

Trading S&P 500[®] (SPX[®] and XSPSM) Options Around-the-Clock with Everyday Expirations

Wednesday, Dec. 14, 2022, 12:00 PM Noon ET



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Manager and
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- **Expected Relationships:** Expected relationships with other financial indicators or financial products may not hold. In particular:
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- Index and benchmark values for the period prior to an index’s launch date are calculated by a theoretical approach involving back-testing historical data in accordance with the methodology in place on the launch date (unless otherwise stated). A limitation of back-testing is that it reflects the theoretical application of the index or benchmark methodology and selection of the index’s constituents in hindsight. Back-testing may not result in performance commensurate with prospective application of a methodology, especially during periods of high economic stress in which adjustments might be made. No back-tested approach can completely account for the impact of decisions that might have been made if calculations were made at the same time as the underlying market conditions occurred. There are numerous factors related to markets that cannot be, and have not been, accounted for in the preparation of back-tested index and benchmark information.

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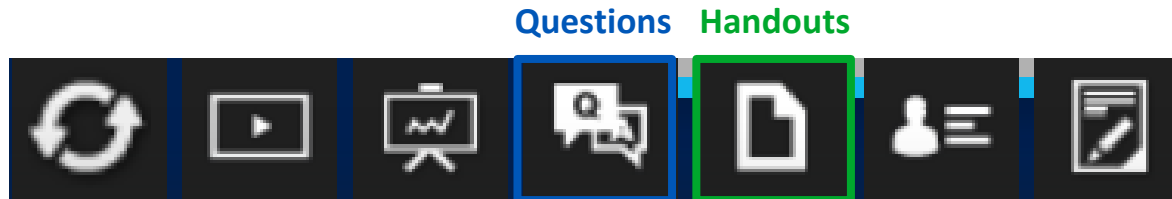
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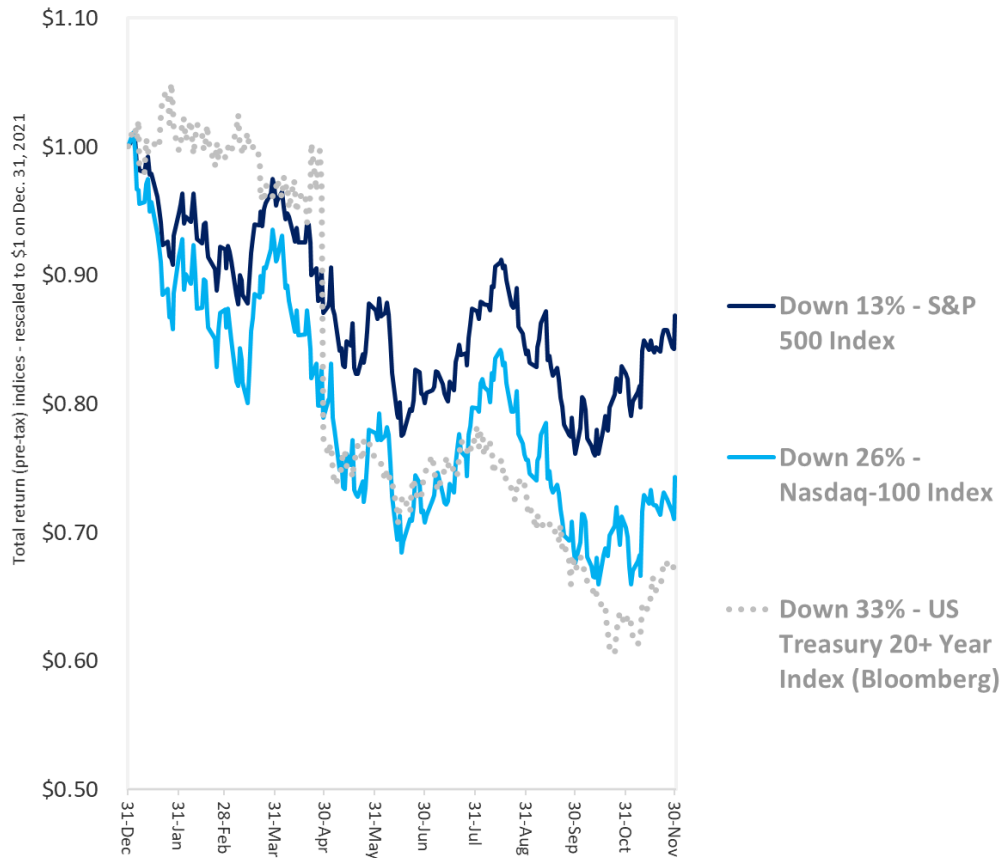
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Today's Topics

- New Global Trading Hours (GTH) for Mini-SPX (XSPSM) Options
- Largest Gains for the S&P 500[®] Index During Global Trading Hours
- More Flexibility for Options Strategies with 5-Days-a-Week Expirations for both SPX[®] and Mini-SPX (XSP) Options
- Recent Record Average Daily Volume (ADV) of 1.9 Million for Short-Dated S&P 500 Options (with Expirations in 0 to 7 Days)
- Recent Record ADV of 54,000 for S&P 500 Options During Global Trading Hours

Challenges for Investors in 2022

Stock & Bond Indices in 2022 (through November)



(Dec. 31, 2021 - Nov. 30, 2022) Past performance is not predictive of future returns.

Source: Cboe Global Markets

Headlines:

Stocks and Bonds Are Falling in Lockstep at Pace Unseen in Decades
WSJ (May 3, 2022)

It's the Worst Bond Market Since 1842
WSJ (May 6, 2022)

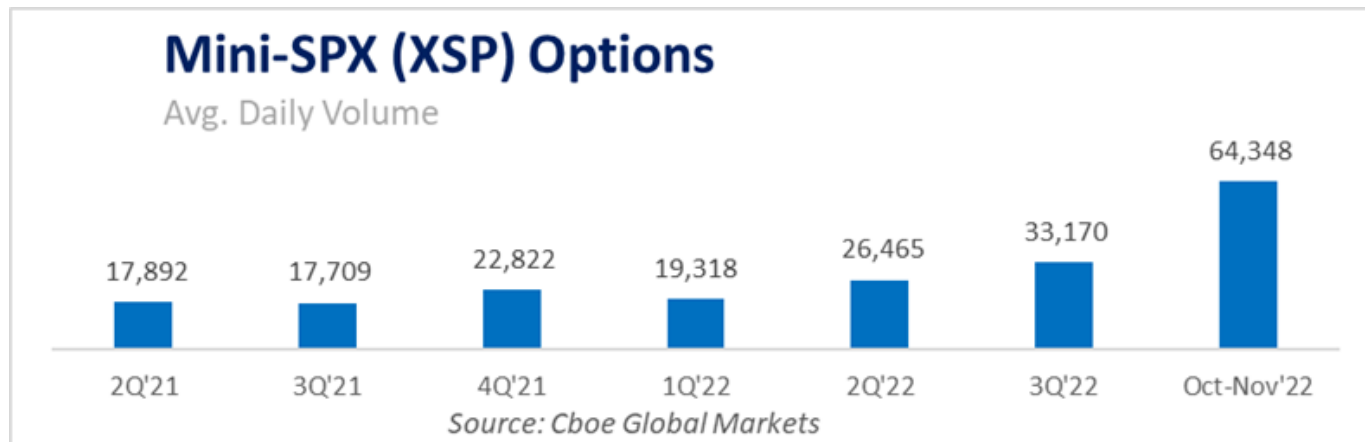
The 60/40 Portfolio Is Having Its Worst Year Ever
Barron's (May 13, 2022)

Bond Slide Deepens, With No End in Sight
WSJ (June 14, 2022)

Investors Face 2 Serious Headwinds As Stocks And Bonds Perform Poorly In 2022
Forbes (Sept. 14, 2022)

This classic investment strategy is on track for its 'worst year ever'
CNBC.com (Oct. 3, 2022)

Mini-SPX (XSP) Index Options



233%
growth in XSP
ADV from
1Q'22 to Oct-
Nov 2022

Q – Why do certain investors use Mini-SPX (XSP) index options?



Cash Settled & European Exercise

Account credited/debited in cash, not ETF shares and no risk of early assignment.



60/40 Tax Treatment

Capital gains may benefit from 60/40 tax treatment.*



Mini Contract

Mini-SPX is 1/10th the size of the standard contract.



Covered Margin Treatment

Receive covered margin treatment on SPY or IVV ETF holdings.**

*Under section 1256 of the Tax Code, profit and loss on transactions in certain exchange-traded options, including SPX and XSP Options, are entitled to be taxed at a rate equal to 60% long-term and 40% short-term capital gain or loss, provided that the investor involved and the strategy employed satisfy the criteria of the Tax Code. Investors should consult with their tax advisors to determine how the profit and loss on any particular option strategy will be taxed. Tax laws and regulations change from time to time and may be subject to varying interpretations. **Cboe Regulatory Circular RG15-183 notes that Cboe rules allow a short position in a cash-settled-index option established and carried in a margin account to receive covered margin treatment if the short option position is offset in the same account by an equivalent or greater position in an index-tracking ETF that is based on the same index that underlies the short option(s) and provided the investor's brokerage firm has such policies in place.

Around-the-Clock Trading – Index Options & Futures



Cboe offers **Global Trading Hours (GTH)** for

- S&P 500® Options, VIX® Index Options, (New) Mini-SPX (XSP) Options
- VIX Index Futures, & Mini VIX (VXMSM) Futures

Trading Hours for SPX, XSP, and VIX Index Options

Time Zone	Global Trading Hours	Regular Trading Hours
Chicago	7:15 PM - 8:15 AM	8:30 AM - 3:15 PM
London*	1:15 AM - 2:15 PM	2:30 PM - 9:15 PM
Hong Kong*	9:15 AM - 10:15 PM	10:30 PM - 5:15 AM
Sydney*	12:15 AM - 1:15 PM	1:30 AM - 8:15 AM

*Trading hours are determined by the time in Chicago. Note that Daylight Saving Time (DST) procedures vary by time zone and will affect the times shown here. For non-U.S. cities shown in this table, the trading hours may shift by one hour as the U.S. changes between Standard Time and Daylight Saving Time.



54,792

ADV during
GTH for S&P
500 opt. in
Oct-Nov 2022

Q – What are some key considerations for investors who wish to trade during Global Trading Hours?

Feb. 24

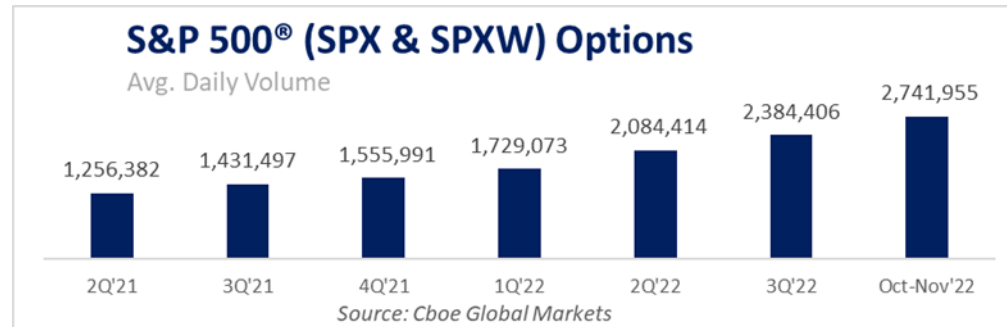
2022 – date on which Russia invaded Ukraine

GTH Volume on Key Dates in 2022 (through Dec. 8th)

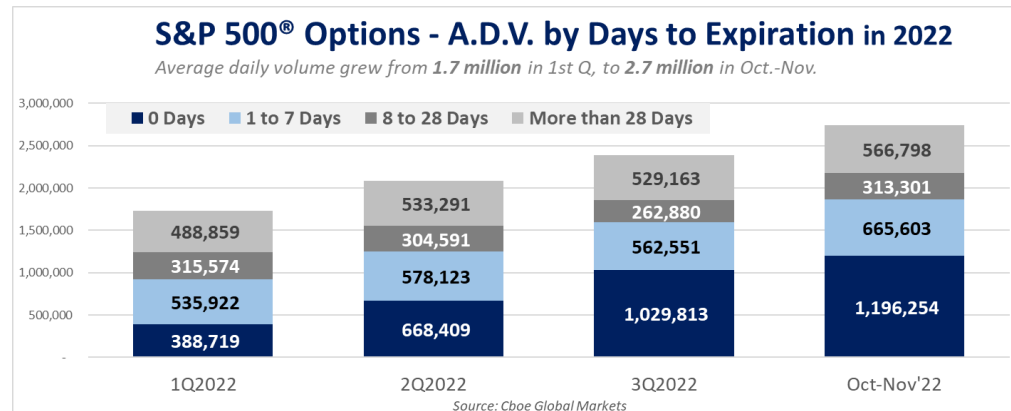
Dates on which the GTH volume for S&P 500 options topped 70,000

		S&P 500 Options in GTH	VIX Index Options in GTH	VIX Index Futures in GTH	Mini-VIX (VXM) Futures in GTH
1	Feb. 24, 2022	70,347	40,863	119,394	13,933
2	Sept. 13, 2022	83,977	5,667	98,861	2,488
3	Sept. 23, 2022	77,162	7,720	79,734	3,154
4	Sept. 28, 2022	70,316	9,691	76,815	5,257
5	Oct. 4, 2022	70,226	4,702	84,037	1,853
6	Oct. 7, 2022	70,588	3,549	56,157	1,937
7	Oct. 13, 2022	136,604	14,994	74,604	3,019
8	Oct. 14, 2022	77,962	8,976	70,974	3,222
9	Oct. 18, 2022	110,724	11,991	70,429	2,491
10	Oct. 24, 2022	74,695	788	49,624	1,239
11	Nov. 4, 2022	71,630	3,153	61,783	1,527
12	Nov. 10, 2022	106,130	17,023	85,534	1,796
13	Nov. 15, 2022	71,578	1,248	59,016	1,300
14	Dec. 1, 2022	73,692	777	48,232	1,358
15	Dec. 2, 2022	93,284	4,811	41,009	1,761
Source: Cboe Global Markets					

S&P 500 (SPX and SPXW) Options

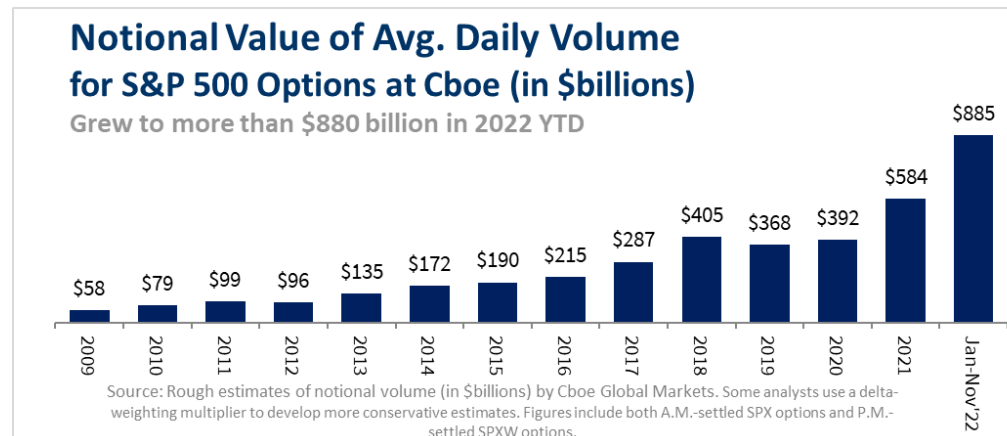


2.74
million ADV
in Oct-Nov 2022



1.86
million ADV
for 0 to 7
short-dated in
Oct-Nov 2022

Q – What are the drivers for the recent growth in S&P 500 options volume?



\$880
Billion
notional
ADV in 2022
YTD

S&P 500 Options – Expirations 5 Days a Week

SPXW Expirations: Cboe introduced:

- **Tuesday**-expiring SPXW options on **April 18, 2022**, and
- **Thursday**-expiring SPXW options on **May 11, 2022**.

With this change, near-term SPXW expirations are available each business day of the week.

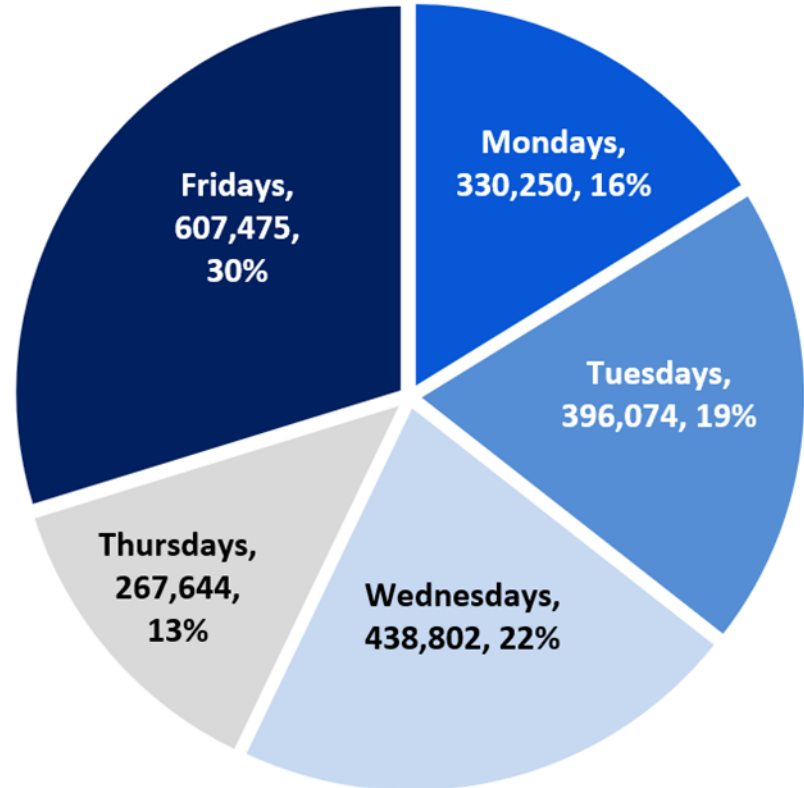
Cboe's Press Release on **April 13, 2022**, noted: *"With more weekly-expiring options, investors can now trade, hedge and express their views with even greater flexibility and precision"*

Q – Why do investors trade options with expirations on different days of the week?

S&P 500® SPXW Options

Avg. Daily Volume (ADV) by Expiration Day in Nov. 2022

Source: Cboe Global Markets



Cboe Webinar “Trading S&P 500 (SPX and XSP) Options Around-the-Clock with Everyday Expirations”

Oleg Bondarenko

Professor of Finance

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December 14, 2022

“Historical Performance of Put-Writing Strategies,” Cboe white paper, 2019

- Analyzes historical performance of two put-writing indices:
 - Cboe S&P 500 PutWrite Index (PUT)
 - Cboe S&P 500 One-Week PutWrite Index (WPUT)
- Compares it to the performance of traditional benchmarks:
 - S&P 500
 - Russell 2000
 - MSCI World
 - 30-year Treasury Bond (FTSE)

as well as the option buying index

- Cboe S&P 500 5% Put Protection Index (PPUT)

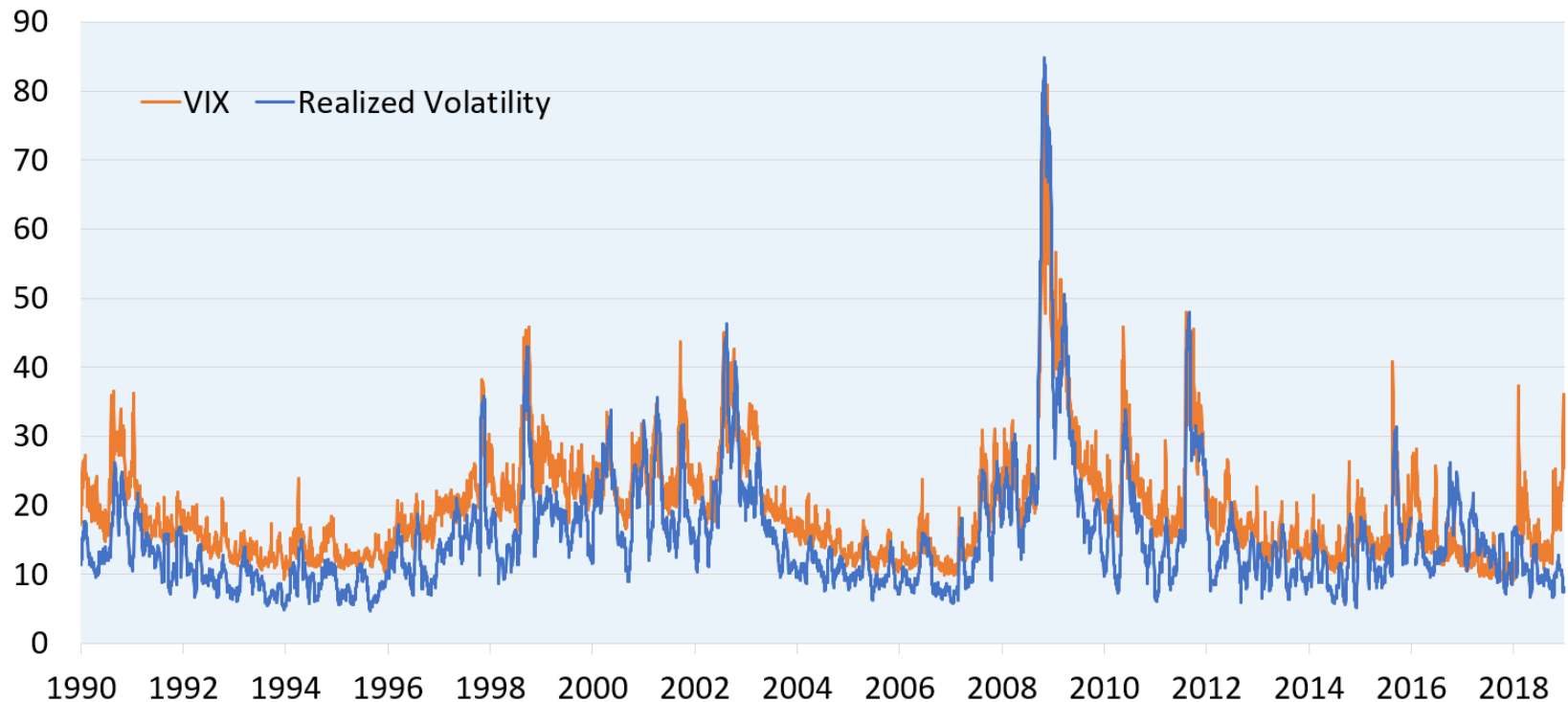
Highlights

- **Long-term performance:** Over 32+ years, PUT outperformed the traditional indices on a risk-adjusted basis. Compared to S&P 500, PUT has a comparable annual compound return, but a substantially lower risk: standard deviation, beta, maximum drawdown, etc.
- **Volatility risk premium:** Since 1990, the option implied volatility (19.3%) has considerably exceeded the realized volatility (15.1%).
- **Lower risk:** Relative to PUT and S&P 500, WPUT has lower risk (standard deviation, beta, and maximum drawdown).
- **Annual premium income:** Since 2006, the average annual gross premium collected is $12 * 1.85\% = 22.1\%$ for PUT and $52 * 0.71 = 37.1\%$ for WPUT.
- **Liquidity:** Trading volume in Weekly S&P 500 options has increased 50+ times over the last 8 years.
- **PUT versus PPUT:** Since 1986, the cumulative return is 1835% for PUT and 708% for PPUT

What is a PUT-Write Strategy?

- A cash-secured put-write strategy systematically sells options collateralized by risk-free investment.
- The Cboe PUT Index tracks the performance of a hypothetical passive strategy that collects option premiums from at-the-money (ATM) puts on S&P 500 Index and holds a rolling money account invested in Treasury bills.
- The strategy attempts to profit from high premiums of index options.

Implied Versus Realized Volatility – Richly Priced S&P 500 Options



VIX and 1-month realized volatility of S&P 500. The period is Jan 1, 1990 to Dec 31, 2018. *Source: Cboe Exchange, Inc.*

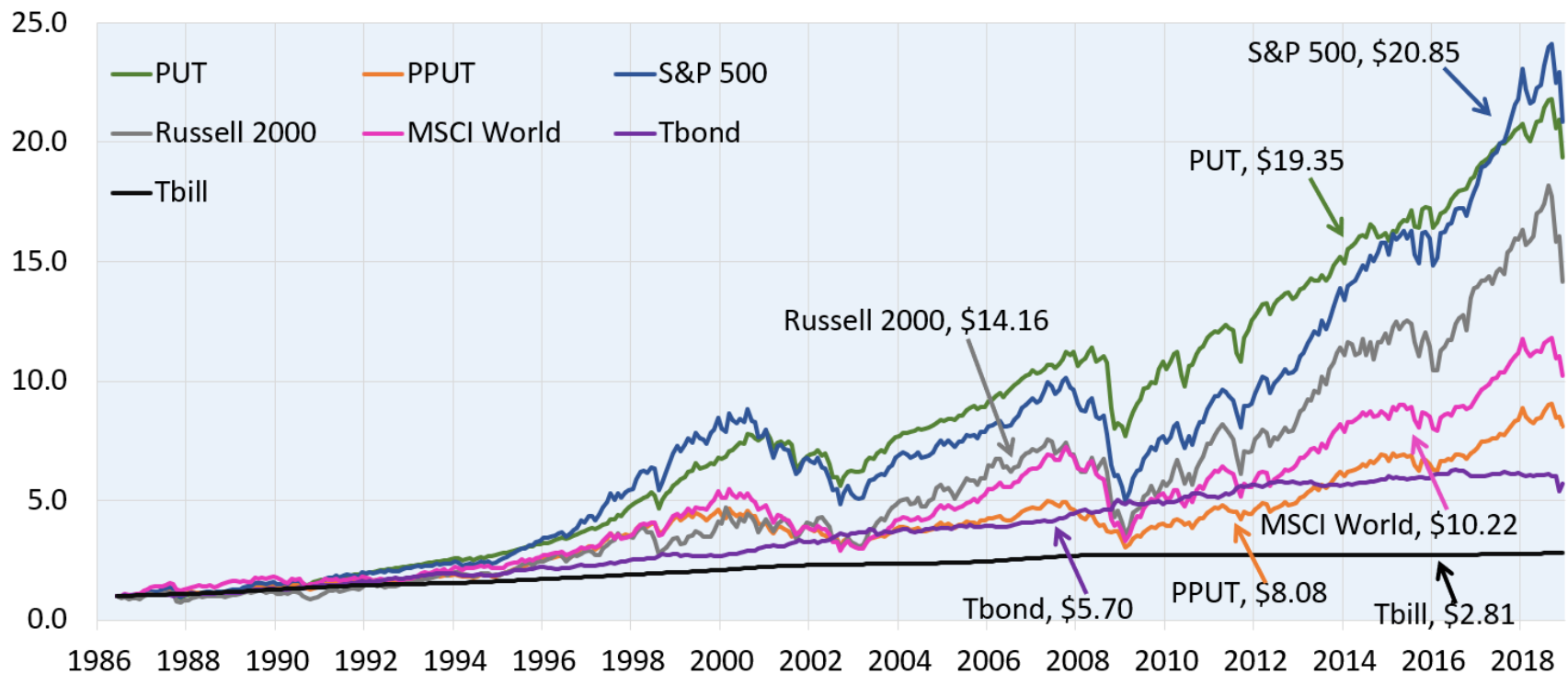
VIX minus Subsequent Realized Volatility - Annual Averages

Year	Implied volatility (VIX)	S&P 500 Realized Volatility
1990	23.1	15.4
1991	18.4	13.6
1992	15.5	9.4
1993	12.7	8.3
1994	13.9	9.5
1995	12.4	8.1
1996	16.4	11.5
1997	22.4	17.6
1998	25.6	18.7
1999	24.4	18.1
2000	23.3	21.6
2001	25.7	19.7
2002	27.3	25.1
2003	22.0	15.7
2004	15.5	11.0
2005	12.8	10.1
2006	12.8	9.4
2007	17.5	15.8
2008	32.7	35.2
2009	31.5	24.1
2010	22.5	16.5
2011	24.2	20.8
2012	17.8	12.6
2013	14.2	10.8
2014	14.2	11.1
2015	16.7	14.3
2016	15.8	11.3
2017	11.1	6.8
2018	16.6	15.9
All	19.3	15.1



VIX minus subsequent 1-month realized volatility of S&P 500. The period is Jan 1, 1990 to Dec 31, 2018. The average difference (4.2) is shown with the horizontal line. *Source: Cboe Exchange, Inc.*

Growth of Benchmark Indices Since Jun 30, 1986

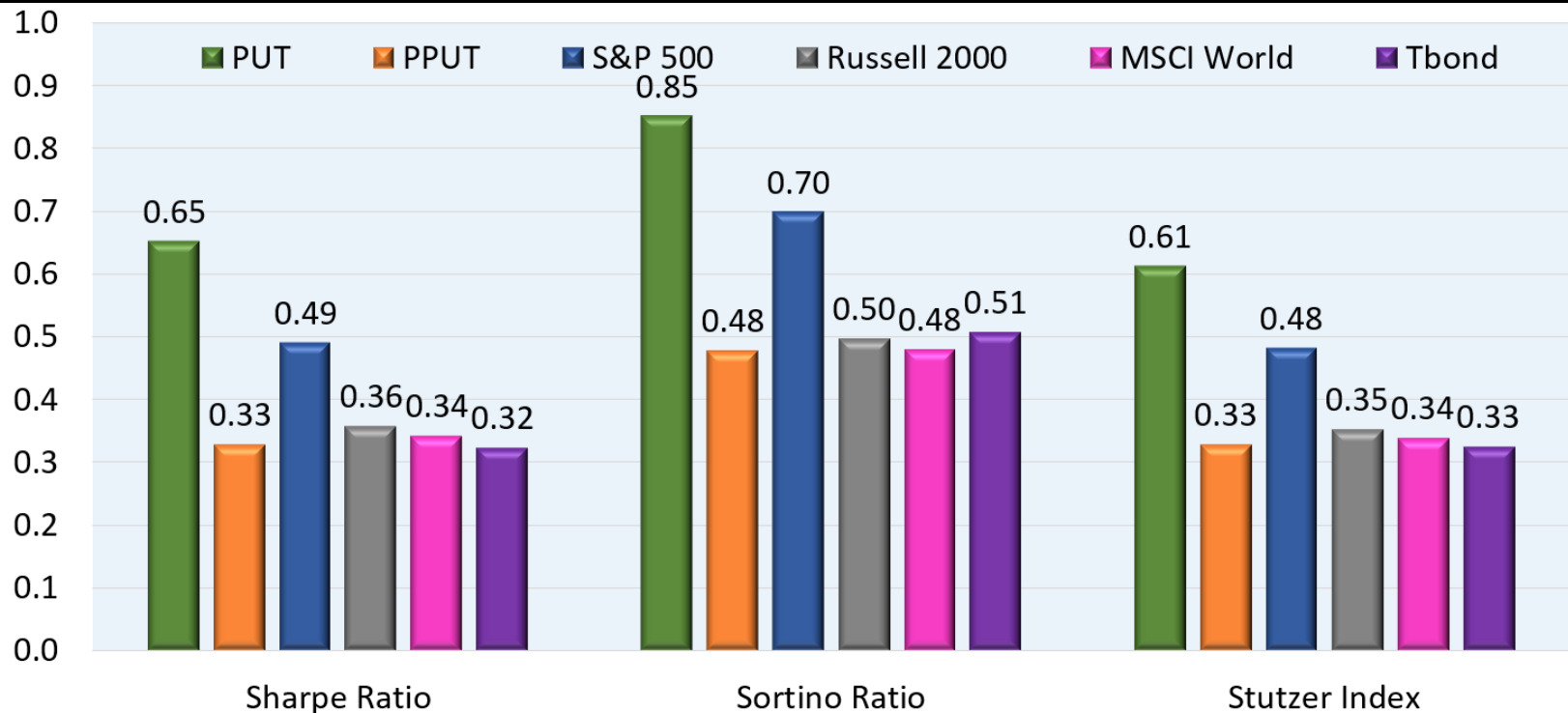


The value of \$1 invested in PUT, PPUT, S&P 500, Russell 2000, MSCI World, 30-year Tbond (FTSE), and 30-day Tbill. The period is from Jun 30, 1986 to Dec 31, 2018. Past performance is not predictive of future returns. Sources: Bloomberg and Cboe Exchange, Inc.

Monthly Statistics (Jun 30, 1986 to Dec 31, 2018)

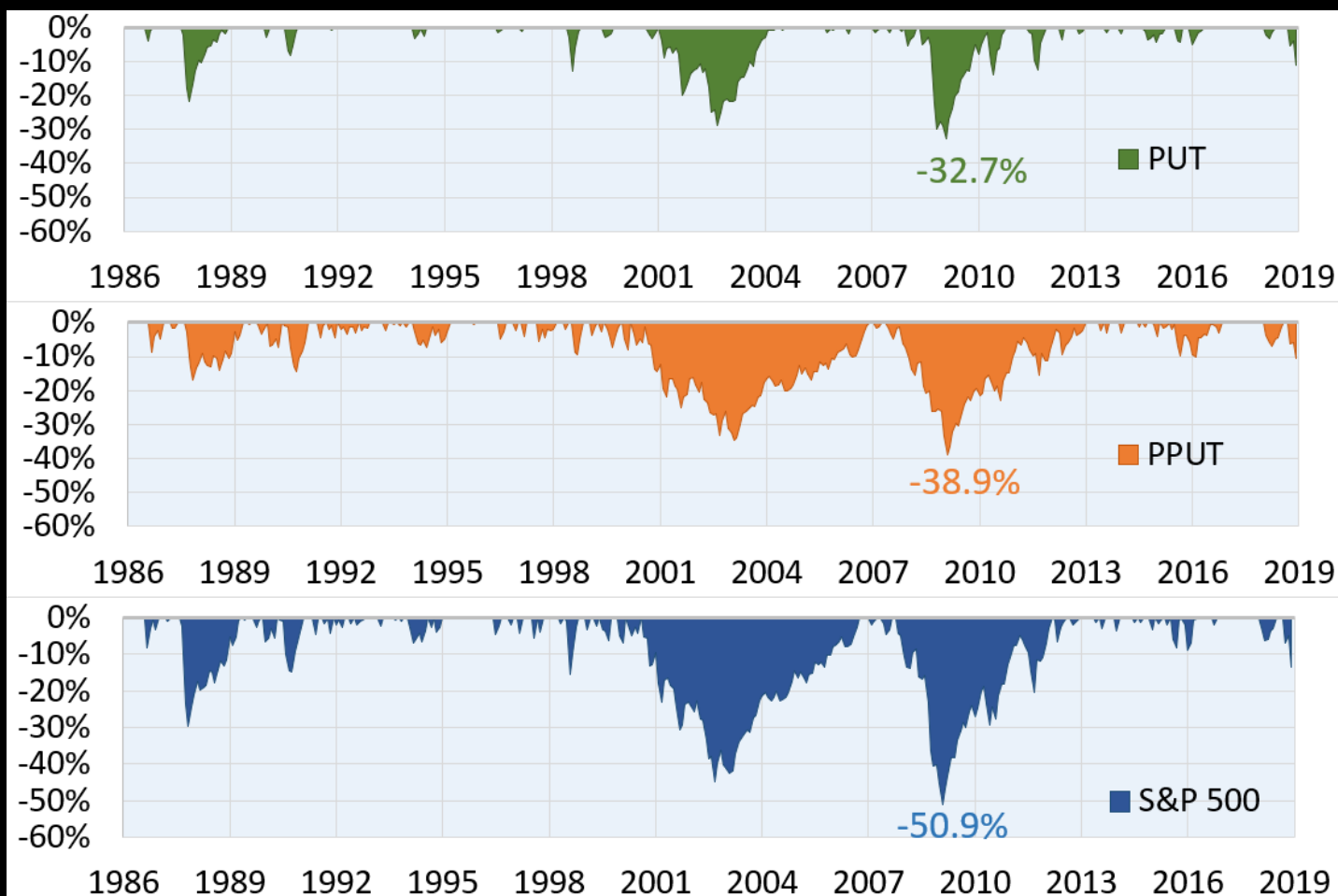
	PUT	PPUT	S&P 500	Russell 2000	MSCI World	30-year Tbond	30-day Tbill
Mean Return	0.81%	0.60%	0.88%	0.84%	0.69%	0.59%	0.27%
Compound Return	<u>0.76%</u>	0.54%	<u>0.78%</u>	0.68%	0.60%	0.53%	0.27%
Min Return	-17.65%	-10.60%	-21.54%	-30.63%	-18.96%	-14.61%	0.00%
Standard Deviation	<u>2.87%</u>	3.49%	<u>4.31%</u>	5.54%	4.31%	3.51%	0.21%
Skewness	-2.09	-0.28	-0.81	-0.88	-0.67	0.25	0.24
Kurtosis	12.58	3.52	5.48	6.07	4.79	5.64	1.87
Alpha	0.20%	-0.12%	0.00%	-0.07%	-0.12%	0.38%	0.00%
Beta	0.56	0.74	1.00	1.06	0.89	-0.08	0.00
Sharpe Ratio	<u>0.19</u>	0.10	<u>0.14</u>	0.10	0.10	0.09	
Sortino Ratio	0.25	0.14	0.20	0.14	0.14	0.15	
Stutzer Index	0.18	0.09	0.14	0.10	0.10	0.09	
M-squared	<u>1.08%</u>	0.68%	<u>0.88%</u>	0.71%	0.69%	0.67%	

Annualized Sharpe Ratio, Sortino Ratio, and Stutzer Index



Annualized Sharpe Ratio, Sortino Ratio, and Stutzer Index for PUT, PPUT, S&P 500, Russell 2000, MSCI World, 30-year Tbond (FTSE). The period is from Jun 30, 1986 to Dec 31, 2018. Sources: Bloomberg and Cboe Exchange, Inc.

Monthly Drawdown for PUT, PPUT, and S&P 500

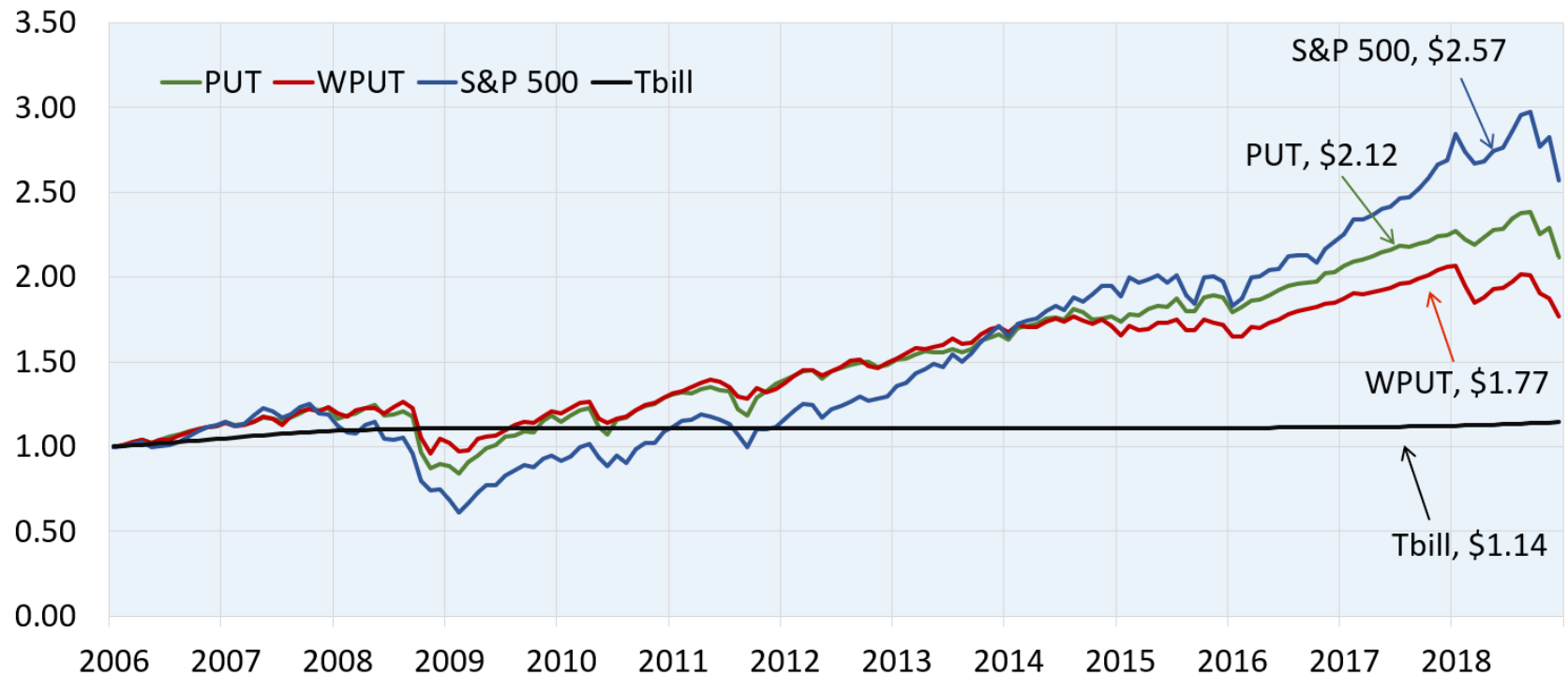


Monthly Drawdown for PUT, WPUT, and S&P 500. The period is from Jun 1986 to Dec 2018. Source: Cboe Exchange, Inc.

Put Writing with Weekly Rollover: WPUT Index

- The Cboe S&P 500 One-Week PutWrite Index (WPUT) was launched in 2015
- Price history available since Jan 31, 2006.
- WPUT extends PUT strategy to weekly S&P 500 options.
- Option premiums are collected weekly, instead of monthly.

Growth of Benchmark Indices Since Jan 31, 2006

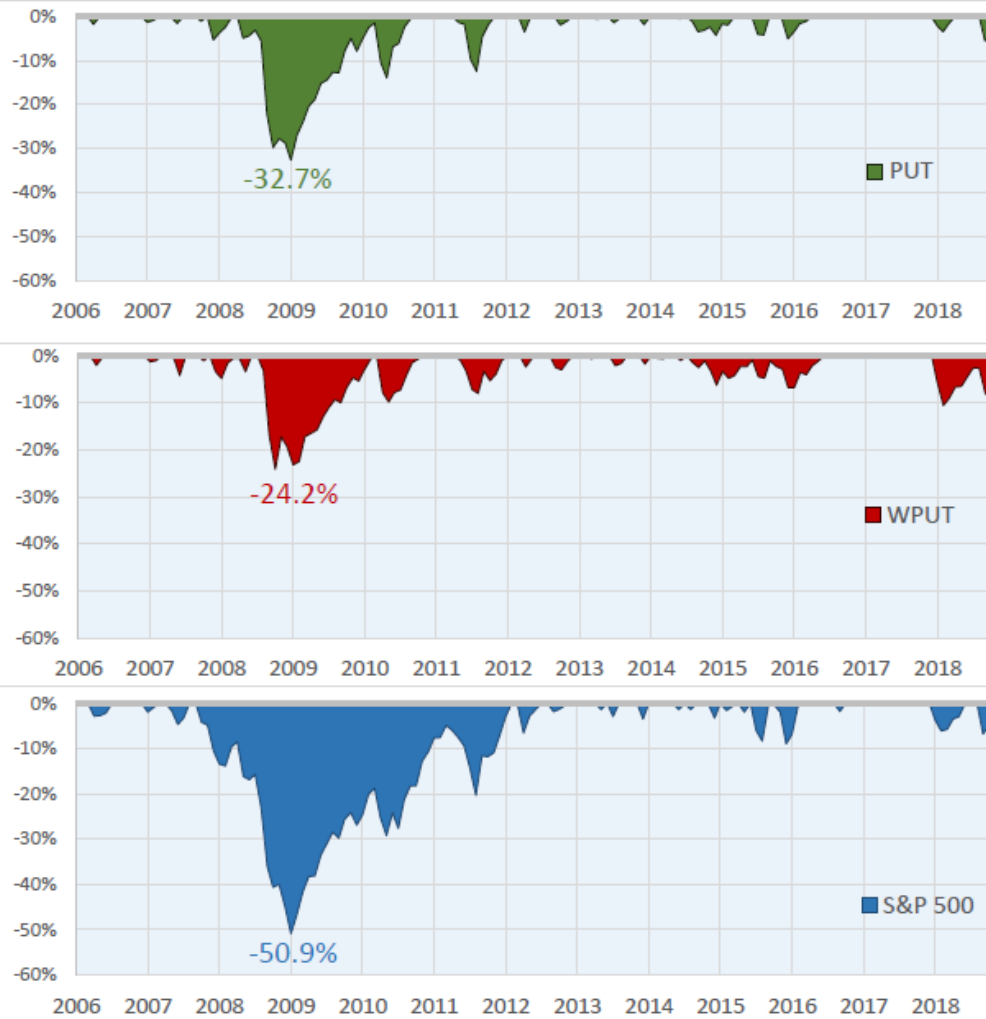


The value of \$1 invested in PUT, WPUT, S&P 500, and 30-day Tbill. The period is from Jan 31, 2006 to Dec 31, 2018. Past performance is not predictive of future returns. *Sources: Bloomberg and Cboe Exchange, Inc.*

Monthly Statistics (Jan 31, 2006 to Dec 31, 2018)

	PUT	WPUT	S&P 500	Russell 2000	MSCI World	30-year Tbond	30-day Tbill
Mean Return	0.53%	0.41%	0.70%	0.66%	0.50%	0.53%	0.09%
Compound Return	0.48%	0.37%	0.61%	0.51%	0.40%	0.45%	0.09%
Min Return	-17.65%	-14.14%	-16.79%	-20.80%	-18.96%	-14.61%	0.00%
Standard Deviation	3.09%	2.74%	4.13%	5.44%	4.38%	4.16%	0.14%
Skewness	-1.84	-1.43	-0.82	-0.57	-0.82	0.53	1.61
Kurtosis	11.63	8.63	4.88	4.33	5.35	5.72	4.18
Alpha	0.05%	-0.01%	0.00%	-0.16%	-0.21%	0.63%	0.00%
Beta	0.65	0.54	1.00	1.19	1.02	-0.31	0.00
Sharpe Ratio	0.14	0.12	0.15	0.10	0.09	0.11	
Sortino Ratio	0.19	0.15	0.21	0.15	0.13	0.18	
Stutzer Index	0.14	0.11	0.15	0.10	0.09	0.11	
M-squared	0.69%	0.57%	0.70%	0.52%	0.48%	0.53%	

Monthly Drawdown for PUT, WPUT, and S&P 500

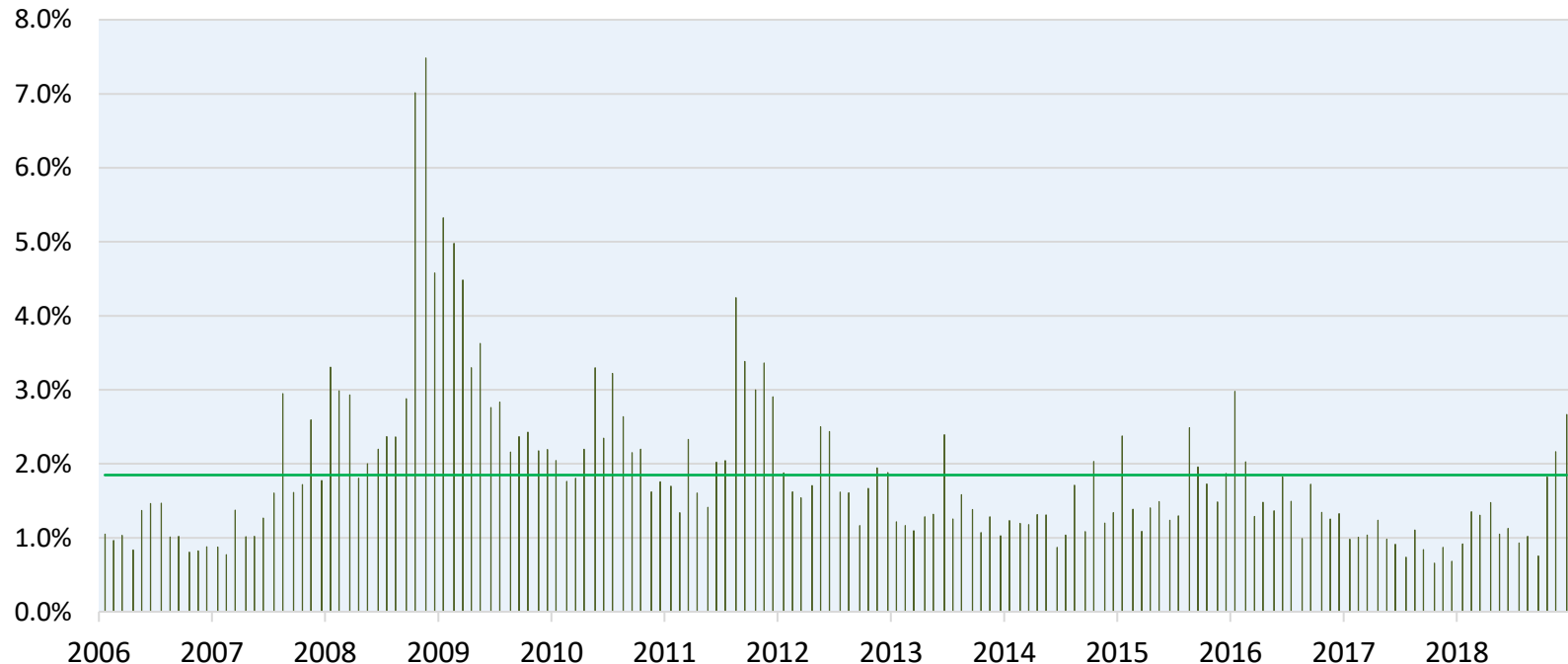


Monthly Drawdown for PUT, WPUT, and S&P 500. The period is from Jan 31, 2006 to Dec 31, 2018.
Sources: Cboe Exchange, Inc.

Sources of Return

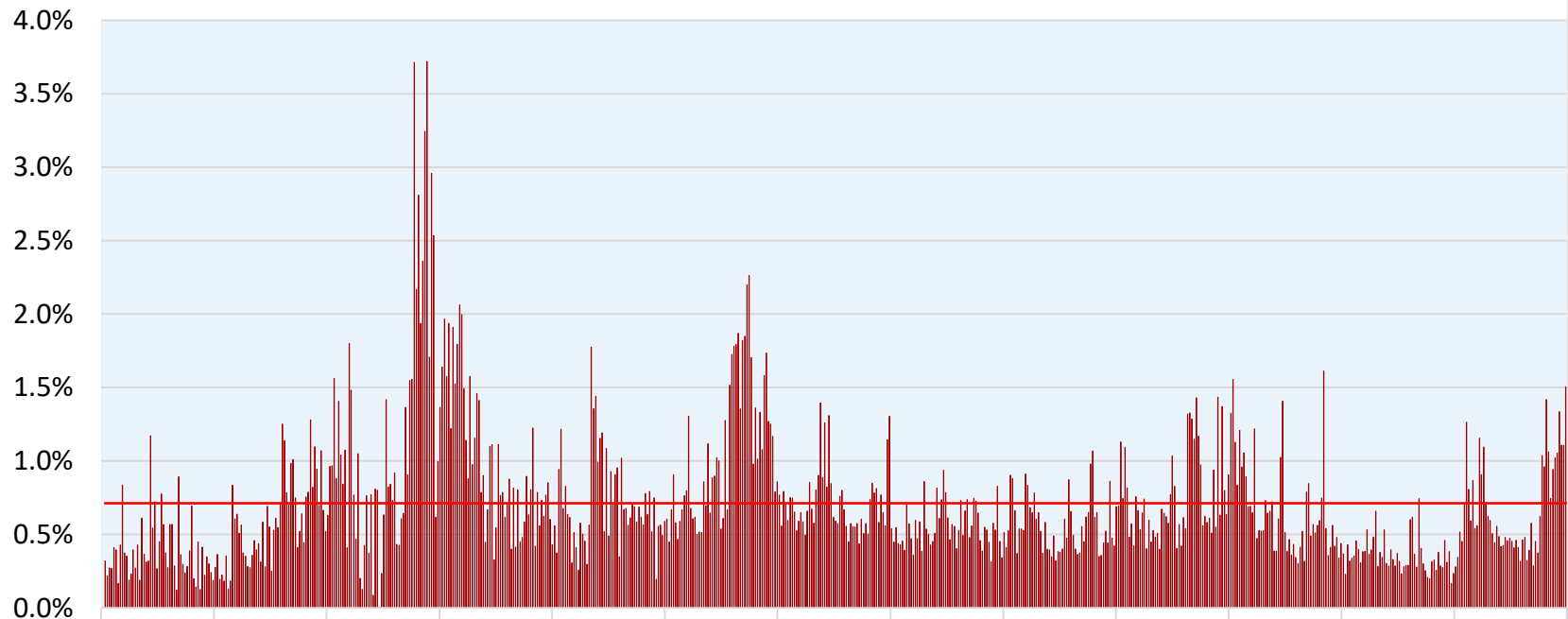
- Selling 1-month ATM puts 12 times a year can produce significant income. Since 2006, the average monthly premium is 1.85%. Annually $12 * 1.85\% = 22.1\%$.
- Selling 1-week ATM puts 52 times a year can produce even higher income. Since 2006, the average weekly premium is 0.71%. Annually $52 * 0.71 = 37.1\%$.
- Intuitively, the premium of ATM put increases as the square root of maturity. Thus, a one-week tenor option rolled over four times per month will approximately generate 2x the premium of a one-month tenor option rolled over once per month ($1/2$ premium times 4).
- Because ATM IVs are typically in **contango**, the factor between 1-month and 1-week option premiums is less than 2.
- Put-write strategies using shorter maturity options can benefit from more frequent resets, which allows to better capture the volatility risk-premium.

PUT Premiums (Jan 31, 2006 to Dec 31, 2018)



PUT monthly premiums earned as a percentage of the underlying value. The period is from Jan 2006 to Dec 2018. The average monthly premium is shown with the horizontal line. Sources: Cboe Exchange, Inc.

WPUT Premiums (Jan 31, 2006 to Dec 31, 2018)



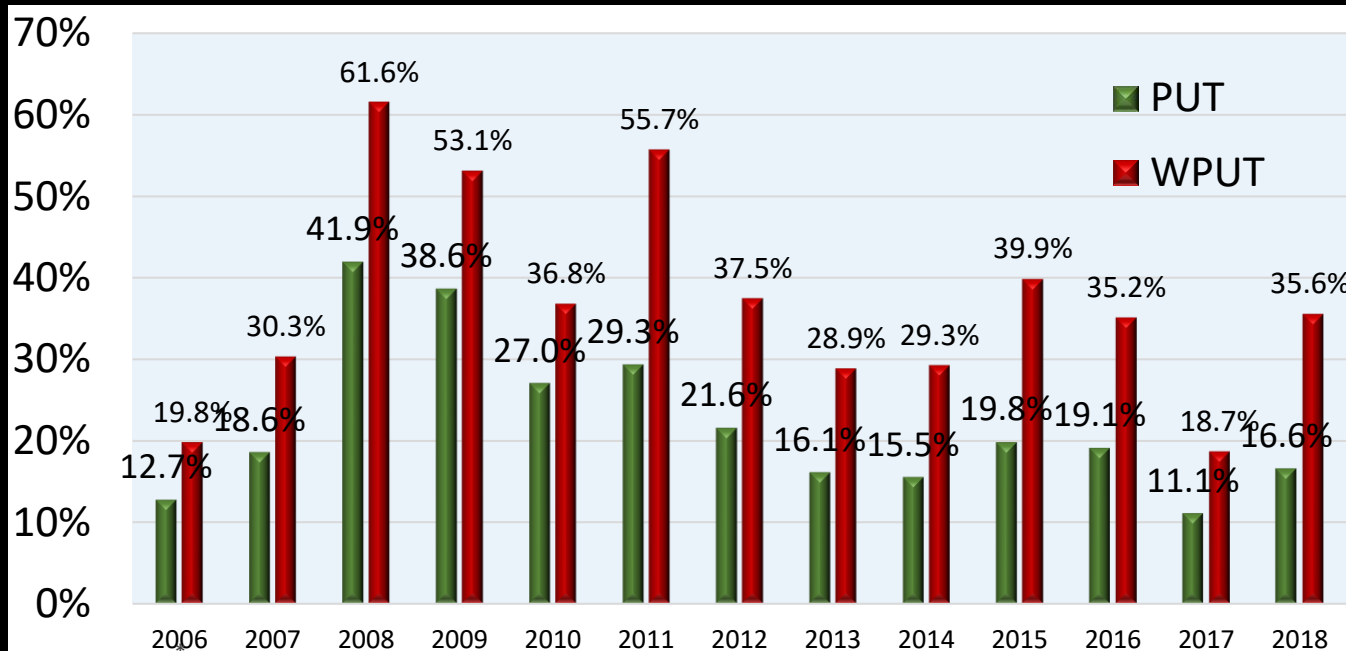
WPUT monthly premiums earned as a percentage of the underlying value. The period is from Jan 31, 2006 to Dec 31, 2018. The average monthly premium is shown with the horizontal line. *Source: Cboe Exchange, Inc.*

PUT and WPUT Aggregate Gross Premiums Received for each Year

From 2006 to 2018, the average annual premium is 22.1% for PUT and 37.1% for WPUT.

The difference between the two is 15.0% annually.

Note: While the gross premiums collected are always positive, the cash-secured put-writing strategy does have downside risk and its net returns can be negative.

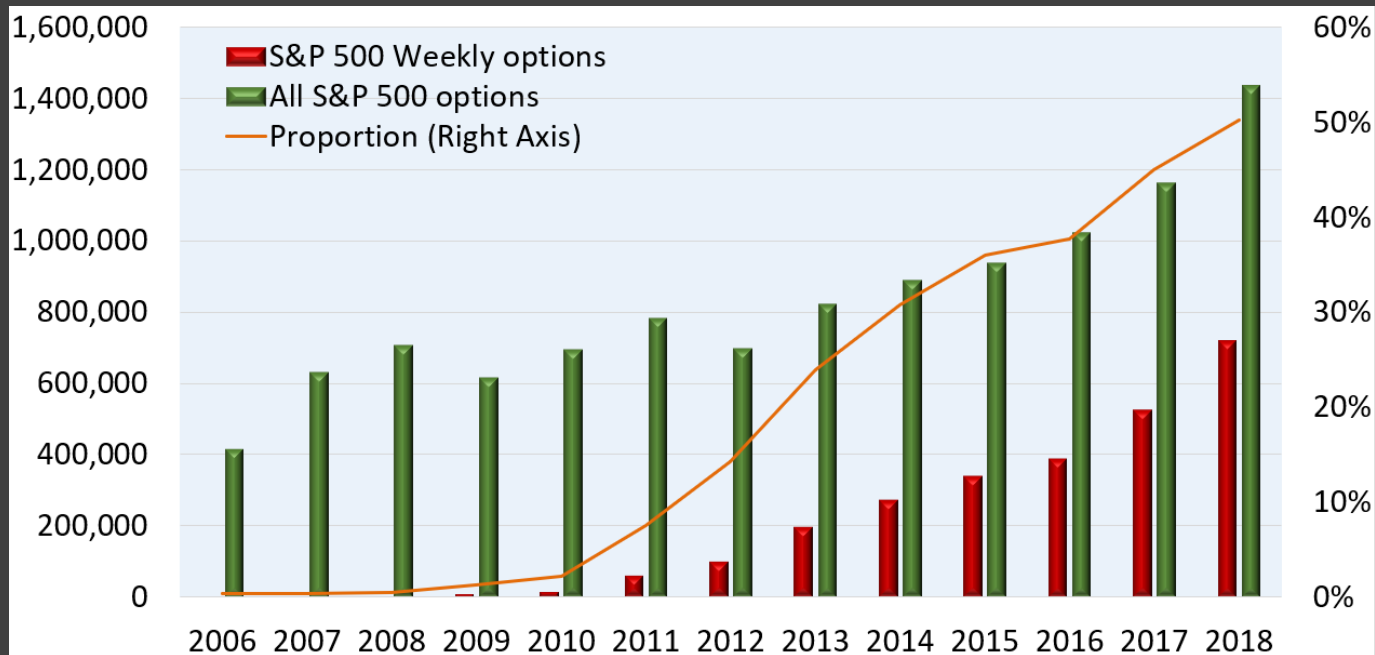


Aggregate gross premiums received by PUT and WPUT strategies for each calendar year. The period is from Jan 31, 2006 to Dec 31, 2018. *Premiums for 2006 are only for 11 months. Sources: Cboe Exchange, Inc.

SPX and SPXW Average Daily Volume for Each Year

Trading volume in SPX Weeklys (SPXW) options has increased more than 50 times over the last 8 years. In 2018, ADV was about 720,000 contracts, or more than 50% of the volume of all S&P 500 options.

In 2018, the notional value of ADV for S&P 500 options was about \$360 billion.



Average daily volume (in contracts) for S&P 500 Weekly options (SPXW) and all SPX options. The orange line shows proportion of SPXW options. The period is from Jan 31, 2006 to Dec 31, 2018. Sources: Cboe Exchange, Inc.

Disclaimer

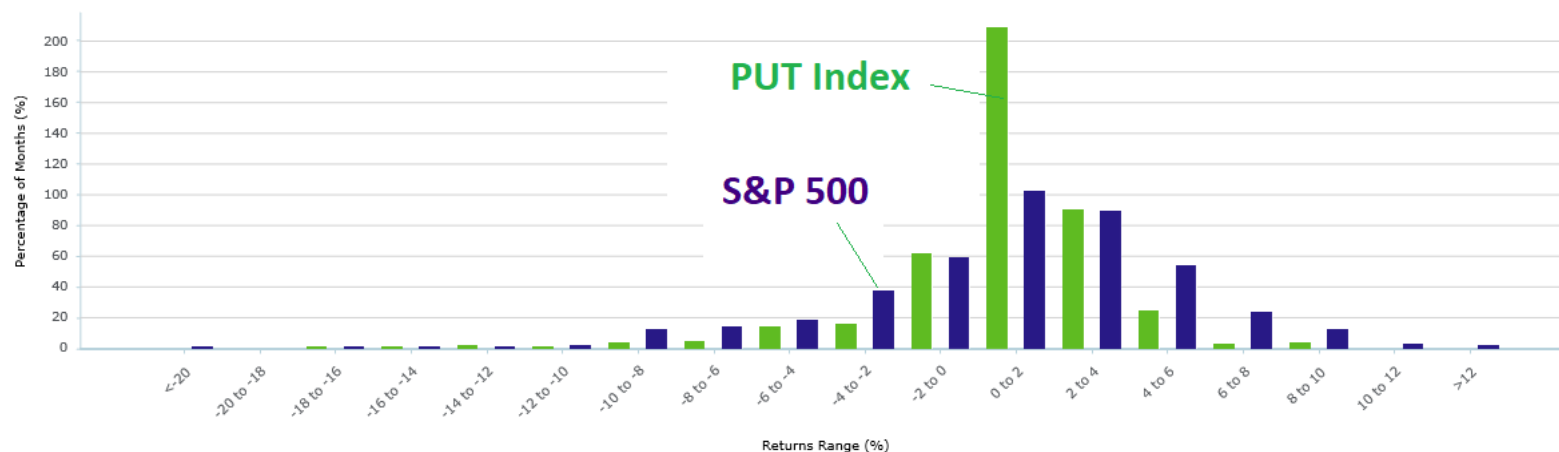
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Past performance does not guarantee future results. This document contains index performance data based on back-testing, i.e., calculations of how the index might have performed prior to launch. Back-tested performance information is purely hypothetical and is provided in this paper solely for informational purposes. Back-tested performance does not represent actual performance and should not be interpreted as an indication of actual performance. No representation is being made that any investment will or is likely to achieve a performance record similar to that shown. It is not possible to invest directly in an index. Cboe calculates and disseminates the Indexes. Supporting documentation for any claims, comparisons, statistics or other technical data in this paper is available from Cboe upon request.

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PUT Index Since Mid-1986

Histogram of Monthly Returns (June 30, 1986 – Nov. 30, 2022)



	SKEWNESS	KURTOSIS	NUMBER OF DOWN PERIODS	AVERAGE NEGATIVE RETURN	DOWNSIDE DEVIATION (MAR = 0.00%)	NUMBER OF UP PERIODS	AVERAGE POSITIVE RETURN	UPSIDE DEVIATION (MAR = 0.00%)
■ PUT - Cboe S&P 500 PutWrite Index	(1.94)	8.38	107	(2.89)	7.61	330	1.98	7.47
■ S&P 500 Index	(0.72)	2.04	150	(3.78)	10.30	287	3.39	11.89

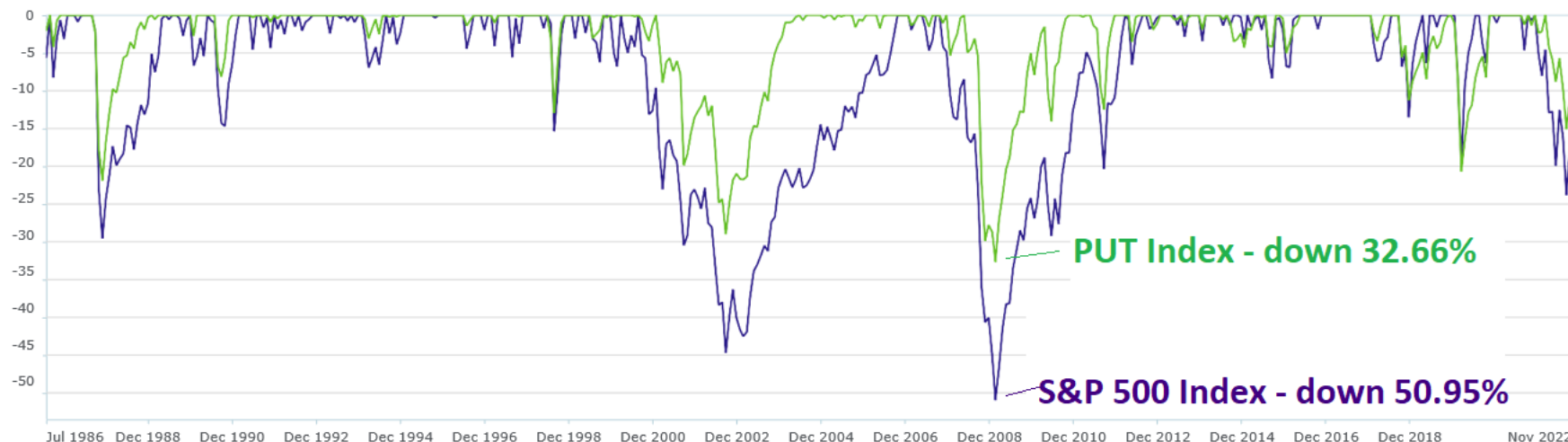
	ANNUALIZED RETURN (%)	STANDARD DEVIATION (%)	MAXIMUM DRAWDOWN LOSS (%)	BETA	SHARPE RATIO	SORTINO RATIO (MAR = CASH EQ.)	TREYNOR RATIO	CUMULATIVE RETURN (%)
■ PUT - Cboe S&P 500 PutWrite Index	9.28	10.31	(32.66)	0.57	0.61	0.80	11.06	2433.27
■ S&P 500 Index	10.37	15.40	(50.95)	1.00	0.48	0.69	7.36	3530.34



Monthly Drawdowns for PUT and S&P 500 Indices



Monthly Drawdowns (July 1986 – Nov. 2022)



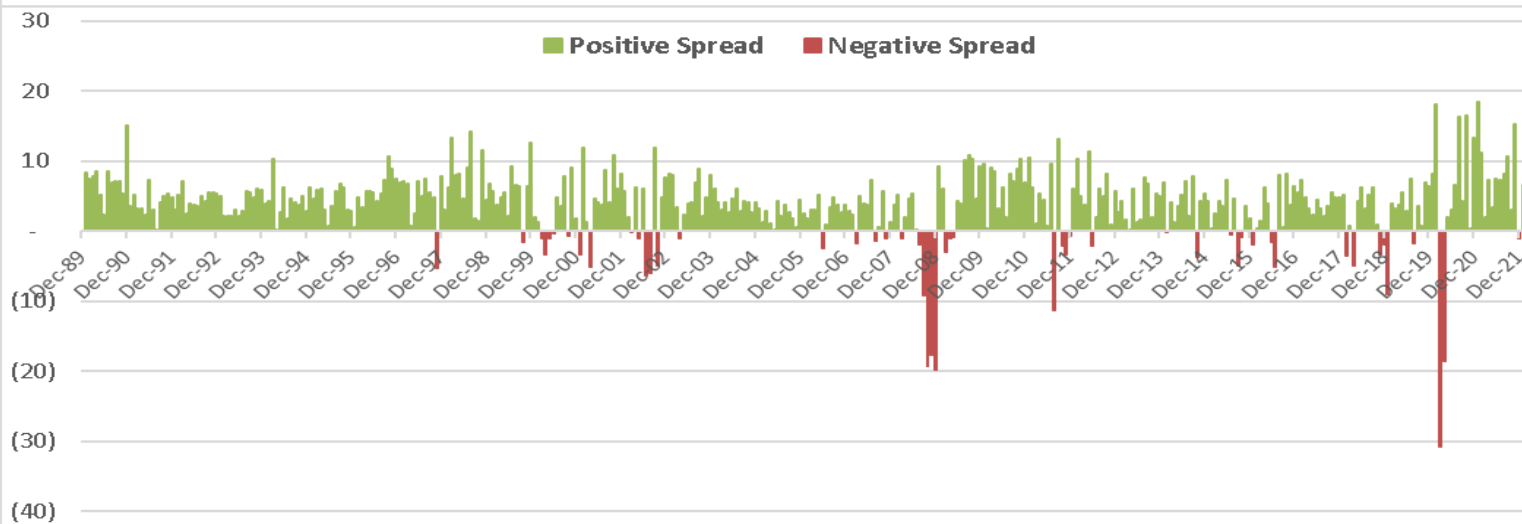
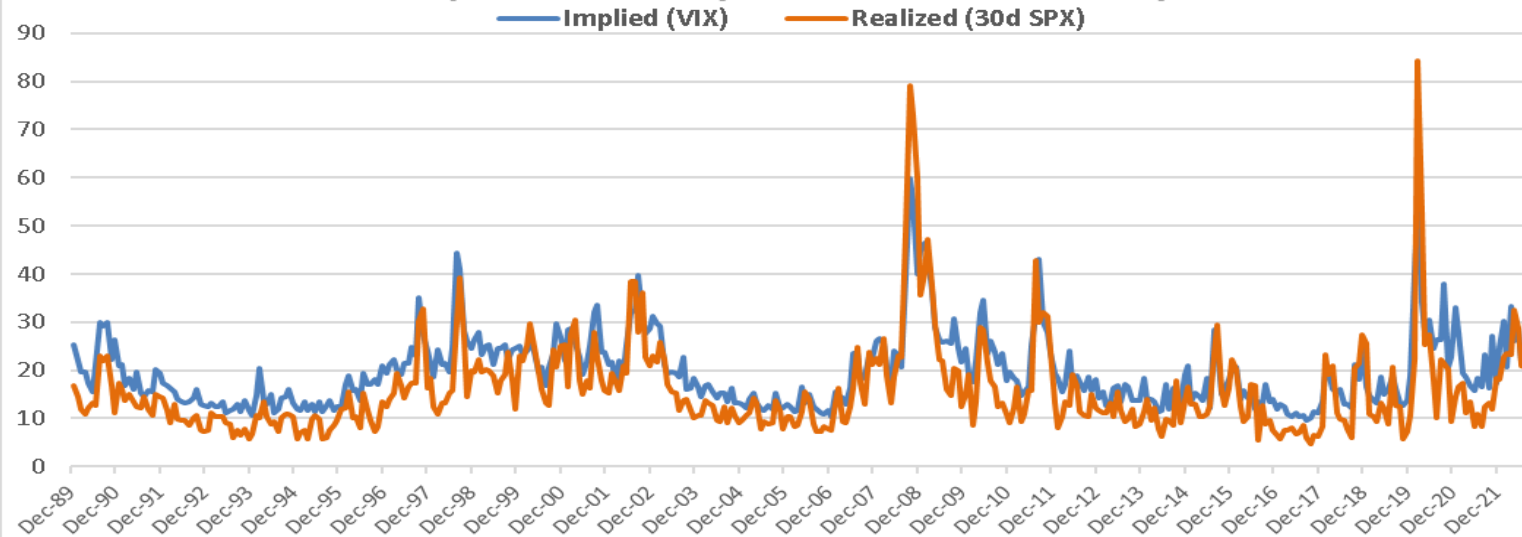
	MAXIMUM DRAWDOWN LOSS (%)	MAXIMUM DRAWDOWN START DATE	MAXIMUM DRAWDOWN END DATE	MAXIMUM DRAWDOWN LENGTH	MAXIMUM DRAWDOWN RECOVERY DATE	HIGH WATER MARK DATE	HIGH WATER MARK	PAIN INDEX	PAIN RATIO
■ PUT - Cboe S&P 500 PutWrite Index	(32.66)	May 2008	Feb 2009	9	Nov 2010	Mar 2022	9.68	3.32	1.89
■ S&P 500 Index	(50.95)	Oct 2007	Feb 2009	16	Mar 2012	Dec 2021	15.08	8.16	0.90

Disclaimer:

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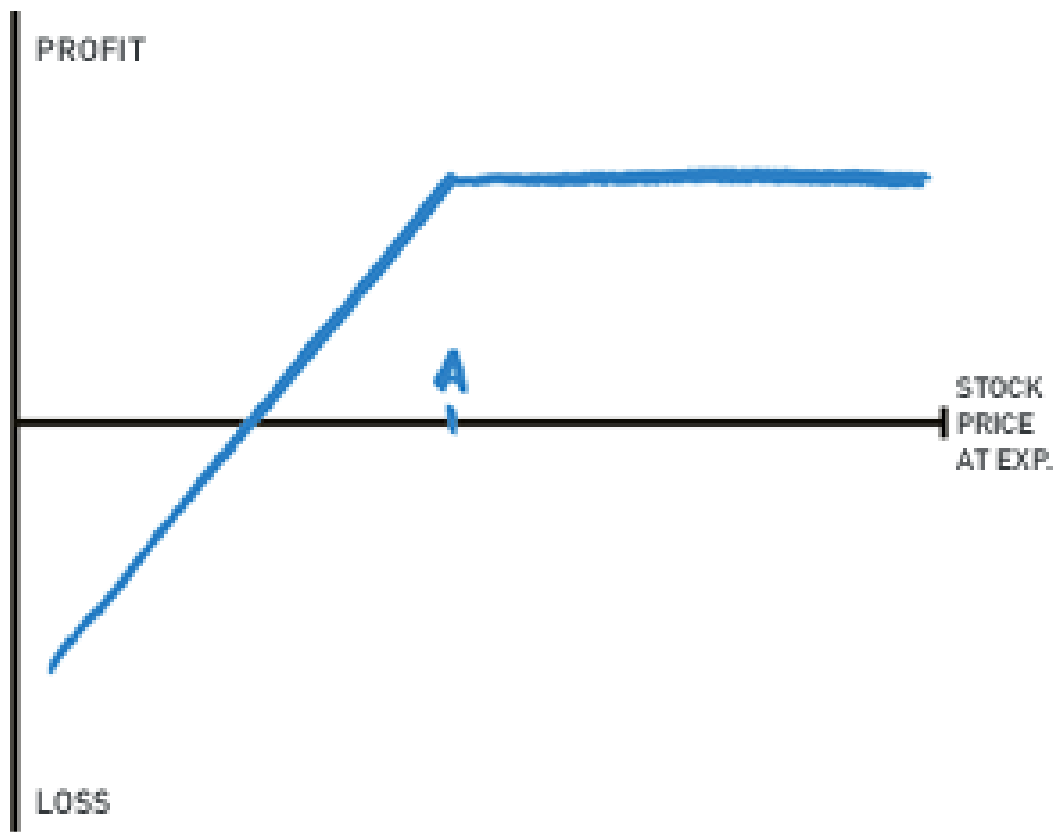


Implied Volatility vs. Realized Volatility



Source: Bloomberg LP. (Jan. 1990-Sep. 2022)

Short Put

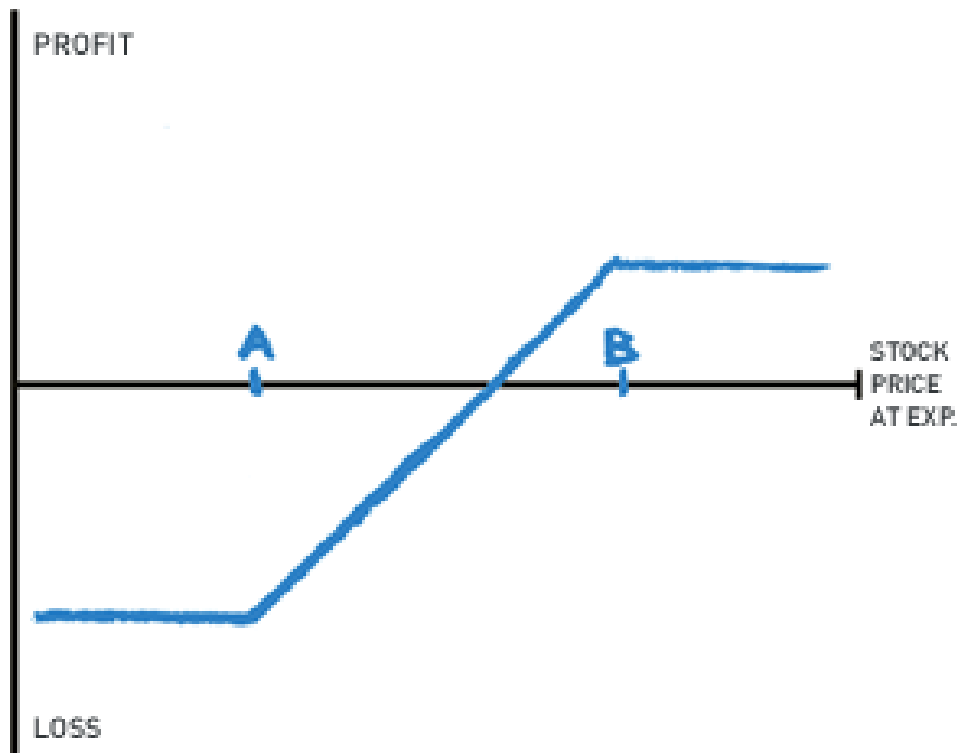


- Sell a Put at strike price A, while underlying price is above strike
- Bullish to neutral on stock
- Goal is to collect premium that is realized at expiration when underlying price is at or above strike
- Maximum potential loss (strike price minus premium) happens when underlying stock price goes to \$0

Source: The Options Playbook



Short Put Spread (Vertical, Bullish)



- Buy a put, strike price A
- Sell a put, strike price B
- Generally underlying price will be above strike B
- Bullish to neutral
- Goal is to collect premium that is realized at expiration when underlying price is at or above strike B
- Maximum potential loss (difference between strikes minus net credit premium) happens when underlying stock price goes below strike price A

Source: The Options Playbook



- We trade approximately 12,500 contracts per month across all our lines of business (Funds, SMAs and Partnerships).
- Contract size provides a high level of customization.
- Liquidity at all levels
- Originally started in SPY and made the move to XSP (next slide to explain differences)
- Eased in to XSP contracts beginning in 2018 (less than 20 per month and have grown to 12,500)
- Work closely with CBOE and trading permit holders to make sure contracts are available when we need them.

XSP or SPY?

XSP (1/10th SPX)

- European Exercise
 - Cash Settled
 - Premium cost to carry
- Global Trading Hours
- 1256 Contracts – may benefit from 60% long-term, 40% short-term capital gains*

SPY

- American Exercise
 - Settled with shares of underlying ETF
 - Assignment Risk
- Standard trading hours
- Standard tax treatment

*Under section 1256 of the Tax Code, profit and loss on transactions in certain exchange-traded options, including SPX Options, are entitled to be taxed at a rate equal to 60% long-term and 40% short-term capital gain or loss, provided that the investor involved, and the strategy employed satisfy the criteria of the Tax Code. Investors should consult with their tax advisors to determine how the profit and loss on any particular option strategy will be taxed. Tax laws and regulations change from time to time and may be subject to varying interpretations.



VIX Index Futures Rose **55%** on 2016 Election Night

On the 2016 election night of November 8th – 9th in the United States, the reported prices for the November futures on the Cboe Volatility Index® (VIX®) rose from a low of **15.10** at 8:07 p.m. E.T., to a high of **23.46** at 10:27 p.m. E.T., an amazing rise of **55%** over a **140-minute period** (source: Bloomberg). Reported volume for VIX futures during non-U.S. trading hours topped 230,000 contracts both on June 24, 2016 (Brexit) and again during the November 9, 2016, trading session (which technically began at 3:30 p.m. C.T. the day before). On the morning of Wednesday Nov. 9th, the price of the VIX Nov. futures fell below 16, as a story at cbsnews.com noted that “*Conciliatory comments from U.S. President-elect Donald Trump in the aftermath of his stunning victory over Hillary Clinton helped global stock markets erase a large chunk of their earlier losses Wednesday.*”



Market Return Around the Clock: A Puzzle

Oleg Bondarenko[#] and Dmitriy Muravyev^{*}

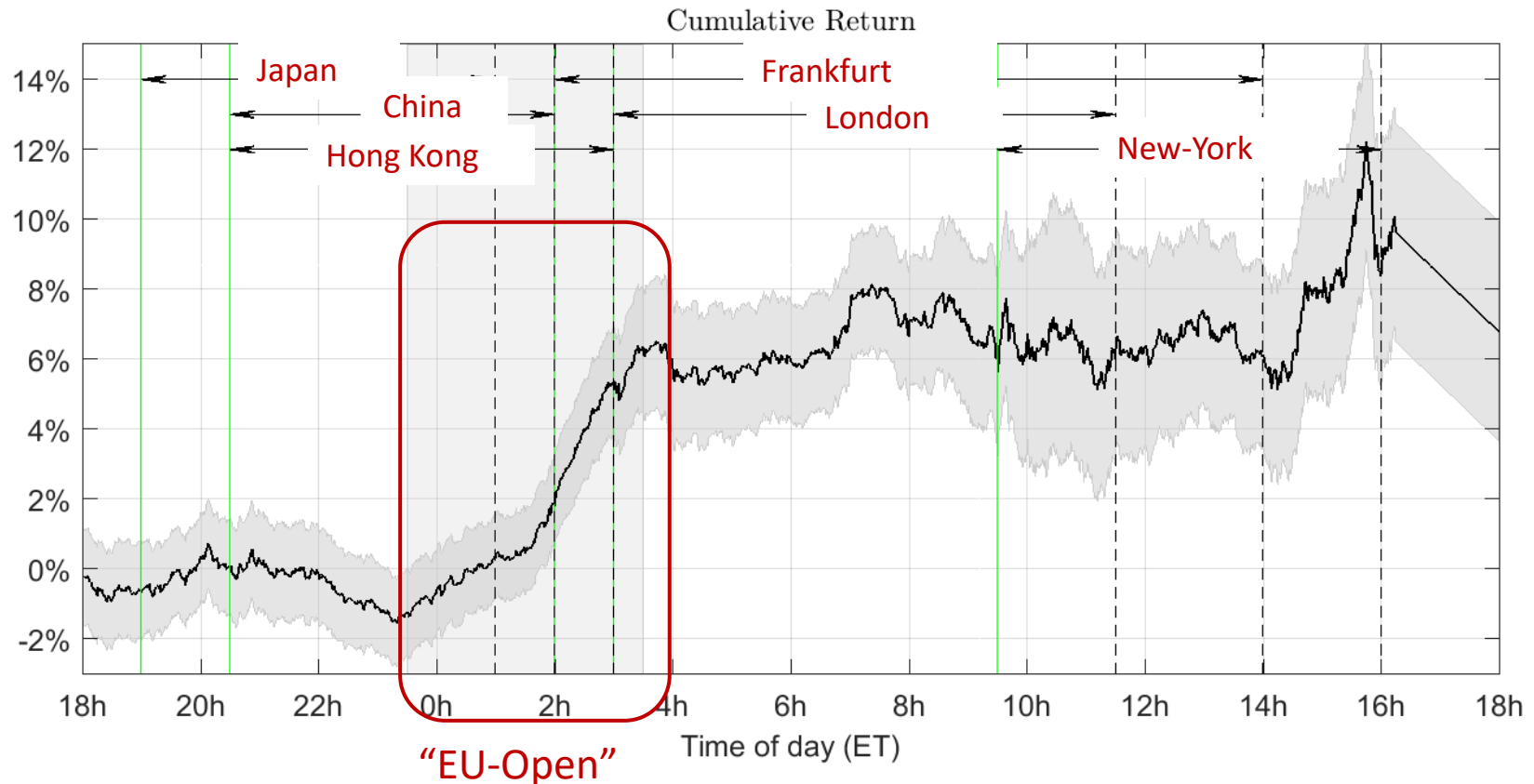
[#] University of Illinois at Chicago

^{*} Michigan State University

Cboe Webinar “Trading S&P 500 (SPX and XSP) Options
Around-the-Clock with Everyday Expirations”

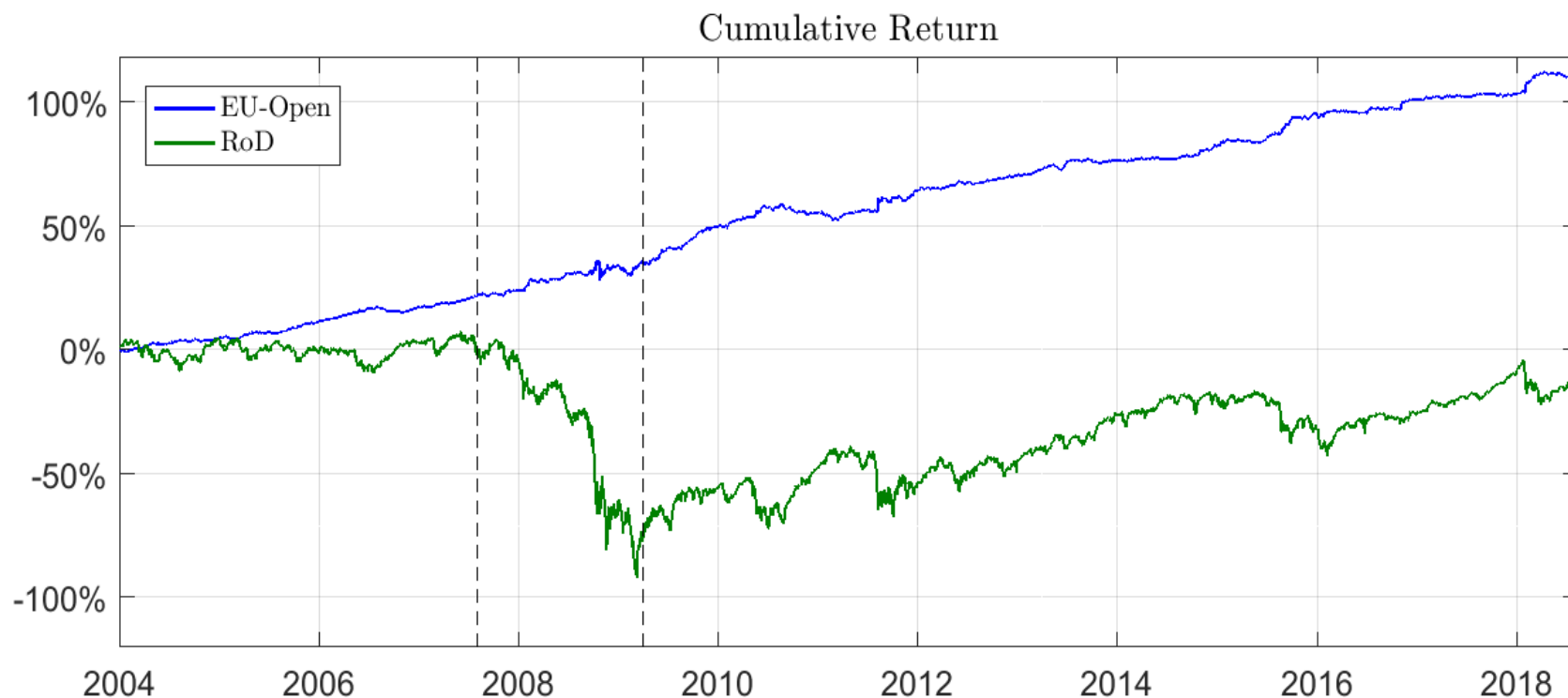
December 14, 2022

Market return around the clock



- Cumulative returns for E-mini S&P futures
- One period stands out – around Asian close & Europe open
- This “EU-open” has a 7.6% p.a. return with t -stat of 6.3
- The rest of the day has return of -0.8% p.a.

EU-open returns are remarkably consistent



Summary

- EU-open return puzzle:
 - Very consistent
 - The most interesting period of the day
 - Plenty of liquidity overnight
- Potential explanations:
 - ~~Asian stock market close~~ or European open?
 - Information uncertainty resolution
- Other explanations? No
 - Limits to arbitrage & trading strategy
 - Data mining & data snooping
 - Inventory risk & overnight illiquidity
 - News arrival, carry costs, investor sentiment, conventional risks

Data & methodology

- E-mini S&P 500 futures
 - data from TickData & CME DataMine
 - front-month contract and carefully rolled over
 - Main sample: trades from 2004 to 2018
- E-mini future returns already include dividends and risk-free rate
- Market return
 - compute minute-by-minute log return
 - average across days, then add up and annualize by $\times 252$
- A trading day is from 6:00 pm to 6:00 pm next day, 5 days a week:
 - continuous session from 6:00 pm to 4:15 pm next day,
 - 4:15 pm to 6:00 pm: 15-minute technical break, 30-minute session, 4:30-5:00 pm, and 60-minute halt

EU-open vs. rest-of-day

	EU-open	Rest of the day	Entire day
Average return, % p.a.	7.60	-0.80	6.80
<i>t</i> -statistic	6.35	-0.17	1.39
Standard deviation, %	4.55	17.79	18.63
Sharpe ratio, p.a.	1.67	-0.05	0.36
Skewness	1.64	-0.99	-0.42
Kurtosis	56.96	15.77	16.80
Min, %	-3.95	-13.07	-12.01
5%	-0.32	-1.77	-1.73
25%	-0.08	-0.41	-0.39
50%	0.02	0.06	0.08
75%	0.13	0.52	0.54
95%	0.41	1.47	1.57
Max, %	4.52	8.47	11.28
Max drawdown, %	7.96	66.40	61.89

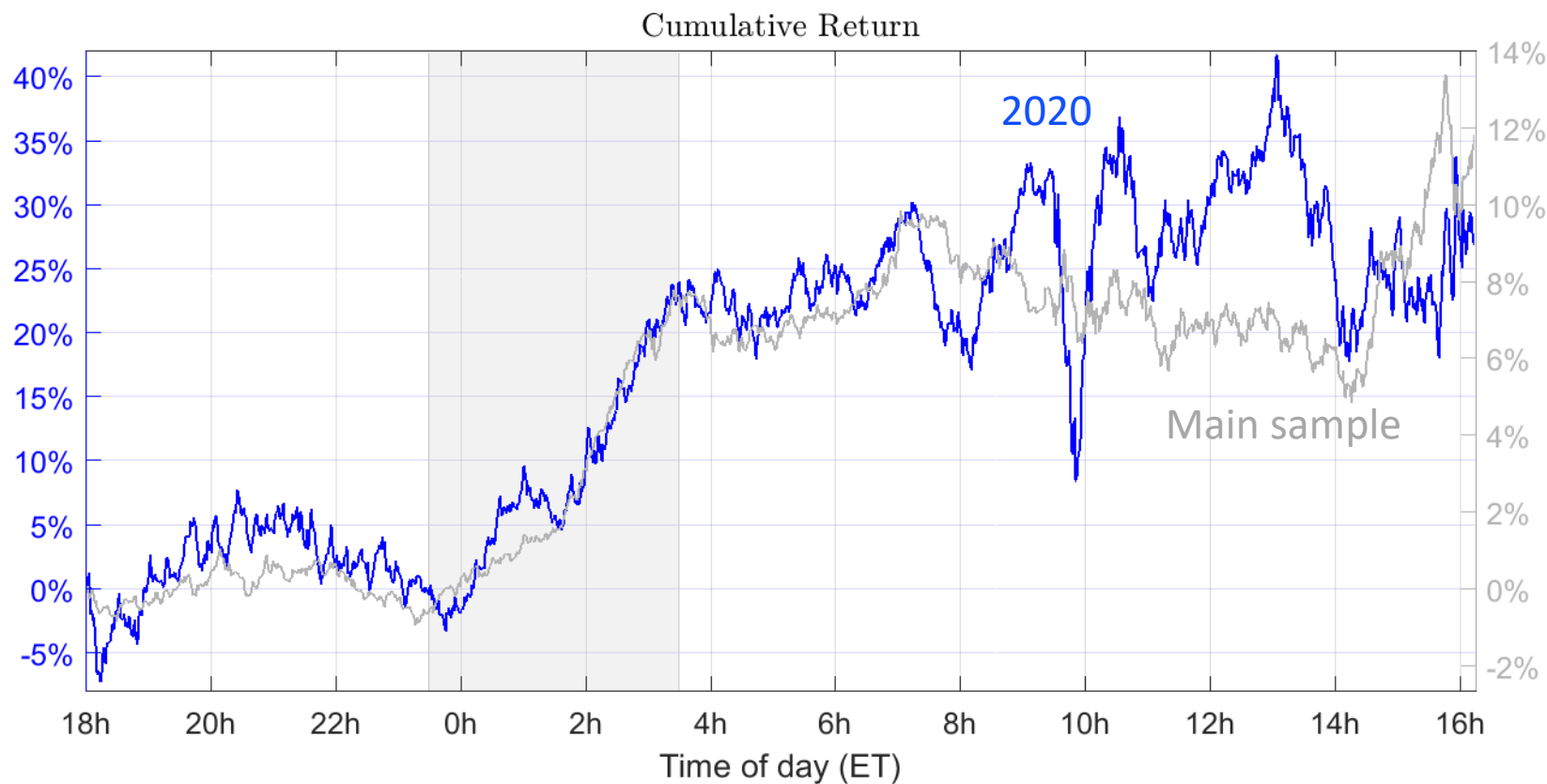
EU-open:

- 100% of total daily return
- 4x lower volatility than RoD
- Sharpe ratio of 1.67
- Positive skewness, large kurtosis
- Small max drawdown (8%)

Rest of day (RoD):

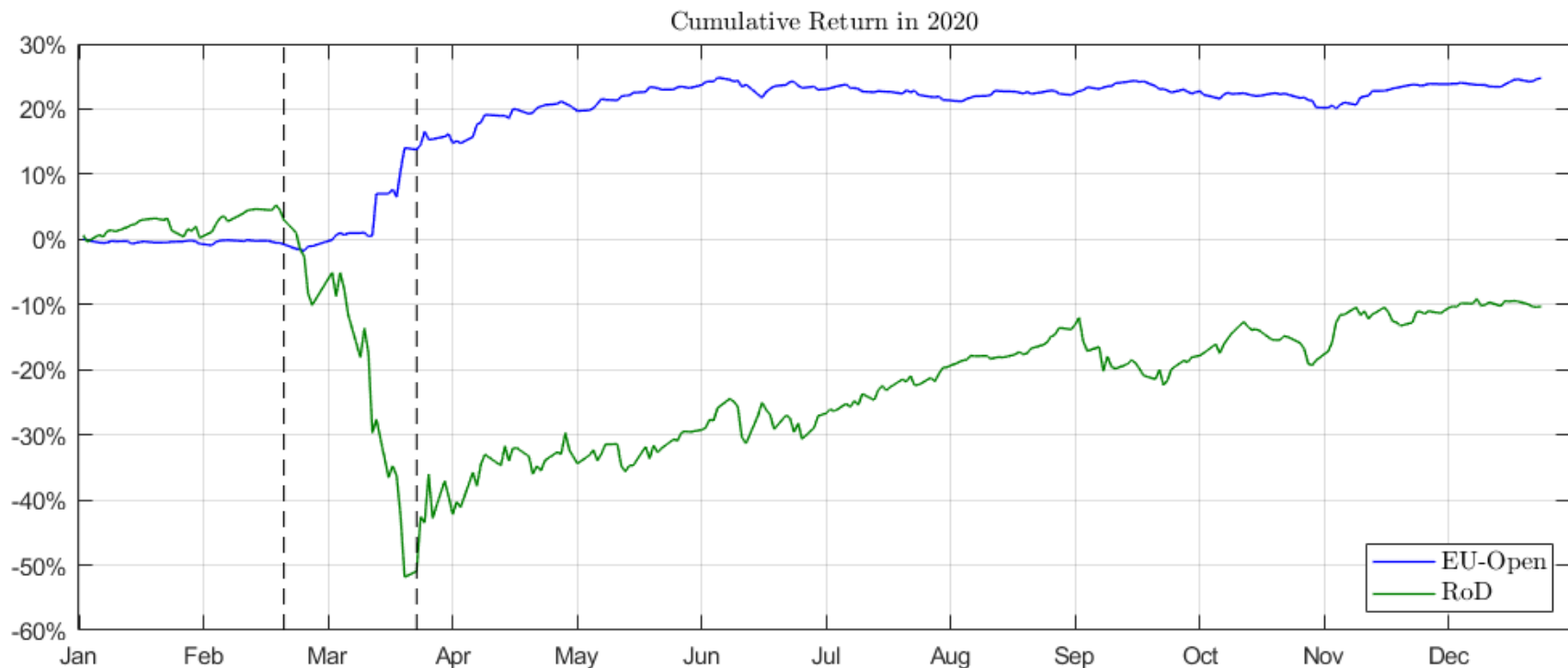
- Zero return
- SR of -0.17
- Negative skewness

The 2020 COVID crisis



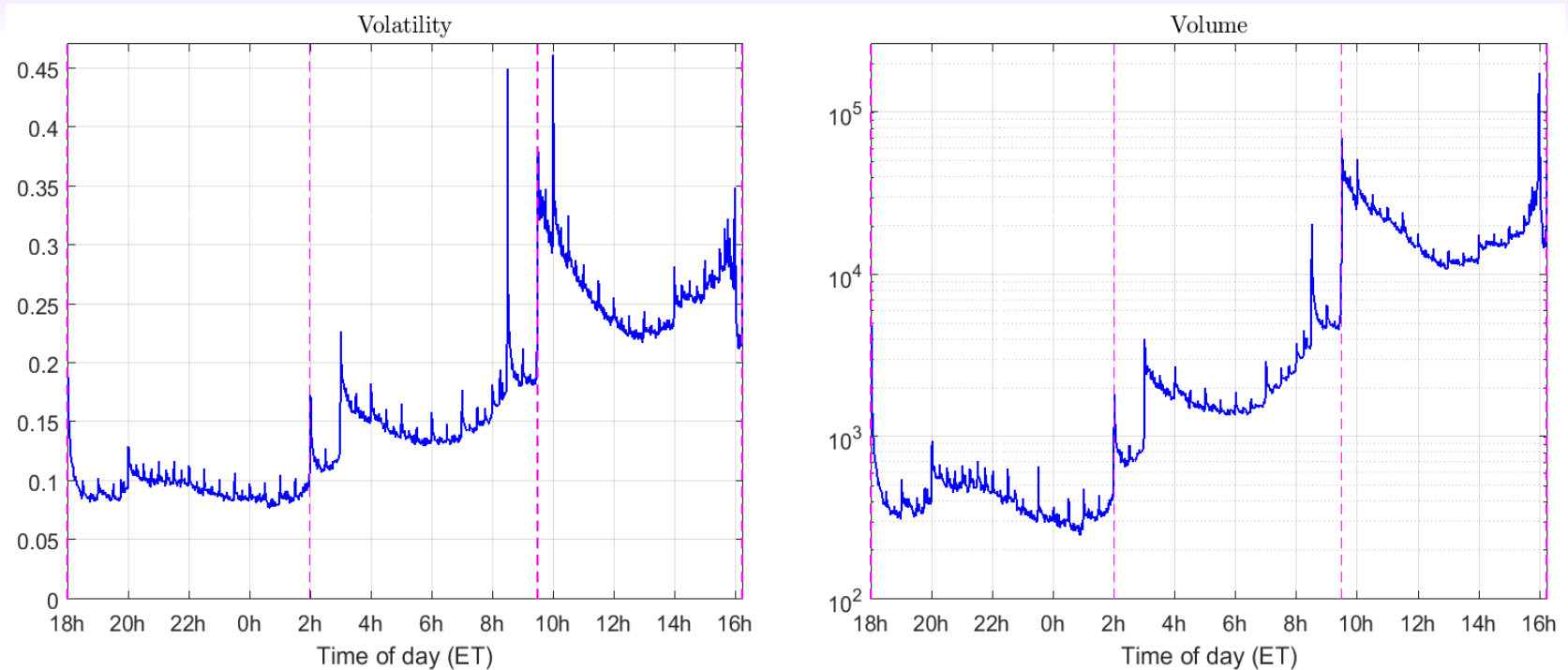
- The 2020 returns $\approx 3x$ the main sample returns
- Positive returns are mainly concentrated during EU-open in 2020 validating its boundaries

The 2020 COVID crisis – time series P&L



- EU-open returns are especially high during the midst of the crisis in March and April 2020 – the period of profound uncertainty

Asian hours are plentifully liquid

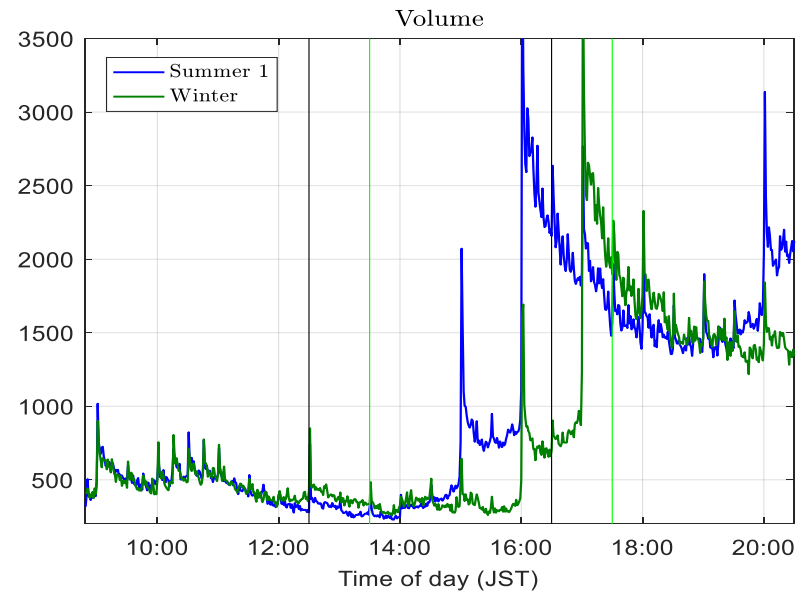
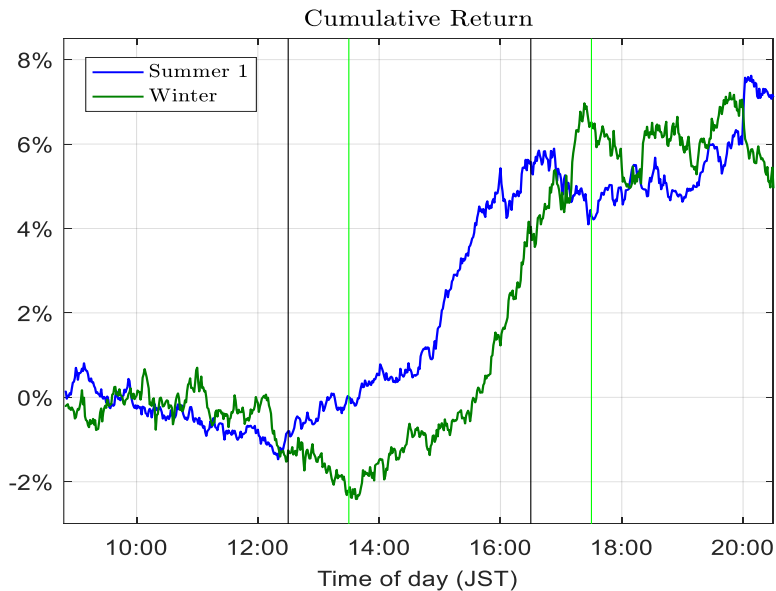
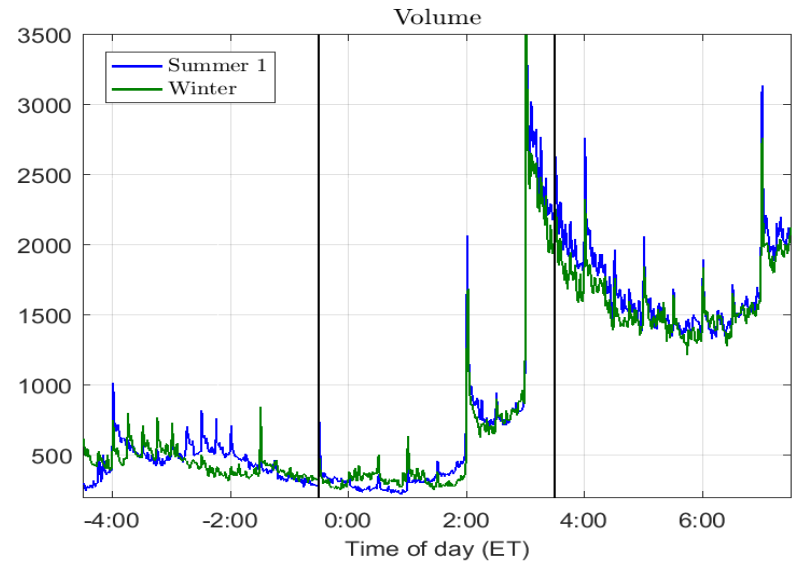
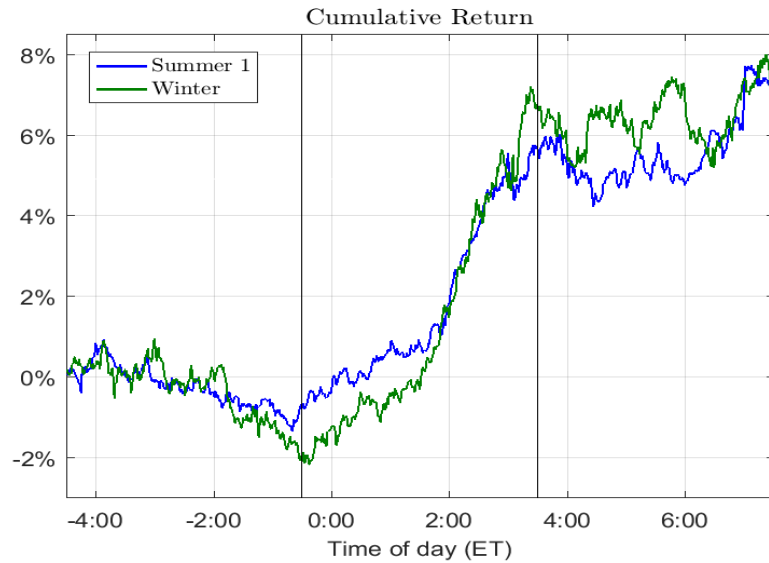


- For volatility and volume, Asia < EU < U.S.
- Volatility and volume spike at the open
- E-mini S&P is the 4th most-active index future during Asian hours
- Bid-ask spread is almost always one tick
- Volume is **\$2.2B per hour** and much more recently

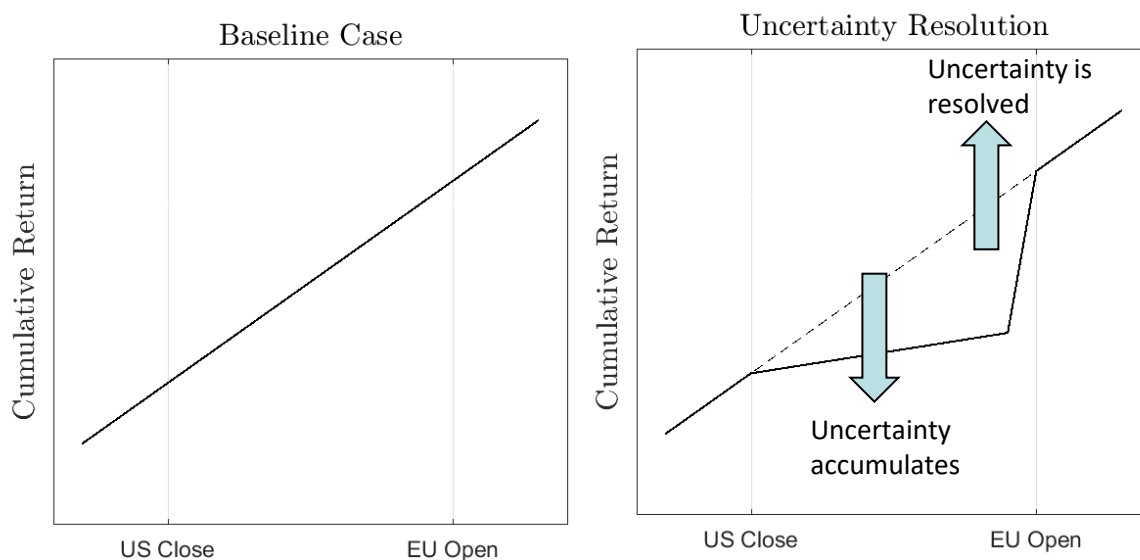
Explanations: Asian close or European open?

- Asia closes and Europe opens at the same time
- Asia does not have daylight saving time, while Europe/US do – Exogenous shock to relative time
- Price run-up and volume stay unchanged in European time
- But they “shift” in Asian time from summer to winter
- Thus, price run-up is driven by European open, hence “EU-open”

Asian close or European open?



Explanations: Uncertainty resolution

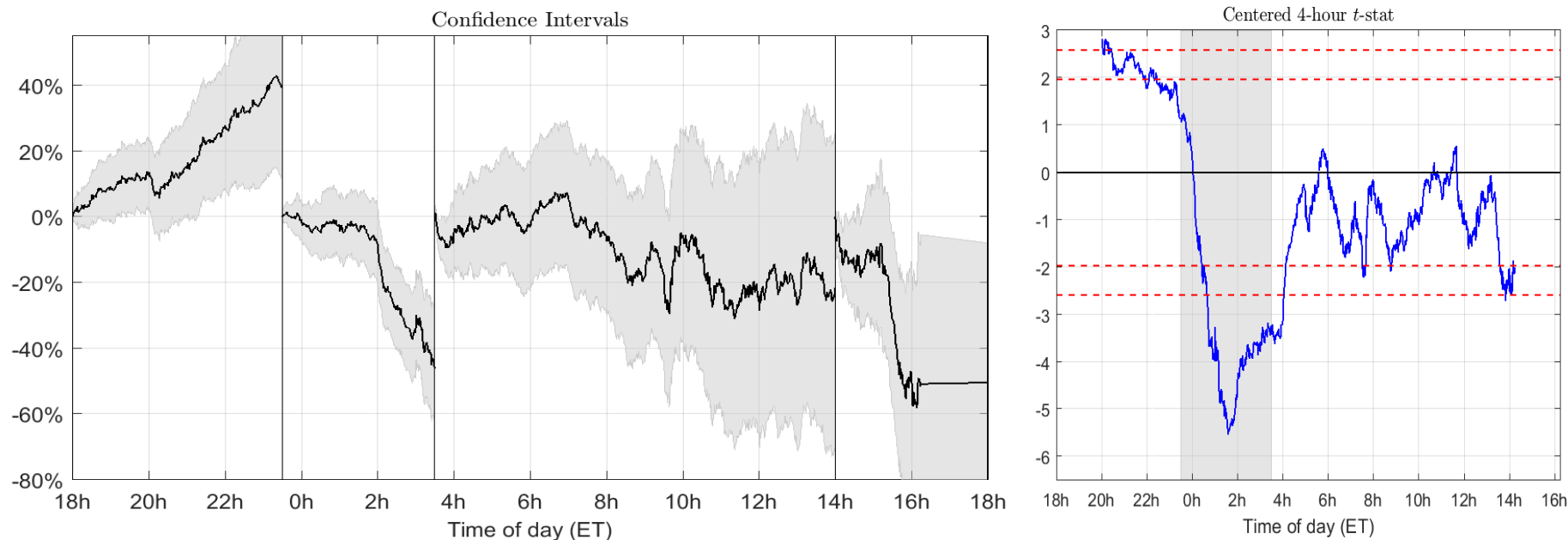


- Uncertainty accumulates during Asian hours as critical investor mass is required to fully process information.
- As European investors wake up and process the accumulated information, uncertainty is resolved, and price increases.
- European investors are compensated for contributing to price discovery.

Returns on EU holidays

- EU holidays when EU is closed but US is open – an exogenous shock
- On EU holidays (81 days),
 - A slightly negative return on EU-open
 - A positive return on the rest of European session
 - Uncertainty resolution shifts to later that day

Uncertainty around the clock: VIX futures



- VIX futures returns reflect changes in uncertainty
 - Uncertainty \uparrow during Asian hours, before EU-open:
 - VIX cum. return > 0 : 37.5% p.a., t -stat = 2.7
 - Uncertainty \downarrow during EU-open:
 - VIX cum. return < 0 : -46.2% p.a., t -stat = -5.2

Trading strategy

Strategy	Average return, %	Std. dev., %	Sharpe ratio	<i>t</i> -stat.
Baseline, no TC, %	7.76	4.72	1.65	6.27
Baseline, with TC, %	2.58	4.71	0.55	2.09
Conditional, no TC, %	6.69	3.86	1.73	6.60
Conditional, with TC, %	4.61	3.84	1.20	4.57

- Buy E-mini futures before EU-open, sell after it ends
- Transaction costs:
 - full bid-ask spread + commissions + exchange fees
 - Buy at Ask, sell at Bid
- Conditional strategy – only trade when expected returns exceed costs:
 - Predict EU-open return with change in daily VIX and Asian volatility
 - Impressive out-of-sample R_{OS}^2 of 6.6%
 - Trades on about 40% of days
 - The strategy can be further improved

Trading strategy: Capacity

Strategy	Average return, %	Std. dev., %	Sharpe ratio	<i>t</i> -stat.	P&L, \$M p.a.	Position size, \$B
Baseline, no TC, %	6.52	4.56	1.43	5.44	80	6.92
Baseline, with TC, %	1.24	4.56	0.27	1.03	40	6.92
Conditional, no TC, %	5.08	3.67	1.38	5.27	60	9.29
Conditional, with TC, %	3.13	3.65	0.86	3.27	50	9.29

- Trade 10% of volume every minute ala VWAP algo without price impact
 - In practice, investors combine limit and market orders
- Accumulate position between 9:30 pm to 1:30 am and sell starting at 3:30 am,
- Constrains the maximum volume traded

Conclusion

- We document a major puzzle about market return:
 - 100% of total market return → four hours at deep night
 - EU-open returns are consistently positive/high
 - Rest-of-day returns are a noisy zero
- Uncertainty resolution is the most plausible explanation
- European investors play an important role

- ssrn.com/abstract_id=3596245
- Forthcoming in *J. of Financial and Quantitative Analysis*
- olegb@uic.edu

Discussion and Q&A



YOUR QUESTIONS AND COMMENTS Submit via the Q icon

Trading S&P 500® (SPX® and XSPSM) Options Around-the-Clock with Everyday Expirations

- New Global Trading Hours (GTH) for Mini-SPX (XSP) Options
- Largest Gains for the S&P 500® Index During Global Trading Hours
- More Flexibility for Options Strategies with 5-Days-a-Week Expirations for both SPX® and Mini-SPX (XSP) Options
- Recent Record Average Daily Volume (ADV) of 1.9 Million for Short-Dated S&P 500 Options (with Expirations in 0 to 7 Days)
- Recent Record ADV of 54,000 for S&P 500 Options During Global Trading Hours

SPEAKERS Louie Humphries, Seth Hickle, Andrew Curto, and Professor Oleg Bondarenko

MORE INFORMATION

- Click on the Handouts icon on your screen
- Cboe Risk Management Conference (**RM**C) in Austin, Texas, October 17 - 20, 2023
<https://go.cboe.com/global-rmc-2023>
- **Webinar** replays and upcoming webinars www.cboe.com/insights/webinars
- Options Education - www.cboe.com/education
- White Papers - www.cboe.com/education/research
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THANK YOU to the speakers and attendees!