A Modern, Behavior-Aware Approach to Asset Allocation and Portfolio Construction

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Diversification has been the cornerstone of investing for thousands of years as evidenced by timeless proverbs like “don’t put all your eggs in one basket.” The magic behind diversification – and one of the reasons it is considered the only “free lunch” available in investing – is that a portfolio of assets will always have a risk level less-than-or-equal-to the riskiest asset within the portfolio.

Yet it was not until Dr. Harry Markowitz published his seminal article “Portfolio Selection” in 1952 that investors had a mathematical formulation for the concept. His work, which ultimately coalesced into Modern Portfolio Theory (MPT), not only provided practitioners a means to measure risk and diversification, but it also allowed them to quantify the marginal benefit of adding new exposures to a portfolio and to derive optimal investment portfolios. For his work, Dr. Markowitz was awarded a Nobel prize in 1990.

The theory, however, has its shortcomings. The assumptions that asset class returns are normally distributed and that expected returns, volatilities, and correlations are both known to investors and are static over time fail to hold up to empirical evidence. Unfortunately, these assumptions appear to fail spectacularly during market crises: the very times that investors rely on diversification the most.

In light of these shortcomings, some have begun to question the merits of asset class diversification and MPT. With the benefit of perfect hindsight, the diversified portfolio will never be return optimal. It will always contain asset classes that disappoint. To judge the outcome of diversification

after the fog of uncertainty has lifted, however, misses the point. Diversification is valuable precisely because investors don't know what the future holds. We can be vaguely right instead of precisely wrong.

Nevertheless, we believe there are pragmatic improvements that can be made to address some of the MPT's flaws. In our opinion, the most glaring of these flaws is the failure to acknowledge the role of investor behavior in long-term investment results.

Despite his foundational research in MPT, even Dr. Markowitz has admitted to forgoing its application within his own personal investments for behavioral reasons. "Instead, I visualized my grief if the stock market went up and I wasn't in it – or if it went way down and I was completely in it. My intention was to minimize my future regret. So I split my contributions 50/50 between bonds and equities."[1]

Today, investors are presented with a larger palette of asset classes than ever before. The rise of nontraditional asset classes, the expansion of sub-asset classes, and the proliferation of mutual funds and exchange traded funds (ETFs) provide investors with new diversification opportunities wrapped in low-cost, liquid packages.

This paper outlines our views about the appropriate asset mix for different types of investors and explains our process for constructing a diversified portfolio that includes many of these new diversification opportunities. Most importantly, it highlights the steps that can be taken within asset

[1] Zweig, Jason (2009, January 3). Investing Experts Urge 'Do as I Say, Not as I Do'. *The Wall Street Journal.* Retrieved from http://www.wsj.com

allocation to address the behavioral shortcomings of investors. Our ultimate goal is to acknowledge that the optimal investment plan is, first and foremost, the one the investor can stick with.

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I. Challenges for traditional asset allocation

There are few justifiable arguments against asset-based diversification as a foundational core for most investors. Yet for many of the same reasons that the traditional stock-bond mix was so effective over the last thirty years, *traditional* diversification may no longer be suitable or sustainable going forward. In this section, we not only challenge many of the foundational assumptions of Modern Portfolio Theory (MPT), but also explore how historical tailwinds to traditional asset allocation may be turning into headwinds.

1. MPT's shaky foundational assumptions

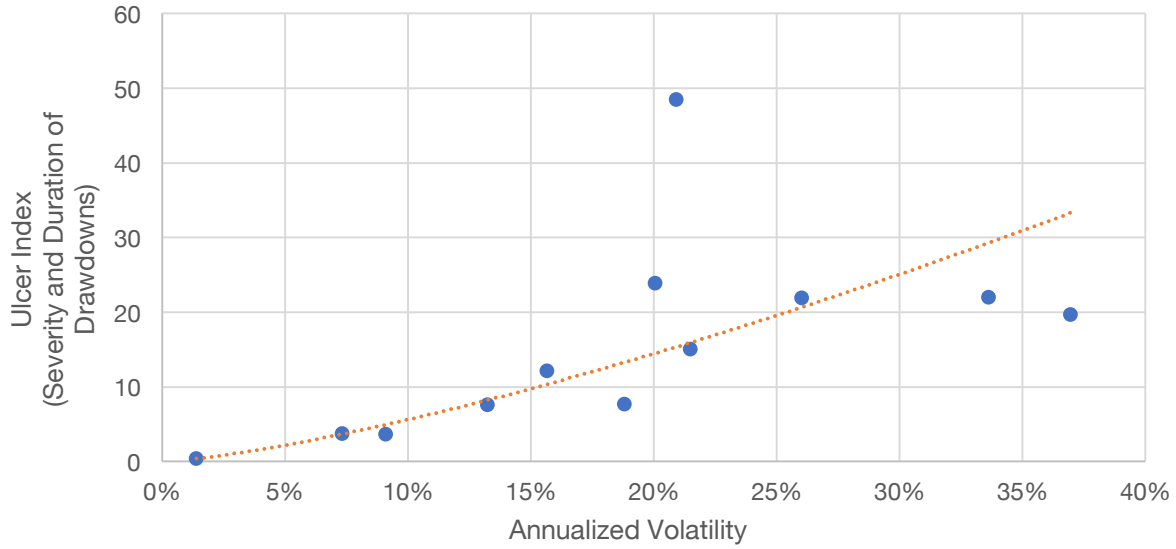
While MPT was a dramatic leap forward in its ability to quantify and measure diversification, many of its foundational assumptions have proven to be empirically invalid.

For example, MPT assumes that asset class returns are normally distributed, that volatility is risk, and that correlations not only completely capture cross-asset return relationships, but are also constant over time.

In reality, asset class returns are highly non-normal, exhibiting significant fat tails that make seemingly rare events far more probable in reality. Furthermore, asset class relationships tend to be extremely regime driven. Consider that in the late 1980s, the 3-year correlation between U.S. stocks and 10-year U.S. Treasuries was north of +0.6, while in the early 2010s it was below -0.6.

Additionally, investors take a multi-dimensional view of risk. They exhibit both loss aversion and tracking error aversion to both popular benchmarks and their neighbors (*misery loves company*). Volatility alone cannot fully capture this complexity.

Figure 1: Relationship Between Volatility and Ulcer Index for 12 Asset Classes (Dec-07 to Oct-16)



Data Source: Yahoo! Finance. Calculations by Newfound Research. Securities used in the analysis are represented by the following list of tickers: SPY, EFA, EEM, HYG, PCY, VNQ, TLT, IEF, SHY, LQD, GLD, and DBC. Past performance does not guarantee future results.

Finally, taken to its logical conclusion, MPT suggests that all investors should hold an identical global asset portfolio (the market portfolio), and simply lever or delever their exposure based upon their desired risk tolerance. In reality, leverage aversion causes investors to increase or decrease exposure to higher volatility assets as a proxy for leverage. This often leads to portfolios whose risk composition is dramatically skewed towards equity risk.

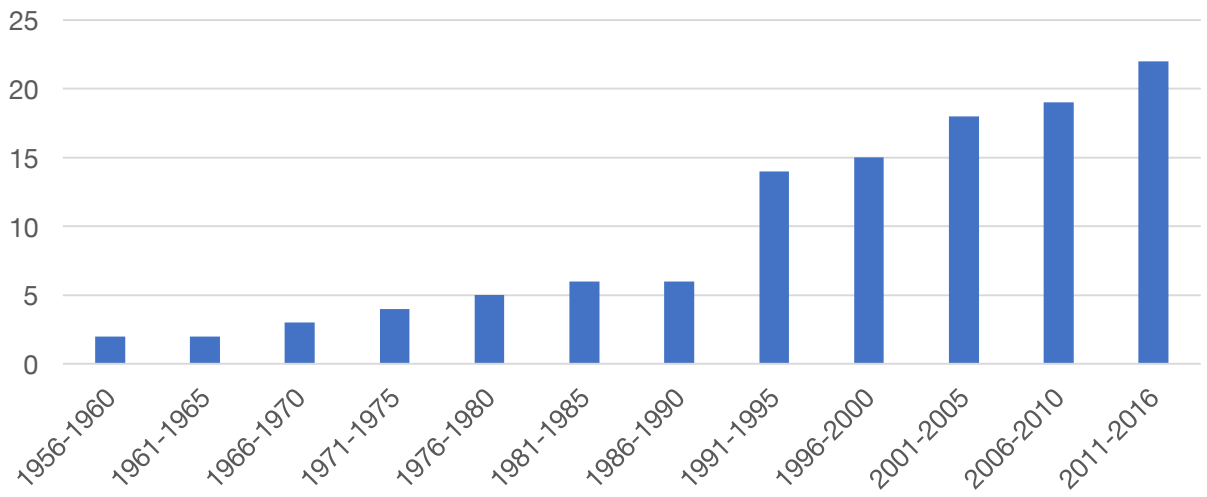
These assumptions can have devastating effects upon an investor's experience as latent risks can go unaccounted for, manifesting as unexpected and significant losses.

A modern portfolio construction approach should have a means to address these flawed assumptions. Investors should be able to construct portfolios that are in line with their actual perception of risk.

2. Increasing correlations

One of the greatest economic growth engines over the last twenty years has been the continued march of globalization. Before the 1990s, there were only 6 multilateral free-trade agreements. In 2016, there are over 20. These agreements have allowed companies to look abroad for sources of growth. According to the S&P Dow Jones Indices *S&P 500 2015: Global Sales* report, 44.3% of sales in S&P 500 companies are now generated outside of the United States.

Figure 2: Number of Operating Multilateral Free-Trade Agreements Over Time



Source: List of Multilateral free-trade agreements. (n.d.). In *Wikipedia. Retrieved November 17, 2016, from* https://en.wikipedia.org/wiki/List_of_multilateral_free-trade_agreements.

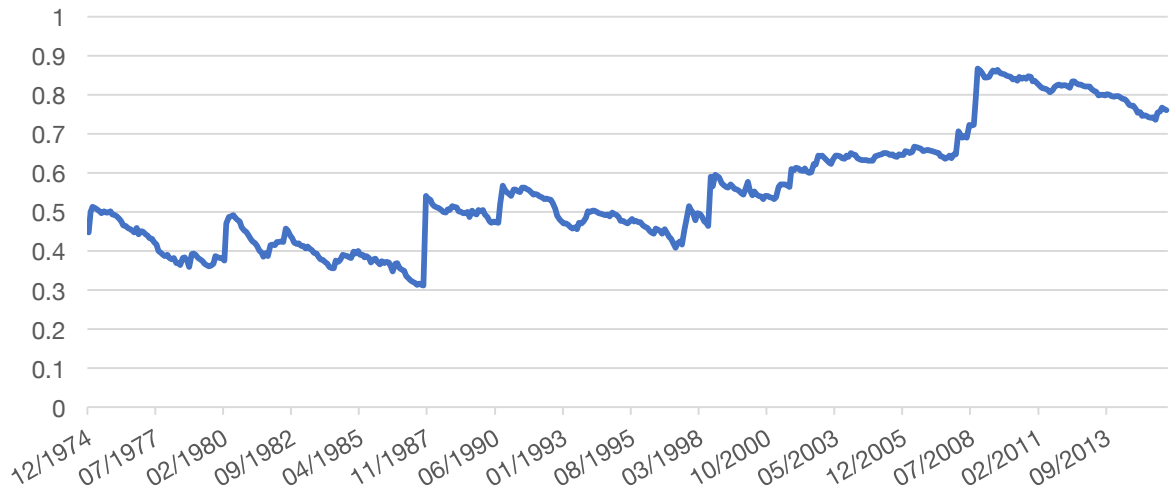
While globalization has been a boon to economic growth in many sectors, leading to earnings growth and corresponding equity price appreciation, it has also arguably led to a significant increase in cross-geographic correlations. This geographic decline in diversification opportunity is not limited only to equities, but also affects bonds and real estate[2].

This is an important trend for traditional approaches to achieving diversification because correlation is the primary measure of cross-asset relationships in MPT. Higher

[2] See Cotter, Gabriel, and Roll (2016)

correlations imply decreasing opportunities for diversification to serve as a risk mitigation tool.

Figure 3: Average 5-Year Exponentially-Weighted Correlation of 16 Developed Equity Markets



Source: MSCI. Calculations by Newfound Research. Data from 12/1969 to 12/2015. Countries included: Australia, Austria, Canada, France, Germany, Hong Kong, Italy, Japan, Netherlands, Norway, Singapore, Spain, Sweden, Switzerland, United Kingdom, and the United States. 12/1969 is the first date of available shared index data, making 12/1974 the first date that the average 5-year exponentially-weighted correlation could be computed.

Compounding the problem of generally rising in correlations is their tendency to spike during crisis events. In the graph above, distinct spikes in correlation can be seen in both October 1987 (Black Monday) and through the 2008 global credit crisis. These figures suggest the worrying possibility that diversification opportunities are often least available when we need them most.

3. Lower bond yields

The persistent decline of both the nominal and real U.S. Treasury rate has been a significant tailwind to core fixed income total returns over the last 30 years. Yet global interest rates are currently at, or near, all-time historic lows. Some central banks, including the European Central Bank and the Bank of Japan, have started charging *negative* interest rates on commercial bank deposits. While these low-to-negative rates

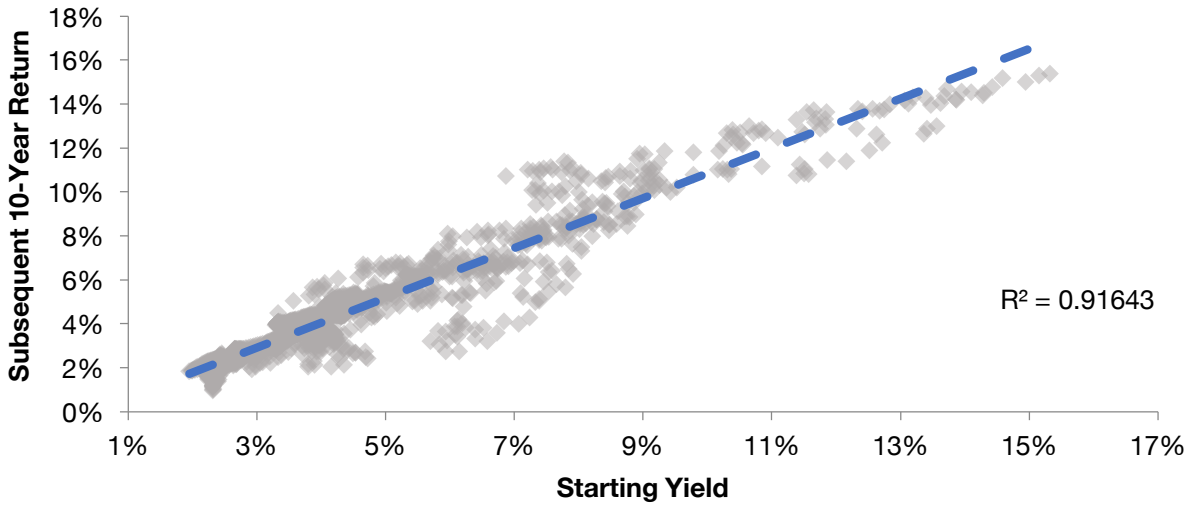
complicate the investment plans of income-focused investors like retirees, they also complicate asset allocation decisions for two reasons.

Figure 4: 10-Year U.S. Treasury Rate

Source: Federal Reserve of St. Louis.

First, starting yields are an excellent predictor of forward expected returns for core fixed income. For example, the R^2 of starting yield versus subsequent nominal 10-year returns for a constant maturity 10-year U.S. Treasury index is 0.91. Therefore, low current yields imply low forward expected returns. Traditionally allocated portfolios holding significant positions in fixed income today should expect very low nominal returns over the next five-to-ten years. This makes fixed income a very expensive risk mitigator in terms of opportunity cost since allocations to fixed income must necessarily come at the expense of holding higher expected return asset classes and strategies.

Figure 5: Bond Valuations vs. Subsequent Nominal 10-Year Returns (1871-2015)



Source: Federal Reserve Bank of St. Louis. Analysis provided by Newfound Research. 1963 is the first year for the information presented because 1953 is the first date with monthly 10-year constant maturity interest rate data. Data is through 12/31/15.

***Past performance does not guarantee future results**. The 10-Year U.S. Treasuries index is a constant maturity index calculated by assuming a 10-year bond is purchased at the beginning of every month and sold at the end of that month to purchase a new bond at par at the beginning of the next month. You cannot invest directly in an index and unmanaged index returns do not reflect any fees, expenses or sales charges. The referenced index is shown for general market comparisons and is not meant to represent any Newfound index or strategy. Hypothetical performance results have many inherent limitations, some of which, but not all, are described in the disclosures at the end of this presentation. No representation is being made that any fund or account will or is likely to achieve profits or losses similar to those shown on this page.*

Just as important, core fixed income – particularly U.S. Treasuries – is often used for its *crisis alpha* qualities, where a flight-to-safety effect causes a pop in fixed income returns during a crisis. This pop can help offset losses in equities. These gains occur as investors flee risky asset classes and bid up the prices of bonds.

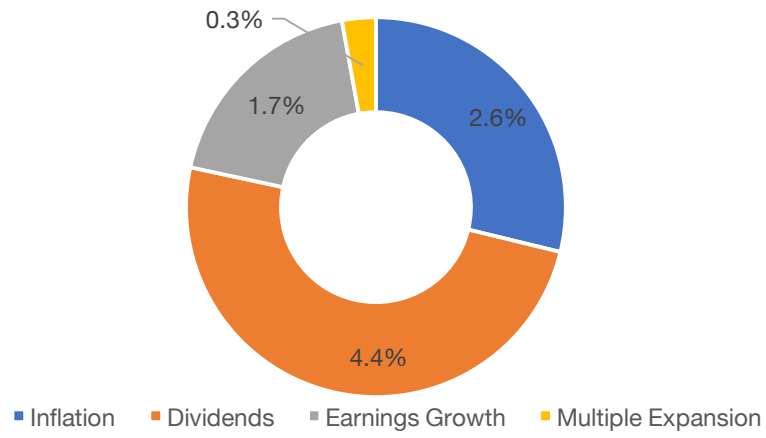
Consider that from peak-to-trough during the dot-com sell-off (March 10, 2000 to October 9, 2002), the 10-year U.S. Treasury rate fell from 6.39% to 3.61%, a 2.78 percentage point move. During the peak-to-trough sell-off of the Great Recession (October 9, 2007 to March 10, 2009), the 10-year U.S. Treasury rate fell from 4.67% to 2.89%, a 1.78 percentage point move.

From a risk management standpoint, low yields in core fixed income are problematic in that they may limit the offsetting return potential of *crisis alpha* unless rates go negative.

4. **Lower expected forward returns**

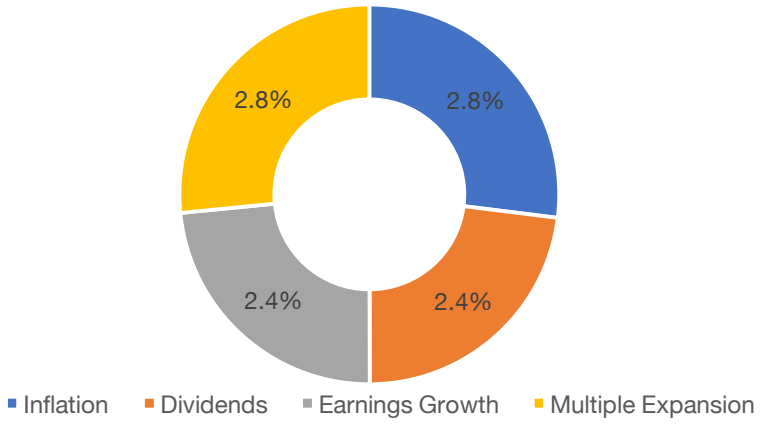
   Nominal equity returns can be decomposed into four sources: inflation, dividend yield, real earnings growth, and valuation changes. If we are interested in real returns, then inflation disappears and we are left with three return sources. This decomposition is helpful both for understanding the past and setting expectations for the future. Over the very long run, i.e. since the late 1800s, dividends and earnings growth have together accounted for more than 95% of real U.S. equity returns. The last 30 years has deviated from this pattern as significant valuation expansion drove annualized returns above 10%.

Figure 6: Historical U.S. Equity Growth Decomposed Into Component Pieces (1881-2015)



Data Source: Robert Shiller. Calculations by Newfound Research. Data through 12/31/2015. Past performance does not guarantee future results. Returns are hypothetical index returns. You cannot invest directly in an index and unmanaged index returns do not reflect any fees, expenses or sales charges. The referenced indices are shown for general market comparisons and are not meant to represent any Newfound index or strategy.

Figure 7: Historical U.S. Equity Growth Decomposed Into Component Pieces (1985-2015)



Data Source: Robert Shiller. Calculations by Newfound Research. Data through 12/31/2015. Past performance does not guarantee future results. Returns are hypothetical index returns. You cannot invest directly in an index and unmanaged index returns do not reflect any fees, expenses or sales charges. The referenced indices are shown for general market comparisons and are not meant to represent any Newfound index or strategy.

Looking forward, we know that the S&P 500 was yielding approximately 2.1% as of June 30, 2016 and its cyclically adjusted price-to-earnings (CAPE) ratio was in the 91st percentile. Based on the latter data point, we believe that the multiple expansion of the last 30 years is unlikely to continue indefinitely. If we assume constant valuations, then our real equity return forecast will equal 2.1% (dividend yield) plus an estimate of earnings growth.

Over the long run, we can expect earnings growth to lag GDP growth since not all economic growth accrues to public equity holders. For example, significant growth comes from private companies. Historically, a more reasonable proxy for earnings growth has been growth in GDP per capita. That being said, understanding the outlook for future GDP growth is informative since it serves as a upper-bound for long-term earnings growth.

Short-term interest rates have a similar, albeit somewhat more complicated model: the sum of trend GDP growth, time preference (i.e. the relative preference between savings and investment), and monetary policy effects.

GDP growth, then, is critical for traditional asset class returns. There are a number of valid approaches for decomposing GDP growth. A supply-side approach breaks GDP changes into five components: changes in productivity, changes in hours worked, changes in unemployment, changes in labor force participation, and changes in population.

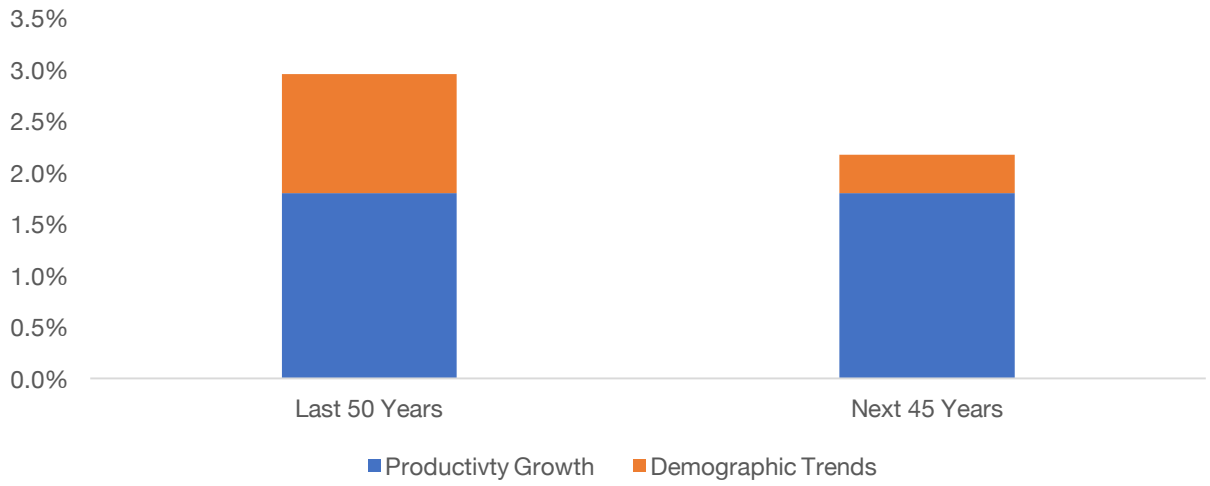
The third component, unemployment, is almost entirely cyclical and so its impact should be negligible in the long-run. The fourth component, hours worked, has largely flatlined after declining significantly through the early 1980s. This decline coincided with an increasing percentage of women in the work force. Once the percentage of women in the work force stabilized, so did hours worked[3]. Therefore, we assume that these two components will contribute 0% to GDP growth on a forward-looking basis.

The fourth and fifth components, labor force participation and population growth, are largely driven by demographics.

As a result, we simplify and consider two sources of growth: productivity and demographics.

[3] Historically, the average hours worked by both part-time and full-time workers has been relatively stable. In addition, a higher proportion of women work part-time than men. As a result, the increase in women in the workforce had the side-effect of increasing the percentage of workers with part-time jobs, leading to the decline in hours worked.

Figure 8: GDP Growth Assuming Similar Productivity Trends Going Forward

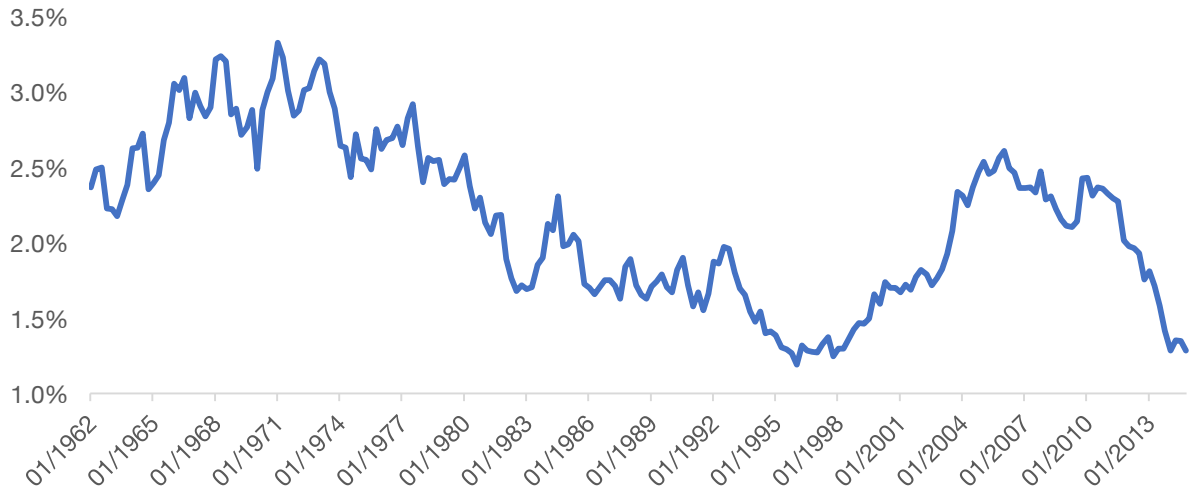


Data Source: Federal Research of St. Louis and United States Census Bureau. Calculations by Newfound Research.

Over the last fifty years, the U.S. economy has benefited simultaneously from the entry of the Baby Boomer generation into the workforce and significant productivity growth due to the invention and adoption of computer technology, global communication (e.g. the Internet), and increasing global trade.

Even assuming similar productivity growth (which may be generous especially since productivity growth and demographics are not independent variables), demographic trends are decidedly weaker. Baby Boomers are at or near retirement and the U.S. birth rate has spent many years below its circa 1960 peak level. A structurally lower GDP growth level will likely weigh down both long-term equity returns and fixed income yields for decades to come, dampening the continued effectiveness of traditional stock-bond asset allocation profiles.

Figure 9: Ten-Year Growth U.S. Productivity



Data Source: Federal Research of St. Louis. Calculations by Newfound Research. Productivity is defined as real gross domestic product per hour worked.

II. The evolution of asset allocation

Asset allocation and portfolio construction has not been a static field over time. There have been significant evolutions, both in the asset classes utilized as well as the processes employed. Whereas portfolios used to simply be a combination of stocks, bonds and cash, it is now common to see sub-asset class exposures (e.g. style boxes) and alternative assets (e.g. commodities).

Many institutions have pushed the bounds of traditional asset allocation as well, not only introducing enhancements to MPT, but also embracing truly alternative approaches to help better meet their objectives.

1. The expanding palette

Historically, traditional asset allocation has been limited to long-only equity and long-only bond investments.

Traditional Equity	Traditional Fixed Income
• Capitalization-Driven • Style-Driven • International • Emerging Markets	• Treasuries • Agency • Corporates • MBS/ABS • Floating Rates • International

The goal of expanding the investment palette is to go beyond what a traditional asset allocation might look like by incorporating asset classes that are not already present or by engaging in active strategies that can provide new and unique sources of diversification.

Alternative Equity	Alternative Fixed Income	Alternative Assets	Alternative Strategies
• Long/Short • Short Bias • Convertible/Merger Arbitrage • Private Equity	• Credit • Emerging Market Debt • Duration Management • Yield Management • Opportunistic	• Gold • Commodities • Currencies • Infrastructure • Real Assets • Real Estate	• Managed Futures

Historically, many of these asset classes were only available to institutions and high net worth investors. Today, they are available in mutual fund and ETF formats, providing retail investors with low cost and efficient means for expanding diversification opportunities within their portfolios.

2. New approaches to asset allocation

While MPT was a profound breakthrough in asset allocation, it oftentimes leaves investors with results that are not as optimal as they initially seemed on paper. Alternative approaches to MPT fall into a number of categories. Some seek to capitalize on specific areas of behavioral economics while others seek to maximize objectives other than risk-adjusted returns.

a. Risk parity

Risk parity acknowledges that an asset's weight within a portfolio is not necessarily proportional to its contribution to overall portfolio risk. For example, it is often quoted that equities contribute over 90% of portfolio risk to a standard

60/40 portfolio.

The basic principle shared by all risk parity approaches is to balance risk sources within the portfolio. How risk sources are measured vary by implementation. Some utilize asset class volatility as a measure of risk. Some incorporate economic environment sensitivity. Others use factor-based analysis.

b. Tactical asset allocation

As more global asset classes have become available, investors have looked beyond security selection for outperformance and risk management opportunities. Unlike traditional asset allocation profiles, which remain largely static, tactical asset allocation strategies dynamically adjust the asset profile over time in order to take advantage of short-to-mid term opportunities stemming from attractive valuations, momentum shifts, or macroeconomic conditions.

c. Outcome oriented

Many institutions and investors define specific goals outside the strict realm of risk-adjusted returns. Rather, they may define goals and objectives at intermediate points within the investment horizon. One example is liability-driven investing, a popular approach in the institutional space where allocation choices are made in effort to match the portfolio's cash-flow generation of the portfolio with future liabilities.

d. Endowment model

Popularized by the success of institutions like Yale University in the 2000s, the endowment model relies upon large allocations to alternative assets and strategies, including private equity, real assets, and absolute return strategies.

III. The (ir)rational investor

While behavior has always been an important component of classical economic discussions, investors – at least in aggregate - were largely assumed to be *rational* agents.

In 1979, Amos Tversky and Daniel Kahneman published *Prospect Theory: An Analysis of Decision Under Risk*, helping establish the field of Behavioral Finance by using cognitive psychology to explain inconsistencies between empirical economic decision making and classical theory. (In 2002, Kahneman became the first psychologist to win the Nobel Prize for economics.)

Since then, a score of cognitive biases have been identified and used to explain investor behavior, including limited attention, overconfidence, overoptimism, anchoring, confirmation bias, and herding. While the fields of Economics and Behavioral Finance remain in debate, we believe there are central tenets that should not be ignored in any modern portfolio construction process.

After all, the optimal investment plan is first and foremost the one the investor can stick with.

1. **Not risk averse, but *loss* averse**

   In MPT, volatility is used as the main metric of risk. Investors, however, are not necessarily risk averse. In fact, Frazzini and Pedersen (2014) find that investors actually have a preference for high risk, "lottery" style investments. By using volatility as the primary measure, MPT punishes both bad, downside risk and preferable, upside risk.

   In their 1979 paper, Kahneman and Tversky calculated a *median coefficient of loss aversion.* They found the value to be 2.25, i.e., losses are about 2.25 times more painful than equivalent gains are pleasurable.

2. **Keeping up with the Joneses**

When evaluating outcomes, investors often have an established reference point. Outcomes are classified as gains if they are above the reference point, and losses if they are below. In investing, reference points are often established public benchmarks (e.g. the S&P 500), but may also be the performance of peers.

3. **A preference for a smooth ride**

   While classical MPT is concerned with optimizing for the end result, investors live in a continuous environment. Thaler, Tversky, Kahneman and Schwartz (1997) find that investors who monitor their portfolios more frequently will actually perceive their investments to be riskier: a phenomenon known as *myopic loss aversion.* Framing investment results over short investment horizons, combined with an asymmetric treatment of gains and losses, creates a preference for a "smoother" ride over time.

IV. Constructing a modern, behavior-aware asset allocation

At Newfound Research, we believe that asset allocation should remain a foundational step for investors looking to tailor portfolios to their individual risk appetites and objectives.

In our evaluation of portfolio construction trends, we believe a modern asset allocation process should:

- be *strategic,* but not static;
- address the flawed assumptions of MPT (e.g. volatility as a risk measure, normality of returns, and a constant correlation structure);
- include new and diversifying asset classes and strategies; and
- address the role investor behavior plays in long-term investment results.

We believe that the final point is perhaps the most salient. Theoretically optimal and realistically attainable may be mutually exclusive concepts in the face of behavioral biases that can lead to sub-optimal decision making. To quote Davies and Lim (2013),

> "[…] anxiety will induce interim decisions that cause the investor to deviate from the normatively optimal portfolio (portfolios with too much anxiety along the journey will be unattainable in practice). The rational investor will therefore take account of his own behavioral distortions and seek to reduce anxiety by choosing normatively sub-optimal portfolios, which nonetheless offer the best attainable result."

To achieve these goals, we embrace several philosophies:

- **Traditional, long-term asset allocation:** 7-15 year capital market assumptions are employed to develop portfolios that maximize expected returns for a given risk level.

- **Reference-point relative:** Non-traditional asset classes and strategies are only added to a traditional benchmark portfolio when there is a high degree of certainty in their ability to increase return or reduce risk.

- **Risk budgeting:** Assets weights are assigned to balance each asset's overall contribution to portfolio risk.

For each of these philosophies, we have developed a unique approach that generates a locally optimal solution. As our final step, we blend the three solutions to create a portfolio that balances optimizing for the final destination with optimizing for the journey.

1. **Assets included**

When deciding which asset classes to include in our asset allocation and which to leave out, we balance the following considerations:

- **Diversification:** Asset classes should provide unique risk or return characteristics not already represented in the investible universe.

- **Accessibility:** Asset classes that are available in low-cost, liquid wrappers like mutual funds or ETFs.

- **Coverage:** Capital market assumptions (expected return and risk assumptions) must be available from a number of institutions (see IV.2).

We believe the following asset classes currently meet the criteria:

Traditional Equity	Traditional Fixed Income	Credit	Alternative
• U.S. Large-cap • U.S. Mid-cap • U.S. Small-cap • EAFE • Emerging Markets	• Cash • Int.-term U.S. Tres. • Long-term U.S. Tres. • US Aggregate • Int'l Gov't (Hedged) • Int'l Gov't (Unhedged) • Investment Grade	• High Yield Bonds • Levered Loans • EM Debt (USD) • EM Debt (Local) • REITs	• TIPS • Commodities • Gold • Event Driven • Long Bias • Relative Value • Macro

2. Addressing the flaws of MPT

We believe that a modern portfolio construction process must address the assumptions of MPT that are empirically false, namely:

- asset class returns are normally distributed
- expected returns, volatility, and correlation structures are known and constant

To address these concerns, we employ three techniques:

- **A simulation-based approach:** Instead of relying upon the results of a single optimization, we average the results of thousands of optimizations, each relying on a uniquely simulated set of market returns. This approach allows us to account for and incorporate the potential non-linear tradeoffs that the optimizer may find in different simulated environments as well as address uncertainty in the capital market assumptions.

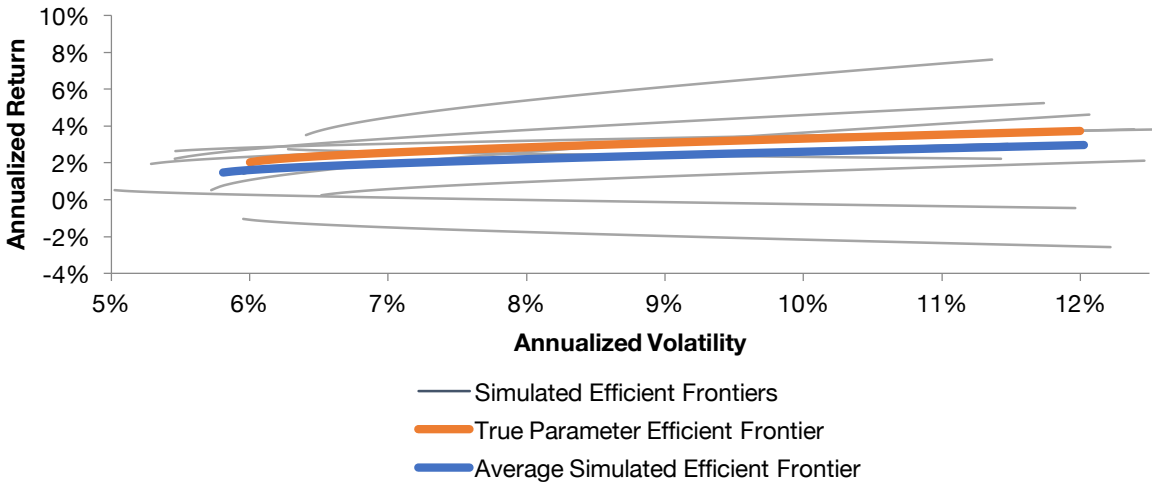
- **A diverse set of capital market assumptions:** In generating market simulations, we leverage capital market assumptions from multiple leading institutions. This allows us to incorporate differentiated views, diversifying process risk and creating a richer set of market simulations.

- **A factor-based stress test:** In the process of generating market simulations, statistical risk factor-based shocks are randomly applied to generate stressed market scenarios, helping enforce portfolio robustness to fat-tail events[4].

To illustrate these techniques, consider a simple two asset model of stocks and bonds. Using representative numbers for expected returns, volatilities, and correlations from the institutional capital market assumptions, we can calculate the efficient frontiers under a variety of scenarios.

The chart below shows the variation that comes from acknowledging that stated parameters are inherently uncertain. Simply simulating the asset class returns using the given parameters can lead to vastly different efficient frontiers.

Figure 10: Simulation-Based Efficient Frontiers versus Single Parameter Efficient Frontier



Source: Capital market assumptions from J.P. Morgan, BNY Mellon, and Morgan Stanley. Optimization performed by Newfound Research.

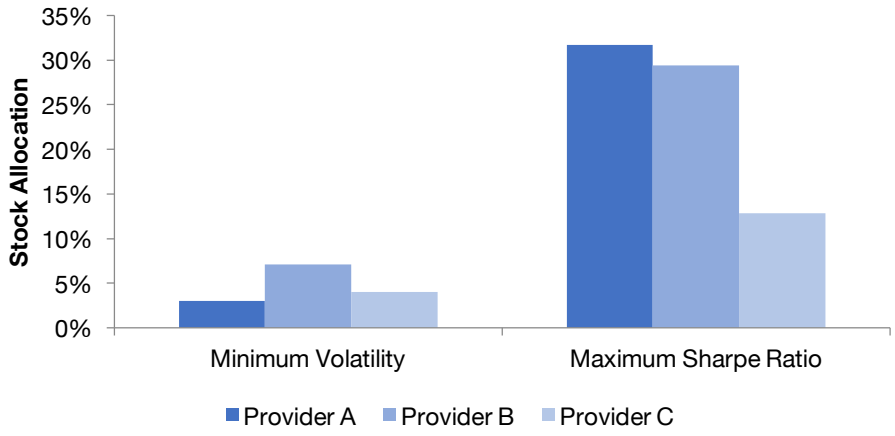
[4] A detailed description of our process is available in our research piece *A Shock to the Covariance System* (https://blog.thinknewfound.com/2016/10/shock-covariance-system/)

While the average simulated efficient frontier looks similar to that calculated using the stated parameters, the allocations of the portfolios on those frontiers can vary. For instance the mean-variance optimal allocation is 25% stocks / 75% bonds under the MPT framework and 29% stocks / 71% bonds for the average simulated efficient frontier. While this difference is not extreme, adding more asset classes, and hence estimated parameters, increases the chances that a single optimization could end up in a corner case that leads to a non-robust portfolio.

One issue that comes with this approach is that these simulations are always anchored to the starting parameter assumptions. Using multiple capital market assumptions mitigates this effect by increasing the parameter set for simulations.

The chart below shows how the stock allocation in the simple two-asset class example can vary considerably depending upon the capital market assumptions employed.

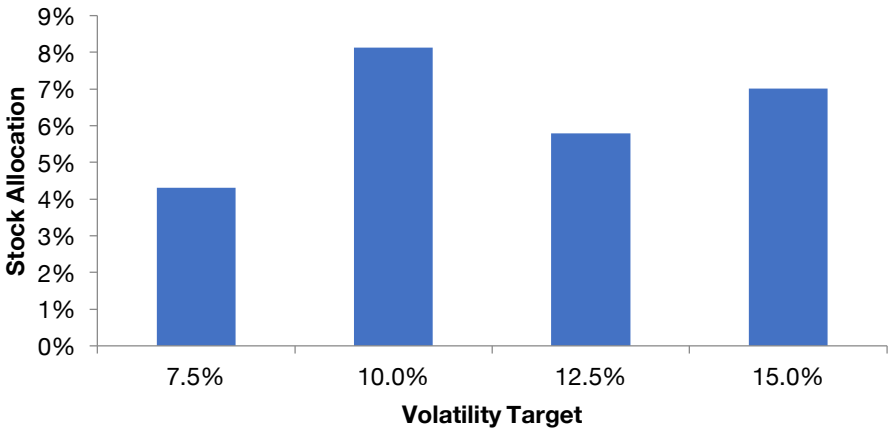
Figure 11: Stock Allocations Across Capital Market Assumptions – Minimum Volatility and Maximum Sharpe Ratio



Source: Capital market assumptions from J.P. Morgan, BNY Mellon, and Morgan Stanley. Optimization performed by Newfound Research.

If instead we restrict our portfolio optimization to target constant volatility levels, we still see a spread in stock allocations among provider assumptions. This sensitivity to the inputs becomes even more pronounced as the number of assets increases.

Figure 12: Stock Allocation Range Across Capital Market Assumptions – Targeted Volatility

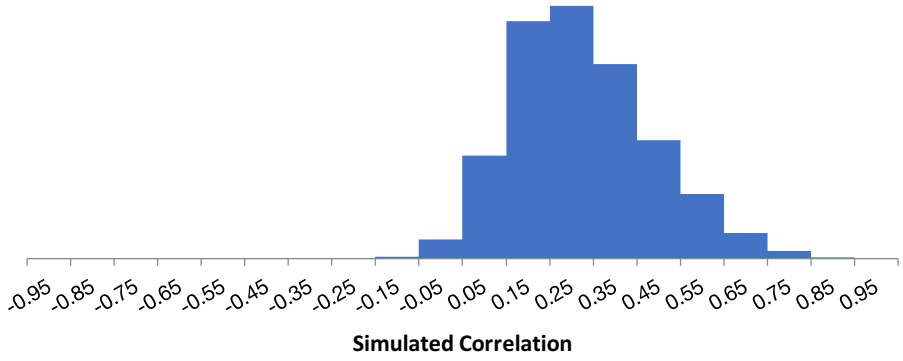


Source: Capital market assumptions from J.P. Morgan, BNY Mellon, and Morgan Stanley. Optimization performed by Newfound Research.

Finally, to generate a richer set of scenarios within the simulation framework, the factor-based stress test to correlations accounts for times when traditional diversification is ineffective, e.g. in a crisis when correlations tend to increase.

The chart below shows the sample distribution used in the two-asset example. The assumed true value for the correlation was 0.26. In many scenarios, a higher value is generated. Yet there are also times when more diversification is available.

Figure 13: Example Simulated Correlation Histogram in Factor-Based Stress Test



Source: Newfound Research.

MPT has its flaws. However, a naïve simulation approach has flaws, too. In a universe of 24 asset classes, there are over 300 parameters. Even if every variable could take only one of two values, the total number of possible states would outnumber the number of atoms in the universe. The market paths simulated must balance covering a wide enough scope of possible states of the world while staying close enough to reality to be relevant.

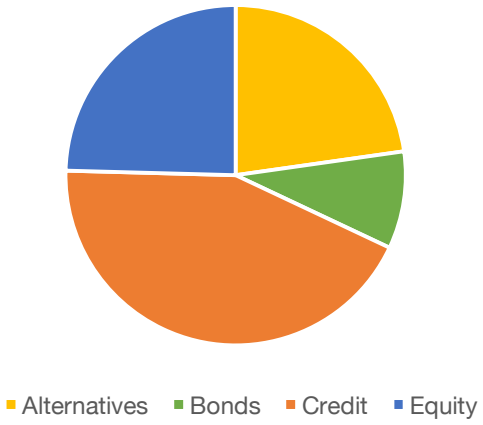
By systematically constructing multiple simulation paths while accounting for parameter uncertainty in a variety of ways, we strive to dampen the effects of non-normal asset class returns and unknown and non-constant parameters to arrive at a robust portfolio that is not reliant on the same empirical pitfalls that MPT assumes do not exist.

3. Creating a long-term optimal portfolio

Our process begins with a traditional asset allocation approach, aiming to identify the long-term, normatively optimal investment mix that maximizes expected return for a given risk target. Going beyond standard mean-variance optimization, however, our simulation-based process helps address the many shortcomings of MPT (non-normal returns, non-constant parameters, tendency for highly concentrated portfolios), creating a portfolio that we believe will be more robust to potential variety of future outcomes.

While we constrain the process to disallow shorting or leverage, the portfolio optimization is otherwise run unconstrained, which can lead to highly non-traditional asset allocations depending on capital market assumptions. For example, current projections of low economic growth and low yields lead to an optimized result that relies heavily on credit-based asset classes (e.g. high yield, senior loans, emerging market debt, and REITs) for return generation and alternative asset classes and strategies for risk mitigation.

Figure 14: Example Category Weights for Long-Term Optimal "Balanced" Portfolio



Source: Capital market assumptions from J.P. Morgan, BNY Mellon, and Morgan Stanley. Optimization performed by Newfound Research using a simulation-based process to account for parameter uncertainty, behavioral biases, and tail-risks. Certain asset classes listed in J.P. Morgan's, BNY Mellon's, and Morgan Stanley's capital market assumptions were not considered because they were either (i) redundant due to other asset classes that were included or (ii) difficult to access outside of private or non-liquid investment vehicles.

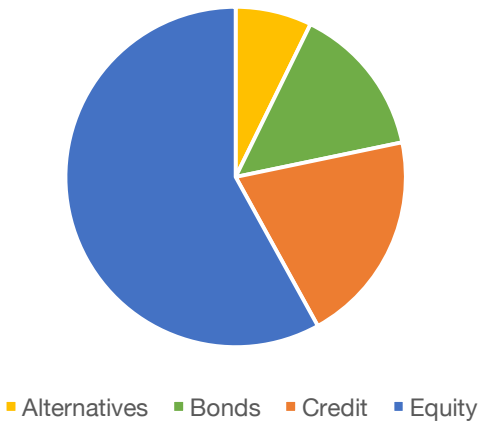
4. Managing reference point risk

This risk of an unconstrained traditional asset allocation process is that it can create allocation profiles that, while optimal through the lens of expected risk-adjusted returns, incorporate heavy tilts towards unfamiliar asset classes that can exacerbate behavioral risks. For example, our "balanced" portfolio above holds less than 35% of its weight in traditional asset classes and less than 25% of its weight in equities. Such a large deviation from a traditional 60/40 portfolio can cause anxiety in investors when short-

term performance deviates meaningfully from traditional benchmarks like broad U.S. equities.

To account for this, our second optimization process seeks to maximize returns *relative* to a traditional stock-bond benchmark, accounting for the fact that underperformance is approximately twice as painful as outperformance is pleasurable. The effect is that the optimizer will only deviate from the benchmark when these deviations have a high probability of increasing return without unduly increasing anxiety.

Figure 15: Example Category Weights for Reference-Point Optimal "Balanced" Portfolio



Source: Capital market assumptions from J.P. Morgan, BNY Mellon, and Morgan Stanley. Optimization performed by Newfound Research using a simulation-based process to account for parameter uncertainty, behavioral biases, and tail-risks. Certain asset classes listed in J.P. Morgan's, BNY Mellon's, and Morgan Stanley's capital market assumptions were not considered because they were either (i) redundant due to other asset classes that were included or (ii) difficult to access outside of private or non-liquid investment vehicles.

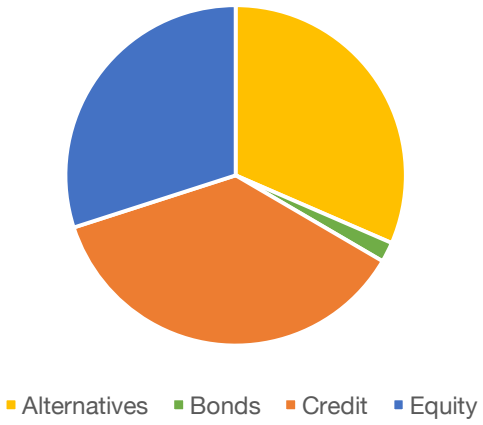
We can see that in our example balanced portfolio, nearly the full 60% weight remains in traditional equity. Traditional fixed income is supplemented with credit-based and alternative assets, which can diversify equity exposure without the expected return drag inherent with large core fixed income allocations in a low yield environment.

5. **Accounting for the journey**

While the first approach seeks to maximize *absolute* returns and our second approach seeks to maximize *relative* returns, the third approach is return agnostic. In an effort to smooth out the realized returns of the portfolio, this step seeks to maximize internal portfolio diversification through risk parity.

Specifically, we implement *hierarchical* risk parity, which seeks to first balance the risk contributed by each broad asset class category (e.g. equity) and then balance the asset class contributions within each category (e.g. U.S. large-cap). We believe that hierarchical risk parity helps further enforce structural stability within the portfolio.

Figure 16: Example Category Weights for Risk-Budget Optimal "Balanced" Portfolio



Source: Capital market assumptions from J.P. Morgan, BNY Mellon, and Morgan Stanley. Optimization performed by Newfound Research using a simulation-based process to account for parameter uncertainty, behavioral biases, and tail-risks. Certain asset classes listed in J.P. Morgan's, BNY Mellon's, and Morgan Stanley's capital market assumptions were not considered because they were either (i) redundant due to other asset classes that were included or (ii) difficult to access outside of private or non-liquid investment vehicles.

While still constrained by a risk target, we can see that the result of the hierarchical risk parity method finds near parity among three of the four categories, helping offset the more concentrated risks found in the long-term and reference-point portfolios generated above.

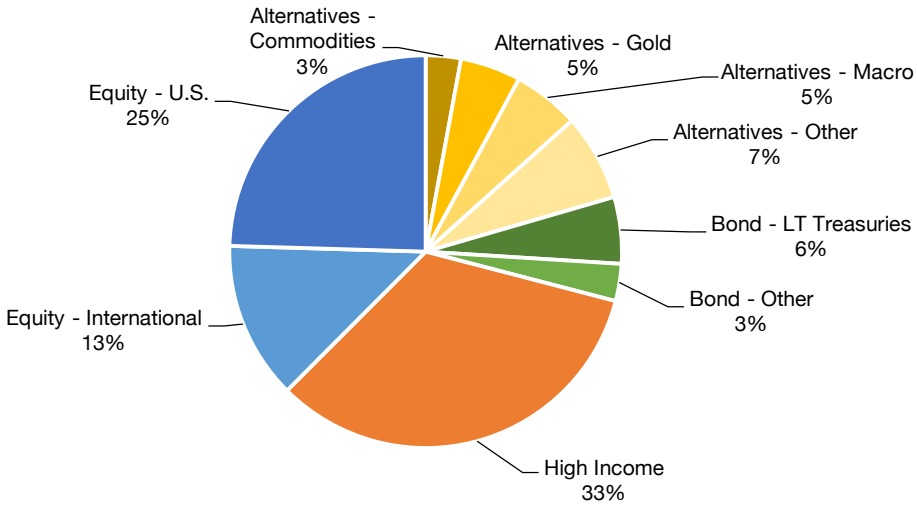
6. **Putting it all together**

Together, the three methods cover several important categories:

- Absolute return, relative return, and return agnostic
- The destination and the quality of the journey
- Investor rationality and irrationality
- Holistic risk management

To find the optimal asset mix, we simply blend the portfolio results from each of the three methods equally.

Figure 17: Example Weights for Behavior-Aware Optimal "Balanced" Portfolio



Source: Capital market assumptions from J.P. Morgan, BNY Mellon, and Morgan Stanley. Optimization performed by Newfound Research using a simulation-based process to account for parameter uncertainty, behavioral biases, and tail-risks. Certain asset classes listed in J.P. Morgan's, BNY Mellon's, and Morgan Stanley's capital market assumptions were not considered because they were either (i) redundant due to other asset classes that were included or (ii) difficult to access outside of private or non-liquid investment vehicles.

V. From asset classes to investments

After establishing the asset allocation framework, the final step in portfolio construction is identifying the means of gaining access to that asset class. Today, investors have access to individual securities, mutual funds, ETFs, and separately managed accounts

(SMAs). Accredited investors may even be able to access alternative asset classes through hedge funds.

In seeking to design the most broadly accessible investment portfolio, we elect to implement our asset allocation framework using mutual funds and ETFs, which allows for much lower account minimums than if we considered individual securities, SMAs, or hedge funds.

Which mutual funds and ETFs are selected, however, can lead to dramatically different experiences. Poor investment selection can even unravel the efforts of our asset allocation process.

Consider if we replaced 100% of U.S. equity exposure with Warren Buffett's Berkshire Hathaway stock ("BRK-B"; arguably a value/quality/low volatility hedge fund in public equity drag). While such a strategy has historically garnered a significant excess return premium, there are periods where it can significant lag the broad equity market. BRK-B not only underperformed the broad U.S. equity market by nearly 60 percentage points from February 1999 to February 2000, but also returned -39% on an absolute basis over the period. If unchecked, this type of extreme short-run tracking error – not unusual for a highly concentrated investment process – can heighten the risk of sub-optimal, short-term investment decisions driven by behavioral biases.

Therefore, in choosing investments, we consider several key questions:

- What are we gaining exposure to?
- Is the process disciplined and repeatable?
- Is the process supported by academic and practitioner evidence?
- Are there reasonable theories as to why past success is likely to continue in an uncertain future?
- How much tracking error may be incurred?
- How much are we paying for it?

1. Guiding principles

At Newfound, we adhere to several guiding principles when managing our own investment strategies, and apply these principles in our selection of other funds as well.

- **Simple.** We believe in the unreasonable effectiveness of simplicity. Our research shows that simple processes are more robust to uncertainty than complicated ones: an important factor in delivering consistent, repeatable results.

- **Disciplined.** We believe that the best way to ensure process consistency is through rules-based approaches, which can help mitigate the behavioral biases that often lead to poor investment decisions. As James Montier said, "As much as we all like to think we can add something to the quant model output, the truth is that very often quant models represent a ceiling in performance (from which we detract) rather than a floor (to which we can add)."

- **Thoughtful.** Just as important as the models are that generate investment signals, so are the rules that combine these signals to create portfolio allocations. We believe that it is in these rules that the portfolio objective is met and model risk can be addressed.

2. **Open-architecture approach**

We believe that no firm has a monopoly on good investment ideas and therefore it is critical to embrace an open-architecture approach in investment selection.

We find that larger fund families, for example, tend to have a competitive advantage in strategies that are capital intensive (e.g. credit or complex derivative research) and benefit from economies of scale (e.g. market-capitalization weighted index portfolios).

Smaller fund families, on the other hand, tend to thrive in the space of strategies that either create too much brand risk for large, established firms (e.g. highly concentrated portfolios) or are capital constrained (e.g. small-cap investing).

Our Q3 2016 model allocations include investment products from 12 unique investment managers.

3. **Hybrid active/passive philosophy**

While much of the industry debates *active* versus *passive* investment strategies, we believe the real debate is between *expensive* and *cheap.* We do not measure expensive and cheap on an absolute scale, however, but believe that price must be considered relative to the value of what is being delivered.

For example, a closet-indexing equity manager charging 0.20% may be expensive while a highly concentrated, deep value manager charging 0.75% may be cheap.

We utilize a three-tiered spectrum in evaluating strategies:

- **Outcome-Focused Active Strategies:** Diversifying strategies and asset classes whose mandates may go beyond delivering excess risk-adjusted return (e.g. downside risk management, income management, duration management, or diversification enhancement). These are often the most expensive investment strategies because they require significant active work.

- **"Smart" Beta Solutions:** Portfolios that seek to identify rules-based investment factors that can be systematically and efficiently employed. These solutions have commoditized active management over the last decade, replacing closet-indexers with cheaper, more disciplined solutions, especially in the equity space.

  While a variety of smart beta solutions exist, we focus our attention solely on factor investing. Factors are the broad, persistent forces that drive the returns of stocks, bonds, and other assets. We limit our search to only those factors that we believe are unique, have sufficient academic foundation, have robust empirical evidence (with a preference towards factors that exhibit cross-asset, cross-geographic, and cross-temporal robustness), have a simple and intuitive explanation, and can survive the cost of implementation. We believe the factors

that meet those criteria are value, size, momentum, carry, term, low volatility, and trend.

- **Index-Based Portfolios:** Low-cost, tax efficient investment options providing cheap access to market beta.

At the margins, these tiers can blend into one another. Consider that while the State Street Global Advisors SPDR S&P 500 ETF ("SPY") is currently available for an annualized expense ratio of only 0.05%, the Goldman Sachs ActiveBeta U.S. Large Cap Equity ETF ("GSLC") has an annualized expense ratio of 0.09%. For the added 0.04% fee, GSLC provides access to value, momentum, quality, and volatility factor tilts that have historically provided excess risk-adjusted returns.

4. **Making the total greater than the sum of the parts**

In active management, there are two broadly theorized reasons why the opportunity for outperformance relative to standard benchmarks exists. Outperformance is either compensation for bearing risk or the result of taking advantage of other investors' behavioral biases.

In the risk explanation, underperformance will occur when the risks are realized. For example, if the value premium exists because investors are offloading default risk to value investors, then value investors will underperform when higher default rates occur. In the behavioral case, the investment strategy seeks to exploit the behavioral biases of investors. Momentum, for example, seeks to exploit investor under- and subsequent over-reaction to new information.

In either case, the investment strategy must be sufficiently difficult to stick with such that it does not invite the attention of too much capital. If too many investors adopt the strategy, capital inflows will drive up the prices of the underlying securities, and therefore the valuations, driving down forward expected returns and causing the outperformance opportunity to converge towards zero.

So even though investors are broadly aware that value investing has historically generated excess risk-adjusted returns, it required suffering through excruciatingly long periods of underperformance (consider that the Barron's cover article in December 1999, *What's Wrong, Warren?*, opined that "Warren Buffett may be losing his magic touch." The bubble peaked three months later.)

Simply: if we expect to generate long-term outperformance, we must expect periods of potentially significant short-term underperformance in which the weak hands that *fold* pass the premium to the strong hands that *hold*.

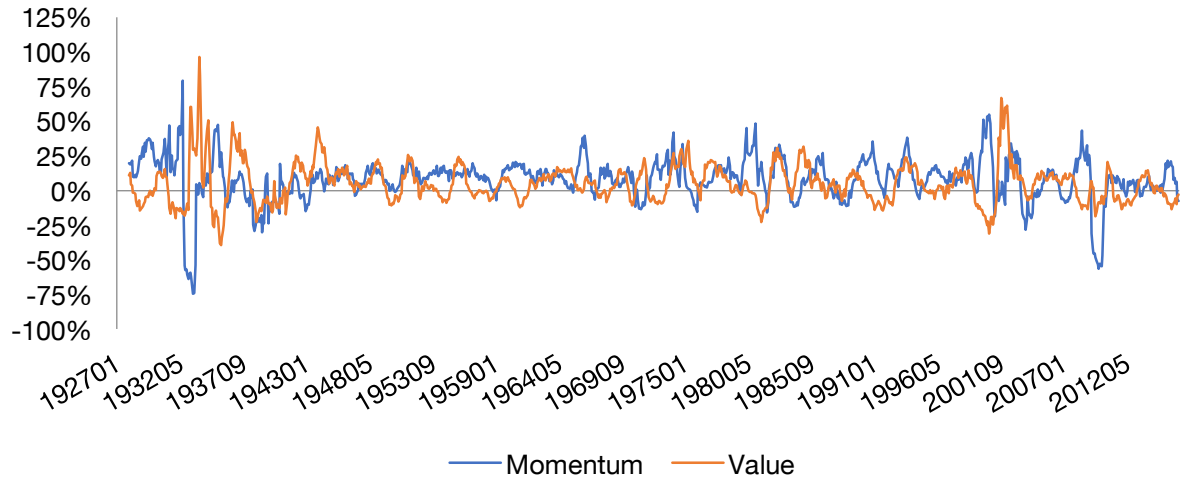
We believe it is paramount, then, to take a holistic view of investment selection and seek to diversify *process* risk.

Process risk is the systematic and idiosyncratic risks introduced by an active approach.

Consider, for example, that while value investing approaches based upon price-to-book, price-to-sales, and price-to-earnings have all historically captured some aspect of the value premium, the historical 12-month spread in returns between the three strategies has been as wide as 20 percentage points. Faber (2016) demonstrates that a portfolio leveraging all three approaches, however, reduces the average underperformance of the portfolio.

Similarly, Asness, Moskowitz, and Pedersen (2012) find that value and momentum strategies are negatively correlated both within and across asset classes, making the strategies excellent diversifiers to one another.

Figure 18: Trailing 12-Month Returns for Value and Momentum Factors



Source: Kenneth French Data Library. Calculations by Newfound Research. ***Past performance does not guarantee future results***

An important consequence of this is that active strategies must be long-term allocations, not short-term trades. The benefits of process diversification are not realized if the holding period of the strategies is not long enough to experience the benefits of complementarity.

As such, the degree of internal diversification across and within active strategies must be specified in the allocation process, not in reaction to the necessary periods of underperformance.

Generally, as position sizes increase, so does the degree of internal diversification we look for.

- **Small – Concentrated active approaches:** If we are going to pay for active returns, we prefer higher potency, more concentrated portfolios than those

watered down by market beta. For example, we prefer a deep value portfolio of 50 stocks to a value-tilt portfolio with 250 holdings.

- **Medium – Internally managed process risk**: If the same factor can be targeted multiple ways, we prefer the strategy that internally diversifies its approach. For example, we prefer a deep value portfolio that incorporates price-to-book, price-to-sales, and price-to-earnings over one that just incorporates price-to-book.

- **Large – Diversified strategy risk**: Portfolios that internally diversify across multiple active return factors can mitigate the risk of any single factor underperforming for a prolonged period. For example, we prefer a strategy that allocates internally to both momentum and value strategies to one that just allocates to value.

For the largest holdings, we also look to diversify process risk *across* holdings. For example, the Global X Scientific Beta US ETF ("SCIU") provides similar exposure to GSLC, embracing a multi-factor tilt towards value, size, momentum, and volatility, but doing so through a different process. While both ETFs are broadly aligned in long-term core objective, the means by which they do it are unique. Diversifying across both may help reduce short-term tracking error driven by process risk.

Importantly, diversifying process risk lessens the load that must be shouldered by any one strategy. For example, the following two scenarios both lead to a Sharpe Ratio of 0.5: (1) Investing with a single manager who achieves a 0.50 Sharpe Ratio and (2) Investing with three managers, whose returns are independent, who each achieves a Sharpe Ratio of 0.29. The latter situation is more robust to the extent that managers with truly independent investment processes can be identified.

5. Managing equity concentration risk

Taken to its conclusion, MPT recommends that investors construct the optimal risk-adjusted return portfolio and then lever or de-lever that portfolio to achieve their

expected return target. In reality, most investors exhibit leverage aversion, and instead choose to overweight higher volatility exposures like equities.

While a structural component of the asset allocation framework, we believe this equity risk concentration can be partially managed through investment selection. Our research indicates that managed futures and tactical equity are two of the most effective diversifiers of equity risk[5].

At Newfound, we believe in the conservation of risk: risk cannot be destroyed, only transformed. Every decision in portfolio construction that eliminates one risk in turn introduces another.

Conservation of risk tells us, therefore, that while managed futures and tactical equity exposures may help reduce the impact of equity risk, they introduce their own risks (e.g. whipsaw risk). For investors familiar with traditional stock-bond portfolios, these risks may create stressful tracking error. Therefore, while we believe that replacing some traditional equity exposure with these positions may be prudent from a risk management standpoint, we recognize that appropriate sizing is necessary so as to not introduce undue cumulative tracking error in the portfolio.

VI. Conclusion

Choosing an asset allocation can be an extremely involved process for investors. The wealth of research on portfolio construction techniques and the 24-hour news cycle touting the benefits and detriments of nearly every asset class frequently and quickly lead to information overload, which in turn strengthens many behavioral biases.

Having a system is a crucial way to sidestep these potentially damaging cognitive biases.

[5] See our presentation *The State of Risk Management (May 2016).*

Modern portfolio theory presents one systematic way to take a limited set of beliefs and translate them into an optimal portfolio, but this "optimality" relies on a world that, while simple on paper, is not often mirrored by reality. Volatility is only one way to measure risk and is not appropriate for many investors.

We often say that risk cannot be destroyed, only transformed. Beyond the "free lunch" of traditional diversification, most reductions in one type of risk come with increases in other types of risk. For example, holding a higher cash allocation will reduce volatility but will lead to more inflation risk.

Likewise, a significant amount of effort can go into providing an investor with an optimal portfolio under the MPT framework, only to see it discarded before the end goal has a chance of being realized.

An investor's behavior can be one of the biggest risks facing a successful investing career.

In this paper, we outlined our process for constructing behavior-aware portfolios that address many of MPT's flaws and provide investors with outcome-oriented portfolios that mitigate the influence of behavioral biases.

By construction, these behavior-aware portfolios will not be "optimal" in the traditional sense of achieving the highest risk adjusted returns over their investment horizon. However, their focus on managing both the destination and the journey aims to provide a smoother ride overall, a ride that can be weathered. These portfolios balance long-term results while managing the risk of short-term underperformance to common benchmarks and the impact of uncertain parameter estimates.

As the palette of asset classes and ways of accessing each asset class through liquid, low-cost investment vehicles continue to grow, this adaptable, open-architecture process can be utilized to fully exploit diversification both from an asset class and process perspective.

As we stated at the beginning, our ultimate goal in constructing behavior-aware portfolios is to avoid turning short-term losses into permanent portfolio impairment. By holistically managing risk at all levels of portfolio construction, we can create a robust, yet flexible, framework for getting investors where they want to be with reduced stress along the way.

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