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® Index) and Cboe S&P 500 One-Week PutWrite Index (WPUT® 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®)). 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

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

#### 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.
HISTORICAL PERFORMANCE OF PUT-WRITING STRATEGIES

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

EXHIBIT 4 – GROWTH OF BENCHMARK INDICES SINCE JUN 30, 1986


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

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

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

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

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.
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.

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

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

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

Sortino Ratio is defined as:

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

where $\sigma_d$ 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:

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

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

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)


### 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.

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

Exhibit 13 – Growth of Benchmark Indices Since Jan 31, 2006


Exhibit 14 – WPUT Index

<table>
<thead>
<tr>
<th>Index</th>
<th>Ticker</th>
<th>Strategy</th>
<th>Rollover</th>
<th>Year Launched</th>
<th>Price History Begins</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cboe S&amp;P 500 One-Week</td>
<td>WPUT</td>
<td>Short one-week ATM put options on S&amp;P 500 Index, long</td>
<td>Weekly (typically</td>
<td>2015</td>
<td>Jan 31, 2006</td>
</tr>
<tr>
<td>PutWrite Index</td>
<td></td>
<td>Treasury bills</td>
<td>every Friday)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- 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)

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

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

<table>
<thead>
<tr>
<th></th>
<th>PUT</th>
<th>WPUT</th>
<th>S&amp;P 500</th>
<th>Russell 2000</th>
<th>MSCI World</th>
<th>30-year Tbond</th>
<th>30-day Tbill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Compound Return</td>
<td>5.97%</td>
<td>4.51%</td>
<td>7.59%</td>
<td>6.27%</td>
<td>4.96%</td>
<td>5.47%</td>
<td>1.04%</td>
</tr>
<tr>
<td>Standard Deviation</td>
<td>10.69%</td>
<td>9.48%</td>
<td>14.32%</td>
<td>18.85%</td>
<td>15.18%</td>
<td>14.43%</td>
<td>0.47%</td>
</tr>
<tr>
<td>Sharpe Ratio</td>
<td>0.50</td>
<td>0.40</td>
<td>0.51</td>
<td>0.36</td>
<td>0.33</td>
<td>0.37</td>
<td></td>
</tr>
<tr>
<td>Sortino Ratio</td>
<td>0.14</td>
<td>0.12</td>
<td>0.15</td>
<td>0.10</td>
<td>0.09</td>
<td>0.11</td>
<td></td>
</tr>
<tr>
<td>Stutzer Index</td>
<td>0.48</td>
<td>0.39</td>
<td>0.50</td>
<td>0.36</td>
<td>0.33</td>
<td>0.37</td>
<td></td>
</tr>
</tbody>
</table>

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

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).


<table>
<thead>
<tr>
<th>Max Drawdown</th>
<th>PUT</th>
<th>WPUT</th>
<th>S&amp;P 500</th>
<th>Russell 2000</th>
<th>MSCI World</th>
<th>30-year Tbond</th>
<th>30-day Tbill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max Drawdown Month</td>
<td>Jan-09</td>
<td>Oct-08</td>
<td>Jan-09</td>
<td>Jan-09</td>
<td>Jan-09</td>
<td>Feb-10</td>
<td>Jan-06</td>
</tr>
<tr>
<td>Longest Drawdown (months)</td>
<td>29</td>
<td>22</td>
<td>52</td>
<td>44</td>
<td>68</td>
<td>32</td>
<td>0</td>
</tr>
</tbody>
</table>
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.

Sources: Cboe Exchange, Inc.
HISTORICAL PERFORMANCE OF PUT-WRITING STRATEGIES

ANNUAL PREMIUMS

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

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

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.

LIQUIDITY

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

Trading volume in SPX WeeklysSM (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.
COMPARISON OF PUT SELLING TO PUT BUYING

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

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).

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

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

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.

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.
RISK-ADJUSTED PERFORMANCE MEASURES


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

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.

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

\[ \text{Appraisal Ratio} = \frac{\alpha}{\sigma_e} \]

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); \( \beta \) is the corresponding beta coefficient; \( \sigma_e \) is the standard deviation of the residuals.

MAR Ratio is defined as:

\[ \text{MAR Ratio} = \frac{\text{CAGR}}{\text{MDD}} \]

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.
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:

\[ \hat{r} = \alpha + \beta_- \hat{r}_{m,-} + \beta_+ \hat{r}_{m,+} + \epsilon \]

where

\[ \hat{r} = r - \bar{r} \] is the monthly excess return on PUT or PPUT;

\[ \hat{r}_m = r_m - \bar{r} \] 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.

<table>
<thead>
<tr>
<th>PUT</th>
<th>PPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>(\alpha)</td>
<td>0.89%</td>
</tr>
<tr>
<td>(\beta_-)</td>
<td>0.75</td>
</tr>
<tr>
<td>(\beta_+)</td>
<td>0.34</td>
</tr>
<tr>
<td>(R^2)</td>
<td>74.2%</td>
</tr>
</tbody>
</table>

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.

Scatter plot of monthly excess returns for PUT 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.

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:

\[ \hat{r} = \alpha + \beta_m \hat{r}_m + \beta_v \Delta VIX + \epsilon \]

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.

<table>
<thead>
<tr>
<th>PUT</th>
<th>PPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.29%</td>
<td>-0.17%</td>
</tr>
<tr>
<td>( \beta_m )</td>
<td>0.44</td>
</tr>
<tr>
<td>( \beta_v \times 100 )</td>
<td>-0.18</td>
</tr>
<tr>
<td>( R^2 )</td>
<td>72.3%</td>
</tr>
</tbody>
</table>

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.
Oleg Bondarenko is Professor of Finance at University of Illinois at Chicago, and he serves on the Product Development Committee of Cboe.

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