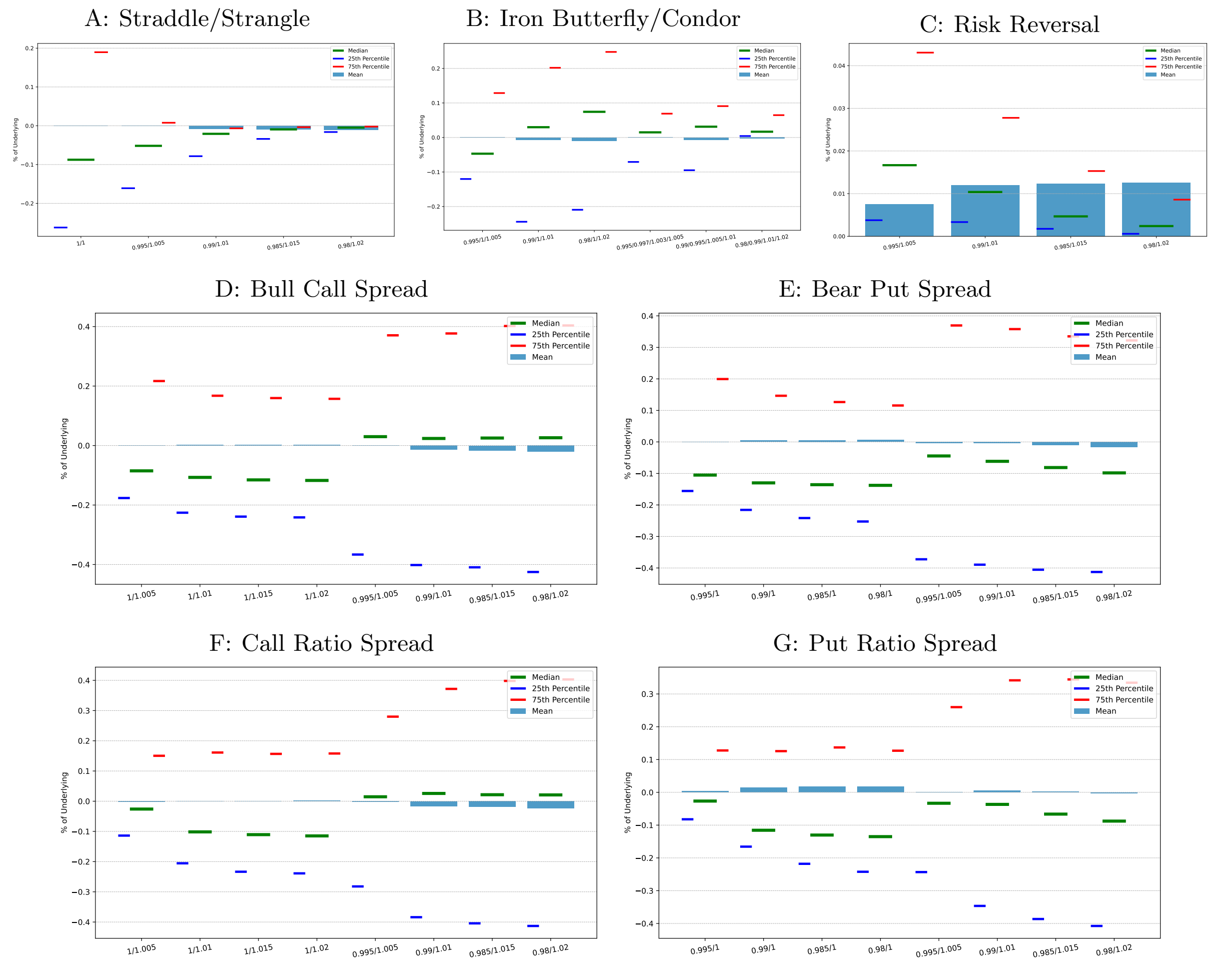

Figure 4: 0DTE Static Option Strategies. The figure shows statistics on the profitability of 0DTE option strategies; positions are taken at 10:00 ET and held to expiry at 16:00 ET. All panels show strategies' realized PNL relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. Bars show mean values, accompanied by median, 25th and 75th percentiles. X-axis labels show the combination of moneyness of options used for a strategy. The sample period is from 09/2016 to January 11, 2024.

compact distribution with both extreme quartiles negative, so selling them made money in at least 75% of the historical observations. Risk reversal is the only strategy consistently producing positive mean, median, and even 25th percentile PNL. However, its average PNL is very modest, only about 0.01% of the underlying index price, and trading 0DTE reversals may be unfeasible for most investors. The performance of the same strategies from 16:00 on the previous day and from 13:00 and 15:00 on the current day is shown in Figures A5, A6 and A7. The unconditional results over all the years in our data period are similar for different starting times of the positions. The results for the strategies in sub-periods (2016-2019, 2020-2021, 2022-2023, 2023-01/2024) are

Strategy	Moneyness	Count	Mean	Volatility	Min	1%	25%	50%	75%	99%	Max	Skew	SR, p.a.
Strangle/Straddle	1/1	1284	-0.0011	0.50	-2.69	-0.96	-0.26	-0.09	0.19	1.71	2.96	1.14	-0.04
	0.995/1.005	1285	-0.0010	0.42	-2.70	-0.82	-0.16	-0.05	0.01	1.60	2.90	1.69	-0.04
	0.99/1.01	1285	-0.0078	0.32	-2.75	-0.53	-0.08	-0.02	-0.01	1.29	2.73	2.18	-0.38
	0.985/1.015	1283	-0.0102	0.25	-2.37	-0.41	-0.03	-0.01	-0.00	0.92	2.47	2.08	-0.66
	0.98/1.02	1282	-0.0107	0.19	-2.14	-0.33	-0.02	-0.00	-0.00	0.59	2.12	0.65	-0.88
Iron Butterfly/Condor	0.995/1/1.005	1284	0.0001	0.16	-0.50	-0.27	-0.12	-0.05	0.13	0.35	0.43	0.44	0.01
	0.99/1/1.01	1284	-0.0067	0.29	-1.00	-0.63	-0.24	0.03	0.20	0.57	0.83	-0.17	-0.36
	0.98/1/1.02	1281	-0.0098	0.42	-1.50	-1.26	-0.21	0.07	0.25	0.79	1.46	-0.82	-0.37
	0.995/0.997/1.003/1.005	1285	-0.0000	0.08	-0.20	-0.16	-0.07	0.01	0.07	0.15	0.18	-0.03	-0.01
	0.99/0.995/1.005/1.01	1285	-0.0068	0.17	-0.50	-0.43	-0.09	0.03	0.09	0.29	0.40	-0.74	-0.64
	0.98/0.99/1.01/1.02	1282	-0.0029	0.20	-0.96	-0.85	0.00	0.02	0.06	0.34	0.74	-2.31	-0.23
Risk Reversal	0.995/1.005	1285	0.0075	0.56	-3.48	-1.82	0.00	0.02	0.04	1.78	5.36	0.86	0.21
	0.99/1.01	1285	0.0120	0.39	-3.00	-1.32	0.00	0.01	0.03	1.30	4.92	2.23	0.49
	0.985/1.015	1283	0.0124	0.28	-2.52	-0.83	0.00	0.00	0.02	0.83	4.47	4.70	0.71
	0.98/1.02	1282	0.0126	0.20	-2.04	-0.34	0.00	0.00	0.01	0.32	4.01	8.39	0.99
Bull Call Spread	1/1.005	1285	0.0009	0.20	-0.43	-0.24	-0.18	-0.09	0.22	0.36	0.50	0.49	0.07
	1/1.01	1285	0.0020	0.31	-0.51	-0.42	-0.23	-0.11	0.17	0.75	1.00	0.91	0.10
	1/1.015	1283	0.0027	0.37	-0.74	-0.55	-0.24	-0.12	0.16	1.11	1.36	1.24	0.11
	1/1.02	1282	0.0029	0.41	-0.94	-0.64	-0.24	-0.12	0.16	1.40	1.61	1.45	0.12
	0.995/1.005	1249	0.0007	0.37	-0.70	-0.56	-0.37	0.03	0.37	0.51	1.00	-0.13	0.03
	0.99/1.01	1129	-0.0139	0.59	-1.12	-1.06	-0.40	0.02	0.38	1.00	2.00	-0.12	-0.37
	0.985/1.015	984	-0.0165	0.74	-1.65	-1.55	-0.41	0.03	0.40	1.49	2.86	-0.10	-0.36
	0.98/1.02	864	-0.0211	0.83	-2.12	-2.02	-0.43	0.03	0.40	1.95	3.36	-0.10	-0.41
Call Ratio Spread	1/1.005	1285	-0.0024	0.31	-3.55	-1.08	-0.11	-0.03	0.15	0.52	1.80	-3.80	-0.12
	1/1.01	1285	-0.0001	0.32	-3.05	-0.39	-0.21	-0.10	0.16	0.74	1.26	-0.95	-0.00
	1/1.015	1283	0.0016	0.36	-2.49	-0.43	-0.23	-0.11	0.16	1.09	1.56	0.77	0.07
	1/1.02	1282	0.0020	0.39	-1.89	-0.51	-0.24	-0.11	0.16	1.34	1.61	1.35	0.08
	0.995/1.005	1249	-0.0028	0.39	-3.34	-0.88	-0.28	0.01	0.28	0.69	1.52	-1.51	-0.11
	0.99/1.01	1129	-0.0164	0.56	-2.65	-1.02	-0.38	0.03	0.37	1.02	1.64	-0.30	-0.47
	0.985/1.015	984	-0.0186	0.70	-1.92	-1.51	-0.40	0.02	0.40	1.46	2.86	-0.14	-0.42
	0.98/1.02	864	-0.0233	0.79	-2.05	-1.99	-0.41	0.02	0.40	1.83	3.36	-0.13	-0.47
Bear Put Spread	0.995/1	1284	-0.0011	0.20	-0.27	-0.21	-0.16	-0.11	0.20	0.39	0.45	0.80	-0.09
	0.99/1	1284	0.0046	0.33	-0.46	-0.37	-0.22	-0.13	0.15	0.81	0.89	1.19	0.22
	0.985/1	1284	0.0060	0.40	-0.65	-0.49	-0.24	-0.14	0.13	1.22	1.31	1.51	0.24
	0.98/1	1284	0.0063	0.45	-0.81	-0.57	-0.25	-0.14	0.12	1.61	1.75	1.78	0.22
	0.995/1.005	1239	-0.0035	0.37	-0.58	-0.51	-0.37	-0.04	0.37	0.56	0.77	0.17	-0.15
	0.99/1.01	1119	-0.0046	0.58	-1.04	-1.00	-0.39	-0.06	0.36	1.06	1.12	0.22	-0.13
	0.985/1.015	1033	-0.0098	0.70	-1.52	-1.48	-0.41	-0.08	0.33	1.55	1.70	0.28	-0.22
	0.98/1.02	970	-0.0159	0.76	-2.03	-1.95	-0.41	-0.10	0.32	2.01	2.10	0.34	-0.33
Put Ratio Spread	0.995/1	1284	0.0032	0.29	-2.51	-1.23	-0.08	-0.03	0.13	0.56	1.43	-2.52	0.17
	0.99/1	1284	0.0145	0.31	-1.68	-0.48	-0.17	-0.12	0.13	0.83	1.99	0.93	0.76
	0.985/1	1284	0.0172	0.37	-0.79	-0.36	-0.22	-0.13	0.14	1.19	1.63	1.61	0.74
	0.98/1	1284	0.0179	0.43	-0.48	-0.44	-0.24	-0.14	0.13	1.52	2.19	1.86	0.66
	0.995/1.005	1239	0.0002	0.37	-2.32	-1.01	-0.24	-0.03	0.26	0.80	1.68	-0.50	0.01
	0.99/1.01	1119	0.0057	0.54	-1.45	-0.96	-0.35	-0.04	0.34	1.20	2.46	0.33	0.17
	0.985/1.015	1033	0.0025	0.67	-1.49	-1.42	-0.39	-0.07	0.34	1.53	2.32	0.34	0.06
	0.98/1.02	970	-0.0021	0.75	-2.00	-1.81	-0.41	-0.09	0.33	2.01	3.02	0.45	-0.04

Table 1: 0DTE Static Option Strategies Performance. The table shows the summary statistics for the holding period PNL of 0DTE option strategies (from 10:00 ET to 16:00 ET) relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. The SR, p.a. is the Sharpe Ratio annualized by scaling it up by $\sqrt{252}$. The sample period is from 09/2016 to January 11, 2024.

given in Tables A2 to A5, and they show that there are some crucial differences in performance of unconditional static rules across the years. If we are able to identify variables identifying such periods and link them to performance of particular strategies, we have a chance for a set successful conditional static rules.

Overall, our analysis shows that unconditional and static trading rules in 0DTE SPX options hardly pay off: the realized PNL is exceptionally volatile, and the variance risk premium is tiny due to the short time to expiry. The results demonstrated by some strategies may be a consequence of an on-average growing S&P500 index during our sample period, and their future average performance may be different in case the market growth slows down. Note that we provide all the statistics without winsorizing extreme outcomes, and we do it on purpose to illustrate that downside risk unlimited can be extremely costly, even when it comes to realization of this risk only once per year. To understand how strategies behave over time, we plotted the

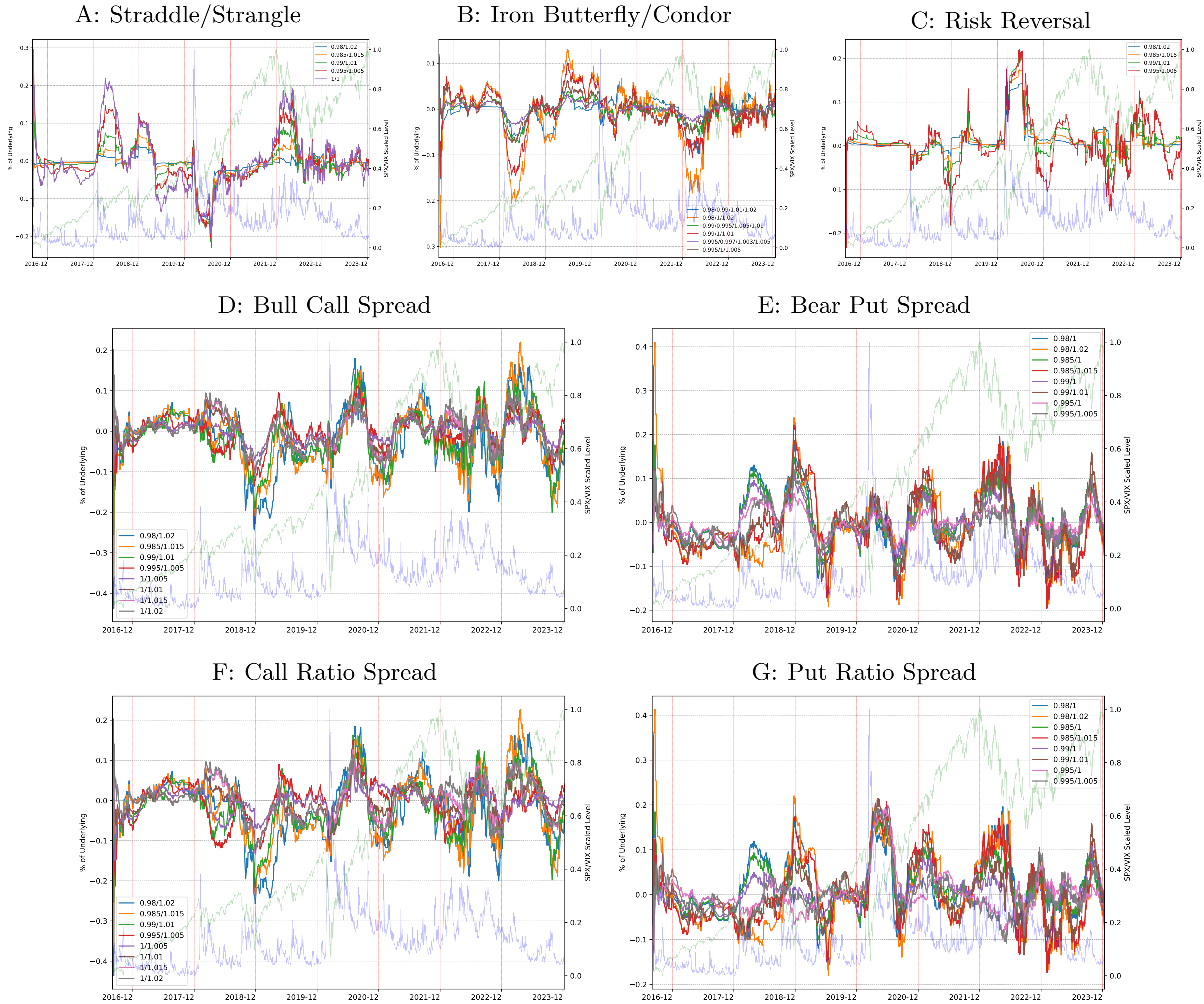

Figure 5: 0DTE Static Option Strategies: Time-series PNL. The figure shows 63-trading day moving average PNL of option strategies (from 10:00 ET to expiry at 16:00 ET) relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. Secondary y-axis shows scaled to (0,1) series of SPX and VIX. The sample period is from 09/2016 to January 11, 2024.

smoothed series (63 trading day moving average) of their relative PNL in Figure 5, along with scaled levels of SPX and VIX. Clearly, investment in any of the strategies is far from being risk-free, and while visually the profit- vs. loss-making regimes are have a rather long duration (or half-life as in a mean-reverting process?), it is not clear whether such regimes can be successfully identified *a priori*. In any case, conditioning trading decisions on the current environment and making trading rules dynamic, i.e., adjusting complete combos or individual options positions during the day, can be crucial in improving the performance of 0DTE trading, and we explore one of such directions next.

3 Conditional Trading Rules

The next enhancement of trading rules is conditioning position opening and potentially sizing decisions on a set of variables that can predict the performance of option strategies.[1]

Note that naked options and all considered strategies are not delta-hedged and are held to expiry, so the primary drivers of the PNL are the initial cost and the realized move of the underlying from position opening to expiry. Costs are directly observable and are correlated with the expected realized variance; however, prediction of the *signed* magnitude of the *realized daily return* of the underlying market index is extremely hard, if not impossible, under most circumstances.[2] Even though the long-term average of daily market returns shall be positive due to the positive equity risk premium, it may take an extremely long series of realizations for this expectation to come true (e.g., Merton 1980). We have better odds of predicting conditional higher-order moments and reaping conditional premiums for the respective higher-order risk. In this case, it is important to understand how each strategy PNL reacts to the realized higher-order moments and how it is "contaminated" by the realized return.

[1]We provide additional materials for this section in Appendix B, e.g., a description of failed approaches in Appendix B.1.

[2]A disclaimer: we do not believe in the efficient predictability of the short-term (daily) returns and feel that any experimentation in this direction is futile.

Recall that the idea of constructing option strategies is to get a relatively concentrated exposure to particular moments of return distribution while eliminating (fully or partially) the effects of other moments. From the description of the strategies in Section 2.3 we can expect the best predictability for the combos exploiting variance risk premium (strangles/ straddles) and skewness risk premium (risk reversals). Call and put spreads load strongly on directional exposure, and though they benefit from the variance and asymmetry of returns, the predictability results are likely to be distorted. Overall, the price of a strategy aggregates implied costs of risks (which we interpret broadly to include opportunities) that we are exposed to by taking a position in a strategy. A strategy's payoff comes from realizing these risks, and the PNL (or return) reflects the *ex-post* or realized risk premiums.

While there are several alternative ways to describe a financial instrument's risks, it is common to use moments of underlying return distribution or their *ad hoc* proxies. The primary risk comes from the variance, and we compute implied and realized variances to describe its price (fixed side of a variance swap) and realization (floating side of a variance swap) and to define an ex-post variance risk premium (as a payoff to a short variance swap). Asymmetry of the distribution is equally important for asymmetric instruments like options, and depending on the particular strategy, we may emphasize up or down semivariances and skewness, using their implied and realized values and the risk premiums as the difference thereof.[3]

To establish how the PNL of each strategy depends on realized premiums for particular risks, decomposing the effects into implied and realized values, and analyze the magnitudes of effects, we run a series of regressions of realized PNL for the option strategies on implied and realized return moments and their risk premiums, separately for each strategy type, but pooling several moneyness combinations into one model. Because changing parameters of a structure changes its sensitivity to the implied and realized distributions, we include in the regressions combo fixed

[3]We define these variables formally in Section 4; in general, we define risk premiums as payoffs on short (i.e., pay floating, receive fixed) swaps on a particular moment of the return distribution.

	Strangle	Irons	R/Reversal	C/Spread	C/R/Spread	P/Spread	P/R/Spread
Panel A. Realized Variance							
RV	-0.003	-0.001**	0.001	-0.004***	-0.002	0.005***	0.007***
	(-1.300)	(-2.410)	(0.254)	(-3.253)	(-1.265)	(4.105)	(6.860)
Combo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2, Adj.	0.016	0.003	0.000	0.011	0.004	0.020	0.045
Obs.	6,419	7,701	5,135	9,361	9,361	9,497	9,497
Panel B. Realized Variance and Skewness							
RV	-0.004*	-0.001***	-0.007**	-0.010***	-0.005**	0.012***	0.011***
	(-1.769)	(-2.855)	(-2.201)	(-4.292)	(-2.242)	(4.737)	(5.204)
RS	0.015	0.007*	0.143***	0.127***	0.047**	-0.128***	-0.065***
	(0.720)	(1.667)	(7.143)	(6.720)	(2.115)	(-6.686)	(-4.214)
Combo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2, Adj.	0.020	0.005	0.345	0.190	0.029	0.199	0.094
Obs.	6,419	7,701	5,135	9,361	9,361	9,497	9,497
Panel C. Implied and Realized Variances							
IV	-0.016***	0.005***	0.012*	0.019***	0.020***	-0.022***	-0.009**
	(-3.081)	(2.871)	(1.804)	(4.027)	(5.261)	(-4.270)	(-2.514)
RV	0.016**	-0.007***	-0.014*	-0.027***	-0.027***	0.033***	0.018***
	(2.033)	(-2.947)	(-1.692)	(-4.901)	(-4.695)	(5.071)	(4.131)
Combo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2, Adj.	0.062	0.012	0.025	0.051	0.048	0.072	0.054
Obs.	6,414	7,695	5,131	9,353	9,353	9,489	9,489
Panel D. Implied and Realized Variances and Skewness							
IV	-0.018***	0.005***	0.006	0.018***	0.023***	-0.022***	-0.010***
	(-3.018)	(2.739)	(0.816)	(4.138)	(5.534)	(-4.601)	(-2.822)
IS	-0.008	0.006	0.027**	0.065***	0.054***	-0.072***	-0.055***
	(-0.489)	(1.093)	(2.155)	(6.835)	(3.702)	(-6.338)	(-5.807)
RV	0.017**	-0.007***	-0.010	-0.024***	-0.026***	0.029***	0.016***
	(2.006)	(-3.028)	(-1.497)	(-5.525)	(-5.061)	(6.372)	(3.713)
RS	0.020	0.010*	0.160***	0.160***	0.068***	-0.167***	-0.098***
	(0.871)	(1.750)	(8.725)	(11.085)	(3.860)	(-11.302)	(-7.677)
Combo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2, Adj.	0.074	0.014	0.361	0.242	0.092	0.275	0.129
Obs.	6,414	7,695	5,131	9,353	9,353	9,489	9,489

Table 2: Option Strategies PNL vs. Implied and Realized Moments. The table shows the results of regressing realized PNL of option strategies (10:00 ET to expiry at 16:00 ET) on implied and realized distribution moments. PNL is specified per one unit of underlying relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. The result in each column is based on a pooled regression of strategy PNL for several moneyness combinations (see Table 1 for a list), including combo fixed effects (Combo FE). The sample period is from 09/2016 to January 11, 2024.

effects as combo dummies.[4] We report the results of these regressions using implied and realized moments of distribution as explanatory variables in Tables 2. Results of regressions of realized return over the last trading hour only (i.e., from 15:00) are provided in the Appendix Table A6.

[4] Adding interactions between combo dummies and other explanatory variables keeps most results intact. Using strategy Greeks as controls leads to unstable and sometimes counter-intuitive results.

Panel A in Table 2 delivers the first set of surprising results: realized returns of most strategies barely depend on the realized variance, and even though the RV coefficient is significant for several strategies, the R^2s are extremely low, with the maximum of 4.5% for put ratio spreads. For call and put spreads, the coefficients have opposite signs, possibly explained by the asymmetric volatility effect: index and its variance are typically negatively correlated, and because these spreads are directional, higher variance also typically means higher profit realization for put spreads, and lower variance – higher profit for call spreads. Adding realized skewness in Panel B considerably improves the regression fit for asymmetric instruments like risk reversals and simple call and put spreads. Ratio spreads also look better, but at some point, they start suffering from large directional moves of the underlying (captured by skewness), and the RS effect gets weaker. Adding proxy for the strategy cost in the form of implied variance and skewness in Panels C, and D have a more minor relative effect in terms of the explained variability; however, it still adds 2 to 7 percentage points to the R^2, boosting it especially strongly for strangles (from 1.6% in Panel A to 6.3% in C), call and put spreads (from 19% to 24.2% and from 19.8% to 27.4% in Panels B and C, respectively), and call ratio spreads (from 2.8% to 9.1% in Panels B and C, respectively).

Except for the strangles, our PNLs depend mainly on the realized skewness capturing the directional move of the underlying. It has a far weaker link to the realized variance risk premium compared to the delta-hedged returns (e.g., documented by Büchner and Kelly 2022) and is far less predictable. Appendix Table A6 documenting the same relationships in the last trading hour shows an even more extreme picture, where the same regression specifications typically deliver much higher R^2's, and again the most important explanatory variable is the realized skewness. It can be obvious after we see the analysis, but it confirms our fear that the final payoff of short-term option strategies is very hard to predict.

The next question: how well can we predict realized skewness for today? Can we predict up and down semivariances and their difference/ ratio? If yes, it would be good news...

4 Data Preparation

Data on Options and Underlying Markets. We use option 30-minute bars from Cboe that include national best bid and offer (NBBO) with size, open/high/low/close (OHLC) prices, trade volumes, and price of the underlying instrument, focusing on the SPX Weeklys with root SPXW. These options are European and cash-settled at the SPX index's close at 16:00 ET. Our analysis runs from 09/2016 until January 11, 2024. Starting from late August 2016, SPXW options have three weekly expiration dates, and then on April 18, 2022, and May 11, 2022, two more days per week were added, so we have SPXW 0DTE options every weekday. We obtain the end-of-the-day (EOD) closing prices for all underlying instruments and also one-minute OHLC (open, high, low, close) prices for SPX from *DTN IQFeed*.

Returns, Variances and Various Risk Premiums. We compute implied variance (IV) to expiration at the end of each available bar t during the expiration day using VIX Cboe (2023) methodology applied to 0DTE options observed at the end of that bar:

$$IV_t = 2e^{rT} \sum_i \frac{\Delta K_i}{K_i^2} Q(K_i) - [F/K_0 - 1]^2, \tag{1}$$

where K_i is the strike price of out-the-money (OTM) call and put options, K_0 is the first strike equal to or otherwise immediately below current option-implied forward price F, $Q(K_i)$, $i \neq 0$ is the mid-quote of OTM call and put options, and $Q(K_0)$ is the average of the K_0 put option price and K_0 call option price, r is the risk-free rate, for which we use 1-month T-bill rate from FRED, and T is time to expiration (in years). We also define measures of up and down semi-variances, IV_t^{up} and IV_t^{dn}, applying computations in (4) only to (weakly) OTM calls or puts, respectively, and scaling the second (subtracted) term as $0.5[F/K_0 - 1]^2$, to have the sum of two variance components equal to the total IV_t. The difference between up and down semi-variances is often used as a proxy for implied skewness (e.g., Feunou, Jahan-Parvar, and Okou (2018), Kilic and Shaliastovich (2019)), and we follow this practice by defining implied skewness:[5]

$$IS_t = IV_t^{up} - IV_t^{dn}. \tag{2}$$

We compute forward-looking realized variance (RV) at the end of each bar t for periods matching each computed IV as the sum of squared one-minute log returns from the end of a bar to the end of the day:

$$RV_t = \sum_{t}^{T-1} r_{t,t+1}^2, \tag{3}$$

where $r_{t,t+1}$ is log return for the minute ending at $t+1$ computed as close to close from t until T=16:00 on the same day. Analogous to up and down implied semi-variances, we compute realized semi-variances RV_t^{up} and RV_t^{dn} by multiplying $r_{t,t+1}^2$ term in equation (3) by an indicator function $\mathbf{1}_{r_{t,t+1}>0}$ or $\mathbf{1}_{r_{t,t+1}<0}$ for up or down semi-variance, respectively. We proxy for realized skewness using

$$RS_t = RV_t^{up} - RV_t^{dn}. \tag{4}$$

We define *ex post* realized variance risk premium VRP to expiration at a given bar t as the payment on a short variance swap from t to expiry, which is equal to the implied minus realized variances from the end of a given intraday bar until expiration time:

$$VRP_t = IV_t - RV_t. \tag{5}$$

[5]Note that one can directly compute implied skewness using results of Bakshi, Kapadia, and Madan (2003), Kozhan, Neuberger, and Schneider (2013), and others; however, the definition of skewness as the difference of semi-variances leads to a simpler expression under both risk-neutral and physical measures, and hence, to a more intuitive skewness risk premium formulation.

Semi-variance risk premiums VRP_t^{up} and VRP_t^{dn} are computed using up and down implied and realized semi-variances.[6] Skewness risk premium then is defined in two alternative ways:

$$SRP_t = IS_t - RS_t = VRP_t^{up} - VRP_t^{dn}. \tag{6}$$

For individual options with today's expiration, observed at a given point in time during the day (e.g., 10:00 ET), we first compute their moneyness (defined as strike to underlying price ratio) and then select all options within moneyness bounds $[0.98, 1.02]$, i.e., $\pm 2\%$ from the ATM level. For each of these options, we express the mid-price and bid-ask spread in terms of the underlying price (i.e., compute the ratio of a variable and underlying price), and then interpolate main variables of interest (mid-price, bid-ask spread, implied volatility, and Greeks) as a function of moneyness with step 0.00125, for calls and puts separately.[7] For each interpolated option, we compute the payoff:

$$Payoff_t(M, Type) = \begin{cases} (M - S_T/S_t)^+ & \text{if } Type = Call, \\ (S_T/S_t - M)^+ & \text{if } Type = Put, \end{cases} \tag{7}$$

where M is the moneyness level for a given option, and S_T/S_t is the total return on the index S from time t to expiry T =16:00. We also compute for each option its intrinsic value as the payoff from an immediate exercise and the time value as the difference between the mid-price and intrinsic value. For options that get a negative time value (due to using mid-price instead of the effective or true price), we set the time value to zero and the intrinsic value to the mid-price. Because the moneyness of an option is its strike level relative to the underlying price, the payoff, time value, and intrinsic are already expressed in terms of the underlying price. To compute

[6]We do not annualize it to get a better feeling of the total return from selling variance until expiry at 16:00 at some point during the day.

[7]The step corresponds to the standard 5-dollar step in strikes for the index level of 4000. We interpolate the options to have standard moneyness levels comparable in time, and we can use them without modifications to construct option strategies. We use 1-dimensional interpolation using piecewise cubic polynomials developed by Akima (1970), and implemented in `Akima1DInterpolator` function in `SciPy Interpolate package`. The results are robust to using other interpolation routines.

the PNL of an option position relative to the underlying price, we need to take the difference between the payoff and the mid-price, assuming that the latter is the effective option price:

$$PNL_t(M, Type) = Payoff_t(M, Type) - Mid_t(M, Type), \tag{8}$$

where $Mid_t(M, Type)$ is the mid-price at time t of an option with moneyness M and type $Type$. The realized return to expiry is then computed as the ratio of PNL to the mid-price:

$$Ret_t(M, Type) = \frac{PNL_t(M, Type)}{Mid_t(M, Type)} = \frac{Payoff_t(M, Type)}{Mid_t(M, Type)} - 1. \tag{9}$$

To express PNL and return in percentage terms, we multiply both by 100. For the structures created as predefined combinations of options, we compute their PNL as the sum of PNLs of individual options scaled by the number of particular options included in the structure. By construction, this PNL will be expressed in terms of underlying price.

The interpolated options and relevant structures data are available at https://osf.io/7q86u/.

5 Relevant Literature

Some recent papers study 0DTE options trading. Beckmeyer, Branger, and Gayda (2023) look at the performance of retail vs. professional traders in 0DTE options. They use the methodology of Bryzgalova, Pavlova, and Sikorskaya (2022) to classify trades as retail or professional and show that retail investors incurred significant trading losses in 0DTE options, averaging losses of more than $500,000 per day since the introduction of five expiration days per week in 2022. Retail investors' losses are primarily from taking long positions, while short positions are generally profitable. Bandi, Fusari, and Renò (2023) derive a theoretical pricing model for short-term options without distributional assumptions. Brogaard, Han, and Won (2023) examine the impact of trading activity in 0DTEs (using the proportion of 0DTEs in total options trading) on the intraday volatility, finding that higher relative turnover in ultra-short-term options is positively related to the intraday volatility of underlying. Dim, Eraker, and Vilkov (2023) show that high open interest gamma in 0DTE options is not contributing to the propagation of past volatility (precisely, last day and overnight volatilities) and that the current state of liquidity in underlying markets absorbs any potential delta-hedging flows from option markets without generating abnormal volume patterns.

Many papers studied the factor structure of options returns and expected returns predictability. For example, Büchner and Kelly 2022 analyze delta-hedged SPX options returns using IPCA (Kelly, Pruitt, and Su 2017) and find that they can be well modeled by only a few factors. In contrast to long-term delta-hedged returns, which depend mainly on realized variance risk premiums, we study unhedged ultra-short returns on option strategies.

6 Conclusion

Our empirical study of zero-days to expiry (0DTE) options trading strategies on the S&P 500 index, spanning from 09/2016 to January 11, 2024, provides valuable insights into this dynamic trading sector. The surge in 0DTE options trading, mainly driven by easy access to user-friendly brokerage platforms and the attraction of low option premiums, has produced a diverse range of outcomes in terms of profitability.

Our analysis has uncovered several key findings. First, 0DTE options offer a substantial variance risk premium, with implied variance consistently higher than realized variance until settlement. However, the success of various strategies is not guaranteed. In the initial part of our analysis, we considered unconditional static trading rules, revealing high volatility and skewed returns in individual 0DTE options held to expiry.[8] Some tactics, such as buying deep

[8] We call such rules unconditional and static because we do not condition our decision about the direction and size of the position on any environmental variables and do not adjust the positions during the day to fix profits, limit losses, or change the exposure profile. Later, we will extend the analysis to conditional and dynamic rules.

in-the-money calls and selling out-of-the-money calls and puts, show promise for profitability. Nevertheless, the median profit and loss (PNL) for most popular strategies tend to be negative, with a wide distribution of potential outcomes. Notably, the risk reversal strategy consistently yields positive PNL, though the magnitude is modest.

Furthermore, our study highlights the challenges of applying unconditional and static trading rules in 0DTE SPX options. These strategies often lead to highly volatile realized PNL and a minimal variance risk premium due to the short time to expiry. Additionally, the upward trend of the S&P 500 index during our study's timeline may have influenced some of the observed outcomes.

Our research underscores that while specific 0DTE unconditional static trading rules can yield profitability, this domain is inherently risky and unpredictable. Traders should be mindful of the volatility and mixed success rates associated with various strategies, emphasizing the importance of a comprehensive and nuanced understanding of the 0DTE options market. These insights provide valuable guidance to market participants navigating this complex and evolving trading landscape.

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A Additional Tables and Figures

A.1 General Information

Date	Content Update
Nov 22, 23	Public data version `ver-2023-11`
	Initial version, static unconditional rules, sample period 09/2016-05/2023
Dec 6, 23	Public data version `ver-2023-12-06`
	Added Iron Butterfly/ Condor to the analysis
	Added annualized (approximate, i.e., simply scaled) Sharpe ratio for strategies
	Changed interpolation step for call and put options from 0.00125 to 0.001
	Removed options with zero Cboe implied volatility
	Included options with zero bids (and positive implied volatility)
	Added results for unconditional static rules for sub-periods in Tables A2 to A4 (2016-2019, 2020-2021, 2022-2023)
	Error corrections: time value and price in Table 2 were given as ratio, not %.
Dec 15, 23	Public data version `ver-2023-12-15`
	Data updated to December 8, 2023.
Jan 14, 24	Public data version `ver-2024-01-12`
	Data updated to January 11, 2024.

Table A1: Updates History. The table shows the important updates to the draft with the respective dates.

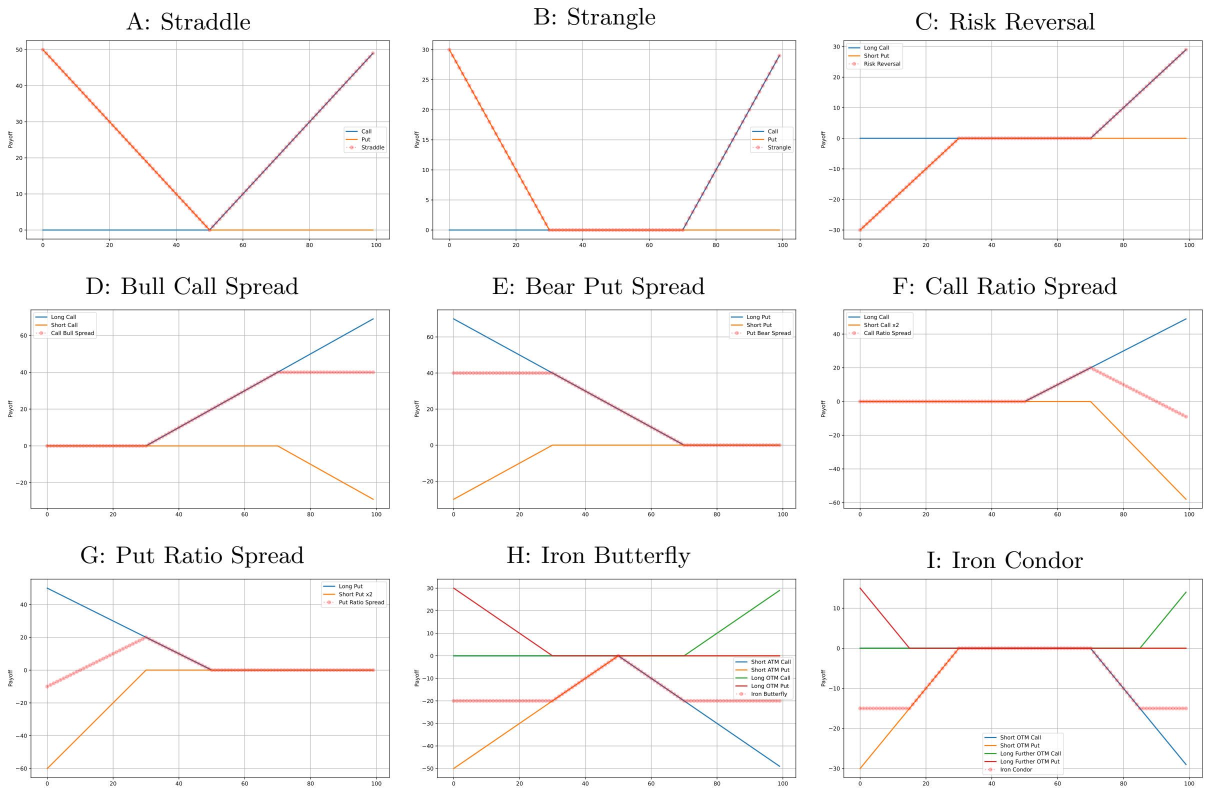

Figure A1: Sample Payoffs of Option Strategies. The figure provides sample final payoffs of the popular strategies used in our analysis. The payoff does not account for the cost of the strategy. To compute PNL of each strategy we need to subtract the premium, and it will shift the payoff down in case of a debit strategy and up in the case of a credit strategy.

A.2 Unconditional Trading Rules

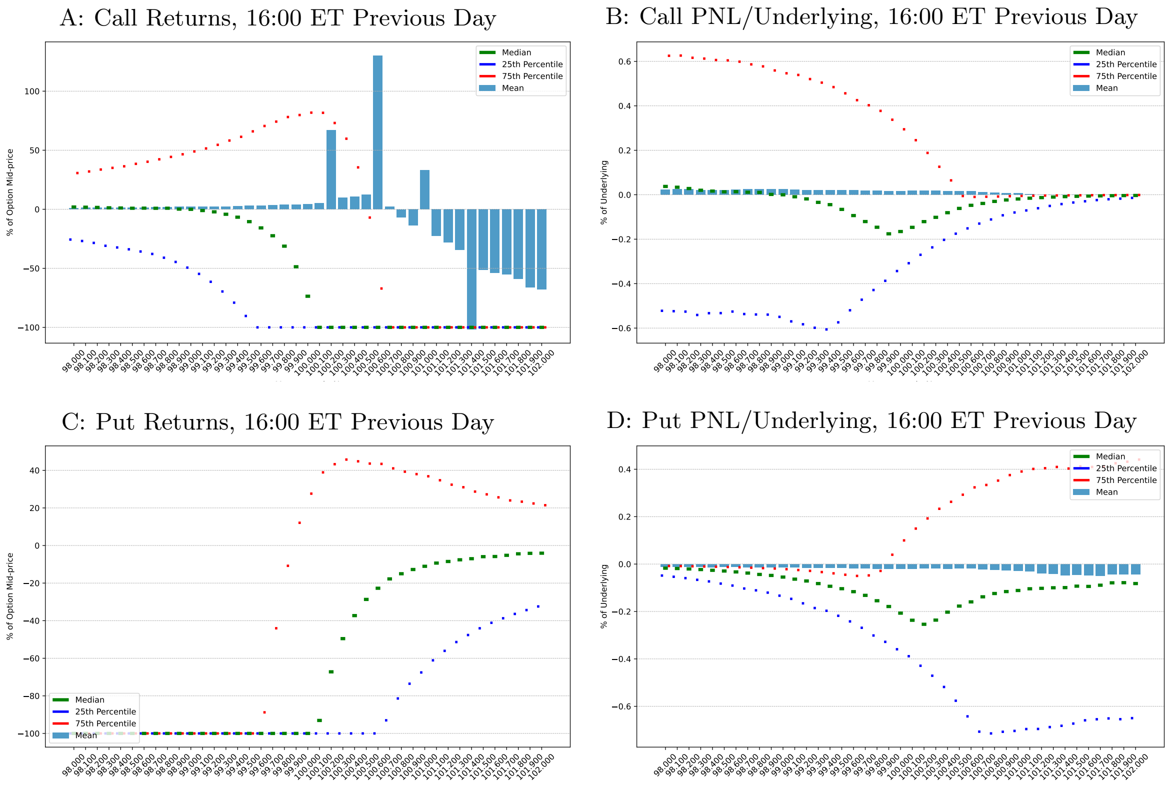

Figure A2: 0DTE Option Returns, 16:00 ET on the Previous Day to Expiry. The figure provides statistics on profitability of naked 0DTE call and put option buying at 16:00 ET on the previous day and holding to expiry at 16:00 ET. Panels on the left show realized return in % relative to option mid-price. Panels on the right show option realized profit (payoff - mid-price) per one unit of underlying relative to underlying price, in %. Bars show mean values, and each bar is accompanied by median, 25th and 75th percentiles. X-axis labels show moneyness of the analyzed options. The sample period is from 09/2016 to January 11, 2024.

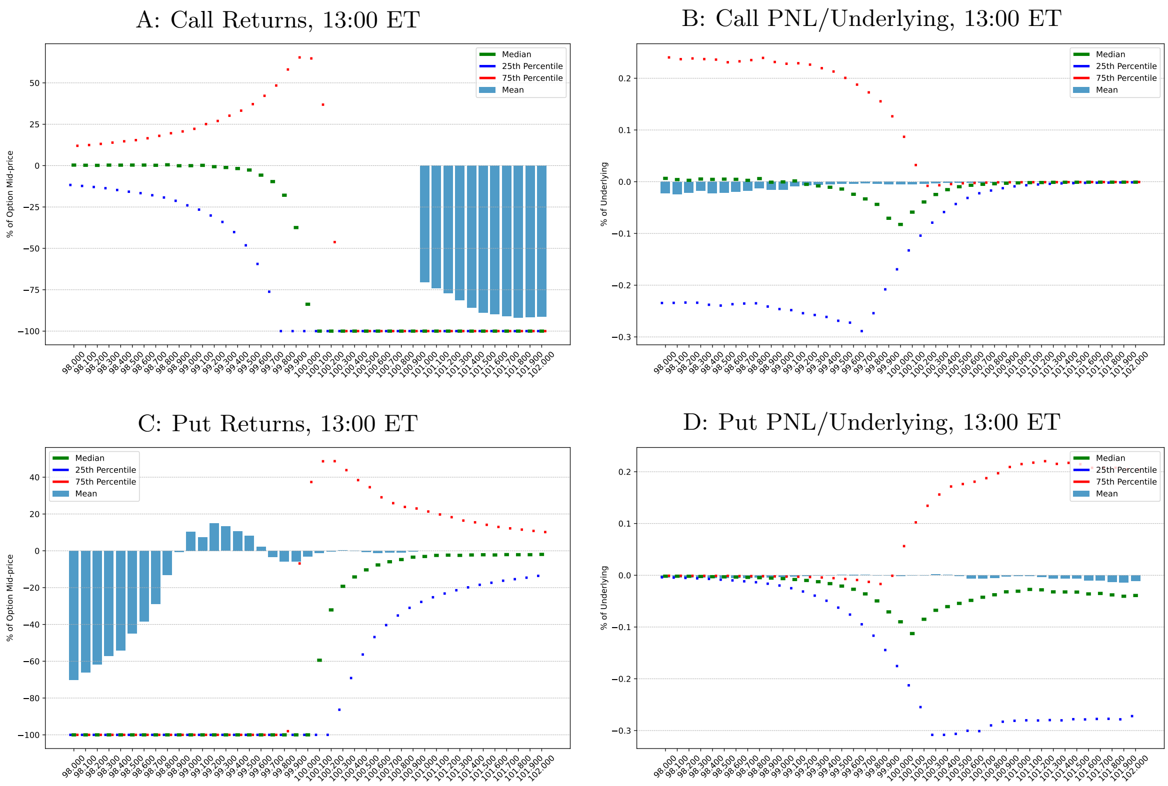

Figure A3: 0DTE Option Returns, 13:00 ET to Expiry. The figure provides statistics on profitability of naked 0DTE call and put option buying at 13:00 ET and holding to expiry at 16:00 ET. Panels on the left show realized return in % relative to option mid-price. Panels on the right show option realized profit (payoff - mid-price) per one unit of underlying relative to underlying price, in %. Bars show mean values, and each bar is accompanied by median, 25th and 75th percentiles. X-axis labels show moneyness of the analyzed options. The sample period is from 09/2016 to January 11, 2024.

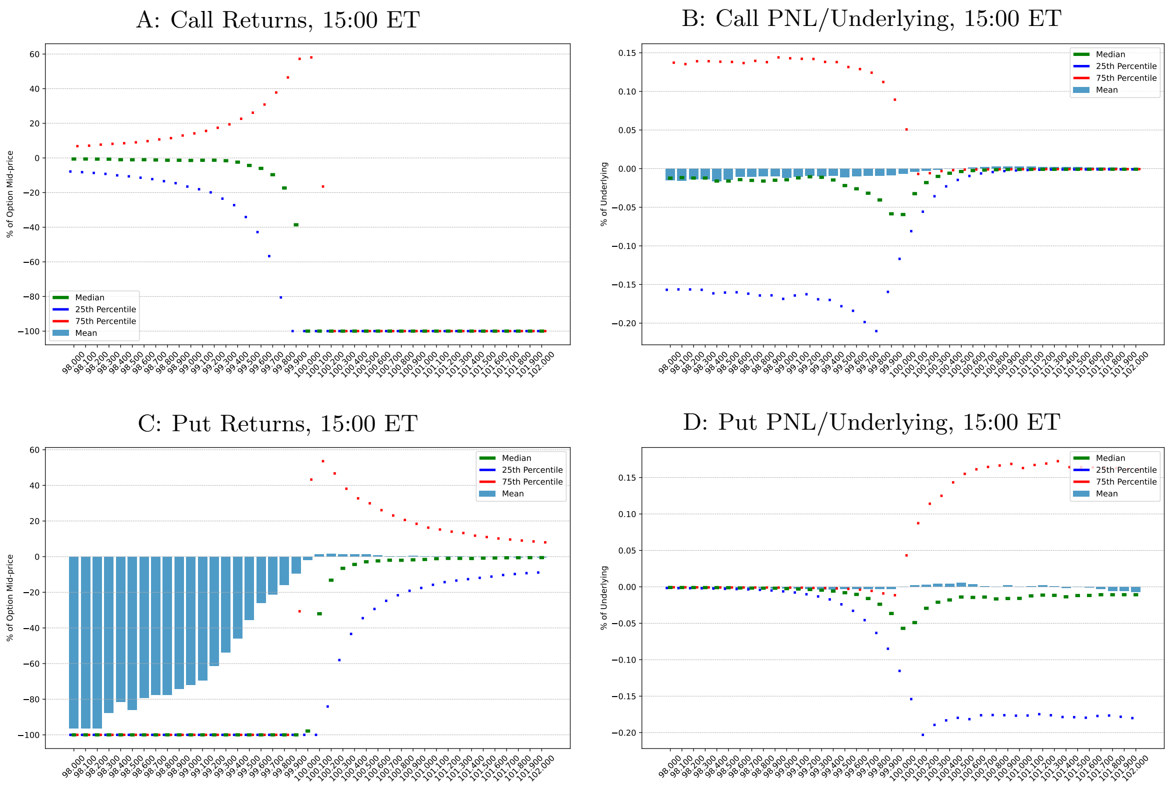

Figure A4: 0DTE Option Returns, 15:00 ET to Expiry. The figure provides statistics on profitability of naked 0DTE call and put option buying at 13:00 ET and holding to expiry at 16:00 ET. Panels on the left show realized return in % relative to option mid-price. Panels on the right show option realized profit (payoff - mid-price) per one unit of underlying relative to underlying price, in %. Bars show mean values, and each bar is accompanied by median, 25th and 75th percentiles. X-axis labels show moneyness of the analyzed options. The sample period is from 09/2016 to January 11, 2024.

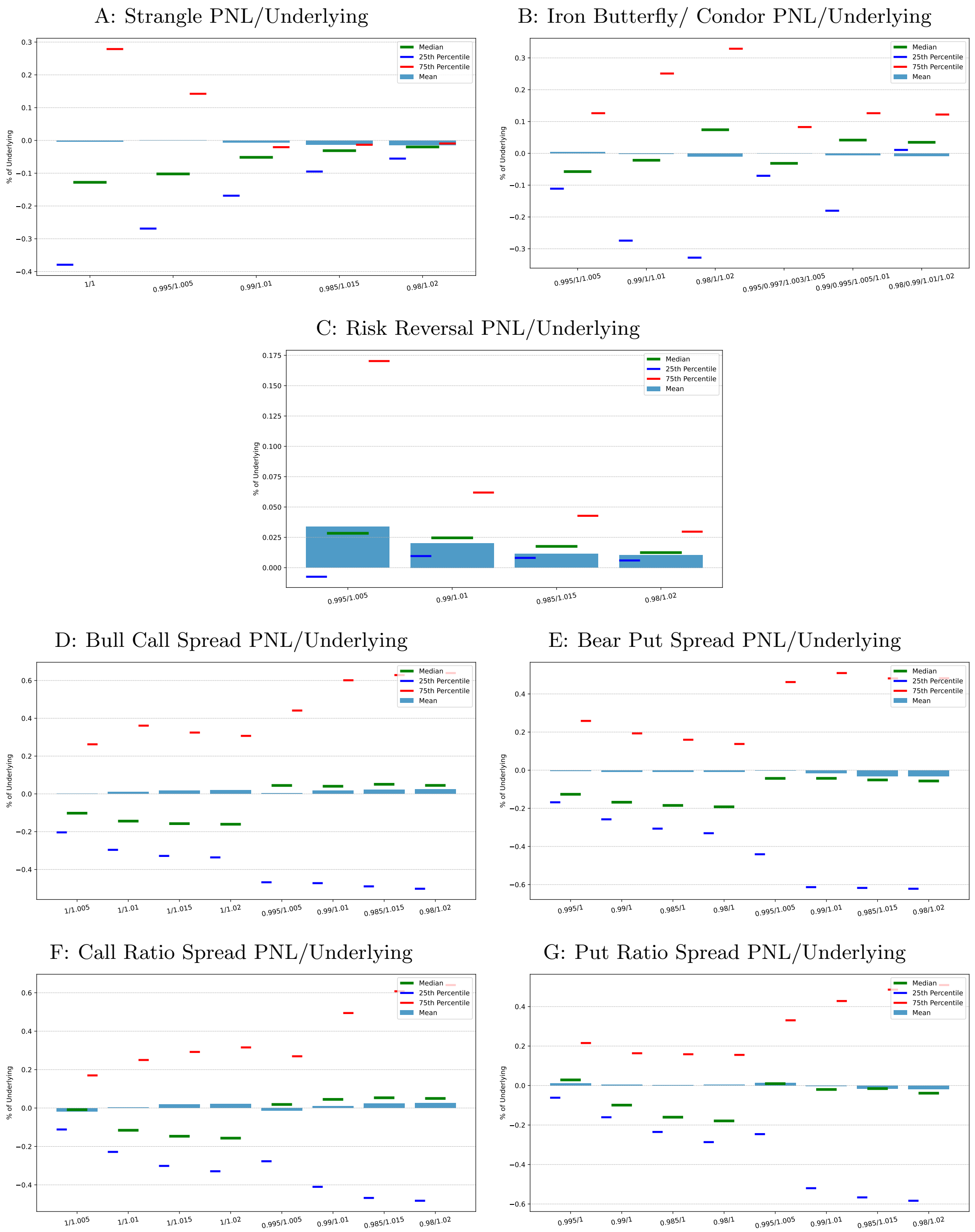

Figure A5: 0DTE Static Option Strategies, 16:00 ET on the Previous Day to Expiry. The figure provides statistics on profitability of several well-known option strategies based on 0DTE call and put options; positions are taken at 16:00 ET on previous day and held to expiry at 16:00 ET. All panels show option strategy realized profit (payoff - mid-price) per one unit of underlying relative to the underlying price, in %. Bars show mean values, and each bar is accompanied by median, 25th and 75th percentiles. X-axis labels show combination of moneyness for options used for a strategy. The sample period is from 09/2016 to January 11, 2024.

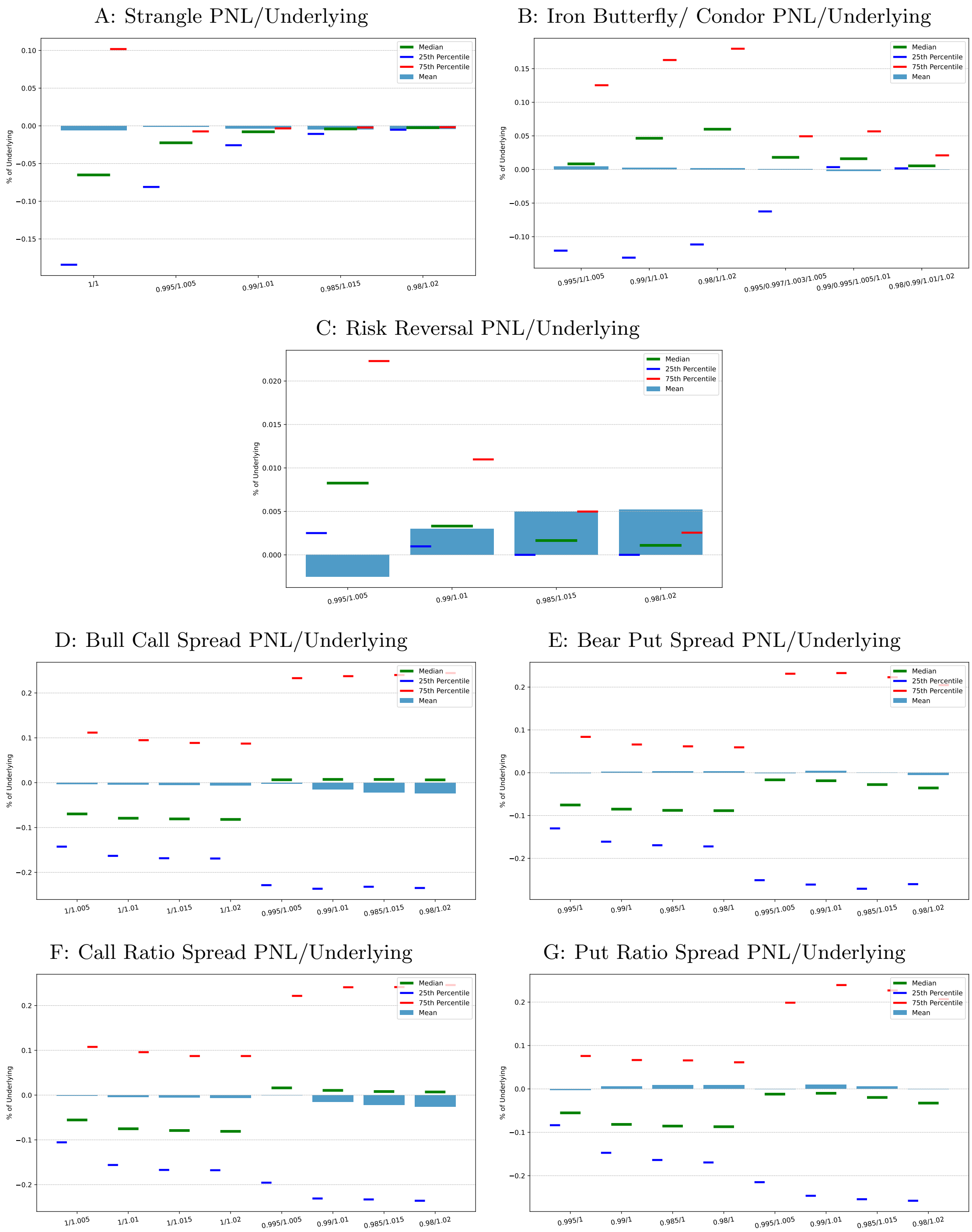

Figure A6: 0DTE Static Option Strategies, 13:00 ET to Expiry. The figure provides statistics on profitability of several well-known option strategies based on 0DTE call and put options; positions are taken at 13:00 ET and held to expiry at 16:00 ET. All panels show option strategy realized profit (payoff - mid-price) per one unit of underlying relative to the underlying price, in %. Bars show mean values, and each bar is accompanied by median, 25th and 75th percentiles. X-axis labels show combination of moneyness for options used for a strategy. The sample period is from 09/2016 to January 11, 2024.

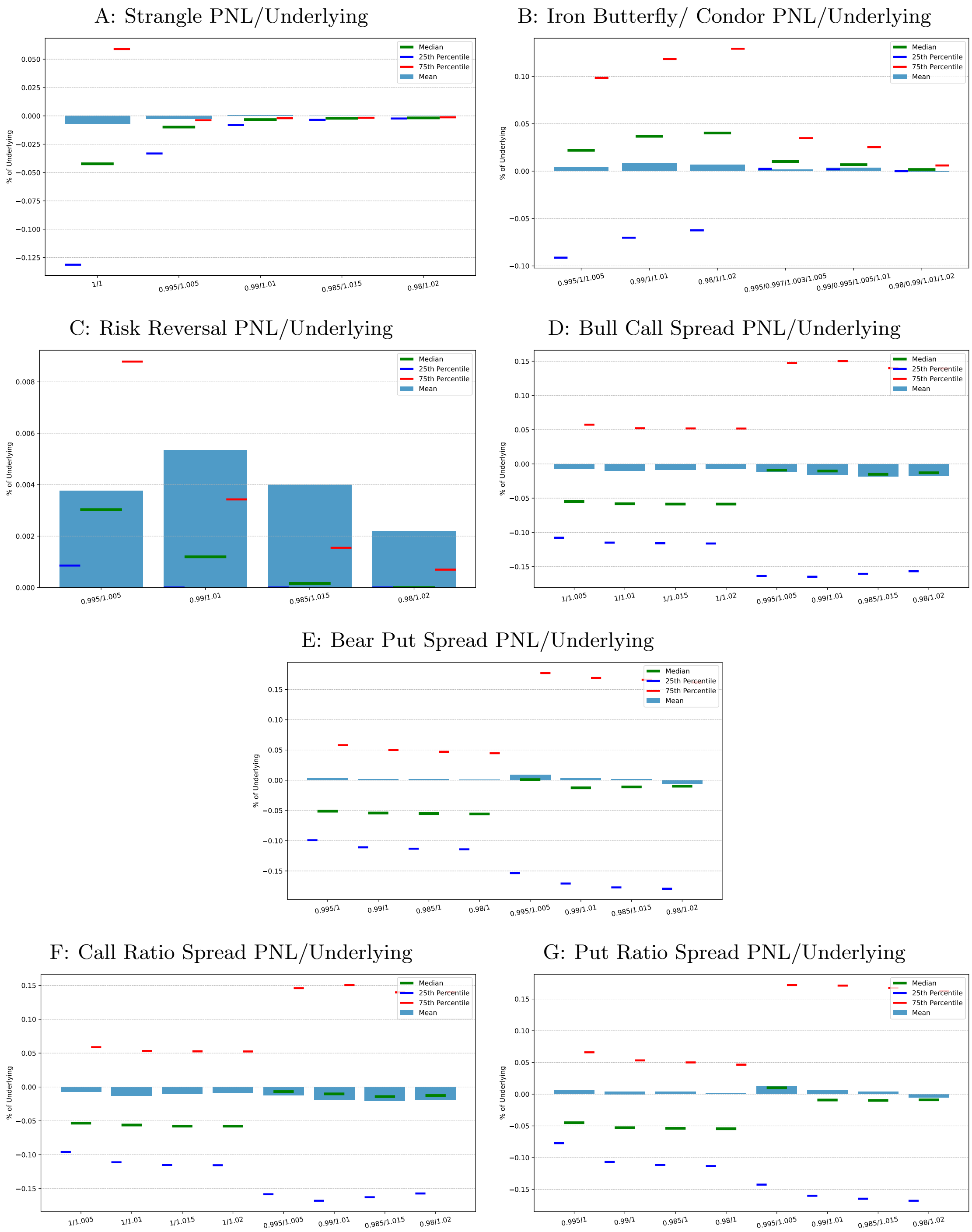

Figure A7: 0DTE Static Option Strategies, 15:00 ET to Expiry. The figure provides statistics on profitability of several well-known option strategies based on 0DTE call and put options; positions are taken at 15:00 ET and held to expiry at 16:00 ET. All panels show option strategy realized profit (payoff - mid-price) per one unit of underlying relative to the underlying price, in %. Bars show mean values, and each bar is accompanied by median, 25th and 75th percentiles. X-axis labels show combination of moneyness for options used for a strategy. The sample period is from 09/2016 to January 11, 2024.

Strategy	Moneyness	Count	Mean	Volatility	Min	1%	25%	50%	75%	99%	Max	Skew	SR, p.a.
Strangle/Straddle	1/1	497	0.0037	0.41	-0.97	-0.66	-0.21	-0.08	0.13	1.38	2.96	2.58	0.14
	0.995/1.005	498	0.0102	0.33	-0.87	-0.49	-0.08	-0.03	-0.01	1.28	2.90	4.20	0.49
	0.99/1.01	498	0.0118	0.24	-0.54	-0.34	-0.03	-0.01	-0.01	1.02	2.73	6.55	0.76
	0.985/1.015	498	0.0060	0.18	-0.34	-0.20	-0.01	-0.00	-0.00	0.66	2.47	9.55	0.54
	0.98/1.02	498	0.0025	0.13	-0.20	-0.11	-0.01	-0.00	-0.00	0.26	2.12	13.21	0.32
Iron Butterfly/Condor	0.995/1/1.005	497	0.0066	0.16	-0.31	-0.29	-0.12	0.01	0.13	0.33	0.37	0.06	0.66
	0.99/1/1.01	497	0.0081	0.25	-0.77	-0.60	-0.16	0.06	0.18	0.51	0.56	-0.48	0.51
	0.98/1/1.02	497	-0.0011	0.35	-1.43	-1.25	-0.14	0.07	0.20	0.64	0.85	-1.38	-0.05
	0.995/0.997/1.003/1.005	498	0.0041	0.08	-0.18	-0.17	-0.06	0.03	0.06	0.14	0.16	-0.53	0.84
	0.99/0.995/1.005/1.01	498	0.0015	0.13	-0.48	-0.41	0.01	0.03	0.06	0.23	0.33	-1.35	0.18
	0.98/0.99/1.01/1.02	498	-0.0092	0.16	-0.94	-0.85	0.00	0.01	0.02	0.25	0.34	-3.84	-0.93
Risk Reversal	0.995/1.005	498	-0.0035	0.41	-2.93	-1.69	0.01	0.01	0.03	1.07	3.94	-0.12	-0.14
	0.99/1.01	498	-0.0023	0.28	-2.46	-1.17	0.00	0.01	0.02	0.57	3.47	1.05	-0.13
	0.985/1.015	498	-0.0004	0.20	-1.98	-0.67	0.00	0.00	0.01	0.12	2.99	3.80	-0.03
	0.98/1.02	498	0.0022	0.14	-1.49	-0.19	0.00	0.00	0.00	0.06	2.48	8.35	0.26
Bull Call Spread	1/1.005	498	-0.0051	0.18	-0.26	-0.24	-0.15	-0.08	0.13	0.37	0.39	0.67	-0.44
	1/1.01	498	-0.0065	0.26	-0.43	-0.38	-0.17	-0.09	0.11	0.71	0.87	1.12	-0.40
	1/1.015	498	-0.0046	0.29	-0.56	-0.45	-0.18	-0.09	0.11	1.03	1.34	1.57	-0.25
	1/1.02	498	-0.0041	0.31	-0.66	-0.48	-0.18	-0.09	0.11	1.20	1.61	1.82	-0.21
	0.995/1.005	468	-0.0090	0.33	-0.57	-0.56	-0.25	0.00	0.25	0.50	0.51	-0.14	-0.44
	0.99/1.01	403	-0.0290	0.49	-1.11	-1.06	-0.28	-0.02	0.25	0.98	1.00	-0.18	-0.95
	0.985/1.015	347	-0.0264	0.58	-1.59	-1.54	-0.29	-0.00	0.25	1.46	1.50	-0.27	-0.72
	0.98/1.02	314	-0.0369	0.65	-2.09	-2.02	-0.30	-0.01	0.25	1.63	1.98	-0.44	-0.91
Call Ratio Spread	1/1.005	498	-0.0085	0.23	-3.16	-0.58	-0.12	-0.06	0.11	0.38	0.49	-5.61	-0.59
	1/1.01	498	-0.0112	0.26	-2.53	-0.29	-0.17	-0.09	0.11	0.65	0.72	-1.01	-0.69
	1/1.015	498	-0.0074	0.29	-1.78	-0.39	-0.18	-0.09	0.11	0.98	1.34	0.96	-0.40
	1/1.02	498	-0.0065	0.30	-0.92	-0.46	-0.18	-0.09	0.11	1.11	1.61	1.71	-0.34
	0.995/1.005	468	-0.0129	0.32	-2.96	-0.53	-0.23	0.00	0.22	0.52	0.67	-1.68	-0.63
	0.99/1.01	403	-0.0353	0.47	-2.17	-1.03	-0.28	-0.01	0.25	0.92	1.04	-0.45	-1.20
	0.985/1.015	347	-0.0310	0.57	-1.53	-1.52	-0.29	-0.00	0.25	1.37	1.47	-0.34	-0.86
	0.98/1.02	314	-0.0414	0.63	-2.05	-2.01	-0.30	-0.01	0.24	1.58	1.88	-0.51	-1.04
Bear Put Spread	0.995/1	497	-0.0016	0.18	-0.20	-0.19	-0.12	-0.10	0.08	0.39	0.41	1.07	-0.14
	0.99/1	497	-0.0018	0.27	-0.35	-0.32	-0.15	-0.11	0.05	0.79	0.87	1.61	-0.11
	0.985/1	497	0.0021	0.33	-0.46	-0.40	-0.16	-0.11	0.04	1.17	1.28	2.09	0.10
	0.98/1	497	0.0051	0.37	-0.54	-0.46	-0.17	-0.11	0.04	1.62	1.72	2.49	0.22
	0.995/1.005	459	-0.0022	0.33	-0.53	-0.51	-0.27	-0.03	0.24	0.56	0.57	0.21	-0.11
	0.99/1.01	396	-0.0058	0.48	-1.03	-0.97	-0.29	-0.05	0.23	1.06	1.09	0.36	-0.19
	0.985/1.015	351	-0.0111	0.56	-1.49	-1.37	-0.31	-0.07	0.21	1.53	1.60	0.62	-0.31
	0.98/1.02	327	-0.0185	0.60	-1.96	-1.51	-0.33	-0.10	0.17	2.01	2.08	0.86	-0.49
Put Ratio Spread	0.995/1	497	-0.0085	0.26	-2.51	-1.15	-0.09	-0.05	0.09	0.46	0.57	-3.58	-0.52
	0.99/1	497	-0.0089	0.25	-1.68	-0.37	-0.14	-0.10	0.04	0.73	0.80	0.59	-0.57
	0.985/1	497	-0.0011	0.29	-0.75	-0.30	-0.16	-0.11	0.05	1.07	1.29	2.04	-0.06
	0.98/1	497	0.0050	0.34	-0.42	-0.38	-0.16	-0.11	0.04	1.37	1.66	2.34	0.23
	0.995/1.005	459	-0.0112	0.34	-2.32	-0.95	-0.22	-0.03	0.20	0.69	0.81	-0.87	-0.52
	0.99/1.01	396	-0.0154	0.43	-1.45	-0.90	-0.29	-0.04	0.24	1.02	1.17	0.21	-0.56
	0.985/1.015	351	-0.0177	0.51	-1.43	-1.29	-0.32	-0.07	0.22	1.46	1.52	0.46	-0.55
	0.98/1.02	327	-0.0207	0.57	-1.88	-1.45	-0.33	-0.10	0.18	1.75	2.04	0.69	-0.57

Table A2: 0DTE Static Option Strategies Performance. The table shows the summary statistics for the holding period returns of several well-known option strategies based on 0DTE call and put options; positions are taken at 10:00 ET and held to expiry at 16:00 ET. The statistics are based on option strategies' realized profit per one unit of underlying relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. The SR, p.a. is the Sharpe Ratio annualized by scaling it up by $\sqrt{252}$. The sample period is from 09/2016 to 12/2019.

Strategy	Moneyness	Count	Mean	Volatility	Min	1%	25%	50%	75%	99%	Max	Skew	SR, p.a.
Strangle/Straddle	1/1	313	-0.0336	0.55	-2.69	-1.78	-0.28	-0.10	0.20	1.53	2.26	0.04	-0.97
	0.995/1.005	313	-0.0402	0.48	-2.70	-1.81	-0.18	-0.07	0.03	1.42	2.21	-0.04	-1.34
	0.99/1.01	313	-0.0488	0.39	-2.75	-1.62	-0.09	-0.03	-0.01	1.24	2.15	-0.65	-1.99
	0.985/1.015	311	-0.0476	0.33	-2.37	-1.57	-0.05	-0.01	-0.00	0.82	2.05	-1.45	-2.28
	0.98/1.02	310	-0.0416	0.30	-2.14	-1.42	-0.02	-0.01	-0.00	0.57	1.90	-2.38	-2.24
Iron Butterfly/Condor	0.995/1/1.005	313	-0.0067	0.16	-0.50	-0.26	-0.12	-0.05	0.11	0.35	0.43	0.45	-0.66
	0.99/1/1.01	313	-0.0152	0.30	-1.00	-0.72	-0.24	0.03	0.20	0.59	0.83	-0.29	-0.80
	0.98/1/1.02	310	-0.0087	0.43	-1.45	-1.33	-0.26	0.08	0.26	0.81	1.46	-0.61	-0.32
	0.995/0.997/1.003/1.005	313	-0.0032	0.09	-0.20	-0.16	-0.07	-0.01	0.07	0.16	0.18	-0.04	-0.59
	0.99/0.995/1.005/1.01	313	-0.0085	0.18	-0.50	-0.46	-0.09	0.04	0.10	0.31	0.40	-0.77	-0.75
	0.98/0.99/1.01/1.02	310	0.0074	0.19	-0.95	-0.77	0.01	0.02	0.07	0.44	0.74	-1.65	0.61
Risk Reversal	0.995/1.005	313	0.0385	0.66	-3.48	-1.67	0.01	0.03	0.06	2.43	5.36	2.01	0.92
	0.99/1.01	313	0.0467	0.49	-3.00	-1.17	0.01	0.02	0.04	1.95	4.92	3.63	1.50
	0.985/1.015	311	0.0428	0.39	-2.52	-0.68	0.00	0.01	0.02	1.47	4.47	5.51	1.76
	0.98/1.02	310	0.0345	0.31	-2.04	-0.19	0.00	0.00	0.01	0.96	4.01	7.64	1.78
Bull Call Spread	1/1.005	313	0.0068	0.21	-0.43	-0.25	-0.18	-0.07	0.24	0.36	0.50	0.39	0.52
	1/1.01	313	0.0069	0.32	-0.51	-0.46	-0.24	-0.10	0.20	0.74	1.00	0.78	0.34
	1/1.015	311	0.0070	0.39	-0.74	-0.63	-0.25	-0.11	0.16	1.09	1.36	1.05	0.28
	1/1.02	310	0.0086	0.43	-0.94	-0.83	-0.25	-0.11	0.16	1.37	1.53	1.18	0.31
	0.995/1.005	309	0.0092	0.39	-0.70	-0.56	-0.39	0.07	0.43	0.49	1.00	-0.17	0.38
	0.99/1.01	273	-0.0085	0.63	-1.10	-1.07	-0.45	0.08	0.44	0.99	2.00	-0.14	-0.22
	0.985/1.015	246	-0.0051	0.79	-1.61	-1.56	-0.48	0.08	0.46	1.48	2.86	-0.02	-0.10
	0.98/1.02	221	0.0078	0.90	-2.12	-2.00	-0.49	0.09	0.48	1.96	3.36	0.07	0.14
Call Ratio Spread	1/1.005	313	0.0077	0.41	-3.55	-1.56	-0.12	0.00	0.19	1.01	1.80	-3.05	0.30
	1/1.01	313	0.0080	0.37	-3.05	-0.95	-0.21	-0.08	0.22	0.82	1.26	-1.89	0.34
	1/1.015	311	0.0094	0.39	-2.49	-0.43	-0.23	-0.09	0.18	1.10	1.56	0.05	0.38
	1/1.02	310	0.0122	0.41	-1.89	-0.51	-0.24	-0.10	0.16	1.24	1.57	0.95	0.48
	0.995/1.005	309	0.0100	0.46	-3.34	-1.36	-0.29	0.08	0.32	1.02	1.52	-1.77	0.35
	0.99/1.01	273	-0.0078	0.59	-2.65	-1.03	-0.40	0.09	0.41	0.99	1.64	-0.53	-0.21
	0.985/1.015	246	-0.0025	0.73	-1.92	-1.51	-0.44	0.09	0.46	1.47	2.86	-0.02	-0.06
	0.98/1.02	221	0.0122	0.83	-2.00	-1.89	-0.47	0.09	0.50	1.89	3.36	0.17	0.23
Bear Put Spread	0.995/1	313	-0.0001	0.20	-0.24	-0.21	-0.15	-0.11	0.21	0.38	0.45	0.79	-0.01
	0.99/1	313	0.0082	0.34	-0.46	-0.41	-0.22	-0.14	0.16	0.85	0.89	1.18	0.38
	0.985/1	313	0.0055	0.42	-0.65	-0.56	-0.25	-0.15	0.14	1.22	1.24	1.41	0.21
	0.98/1	313	-0.0018	0.45	-0.81	-0.68	-0.26	-0.15	0.12	1.32	1.71	1.53	-0.06
	0.995/1.005	306	-0.0048	0.38	-0.52	-0.49	-0.43	-0.07	0.39	0.56	0.77	0.20	-0.20
	0.99/1.01	275	0.0052	0.60	-1.01	-0.99	-0.43	-0.08	0.40	1.07	1.09	0.28	0.14
	0.985/1.015	262	0.0066	0.72	-1.51	-1.46	-0.43	-0.08	0.40	1.55	1.70	0.24	0.15
	0.98/1.02	247	0.0140	0.79	-1.99	-1.92	-0.44	-0.08	0.39	2.01	2.10	0.24	0.28
Put Ratio Spread	0.995/1	313	0.0393	0.30	-1.98	-0.92	-0.08	-0.03	0.16	0.99	1.43	-0.66	2.10
	0.99/1	313	0.0560	0.34	-1.40	-0.23	-0.16	-0.12	0.20	0.88	1.99	1.33	2.58
	0.985/1	313	0.0504	0.42	-0.79	-0.33	-0.22	-0.13	0.18	1.32	1.63	1.63	1.89
	0.98/1	313	0.0359	0.47	-0.45	-0.42	-0.24	-0.15	0.15	1.64	2.19	1.92	1.21
	0.995/1.005	306	0.0351	0.38	-1.74	-0.75	-0.23	-0.03	0.31	1.00	1.68	0.26	1.48
	0.99/1.01	275	0.0566	0.57	-0.98	-0.91	-0.31	-0.04	0.39	1.32	2.46	0.59	1.57
	0.985/1.015	262	0.0571	0.71	-1.40	-1.36	-0.37	-0.07	0.42	2.14	2.32	0.61	1.28
	0.98/1.02	247	0.0576	0.80	-1.81	-1.71	-0.41	-0.08	0.43	2.55	3.02	0.73	1.14

Table A3: 0DTE Static Option Strategies Performance. The table shows the summary statistics for the holding period returns of several well-known option strategies based on 0DTE call and put options; positions are taken at 10:00 ET and held to expiry at 16:00 ET. The statistics are based on option strategies' realized profit per one unit of underlying relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. The SR, p.a. is the Sharpe Ratio annualized by scaling it up by $\sqrt{252}$. The sample period is from 01/2020 to 12/2021.

Strategy	Moneyness	Count	Mean	Volatility	Min	1%	25%	50%	75%	99%	Max	Skew	SR, p.a.
Strangle/Straddle	1/1	466	0.0167	0.56	-1.72	-0.93	-0.32	-0.09	0.29	1.92	2.85	1.19	0.47
	0.995/1.005	466	0.0136	0.47	-1.40	-0.74	-0.24	-0.09	0.14	1.86	2.78	1.90	0.46
	0.99/1.01	466	-0.0012	0.35	-1.02	-0.48	-0.13	-0.05	-0.01	1.64	2.58	3.14	-0.06
	0.985/1.015	466	-0.0026	0.24	-0.73	-0.31	-0.06	-0.02	-0.01	1.31	2.26	4.97	-0.18
	0.98/1.02	466	-0.0044	0.16	-0.50	-0.23	-0.03	-0.01	-0.00	0.88	1.86	7.10	-0.44
Iron Butterfly/Condor	0.995/1/1.005	466	-0.0031	0.16	-0.24	-0.21	-0.12	-0.07	0.13	0.37	0.39	0.82	-0.31
	0.99/1/1.01	466	-0.0179	0.32	-0.71	-0.60	-0.30	-0.03	0.25	0.62	0.70	0.13	-0.88
	0.98/1/1.02	466	-0.0211	0.49	-1.50	-1.24	-0.30	0.07	0.31	0.85	1.22	-0.61	-0.69
	0.995/0.997/1.003/1.005	466	-0.0027	0.09	-0.14	-0.13	-0.07	-0.04	0.08	0.16	0.17	0.38	-0.49
	0.99/0.995/1.005/1.01	466	-0.0148	0.20	-0.47	-0.42	-0.20	0.05	0.14	0.30	0.37	-0.38	-1.20
	0.98/0.99/1.01/1.02	466	-0.0032	0.24	-0.96	-0.83	0.01	0.04	0.11	0.34	0.53	-1.92	-0.21
Risk Reversal	0.995/1.005	466	-0.0028	0.62	-2.84	-1.90	-0.06	0.01	0.06	1.83	3.52	0.11	-0.07
	0.99/1.01	466	0.0041	0.41	-2.35	-1.39	0.00	0.01	0.03	1.32	3.04	0.51	0.16
	0.985/1.015	466	0.0059	0.27	-1.84	-0.89	0.00	0.01	0.02	0.82	2.54	1.56	0.35
	0.98/1.02	466	0.0093	0.17	-1.32	-0.38	0.00	0.00	0.01	0.32	2.02	3.47	0.88
Bull Call Spread	1/1.005	466	0.0031	0.22	-0.26	-0.23	-0.19	-0.13	0.27	0.34	0.37	0.41	0.23
	1/1.01	466	0.0071	0.36	-0.46	-0.40	-0.27	-0.17	0.27	0.77	0.81	0.82	0.32
	1/1.015	466	0.0069	0.43	-0.61	-0.53	-0.30	-0.18	0.25	1.13	1.21	1.12	0.25
	1/1.02	466	0.0061	0.47	-0.71	-0.61	-0.31	-0.18	0.24	1.47	1.59	1.34	0.20
	0.995/1.005	464	0.0036	0.40	-0.56	-0.55	-0.49	0.04	0.46	0.51	0.53	-0.12	0.14
	0.99/1.01	448	-0.0073	0.66	-1.12	-1.05	-0.61	0.03	0.50	1.01	1.04	-0.11	-0.18
	0.985/1.015	387	-0.0180	0.82	-1.65	-1.55	-0.63	0.03	0.58	1.50	1.52	-0.10	-0.35
	0.98/1.02	326	-0.0280	0.93	-2.05	-2.02	-0.64	0.03	0.57	1.96	2.03	-0.10	-0.48
Call Ratio Spread	1/1.005	466	-0.0023	0.32	-2.89	-1.20	-0.11	0.00	0.17	0.51	0.59	-3.50	-0.11
	1/1.01	466	0.0057	0.34	-2.21	-0.49	-0.22	-0.15	0.21	0.75	0.81	-0.13	0.26
	1/1.015	466	0.0053	0.40	-1.39	-0.43	-0.30	-0.17	0.23	1.13	1.19	1.05	0.21
	1/1.02	466	0.0036	0.45	-0.62	-0.52	-0.31	-0.18	0.24	1.41	1.53	1.32	0.13
	0.995/1.005	464	-0.0019	0.40	-2.69	-0.99	-0.32	0.00	0.32	0.70	0.81	-1.11	-0.08
	0.99/1.01	448	-0.0084	0.61	-1.88	-1.01	-0.57	0.04	0.47	1.07	1.17	-0.14	-0.22
	0.985/1.015	387	-0.0209	0.78	-1.52	-1.50	-0.60	0.02	0.56	1.48	1.56	-0.14	-0.42
	0.98/1.02	326	-0.0326	0.89	-2.01	-1.97	-0.63	0.03	0.56	1.87	1.95	-0.18	-0.58
Bear Put Spread	0.995/1	466	-0.0000	0.22	-0.27	-0.22	-0.18	-0.14	0.28	0.36	0.38	0.62	-0.00
	0.99/1	466	0.0108	0.37	-0.40	-0.38	-0.27	-0.17	0.30	0.79	0.86	0.93	0.46
	0.985/1	466	0.0124	0.46	-0.53	-0.50	-0.31	-0.19	0.26	1.25	1.31	1.23	0.43
	0.98/1	466	0.0150	0.52	-0.64	-0.57	-0.32	-0.20	0.25	1.59	1.75	1.50	0.46
	0.995/1.005	466	-0.0027	0.40	-0.58	-0.51	-0.45	-0.04	0.49	0.55	0.56	0.12	-0.11
	0.99/1.01	442	-0.0066	0.66	-1.04	-1.01	-0.52	-0.06	0.57	1.06	1.12	0.13	-0.16
	0.985/1.015	414	-0.0156	0.80	-1.52	-1.50	-0.57	-0.10	0.55	1.54	1.65	0.19	-0.31
	0.98/1.02	390	-0.0291	0.86	-2.03	-1.97	-0.56	-0.11	0.48	2.02	2.05	0.23	-0.54
Put Ratio Spread	0.995/1	466	-0.0082	0.32	-2.22	-1.34	-0.08	0.00	0.14	0.48	0.61	-2.92	-0.41
	0.99/1	466	0.0134	0.33	-1.52	-0.55	-0.19	-0.14	0.19	0.80	0.97	0.61	0.64
	0.985/1	466	0.0167	0.41	-0.70	-0.37	-0.27	-0.18	0.26	1.15	1.27	1.23	0.64
	0.98/1	466	0.0218	0.49	-0.48	-0.47	-0.31	-0.19	0.25	1.54	1.75	1.49	0.71
	0.995/1.005	466	-0.0109	0.38	-2.00	-1.12	-0.27	-0.04	0.28	0.68	0.81	-0.73	-0.46
	0.99/1.01	442	-0.0039	0.59	-1.16	-0.98	-0.47	-0.02	0.42	1.16	1.40	0.17	-0.10
	0.985/1.015	414	-0.0115	0.75	-1.49	-1.46	-0.53	-0.07	0.52	1.54	1.64	0.11	-0.24
	0.98/1.02	390	-0.0207	0.84	-2.00	-1.89	-0.55	-0.09	0.49	1.98	2.24	0.19	-0.39

Table A4: 0DTE Static Option Strategies Performance. The table shows the summary statistics for the holding period returns of several well-known option strategies based on 0DTE call and put options; positions are taken at 10:00 ET and held to expiry at 16:00 ET. The statistics are based on option strategies' realized profit per one unit of underlying relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. The SR, p.a. is the Sharpe Ratio annualized by scaling it up by $\sqrt{252}$. The sample period is from 01/2022 to 12/2023.

Strategy	Moneyness	Count	Mean	Volatility	Min	1%	25%	50%	75%	99%	Max	Skew	SR, p.a.
Strangle/Straddle	1/1	256	-0.0010	0.41	-1.19	-0.68	-0.27	-0.09	0.23	1.21	1.78	1.04	-0.04
	0.995/1.005	256	0.0007	0.30	-0.84	-0.47	-0.14	-0.08	0.05	1.08	1.63	2.03	0.04
	0.99/1.01	256	-0.0120	0.17	-0.53	-0.32	-0.06	-0.02	-0.01	0.74	1.26	3.61	-1.11
	0.985/1.015	256	-0.0103	0.08	-0.32	-0.19	-0.02	-0.01	-0.00	0.32	0.79	5.16	-2.04
	0.98/1.02	256	-0.0082	0.03	-0.19	-0.12	-0.01	-0.00	-0.00	-0.00	0.30	2.94	-4.67
Iron Butterfly/Condor	0.995/1/1.005	256	0.0017	0.17	-0.24	-0.23	-0.14	-0.05	0.16	0.35	0.37	0.50	0.16
	0.99/1/1.01	256	-0.0110	0.31	-0.71	-0.65	-0.27	0.02	0.24	0.52	0.66	-0.26	-0.56
	0.98/1/1.02	256	-0.0072	0.41	-1.50	-1.22	-0.23	0.08	0.26	0.66	1.00	-1.00	-0.28
	0.995/0.997/1.003/1.005	256	0.0000	0.09	-0.14	-0.14	-0.09	0.00	0.08	0.14	0.17	-0.00	0.00
	0.99/0.995/1.005/1.01	256	-0.0127	0.18	-0.47	-0.44	-0.12	0.05	0.10	0.24	0.31	-0.95	-1.13
	0.98/0.99/1.01/1.02	256	0.0038	0.16	-0.96	-0.76	0.01	0.02	0.05	0.22	0.34	-3.66	0.38
Risk Reversal	0.995/1.005	256	0.0167	0.36	-1.79	-1.17	-0.00	0.01	0.03	1.21	1.45	-0.32	0.73
	0.99/1.01	256	0.0095	0.18	-1.29	-0.67	0.00	0.01	0.02	0.70	0.96	-1.10	0.84
	0.985/1.015	256	0.0045	0.08	-0.80	-0.17	0.00	0.00	0.01	0.19	0.44	-4.20	0.93
	0.98/1.02	256	0.0023	0.02	-0.30	-0.00	0.00	0.00	0.00	0.03	0.05	-14.24	1.86
Bull Call Spread	1/1.005	256	0.0068	0.21	-0.23	-0.22	-0.17	-0.12	0.26	0.35	0.37	0.53	0.52
	1/1.01	256	0.0167	0.33	-0.40	-0.36	-0.22	-0.15	0.20	0.80	0.84	1.03	0.82
	1/1.015	256	0.0185	0.37	-0.53	-0.43	-0.23	-0.15	0.19	1.14	1.21	1.35	0.79
	1/1.02	256	0.0184	0.39	-0.60	-0.47	-0.23	-0.15	0.19	1.38	1.52	1.53	0.76
	0.995/1.005	254	0.0151	0.38	-0.55	-0.54	-0.36	0.03	0.41	0.51	0.52	-0.14	0.63
	0.99/1.01	235	0.0195	0.58	-1.04	-1.02	-0.34	0.03	0.44	1.01	1.03	-0.12	0.54
	0.985/1.015	187	0.0250	0.66	-1.53	-1.51	-0.39	0.02	0.45	1.50	1.51	-0.05	0.60
	0.98/1.02	150	0.0300	0.69	-1.80	-1.57	-0.38	0.02	0.40	1.84	1.90	0.17	0.69
Call Ratio Spread	1/1.005	256	-0.0019	0.20	-0.93	-0.77	-0.11	-0.06	0.14	0.43	0.50	-0.72	-0.15
	1/1.01	256	0.0180	0.30	-0.27	-0.26	-0.21	-0.14	0.17	0.75	0.82	1.10	0.96
	1/1.015	256	0.0214	0.36	-0.40	-0.36	-0.23	-0.15	0.20	1.07	1.19	1.29	0.95
	1/1.02	256	0.0214	0.39	-0.53	-0.44	-0.23	-0.15	0.19	1.38	1.53	1.56	0.88
	0.995/1.005	254	0.0062	0.33	-0.74	-0.59	-0.32	0.02	0.29	0.62	0.68	-0.10	0.30
	0.99/1.01	235	0.0216	0.55	-1.02	-1.01	-0.34	0.06	0.42	1.02	1.11	-0.17	0.62
	0.985/1.015	187	0.0278	0.65	-1.51	-1.49	-0.38	0.03	0.48	1.42	1.56	-0.11	0.68
	0.98/1.02	150	0.0339	0.70	-1.80	-1.53	-0.38	0.03	0.41	1.85	1.92	0.18	0.77
Bear Put Spread	0.995/1	256	-0.0085	0.20	-0.27	-0.21	-0.16	-0.13	0.19	0.36	0.38	0.83	-0.66
	0.99/1	256	-0.0057	0.32	-0.40	-0.33	-0.22	-0.16	0.13	0.81	0.86	1.28	-0.28
	0.985/1	256	-0.0091	0.37	-0.50	-0.40	-0.24	-0.17	0.12	1.26	1.28	1.65	-0.39
	0.98/1	256	-0.0112	0.39	-0.57	-0.44	-0.24	-0.17	0.12	1.40	1.75	1.91	-0.45
	0.995/1.005	256	-0.0144	0.38	-0.58	-0.52	-0.41	-0.03	0.36	0.54	0.56	0.14	-0.61
	0.99/1.01	235	-0.0435	0.57	-1.03	-1.01	-0.43	-0.09	0.32	1.02	1.04	0.15	-1.21
	0.985/1.015	220	-0.0670	0.64	-1.51	-1.50	-0.44	-0.11	0.31	1.51	1.52	0.12	-1.67
	0.98/1.02	217	-0.0678	0.65	-1.88	-1.59	-0.44	-0.11	0.30	1.60	2.00	0.17	-1.66
Put Ratio Spread	0.995/1	256	-0.0005	0.21	-1.38	-0.71	-0.09	-0.05	0.10	0.39	0.44	-1.76	-0.04
	0.99/1	256	0.0051	0.29	-0.51	-0.23	-0.19	-0.15	0.13	0.78	0.80	1.33	0.28
	0.985/1	256	-0.0017	0.35	-0.37	-0.33	-0.22	-0.17	0.13	1.18	1.27	1.59	-0.08
	0.98/1	256	-0.0060	0.39	-0.48	-0.41	-0.24	-0.17	0.12	1.35	1.75	1.87	-0.25
	0.995/1.005	256	-0.0065	0.33	-1.20	-0.57	-0.30	-0.02	0.26	0.58	0.65	-0.02	-0.31
	0.99/1.01	235	-0.0312	0.54	-1.02	-0.99	-0.41	-0.06	0.34	1.04	1.16	0.12	-0.92
	0.985/1.015	220	-0.0581	0.63	-1.49	-1.46	-0.43	-0.10	0.34	1.45	1.56	0.07	-1.48
	0.98/1.02	217	-0.0623	0.65	-1.85	-1.58	-0.43	-0.10	0.31	1.66	2.00	0.14	-1.53

Table A5: 0DTE Static Option Strategies Performance. The table shows the summary statistics for the holding period returns of several well-known option strategies based on 0DTE call and put options; positions are taken at 10:00 ET and held to expiry at 16:00 ET. The statistics are based on option strategies' realized profit per one unit of underlying relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. The SR, p.a. is the Sharpe Ratio annualized by scaling it up by $\sqrt{252}$. The sample period is from 01/2023 to January 11, 2024.

A.3 Conditional Trading Rules

	Strangle	Irons	R/Reversal	C/Spread	C/R/Spread	P/Spread	P/R/Spread
Panel A. Realized Variance							
RV	0.012	-0.003***	0.008	0.002	-0.008	0.001	-0.000
	(1.410)	(-2.802)	(0.857)	(0.559)	(-1.156)	(0.312)	(-0.086)
Combo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2, Adj.	0.078	0.009	0.031	0.000	0.016	-0.000	-0.001
Obs.	6,341	7,595	5,077	9,065	9,065	8,493	8,493
Panel B. Realized Variance and Skewness							
RV	0.010	-0.004***	-0.006	-0.011**	-0.012**	0.014***	0.006
	(1.437)	(-3.155)	(-1.156)	(-2.575)	(-2.278)	(3.456)	(1.086)
RS	0.015	0.006	0.126***	0.109***	0.037	-0.111***	-0.056**
	(0.563)	(1.308)	(5.111)	(5.327)	(1.253)	(-5.714)	(-2.554)
Combo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2, Adj.	0.086	0.010	0.585	0.241	0.043	0.252	0.066
Obs.	6,341	7,595	5,077	9,065	9,065	8,493	8,493
Panel C. Implied and Realized Variances							
IV	-0.030***	0.015***	-0.016	0.003	0.026***	-0.014*	-0.010
	(-2.661)	(6.240)	(-0.817)	(0.470)	(3.386)	(-1.815)	(-1.278)
RV	0.048***	-0.021***	0.028	-0.003	-0.040***	0.019*	0.012
	(2.725)	(-6.898)	(0.935)	(-0.322)	(-2.707)	(1.684)	(1.349)
Combo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2, Adj.	0.154	0.037	0.050	0.000	0.048	0.009	0.004
Obs.	6,336	7,589	5,073	9,057	9,057	8,485	8,485
Panel D Implied and Realized Variances and Skewness							
IV	-0.025**	0.015***	-0.004	0.010	0.023***	-0.020***	-0.012
	(-2.284)	(5.979)	(-0.617)	(1.640)	(2.983)	(-3.437)	(-1.377)
IS	-0.083***	0.011*	-0.081***	0.018	0.100***	-0.024	-0.023
	(-3.660)	(1.953)	(-5.341)	(0.863)	(3.220)	(-1.102)	(-1.095)
RV	0.038***	-0.022***	-0.004	-0.023**	-0.038***	0.039***	0.021*
	(3.010)	(-6.186)	(-0.572)	(-2.302)	(-3.215)	(3.786)	(1.685)
RS	-0.006	0.012***	0.111***	0.110***	0.056***	-0.120***	-0.062***
	(-0.444)	(3.013)	(8.666)	(5.392)	(2.980)	(-5.548)	(-2.613)
Combo FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2, Adj.	0.246	0.046	0.662	0.241	0.142	0.280	0.080
Obs.	6,336	7,589	5,073	9,057	9,057	8,485	8,485

Table A6: Option Strategies PNL vs. Implied and Realized Moments. The table shows the results of regressing realized PNL of option strategies (15:00 ET to expiry at 16:00 ET) on implied and realized distribution moments. PNL is specified per one unit of underlying relative to underlying price $(payoff - mid\ price)/underlying\ price \times 100\%$. The result in each column is based on a pooled regression of strategy PNL for several moneyness combinations (see Table 1 for a list), including combo fixed effects (Combo FE). The sample period is from 09/2016 to January 11, 2024.

B Conditional Trading Rules

B.1 Failed Approaches

Before we get to a systematic analysis, we start from a quick description of failures.

Clustering of strategy PNL/ Classification. The first approach we tried was a combination of clustering of PNL of a particular strategy in random test samples and classification algorithms aiming to predict a particular cluster. We performed clustering either using algorithms like `KMeans` or applying a manual split into positives and negatives, terciles, quartiles, etc. In the second step we started from a simple Logictic regression (for a binary split), the used forest-based algorithms (boosted trees `XGBClassifier`, and random forest `RandomForestClassifier`) to classify data into clusters, and also a multi-layer feed-forward neural network with ReLU activation and the output layer with a softmax activation, suitable for multi-class classification. For conditioning we used a set of variables based on SPX, SPX options, VIX, and VVIX, including the last day and last hour returns scaled by the respective standard deviation of returns (from 1-minute bars), last day and last hour variances of returns, current VIX and VVIX levels (lagged by 1 minute to avoid look-ahead bias), implied volatility surface up and down slopes, estimated from interpolated data on SPX options with today's expiration date. The results look promising on the training set, and quite disappointing on the testing and validation sets. Typically, we end up classifying most of the observations into one cluster, and the others get very low precision and recall scores. Neural network showed the best results, and it can be a good direction to try further, especially with the recurrent flavors.[9]

Factor Analysis using Instrumented Principal Component Analysis (IPCA). The next approach we tried was inspired by the application of IPCA (Kelly, Pruitt, and Su 2017) to explaining option returns by Büchner and Kelly (2022).[10] Büchner and Kelly extracted systematic factors from a panel of delta-hedged index option payoffs (relative to underlying, same as we do), with multiple strike levels and maturities, using as instruments various option Greeks and time to expiration. Our setup is different in two aspects: First, we use unhedged payoffs, i.e., betting on both direction and volatility; and second, we work with very short-term options only, i.e., do not have a time-to-expiration dimension. As instruments we used first a set of Greeks, and then a grid of strategy payoffs for simulated moves in the underlying index modeled as number of sigmas times today's implied variance to option expiry. The results for the Greeks are weaker than for the second set of instruments; however, both work well only in the in-sample exercises. Out-of-sample fit is barely positive.

[9] We will include the specifications and the results of the analysis later on.

[10] We appreciate being able to use the IPCA package available on `https://bkelly-lab.github.io/ipca/`.