HISTORICAL PERFORMANCE OF PUT-WRITING STRATEGIES

INTRODUCTION AND EXECUTIVE SUMMARY

We analyzed the historical performance of two put-writing indices, Cboe S&P 500 PutWrite Index (PUT[SM] Index) and Cboe S&P 500 One-Week PutWrite Index (WPUT[SM] Index), and compared 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 strategy (Cboe S&P 500 5% Put Protection Index (PPUT[SM])). We updated the results from the earlier study "*A Comparison of Index Put Writing with Monthly and Weekly Rollover*" (2016). Highlights of our findings are the following:

- **Long-term performance**. Over more than 32-year period, the PUT index outperformed the traditional indices on a risk-adjusted basis. Compared to S&P 500, PUT has a comparable annual compound return (9.54% versus 9.80%), but a substantially lower standard deviation (9.95% versus 14.93%). As a result, the annualized Sharpe ratio is 0.65 (PUT) and 0.49 (S&P 500).

- **Volatility risk premium**. Historically, the option implied volatility has considerably exceeded the realized volatility. From 1990 to 2018, the average implied volatility, as measured by the Cboe Volatility Index® (VIX®), is 19.3%, while the average realized volatility of the S&P 500 index is 15.1%, implying the difference of 4.2%. Due to high volatility risk premium, PUT has delivered attractive risk-adjusted performance.

- **WPUT and PUT Indices over recent history**. The data history for the WPUT Index begins in January 2006. Over that 13-year period, the risk-adjusted performance of WPUT was slightly lower than that of PUT and S&P 500. The annual compound return is 5.97% (PUT), 4.51% (WPUT), and 7.59% (S&P 500), while the annualized Sharpe ratio is 0.50 (PUT), 0.40 (WPUT), and 0.51 (S&P 500).

- **Lower risk.** Relative to PUT and S&P 500, WPUT has lower standard deviation, beta with respect to the market, and maximum drawdown. In particular, over the last 13 years, the standard deviation is 10.69% (PUT), 9.48% (WPUT), and 14.32% (S&P 500); the maximum drawdown is -32.7% (PUT), -24.2% (WPUT), and -50.9% (S&P 500); the longest drawdown is 29, 22, and 52 months, respectively.

- **Annual premium income**. From 2006 to 2018, the average annual gross premium collected is 22.1% for PUT and 37.1% for WPUT. Premiums for WPUT are smaller, but collected weekly instead of monthly, which results in higher aggregate premiums.

- **Liquidity**. Trading volume in Weekly S&P 500 options has increased dramatically over the last 8 years. In 2018, on average it was about 720 thousand contracts per day, representing more than half of the volume of all Cboe S&P 500 options. The notional value of the average daily volume for S&P 500 options was about $360 billion.

- **PUT versus PPUT**. Since June 1986, the cumulative return is 1835% for PUT and 708% for PPUT. Compared to PPUT, PUT has a much higher annual compound return (9.54% versus 6.64%), a lower standard deviation (9.95% versus 12.08%), much higher risk-adjusted measures (the annualized Sharpe ratio of 0.65 versus 0.33), a less severe drawdown (the maximum drawdown of -32.7% versus -38.9%, the longest drawdown of 40 months versus 80 months). PUT has a negative exposure to the volatility risk, which accounts for 0.29% of its average monthly excess return. In contrast, PPUT has a positive exposure to the volatility risk, which accounts for -0.17% of its average monthly excess return.

PUT AND PPUT INDICES

EXHIBIT 1 – PUT AND PPUT INDICES

Index	Ticker	Strategy	Rollover	Year Launched	Price History Begins
Cboe S&P 500 PutWrite Index	PUT	Short one-month ATM put options on S&P 500 Index, long Treasury bills	Monthly (typically, the 3rd Friday of each month)	2007	June 30, 1986
Cboe S&P 500 Put Protection Index	PPUT	Long 5% OTM one-month SPX Put options, long S&P 500 Index	Monthly (typically, the 3rd Friday of each month)	2015	June 30, 1986

WHAT IS A PUT-WRITE STRATEGY?

- A cash-secured put-write strategy systematically sells options collateralized by risk-free investment.
- The Cboe PUT Index is designed to track 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.

WHAT IS A PROTECTIVE PUT STRATEGY?

- A risk-management strategy which buys out-of-the-money (OTM) puts to hedge against large market declines.
- The Cboe PPUT index is designed to tracks the performance of a hypothetical passive strategy that simultaneously purchases S&P 500 Index and 5% OTM monthly SPX Put options.
- PPUT underperforms S&P 500 Index during up and neutral months, due to paying premium for OTM puts.
- However, when S&P 500 declines by more than 5% in a month, PPUT losses are limited.

EXHIBIT 2 – PROFIT-AND-LOSS DIAGRAM FOR ATM PUT-WRITE STRATEGY

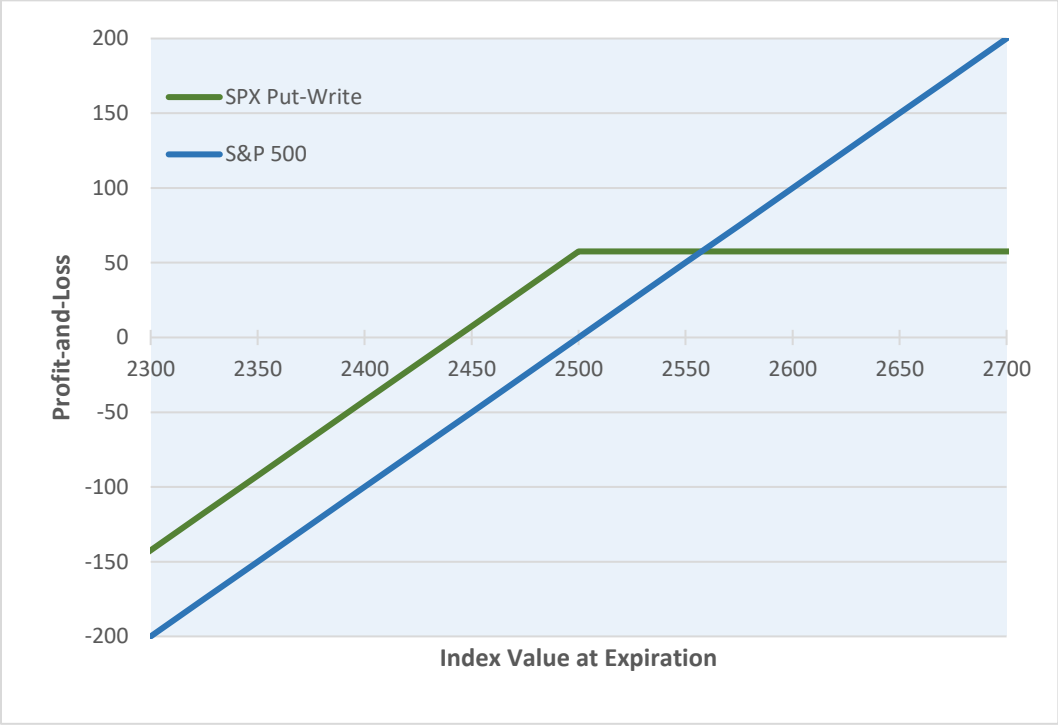
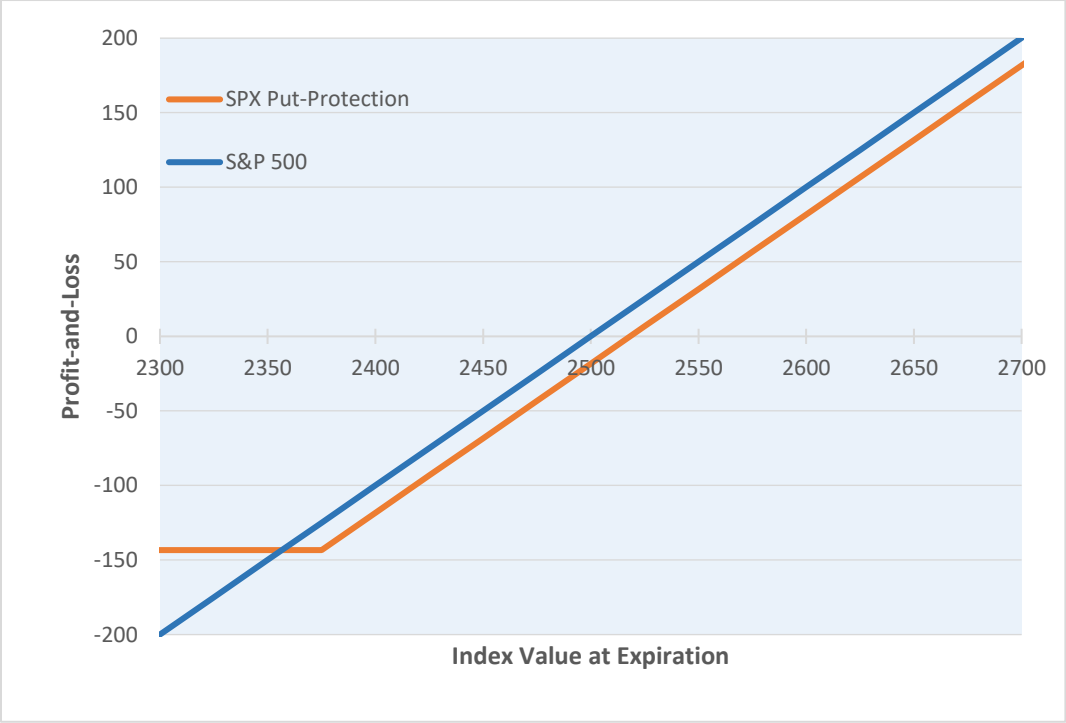


EXHIBIT 3 – PROFIT-AND-LOSS DIAGRAM FOR 5%-OTM PUT-PROTECTION STRATEGY

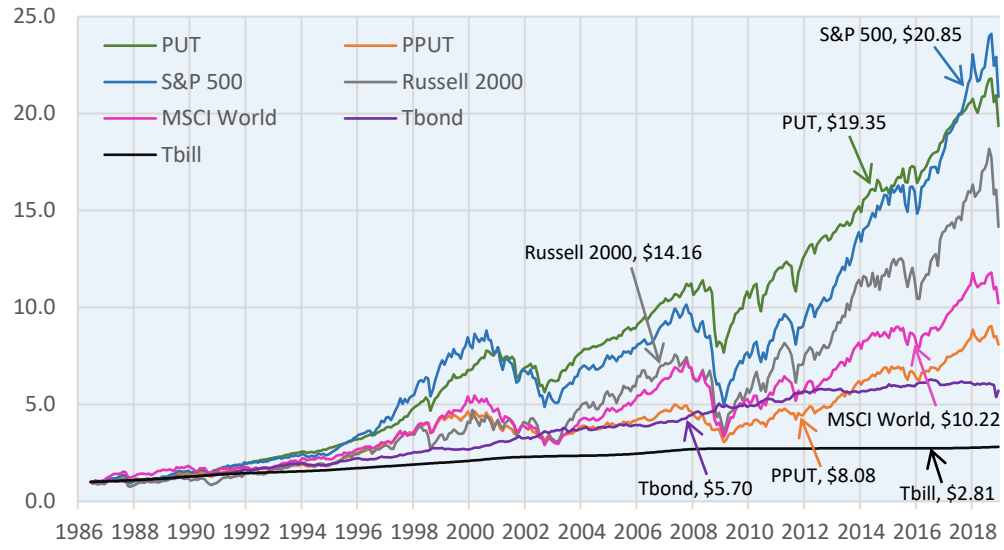


LONG-TERM HISTORICAL PERFORMANCE

Over more than 32-year period, the PUT Index considerably outperformed PPUT and the traditional indices on a risk-adjusted basis.

Note: when applicable, all indices used in this study are **total-return** indices.

EXHIBIT 4 – 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.*

The annual compound return is 9.54% for PUT, 6.64% for PPUT, and 9.80% for S&P 500. The annualized Sharpe ratio is 0.65 (PUT), 0.33 (PPUT), and 0.49 (S&P 500). The Stutzer Index is 0.61 (PUT), 0.33 (PPUT), and 0.48 (S&P 500).

EXHIBIT 5 – MONTHLY STATISTICS (JUN 30, 1986 TO DEC 31, 2018)

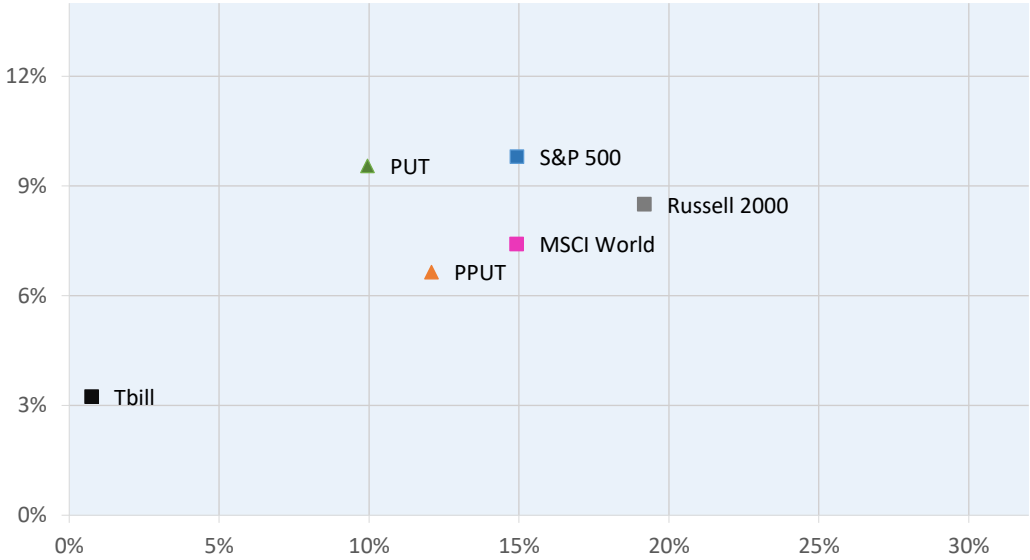
	PUT	PPUT	S&P 500	Russell 2000	MSCI World	30-year Tbond	30-day Tbill
Mean Return	0.81%	0.60%	0.88%	0.84%	0.69%	0.59%	0.27%
Compound Return	0.76%	0.54%	0.78%	0.68%	0.60%	0.53%	0.27%
Min Return	-17.65%	-10.60%	-21.54%	-30.63%	-18.96%	-14.61%	0.00%
Standard Deviation	2.87%	3.49%	4.31%	5.54%	4.31%	3.51%	0.21%
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	0.19	0.10	0.14	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	1.08%	0.68%	0.88%	0.71%	0.69%	0.67%	

EXHIBIT 6 – ANNUALIZED STATISTICS (JUN 30, 1986 TO DEC 31, 2018)

	PUT	PPUT	S&P 500	Russell 2000	MSCI World	30-year Tbond	30-day Tbill
Compound Return	9.54%	6.64%	9.80%	8.50%	7.41%	6.60%	3.24%
Standard Deviation	9.95%	12.08%	14.93%	19.18%	14.92%	12.16%	0.74%
Sharpe Ratio	0.65	0.33	0.49	0.36	0.34	0.32	
Sortino Ratio	0.85	0.48	0.70	0.50	0.48	0.51	
Stutzer Index	0.61	0.33	0.48	0.35	0.34	0.33	

RISK-ADJUSTED PERFORMANCE MEASURES

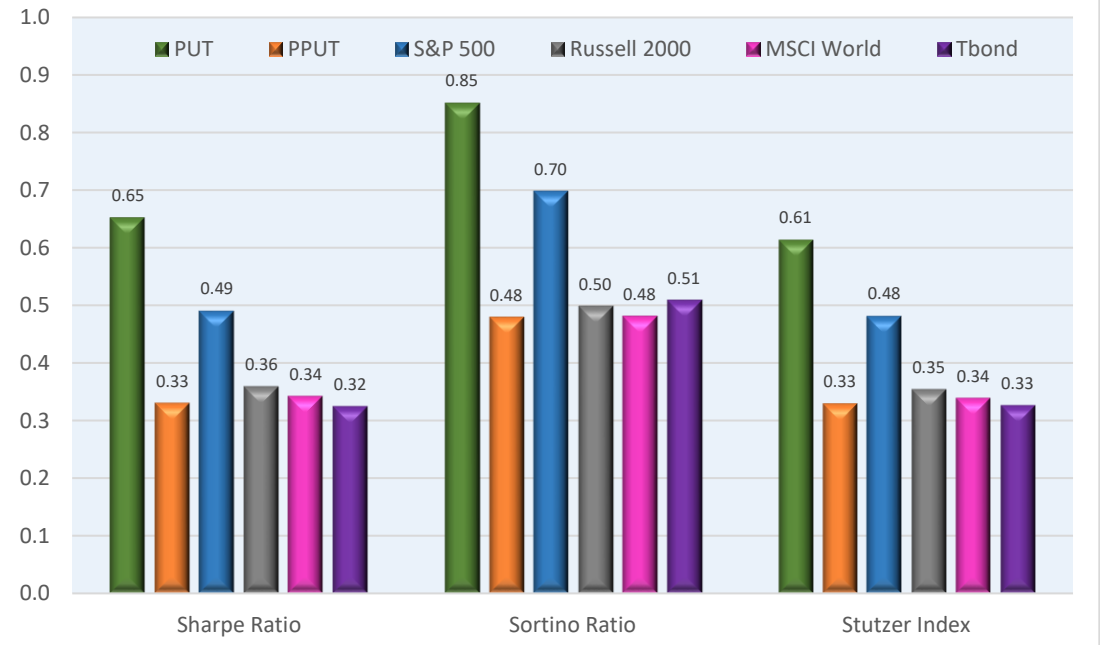
EXHIBIT 7 – RETURN VERSUS STANDARD DEVIATION (JUN 30, 1986 TO DEC 31, 2018)



Annual compound return versus standard deviation for PUT, PPUT, S&P 500, Russell 2000, MSCI World Indices. The period is from Jun 30, 1986 to Dec 31, 2018. *Sources: Bloomberg and Cboe Exchange, Inc.*

The annual compound return of PUT is comparable to that of S&P 500, but its standard deviation is substantially lower. As a result, PUT has delivered a much higher Sharpe ratio.

EXHIBIT 8 – SHARPE RATIO, SORTINO RATIO, AND STUTZER INDEX (JUN 30, 1986 TO DEC 31, 2018)



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.*

Sharpe Ratio is defined as the risk-premium per unit of volatility:

$$Sharpe\ Ratio = \frac{E[r] - r_f}{\sigma}$$

where $E[r]$ is the expected return, r_f is the risk-free rate, and σ is the standard deviation.

Sortino Ratio is defined as:

$$Sortino\ Ratio = \frac{E[r] - r_f}{\sigma_d}$$

where σ_d is the downside semi-deviation. In this definition of Sortino Ratio, Minimum Accepted Return (MAR) is equal to the risk-free rate. Unlike Sharpe Ratio, Sortino Ratio does not penalize for large positive returns.

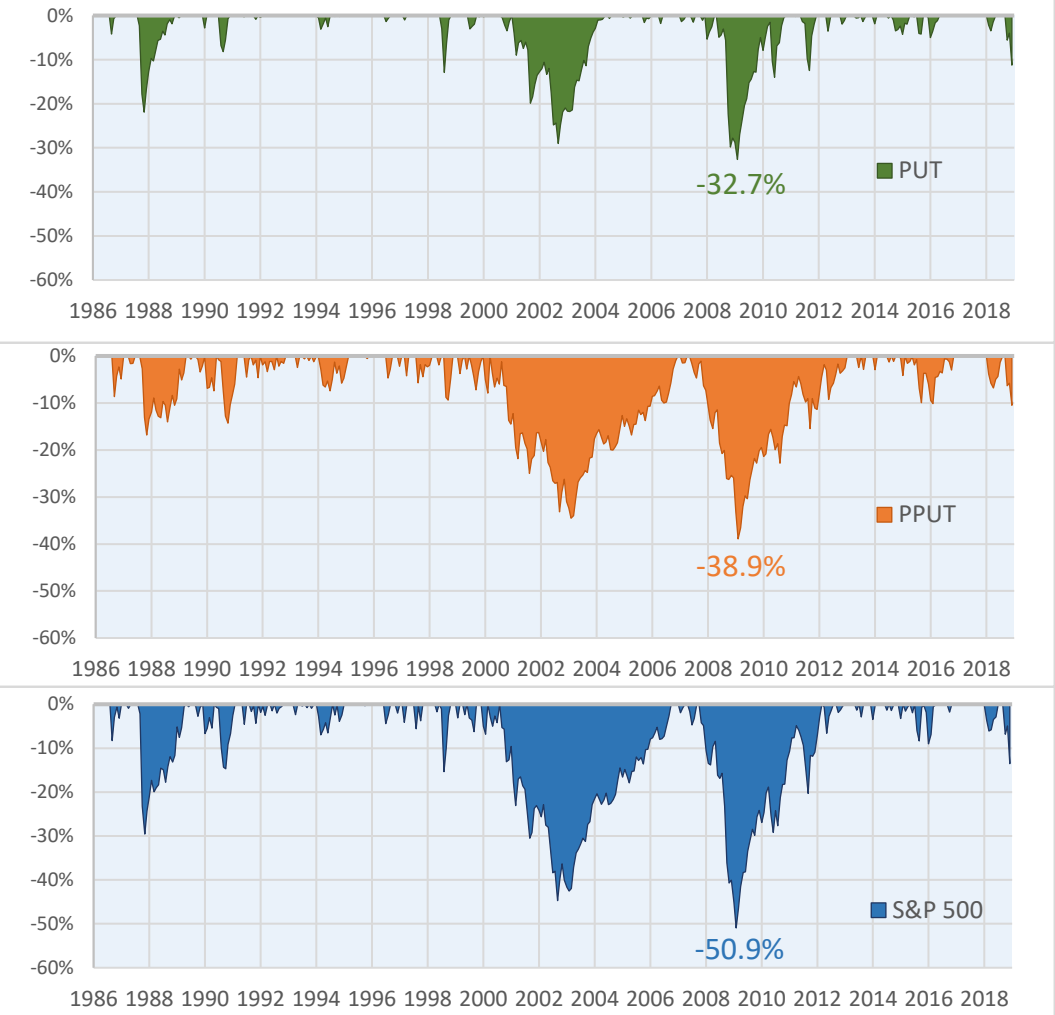
Stutzer Index does not assume that returns are normally distributed. It penalizes negative skewness and high kurtosis:

$$Stutzer\ Index = \sqrt{2I},$$
$$I = \max_{\theta}\{-\log E[e^{\theta r}]\}$$

When returns are normally distributed, Stutzer Index and Sharpe Ratio coincide.

DRAWDOWN

EXHIBIT 9 – MONTHLY DRAWDOWN FOR PUT, PPUT, AND S&P 500 (JUN 30, 1986 TO DEC 31, 2018)



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

From June 1986 to December 2018, the maximum drawdown (MDD) for PUT is -32.7%, as compared to -38.9% for PPUT and -50.9% for S&P 500.

Over same period, the longest drawdown for PUT is much shorter than for PPUT and S&P 500: 40 months (PUT), 80 months (PPUT), and 73 months (S&P 500).

EXHIBIT 10 – MAXIMUM DRAWDOWN (JUN 30, 1986 TO DEC 31, 2018)

	PUT	PPUT	S&P 500	Russell 2000	MSCI World	30-year Tbond	30-day Tbill
Max Drawdown	-32.7%	-38.9%	-50.9%	-52.9%	-54.0%	-26.0%	0.0%
Max Drawdown Month	Jan-09	Jan-09	Jan-09	Jan-09	Jan-09	Feb-10	Jun-86
Longest Drawdown (months)	40	80	73	45	69	32	0

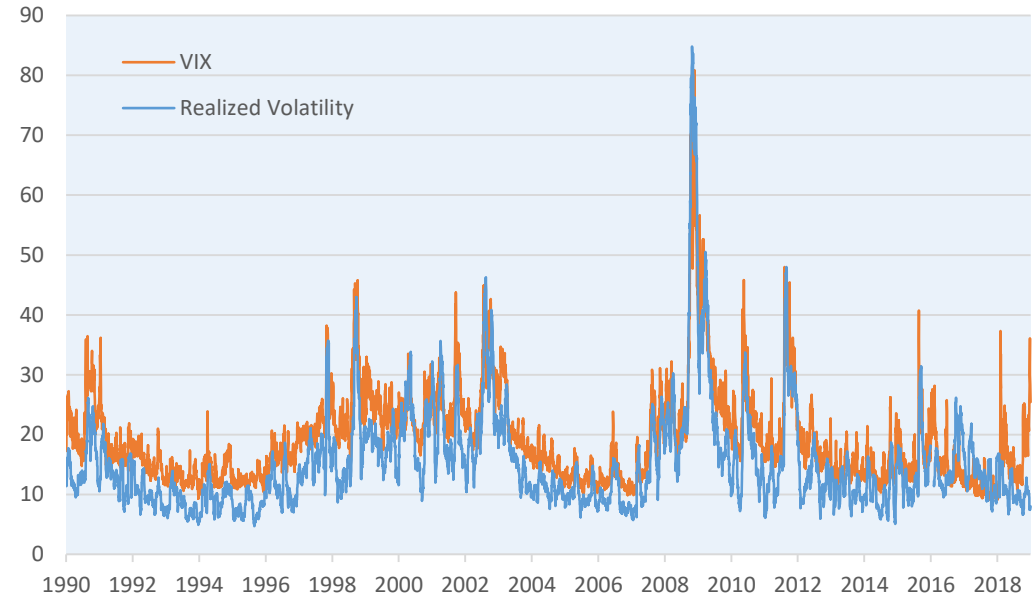
IMPLIED VERSUS REALIZED VOLATILITY – RICHLY PRICED INDEX OPTIONS

Historically, the option implied volatility has considerably exceeded the realized volatility of the S&P 500 index.

From 1990 to 2018, the average implied volatility, as measured by the Cboe Volatility Index® (VIX®) is 19.3%, while the average realized volatility is 15.1%, implying a difference of 4.2 percentage points.

High volatility premium indicates that the index options are richly priced. As a result, put writing strategies have historically delivered attractive risk-adjusted performance.

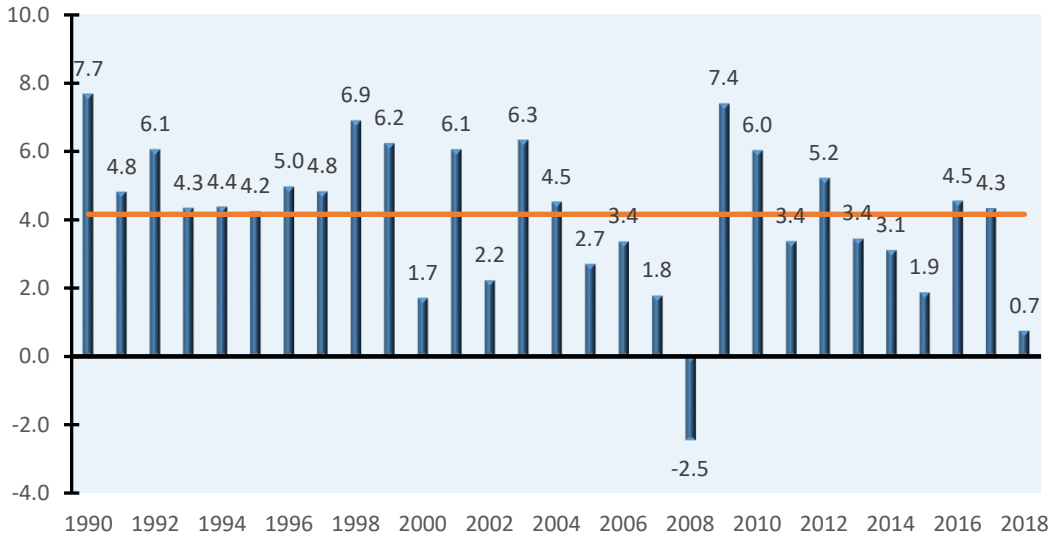
EXHIBIT 11 – VIX INDEX AND S&P 500 1-MONTH REALIZED VOLATILITY (1990-2018)



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

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

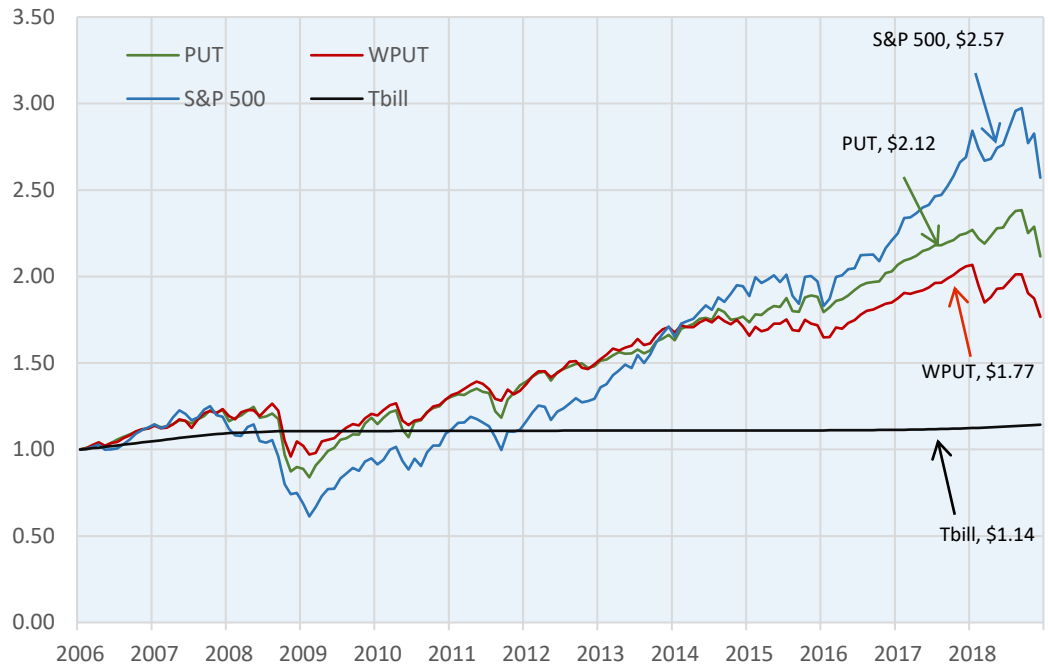
EXHIBIT 12 – VIX INDEX MINUS SUBSEQUENT S&P 500 1-MONTH REALIZED VOLATILITY ANNUAL AVERAGES (1990-2018)



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. *Sources: Cboe Exchange, Inc.*

RECENT HISTORICAL PERFORMANCE AND WPUT

EXHIBIT 13 – 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.*

Over the last 13 years, the PUT index and S&P 500 delivered similar risk-adjusted performance, with the WPUT index being close.

The annual compound return is 5.97% (PUT), 4.51% (WPUT), and 7.59% (S&P 500). The annualized Sharpe Ratio is 0.50 (PUT), 0.40 (WPUT), and 0.51 (S&P 500). The Stutzer Index, which accounts for non-normal returns, is 0.48 for PUT, 0.39 for WPUT, and 0.50 for S&P 500.

EXHIBIT 14 – WPUT INDEX

Index	Ticker	Strategy	Rollover	Year Launched	Price History Begins
Cboe S&P 500 One-Week PutWrite Index	WPUT	Short one-week ATM put options on S&P 500 Index, long Treasury bills	Weekly (typically every Friday)	2015	Jan 31, 2006

- The Cboe WPUT Index was launched in 2015, with price history available since Jan 31, 2006.
- WPUT Index extends the PUT strategy to weekly S&P 500 options.
- Option premiums are collected weekly, instead of monthly.

PERFORMANCE MEASURES

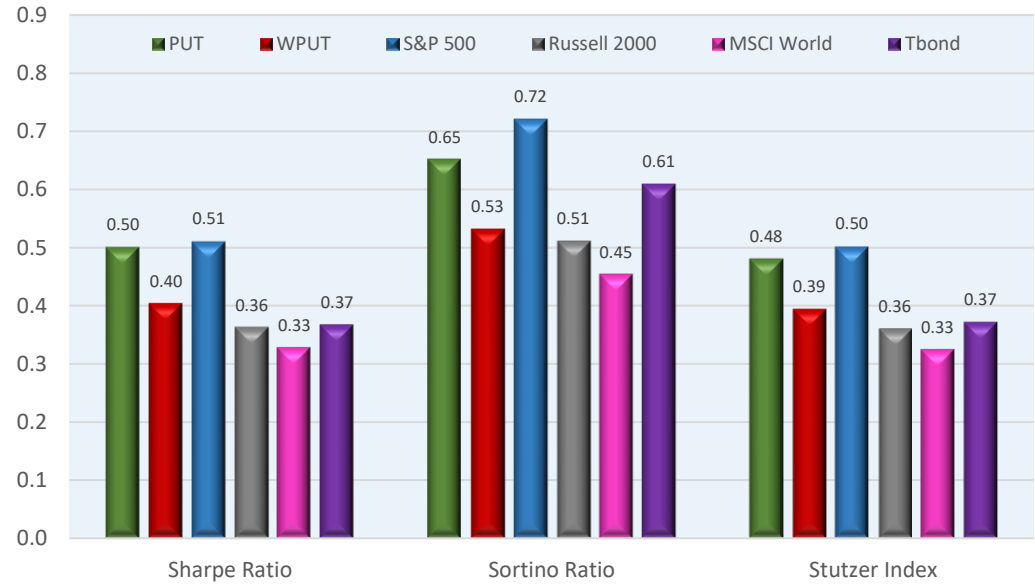
EXHIBIT 15 – MONTHLY STATISTICS (JAN 31, 2006 TO DEC 31, 2018)

	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%	

EXHIBIT 16 – ANNUALIZED STATISTICS (JAN 31, 2006 TO DEC 31, 2018)

	PUT	WPUT	S&P 500	Russell 2000	MSCI World	30-year Tbond	30-day Tbill
Compound Return	5.97%	4.51%	7.59%	6.27%	4.96%	5.47%	1.04%
Standard Deviation	10.69%	9.48%	14.32%	18.85%	15.18%	14.43%	0.47%
Sharpe Ratio	0.50	0.40	0.51	0.36	0.33	0.37	
Sortino Ratio	0.65	0.53	0.72	0.51	0.45	0.61	
Stutzer Index	0.48	0.39	0.50	0.36	0.33	0.37	

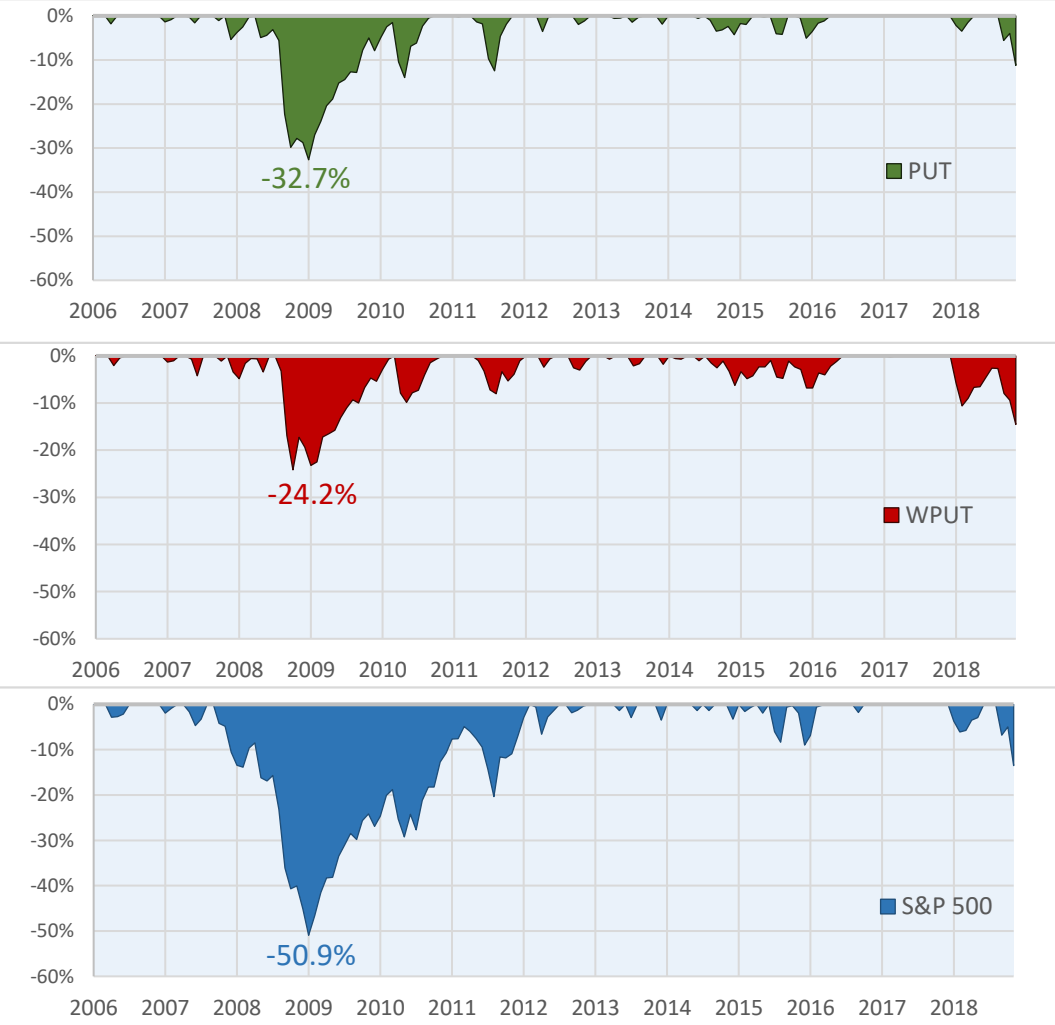
EXHIBIT 17 – SHARPE RATIO, SORTINO RATIO, AND STUTZER INDEX (JAN 31, 2006 TO DEC 31, 2018)



Annualized Sharpe Ratio, Sortino Ratio, and Stutzer Index for PUT, WPUT, S&P 500, Russell 2000, MSCI World, and 30-year Tbond (FTSE). The period is from Jan 31, 2006 to Dec 31, 2018. *Sources: Bloomberg and Cboe Exchange, Inc.*

DRAWDOWN

EXHIBIT 18 – MONTHLY DRAWDOWN FOR PUT, WPUT, AND S&P 500 (JAN 31, 2006 TO DEC 31, 2018)



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

From 2006 to 2018, the maximum drawdown (MDD) for WPUT is -24.2%, as compared to -32.7% for PUT and -50.9% for S&P 500.

Over same period, the longest drawdown for WPUT is much shorter than for PUT and S&P 500: 22 months (WPUT), 29 months (PUT), and 52 months (S&P 500).

EXHIBIT 19 – MAXIMUM DRAWDOWN (JAN 31, 2006 TO DEC 31, 2018)

	PUT	WPUT	S&P 500	Russell 2000	MSCI World	30-year Tbond	30-day Tbill
Max Drawdown	-32.7%	-24.2%	-50.9%	-52.9%	-54.0%	-26.0%	0.0%
Max Drawdown Month	Jan-09	Oct-08	Jan-09	Jan-09	Jan-09	Feb-10	Jan-06
Longest Drawdown (months)	29	22	52	44	68	32	0

SOURCES OF RETURN

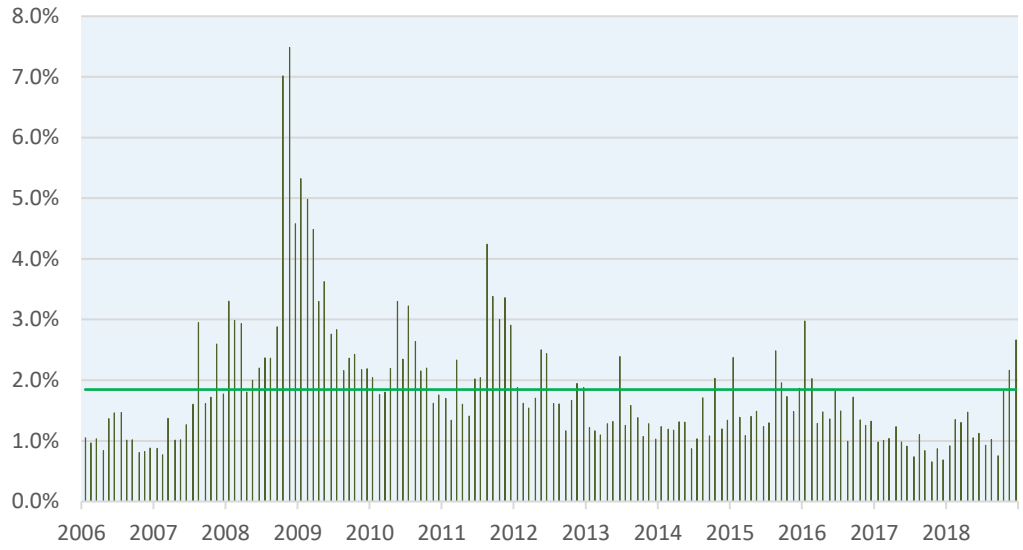
Selling 1-month ATM puts 12 times a year can produce significant income. From 2006 to 2018, the average monthly premium is 1.85%.

Selling 1-week ATM puts 52 times a year can produce even higher income, but please note that transaction costs can be higher with more frequent trading. From 2006 to 2018, the average weekly premium is 0.71%. Although smaller, the premium is collected more frequently.

Intuitively, the premium of the ATM put increases as the square root of maturity. This means that 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 (i.e., 1/2 premium times 4). Because ATM implied volatilities are typically in contango, the factor between 1-month and 1-week option premiums is less than 2.

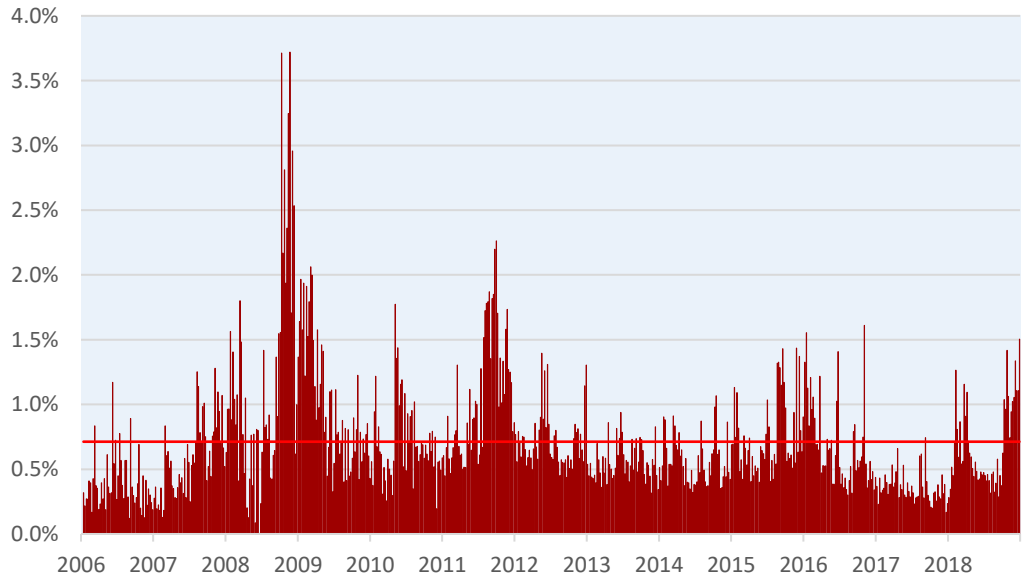
Furthermore, put-write strategies using shorter maturity options can benefit from more frequent resets, which help keep up with market price and changes in volatility. This allows the strategy to better capture the volatility risk-premium.

EXHIBIT 20 – 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.*

EXHIBIT 21 – WPUT PREMIUMS (JAN 31, 2006 TO DEC 31, 2018)



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

Year	PUT	WPUT
2006	12.7%	19.8%
2007	18.6%	30.3%
2008	41.9%	61.6%
2009	38.6%	53.1%
2010	27.0%	36.8%
2011	29.3%	55.7%
2012	21.6%	37.5%
2013	16.1%	28.9%
2014	15.5%	29.3%
2015	19.8%	39.9%
2016	19.1%	35.2%
2017	11.1%	18.7%
2018	16.6%	35.6%
Average	**22.1%**	**37.1%**

From 2006 to 2018, the average annual premium for PUT is 22.1% and for WPUT is 37.1%.
The difference between the two is 15.0% annually.

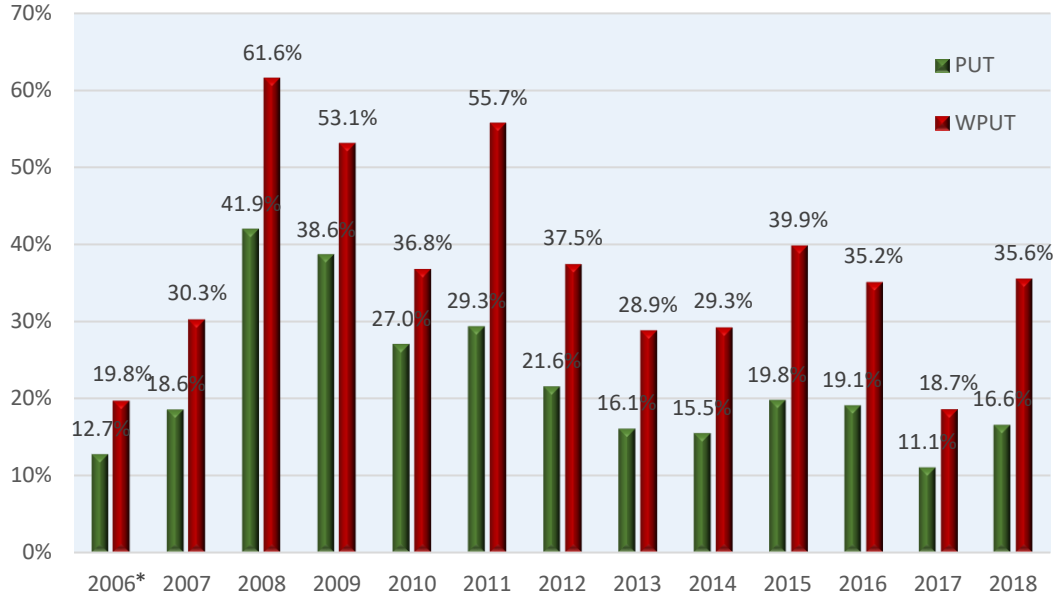
Note: While the gross premiums collected are always positive, the cash-secured put-writing strategy does have downside risk and its net returns can be negative.

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

In 2018, the notional value of the average daily volume for S&P 500 options was about $360 billion.

ANNUAL PREMIUMS

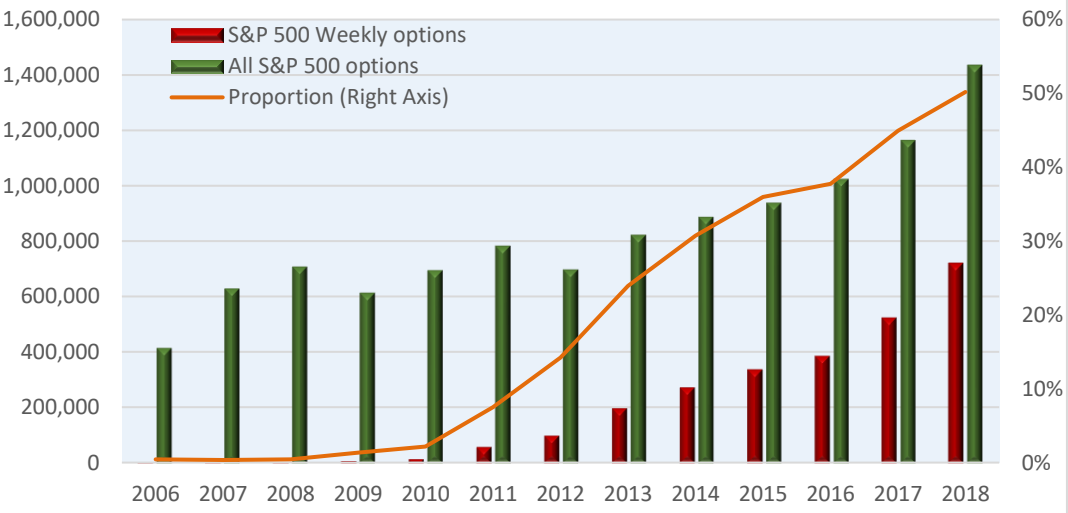
EXHIBIT 22 – PUT AND WPUT AGGREGATE GROSS PREMIUMS RECEIVED FOR EACH CALENDAR YEAR (JAN 31, 2006 TO DEC 31, 2018)



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.*

LIQUIDITY

EXHIBIT 23 – SPX AND SPXW AVERAGE DAILY VOLUME FOR EACH CALENDAR YEAR (JAN 31, 2006 TO DEC 31, 2018)

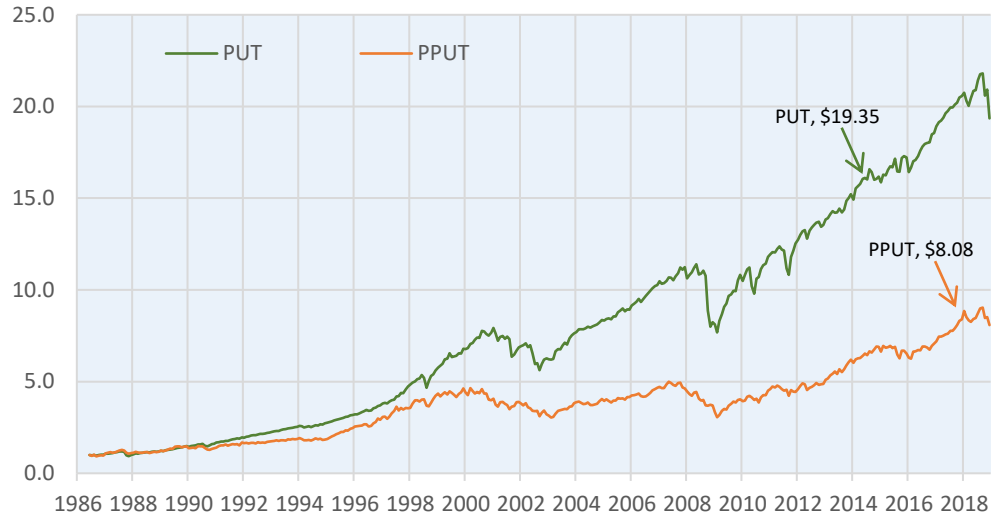


Average daily volume (in contracts) for S&P 500 Weekly options (SPXW) and all SPX options. The orange line shows proportion of SPXW options. The period is from Jan 31, 2006 to Dec 31, 2018.
Sources: Cboe Exchange, Inc.

COMPARISON OF PUT SELLING TO PUT BUYING

Since June 1986, the cumulative return is 1835% for PUT and 708% for PPUT. One of the reasons for that historical outperformance is because PUT involves **selling** while the PPUT involves **buying** richly priced index options (refer to Exhibits 11 and 12).

EXHIBIT 24 – PUT AND PPUT INDICES SINCE JUN 31, 1986

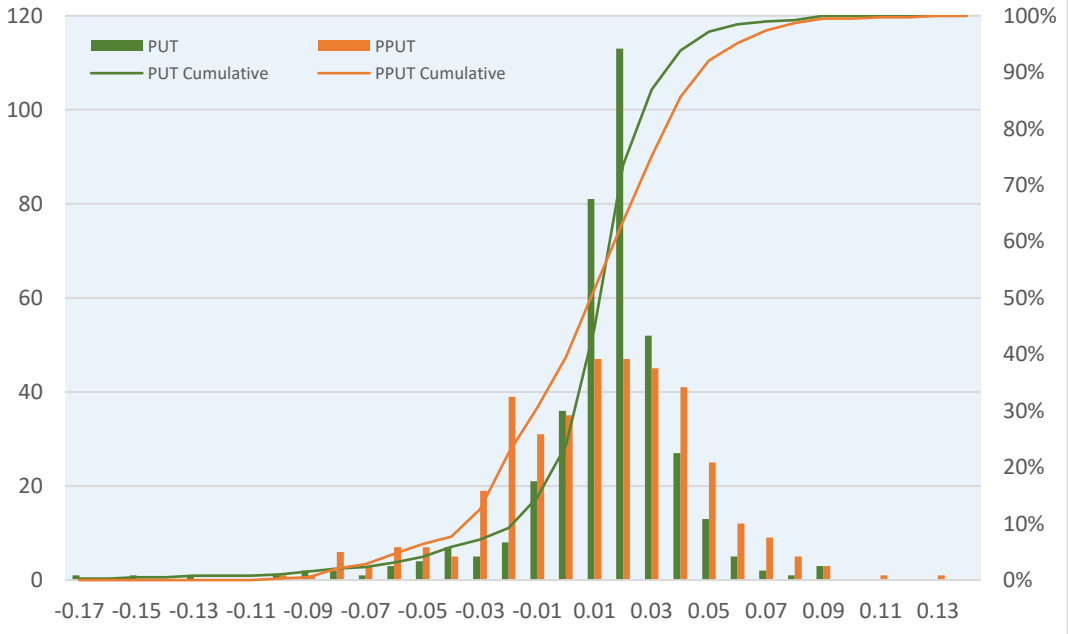


The value of $1 invested in PUT and PPUT indices. The period is from Jun 30, 1986 to Dec 31, 2018. Past performance is not predictive of future returns. *Sources: Cboe Exchange, Inc.*

RETURN DISTRIBUTION

Compared to PUT, PPUT's return has a lower mean. However, unlike PUT, PPUT's distribution does not include extreme negative returns and occasionally delivers high positive returns.

EXHIBIT 25 – DISTRIBUTION OF MONTHLY RETURNS FOR PUT AND PPUT (JUL 1986 TO DEC 2018)



Distribution of monthly returns for PUT and PPUT. The solid lines show cumulative frequencies. The period is from Jun 1986 to Dec 2018. *Sources: Cboe Exchange, Inc.*

Appraisal Ratio is defined as the Jensen's alpha per unit of unsystematic volatility:

$$Appraisal\ Ratio = \frac{\alpha}{\sigma_e}$$

Here, $\alpha = E[\hat{r}] - \beta E[\hat{r}_m]$, where $\hat{r} = r - r_f$ is the monthly excess return (above the risk-free rate) of a given portfolio;
$\hat{r}_m = r_m - r_f$ is the excess return on the Market (S&P 500);
β is the corresponding beta coefficient;
σ_e is the standard deviation of the residuals.

MAR Ratio is defined as:

$$MAR\ Ratio = \frac{CAGR}{MDD}$$

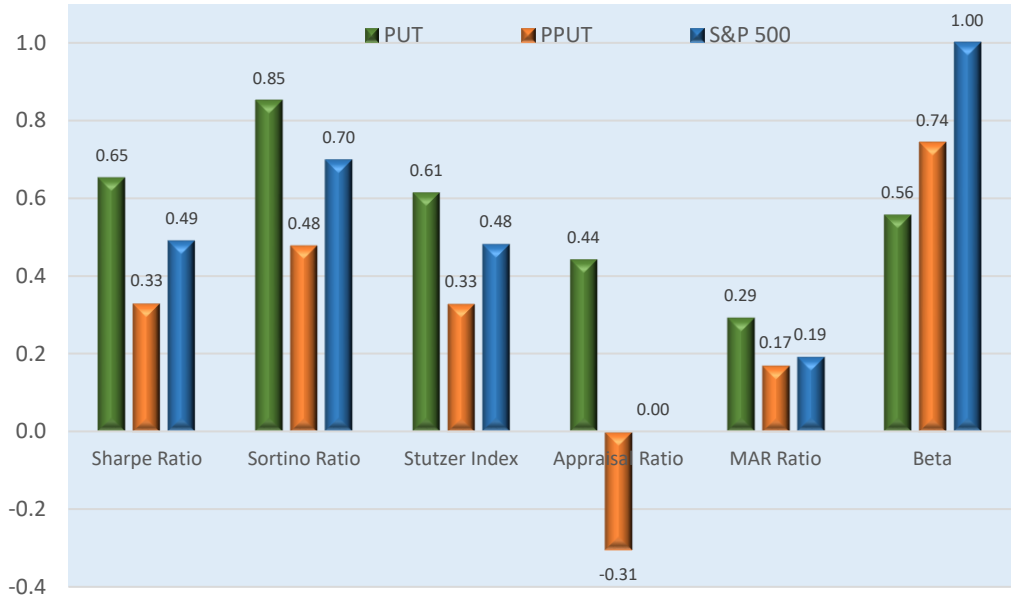
where $CAGR$ is the Compound Annual Growth Rate and MDD is the maximum drawdown since the portfolio's inception.

M-squared measure (or M^2, or Modigliani-Modigliani measure) is equal to the return of the portfolio which is levered or de-levered to have the same standard deviation as the Market.

PUT has more negative skeweness and larger kurtosis than PPUT and S&P 500. As a result, its Stutzer Index, which accounts for negative skewness and high kurtosis, drops more from the Sharpe Ratio. However, even with this adjustment the Stutzer Index for PUT remains considerably higher than for PPUT or S&P 500.

RISK-ADJUSTED PERFORMANCE MEASURES

EXHIBIT 26 – RISK-ADJUSTED MEASURES FOR PUT, PPUT, AND S&P 500 (JUN 30, 1986 TO DEC 31, 2018)



Annualized Sharpe Ratio, Sortino Ratio, Stutzer Index, Appraisal Ratio, MAR Ratio, and Beta with Market for PUT, PPUT, and S&P 500. The period is from Jun 30, 1986 to Dec 31, 2018.
Sources: Bloomberg and Cboe Exchange, Inc.

EXHIBIT 27 – ANNUALIZED STATISTICS (JUN 30, 1986 TO DEC 31, 2018)

	PUT	PPUT	S&P 500
Mean Return	9.66%	7.18%	10.52%
Compound Return	9.54%	6.64%	9.80%
Standard Deviation	9.95%	12.08%	14.93%
Alpha	2.39%	-1.46%	0.00%
Beta	0.56	0.74	1.00
Skewness (monthly)	-2.09	-0.28	-0.81
Kurtosis (monthly)	12.58	3.52	5.48
Sharpe Ratio	0.65	0.33	0.49
Sortino Ratio	0.85	0.48	0.70
Stutzer Index	0.61	0.33	0.48
MAR Ratio	0.29	0.17	0.19
Appraisal Ratio	0.44	-0.31	
M-squared	12.93%	8.11%	10.52%

PERFORMANCE IN DOWN AND UP MARKETS

Returns for PUT and PPUT have non-linear profiles. Consider the following specification, which estimates beta coefficients conditional on whether market is down or up:

$$\hat{r} = \alpha + \beta_{-}\hat{r}_{m,-} + \beta_{+}\hat{r}_{m,+} + \varepsilon$$

where
$\hat{r} = r - r_f$ is the monthly excess return on PUT or PPUT;
$\hat{r}_m = r_m - r_f$ is the excess return on S&P 500;
$\hat{r}_{m,-}$ = min($\hat{r}_m$, 0) and
$\hat{r}_{m,+}$ = max($\hat{r}_m$, 0) are the negative and positive excess returns on S&P 500.

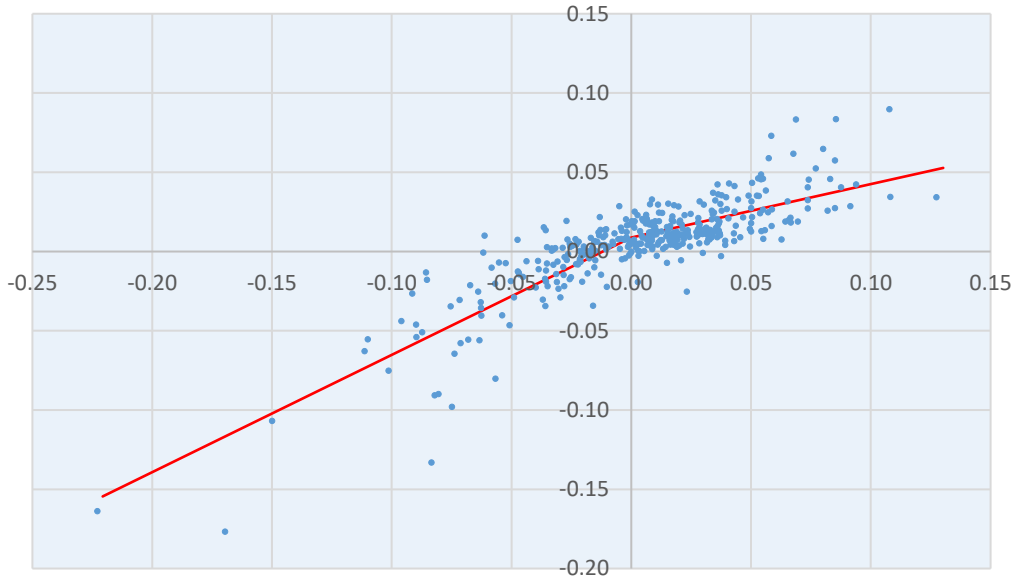
	PUT	PPUT
α	0.89%	-0.71%
β_{-}	0.75	0.58
β_{+}	0.34	0.93
R^2	74.2%	86.3%

For PUT, the down beta is much larger than the up beta. That is, its sensitivity to market moves is higher in down months than in up months. Its alpha is **positive** (0.89% per month), due to **selling** richly priced ATM put options.

In contrast, for PPUT, the down beta is smaller than the up beta. That is, its sensitivity to market moves is higher in up months than in down months. Its alpha is **negative** (-0.71% per month), due to **buying** richly priced OTM puts.

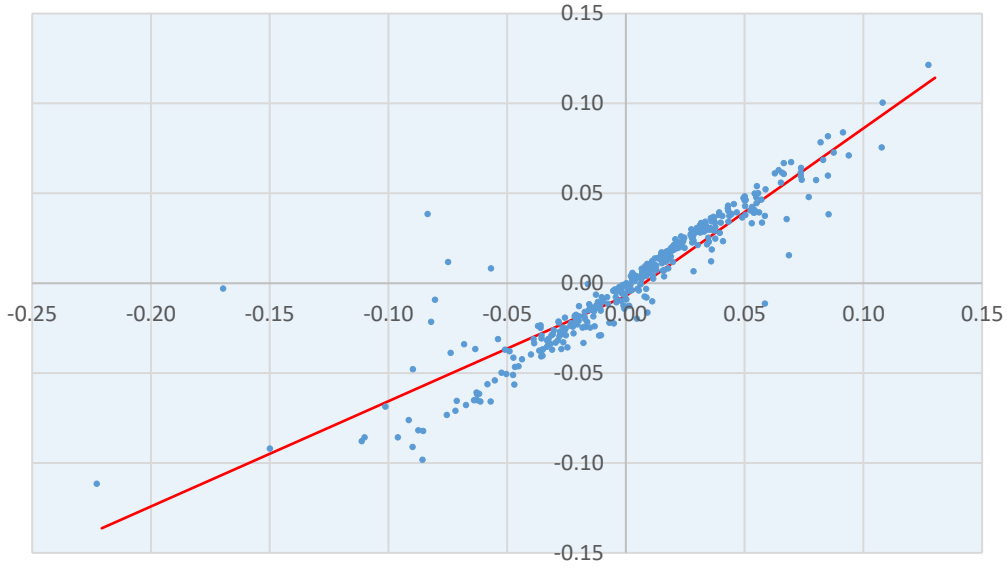
Overall, the return profile is concave for PUT and convex for PPUT.

EXHIBIT 28 – PUT VERSUS S&P 500 MONTHLY RETURNS (JUL 1986 TO DEC 2018)



Scatter plot of monthly excess returns for PUT versus S&P 500. The slope coefficients of the fitted curve are esimated separately for the negative and positive S&P 500 excess returns. The period is from Jun 1986 to Dec 2018. *Sources: Bloomberg and Cboe Exchange, Inc.*

EXHIBIT 29 – PPUT VERSUS S&P 500 MONTHLY RETURNS (JUL 1986 TO DEC 2018)



Scatter plot of monthly excess returns for PPUT versus S&P 500. The slope coefficients of the fitted curve are estimated separately for the negative and positive S&P 500 excess returns. The period is from Jun 1986 to Dec 2018. *Sources: Bloomberg and Cboe Exchange, Inc.*

PUT (PPUT) exhibits a negative (positive) exposure to volatility risk. Consider the following specification:

$$\hat{r} = \alpha + \beta_m \hat{r}_m + \beta_v \Delta VIX + \varepsilon$$

where
$\hat{r} = r - r_f$ is the monthly excess return on PUT or PPUT;
$\hat{r}_m = r_m - r_f$ is the monthly excess return on S&P 500;
$\Delta VIX =$ change in VIX from the previous month.

	PUT	PPUT
	0.29%	-0.17%
β_m	0.44	0.83
$\beta_v * 100$	-0.18	0.12
R^2	72.3%	84.0%

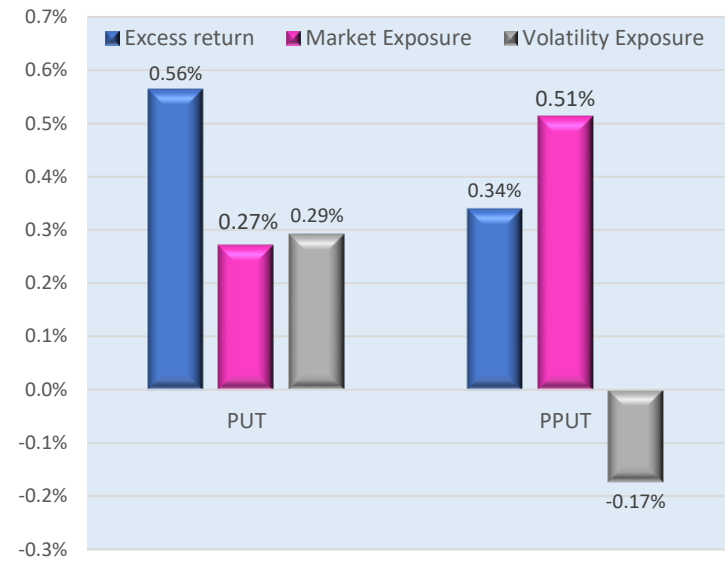
Both PUT and PPUT have positive exposures to the market. The exposure to volatility, however, is **negative** for PUT and **positive** for PPUT. This exposure to volatility risk accounts for 0.29% and -0.17% of the monthly excess returns for PUT and PPUT. (The absolute exposure to volatility is lower for PPUT than PUT because OTM puts have lower Vega than ATM puts.)

Suppose that all months are sorted into five equal groups based on VIX at the beginning of the month (Q1--lowest, Q5--highest) and the average return is computed for each quintile.

Generally, average PUT returns increase with VIX. (Intuitively, a higher VIX implies a higher premium collected by selling the ATM put. However, it is important to stress that, although the **average** return for Q5 is high, this group also includes some months with very negative returns.)
In contrast, average PPUT returns decrease with VIX (buying the OTM put becomes more expensive). However, statistically this relationship is weaker.

VOLATILITY EXPOSURE

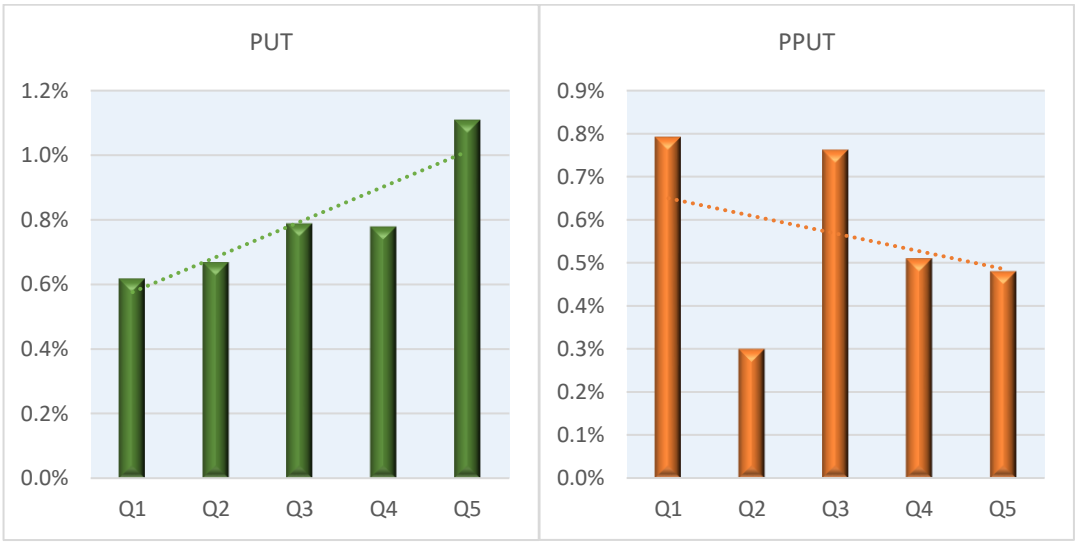
EXHIBIT 30 – DECOMPOSITION OF MONTHLY EXCESS RETURN INTO MARKET AND VOLATILITY EXPOSURES (JAN 1990 TO DEC 2018)



Average monthly excess return for PUT and PPUT is decomposed into two components, due to the market and volatility exposures. The period is from Jan 1990 to Dec 2018. *Sources: Bloomberg and Cboe Exchange, Inc.*

PERFORMANCE IN LOW AND HIGH VOLATILITY MARKETS

EXHIBIT 31 – PUT AND PPUT MONTHLY RETURNS SORTED INTO VIX QUINTILES (JAN 1990 TO DEC 2018)



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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.