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Risks & Rewards

SOCIETY OF ACTUARIES
INVESTMENT SECTION

Strategic Factor Allocation: Case Studies in Applying Factors in Portfolio Design

By Andrew Ang, Sara Shores, Bob Bass with additional contributors Di Sanborn, Kristin Fergis and Katelyn Gallagher

SUMMARY

- Portfolios that appear diversified from an asset class perspective may be less diversified than investors think, as their risk is often concentrated in one or more factors.
- We believe that investors can construct better-diversified portfolios that may be more likely to help them meet specific objectives by incorporating factor insights into their asset allocations.
- To do so, investors must understand which factors they own, which factors they want to own and how to adjust portfolios along factor lines.
- We help answer these questions through two case studies: one starts with a blank slate and then builds a targeted factor portfolio; the other considers multiple options for shifting factor allocations in an existing portfolio.

ABOUT FACTORS AND ASSET ALLOCATION

Investment factors are the broad, persistent drivers of return that underlie all asset classes, and we separate them into two groupings: macro and style factors

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This newsletter is free to section members. Current issues are available on the SOA website (www.soa.org).

To join the section, SOA members and non-members can locate a membership form on the Investment Section webpage at http://www.soa.org/professional-interests/investment/invest-detail.aspx

Publication Schedule
Publication Month: February 2019
Articles Due: Nov. 14, 2018

Chairperson's Corner

By Kelly Featherstone

Actuaries are highly sought-after professionals who develop and communicate solutions for complex financial issues. Actuaries measure and manage risk. They have a deep understanding of mathematics, statistics and business management with which they help businesses grow and provide value to their customers. Actuaries help leaders make strategic decisions and consumers prepare for their future.[1]

As the sole actuary in my company (until very recently), I am asked a plethora of questions across a broad range of topics by colleagues who recognize the actuarial skill set. The actuarial value proposition is about more than just being able to pass exams; it's about developing and communicating solutions for complex financial issues. I don't have all the answers on my own, but I have a deep professional network and professional organizations to support me in delivering value and solutions to my company and clients. Practicing in a nontraditional role, remote from regular actuarial interactions, I have quickly learned that engagement is a requirement to get the most out of my actuarial designation. The Society of Actuaries' (SOA's) website states, "Actuaries deliver value as business leaders and professionals."[2] To deliver on this promise, I need to keep up on current topics and leverage tools available to me through my actuarial memberships.

SOA sections develop and provide the grassroots content for professional interest areas, including newsletters, webcasts, meeting sessions, podcasts, networking events and seminars. I can't think of an actuarial practice area that doesn't interact with financial markets or investments in some way, and the Investment Section seeks to promote investment knowledge across the actuarial profession. This includes investment practitioners and noninvestment actuaries alike. The Investment Section is continuing to find new ways to generate content and add value for section members.

As chair of the Investment Section, I encourage you to be a part of the conversation—volunteer, attend a webcast. Tune into our "How to Be an Investment Actuary" podcast to find out more about interesting investment actuaries. We would love to hear from you, so please contact me or David Schraub *(dschraub@soa.org)* if you have any questions or comments. ■

Kelly Featherstone, FSA, CFA, ACIA, is director, client relations for Alberta Investment Management Corporation and chair of the Investment Section Council. She can be contacted at *kelly.featherstone@aimco.alberta.ca*.

ENDNOTE

1 Society of Actuaries. 2018. "What is an Actuary?" *https://www.soa.org/future-actuaries/what-is-an-actuary*.

2 Ibid.

Staff Corner

By David Schraub

WHAT'S IN IT FOR ME?

In the world of client-serving professionals who globally optimize value generation by minimizing resource-intensive processes and leveraging synergy, Big Data, InsurTech, cost-benefit-risk analysis, Blockchain and other buzz words and/or three-letter acronyms (TLAs) or four-letter acronyms (FLAs), what does the Investment Section do for me? Where's the beef?

THE INVESTMENT SECTION IS FUN

We are sponsoring an Asset Allocation Contest. We will be announcing the three portfolios that won the the prize for best risk-adjusted alpha return, greatest accumulation and best-managed drawdown risk. Visit the Society of Actuaries' (SOA's) website for more information (*https://www.soa.org/sections/investment/investment-resources/*) and click Asset Allocation Contest.

We are also planning some networking activities at the annual meeting and in a few investment hubs. Stay tuned for more.

THE INVESTMENT SECTION IS USEFUL

Need to read a published paper on investment topics? Most academic papers on investment topics are accessible with our EBSCO partnership. A member-exclusive benefit!

THE INVESTMENT SECTION IS EDUCATIONAL

We offer webcasts on investment topics, such as the Redington Webcast (2/20/18), and have a few others in the works. We also have and plan to do more podcasts.

We built the Economic Scenario Generator, a four-hour pre-LAS seminar that tackles intermediate and advance issues with scenario generations.

We had the Investment Symposium in March where attendees were able to learn about advanced investment techniques despite the inclement weather. The impressive sessions got 5.0 ratings!

Later this year, we will deliver the first iteration of an Investment Bootcamp to support the needs of insurance actuaries who feel the need to up their game on investment topics.

And of course, we are already working hard on the SOA annual meeting sessions with a balance of pension and insurance investing.

THE INVESTMENT SECTION IS A GOOD READ

Enjoy the newsletter and all its great articles.

Want to help? Send me an email (*dschraub@soa.org*) or call me (847.706.3560), and we will leverage your volunteer capacity!

David Schraub, FSA, CERA, AQ, MAAA, is a staff actuary for the SOA. He can be contacted at *dschraub@soa.org*.

Interest Rates of the Future

Celebrating the historic launch of the CME SOFR futures contract, with (from left) Thomas Wipf (Morgan Stanley), Sandra O'Connor (JP Morgan, The Alternative Reference Rates Committee [ARRC]) and Bryan Durkin (President of CME group), Rockefeller Center, New York, July 10, 2018. The secured overnight financing rate (SOFR) is on track to replace LIBOR as the index of choice for U.S. derivatives and index-linked debt. As SOFR is based on over $750 billion of actual transactions each day, it will prove to be a reliable reference for financial transactions. Actuaries involved in derivatives hedging, securitized assets, guaranteed investment contracts and more should get to know SOFR—and talk to their attorneys about what LIBOR fallback language is being written into contracts today.

From left: Frank Rybinski (presenting), Erik Thoren (moderator), Jason Celente (presenter) and Hal Pedersen (presenter).

Session 57 at the 2018 Life and Annuity Symposium, "What's Driving Interest Rates," provided the audience with perspectives from three presenters with diverse backgrounds on the factors driving global interest rates in today's economic environment.

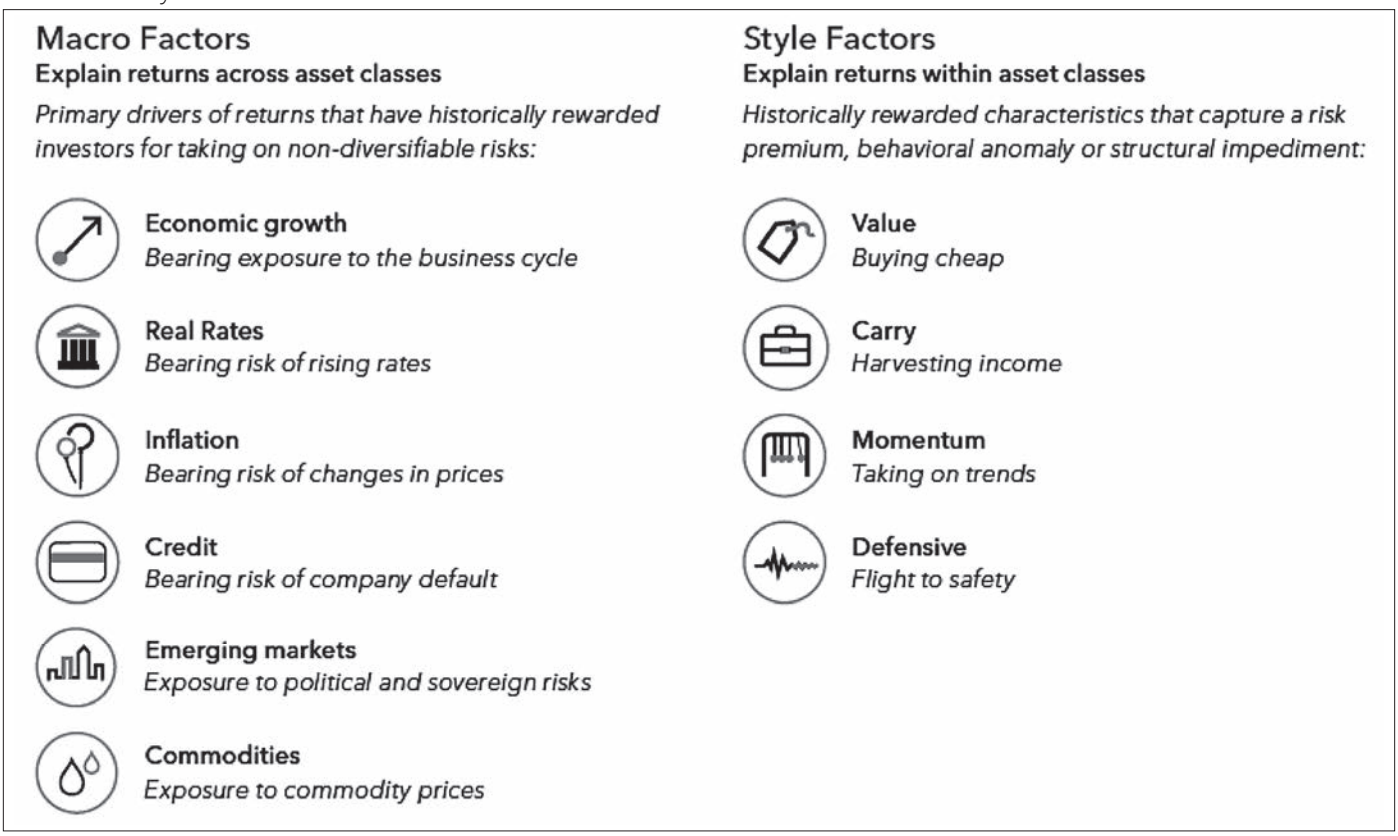
Frank Rybinski, chief macro strategist at AEGON Asset Management US, offered views on macro factors affecting rates. This included potential headwinds from a lower U.S. growth rate, due to changing demographics and a ceiling on productivity growth, and increased inflation uncertainty.

Jason Celente, senior portfolio manager at Insight Investment, provided context around what influences his thinking as a day-to-day practitioner. He noted the difficulty of incorporating the wealth of available information on five factors that drive interest rates (monetary policy, technical, fiscal policy, relative value and fundamentals), particularly when measuring some of these factors can be challenging.

Hal Pedersen, managing director, Risk Solutions with Conning, presented the perspective from an insurance industry practitioner. He focused on how to create a representative economic model for risk management purposes, and the associated difficulties of combining theoretical views of how interest rates behave with "real world" observations.

Despite their wide-ranging viewpoints, one thing was clear: understanding what has driven interest rates is a challenge and predicting where they will go in the future is an even tougher endeavour!

Figure 1
Macro And Style Factors That Underlie All Asset Classes



(Figure 1). Macro factors—economic growth, real rates, inflation, credit, emerging markets and commodities—explain the majority of returns across asset classes. Style factors—value, carry, momentum and defensive—explain the majority of variation within asset classes. While macro factors describe movements of whole markets, style factors explain relative movements of securities within markets.

The determination of these macro and style factor sets are based on adherence to four key principles:

1. Has the factor created value over long periods of time? We are only interested in those factors that have a demonstrated track record of positive risk-adjusted returns over decades.

2. Is there an underlying economic rationale? To avoid data mining and overfitting, a factor's persistent performance must be attributable to one or more reasons such as rewarded risk, structural impediment or investors' biases.

3. Is it diversifying? We look for factors that exhibit low correlations over time with other sources of return such as the broader market or other factors.

4. Is it scalable? We ideally want to invest in factors that are investable in large volumes in a liquid and cost-efficient manner.

To analyze an asset allocation through a factor lens, we need a way to translate seamlessly between assets and factors. We start by proxying a client's strategic asset allocation with a set of asset class representations. Each asset class consists of hundreds, or even thousands, of underlying securities. Each of these securities can be mapped onto a granular set of risk exposures, like spread, duration and sector for corporate bonds, and industry, valuation ratios, and other balance sheet and earnings variables for stocks.

In total, thousands of risk exposures span all asset classes. Once we create a risk exposure representation of a portfolio, we can map those risk exposures onto the much smaller set of macro factors by using a combination of qualitative (such as economic intuition) and quantitative (such as regression analysis) approaches. Time series of the asset classes and factors are used to quantify the magnitude and direction of those relationships. The result is not just a measure of the total risk of a portfolio but also of how each asset class or factor contributes to that total. Although analyses such as these leverage hundreds of thousands

of data points, state-of-the-art tools and models can perform them in a matter of seconds.

ASSET ALLOCATION THROUGH A FACTOR LENS

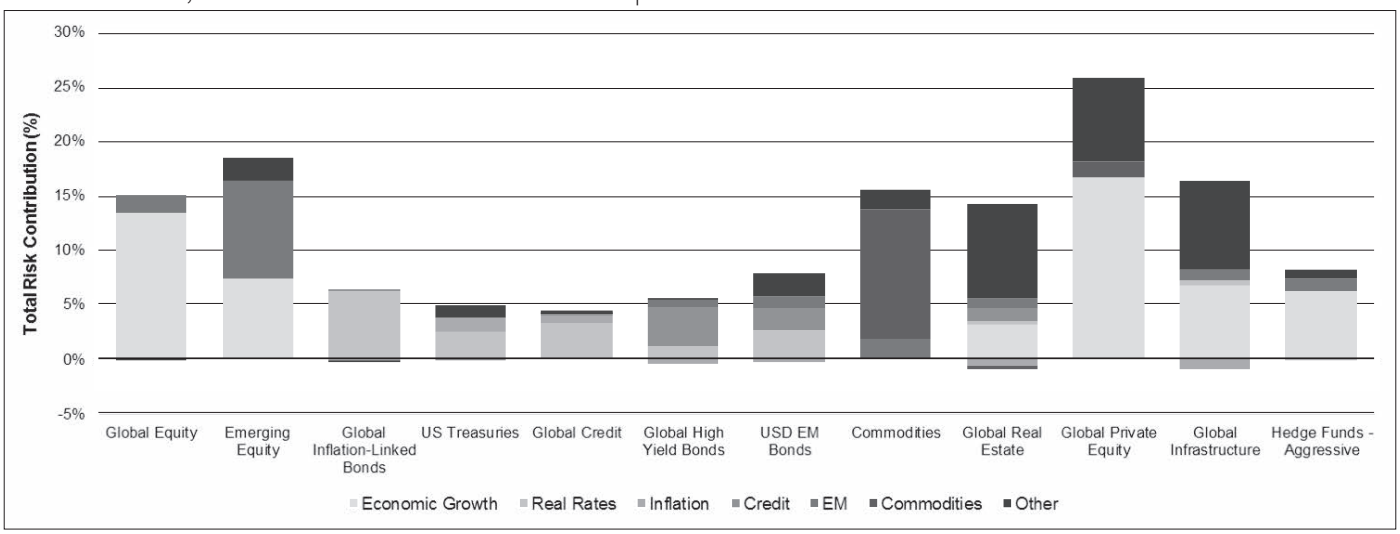
Asset allocation is one of the most important decisions institutional investors have to make. One of the primary goals of the asset allocation process is to construct well-diversified portfolios that are designed to meet risk and return targets in a variety of market and macroeconomic environments. Unfortunately, portfolios that appear diversified from an asset class perspective may be less diversified than investors think, as their risk is often concentrated in one or more macro factors. This became painfully apparent during the global financial crisis of 2008–2009, when many allegedly diversifying assets moved in lockstep. We believe that investors can construct better-diversified portfolios that may be more likely to help them meet their specific objectives by incorporating factor insights into their asset allocation.

Factor investing first involves an understanding that asset classes are merely combinations of factors and, importantly, that many asset classes share similar factor exposures as shown in Figure 2. For example, portfolios with large exposure to equity and private equity are in fact doubling down on economic growth risk rather than diversifying risk away.

The predominance of the economic growth factor across many asset classes has helped that factor to dominate the risk of a variety of institutional investors' portfolios, as Figure 3 illustrates. Pension and endowment portfolios may have a disproportionate exposure to the growth factor due to their heavy reliance on equities and other growth-sensitive assets. Even insurance company portfolios that are heavily concentrated in fixed income and have relatively small weightings to equities may end up with economic growth as their largest source of macro risk due to the relative riskiness of equities. Although economic growth may be attractive from a risk/return perspective, lack of diversification across macro factors can offset some or all of that benefit during periods when the growth factor is not being rewarded.

By examining their total asset allocation—including alternatives and private assets—through a factor lens, investors can gain new insights into their risk and diversification. Different institutions will, of course, have different objectives when thinking about a desired factor allocation. Some, such as well-funded private endowments or family offices, may have relatively few constraints and can simply seek to maximize long-term returns. Pensions and insurers, on the other hand, will likely need to work with tighter constraints. Pensions have to budget for quarterly benefits payments and may wish to consider liability matching,

Figure 2
Different Assets, Common Risks: Macro Factor Decomposition Of Different Asset Classes



Source: Aladdin Factor Workbench, June, 2017. Global asset classes are all hedged to USD. Risk contribution is the risk decomposition of the portfolio by factor, taking into account the correlations between the factors and the benefits of diversification, using a lookback period of 15 years. "Other" includes risk contributions from style factor exposures and idiosyncratic risks. Asset classes are represented by the following indices: Global equity, MSCI All Country World Index; Emerging equity, MSCI Emerging Markets; Global inflation-linked bonds, BofA ML Global Governments Inflation-Linked Index; U.S. Treasuries, Bloomberg Barclays Government Index; Global credit, Bloomberg Barclays Global Aggregate Corporate Index; Global high yield bonds, Bloomberg Barclays Global High Yield Index; USD EM Bonds, JP Morgan EMBI Global Diversified Index; Commodities, Bloomberg Commodity Index Total Return; Global real estate, BlackRock Proxy; Global private equity, BlackRock Proxy; Global infrastructure, BlackRock Proxy; Hedge funds—aggressive, HFRI Equity Hedge Index.

while insurers need to consider surplus risk and account for uncertain future payouts. Other parameters such as investment horizon (very long for an endowment, shorter for a pension), the willingness to take risk in illiquid assets, and the ability to employ leverage can also play into the allocation decision.

While each institution faces a unique set of circumstances, a factor-based approach to strategic asset allocation may provide benefits to all. By deliberately diversifying across macro factors, institutions may unlock potential sources of return that were previously underrepresented, or not represented at all, in their portfolios, such as credit and emerging markets. Adding an allocation to style factors may bring an additional source of return and diversification. Diversifying across macro and style factors may also help improve risk mitigation, as factors have historically displayed low correlations to each other, even during periods of market stress.[1]

To illustrate these ideas, we present two case studies. First, we examine a hypothetical institution's investment goals and guidelines and, starting with a blank slate, outline three approaches to adopting factor-based allocations to help meet their objectives. Next, we draw on real-world data from our 2017 U.S. Public Pension Peer Survey to create a representative model portfolio, and then examine how institutions looking to reduce their reliance on economic growth can use factor-based allocations to help improve diversification. Similar analyses can be performed for any type of institutional investor to help meet a particular investment outcome.

CASE STUDY: THE BLANK SLATE

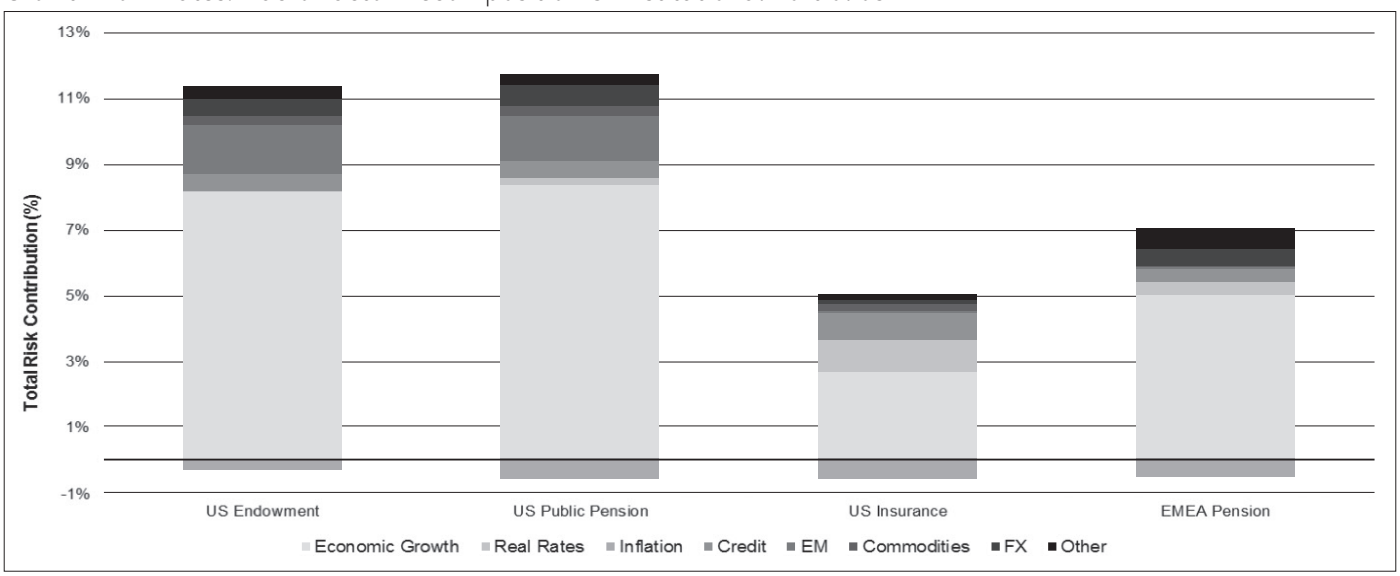
Building a Targeted Factor Allocation From the Ground Up

To illustrate how a factor-based approach to asset allocation may help meet specific objectives, we will examine a hypothetical asset owner, referred to as the ABC Plan. ABC targets a total plan risk of 10 percent and does not target an explicit level of return. The investment committee at ABC is particularly sensitive to extended periods of losses and would like to limit the possibility and magnitude of two-year drawdowns. Given modest *forward-looking asset class returns*, ABC is particularly concerned about maximizing potential returns relative to its risk target. ABC has a strong preference for liquid investments to accommodate annual spending needs.

Portfolio 1: Equal-Weighted Macro Factors

We start by examining an equal risk-weighted combination of the six macro factors. Allocating an equal amount of risk to each factor helps to ensure that the hypothetical portfolio is diversified, with the opportunity to benefit from many independent sources of return. The equal-weighted portfolio has the benefit of being simple and not overly reliant on forward-looking assumptions of risk, return or correlations.

Figure 3
Growth Dominates: Macro Factor Decomposition Of Institutional Portfolios



Source: Aladdin, December 2016. Risk contribution is the risk decomposition of the portfolio by factor, taking into account the correlations between the factors and benefits of diversification, using a lookback period of 15-years. U.S. Endowment portfolio is based on the Nacubo Survey. U.S. Public Pension portfolio is based on the BlackRock Public Pension Peer Survey. U.S. Insurance portfolio is based on BlackRock FIG Study (SNL Data). EMEA Pension portfolio is based on a representative portfolio. "Other" includes risk contributions from style factor exposures and idiosyncratic risks. "FX" is included to show an important source of risk common in institutional portfolios, however we do not consider it a rewarded factor and it is not included in the analysis going forward.

But this simple, equal risk-weighted portfolio does not take into consideration the varying characteristics of each factor and does not meet all of our investor's specific preferences. However, this well-diversified portfolio would have a conservative drawdown profile.

Portfolio 2: Targeted Macro Factors

We can enhance the equal-weighted macro portfolio by taking into consideration the differing characteristics of each factor along with three key considerations for ABC: Sharpe ratio, drawdown mitigation and liquidity.

First, we consider the potential risk-adjusted return of each factor. BlackRock research, supported by economic intuition and historical data, tells us that the economic growth and credit factors have had the highest risk-adjusted returns and are decidedly procyclical. The real rates factor has also historically displayed high risk-adjusted returns, with the persistent decline in global interest rates over the last 30 years driving robust returns in bond markets. However, with interest rates now beginning to rise from record lows in much of the world, we expect more modest returns in the years ahead.

ABC is also highly sensitive to the potential for drawdowns. The real rates and inflation factors are defensive in nature and have historically performed well when investors seek perceived safe-haven securities like nominal and inflation-adjusted bonds. In contrast, the economic growth, credit and emerging markets factors have exhibited deeper drawdowns in times of market crisis or a slowing global business cycle.

Finally, ABC's preference for liquidity suggests allocating to factors that can be accessed via assets that have generally displayed relatively high liquidity, even during periods of market stress. The following table (Figure 4) ranks each factor according to ABC's criteria and leads us to overweight real rates; to underweight credit, emerging markets and commodities; and to keep neutral weights for economic growth and inflation.

Portfolio 3: Targeted Macro Plus Style Factors

Our hypothetical targeted macro portfolio is well-diversified and allocates to systematic risk premiums in a way that incorporates ABC's goals. ABC might consider trying to boost returns and enhance diversification by incorporating new sources of return, namely style factors, which can be implemented via a long/short, multi-asset strategy.

To illustrate, we add a 20 percent allocation to a hypothetical long/short style factor strategy to our hypothetical targeted macro portfolio. While any individual style factor may be highly cyclical, the addition of style factors is diversifying. The average pairwise correlation between style and macro factors

Figure 4
Consider The Factors: Ranking Of Each Macro Factor When Considering ABC Plan's Criteria

Consideration	Economic growth	Real rates	Inflation	Credit	Emerging markets	Commodities	
Drawdown Mitigation	–	+	+	–	◆▶	◆▶	Real rates and inflation can provide a natural hedge during downturns
Return/Risk Ratio	+	◆▶	–	+	◆▶	–	Economic and credit factors have had higher expected return/risk ratios
Liquidity in Market Downturns	◆▶	+	+	◆▶	◆▶	◆▶	Certain asset class representation of the factors have provided more liquidity in times of stress
Conclusion: Overweight/Neutral/ Underweight? (Relative to Equal Risk Weighting)	◁▷	✚	◁▷	▭	▭	▭	

Source: BlackRock, September 2017. For illustrative purposes only. This information is not indicative of future results and is not a recommendation of an investment strategy or allocation.

is approximately zero, and very low between the style factors themselves as Figure 5 shows.

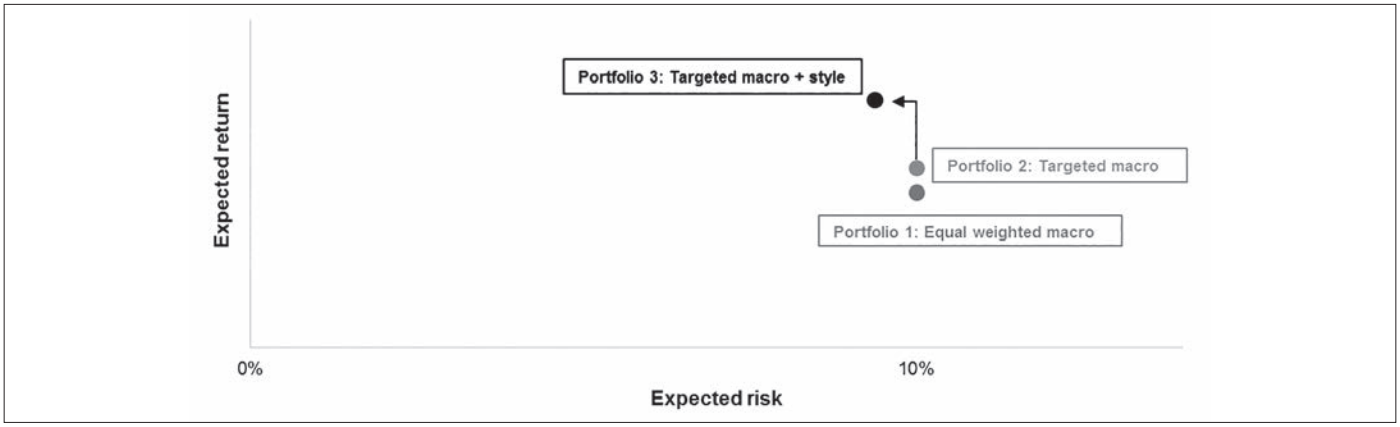
If we now examine the expected risk and return of each of our three hypothetical factor-based portfolios, we can see the results of incorporating a broader and more targeted approach to factor investing in Figure 6. While each of the portfolios is diversified across the most important drivers of return, and each fulfills our hypothetical client's desire for a 10 percent risk target, moving from the equal-weighted portfolio to the targeted one would modestly improve expected returns, and adding style factors could help improve returns further while reducing risk.

Figure 5
Diversifying Factors: Five-year Correlations Of Macro Factors And Long/Short Style Factors

	Carry	Momentum	Value	Quality	Min Vol	Economic growth	Real rates	Inflation	Credit	Emerging markets	Commodities
Carry	1	-0.2	0.2	-0.1	0.1	0.3	0.3	-0.2	0.2	0.3	0.4
Momentum		1	-0.4	0.1	0.0	-0.3	0.1	0.4	-0.5	-0.6	-0.5
Value			1	0.2	0.2	0.2	-0.1	-0.1	0.2	0.2	0.0
Quality				1	0.2	0.0	-0.1	0.1	-0.1	-0.2	-0.3
Min Vol					1	0.2	0.0	-0.1	0.1	0.0	0.0

Source: BlackRock, June 2017. Correlations are calculated over five years of monthly data. Macro factor returns are adjusted to ex-ante annualized risk level of 10%. Style factor returns are adjusted to ex-ante annualized risk level of 5%. Factor returns are based on underlying exposures to the particular factor premium, based on BlackRock's models. Exposures include broad index exposures across markets. This analysis is limited to the index universe available to BlackRock in Aladdin. Factor returns are gross of all fees and transaction costs.

Figure 6
Targeted Outcomes: Risk And Return Profiles Of Hypothetical Equal-weighted, Targeted Macro And Targeted Macro Plus Style Portfolios



Source: BlackRock. For illustrative purposes only. The Targeted Macro & Equal-Weighted portfolios are constructed to target 10% risk.

CASE STUDY: THE REAL-WORLD FRAMEWORK

Implementing Factor Shifts in Existing Portfolios

Investors usually are not working from a blank slate. They have well-ingrained asset allocation frameworks and existing portfolios, and it may be unrealistic to make drastic changes to these. Instead, investors may want to make strategic and tactical shifts away from their existing portfolios.

One change that may be worth considering is a targeted reduction in exposure to the economic growth factor. As we highlighted earlier, many institutional investors' portfolios are highly dependent on this factor, making their results quite reliant on the strength of the global economy. This may have been a boon over the last several years, but it leaves portfolios susceptible to a softening in the economy or a spike in geopolitical tensions that leads to adverse market movements.

There are many incremental steps investors can take to help diversify portfolios along factor dimensions. For our example, we use the asset allocation and macro exposures of the average U.S. pension, as determined by BlackRock's 2017 U.S. Public Pension Peer Survey, as the starting portfolio in Figure 7. Our objective is to reduce the relative risk exposure to economic growth by 20 percent and to reallocate that risk among other rewarded factors.

Option 1: TIPS Plus Smart Beta

Shifting a portion of the portfolio from developed equities to inflation-linked debt results in a direct reduction in exposure

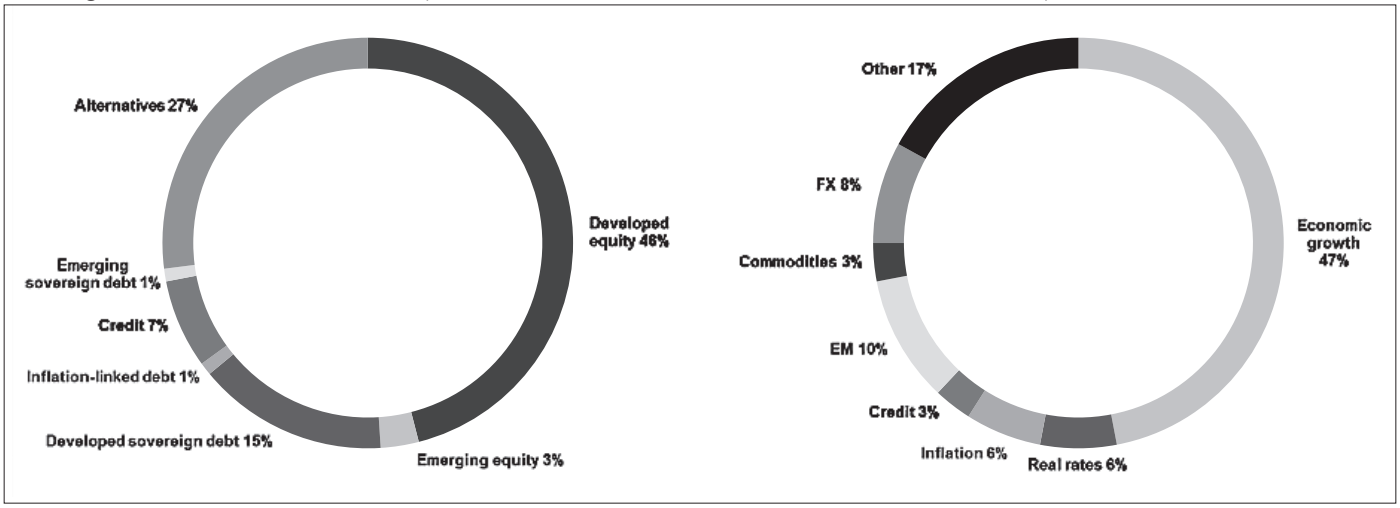
One change that may be worth considering is a targeted reduction in exposure to the economic growth factor.

to the economic growth factor and an increase in exposure to the real rates factor. However, given the significantly lower levels of expected risk and return of TIPS relative to equities, this shift would reduce the total risk and return of the plan. Leverage would be required to maintain the same level of return as the starting portfolio, and leverage is hard to find (and costly) in inflation-linked bond markets where synthetic exposures are not readily available. To offset the reduction in risk and to seek enhanced returns, our approach instead shifts a portion of the plan's cap-weighted equity exposure into a multifactor smart beta strategy that offers exposure to rewarded style factors.

Option 2: Leveraged Nominal Bonds Plus Smart Beta

Another option is to shift from developed equities to nominal developed market bonds. An allocation to nominal bonds would result in an increase in exposure to real rates and inflation, both of which are highly diversifying to economic growth. As with option one, such a shift would also reduce the expected risk and

Figure 7
Starting Point: U.S. Pension Plan Representative Portfolio Asset Allocation And Factor Exposure



Source: BlackRock Public Pension Peer Survey, August 2017.

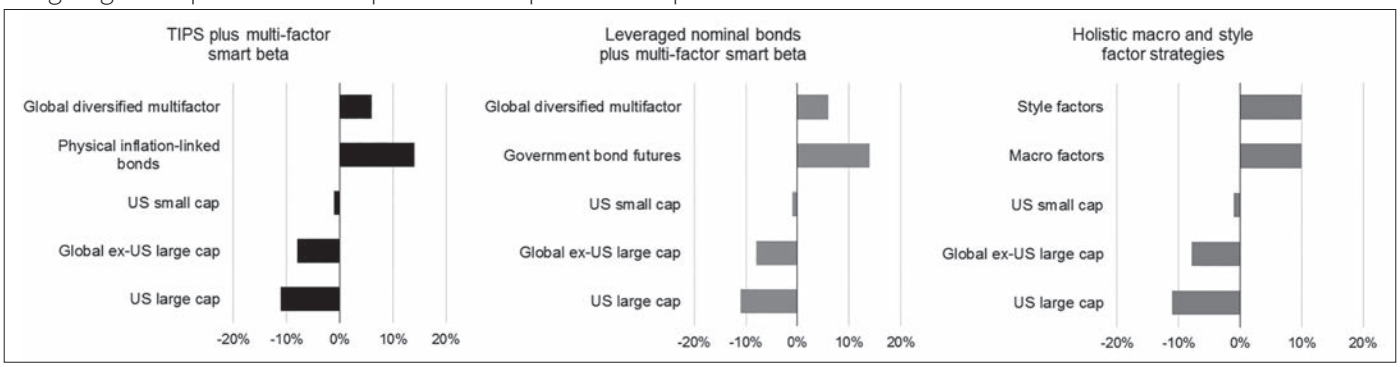
return of the portfolio. With nominal bonds, however, leverage is readily available via exchange-traded futures, which are highly liquid and relatively inexpensive to trade. In order to diversify risks further and to limit the amount of leverage, our approach here also shifts a portion of the plan's cap-weighted equity exposure into a multi-factor smart beta strategy.

Option 3: Holistic Macro And Factor Strategies

A more holistic approach to factor diversification can be found in strategies that explicitly target balanced exposure to macro or style factors, or both. These strategies employ modest amounts of leverage to target a similar level of expected return as equities, while retaining broad diversification across return drivers. The task of managing factor exposures and leverage can be outsourced to the manager. While holistic macro factor strategies will generally include a healthy allocation to economic growth to seek robust long-run returns, the strategies can still be highly diversifying to investors' portfolios.

The portfolio changes are detailed below. Each approach may be appropriate for institutions with varying investment parameters. Options one and two offer the most direct diversification benefit by explicitly reducing exposure to economic growth in favor of real rates, and, in the case of option two, inflation. However, these options require leverage to maintain returns in-line with equities, which may be costly in the case of option one, or prohibited altogether at the plan level. Option three mitigates this leverage concern without sacrificing returns.

Figure 8
Weighing The Options: Three Options To Help Reduce Exposure To The Economic Growth Factor



Source: Aladdin Factor Workbench, BlackRock Investment Institute, September 2017. See factor strategies modeling assumptions following article for more information.

Investors choosing any of these options may additionally attempt to boost returns further by tactically rotating between single-factor smart beta strategies, to take advantage of the inherent cyclicality in style factor returns.

A Future With Factors

As we've now seen, macro factors can provide an intuitive way to build an institutional portfolio from the ground up and to reallocate the risks within an existing portfolio. In either case, the addition of a targeted exposure to style factors can introduce a diversifying source of returns. The examples we've laid out are just some of the many ways that investors can use factors to incorporate their unique market views, preferences and constraints into the portfolio construction process. As investors become better versed with the language of factors and their fundamental role in driving both risk and return, we expect their usage to grow in the years ahead. ■

This material is provided for educational purposes only and is not intended to be relied upon as a forecast, research or investment advice, and is not a recommendation, offer or solicitation to buy or sell any securities or to adopt any investment strategy.

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ENDNOTE

1 K. Hogan, P. Hodges, M. Potts, D. Ransenberg. 2015. "Rewarding risk: How the science of 'rewarded risks' is redefining diversification."

Optimizing CPPI Investment Strategy for Life Insurance Companies: A Risk-Reward Analysis

By Aymeric Kalife and Saad Mouti

ABSTRACT

Individualized constant proportion portfolio insurance (iCPPI) products are attractive alternatives to traditional unit-linked products because the former offer a guaranteed minimum return, such as variable annuities. They also offer high potential returns whilst limiting the downside risk by implementing a dynamic allocation strategy between high-risk and risk-free assets tailored to the risk appetite of the beneficiary. But the performance evaluation of iCPPI products should not rely on the unrealistic assumptions of continuous market price variation and continuous rebalancing of asset allocations. We adopt a more general and realistic pricing jump model and examine several dynamic strategies and put options to mitigate the risk that the value of the product will fall below the guaranteed minimum (so-called "gap risk").

With rising life expectancies, current provisions for retirement may not be sufficient for people to secure an acceptable standard of living after retirement. To achieve sufficiently high investment returns together with low risks over the long term, customers' funds should remain invested in risky assets as well as in safer bonds over an extended period well into retirement. The design of long-term investment products should also reflect the requirements and risk appetites of individual investors.

From the point of view of the provider as well, iCPPI products provide an attractive alternative to many traditional retail long-term investment products and offer a guaranteed minimum return for several key reasons:

- They lower exposure to volatility and extreme market price movements along with slightly lower returns.
- They have lower costs.
- They require lower regulatory capital.

Besides their price transparency, open time horizon, and no early redemption penalty, CPPI products generally offer a wide range of alternative investments for the risky asset and the flexibility to add other guarantees such as ratchets.

The CPPI investment strategy provides a minimum guaranteed return, the *floor* (usually defined as the discounted value of the final capital guarantee), and aims to maintain a risk asset exposure equal to a constant multiple of the *cushion* (defined as the excess value of the fund above the floor) at all times. The capital guarantee at maturity and the multiplier are customized to the customer's risk appetite, usually between three and six (which may be constant or not, depending on the contract).

However, implementation comes with many concrete challenges, as raised in section 1. The rebalancing of the asset allocation can be made only at discrete times. There are transaction costs, and risky asset prices may jump. There is likely to be a difference between the realized return compared to the hypothetical value of a CPPI strategy computed under traditional unrealistic theoretical conditions of continuous price movements, unfettered zero-cost trading, and continuous rebalancing. In particular,

there is a non-zero probability for the value of the fund to fall below the guaranteed floor, called the "gap risk," as illustrated by the impact of introducing discontinuous jump processes in the modeling within the risky asset dynamics.

Section 2 deals with concrete strategies that at least partially mitigate such gap risk through a dynamically risk-adjusted multiplier and the use of put options.

SECTION 1. CPPI MANAGEMENT: FROM THEORY TO PRACTICE

CPPI Mechanism Basics

Consider that at time t a risky asset (e.g., a share) with price S and a risk-free asset (e.g., a Treasury bond) with price B returns a constant rate r. The CPPI fund is invested in these two assets so that part of its value—the floor F_t—is guaranteed, whilst the excess value above the floor—the cushion C_t, which equals $V_t - F_t$—remains exposed to the risky asset price fluctuations. At any time, the exposure to the risky asset is kept at a constant multiple m of the cushion, that is, $m \times C_t$ (where m is usually held in practice between 3 and 6, implying that the asset manager borrows dynamically to buy the risky asset or may in practice buy the non-risky part only close to the expiration of the contract).

The risky asset S is defined by the usual lognormal continuous-time diffusion equation with drift μ and volatility σ;

$$\frac{dS_t}{S_t} = \mu dt + \sigma dW_t \qquad \frac{dB_t}{B_t} = rdt$$

$$dV_t = m(V_t - F_t)\frac{dS_t}{S_t} + (V_t - m(V_t - F_t))rdt$$

$$V_t = F_t + (V_0 - F_0)\exp\left(\left(m(\mu - r) + r - \frac{m^2\sigma^2}{2}\right)t + m\sigma W_t\right)$$

This makes the portfolio value V independent on the path followed by the underlying S, while the probability to touch the floor is zero.[1]

The cushion C_t is then also lognormally distributed:

$$\frac{dC_t}{C_t} = (m\mu + (1-m)r)dt + m\sigma dW_t$$

$$C_t = C_0\exp\left(\left(m(\mu - r) + r - \frac{m^2\sigma^2}{2}\right)t + m\sigma W_t\right)$$

However, such statistical assumptions are unrealistic and not consistent with market practice. Two alternatives are studied to remedy this: modeling in a discrete-time framework and using discontinuous jump processes (such as the Kou model)

Discrete-Time CPPI

A sequence of equidistant points in the interval [0, T] is defined, between which the portfolio asset allocation is updated. The first time the portfolio value touches the floor is defined by the following formula:

$$t_s = \min\left\{t_k \in \Theta \,|\, V_{t_k} - F_{t_k} \le 0\right\}$$

The probability of touching the floor now becomes greater than zero, assuming the portfolio has not breached the floor up to time t_k. The probability of breaching the floor at time t_{k+1} is that of a downside jump in the risky asset of more than about $1/m$, as evidenced below:

$$V^{\tau}_{t_{k+1}} - F_{t_{k+1}} = \begin{cases} (V_{t_k} - F_{t_k})\left(m\frac{S_{t_i}}{S_{t_{i-1}}} - (m-1)e^{r\frac{T}{n}}\right) & \text{if } V_{t_k} - F_{t_k} > 0 \\ (V_{t_k} - F_{t_k})e^{r\frac{T}{n}} & \text{if } V_{t_k} - F_{t_k} \le 0 \end{cases}$$

Assuming the breach of the floor did not occur until t_k,

$$V^{\tau}_{t_{k+1}} > F_{t_{k+1}} \Leftrightarrow \left(m\frac{S_{t_i}}{S_{t_{i-1}}} - (m-1)e^{r\frac{T}{N}}\right) > 0$$

$$\Leftrightarrow \frac{S_{t_{k+1}}}{S_{t_k}} > \frac{m-1}{m}e^{r\frac{T}{N}}$$

As the interest rate return is close to zero over one day, we get the following result:

$$\frac{S_{t_{k+1}}}{S_{t_k}} - 1 > -\frac{1}{m}$$

Backtesting on three rebalancing frequencies (daily, weekly and monthly), over Q1 2006 to Q3 2007 S&P 500 index in Figure 1, illustrates that the CPPI strategy under daily rebalancing performs better than the weekly and monthly ones within bearish markets. We tested 10,000 simulation paths using the Black & Scholes model with a three-month realized volatility, a constant asset return m = 8%, a risk-free rate r = 4%, a duration of five years and 10 basis points (bps) transaction costs. This result reflects how highly responsive daily rebalancing is to decreasing the risk exposure, which prevents the bond floor from being breached and thus ensures the capital guarantee at maturity (as illustrated by fatter left tails in Figure 2). On the other hand, the 5 percent and 0.5 percent quantiles in Figure 3 show that the CPPI with m = 6 has a larger right tail. It performs better than the other two in a bullish market even though the mean return is similar to CPPI with m = 3.

Figure 1
Performance Depending On Multiplier vs. Buy and Hold Strategy

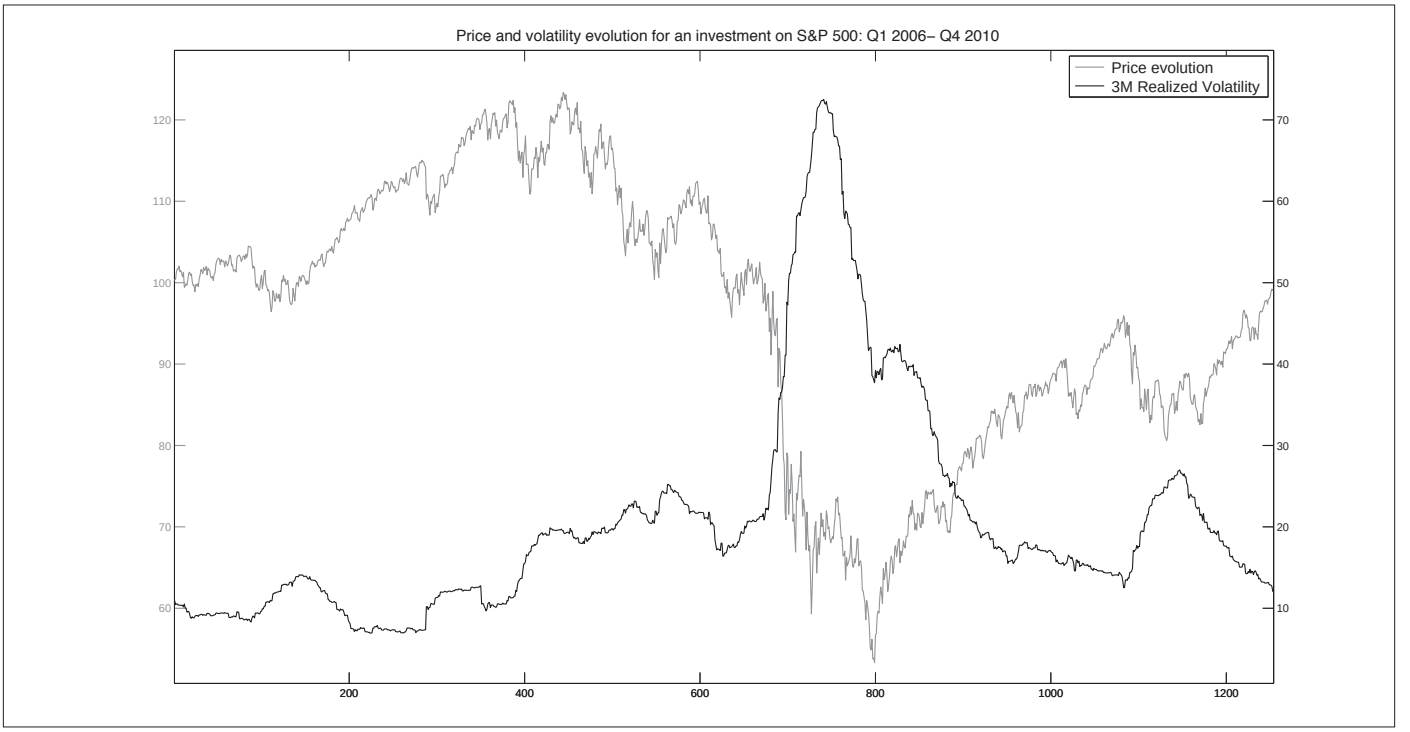


Figure 2
Statistical Metrics Depending On Multiplier and Rebalancing Frequency

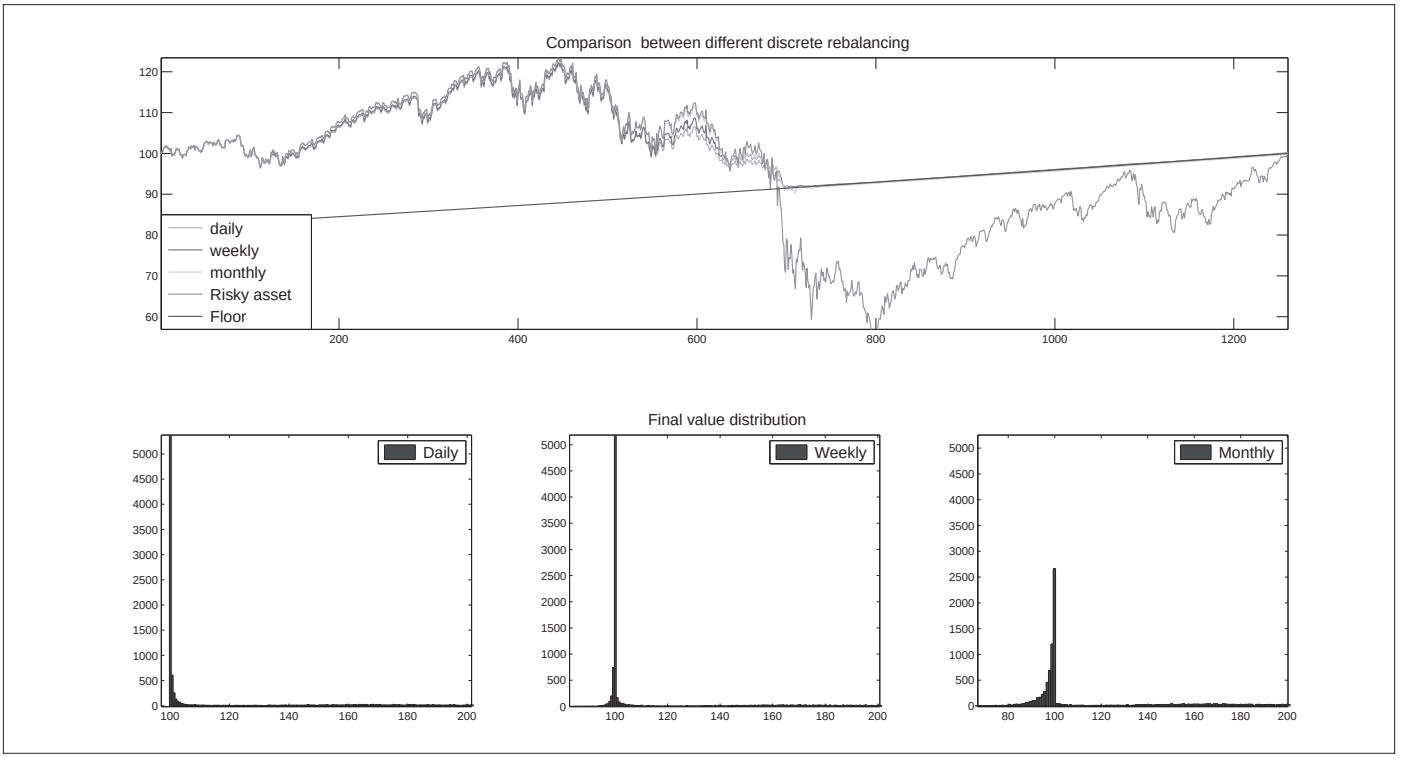


Figure 3
Statistical Metrics Depending On Multiplier and Rebalancing Frequency

	CPPI with $m = 3$			CPPI with $m = 6$		
	Daily	**Weeky**	**Monthly**	**Daily**	**Weeky**	**Monthly**
Man	123.31	122.39	119.75	124.10	124.87	125.01
Std-dev	31.58	32.66	36.86	42.62	43.88	48.10
95% quantile	100.48	99.98	97.01	99.99	99.13	89.69
99.5% quantile	100.02	99.88	91.47	99.98	95.20	74.26
5% quantile	194.37	195.23	197.94	216.51	218.50	225.46
0.5% quantile	266.47	284.07	282.58	294.49	293.75	311.46
Rebalancing cost	0.91	0.44	0.26	0.78	0.46	0.31

However, using a constant volatility and lognormal distribution modeling is not consistent with empirically observed jumps during extreme market moves. They are likely to breach the bond floor. Jumps are thus added in the next section.

Jump Modeling

For computational tractability, we chose the double exponential Kou model.[2] The Kou model introduces jumps into the stochastic process for stock returns as a set of random Poisson processes. The Kou model is defined as follows:

$$\frac{dS_t}{S_{t^-}} = \mu dt + \sigma dW + d\left(\sum_{i=1}^{N_t} e^{Y_i} - 1\right)$$

where W is a standard Brownian motion, N is the added (Poisson) jump process, where the jump sizes {Y1, Y2, . . .} are independent and identically distributed (iid) random variables with a common asymmetric double exponential density and

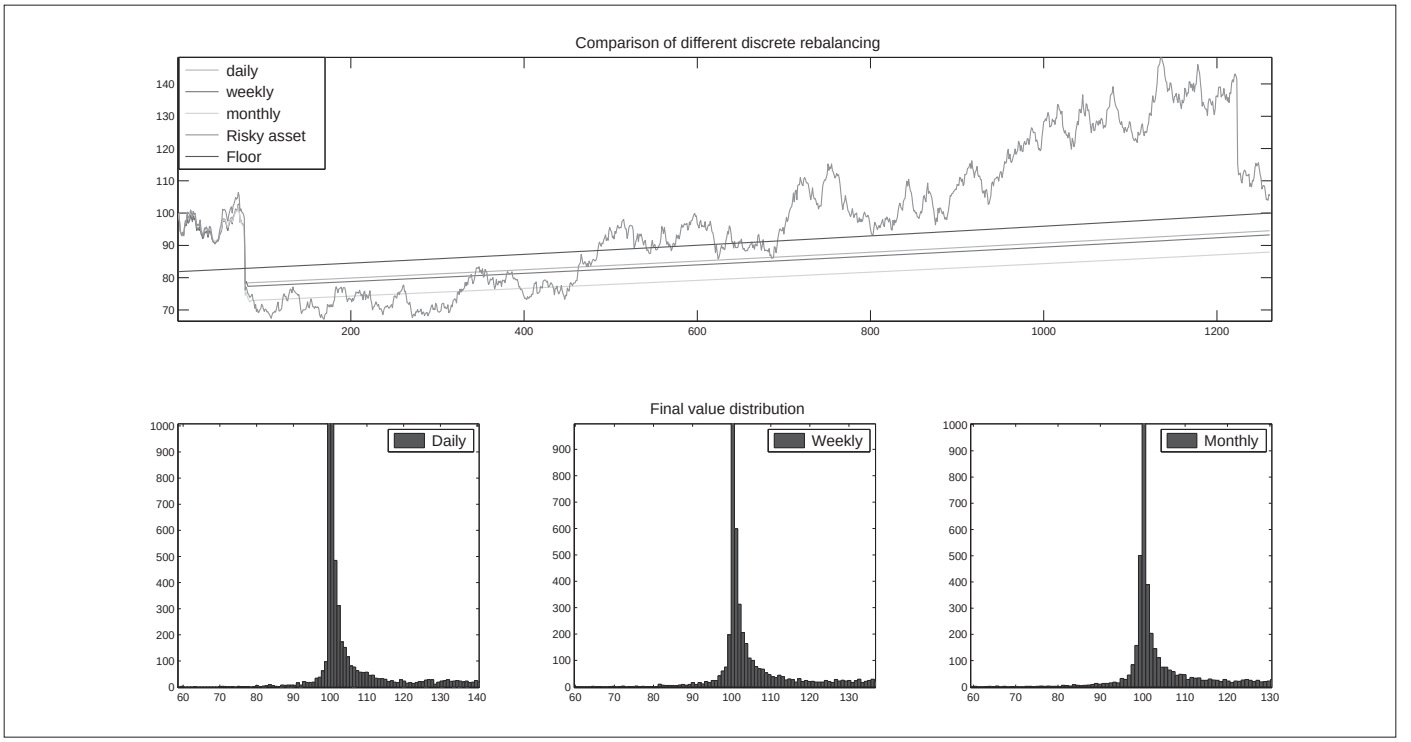
$$f(y) = (1-p)\gamma^{+}e^{-\gamma^{+}y}1_{y\geq 0} + p\gamma^{-}e^{-\gamma^{-}y}1_{y<0}$$

γ^{+}/γ^{-} are the intensity of positive/negative jumps, and $(1 - p)$ and p are the likelihood of positive and negative jumps, respectively. The calibration has been carried out by minimizing the quadratic error on options prices with a one-month maturity and strikes from 80 percent to 110 percent of the underlying. The strategy results are shown in Figures 4 and 5.

Figure 4
Statistical Metrics Depending On Multiplier and Rebalancing Frequency

	Kou model		
	Daily	**Weeky**	**Monthly**
Man	146.28	147.10	147.57
Std-dev	52.84	52.93	53.11
95% quantile	92.19	92.21	92.03
99.5% quantile	59.38	59.08	59.23
5% quantile	238.13	238.67	239.41
0.5% quantile	349.41	350.92	350.37
Rebalancing cost	0.92	0.45	0.26

Figure 5
Simulation and Distribution of the Three Rebalancing Frequencies Under the Kou Model



The results in Figure 6 demonstrate that, whereas the probability of breaching the floor (the gap risk) significantly decreases to negligible under the traditional unrealistic assumption of continuous price movements (B&S in the figure) as the rebalancing frequency increases to daily, that is no longer the case under more realistic discontinuous modeling assumptions (here the Kou model), even with continuous rebalancing frequency.

Figure 6
Probability Of Breaching The Floor Depending On Asset Dynamics Modeling And Rebalancing Frequency

Model	Frequency	Prob(Breach Floor)
B&S	Monthly	9.07×10^{5}
	Weekly	1.2×10^{10}
	Daily	~
Kou	Continuos	0.00410

Section 2 deals with concrete strategies that at least partially mitigate gap risk through a dynamically risk-adjusted multiplier and the use of put options.

SECTION 2: MITIGATING THE DOWNSIDE RISK (GAP RISK)

Adjusting The Multiplier To Market Conditions

The manager usually sets the multiplier at the beginning of the period. Still, the probability of breaching the floor may surge in a market crash, or the manager might miss the subsequent market recovery. Thus, the multiplier needs to be adjusted according to current market conditions.

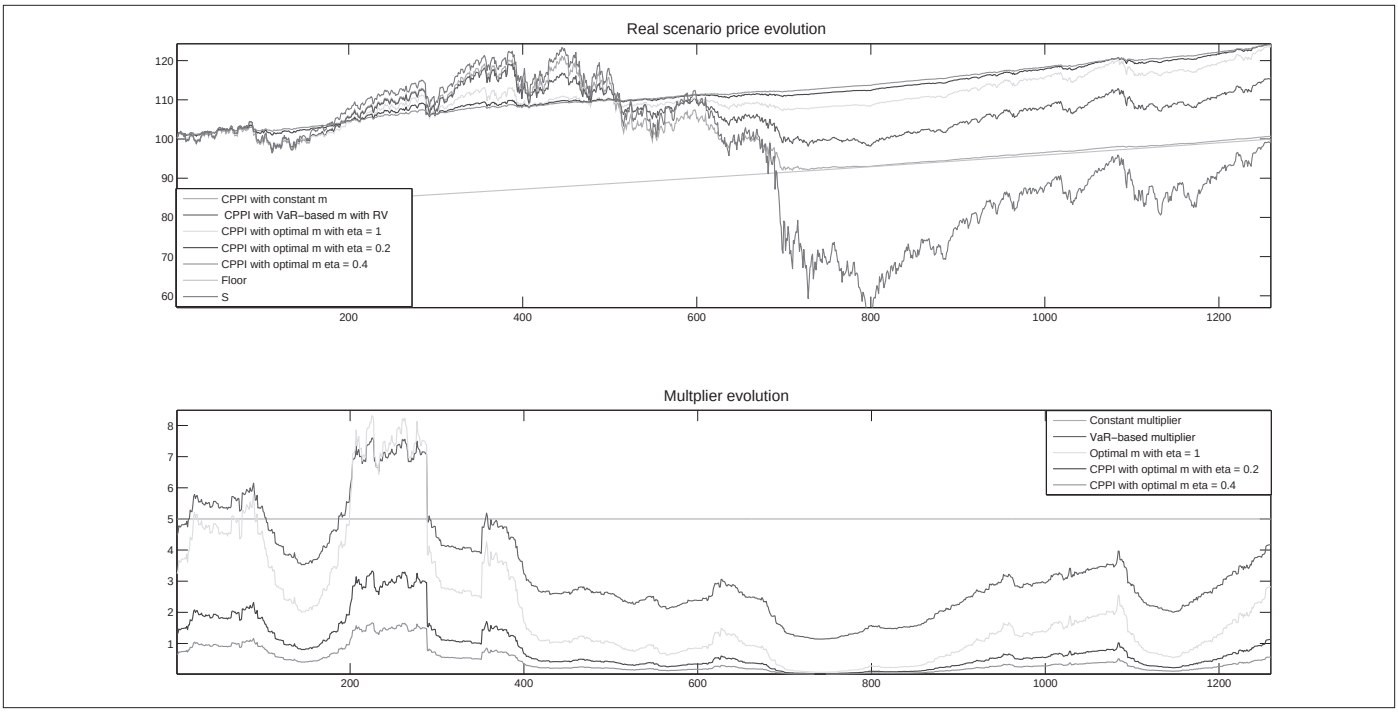
A first approach to defining a dynamic multiplier is the choice of an "optimal" m^* (for instance, using optimal certainty equivalent returns with hyperbolic absolute risk aversion utilities and log-normal distribution[3]). m^* is defined by the following formula:

$$m^* = \eta \frac{(\mu - r)}{\sigma^2}$$

where η is the sensitivity of the investor's risk tolerance to the level of wealth.

An alternative is a value-at-risk (VaR)–based multiplier where investors choose the confidence level according to their tolerance for tail risks.[4] m_t is defined as follows:

Figure 7
Comparison of Different Multipliers (VaR-based with p = 99.5% vs. the Optimal One with γ = 0.2, 0.4 and Based On Realized Volatility)



$$m_t = \frac{1}{1-\exp\left((\mu - r - \frac{1}{2}\sigma^2)(T-t) - z_p\sigma\sqrt{T-t}\right)}.$$

These two approaches offer an interesting alternative to the constant multiplier, which lacks flexibility depending on market conditions. Based on backtesting of data from 2006 to 2011 (Figure 7), the VaR-based multiplier performs better than the "optimal" one in bullish and recovery markets. In contrast, during bear markets, using the "optimal" multiplier (through $m < 1$) helps keep a relatively higher cushion (but misses the recovery as it makes no provision for high leverage).

To allow for a higher level of participation in the market recovery, the multiplier is adjusted with a modified volatility estimator. This is done either through a short-term exponentially weighted moving average (EWMA) realized volatility ($\lambda = 0.94$) or an estimator based on implied volatility of the strike consistent with the latest market returns. For example, if the underlying jumped 5 percent downward, the implied volatility with strike 95 percent would be chosen. This adjustment would enable the model to capture more of the upside return when markets rebound. For example, reinvesting in the risky asset in Q3 2009 in the backtest results in higher returns, as illustrated with the stock's rising ongoing performance shown in Figure 8.

Finally, the fixed frequency rebalancing may be switched to a trigger rebalancing when the multiplier is out of a specific range chosen by the portfolio manager, as illustrated by the stock's higher performance in Figure 9. On average, the rebalancing frequency becomes every other day, which is consistent with the usual practice in CPPI asset management—while the cost of rebalancing is cut by half in comparison to a daily rebalancing (that is, as low as weekly or monthly).

Adjusting the multiplier dynamically allows it to be more reactive to market conditions and explicitly dependent on the investor's risk aversion. However, it is still exposed to the downside risk in case of sudden jumps (a "black swan" event such as a market crash of 20 percent in one day) where options may be useful to hedge such gap risks.

Hedging Gap Risk

A simple hedging strategy for the CPPI can be constructed using short maturity put options. Touching the bond floor is

Figure 8
Comparison Of Dynamic Multiplier Based On Realized Volatility (RV) And Implied Volatility (IV) Through Backtesting

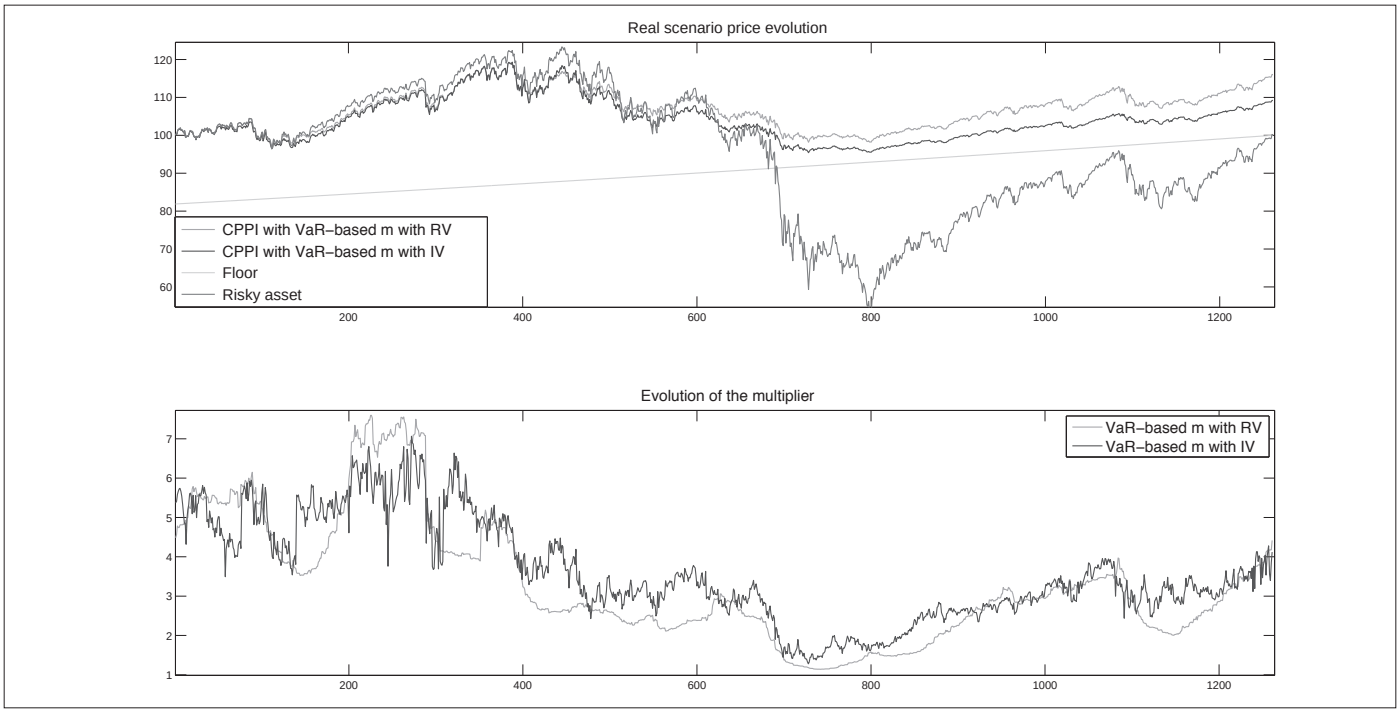


Figure 9
Comparison Of Trigger Rebalancing And Fixed Frequency Rebalancing

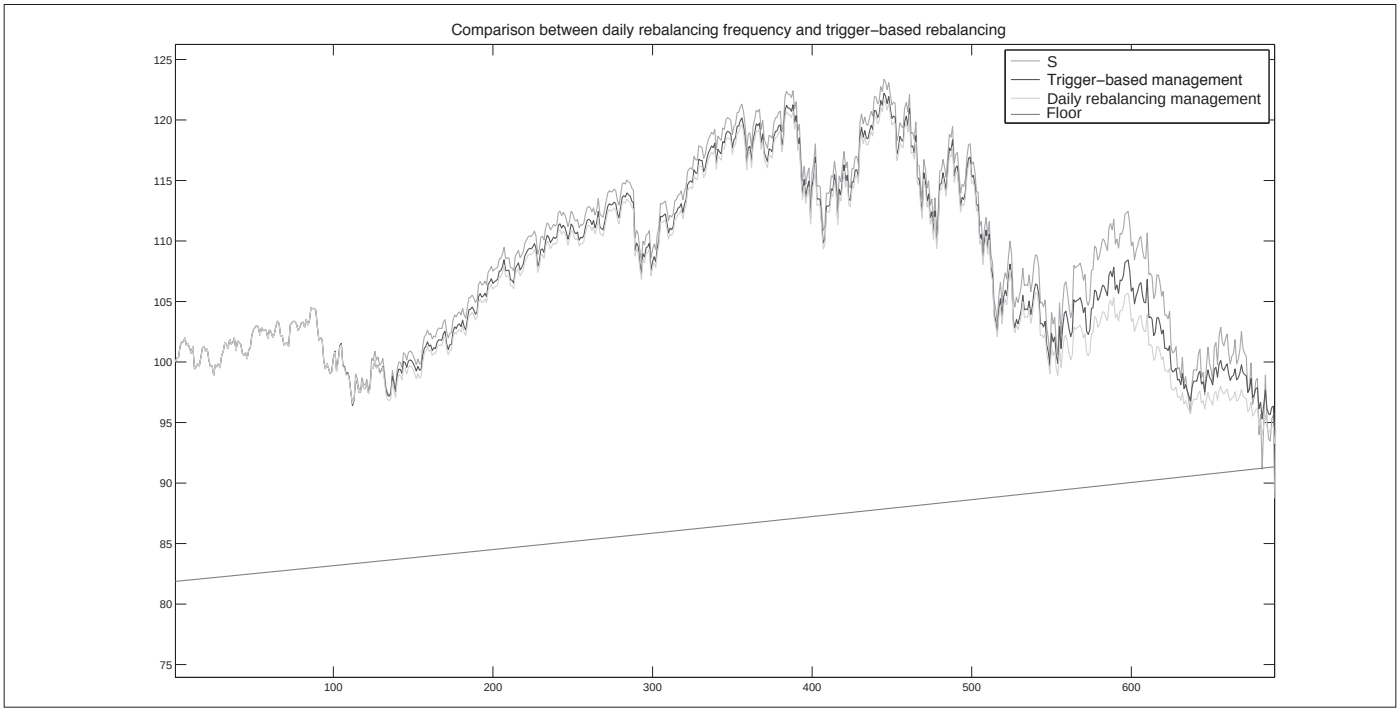
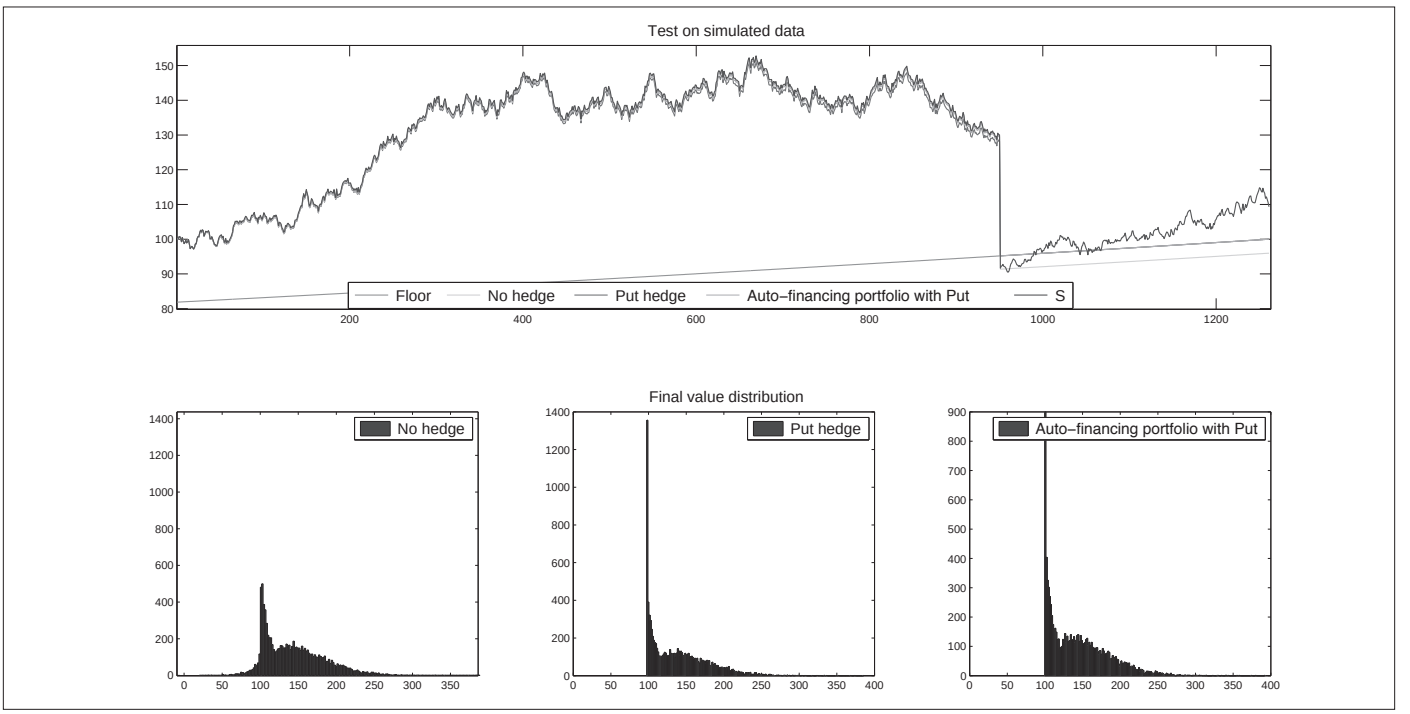


Figure 10
Comparison Of No Hedging And Put Hedging



mathematically equivalent to the cushion becoming negative. Assuming the event has not occurred up to time t_k, the gap risk is defined by

$$C_{t_{k+1}} < 0 \Leftrightarrow m\frac{S_{t_{k+1}}}{S_{t_k}} - (m-1)e^{r\frac{T}{N}} < 0$$

This risk can be hedged by buying put options at each rebalancing period with a strike price of

$$(1-\frac{1}{m})e^{r\frac{T}{N}}S_{t_k}$$

and with maturity equal to the CPPI rebalancing frequency. To hedge the whole portfolio, the manager needs a number of puts equal to

$$m\frac{C_{t_k}}{S_{t_k}}$$

which is the risky asset exposure. The discounted payoff in this case is then

$$e^{-r\frac{T}{N}}C_{t_k}((m-1)e^{r\frac{T}{N}} - m\frac{S_{t_{k+1}}}{S_{t_k}})^+$$

While the hedging cost is

$$\text{Cost}_{t_k} = m\frac{C_{t_k}}{S_{t_k}}\mathbb{E}^{\mathbb{Q}}\left[\left((1-\frac{1}{m})e^{r\frac{T}{N}}S_{t_k} - S_{t_{k+1}}\right)^+\right].$$

We observe the following impacts of hedging with puts:

- The guarantee is ensured, and the manager no longer holds the risk of breaching the floor. However, once the put is exercised and the floor recovered, the manager needs to monetize that option to keep the guarantee until maturity.
- In terms of profit and loss distributions, the CPPI distribution with put option hedging is a truncation of the classic CPPI where losses are cut (left tail limited by the guarantee).

CONCLUSION

In this article we have presented a study of the CPPI as an insurance contract, a review of its theory and practice as well as its modeling and hedging issues for a risk/return/cost perspective. The main conclusions are as follows:

- Jump modeling is an essential element of CPPI modeling. It allows the model to measure the non-zero probability of breaching the floor.
- Correctly choosing and adjusting the multiplier dynamically significantly reduces the downside risk according to a VaR indicator. The multiplier decreases in periods of market turmoil, reducing the risk exposure, and increases during periods of market recovery.
- Hedging the gap risk is possible through normal put options. ■

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Putting Forward the Case for a "Middle Way" for Long-term Interest Rates

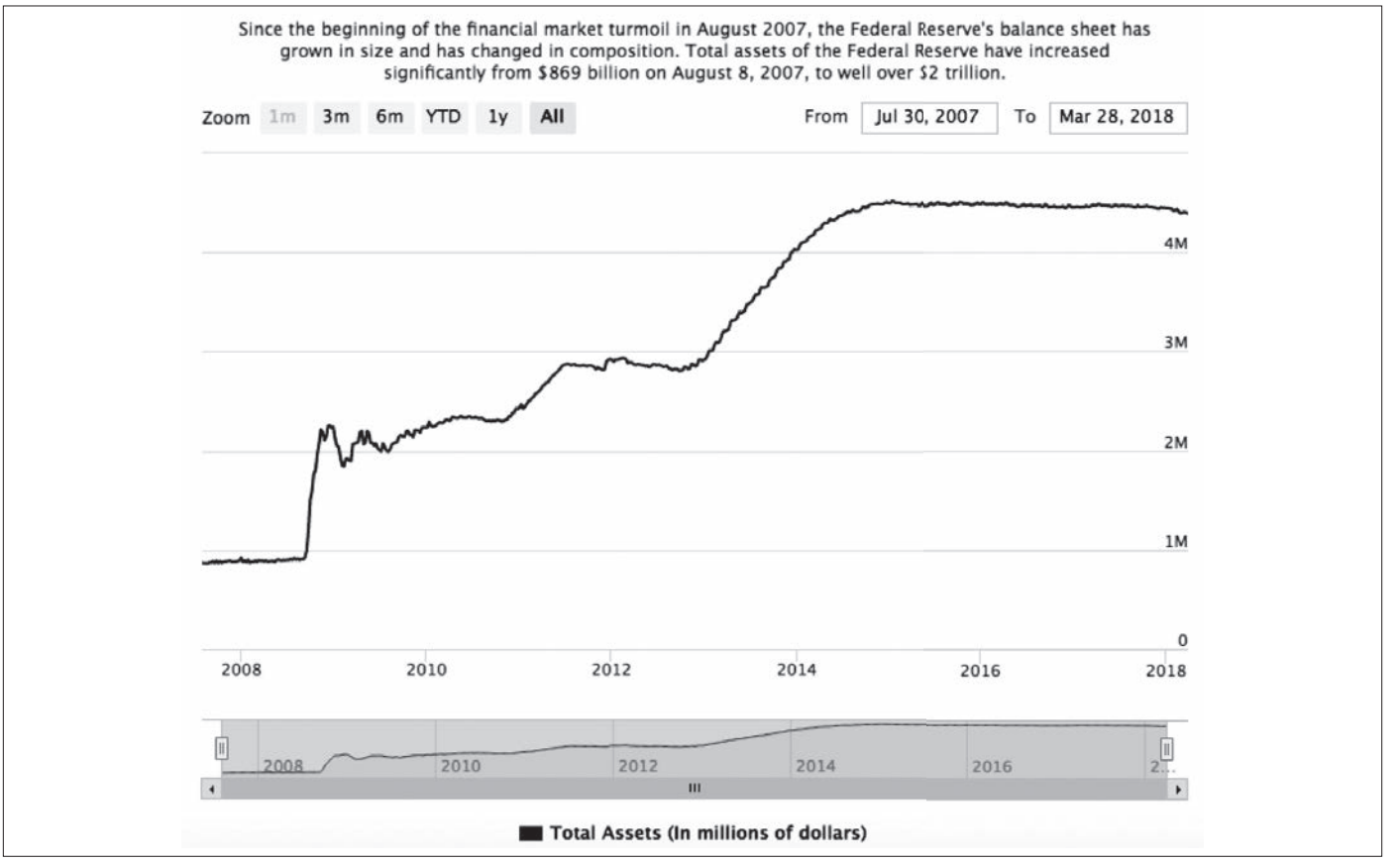
By Suhrid Swaminarayan

Disclaimer: *Last year, the Investment Section put out a call for essays in a point/counterpoint format, with actuaries arguing opposite sides of an issue. We are pleased to present two pairs of essays in this issue of Risks & Rewards: Joe Koltisko and Suhrid Swaminarayan debate the future path of interest rates and inflation, while John Hegstrom and Jim Kosinski square off over when (or if?) fossil fuels will be displaced by renewable energy. Two more pairs of essays can be found on the section website* https://www.soa.org/sections/investment/investment-landing/, *with Max Rudolph arguing both sides of the efficiency of markets and Nate Worrell arguing both sides of the type of investors that will succeed in the current market environment.*

Please note that this pro/con debate format forces both authors to develop arguments in support of the view assigned to them, even if they hold a differing opinion. The positions expressed in this role-playing setting should not be taken for the view of the authors, their companies, the SOA or any of its affiliate organizations.

Following three programs of quantitative easing (QE), the Federal Reserve began the next phase of its interest rate policy in October 2017—a process of "normalization" involving a reduction to its balance sheet to move it to more normal levels. Precrisis, the Fed's balance sheet stood at 5.5 percent of U.S. gross domestic product (GDP); now it is approximately 25 percent of U.S. GDP, or approximately $4.5 trillion (Figure 1). The natural question is with this (almost) unprecedented

Figure 1
Total Assets of the Federal Reserve



Source: Board of Governors of the Federal Reserve. 2018. "Recent balance sheet trends: Total assets of the Federal Reserve," *https://www.federalreserve.gov/monetarypolicy/bst_recenttrends.htm*.

buildup in the Fed's ownership of Treasury bonds, will a deluge of bond sales not only end the bull market in bonds (dating back to 1981), but also usher in a period of rampant inflation?

WHY RATES ARE UNLIKELY TO SPIKE

Unless there is unrestrained mismanagement of the balance sheet runoff, it is unlikely that long-term rates will spike. We have only one prior example of the Fed balance sheet rising above 20 percent of GDP (approximately 23 percent in the aftermath of the Great Depression and World War II). In that case, through the emergence and firm demonstration of Fed independence, long-term interest rates were successfully guided above 2 percent without the emergence of inflation for the better part of two decades. Yes, in that environment there was greater scope to increase interest rates without worrying about follow-on economic drag from the debt overhang that is pervasive today in most of the developed world. The article will revisit the implications of a debt overhang later when it discusses whether we will see further QE programs from the Fed in the near future. But for now, let's at least point to the 1950s as a time when interest rates were successfully raised from near today's levels.

While the Federal Open Market Committee (FOMC) has not defined a specific balance sheet target as the outcome of the normalization process, it is safe to say that the Fed will manage the runoff cautiously so as not to boost bond yields unexpectedly. The Fed has provided guidelines, including a consensus path of deliberately sluggish balance sheet reduction based on a reduction in the reinvestment of proceeds from maturing Treasury and mortgage-backed securities (MBS) bonds rather than active bond liquidation. Estimates project that $180 billion will run off in the next 12 months, with $360 billion each year thereafter. And while the Fed has been an important buyer of Treasury debt during its QE programs, foreign and institutional financial sector buyers have actually dominated the market. Low inflation, a forward guidance commitment from the Fed toward stable rate movement and deleveraging in the household and banking sectors all provide anchors to prevent global rates swiftly lifting off from low yields. Let's also not forget the aged and aging populations in Europe and Japan who would be loath to see any inflationary reduction in their purchasing power and who add to the overall global demand for long-term bonds.

THE BASE CASE AS A "MUDDLE-THROUGH" TO NORMALIZED INTEREST RATES AND INFLATION MODERATION

The Fed is moving slowly for fear that raising interest rates too far too fast may halt the postcrisis economic recovery. Macroeconomic measures, including unemployment (at a 49-year low) and the modest, positive level of real GDP growth, together with common economic principles such as the Taylor rule suggest that monetary policy should be much tighter and the federal funds rate should be hiked aggressively to prevent potential inflation. Tayyeb Shabbir, an adjunct professor at

Wharton Business School, confirmed that he sees a normalization of monetary policy in terms of the current functionality of the economy, although there "may not be an exact reversion to precrisis level(s)." He observes that the deep structural changes to the labor market in the United States from the financial crisis—such as the unprecedented, lengthy average duration of unemployment—have dented the traditional Phillips curve relationship between wage inflation and unemployment. Shabbir argues that "(the) last time the unemployment rate hovered around the current levels, wage growth was 4 percent vs. the present 2.3 percent."

Longer-term interest rates can also typically be expressive of inflation expectations. With that in mind, the case against out-of-hand wage growth leading to both unchecked inflation and long-term interest rates is strong. In addition to the demographic anchor to inflation highlighted earlier, commodity inflation and wage pressures are weak (these were both unchecked drivers of the uncontrolled inflation of the 1970s).

The danger of debt deflation caused by public and private indebtedness may also be overblown. The case for public indebtedness leading to stunted GDP growth has not been proven, with historical data suggesting that moderate growth is the average case even for indebtedness in excess of 90 percent of GDP.[9] The current U.S. economy also seems to be adhering to that historical average. In terms of fighting off a future stumble back into persistent meager growth territory or recession, the economist Christine Romer suggests a more flexible approach than the norm in terms of using fiscal programs or revising inflation tolerance (for example, changing inflation targeting to 3 percent rather than 2 percent).

In summary, both inflationary and deflationary risks are overblown and overly pessimistic, and the most likely base case for future interest rates and inflation is a return to moderation. ■

Suhrid Swaminarayan has worked in the financial services industry for more than 25 years and has experience as a pensions consultant, as a management consultant and within the fixed-income capital markets. He can be reached at *vegarhoadvisors@gmail.com*.

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Inflation: The Case for a Breakout

By Joe Koltisko

Editor's note: This article is a personal opinion only and does not reflect the views of the author's firm or any other organization.

As one Wall Street maven says, "It is NEVER different this time," and "It is ALWAYS about character."[1] I apply this filter to the inflation outlook and conclude that we are complacent and not yet willing to do what it will take to contain a debilitating, divisive and stagflationary rise in consumer prices.

We are complacent because the aggregate money supply has not grown faster than gross domestic product. We experience the creative destruction of the shared economy as consumers and find it pretty neat, cheap and disinflationary. We imagine one day there will be an app for everything; we'll get as much detail as we need just in time from an automated persona like Siri or Alexa. We feel warm and safe in the bubble since we look at aggregates that mask the impact of the huge forces at work.

The economy is really about networks of productive activity, of work teams that turn resources into goods and services through intermediaries like public and private corporations, associations and government. It's an ecosystem that learns, innovates, grows and distributes rewards. It is quite robust, but it depends on political leadership—mainly through regulatory and tax choices—to define the sandbox within which we all compete. In short, whatever statistics we watch about the average wage earner, the widening gap between people who consider themselves winners and losers fuels political polarization, which in turn invites destructive policy such as tariffs and trade wars.

By this I mean, of course, the pattern of decisions to penalize global business—from pulling out of the Trans-Pacific Partnership, to undermining the North American supply chains that have flourished under the North American Free Trade Agreement, to aluminum and steel tariffs, to who knows what's next? These invite reprisals and at best create opportunities to substitute products. What has been missing is the commitment to share the benefits of free trade more broadly within our sandbox over many administrations and many years. Measures that might help in this area include corporate and public investment in apprenticeship programs and useful infrastructure. In the short run, higher trade barriers will mean higher prices at the retailers for consumer products, which will translate into wage growth, which is approaching 3 percent. This is the bad kind of inflation since it comes with no pickup in productivity.

The unemployment rate continues to break through whatever red lines for nonaccelerating inflation rate of unemployment (NAIRU) that may have been set back in the crisis; labor force participation has certainly improved. It seems that we are accomplishing as much as one can expect from monetary policy with a cautious data-driven Fed. However, fiscal policy has tilted toward tax cuts and spending increases, which are stimulative in the short run. The test will be how much of it translates into real growth and how broadly that growth either spreads or goes to fuel an asset price bubble.

A relatively high old age population is not necessarily disinflationary. Entitlements for health care and pensions can grow larger than the savings this group has generated. Theoretically governments can fund them with unlimited tax increases, but in real life, the tax base can move to a warmer climate and let inflation make up the difference.

The Fed has started on a "stealth tightening" program of allowing a portion of its Treasury and agency holdings to mature at a pace of up to $30 billion/month in April 2018, rising to a cap of $50 billion/month from October 2018. While it could take seven years at this pace to reduce the Fed's $4.5 trillion balance sheet to precrisis levels, the reduction in demand should boost Treasury yields. By itself, it is clearly a manageable and needed adjustment. But the Fed is not the whole picture. Counting intragovernmental holdings (like the Social Security

trust funds), Treasury debt totals about $20 trillion. About 40 percent of outstanding Treasury debt matures within five years, while the average interest rate of outstanding federal debt is 2 percent.[2] Two percent of $20 trillion is $400 billion of interest expense. Replacing $10 trillion of it at 5 percent raises the annual cost to $700 billion. That's expensive.

At the same time, foreign central banks held $6.3 trillion of Treasuries as of December 2017, and of that, more than a third was held by the central banks of Japan and China. If central banks and sovereign wealth funds were to shift a meaningful portion of their holdings to Euros or yen, that could add to upward pressure on market rates and a weaker dollar. The "perfect storm" aspect of this scenario is that trade barriers and global trade friction reduce the export benefit opportunity from a weaker dollar and leave us with just the high import costs. A weaker dollar increases commodity and food prices, which impacts anyone who eats, drives or turns on the lights.

All of this assumes that the world muddles through all the geopolitical risks without an escalation in the cost of a prolonged, large-scale military deployment. Given the other economic forces at work, higher military spending could be inflationary.

So, are we "on the cusp of an inflationary cycle as in 1979–1981"? Not yet, but the factors that lead to such a bad outcome are on the march. High inflation is a failure of the fiscal and political system first of all, and on that front, "it is ALWAYS about character." What would help is a functioning political center. Imagine a world where the leaders of opposing political factions are able to set consensus compromise goals and govern together.[3] Then some real progress on our fiscal challenges would be likely. Let's work on that.

Bottom line, the risk is that we will keep interest rates low despite inflation. As half the current debt matures and rolls out of 2 percent securities, the non-negotiable cash needs due to rising entitlements, lower tax revenues and global uncertainty could mount. Despite our best intentions to keep inflation contained, higher inflation could be seen as the lesser evil. ■

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3 As we recently saw in the renewed coalition between Angela Merkel's CDU and Martin Schulz's SDP in Germany.

The Future of Renewable Energy

By John Hegstrom

Editor's note: This article is a personal opinion only and does not reflect the views of the author's firm or any other organization.

The arguments surrounding the near-term viability of renewable energy take many shapes. There are discussions about environmental impact, transmission and delivery infrastructure, storage capacity and the current political outlook. However, the focus always turns to cost in the end. While by most measures, the unsubsidized cost of renewable energy is still higher than that of traditional forms of power generation, the gap is closing rapidly. According to a recent report from the International Renewable Energy Agency (IRENA), current trends indicate that renewable energy will be cost-competitive by 2020.

According to the report, onshore wind power now costs an average of $0.06 per kilowatt-hour (kWh) globally, while solar (photovoltaic) power comes in at $0.10 per kWh. Wind and solar rates have decreased by 23 percent and 73 percent, respectively, since 2010. In contrast, fossil-fuel power costs in the range of $0.05 to $0.17 per kWh. Even with a conservative trend assumption, we will soon see cost-efficient renewable energy.

Another concern is the ramp-up of infrastructure to meet the demands of renewable energy users. The prime example of this is the need for widespread charging stations for electric cars. In much of the intermountain western United States, the distances between charging stations are currently very large, causing anxiety for drivers of electric vehicles on interstate highways. In response to this, the governors of several western states joined together in 2017 to develop a regional electric vehicle plan called the REV West Plan. This plan will generate new economic development along interstate corridors, and states have already begun to implement it. Some states, such as Nevada, have state-level plans. Nevada has almost completed an electric highway from Reno to Las Vegas. Also, Nevada is committed to completing an electric highway system serving the entire state by 2020. Recently both ExxonMobil and BP significantly revised their estimates of electric car usage upward. ExxonMobil expects 100 million electric cars on the road by 2040, and BP expects that many by 2035.

A primary component of renewable power infrastructure is the distribution and storage of wind, tidal and solar power. Water releases can control renewable power generated by hydroelectric facilities. However, wind, tidal and solar power do not have the same controllability. Peak demand that does not match up with renewable generation must be met by grid storage, demand-side management or traditional power generation. Grid storage technology consists of batteries in electric vehicles, storage heaters, district heating systems or ice storage. Demand-side management mainly consists of instantaneously adjusting the cost of electricity based on the cost of supply to encourage efficient usage. Finally, peak needs that are not met by solar or wind power can be met by hydroelectric plants, which can adjust quickly. Coal and nuclear power plants take longer to adjust. The conclusion is that large-scale use of renewable energy is possible using current technology, and future technology will only speed up the adoption of renewable energy.

At first there will be some resistance to replacing heavily embedded nonrenewable technology such as natural gas home heating. However, as the costs of solar technology continue to plunge, legacy sources such as natural gas will become more expensive due to their reduced scale. At some point in the near future, it will become economically infeasible to continue to use natural gas, and gas heating will be as rare as horses on the freeway.

There is much debate as to whether or not human-made global warming is a real phenomenon. In any case, renewable energy is without a doubt more environmentally friendly than fossil-fuel usage. There is no question that air pollution is responsible for many health problems around the world. The bottom-line costs of environmental damage and cleanup to humanity are enormous. The United Nations estimates the annual cost of environmental damage to be $6.6 trillion globally, which works out to about 11 percent of the world's gross domestic product (GDP). This amount is expected to grow to $28 trillion by 2050 (18 percent of GDP). The main culprits are oil and gas production and mining.

One factor that could slow down the adoption of renewable energy is the entrenched interests of oil, gas and coal producers and the politicians who support them. The political situation is always in flux. In other words, just wait a few years, and the political climate always changes. You can bet that when the cost of renewables reaches a critically low point, the opposition will crumble.

We are part of a global community now. Countries around the world have invested heavily in renewable energy. According to IRENA, China has more than 2.5 million people working in the solar energy sector, compared to 260,000 in the United States. "Even in China where coal is —or was—king, the government still recognizes that the economic opportunities of the future are going to be in clean energy," according to Alvin Lin, head of the Natural Resources Defense Council. China's National Energy Administration recently created a mandatory target for reducing coal usage. The country also set a goal for renewable energy to provide 20 percent of China's energy needs by the year 2030. According to a United Nations report, China invested a whopping $102.9 billion into wind, solar and other renewable projects in 2015. Prime Minister Modi of India has targeted bringing 100 gigawatts of solar power online by 2020, as part of a goal to bring reliable power to all Indians.

Several leading-edge companies based in the United States have made renewable energy a priority. Apple has made several moves into renewable energy operations in China, where it manufactures many of its products. These include a solar project in the Sichuan mountains, where the panels are designed to allow the local yak population to graze around them. Facebook and Google are pushing to reach 100 percent renewable energy, and Microsoft has been at 100 percent renewable since 2017. Even the traditional energy companies are getting in on the action. In 2017, Shell Oil purchased the electric car charging company NewMotion.

Historically new, cost-effective technologies have replaced obsolete practices in varying amounts of time. It took about 40 years for the automobile and tractor to replace the horse and mule entirely. In today's fast-paced world, change happens much more quickly. It is not overly optimistic to expect renewable energy to predominate in our lifetime. ■

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Fossil Fuel Replacement Will Take Longer Than We Think

By Jim Kosinski

Editor's note: This article is a personal opinion only and does not reflect the views of the author's firm or any other organization.

Renewable energy has seen huge growth in recent years, with some sources estimating that wind farms are now the cheapest source of energy[1] and solar becoming more competitive every year. While some people proclaim that the end of fossil fuels is near, this article will argue that fossil fuels will continue to be a substantial part of the energy mix for the foreseeable future.

First, let's look at power generation, which is potentially the easiest place to make a case for renewable energy. Data on electricity generation from the U.S. Energy Information Administration[2] shows that in 2017, about 63 percent of electricity was generated by fossil fuels, split roughly 50/50 between coal and natural gas. The 17 percent of electricity generation due to renewables includes 7.5 percent hydropower, 6.3 percent wind, and about 3 percent other (including solar). Despite the rapid growth in solar (and positive publicity), solar still produces only about as much electricity as biomass (mostly wood). Hydropower is not likely to grow substantially, as many of the most suitable sites are already in use. So to displace fossil fuels, wind and solar will have to expand their share of electricity generation massively, from a combined 7 percent to 8 percent today to 70 percent to 80 percent, assuming nuclear power continues to produce its current 20 percent.

But producing 70 percent to 80 percent of electricity from wind and solar power brings up the need for baseload capacity. What powers the grid at nighttime or when the wind is not blowing? The potential technologies suggested as future solutions to this issue (grid-scale battery storage, fuel cells, hydrogen, pumped storage hydropower, thermal storage using molten salt) are all still experimental, and it is unclear whether any of them will be practically and economically feasible over the intermediate term. Producing electricity from wind/solar may be inexpensive, but it is unclear whether running a reliable electric grid on wind/solar will be.

Second, let's talk about home heating. Roughly 50 percent of homes in the United States are heated with natural gas, with another 10 percent or so heated by fuel oil or propane/liquified petroleum gas (LPG).[3] Presumably a "renewable energy" world would involve heating homes with electricity generated from wind/solar, greater energy efficiency, better insulation, and more use of "passive solar." While it seems likely that we will see newer construction adopt renewable energy approaches more often as costs fall, there is a huge existing housing stock that would require renovation, substantial overhaul and replacement of home mechanicals at great expense to the homeowners. That may happen over time, but it will not be a fast process absent regulation or other substantial government intervention.

Regarding government intervention, there is vocal opposition in the United States to "letting government pick winners and losers." Any substantial push toward mandating renewable energy is likely to be met with well-organized and well-funded lobbying campaigns. It is difficult to see how a mandate requiring homeowners to retrofit their houses to use electric heat at huge expense would ever get any traction. (And if it did, it would likely result in a lot of politicians being voted out and replaced by people who would overturn the mandate.)

Government intervention can impede the adoption of alternative energy to the benefit of well-connected incumbents.

> Too much infrastructure is built around fossil fuels for them to be discarded lightly.

Despite the opposition to letting government pick "winners and losers," incumbent operators are happy to hire lobbyists to gain advantages so they can continue to "win." Electric utility companies have lobbied in recent years to restrict the ability of rooftop solar to hurt their bottom lines, coal operators have lobbied for relaxed treatment of emissions rules from power plants to try to maintain profitability, and oil/gas companies have argued for expanded drilling access. Renewable energy is capable of being hugely disruptive to very well-entrenched, profitable companies' business models, so there will be intense lobbying and efforts to change the rules to maintain fossil fuels companies' advantages and limit the growth of renewables. Renewables' growth may be inevitable over the long run, but it can be delayed and hampered by government actions.

Finally, transportation is an even more difficult issue for renewable energy advocates to address. Roughly 50 percent of a barrel of crude oil eventually turns into gasoline and goes to power automobiles. (An additional 25 percent is refined into diesel fuel.[4]) While numerous articles have chronicled the drop in price of electric vehicles and expressed the view that they will be cost-competitive with gasoline vehicles in a few years, as of 2017, plug-in electric vehicles made up just over 1 percent of the U.S. market.[5] Even if electric vehicles become cost-neutral with gasoline vehicles, it is likely that gasoline vehicle sales will predominate as long as charging is slow, range is limited, and gasoline is cheap. With gasoline, you can get 500 miles of range in less than 5 minutes, and all the necessary infrastructure is already available. Until the electric charging infrastructure is as well-developed as the gasoline infrastructure, electric vehicles will be more the exception than the rule. And that means gasoline will still be around.

Additionally, how far can electric vehicle sales scale up before running into shortages of key battery materials or other technological limitations? There are well over one billion vehicles on the road worldwide, roughly 250 million of which are in the United States.[6] Are they all going to be electric? If so, how much additional electrical generation capacity will be required? Add that to the "power generation" demanded of wind/solar.

And then there is air travel. Jet fuel comprises about 12 percent of the refined yield of a barrel of oil.[7] Even if there were an alternative propulsion source, a huge amount of work, time and expense would still be needed to retrofit engines and planes to use that source. Even if power generation demand and motor vehicle demand for fossil fuels were to go away completely, which seems unlikely, expanded air travel demand is likely to result in substantial fossil fuel usage for the foreseeable future.

In short, renewable energy is very promising, growing fast and becoming more cost-competitive. That said, the economy runs on fossil fuels, is built to run on fossil fuels and is likely to continue to run on fossil fuels for the foreseeable future. Too much infrastructure is built around fossil fuels for them to be discarded lightly, and the cost of migrating existing uses from fossil fuels to renewable energy is likely to delay adoption. On the transportation side, it is hard to see electric cars fully replacing gasoline-powered cars without government intervention (or electric cars becoming not only as inexpensive, but as convenient as gasoline-powered cars), and it is unclear what technology will replace jet fuel. Fossil fuels will be here for a while yet. ■

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Asset Allocation Contest

By Alan Chan

The 2018 Asset Allocation Contest sponsored by the SOA Investment Section is now underway. More than 60 Investment Section members have entered their portfolios to compete in the contest, which runs from April 1 through September 30.

Last year, changes were made to simplify the rules to encourage higher participation, and this year the contest has stayed essentially the same with only a couple of adjustments. One exchange-traded fund (ETF) has been added to increase the choices from 18 to 19. For the Manage Drawdown Risk Contest described below, the daily drawdown amount has been increased from $800 to $900. To encourage more thoughtful allocation, each portfolio is still required to have at least four asset classes with an individual allocation of 10 percent of the portfolio or greater.

The contest is broken up into three categories, testing the skill of section members' portfolio design capabilities. Each category mimics a real-world activity that could be seen in practice:

MAXIMIZE RISK-ADJUSTED ALPHA

For this contest, the goal is to produce the highest risk-adjusted alpha over the benchmark fund—60 percent All Country World Index (ACWI), 40 percent U.S. Aggregate Bond (AGG), rebalanced monthly. Risk-adjusted alpha is defined as the realized return of the contestant's portfolio less the realized return of the benchmark fund, scaled to the same realized volatility of the contestant's allocation over the contest period.

MAXIMIZE ACCUMULATION

For this contest, the goal is to accumulate the maximum amount over the contest period. This is the most straightforward of the three categories and best aligns with what most people try to achieve—to accumulate the maximum amount of wealth. The allocation requirement helps to reduce the tendency for contestants to try to win by randomly "throwing darts" while still preserving the ability to make large-scale bets in certain asset classes.

To encourage more thoughtful allocation, each portfolio is still required to have at least four asset classes with an individual allocation of 10 percent of the portfolio or greater.

MANAGE DRAWDOWN RISK

The goal for this contest is to maximize the lifetime of the portfolio. A withdrawal of $900 occurs at the end of each trading day until the account value is exhausted. If no portfolio survives to the end of the contest period, the last portfolio with positive value wins. If multiple portfolios remain positive at the end of the contest, the highest value wins. The withdrawal aims to encourage diversification, as volatile portfolios may be punished on a bad trading day.

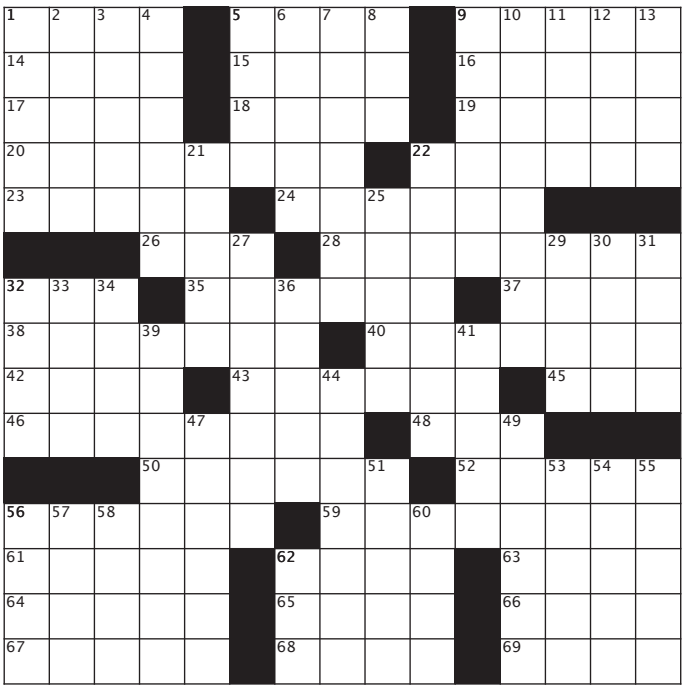
The contest has been set up for the Investment Section members as a fun way to compete with their peers using real-world data. Regular updates are sent monthly with the latest standings. We encourage you to make your plans now for next year's contest!

Follow along online (and get a head start thinking about next year's contest) at *https://www.soa.org/sections/investment/investment-allocation-contest*. ■

Alan Chan, ASA, MAAA, is a senior consultant at Deloitte in New York. He can be reached at *pchan@deloitte.com*.

Crossword Puzzle: A Bit(coin) of Trivia

By Warren Manners



The solution will be provided in the next issue of *Risks & Rewards* along with the names of those who were able to successfully complete it. Submissions should be made to *e-news@soa.org* by Nov. 30, 2018.

In the February issue of *Risks & Rewards* the submission email address was incorrect. The SOA staff editor apologizes to anyone who made a submission. ■

Warren Manners, FSA, CFA, MAAA, is the controller at Swiss Re in Armonk, N.Y. He can be reached at *warren_manners@swissre.com*.

Across

1 Capital of Azerbaijan
5 A/C units
9 Song of praise
14 Rhine feeder
15 Husk
16 Red River capital
17 Part of the UAE
18 Woes
19 List entries
20 Creator?
22 Bed occupant
23 Wild ox
24 _____ a waking dream: Aristotle
26 Designation for radio frequencies in the range of 3 to 30 kilohertz
28 Sulfur combined with another element
32 Bowler or wrestler target
35 Take care
37 Pastoral poem (Var.)
38 Japanese goddess of creation
40 Cocktails served with an onion garnish
42 Wine region
43 Abstruse
45 Kind of tide
46 Quaker
48 Military sleuths: Abbr.
50 Eponym for a female adviser
52 At full speed
56 Synopsis
59 Blockchain?
61 Struggle
62 Engine stats
63 Plinth
64 Four of twelve
65 Muhammad and Baba
66 Store
67 Some Dodges
68 Napoleon triumphed here: 1806
69 Deflation indication

Down

1 Small wild goose
2 Spirits
3 Military material
4 Predecessor of Gregory XI
5 Panache
6 Cultivated land
7 Let go
8 Old campus sit-in org.
9 Futurama protagonist
10 100 million of these equals one bitcoin?
11 Again
12 Capital of Togo
13 Arabic name of Egypt
21 Peach dessert
22 La Strada director
25 La _____, Messi's sobriquet
27 Cows and sows
29 Luminary
30 Newton fraction
31 Otherwise
32 Guinness measure
33 Muslim garment
34 Pickup spot?
36 Electrician
39 First altcoin?
41 Old Testament verb
44 Incapacitate
47 Toronto punk rock band from the late 1970s
49 Frightens
51 _____-arm
53 Large quantities
54 Unforgettable duo
55 Fish commonly referred to as skipjacks
56 Aim
57 Rembrandt's "The _____ of Europa"
58 Iberian Peninsula river
60 Mount of Greek myth
62 Former British rule in India

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