Ibbotson Associates Research Paper

Lifetime Asset Allocations: Methodologies for Target Maturity Funds

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Contents

Executive Summary

Ibbotson Associates is a leading developer of lifetime asset allocation (date-based or age-based) funds.[1] We offer a family of target maturity investment options that seamlessly integrate with each other and other Ibbotson products to provide a complete lifetime asset allocation solution. Lifetime Asset Allocation Funds continue to evolve during retirement and are optimized to provide a relatively stable, inflation-adjusted real income stream in retirement.

The Ibbotson Target Maturity Methodology embraces the latest academic research regarding modern portfolio theory, the role of human capital, the application of liability-driven investing techniques to retirees, advanced optimization techniques, alternative asset class research, and more than 30 years of asset allocation thought leadership. The result is a methodology that can be used to create custom lifetime asset allocation solutions for individuals or specific demographic groups, such as employees from a specific company.

The creation of robust lifetime asset allocation solutions begins with an analysis of the changing risks investors face throughout their lifetimes. During the accumulation phase, investors are primarily concerned with expense risk, savings risk, mortality risk, and market risk. During the decumulation phase, or retirement phase, the primary risks are expense risk, longevity risk, bequest risk, and market risk. Just as the nature and magnitude of these risks evolve over time, so do the methods for controlling them. The changing nature of these risks is closely related to the size of the investor's financial and human capital.

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[1] While we use the word "funds," the exact legal structure of the solution has little impact on the characteristics of the investment solution. The target maturity methodology can be used to form indexes, mutual funds, exchange-traded funds, insurance trusts, commingled trusts, and variable annuities as well as less formal structures such as model glide paths and model strategies.

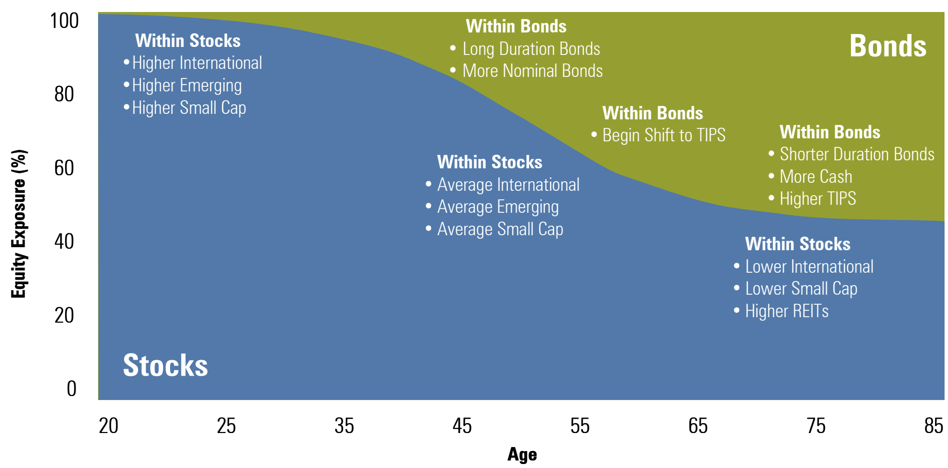
Although competing firms race to release target maturity solutions, most target maturity equity glide paths lack theoretical substance. The Ibbotson approach, however, embraces modern portfolio theory, which tells us that the single portfolio with the best risk and return trade-off is the unobservable market portfolio. Correspondingly, we have created a robust working version of the market portfolio that includes financial assets as well as the largest and most important non-tradable asset: human capital. Both the hypothetical market portfolio and the total economic worth of individuals consist of a combination of financial capital and human capital. The high level stock-bond split of the market portfolio serves as the target portfolio for an individual's total economic worth. For younger investors, human capital is typically their largest asset. As investors age, their human capital is converted into financial capital, and eventually the value of their financial capital exceeds their human capital's value. Because human capital is more bond-like than stock-like, younger investors should invest mostly in equities. As human capital is depleted, the asset allocation of financial capital approaches the market portfolio's target asset allocation.

No single glide path is right for everyone: individuals differ widely in their risk preference and risk capacity. Customized glide paths should take these dimensions into account, providing optimized asset allocations for investors that evolve over time.

For individuals, assets exist primarily to pay for their retirement income liability. As a result, the retirement income liability affects asset allocation policy throughout the investor's lifetime. Yet many asset allocations are based on an asset-only optimization framework, which focuses solely on a subset of the investor's portfolio. Acknowledging the retirement income liability's importance establishes a glide path that incorporates evolving intra-stock and intra-bond allocations. This liability-relative optimization framework focuses on the investor's total financial health. During the accumulation phase, human capital pays for current expenses and provides the investor with inflation protection. As financial capital supersedes human capital, however, asset allocations need to evolve.

Overall, as investors age, asset allocations should have a more pronounced home country bias. This pertains to both intra-stock and intra-bond allocations. Additionally, real return asset classes, such as TIPS, commodities, and real estate, should play an increasing role as human capital provides less and less inflation protection. Finally, intra-bond allocations should gradually shift from high-return, long-duration, nominal-bond-oriented asset allocations towards a less volatile, shorter-duration, real-return-oriented asset allocation.

Generalized Ibbotson Target Maturity Glide Path



For those investors who are seeking retirement solutions, we apply these methodologies to create retirement income solutions that seek to provide the maximum amount of inflation-adjusted income.

Introduction

"As the Baby Boomers begin to retire, their many trillions of dollars of savings and investments are shifting from accumulation to decumulation, making the ideas and techniques described in Lifetime Financial Advice timely and necessary. We hope and expect that researchers will continue to follow this path in the future by placing a much greater emphasis on life-cycle finance than in the past. We intend that upcoming Research Foundation monographs will reflect the heightened emphasis on life-cycle finance. The present monograph is an unusually complete and theoretically sound compendium of knowledge on this topic. We are exceptionally pleased to present it."

Laurence B. Siegel, Research Director
The Ford Foundation and The Research Foundation of CFA Institute

The above quote, taken from the forward of *Lifetime Financial Advice: Human Capital, Asset Allocation, and Insurance*, highlights the importance of "life-cycle finance." [2]

For most individual investors, the core goal of their investment plan is to provide an adequate retirement income. An investment plan's ability to provide the best possible retirement income is affected by the decisions investors make throughout their lifetimes. As investors age, the fundamental nature of their total economic worth evolves, as do the risks that they face. "Life-cycle finance" helps investors achieve their goal of an adequate retirement income. Target maturity investment solutions should help investors through the investment phases of accumulation, transition, and retirement.

Ibbotson Associates is a leading developer of asset allocation funds. The two major types of asset allocation funds are target maturity funds (often called life*cycle* funds) and target risk funds (often referred to as life*style* or balanced funds). We estimate that during 2007 the amount invested in target maturity funds surpassed the amount invested in target risk funds for the first time. At the end of 2007, there were approximately 38 registered target maturity fund families in the U.S. representing 256 individual target maturity funds with asset under management of $178 billion. Lifecycle funds' asset allocations evolve over time, while lifestyle funds typically have long-term, fixed, strategic asset allocations. This report focuses on lifecycle funds. We also provide related solutions that blend traditional investment products with investment products that offer guarantees, such as immediate

[2] *Lifetime Financial Advice: Human Capital, Asset Allocation, and Insurance*, a 2007 research monograph published by the Research Foundation of the CFA Institute, is co-authored by Ibbotson Associates' Roger Ibbotson, Peng Chen, and Kevin Zhu as well as Moshe Milevsky, a York professor and longtime consultant to Ibbotson Associates.

annuities, living benefits, and structured products. A full description of these methodologies is beyond the scope of this report.

The Ibbotson Lifetime Asset Allocation Family includes two major types of solutions:[3]

- Lifetime Asset Allocation Funds (enhanced Target Retirement-Date Funds)
- Retirement Income Funds (Target Retirement-Income Funds)

These two types of solutions are closely related; a Retirement Income Fund is simply the retirement half of a Lifetime Asset Allocation Fund that continues to evolve and provide income during retirement. Many current target retirement-date funds cease to evolve at the assumed retirement date, which prevents them from providing the best possible income in retirement. In contrast, Ibbotson Lifetime Asset Allocation Funds continue to evolve during retirement. Ibbotson Lifetime Asset Allocation Funds can be used for any age investor and are optimized to provide a stable, inflation-adjusted real income stream in retirement, which eliminates an investor's need to switch investment vehicles upon reaching retirement age.

Lifetime Asset Allocation Funds can be based on a target retirement date, or perhaps more preferably, the investor's birth date or age. The Ibbotson Lifetime Income Funds are designed to create a "do-it-yourself" retirement income stream.[4] Changing legislation, most notably the Pension Protection Act of 2006, should dramatically increase the usage and popularity of Lifetime Asset Allocation Funds and traditional target retirement-date funds in the coming years.

For those who want assistance creating a steady, real retirement income, the newest innovation in the target maturity arena is the target retirement-income fund. Target retirement-income funds are for "decumulators" (i.e., retirees). Target retirement-income funds provide a natural complement to existing target retirement-date funds. Collectively, target retirement-*date* funds and target retirement-*income* funds form a powerful lifetime investment solution. Lifetime Asset Allocation Funds combine a target retirement-date fund with a target retirement-income fund to produce a unified lifetime investment solution.

In the marketplace, there are two primary types of retirement-income funds: "depletion-date" funds and endowment-like funds. Depletion funds pay an increasing percentage of the remaining portfolio balance until reaching the final year, at which time the payout or

[3] Other types of target maturity funds include college saving plans, such 529 plans. For details about specialized target maturity funds like these, please contact Ibbotson Associates.

[4] "Do-it-yourself" retirement income simply indicates that the investor will sell off shares (perhaps through an automated program) to create the income stream. Alternatively, Ibbotson can systematically sell off holdings to generate a target income stream in the form of a dividend.

yield equals 100% of the remaining portfolio balance. The endowment-like funds pay out a fixed percentage (e.g., 3%, 5%, or 7%) of the portfolio balance. Endowment-like funds typically have a fixed or steady stock-bond split and are therefore considered lifestyle or target risk funds rather than lifecycle funds.

The Ibbotson Target Maturity Methodology is a multifaceted approach that embraces the latest academic research regarding modern portfolio theory together with a sophisticated understanding of human capital's role in asset allocation, application of liability-driven investing techniques to retirees, robust optimization techniques, leading traditional and alternative asset class research, and nearly 30 years of asset allocation thought leadership. The resulting methodology can be used to create 1) target maturity indices, 2) retail and institutional investment products, 3) custom target maturity solutions for plan sponsors, and 4) advice solutions through a managed accounts offering.

This Ibbotson Lifetime Asset Allocation Methodologies primer is organized into three sections:

Section 1: Lifetime Financial Advice. Section 1 introduces the primary risks that investors face during their lifetimes. The nature of these risks is closely related to an investor's financial and human capital. Creating robust lifetime asset allocation solutions begins by analyzing the evolving risks investors face throughout their lives.

Section 2: Customized Stock-Bond Glide Paths. Section 2 explains how the Ibbotson Target Maturity Methodology embraces modern portfolio theory, including an enhanced understanding of human capital's important role in the market portfolio. This section introduces the key elements of the individual investor's balance sheet, including financial capital, human capital, and the often unrecognized retirement income liability that all retirees face. The result is a robust methodology that leads to custom equity glide paths based on a given investor's unique risk preferences and risk capacity.

Section 3: Inside the Glide Path. Section 3 focuses on Ibbotson's use of liability-driven investing techniques to develop detailed asset allocation guidelines that are optimized for inflation-protected retirement income. We explain the intuition behind applying liability-driven investing to individuals, contrast asset-only optimization asset allocations to liability-relative optimization asset allocations, and delineate how the intra-stock and intra-bond allocations should evolve within the glide path.

Section 1: Lifetime Financial Advice

"I think the time has come to extend the models by trying to capture the myriad of risk dimensions in a real-world lifetime financial plan."

Robert C. Merton, Harvard Business School

In order to build the best possible solution, we must understand the problems faced by investors as fully as possible.

A Lifetime of Risks

Investors face a myriad of risks throughout their lifetimes. The nature and magnitude of these risks, as well as methods for controlling them, evolve over time. When designing target maturity strategies, it is important to have a holistic view of the investor and the changing risks that he or she faces. It is equally important to realize the target maturity strategies' limitations and to understand how target maturity strategies can and should be used in conjunction with other products to create more complete solutions.

Figure 1 presents the four primary risks that a typical investor faces during the accumulation phase of life as well as the typical tools for hedging, mitigating, and controlling each type of risk.

Figure 1: Risks Faced by Asset Accumulators

- Expense Risk → Human Capital
- Savings Risk → Savings Rate
- Mortality Risk → Life Insurance
- Market Risk → Asset Allocation

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Expense Risk – The most obvious and immediate financial risk that investors face is the risk of financial ruin: the risk that they will be unable to pay their current expenses. Expenses typically increase with inflation. During the accumulation phase of the investor's life, the investor's current salary provides the primary protection (or hedge) against current expenses. In general, salaries tend to grow with inflation. Previously saved financial capital provides a buffer should the individual's current labor income be either interrupted or inadequate to pay current expenses. Financial planners typically recommend that individuals have three to six months' worth of expenses on hand in relatively liquid forms, such as cash equivalents, to weather temporary disruptions in their current salaries. While this cash allocation is a part of the individual's overall allocation policy, during the accumulation phase we assume that this decision is made separately by each individual.

Savings Risk – This is the risk that the investor will not save enough of his or her income to pay for future expenses. Investors can mitigate this risk by living within their means and saving at an appropriate rate.[5]

Mortality Risk – From an individual's perspective, the most serious risk is mortality risk, the risk that he or she will die. From a financial perspective, this is a particular concern for individuals with loved ones who depend on the individual's current and future income for financial security. This risk can be mitigated with life insurance.[6]

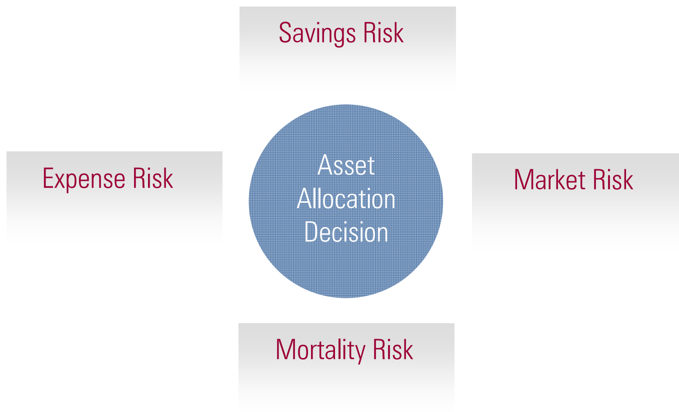
Market Risk – This is the risk that an investor's assets will lose value because of a decline in financial markets, and it is the primary risk that affects the investor's financial capital. Market risk is controlled through asset allocation policy as well as the financial instruments used to implement the target asset allocation.

[5] A potential advantage of a "managed account" over a target maturity solution is that most managed account programs can help manage savings rate risk. Monte Carlo simulation estimates whether or not an investor is saving enough to meet his or her future retirement income need and whether or not a savings rate adjustment is required.

[6] A fifth category or type of risk that is closely related to mortality risk that threatens an individual's human and financial capital is an impairment that prevents him or her from working. Health insurance and long-term care insurance hedge human capital impairments.

During accumulation, the first three risks—expense risk, savings risk, and mortality risk—are most closely related to an individual's human capital. Market risk, however, is related to an individual's financial capital as well as his or her human capital. In all cases, these four risks form an interconnected system (see Figure 2), and their relationship to each other depends on an individual's unique circumstances. As we will demonstrate shortly, the nature of these risks is closely related to the size of the investor's financial and human capital.

Figure 2: Accumulation Risks and the Asset Allocation Decision



Expense risk, savings risk, mortality risk, and market risk change throughout the investor's lifecycle.

Once an individual reaches retirement, his or her risks are somewhat different. Figure 3 presents the four primary risks that a typical investor faces during the retirement phase of life as well as the typical tools for hedging, mitigating, and controlling each of these retirement risks.

Figure 3: Retirement Risks

- Expense Risk ➔ Financial Capital
- Longevity Risk ➔ Guaranteed Lifetime Income
- Bequest Risk ➔ Life Insurance
- Market Risk ➔ Asset Allocation

Expense Risk – During the retirement phase of the investor's life, the investor continues to face expense risk. In contrast to the accumulation phase, where the investor's salary hedged this risk, accumulated financial capital and human capital must work together to hedge expense risk in retirement. Human capital in the form of deferred labor income from Social Security and defined benefit pensions can provide a steady, inflation-adjusted retirement income stream. Unfortunately, for many people this income will be inadequate; as a result, they will be forced to draw down their financial capital. The more dependent an investor is on financial capital, the larger the portion of his or her financial capital that must be invested in liquid or income-generating securities.

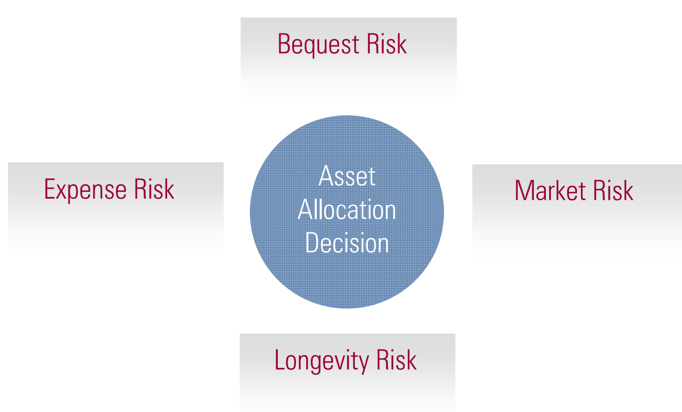
Longevity Risk – Longevity risk is the risk of outliving one's assets. On average, individuals are living longer than ever before; thus, their money must last longer. This risk can be hedged with products that offer insurance against longevity risk. An individual may further mitigate longevity risk by adopting a conservative spending policy (relative to the individual's economic worth) as well as through proper asset allocation.

Bequest Risk – Many people want to leave financial assets to their loved ones or other beneficiaries. Longevity risk and market risk threaten an individual's ability to leave a bequest, but this risk can be managed with life insurance.

Market Risk – Market risk continues to affect the investor's assets during retirement. However, a new negatively performing portfolio constituent emerges in the investor's portfolio as he or she retires: the investor's retirement income liability. Market risk affects the size of the investor's asset portfolio as well as the size of his or her retirement income liability.

As before, the risks investors face in retirement form an interconnected system (see Figure 4), and their relationship to each other depends on the individual's unique circumstances.

Figure 4: Retirement Risks and the Asset Allocation Decision



Conclusions

The creation of robust lifetime asset allocation solutions begins with an analysis of the evolving risks investors face throughout their lifetimes. During the accumulation phase the primary risks are expense risk, savings risk, mortality risk, and market risk. During the decumulation phase the primary risks are expense risk, longevity risk, bequest risk, and market risk. The nature and magnitude of these risks, as well as the methods for controlling them, evolve over time. As the following sections detail, the nature of these risks is closely related to the size of the investor's financial and human capital.

Section 2: Customized Stock-Bond Glide Paths

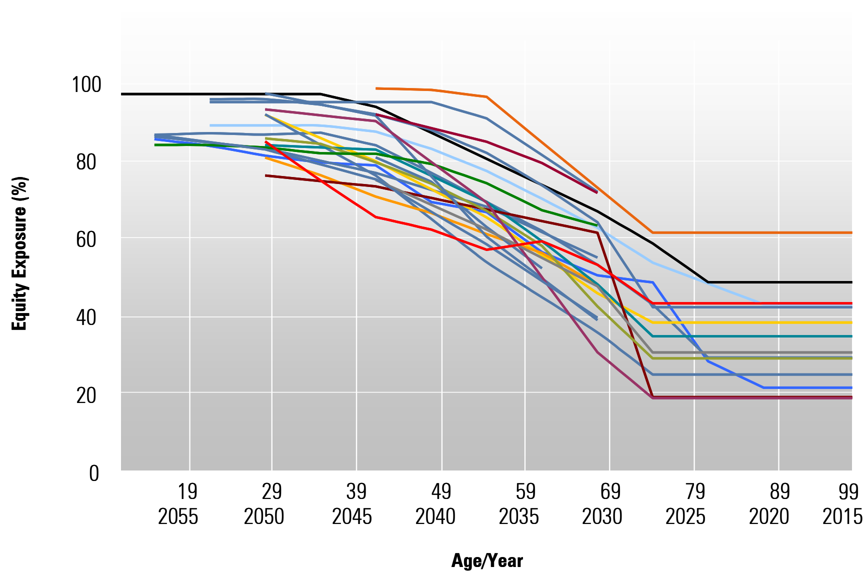
"…according to the CAPM of William Sharpe, the cap-weighted market index is the only portfolio of risky assets that is mean-variance efficient (that is, no portfolio can be constructed with the same risk and a higher expected return, or with the same expected return and lower risk)."

Francis Enderle, Brad Pope, and Laurence Siegel [2004]

Who's Right?

Asset allocation is the dominant determinant of a portfolio's risk and return characteristics. Thus, when it comes to describing, comparing, and designing target maturity solutions, the primary tool is the equity glide path. The equity glide path plots the percentage allocated to all equity asset classes on the vertical axis for different ages. Figure 5 presents the equity glide paths of the largest target maturity fund families.

Figure 5: Equity Glide Paths



Source: Ibbotson Associates

Using data from Morningstar Direct as well as other sources, the *Ibbotson Associates' Target Maturity Quarterly Report* tracks detailed asset class holdings for all target maturity fund families. Guidelines are used to classify asset classes such as commodities, convertibles, and real estate that don't fit neatly into the equity or fixed-income buckets that constitute the equity glide path.

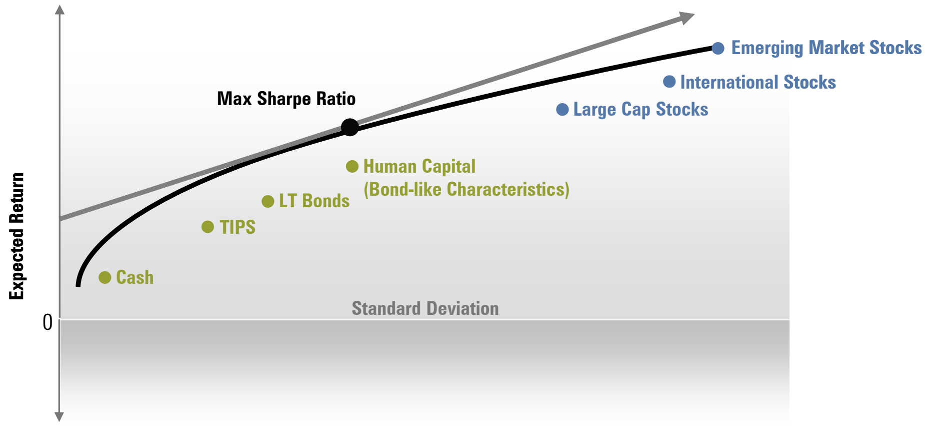
As is evident from Figure 5, the equity exposure in these funds varies widely. At age 42, which generally corresponds to what would currently be called a 2030 target retirement-date fund, the most aggressive fund has a nearly100% equity allocation, while the most conservative fund has a 65% equity allocation—a difference of 35%. Additionally, shapes of the various glide paths differ significantly. Who is right and who is wrong? Is there a sound theory that explains how much one should allocate to equities? What explains the shape of a particular glide path?

Financial Capital, Human Capital, and the Market Portfolio

The answer lies in the concept of the market portfolio. The market portfolio is the cornerstone of modern portfolio theory and is at the heart of Markowitz's mean-variance optimization and Sharpe's CAPM. In contrast with many textbooks that proxy the market portfolio using either the S&P 500 Index or the MSCI World Index, the true market portfolio of modern portfolio theory is much more inclusive and, unfortunately, unobservable. Portfolio theory tells us that the unobservable, all-inclusive market portfolio includes all tradable assets, such as traditional capital assets, as well as non-tradable assets, such as human capital (see Roll 1977).

Markowitz [1952, 1959] develops mean-variance efficiency, the notion that investors should select a portfolio that maximizes expected return for a given level of risk. Sharpe [1964] extends Markowitz's work to show that the optimum mean-variance efficient portfolio is the market portfolio. As Figure 6 illustrates, the theoretical market portfolio is the point on Markowitz's efficient frontier with the best risk-return trade-off and the maximum diversification possible.

Figure 6: Modern Portfolio Theory and the Market Portfolio



Under Tobin's two-fund separation theorem, all investors should hold some portion of their wealth in the market portfolio and achieve their desired risk level with either a long or short position in the risk-free asset, often assumed to be cash. While in practice few investors fully adopt two-fund separation, the theoretical notion of a true, all-encompassing global market portfolio provides a compelling structure for strategic asset allocation. As we shall demonstrate, modern portfolio theory also offers a powerful framework for the creation of custom lifetime asset allocation glide paths.

Integrating Human Capital into the Asset Allocation Decision

Ibbotson Associates is at the leading edge of emerging thought about human capital's role in the asset allocation decision. Recent Ibbotson research on integrating human capital includes the award-winning article "Human Capital, Asset Allocation, and Life Insurance," by Peng Chen, Roger Ibbotson, Moshe Milevsky, and Kevin X. Zhu, as well as the 2007 CFA Institute Research Foundation monograph by the same authors entitled *Lifetime Financial Advice*.[7]

Based on this research, we know that when trying to consider human capital's impact on asset allocation choices, one must understand 1) human capital's role in both the hypothetical market portfolio and individual investor portfolios, and 2) human capital's systematic (or market-like) characteristics. Human capital affects all four of the primary accumulation phase risks that investors face.

[7] In addition to Chen, Ibbotson, Milevsky, and Zhu [2006, 2007] other important works include Williams [1978], Bodie, Merton, and Samuelson [1992], Campbell and Viceira [2002], Milevsky [2004], and Chen [2007]

Expense Risk – During the accumulation phase, human capital generates current income that hedges current expenses. In addition to protecting against financial impairment, human capital has an additional effect: because human capital pays for current expenses, it allows financial capital to grow untouched until retirement. Over time, expenses and salaries increase with inflation.

Savings Risk – As is the case with expense risk, human capital's income pays for current expenses. However, if current expenses require all of the investor's current income, the investor runs a high risk of not saving enough to fund future (retirement) expenses.

Mortality Risk – Mortality risk is a catastrophic risk to human capital and the current and future income that it is expected to generate.

Market Risk – For younger investors, human capital is likely their largest single asset, albeit a non-tradable one.

Human capital has a key function in the unobservable, all-inclusive market portfolio of modern portfolio theory. Likewise, at the individual investor level, human capital plays an important role. When determining an appropriate target asset allocation for an individual investor's financial capital, the risk a person can afford depends not only on his or her attitude or preference regarding risk, but also on his or her risk capacity as dictated by his or her overall economic situation.

Just as the hypothetical market portfolio includes an allocation to human capital, an individual investor's total portfolio also includes a non-tradable allocation to human capital. For an individual investor, his or her overall economic situation is influenced by the same two sources that make up the bulk of the market portfolio: 1) financial capital (tradable assets) and 2) human capital (non-tradable assets).

Practitioners and academics alike are starting to acknowledge that human capital's return, risk, and correlation characteristics should be taken into account when building target asset allocations for investors. For example, Merton [2003] contends that it is important to include human capital's amount, volatility, and correlation (to other assets) into the asset allocation decision. To paraphrase the titles of recent works by Peng Chen and Moshe Milevsky (see Chen [2007] and Milevsky [2004]), is an investor a bond or a stock? This is a question we shall attempt to answer shortly.

Human capital is a precious asset that helps investors overcome many of the primary risks they face. However, unlike financial assets, for which monthly bank and brokerage statements identify the total value, weekly or monthly paychecks do not adequately capture the total value of human capital. Rather, they identify the *rate* at which labor income is earned. Because human capital's value is unobservable, its value must be estimated. A basic tenet of finance is that the current value of any asset is the present value of the discounted cash flows the asset will generate. Considered in light of this asset valuation principle, and accounting for mortality risk, an individual's total human capital is the present value of all future labor income.

Figure 7 depicts the major entries on an individual's balance sheet. The asset column on the left contains the two major assets: financial capital and human capital. As illustrated, human capital can be divided into three segments: 1) earnings to be used for pre-retirement expenses, 2) earnings to be directed toward savings (typically to fund post-retirement expenses), and 3) earnings that will lead to deferred labor income in the form of Social Security and defined benefit pensions.

Figure 7: An Individual's Balance Sheet (During Accumulation)

Assets	Liabilities
Financial Capital	**Future Expenses**
Human Capital	PV of Pre-Retirement Expenses
PV of Earnings used for Pre-Retirement Expenses	PV of Post-Retirement Expenses
PV of Earnings directed toward Savings	PV of Bequest
PV of future Social Security and Pensions	
Surplus (Deficit)	

From Figure 7, we can see that the individual's balance sheet also includes liabilities. The liability column on the right side of the individual's balance sheet can also be segmented into three segments: 1) the present value of all future pre-retirement expenses, 2) the present value of all future post-retirement expenses, and 3) the present value of assets that will be given away (typically this is residual financial capital that will pass to beneficiaries at death).

During the accumulation phase of the investor's lifecycle, the present value of earnings used for pre-retirement expenses cancels (or hedges) the present value of pre-retirement expenses. We hope that investors' salaries exceed their expenses, allowing investors to save some of their income. Saving a portion of their income converts investors' human capital into financial capital to pay for future retirement expenses.

When calculating the value of an individual's human capital in the context of the asset allocation decision, it is common to exclude the present value of earnings to be used for pre-retirement expenses from the equation and to focus solely on the present value of earnings directed toward savings and the present value of earnings directed toward Social Security and pensions. However, when evaluating mortality risk and calculating the proper amount of life insurance, it is more common to use the complete definition of human capital. By considering human capital from a holistic perspective, we acknowledge that the present value of earnings to be used for pre-retirement expenses is critical to the financial well-being of the investor's dependants.[8]

In Figure 7 above, the "PV" in front of the entries stands for "present value," indicating that these future cash flow streams are being discounted with an appropriate market-based discount rate that reflects the cash flow characteristics. Human capital's systematic or "market-like" characteristics are different for different individuals. For example, tenured university professors most often have steady salaries that increase on an annual basis based on inflation with little chance of dramatic changes or interruptions. Correspondingly, their human capital is very bond-like. This type of stable income typically has a low correlation with equity markets. In contrast, hedge fund managers or investment bankers have salaries that vary substantially from year to year and are usually highly correlated with the equity markets. Their human capital is very equity-like.

The average investor's human capital is somewhere in between these two extremes. A typical investor's human capital is often described as a junk bond. During "normal" times junk bonds trade more like bonds, but during times of economic turmoil junk bonds trade more like equities. Overall, Ibbotson estimates that the typical investor's human capital is more bond-like than stock-like. Ibbotson models average human capital as 30% equities and 70% bonds. This decision was reached after great debate in June 1998 among members of an Ibbotson's advisory board at the time. Members included Harry Markowitz, Daniel Kahneman, Jeff Jaffe, Shlomo Benartzi, John Carroll, and Richard Thaler.

Applying these models provides important insights. For example, using human capital models it becomes clear that younger investors, who have large amounts of human capital, have a large (often too large), untradeable asset allocation to a bond-like asset. More importantly, these models are flexible. Depending on the format of the target maturity solution, Ibbotson can use human capital assumptions based on a typical investor, tailored assumptions for a specific cohort (e.g., government employees or a particular retirement plan), or specific individual data to create individualized solutions.

To build custom glide paths using modern portfolio theory, we must attempt to quantify human capital's role in the hypothetical market portfolio in order to build a working version of the market portfolio that includes human capital. This can be done using either a top-down or bottom up approach. Both approaches rely heavily on information about the typical or average investor. We have found that both approaches lead to similar working versions of the hypothetical market portfolio.[9]

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[8] For more details on identifying the appropriate amount of life insurance, see Chen, Ibbotson, Milevsky, and Zhu [2006, 2007].

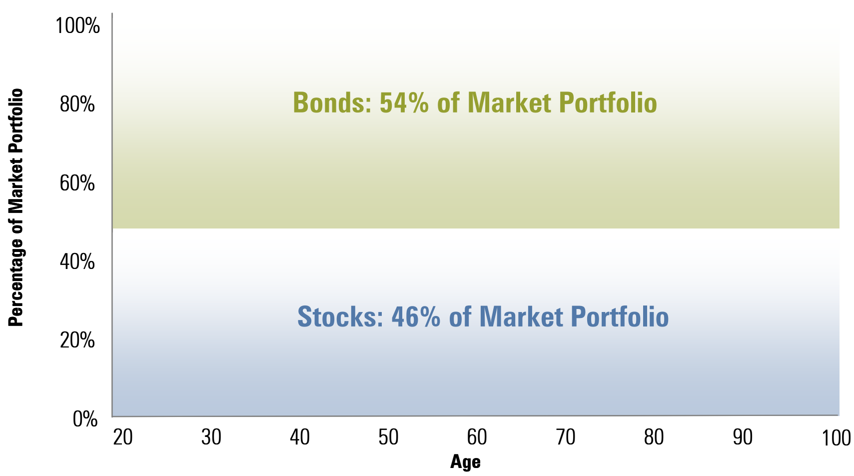
[9] We update our estimates of the high-level stock and bond asset allocation of the market portfolio annually. Historically, this split has been very stable with annual changes averaging less than 1%.

The top-down approach uses publicly available market capitalization numbers for the major stock and bond indices. We couple this with salary information from government surveys to estimate the aggregate amount of human capital.

The bottom-up approach depends on government survey data. Instead of aggregating human capital, we determine the amount of equities and fixed-income assets the average investor owns as well as his or her human capital. Thus the average investor's portfolio composition can serve as an estimate of the unobservable market portfolio.

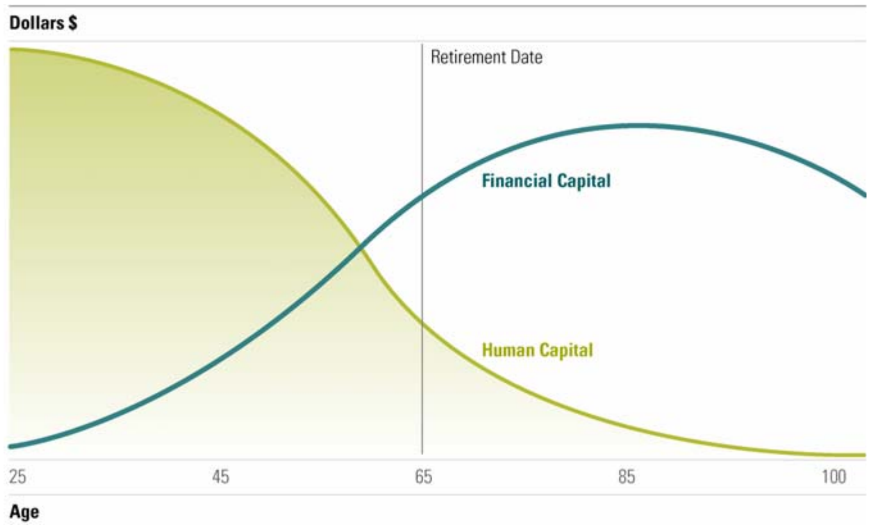
Using these models, we estimate that the unobservable market portfolio, which includes all financial assets and non-financial assets, is approximately 54% bonds and 46% equities. Modern portfolio theory tells us is that this is the most efficient stock and bond asset allocation possible. Additionally, this working version of the hypothetical market portfolio serves as a high-level target for an individual's overall asset allocations (consisting of financial and human capital). This rather unexciting glide path for an individual's total economic worth is presented in Figure 8.

Figure 8: Total Economic Worth Glide Path



It is important to realize that the target glide path for an investor's total economic worth is different from the glide path for an investor's financial capital. To create a glide path for financial capital, we must analyze the changing roles of financial and human capital in an individual's portfolio. Figure 9 is a stylized depiction of the ways in which a typical individual's human capital and financial capital evolve in relation to each other over an individual's lifetime.

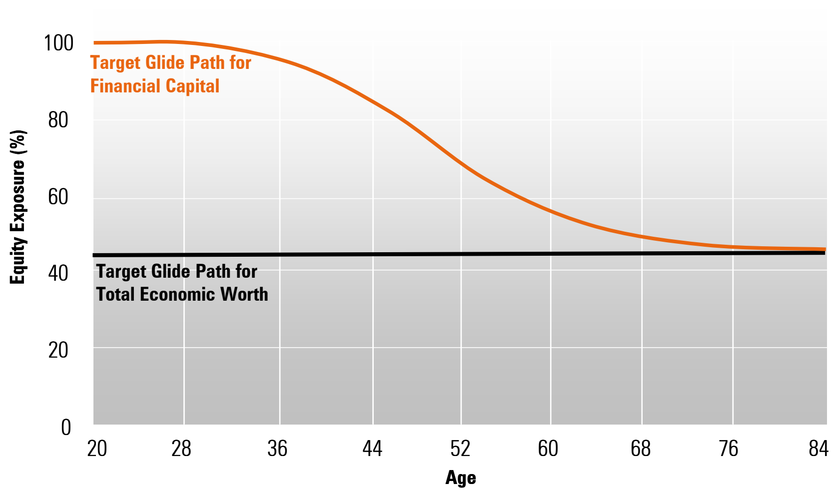
Figure 9: Typical Lifecycle of Human Capital and Financial Capital



Ignoring the liability side of an investor's balance sheet, the investor's total economic worth is the sum of his or her financial capital and human capital. Remember, for most investors human capital is bond-like, and for younger investors it constitutes the largest portion of their economic worth. Because of this large bond-like holding and relatively small amount of financial capital, most young investors have total portfolios that are too bond-centric. Thus, most younger investors' financial capital should be invested 100% in equities. As investors reach their late 30s or early 40s, they have typically amassed enough financial capital that they no longer need to invest 100% of their financial capital in equities in order to match their total portfolio's asset allocation with the overall target asset allocation (see Figure 8).

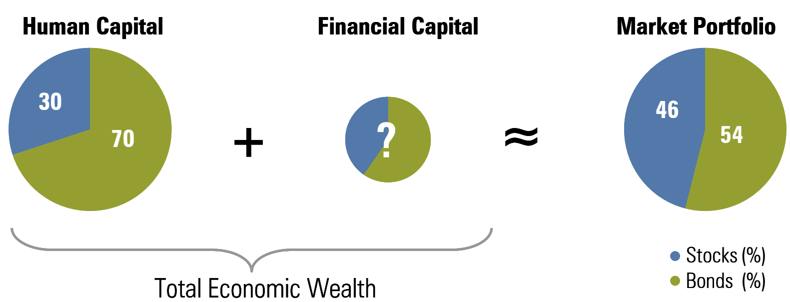
It is not a coincidence that the shape of the financial capital glide path in Figure 10 is similar to the stylized human capital path depicted in Figure 9. Notice that as human capital nears depletion, the financial capital equity glide path approaches the asset allocation of our working version of the market portfolio—in this case, a 54% bond and 46% equity mix. In contrast to a number of target maturity funds, which simply go into "income mode "at retirement, Ibbotson's modern portfolio theory method produces a financial capital glide path that continues to evolve after retirement.

Figure 10: Financial Capital Glide Path vs. Total Economic Worth Glide Path



The equity glide path in Figure 10 is directly related to the risks investors face. The dominant factor that changes the asset allocation throughout the investor's lifetime is human capital. As we have shown, younger investors typically have a large investment in the bond-like human capital asset and must therefore invest their financial capital aggressively in order to maintain an equity-bond split that matches that of the market portfolio. Targeting the hypothetical market portfolio helps control the market risk of the investor's total portfolio and places him or her in the optimal target asset allocation mix based on modern portfolio theory. Figure 11 depicts the process of adjusting the financial capital's asset allocation to reach the target.

Figure 11: Targeting the Hypothetical Market Portfolio



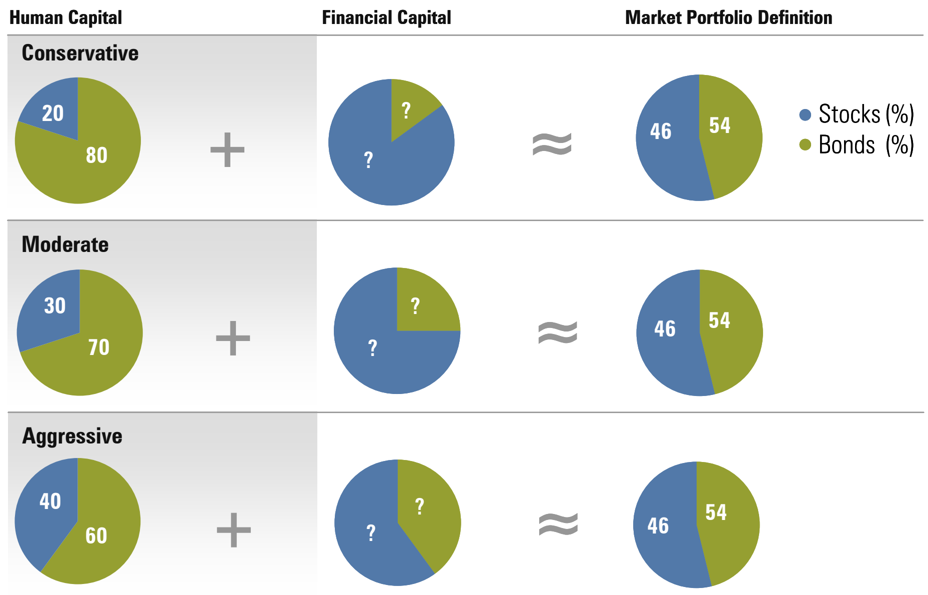
The amount (or size) of an individual's human capital and the amount (or size) of his or her financial capital change over time. Since most investors have settled on a career path, it is relatively difficult to change the value (i.e., size) and market-like characteristics of an investor's human capital (depicted in Figure 11). An investor's financial capital, on the other hand, can easily be reallocated.

To optimize an individual's total portfolio, Ibbotson changes the investor's financial capital asset allocation so that the investor's total economic wealth matches the stock-bond split of the target market portfolio. To calculate the amount of an investor's human capital, we use the mortality weighted, present value of their future expected income (more specifically, income directed toward savings as well as deferred income in the form of Social Security and defined benefit pensions). When constructing the standard Ibbotson glide paths, Ibbotson uses income and savings information from the *Survey of Consumer Finance* and *Consumer Expenditure Survey*. To this information, we apply a discount rate based on Ibbotson's capital market assumptions to estimate the value of human capital for an "average" or "typical" investor. To construct the amount of financial capital for different ages, we employ data from the *Survey of Consumer Finance*. In a managed accounts setting, or when designing custom glide paths for a specific plan, we customize the glide path at either a participant or plan level.

Our working assumption that human capital is 30% equities and 70% bonds may be customized at an individual or plan level. As mentioned earlier, everyone's human capital is unique: at one extreme we have tenured university professors with very safe human capital (known future wages and almost no chance of being fired), and at the other extreme we have professional gamblers with very volatile human capital (unknown and volatile future wages). In his well-known book *A Random Walk Down Wall Street*, Burton Malkiel [2004] states, "The risks you can afford to take depend on your total financial situation, including the types and sources of your income exclusive of investment income." We embrace this idea.

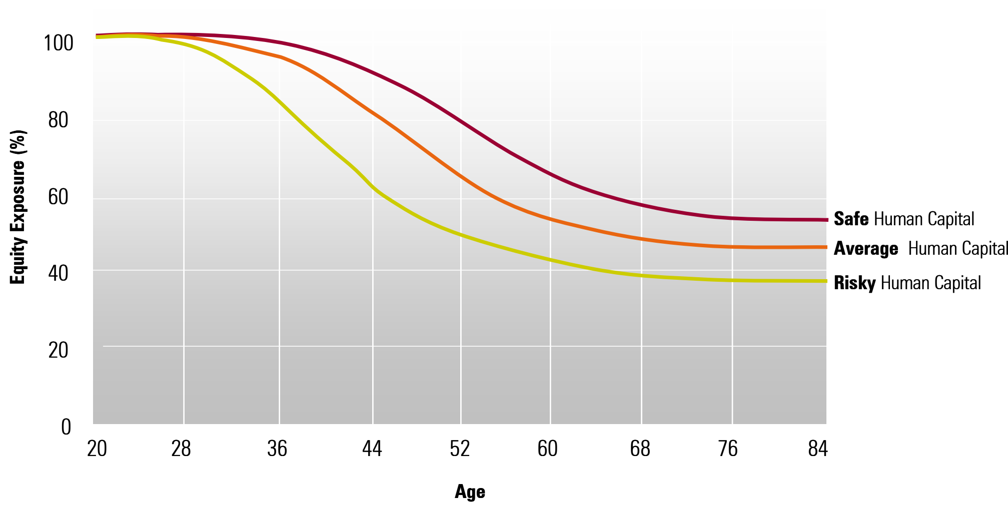
In Figure 12, we hold the target market portfolio for an individual's total economic worth constant and explore the use of two alternative human capital models, a "safer" human capital mix (top panel of Figure 12) and a "riskier" human capital mix (bottom panel of Figure 12).

Figure 12: Changing Human Capital Characteristics



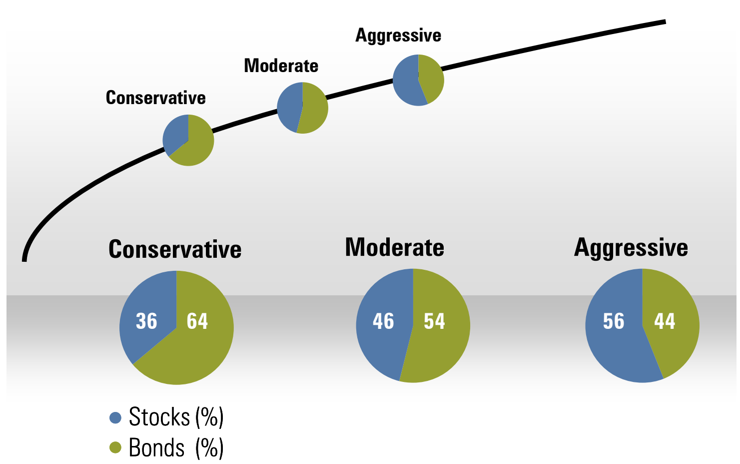
All other things being equal, if an individual has "safe" human capital, his or her financial capital should be invested more aggressively to create a total portfolio that matches the target market portfolio. Conversely, if an individual has "risky" human capital, his or her financial capital ought to be invested less aggressively to hit the target. Figure 13 illustrates the resulting glide paths associated with these three different human capital models.

Figure 13: Glide Paths Based on Changing Human Capital Characteristics



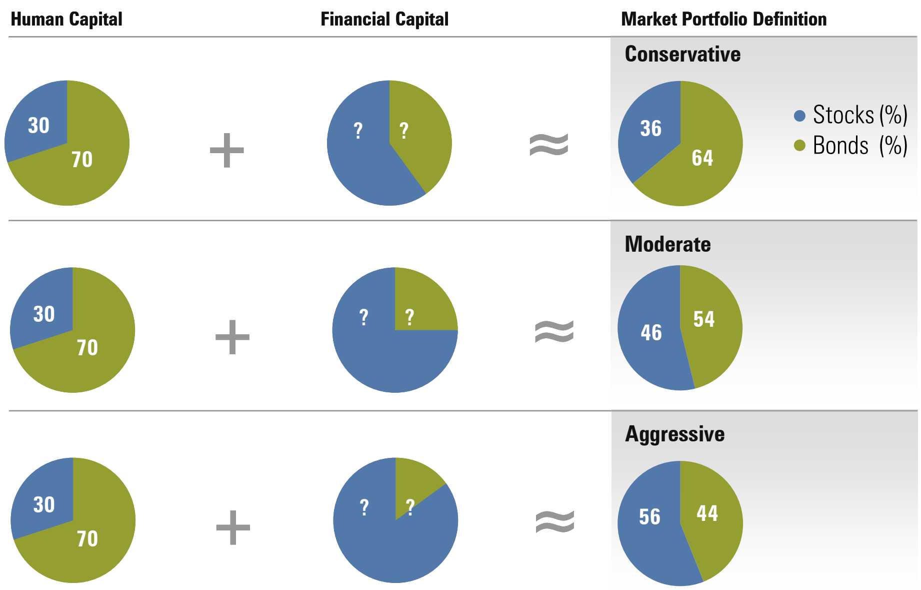
The nature of one's human capital directly affects one's capacity to take on risk with one's financial capital. Another dimension that influences the equity glide path is the investor's attitude or preference regarding risk. Two investors may have similar human capital characteristics but wildly different risk preferences. Returning briefly to modern portfolio theory, all investors should own the market portfolio plus either a long or short position in the risk-free asset (see Figure 6). In practice, few investors fully embrace Tobin's two-fund separation theory, which advises that they invest their assets in a mix of a risk-free asset (long or short) and the market portfolio. It is far more common to select different mixes from the curved section of the efficient frontier. Figure 14 identifies three potential stock-bond mixes corresponding to different risk appetites.

Figure 14: Risk Preference Leads to Different Target Stock-Bond Mixes



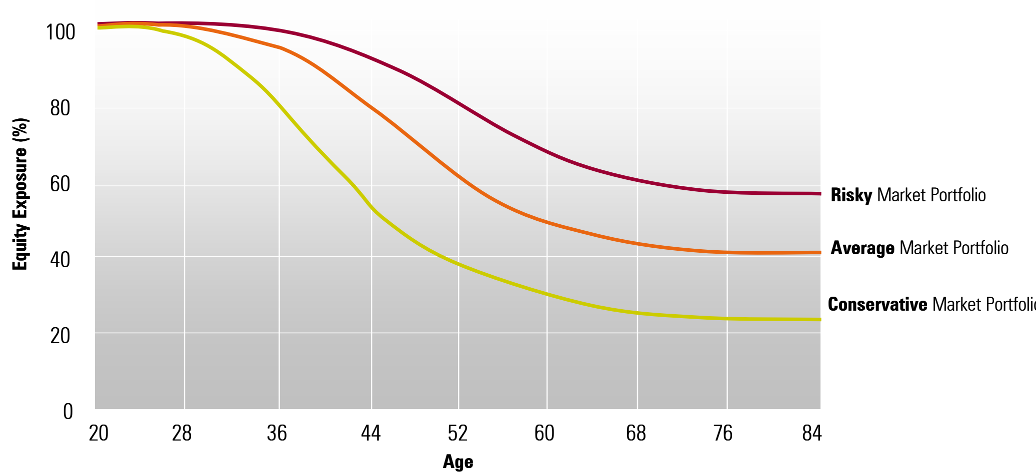
In Figure 15, we now hold the human capital mix constant and explore the use of the three different stock-bond mixes.

Figure 15: Changing Targets based on Risk Preference



All else being equal, the more aggressive the target market portfolio is, the more aggressively the investor's financial capital needs to be invested. As one would expect, adopting different target market portfolio definitions leads to different equity glide paths. Figure 16 illustrates the glide paths associated with these three different target market portfolio definitions.

Figure 16: Glide Paths based on Changing Risk Preferences

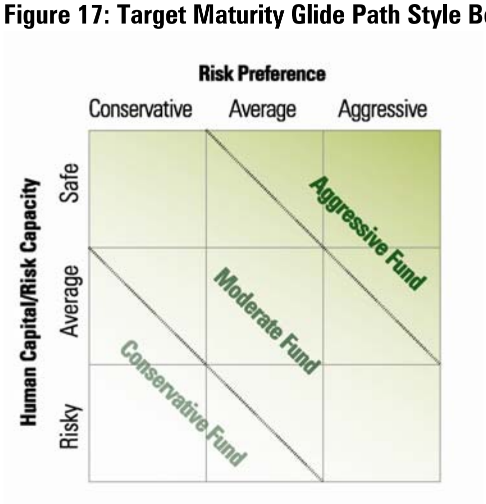


Clearly, there is not a single "best" glide path. In order to design custom glide paths that meet the needs of a given individual or plan, we employ the concepts of modern portfolio theory. Several factors influence the creation of a custom glide path that is "best" for an investor. Broadly speaking, we categorize the factors that determine the glide path into two dimensions:

- Risk Capacity
- Risk Preference

Risk capacity is objective: it is derived from the investor's overall economic situation based on his or her individual balance sheet. The major factors that make up an investor's risk capacity include the investor's amount of financial capital, the investor's amount of human capital, and the investor's liabilities. Unlike risk capacity, risk preference is subjective. Risk preference is the result of an individual's unique personality and perspective. These two dimensions, risk capacity and risk preference, form the basis of a new type of style box: a target maturity glide path style box (see Figure 17).

Figure 17: Target Maturity Glide Path Style Box



Intuitively, different individuals or cohorts of individuals will plot in different spots based on their risk preference and risk capacity. Each plot point corresponds to a unique equity glide path. Of course, risk preferences and risk capacity change over time. In a managed account setting, a custom equity glide path adjusts automatically. Investors can also decide to switch glide paths as a result of a significant shift in their risk preference or risk capacity. For example, a career change could dramatically affect both the nature and amount of an individual's human capital.

Conclusions

While most target maturity equity glide paths lack a solid theoretical foundation, the Ibbotson approach embraces modern portfolio theory. Modern portfolio theory states that the single portfolio with the best risk and return trade-off is the unobservable market portfolio. We have created a robust working version of the market portfolio that includes financial assets as well as the largest and most important non-tradable asset: human capital. Both the hypothetical market portfolio and the total economic worth of individuals consist of a combination of financial and human capital. The market portfolio's high-level stock-bond split serves as the target portfolio for an individual's total economic worth. For younger investors, human capital is typically their largest asset. As investors age, human capital is converted into financial capital. Eventually, the value of an investor's financial capital exceeds the value of his or her human capital. Because human capital is more bond-like than stock-like, younger investors should invest mostly in equities. As human capital is depleted over time, the asset allocation of financial capital slowly approaches the target asset allocation defined by the market portfolio.

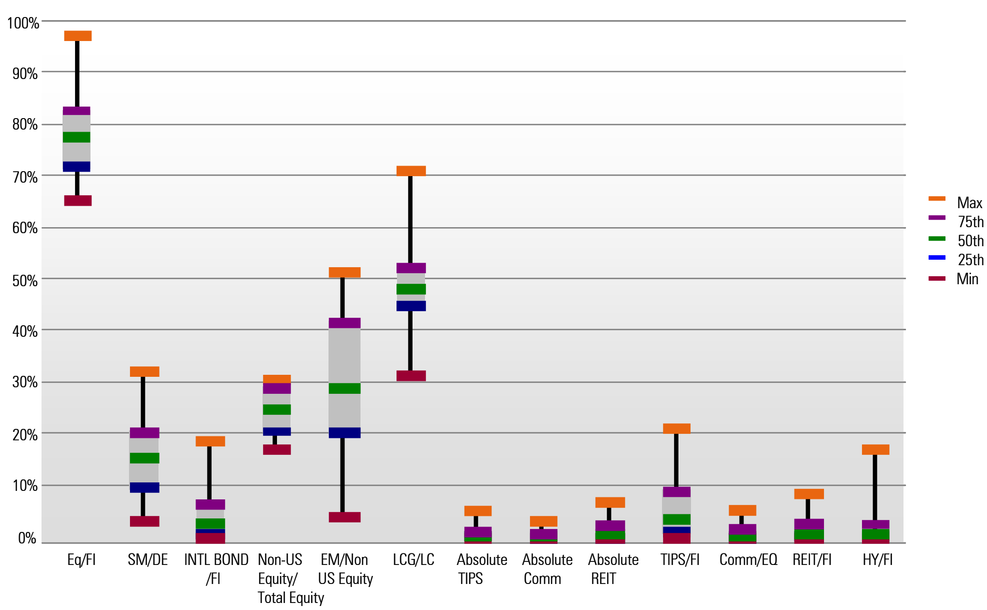
No single glide path is right for everyone. The two key dimensions that affect an investor's particular glide path are risk preference and risk capacity. Glide paths should be customized based on these dimensions in order to best meet the evolving risks faced by investors.

Section 3: Inside the Glide Path

"The goal of asset allocation analysis should be stated in terms of surplus. The objective is to maximize the risk-adjusted future value of the surplus."
Bill Sharpe

Just as equity glide paths vary widely, there is also a wide variation in how the assets are allocated inside the glide path. According to the *Ibbotson Associates' Target Maturity Quarterly Report*, a large number of the target maturity fund families available have relatively static intra-stock and intra-bond allocations / asset allocation characteristics. For example, some funds hold non-U.S. equities, non-U.S. bonds, and U.S. small cap stocks constant as a percentage of total bonds and equities across the glide path. Other funds vary these intra-stock and intra-bond detailed asset allocations. Again, we are faced with the question of who is right. Is there a solid rationale or theory that explains how the intra-stock and intra-bond allocations should evolve across the glide path? Figure 18 graphs several of the key detailed asset allocation dimensions tracked in the *Target Maturity Quarterly Report*.

Figure 18: Large Intra-Asset Class Differences (2025 funds)



In Figure 18 we see a relatively large dispersion in:

- The ratio of non-U.S. equity to total equity,
- The ratio of emerging market stocks to total non-U.S. equity,
- The ratio of small cap U.S. equity to U.S. equity, and,
- The ratio of large-cap growth to large-cap equity.

However, there are surprisingly low allocations and differentiation among the fixed income allocations, commodities, and real estate.

During retirement, controlling the market risk of an investor's overall portfolio remains critical. During the accumulation phase, we emphasized the importance of capturing the size and market-like characteristics of the investor's total portfolio –a portfolio that included financial capital and human capital. As an investor approaches retirement, another part of the investor's total portfolio becomes more relevant: the investor's retirement income liability. The relationship of the retirement income liability to financial and human capital drives the detailed asset allocations decision's evolution during retirement. Below, we explain the rationale behind applying liability-driven investing to individuals. Next, we demonstrate a series of optimizations in order to compare and contrast asset-only optimization asset allocations versus liability-relative optimization asset allocations, which is our preferred approach. Throughout this section, we will focus on how liability-relative investing affects the intra-stock and intra-bond detailed asset allocations.

The Case for Liability-Driven Investing

Liability-Driven Investing for Individuals

Earlier, we established that the core goal of most individuals' investment plans is to provide an adequate retirement income. Put somewhat differently, the primary reason individuals convert a portion of their human capital into financial capital is to fund their retirement. Once in retirement, individuals prefer reliable, inflation-adjusted real income.

Retirement expenses form the retiree's retirement liability. Optimal strategic asset allocation plans must consider the investor's total portfolio, including liabilities as well as assets. More specifically, the difference between the value of the assets and the value of the liabilities is crucial, because this difference will determine whether the investor can pay for retirement.

Assessing the value of financial capital, such as stock funds and bond funds, is typically straightforward; in fact, it probably arrives on a series of financial statements each month. In the previous section, we discussed Ibbotson's method for valuing human capital. Assessing the value of the retiree's liabilities is also a challenge. However, without an assessment of the retirement liability, an investor's total wealth picture is incomplete: an investor's total portfolio, and hence, total wealth includes both assets and liabilities.

Many wise financial professionals have made the mistake of only focusing on the risk and return characteristics of the investor's financial capital. As you would expect, decisions based on only some of the available information are less than ideal. Optimal solutions consider the investor's total financial situation focusing on the risk and return characteristics of the investor's net portfolio, which contains both the assets (financial capital and human capital) and the liabilities. After all, it is the investor's total financial health that matters, not the risk and return of the financial capital in isolation.

Creators and innovators of modern portfolio theory such as William F. Sharpe, Jack Treynor, and our own Roger Ibbotson advanced tools and techniques to create optimal strategic asset allocations that consider both assets and liabilities.[10] Today, institutional investors are anxiously adopting techniques such as "liability-driven" investing, "liability-relative" investing, "asset-liability" investing, and "surplus" optimization.

These techniques focus on the risk and return characteristics of the investor's net portfolio. The traditional "asset-only" framework is an *absolute* framework built around the absolute return and risk of the possible asset mixes. However, when assets exist to pay for liabilities, there is an implicit baseline or benchmark for measuring success or failure. Did the assets allow the investor to pay for the liabilities? Are the assets expected to grow as fast as the liabilities do? Thus, an improved framework that explicitly incorporates liabilities into the asset allocation decision-making process is a *relative* framework in which success, failure, risk, and return are all measured relative to the liabilities.

The Investor's Retirement Liability

The size of the investor's retirement liability depends on annual expenditures, life expectancy, and the liability's risk characteristics. More formally, it is the actuarial present value of all future retirement expenses.

Prior to retirement, most people use the majority of their salaries to pay for current expenses with, ideally, a portion left over to invest for future retirement expenses. The nature of expenses evolves over a lifetime, but for most people annual expenses in the years *prior* to retirement are not that different from annual expenses *after* retirement. Some people aspire to a somewhat more luxurious lifestyle, while others plan (or need) to live more frugally. Armed with life expectancy tables, estimating the *nominal* value of the

[10] Former Ibbotson employees Barton Waring (Chief Investment Officer for Investment Policy and Strategy) and Larry Siegel (Director of Research at the Ford Foundation and CFA Institute Research Foundation) are two of the current leading experts on liability-driven investing.

investor's future expenses is relatively straightforward. The expected nominal value of the investor's future expenses is the present value of future expenses weighted by the probability of the investor continuing to live. Unfortunately, because the purchasing power of a dollar will be less in the future than it is today, we cannot directly compare the nominal value of the investor's future expenses to the value of the investor's assets to assess his or her financial health.

In order to compare the value of the investor's liabilities to the value of the investor's assets, we need to convert the future dollars of the liabilities into today's dollars. This is done using an appropriate "discount rate" that is based on the fundamental characteristics of the investor's expenses. There are three primary risks that affect the liabilities, and hence, the discount rate: interest rates, inflation, and the timing or duration of the liabilities. The duration of the liabilities is relatively easy to predict for large groups of people, but for any given individual, the liabilities' duration can vary significantly from the average. These individuals face one of the four retirement risks identified earlier: *longevity risk*—the risk of outliving their money.

If you asked a large group of financial planners to estimate the annual retirement expenses for a group of retirees, you would see a *systematic* pattern. That is to say, you would see a relatively steady set of cash flows that grows a little bit each year with inflation. In the real world, everyone has unique expenses as well as unpredictable expenses that don't follow a systematic pattern. In the world of finance, these unpredictable, investor-specific expenses are called idiosyncratic or non-systematic expenses. Conceptually, these idiosyncratic expenses are the alpha (positive or negative) of the liability. In general, over the retiree's life time these unique and unpredictable expenses tend to wash out (i.e., the alpha is close to zero). Therefore, the systematic pattern helps us to find an appropriate discount rate.

The systematic pattern of cash flows that grows with inflation is similar to the cash flows associated with an inflation-linked bond.[11] Recognizing similar cash flow patterns between inflation-linked bonds and the retiree's portfolio provides two important insights: 1) a market-based discount rate for determining the current value of the investor's future liabilities, and 2) a possible strategy for dramatically reducing the retiree's true risk of not meeting his or her liabilities.

Why Are Strategic Asset Allocations That Just Focus on Assets Dangerous?

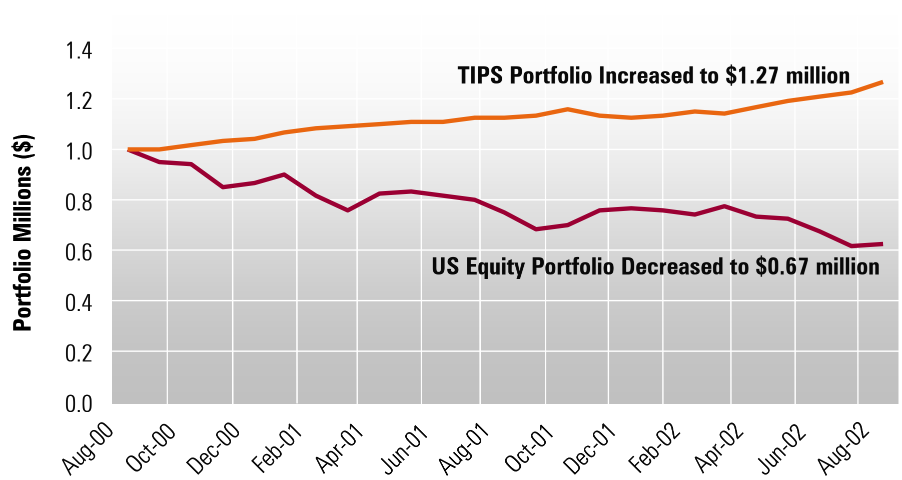
The worst thing for an investor's financial health is for the value of the investor's assets to decrease at the same time that the value of the investor's liabilities increases. This is exactly what occurred after the market peak in 2000: the market crashed, causing the value of equity portfolios to plummet at the same time interest rates were falling, which

[11] Later, we will work with several different models of the retiree's liability.

increased the value of liabilities. Retirees were probably poignantly aware that the value of their equity-centric assets had decreased, but they were probably blissfully unaware that the value, or perhaps we should say cost, of their retirement liabilities had increased. Yet while small changes in monthly expenses may go unnoticed, the cumulative lifetime increase may be significant.

Let's clarify this with a quick example in which we assume that a retiree has an asset portfolio worth $1 million invested 100% in stocks. We will also assume that the present value of the investor's liability portfolios is also $1 million and that it is represented by a portfolio of 100% inflation-linked bonds.[12] In Figure 19, we see that this retiree's equity-only portfolio decreased in value from $1 million to less than $700,000. While this loss in assets was painful, the true devastation comes from the dramatic increase in the liability portfolio's current value from $1.0 million to more than $1.25 million. In this simplified example, the investor went from a "fully funded" retirement to a $600,000 deficit in two years! Perhaps even worse is that the retiree will not immediately realize the full extent of this financial-health train wreck. The retiree will have to reduce his or her standard of living drastically. Should the retiree maintain the same standard of living, the retiree will go broke or have to die early to avoid going broke—two options most of us hope to avoid.

Figure 19: Growth of $1 Million



As this example makes clear, the risk and return of financial assets are not the only factors that matter when it comes to retirement success.

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[12] In this example we use the Russell 3000, a broad U.S. equity market index, to represent the performance of stocks and the Lehman Brothers U.S. Treasury TIPS Index, an index of inflation-linked bonds issued by the U.S. Government, to represent the performance of inflation-linked bonds.

A Better Approach

Liability-relative optimization is an extension of the traditional Markowitz asset-only approach to determining an optimal asset allocation. In liability-relative optimization, the mean-variance optimizer is constrained to hold an asset class (or combination of asset classes) representing the liability short. Liabilities are typically modeled as a combination of TIPS, long-term nominal bonds, and perhaps a small allocation to equities or real estate. The liability model attempts to capture the liabilities' systematic characteristics.[13]

Earlier we introduced the concept that an investor's liabilities had characteristics similar to inflation-linked bonds, which illuminates a strategy for reducing the retiree's true risk dramatically. In our working example, we have modeled the investor's liabilities using a portfolio of TIPS. The investor isn't the owner of the TIPS portfolio and doesn't receive the payments from owning a TIPS portfolio; the investor is the issuer of the TIPS portfolio and must make the payments. In other words, rather than having a long or positive investment in TIPS, the investor has a short or negative investment in TIPS. This suggests a natural hedging strategy for the investor. When the value of the investor's assets equals the value of the investor's liabilities and the liabilities are modeled as a *short* investment in TIPS, the investor can perfectly hedge the liabilities' systematic characteristics with a long investment in TIPS.

[13] In other words, these other asset classes are treated as explanatory factors that represent the systematic exposure of the investor's retirement income liability.

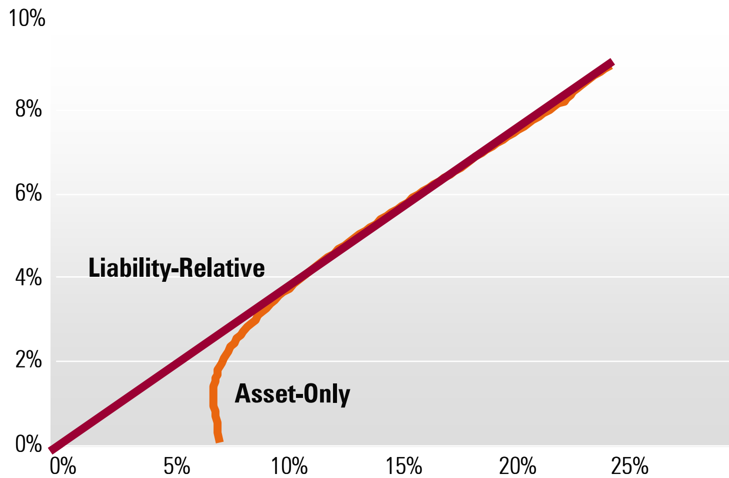
Figure 20 illustrates some of the key relationships in traditional risk and return space. Notice that the asset portfolio and the liability portfolio plot at exactly the same point on the horizontal (asset risk) axis and are mirror images of each other on the vertical (asset return) axis. The larger dot displayed where the two axes intersect represents the total portfolio: assets and liabilities. The total portfolio has zero expected return and zero expected risk (standard deviation). This means that the retiree's systematic cash flows will be perfectly met.

Figure 20: Asset-Only Risk and Return Space

We will now switch from traditional asset risk and return space to liability-relative space. Here the variability of the total portfolio and the assets' value relative to the liabilities' value are the dimensions that reflect the investor's overall financial health.

The two efficient frontiers shown in Figure 21 were created using two different optimization approaches: asset-only optimization and liability-relative optimization. The asset-only efficient frontier represents the combination of the available assets that maximizes expected asset return per unit of expected asset standard deviation. However, this asset-only approach ignores the investor's liabilities. The second efficient frontier was developed using liability-relative optimization, in which the optimizer was constrained to hold a negative position in TIPS that represented the investor's liability. The liability-relative optimization efficient frontier represents the combination of the available assets that maximizes the expected liability-relative return per unit of expected liability-relative risk (standard deviation).

Figure 21: Efficient Frontiers in Liability-Relative Risk and Return Space



As the risk approaches nearly 15%, both optimization approaches produce nearly identical results; thus, the liability-relative frontier is drawn on top of the asset-only frontier. This is an important observation. If an investor has a high tolerance for risk relative to the liability, asset-only optimization and liability-relative optimization lead the investor to the same asset allocations. This can be observed in practice. During the accumulation phase, investors rarely use liability-relative optimization to develop their asset allocations. However, when investors reach retirement and no longer have salaries from human capital to offset current expenses, liability-relative risk becomes an increasingly large concern. This creates a natural *transition* from asset-only-based asset allocations in the accumulation phase to liability-relative-based asset allocations as investors near retirement. **In addition to leading to a more liability-centric stock-bond asset allocation (a feature already captured in our modern-portfolio-theory-based glide path), this transition suggests that the intra-stock and intra-bond allocation should also evolve over time.**

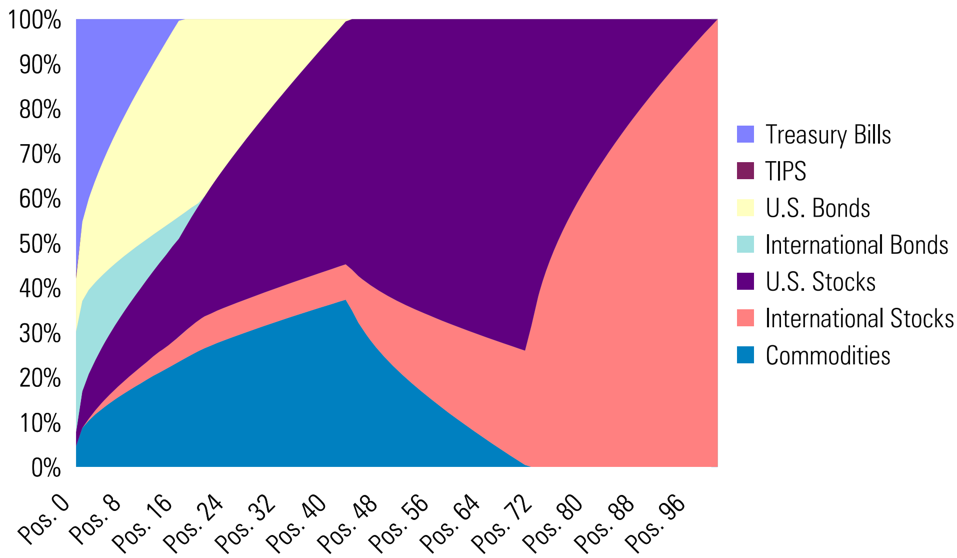
For retirees drawing down their assets to pay for retirement, with every passing year the capacity for a negative investment event decreases while concern regarding the ability to pay for the liability increases. This creates a natural glide path of increasingly liability-centric asset allocations as the retiree's liability-relative risk aversion increases.

Prior to looking at the natural glide path, let's compare the asset allocations from the liability-relative optimization efficient frontier to those from the asset-only optimization efficient frontier. We can see that efficient frontier graphs mask the relatively large differences in the underlying asset allocations. Panels A and B of Figure 22 display the evolution of the "efficient" asset mixes.

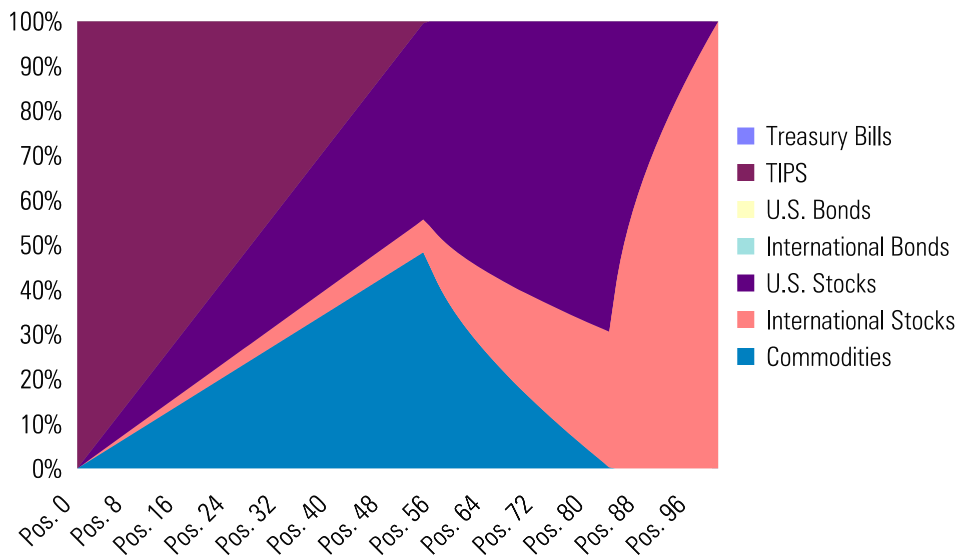
We should mention that Figure 22 contains the results of unconstrained optimizations. The mean-variance framework can produce extreme results, which should not be used in practice. However, it is useful to study the high-level differences between the asset allocation sets.

Figure 22: Asset Allocation Comparison

Panel A – Asset-Only Optimization Based Asset Allocations



Panel B – Liability-Relative Optimization Based Asset Allocations



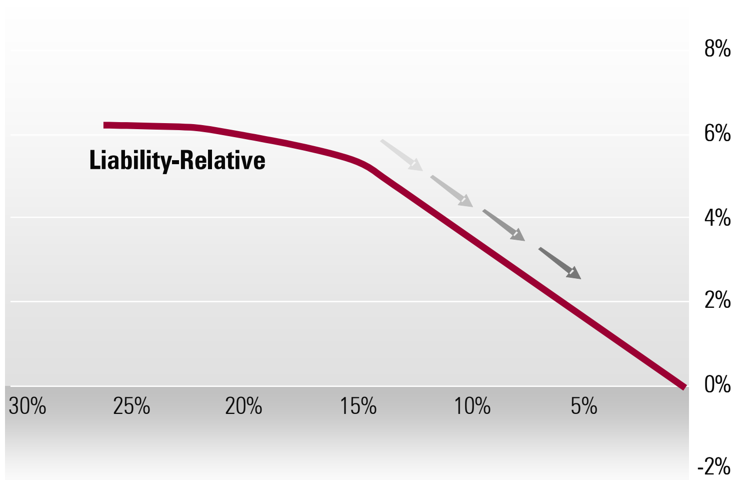
Panels A and B contain unconstrained optimization-based asset allocations based on a reasonable set of capital market assumptions. These results are for illustration purposes only and are not recommended asset allocations.

As one might expect given the two efficient frontiers in Figure 21, the right-hand sides of Panels A and B from Figure 22 demonstrate that the underlying asset allocation from the two approaches is nearly identical. In contrast, the more conservative asset allocations from the left-hand sides of Panels A and B are significantly different. Liability-relative optimization leads to asset allocations that take advantage of a natural hedge that exists between the assets and the systematic characteristics of the liability.

In this example, relative to the asset-only-based asset allocations, the liability-relative optimization-based asset allocations include far more TIPS and no international stocks and bonds. The increase in TIPS and the reduction of international stock and bond allocations are intuitive. Liability-relative optimization prefers asset classes that have a strong negative correlation with the liability. In this case, allocations to asset classes that are negatively correlated to a short position in TIPS include TIPS and commodities.

To illustrate the natural glide path that an investor might follow as aversion to liability-relative risk increases, we will look at the mirror image of Figure 21 and a subsection of Panel B from Figure 22.[14] Reversing the horizontal axis brings us closer to the standard glide path convention of showing asset allocations for younger investors on the left. In Figure 23, in addition to reversing the horizontal axis, we have added arrows depicting how an individual who is more concerned about liability-relative risk would likely move down the liability-relative efficient frontier over time.

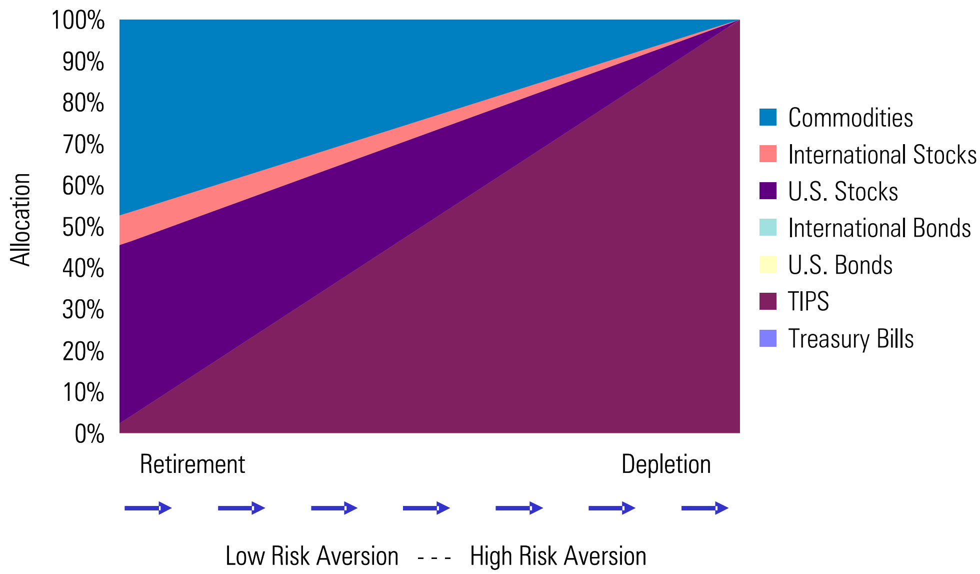
Figure 23: Moving Down the Liability-Relative Efficient Frontier



[14] In the examples presented here we assume the systematic characteristics of the liability remain constant and the investor's aversion to liability-relative risk increases as they draw down their portfolio. Although we have not presented the results, similar

As before, it is informative to look at the asset allocations that form the efficient frontier. Figure 24 displays the corresponding intra-stock and intra-bond allocations. As before, we encourage the reader to look beyond the extreme nature of the unconstrained optimization results and to focus on the major trends that one would use to form appropriate asset allocation guidelines.

Figure 24: Hypothetical Glide Path



Overall Financial Health

The investor's overall financial health depends on the value of assets vs. the value of the liabilities. When the value of the assets is *greater* than the value of the liabilities, the investor's retirement income is more than fully funded. When the value of the assets is *less* than the value of the liabilities, the investor's retirement income is not fully funded. This "funding status" affects the optimal asset allocation.

Fully funded investors can choose to invest more conservatively or more aggressively. Their funding status provides them with risk-taking capacity, should they wish to use it. In contrast, under-funded investors may want to invest more aggressively in hopes of making up a funding shortfall. We should emphasize that aggressive investing in the hopes of making up a shortfall is very risky because the investor does not have the capacity to take

conclusions are reached by holding risk aversion constant and changing the characteristics of the liability (primarily the duration) based on the age of the investor.

on this risk. Unlike pension plans that can seek additional funding, retirees cannot seek additional funding. When individuals engage in aggressive investing to make up a perceived funding shortfall, they are flirting with financial ruin.

However, all is not lost for investors with under-funded retirement income liabilities. First, if an investor recognizes a potential shortfall early enough, there may be ample time to save more and eliminate the shortfall.[15] Next, the retirement income liability is not a fixed or hard liability; it is a flexible or soft liability. Investors can and should adopt a more frugal lifestyle when portfolio performance is lower than expected. Conversely, investors may be able to adopt a more luxurious lifestyle when portfolio performance is higher than expected, although this can be dangerous if the investor isn't prudent. The primary levers for improving a retiree's financial health are 1) to save more during accumulation, 2) to decrease the size of the liability (decrease the retiree's annual income need during disbursement), and 3) to adopt good asset allocation policy based on the methods described above.[16]

Asset-Only Optimization vs. Liability-Relative Optimization

In order to have a better understanding of liability-relative optimization's impact, we conducted a series of optimizations in which we compared and contrasted the results of an asset-only optimization with the results of a liability-relative optimization. The optimization results presented here are a subset of the thousands of optimizations Ibbotson uses to design actual glide paths for clients.

We began with a relatively robust opportunity set of asset classes for the two optimizations. We used an enhanced version of the Markowitz framework, called *resampled* mean-variance optimization (or *resampled* MVO), which expressly acknowledges that the capital market assumptions driving the model are not known with certainty in a forward-looking context.[17] *Resampled* mean-variance optimization combines *traditional* mean-variance optimization with multivariate Monte Carlo simulation.

With the exception of no short selling and the usual budget constraints, we used an unconstrained optimization. Therefore, the resulting asset allocations do not incorporate typical client-driven constraints, such as constraints on international asset classes

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[15] This highlights a major weakness of target maturity funds relative to managed account solutions: managed account solutions identify saving shortfalls while target maturity fund do not.

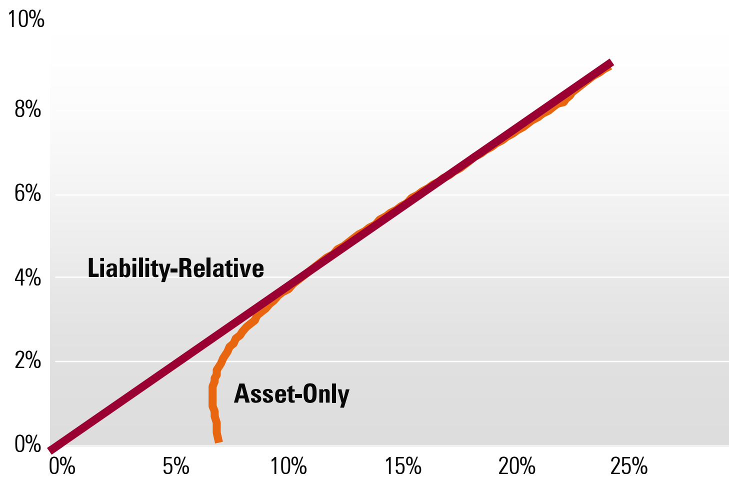
[16] Although it is an unpopular subject, for those investors who have under-saved or who have invested aggressively during a down market, a third option is to return to work.

[17] Ibbotson's proprietary version of *resampled* MVO grew out of the pioneering work of Jobson and Korkie [1980, 1981], Jorion [1992], DiBartolomeo [1993], and Michaud [1998].

reflecting the home bias of many U.S. investors. In an attempt to avoid biasing the results, we used market-neutral equilibrium returns. More precisely, we used the specialized version of the CAPM from Sharpe [1974] that is often referred to as reverse optimization. Finally, readers should not interpret the unconstrained asset allocations as recommended asset allocations; rather, readers should focus on the major trends and how these trends should influence asset allocation policy.

Figure 25 presents two efficient frontiers drawn in liability-relative risk and return space. The efficient frontier labeled "Asset-Only" is the result of the asset-only optimization, and the efficient frontier labeled "Liability-Relative" is the result of the liability-relative optimization.

Figure 25: Efficient Frontiers in Liability-Relative Risk and Return Space



The vertical axis represents the expected annual return on the *total* net portfolio. The horizontal axis represents the expected standard deviation of the annual return on the *total* net portfolio. Notice that as we saw earlier, the two efficient frontiers converge as we move up the risk spectrum, indicating that at higher risk levels, the approaches result in similar asset allocations.

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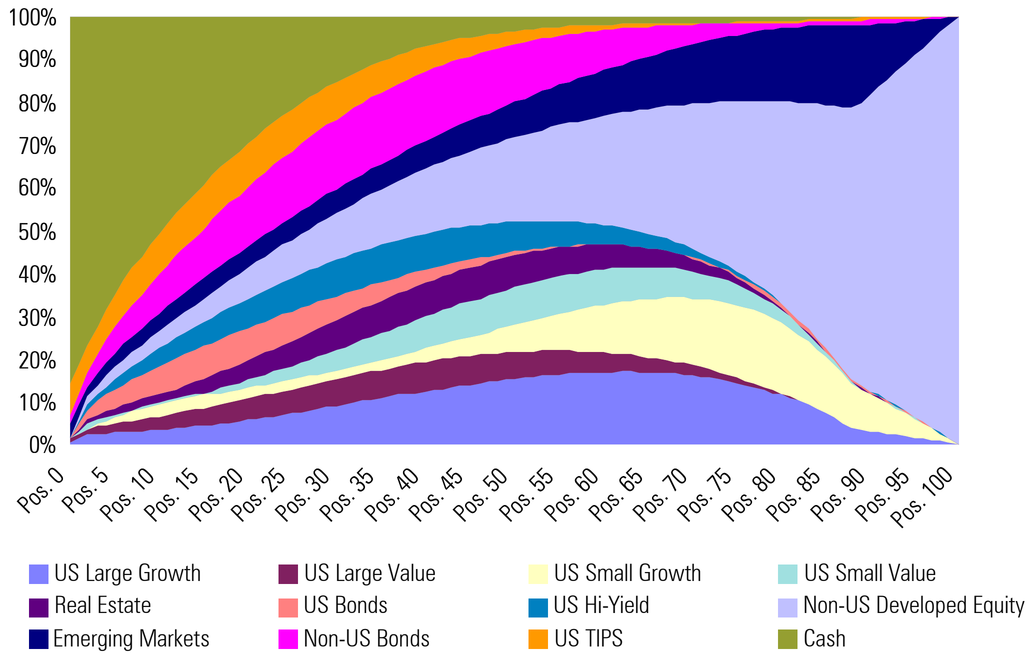
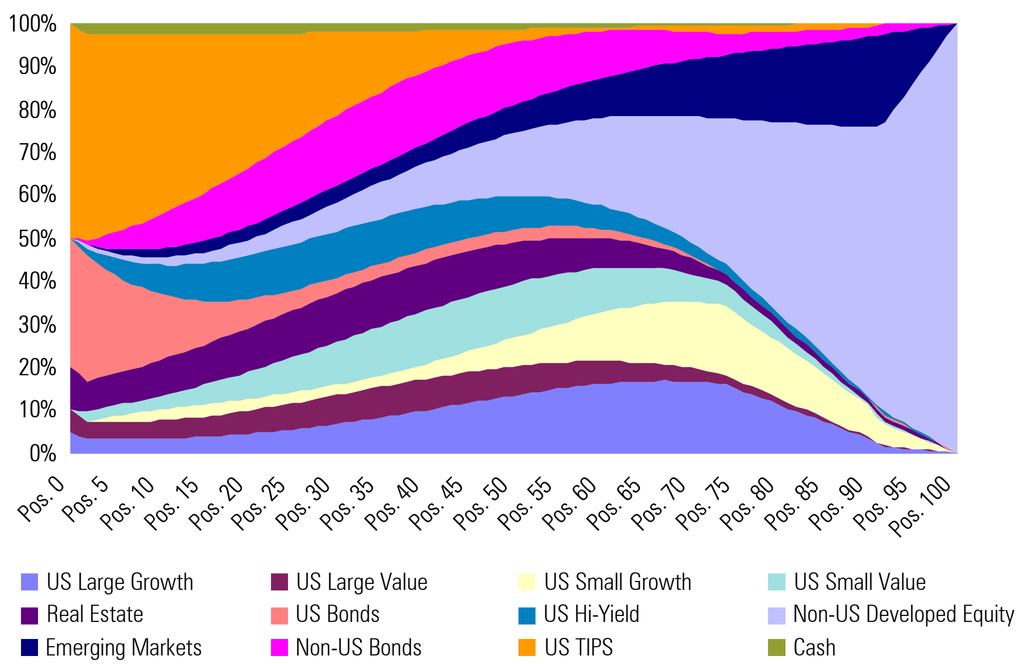
As we saw earlier, efficient frontier graphs can mask the relatively large differences in underlying asset allocations (see Kritzman [2006]). A better tool for studying the differences between the two approaches is the efficient frontier asset allocation area graph. Efficient frontier area graphs display the efficient frontier's asset allocations across the entire risk spectrum. Conceptually, the efficient frontier area graph is similar to a standard asset allocation pie chart that shows the asset allocation that corresponds to a particular spot on the efficient frontier. The difference is that while the standard asset allocation pie chart shows one asset allocation, the efficient frontier area graph displays *all* of the asset allocations on the efficient frontier. In our efficient frontier area graph below (Figure 26), the asset allocations from the asset-only optimization are presented in the top panel (Panel A), while the asset allocations from the liability-relative optimization are in the bottom panel (Panel B).

Figure 26: Asset Allocation Area Graphs

Panel A: Asset-Only Optimization



Panel B: Liability-Relative Optimization



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In Figure 26, the vertical cross-section at the point labeled "Pos. 0" represents the allocations of the minimum risk asset allocation while the vertical cross-section at the point labeled "Pos. 100" represents the allocations of the maximum return asset allocation.

The asset allocation area graphs contain a wealth of information. In the following three tables, we examine the two allocation sets in detail. For each of the asset allocation sets, we identified eight mixes, starting with a 20% stock / 80% bond mix and finishing with a 90% stock / 10% bond mix. For the purpose of identifying the high-level stock-bond split, U.S. large growth, U.S. large value, U.S. small growth, U.S. small value, real estate, non-U.S. developed equity, and emerging markets were classified as stocks. Cash, TIPS, U.S. bonds, non-U.S. bonds, and high-yield were classified as bonds.

Table 1 identifies the percentage of the total assets that are invested in the two real return asset classes: TIPS and real estate.

Table 1: Percentage of Total Assets Allocated to TIPS and Real Estate

Asset Mix	Asset-Only Optimization	Liability-Relative Optimization
20% Stocks / 80% Bonds	12%	60%
30% Stocks / 70% Bonds	14%	46%
40% Stocks / 60% Bonds	16%	38%
50% Stocks / 50% Bonds	15%	29%
60% Stocks / 40% Bonds	14%	20%
70% Stocks / 30% Bonds	11%	13%
80% Stocks / 20% Bonds	8%	8%
90% Stocks / 10% Bonds	4%	5%

Relative to the asset-only optimization, the liability-relative optimization tilts the composition of the asset allocation mixes toward the real return asset classes of TIPS and real estate. Using liability-relative optimization, the allocations to the two real return asset classes are highest in the 20% stocks / 80% bonds asset allocation mix. As the stock-bond split becomes more equity-centric, the allocations to the real return asset classes decrease.

Table 2 identifies the percentage of the total equity asset allocation that is invested in the two non-U.S. equity asset classes: non-U.S. developed equity and emerging markets. In all of these examples, real estate was classified as stock for the purpose of identifying the stock-bond split; in Table 2, real estate was not included in the analysis.

Table 2: Percentage of Total Equity Allocated to Non-US Developed Equity and Emerging Markets

Asset Mix	Asset-Only Optimization	Liability-Relative Optimization
20% Stocks / 80% Bonds	46%	0%
30% Stocks / 70% Bonds	45%	25%
40% Stocks / 60% Bonds	43%	28%
50% Stocks / 50% Bonds	42%	29%
60% Stocks / 40% Bonds	42%	32%
70% Stocks / 30% Bonds	43%	35%
80% Stocks / 20% Bonds	45%	41%
90% Stocks / 10% Bonds	52%	54%

In this example, liability-relative optimization tilts the composition of the asset allocation mixes away from the two non-U.S. equity asset classes (non-U.S. developed equity and emerging markets) relative to asset-only optimization. Using liability-relative optimization, the allocations to the two non-U.S. equity asset classes increases as the stock-bond split becomes more equity-centric. In contrast when asset-only optimization is used, the allocations to the two non-U.S. equity asset classes stayed in a relatively tight range (42% to 52%) across the stock-bond splits.

Table 3 identifies the percentage of the total fixed-income asset allocation that is invested in non-U.S. bonds.

Table 3: Percentage of Total Fixed Income Allocated to Non-U.S. Bonds

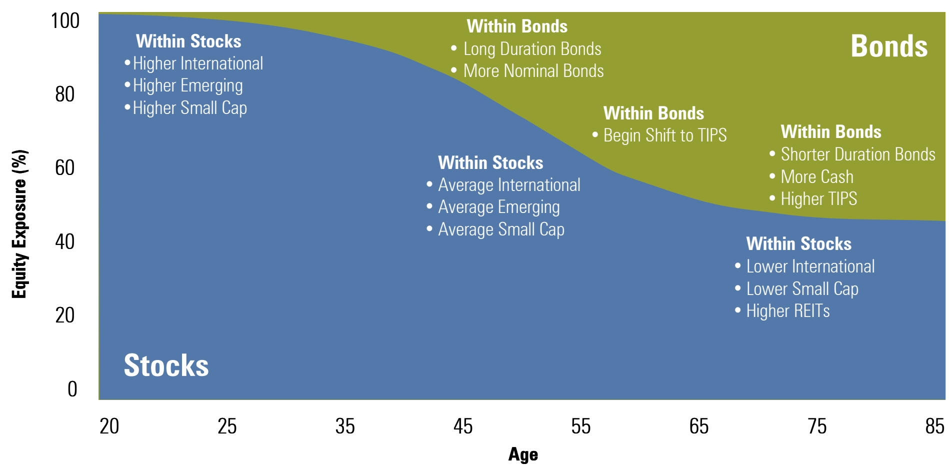
Asset Mix	Asset-Only Optimization	Liability-Relative Optimization
20% Stocks / 80% Bonds	11%	0%
30% Stocks / 70% Bonds	18%	16%
40% Stocks / 60% Bonds	26%	30%
50% Stocks / 50% Bonds	33%	33%
60% Stocks / 40% Bonds	40%	42%
70% Stocks / 30% Bonds	47%	48%
80% Stocks / 20% Bonds	53%	53%
90% Stocks / 10% Bonds	54%	52%

Relative to asset-only optimization the liability-relative optimization tilts the composition of the asset allocation mixes away from non-U.S. bonds in the 20% stocks and 80% bonds asset allocation mix. In the more aggressive stock-bond splits, the allocations did not differ significantly.

Implications of Liability-Driven Investing

Ibbotson has conducted numerous liability-relative analyses in addition to the results presented here. We have experimented with different opportunity sets of available asset classes, multiple definitions of the liability model, a wide array of capital market assumptions, and variations in the investor's assumed funding status. The result is a detailed asset allocation guideline that changes the intra-stock and intra-bond asset allocations throughout the investor's lifecycle. The high-level features are depicted in Figure 27.

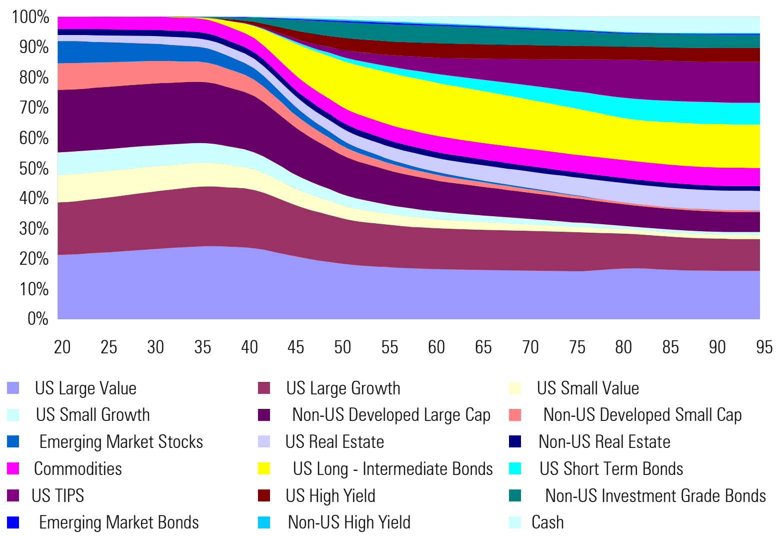
Figure 27: Implications of Liability-Driven Investing on the Glide Path



The characterizations in Figure 27 are made relative to typical U.S.-risk-based asset allocations with similar overall stock-bond splits. For younger investors, there is relatively high exposure to high-expected-return asset classes like non-U.S. equity, emerging markets, and small-cap equities. Younger investors are relatively unconcerned with currency exposure, and human capital provides an ample defense against inflation. As bonds enter the glide path, these initial allocations are fulfilled with long duration nominal bonds. As investors approach their 50s, allocations to non-U.S. equity, emerging markets, and small-cap equities slowly decline to a point were we would characterize them as average. Additionally, the increasing allocation to bonds is now implemented with a mixture of long and intermediate bonds. With retirement looming and human capital declining relative to financial capital, a gradual shift from nominal bonds to inflation-linked bonds begins. As investors move into retirement, the allocation to bonds continues to grow. Within bonds, the duration of the overall mix decreases and there is greater emphasis on inflation-linked bonds. Within equities, there is relatively low exposure to non-U.S. equity, emerging markets, and small-cap equities.

Figure 28 displays the detailed asset allocations for one embodiment of this methodology.

Figure 28: Glide Path with Detailed Asset Allocations



Conclusions

For most individuals, assets exist primarily to pay for a retirement income liability. The retirement income liability affects asset allocation policy throughout the investor's lifetime. Recognizing the retirement income liability leads to intra-stock and intra-bond allocations that change over time. In contrast to the asset-only optimization framework, which focuses on a subset of the investor's portfolio alone, the liability-relative optimization framework considers the investor's total financial health. During the accumulation phase, human capital pays for current expenses and provides the investor with inflation protection. As human capital is superseded by financial capital, asset allocations need to evolve.

Overall, as investors age, asset allocations should have a more pronounced home country bias. This pertains to both intra-stock and intra-bond allocations. Additionally, real return asset classes, such as TIPS, commodities, and real estate, play an increasing role as human capital no longer provides inflation protection. Finally, intra-bond allocations slowly evolve from high-returning, long-duration, nominal-bond-oriented asset allocations toward less volatile, shorter-duration, real-return-oriented asset allocations.

Conclusions

Little rigorous work has been done to answer how and why the equity-bond glide path should evolve throughout an investor's lifetime, and even less work has been done to answer how and why intra-stock and intra-bond splits should evolve over time. This paper provides a rich theoretical framework for answering these questions.

The creation of robust lifetime asset allocation solutions begins with an analysis of the evolving risks investors face throughout their lifetimes. During the accumulation phase, the primary risks are expense risk, savings risk, mortality risk, and market risk. During the decumulation (or retirement) phase, the primary risks are expense risk, longevity risk, bequest risk, and market risk. The nature and magnitude of these risks, as well as the methods for controlling them, evolve over time. The changing nature of these risks is closely related to the size of the investor's financial capital and human capital.

Modern portfolio theory tells us that the single portfolio with the best risk and return trade-off is the unobservable market portfolio. We have created a robust working version of the market portfolio that includes financial assets as well as the largest and most important non-tradable asset: human capital. Both the hypothetical market portfolio and the total economic worth of individuals consist of a combination of financial and human capital. The market portfolio's high-level stock-bond split serves as the target portfolio for an individual's total economic worth. For younger investors, human capital is typically their largest asset. As investors age, human capital is converted into financial capital. Eventually, financial capital's value exceeds that of human capital. Because human capital is more bond-like than stock-like, younger investors should invest mostly in equities. As human capital is depleted, the asset allocation of the investor's financial capital slowly approaches the target asset allocation defined by the market portfolio.

No single glide path is right for everyone. The two key dimensions that affect the glide path are risk preference and risk capacity. An investor's glide path should be customized based on these dimensions.

For individuals, the primary reason that assets exist is to pay for a retirement income liability. Recognizing the retirement income liability leads to intra-stock and intra-bond allocations that change over time. In contrast to the asset-only optimization framework that focuses on a subset of the investor's portfolio, the liability-relative optimization framework focuses on the investor's total financial health. During the accumulation phase, human capital pays for current expenses and provides the investor with inflation protection. As human capital is superseded by financial capital, asset allocations should evolve.

Overall, as investors age, asset allocations should have a more pronounced home country bias. This pertains to both intra-stock and intra-bond allocations. Additionally, real return asset classes, such as TIPS, commodities, and real estate, should play an increasing role, since human capital no longer provides inflation protection. Finally, intra-bond allocations slowly evolve from high-returning, long-duration, nominal-bond-oriented asset allocations toward a less volatile, shorter-duration, real-return-oriented asset allocation.

The Ibbotson Target Maturity Methodology is a multifaceted approach that embraces the latest academic research regarding modern portfolio theory and combines it with a sophisticated understanding of human capital's role in asset allocation, application of liability-driven investing techniques to retirees, advanced optimization techniques, alternative asset class research, and 30 years of asset allocation thought leadership. The result is a methodology that can be used to create custom lifetime asset allocation solutions for individuals and groups.

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About Ibbotson

Ibbotson Associates is a leading independent provider of asset allocation, manager selection, and portfolio construction services. The company leverages its innovative academic research to create customized investment advisory solutions that help investors meet their goals. Founded by Professor Roger Ibbotson in 1977, Ibbotson Associates is a registered investment advisor and a wholly owned subsidiary of Morningstar, Inc.

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