Indexing Principal Protection:
A Comparison of Index Protection Strategies

- In response to the market’s turmoil over the last decade, investors are increasingly looking for downside protection. While a variety of insurance and structured product solutions exist, a principal or downside protected index potentially offers a simple way to bring transparent, lower cost solutions to investors.

- In this paper, the performance of the following portfolio insurance approaches are compared to evaluate how well each fares as a “protected S&P 500®” index:
  - Options based protective collars
  - Constant Proportion Portfolio Insurance (CPPI) and Dynamic Proportion Portfolio Insurance (DPPI)
  - Risk control or volatility capping
  - Risk budgeting

- Simulations from 1992 to 2009 show that protected collars achieved the highest risk-adjusted returns, and exhibit the lowest risk in terms of standard deviation and maximum drawdown. Protective collars also had the highest return to risk ratio in various market environments.

- Given the reasonably high liquidity of S&P 500 index options, an S&P 500 protective collar index can be calculated and implemented easily. Our earlier research, “Indexation of Principal Protection: A ‘S&P 500 Protective Put Index’ Concept,” discussing the mechanics of accomplishing this type of index can be accessed here.
I. Introduction

Given the market turmoil over the last decade, investors increasingly look for downside protection. While various insurance and structured product solutions exist, they often suffer criticisms related to relative opacity or higher costs. A principal, or downside protected, index potentially offers a simple way to bring transparent, lower cost solutions to investors. Most protected index products are linked to a headline index such as the S&P 500, and a variety of techniques can be used to derive the protection. Accordingly, an empirical revisit of each approach using S&P 500 data is worthwhile. Specifically, this paper seeks to provide further insight into the debate over which technique should be adopted when constructing principal protected indices. Four popular broad approaches to dynamic portfolio insurance have been examined: Options Based Portfolio Insurance (OBPI), Constant or Dynamic Proportion Portfolio Insurance (CPPI/DPPI), risk control or volatility capping (VC), and the recently developed risk budgeting (RB).

After introducing these strategies, the mathematical model underlying each approach will be discussed, and finally, historical market scenarios to illustrate the behaviors of different strategies during the sample period will be used. The objective is to determine which approach is more suitable to construct a principal protected S&P 500 index.

The OBPI approach consists of buying a risky asset such as the S&P 500, and a put option written on it. When the put option expires, there are two possible outcomes. If the index is above the exercise price, the put option has no value and the premium initially paid is lost, but the portfolio value has no cap on the upside. If the index is below the exercise price, the put option will be exercised to limit the portfolio’s downside. In either case, the value of this portfolio at maturity is always greater than the strike price of the put option, whatever the market fluctuations. Despite its simplicity, OBPI suffers from a few drawbacks. First, out-of-the-money-put options are usually very expensive. Second, the set of available maturities for options is limited and the longer term maturities are often illiquid. Consequently, investors may need to roll out a sequence of short maturity options, which results in a highly path-dependant strategy, as market conditions will have a dramatic impact on the cost of rolling the insurance. Often, selling some of the upside via sale of calls is used to finance part of the put purchase. Our earlier research entitled, “Indexation of Principal Protection: A ‘S&P 500 Protective Put Index’ Concept,” focusing on the mechanics of executing this strategy in an index framework can be accessed here.

CPPI is a common strategy used to allocate assets dynamically over time. The investor starts by choosing a floor equal to the lowest acceptable value of the portfolio. Then, he/she computes the cushion which is equal to the excess of the portfolio value over the floor. Finally, the amount allocated to the risky asset is determined by multiplying the cushion by a predetermined multiple. The remaining funds are invested in the reserve asset, which might be Treasury Bills or other liquid money market instruments. Initial cushion, multiple, floor, and tolerance variables can be chosen according to the investor’s own objective. When the price of the risky asset increases, the cushion increases, calling for an investor to buy more risky assets to be financed by selling bills. Conversely, when the price of the risky asset falls, the cushion reduces, triggering sales of the risky asset and investment of the proceeds in bills. In case of a heavy and repeated market slump, the CPPI strategy can lead to a cash-out event.
followed by investment in fixed income instruments until maturity. Consequently, the CPPI strategy will do very well in a trending bull market with no reversals, as the investor keeps increasing his exposure. In a flat oscillating market, however, CPPI will do relatively poorly, as the investor buys on strength only to see the market weaken and then sells on weakness only to see the market rebound. While the CPPI resembles a standard option replication strategy in essence, it diverges by making no assumptions about future portfolio volatility or about the distribution of portfolio returns. It does not require the investor to specify a finite time horizon.

In addition to the traditional CPPI approach, an advanced version called DPPI (Dynamic Proportion Portfolio Insurance) deserves examination. DPPI is designed to address the limitations in the traditional CPPI, in which the multiple is fixed, the protection level is only determined at the beginning of the strategy, and both variables are functions of the investor’s risk tolerance. Fixing the multiple fails to recognize the essential fact that the risk of the risky underlying asset, together with the investor’s asymmetric tolerance to the risk, changes according to market evolutions. Determining the protection level at the beginning of the strategy also ignores the fact that most investors tend to anchor on a recent “high” level that the portfolio has achieved, and consequently form investment decisions based on that high level. Therefore, investors care about not only the final wealth level of the portfolio, but also the path it takes to reach that level. Unlike CPPI, the DPPI approach implements a variable multiple based on the downside risk measure of the portfolio. As the downside risk level increases, the multiple decreases to reflect the diminishing risk tolerance of the investor, and vice versa. Instead of setting the floor level based on the initial level of the portfolio, the floor is set as a percentage of the highest ever portfolio level. As with traditional CPPI, if the risky asset starts to fall then it is reduced in favor of cash, but more importantly, previous gains are locked in.

The risk control or volatility capping (VC) approach implements an overlying mathematical algorithm designed to control the level of risk of the risky asset by establishing a specific volatility target and dynamically adjusting the exposure to the risky asset based on its observed historical volatility. If the risk level reaches a threshold that is too high, the cash level is increased to maintain the target volatility. If the risk level is too low, the index will employ leverage to maintain the targeted level of volatility. The rationale of VC is based on the observation that market volatility may be easier to predict than market returns: periods of high volatility tend to be clustered, and in these periods, investors might want to reduce their index exposure and wait for volatility to revert to normal levels before rebalancing their portfolio toward risky assets. The VC strategy attempts to provide downside protection by reducing the risky exposure during high volatility periods. In contrast to CPPI and OBPI, it does not truly guarantee a floor amount, and completely ignores gains and losses on the portfolio.

When taking the Risk Budgeting (RB) approach, the investor starts by setting a total risk budget as the maximum allowable loss on the overall portfolio over a given period, a function of the investor’s risk tolerance. A daily risk budget is then derived as a portion of this total risk budget. The RB approach consists of rebalancing the portfolio between the risky asset and the risk free asset so that the portfolio’s daily 1% Value at Risk is always equal to the daily risk budget. This ensures that the loss in portfolio value over a day will be smaller than the portfolio’s risk budget 99% of the time. Gains or losses on the portfolio are immediately added to the total risk budget, and therefore, affect the risk exposure. Changes in the market volatility will impact the Value at Risk of the portfolio, and therefore, will result in a change in the risky exposure.
II. The Models

Option Based Portfolio Insurance (OBPI)

The investment rationale for buying put options is to protect a long position in the asset and limit downside risk. For the protected put strategy, the investors divide their principal to invest in both risky assets and put options. The investors pay a premium regardless of the risky asset price at maturity, but will benefit from the predetermined floor set by put strike if the risky asset depreciates. The combined position of risky asset and put option still has unlimited upside potential, but the profit from the put offsets the loss from the risky asset once the risky asset price goes below the strike. The maximum loss of the combined position is limited to the difference between the spot and strike, plus the premium paid upfront. Dash and Liu (2008) investigated a protected put strategy based on S&P 500 and explored the trade-offs associated with various financing and maturity options. They found that quarterly rollover of option contracts is more efficient than monthly rollover, and that using OTM options instead of ATM options can significantly increase the risk-adjusted performance. They also suggest that in addition to straight put options, an investor could finance the put by shorting out of the money (OTM) calls as long as he/she is willing to give up some of the upside in return for lowering the cost of the protection. In this paper, we draw upon their findings and explore the protected put strategy using 2% collars with quarterly rollover frequency to represent the protected put strategy. Per earlier research, we calculate the accumulated total return for the strategy as follows:

$$ R = \frac{PX_t + DVD_t + C_t^{\text{put}} - C_t^{\text{call}}}{PX_{t-1} + C_{t-1}^{\text{put}} - C_{t-1}^{\text{call}}} $$

Where,

- $PX_t$ = index close price,
- $DVD_t$ = dividend points of index
- $C_t$ = option close price

Constant Proportion Portfolio Insurance (CPPI)

$W_t$ denotes the value of a portfolio at time $t$, $F_t$ is the floor of a portfolio, and $CU_t$ is the cushion defined as difference between $W_t$ and $F_t$. $E_t$ is the exposure to the index, which is a multiplier $m$ of $CU_t$, where $m$ is a constant greater than one. The key idea of CPPI is to keep the multiplier $m$ static, we set it at 4. Our simulation is based on the linear rule:

$$ E_t = m \times CU_t = m \times (W_t - F_t) $$

We rebalance the CPPI strategy on a quarterly basis to be consistent with OBPI simulations. The floor is set at 90% of the initial value of the portfolio. To avoid a complete cash-out situation, we set the minimum exposure to the S&P 500 at 15%.

Dynamic Proportion Portfolio Insurance (DPPI)

Though the DPPI strategy is based on a theoretical foundation similar to that which informs the CPPI strategy, it introduces variability into the determination of the multiple $m$ and the portfolio floor $F$. Another difference between traditional CPPI and DPPI is that rather than setting the cushion as the difference between the current wealth level of the portfolio and the floor (which is usually set as a percentage of the initial investment), it is set as the difference between the wealth level of the portfolio
and a dynamic guaranteed minimum value, which is a percentage of the highest ever wealth level of the portfolio. As with traditional CPPI, if the risky asset starts to fall, then the risky exposure is reduced in favor of cash, but importantly, any earlier gains made are locked in.

DPPI is based on the linear rule:

\[ E_t = m_t \times CU_t = m_t \times (W_t - F_t) = m_t \times (W_t - MAX(W) \times q\%) \]

\[ m_t = \left[ \frac{VaR_t}{\alpha R_{99\%}} \right]^{-1} \]

To avoid generating extreme multiples and remain consistent with multiples used by practitioners, we constrain it between 1 and 6. To avoid a complete cash-out situation, we set the minimum exposure to the S&P 500 at 15%.

Volatility Capping (VC)
The risk control or volatility capping strategy applies dynamic exposure to a risky asset in an attempt to control the level of volatility. The S&P Risk Control Index Series is built around this approach. This approach is commonly used by structured product issuers to reduce the volatility, and therefore upfront cost, of products. The strategy includes a leverage factor that changes based on realized historical volatility. If realized volatility exceeds the target level of volatility, the leverage factor will be less than one, representing a deleveraged position. If the realized volatility is lower than the target level, the leverage factor will be greater than one and less than the maximum allowable level, representing a leveraged position. We calculate the return for the strategy as follows:

\[ R = K_t \times \left( \frac{\text{Index}_t}{\text{Index}_{t-1}} - 1 \right) + (1 - K_t) \times \left( \frac{r_{t-1}}{360} \right) \]

\[ K_t = \text{Min} (\text{Max } K, \text{Target Volatility} / \text{Realized Volatility}) \]

The target volatility can be set to a specific level as appropriate. In our simulations, we set the target volatility at 10% and the maximum leverage, Max K, at 150%. To be consistent with earlier approaches, we rebalance the positions quarterly.

Risk Budgeting (RB)
Our risk budgeting (RB) approach is based on the pragmatic rule that the investor is willing to risk up to 10% of the value of his portfolio over one quarter. The daily risk budget is then simply a portion of the annual risk budget, calculated as:

Daily risk budget = Min (30% of the total risk budget, 3% of portfolio value)

To implement the RB approach, one needs to find the appropriate weight split between the risky asset and the risk free asset so as to have the daily 1% Value at Risk equal to the daily risk budget.

III. Empirical Tests
Table 1 shows that during the whole sample period, the protected collars strategy tends to exhibit the lowest risk in terms of standard deviation and maximum drawdown. Moreover, on relative performance (Sharpe Ratio), the protected collars approach outperforms others. On absolute performance, the risk control strategy shows some advantages. DPPI outperforms the traditional CPPI strategy without bearing more risks. Indeed, DPPI offers the lowest risk among the strategies, other than OBPI. The risk budgeting approach produces a risk/return profile similar to that of the DPPI strategy.
We also analyze the strategies using a scatter plot, where each point represents the portfolio’s return versus the S&P 500’s return at the end of a given one quarter holding period. The protected collars strategy provides the best downside protection, but it comes at the expense of relatively low upside participation during bull markets, as indicated by the flatter slope of the curve in the positive territory of the market return. With the risk control approach, the lack of downside protection and upside potential is visible, as demonstrated by the steeper slope of the curve in the negative territory of the market return, and the limited upper area of the curve in the positive territory of the market return. Both the CPPI and DPPI strategies provide decent downside protection as shown by the flattening of the curve in the negative territory of the market return. However, DPPI tends to provide more consistent upside participation during bull markets, as the scatter plot is more narrowly spanned in the upper area. The risk budgeting approach not only provides some downside protection, but also exhibits strong upside participation during bull markets, as indicated by the steeper slope of the curves in the positive territory of market return.

While the first set of scatter plots covers the entire simulation history, it is important to understand the performance of various approaches in specific market conditions. We investigated some special market environments during the sample period to determine performance differences among the strategies, the results of which can be found in Figure 2. Below is a summary of the results:

- Looking at the period from May 2008 to March 2009, a dramatic market crash environment. In this environment, protected collars and risk budgeting provided good downside protection, while other approaches did not.
- Next, we considered the case of a strong bull market between October 1998 and August 1999. In this environment, the protected collars deliver the best risk-adjusted performance and the lowest drawdown. CPPI and DPPI deliver higher returns, albeit with higher risk and drawdown.
- We also analyzed a situation where a crash is followed by a volatile recovery, such as the market environment over the period of March 2002 to January 2004. Again, the protected collar approach delivers the best risk adjusted returns, and has the lowest downside risk. CPPI and DPPI fare the worst, as expected, because they hit the floor twice and did not catch up in the recovery.
The last scenario analyzed was a volatile sideways market, such as the period from January 2004 to November 2004. In this market environment, the protected put strategy outperforms, as it doesn't rely on price trend signals and is much less volatile than other strategies.

**Figure 1 Historical Scatter Plots of Protected S&P 500**

*(December 1992 to January 2010)*

Data source: S&P Indices, Bloomberg. Charts, calculations and values used in this analysis are shown for illustration purposes only. Hypothetical returns are for illustration purposes only.
Figure 1 Historical Scatter Plots of the Portfolio Insurance Strategies (December 1992 to January 2010 – Continued)

CPPI
1-quarter holding returns

S&P 500 1-quarter holding returns

DPPI
1-quarter holding returns

S&P 500 1-quarter holding returns

Data source: S&P Indices, Bloomberg. Charts, calculations and values used in this analysis are shown for illustration purposes only. Hypothetical returns are for illustration purposes only.
Figure 1 Historical Scatter Plots of the Portfolio Insurance Strategies (December 1992 to January 2010 – Continued)

Data source: S&P Indices, Bloomberg. Charts, calculations and values used in this analysis are shown for illustration purposes only. Hypothetical returns are for illustration purposes only.
Figure 2: Scenario Analysis of Protected S&P 500
Scenario 1: Market Crash (May 2008 – March 2009)

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P 500</th>
<th>Protected Collars</th>
<th>Risk Control (10%)</th>
<th>CPPI</th>
<th>DPPI</th>
<th>Risk Budgeting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>-44.7%</td>
<td>-6.3%</td>
<td>-20.1%</td>
<td>-27.2%</td>
<td>-20.5%</td>
<td>-3.2%</td>
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<tr>
<td>Risk</td>
<td>45.8%</td>
<td>15.5%</td>
<td>14.7%</td>
<td>16.0%</td>
<td>13.3%</td>
<td>6.2%</td>
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<tr>
<td>Skew</td>
<td>0.24</td>
<td>3.16</td>
<td>-0.54</td>
<td>-1.43</td>
<td>-0.79</td>
<td>-2.46</td>
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<tr>
<td>Kurtosis</td>
<td>5.27</td>
<td>55.72</td>
<td>5.84</td>
<td>10.55</td>
<td>5.35</td>
<td>26.86</td>
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<tr>
<td>Beta</td>
<td>0.09</td>
<td>0.28</td>
<td>0.27</td>
<td>0.23</td>
<td>0.23</td>
<td>0.02</td>
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<tr>
<td>Max Drawdown</td>
<td>51.5%</td>
<td>9.0%</td>
<td>22.5%</td>
<td>27.0%</td>
<td>22.1%</td>
<td>6.2%</td>
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</table>

Data source: S&P Indices, Bloomberg. Charts, calculations and values used in this analysis are shown for illustration purposes only. Hypothetical returns are for illustration purposes only.
Figure 2: Scenario Analysis of Protected S&P 500 (Continued)
Scenario 2: Bull Market (October 1998 – August 1999)

Data source: S&P Indices, Bloomberg. Charts, calculations and values used in this analysis are shown for illustration purposes only. Hypothetical returns are for illustration purposes only.

<table>
<thead>
<tr>
<th></th>
<th>S&amp;P 500</th>
<th>Protected Collars</th>
<th>Risk Control (10%)</th>
<th>CPPI</th>
<th>DPPI</th>
<th>Risk Budgeting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Return</td>
<td>1.3%</td>
<td>7.3%</td>
<td>2.5%</td>
<td>1.7%</td>
<td>-3.8%</td>
<td>7.4%</td>
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<tr>
<td>Risk</td>
<td>22.3%</td>
<td>6.4%</td>
<td>10.4%</td>
<td>13.7%</td>
<td>8.1%</td>
<td>10.6%</td>
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<tr>
<td>Skew</td>
<td>0.36</td>
<td>4.44</td>
<td>0.25</td>
<td>0.18</td>
<td>0.29</td>
<td>0.64</td>
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<tr>
<td>Kurtosis</td>
<td>4.25</td>
<td>47.52</td>
<td>3.42</td>
<td>4.33</td>
<td>7.15</td>
<td>9.36</td>
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<td>Beta</td>
<td>0.15</td>
<td>0.44</td>
<td>0.55</td>
<td>0.31</td>
<td>0.24</td>
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<tr>
<td>Max Drawdown</td>
<td>33.0%</td>
<td>4.6%</td>
<td>18.7%</td>
<td>18.9%</td>
<td>18.8%</td>
<td>13.8%</td>
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Data source: S&P Indices, Bloomberg. Charts, calculations and values used in this analysis are shown for illustration purposes only. Hypothetical returns are for illustration purposes only.
Figure 2: Scenario Analysis of Protected S&P 500 (Continued)
Scenario 4: Volatile Market (January 2004 – November 2004)

<table>
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<tr>
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<th>S&amp;P 500</th>
<th>Protected Collars</th>
<th>Risk Control (10%)</th>
<th>CPPI</th>
<th>DPPI</th>
<th>Risk Budgeting</th>
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<tr>
<td>Return</td>
<td>4.0%</td>
<td>4.7%</td>
<td>2.3%</td>
<td>0.8%</td>
<td>3.4%</td>
<td>0.9%</td>
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<tr>
<td>Risk</td>
<td>11.3%</td>
<td>5.2%</td>
<td>10.5%</td>
<td>7.9%</td>
<td>9.1%</td>
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<tr>
<td>Skew</td>
<td>-0.10</td>
<td>1.95</td>
<td>-0.19</td>
<td>-0.19</td>
<td>-0.11</td>
<td>-0.31</td>
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<tr>
<td>Kurtosis</td>
<td>2.75</td>
<td>17.65</td>
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<td>3.01</td>
<td>2.74</td>
<td>5.07</td>
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<td>Beta</td>
<td>0.32</td>
<td>0.92</td>
<td>0.60</td>
<td>0.80</td>
<td>0.80</td>
<td>0.50</td>
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<tr>
<td>Max Drawdown</td>
<td>7.4%</td>
<td>2.0%</td>
<td>8.1%</td>
<td>5.2%</td>
<td>5.9%</td>
<td>8.6%</td>
</tr>
</tbody>
</table>

Data source: S&P Indices, Bloomberg. Charts, calculations and values used in this analysis are shown for illustration purposes only. Hypothetical returns are for illustration purposes only.
IV. Conclusions
Given the market turmoil over the last decade, investors are increasingly looking for downside protection. While a variety of insurance and structured product solutions exist, a principal or downside protected index potentially offers a simple way to bring transparent, lower cost solutions to investors. We compared four portfolio insurance approaches in order to evaluate how well each fares as the basis for a “protected S&P 500” index, and found that protected collars seem to provide the best downside protection and the best risk-adjusted returns, over the long run. Given the reasonably high liquidity of S&P 500 index options, an S&P 500 protective collar index can be calculated and hedged easily, and could be an attractive alternative to more expensive principal protected investment vehicles.
References
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