Life-Cycle Funds

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Abstract. This paper reviews recent advances in academic models of asset allocation for long-term investors, and explores their implications for the design of investment products that help investors save for retirement, particularly life-cycle funds and life-style (or balanced) funds. The paper argues that modern portfolio theory provides scientific foundation for the "risk-based" asset allocation strategies and the "age-based" asset allocation strategies that characterize life-style and life-cycle funds. Risk-based allocation strategies can be optimal in an environment where investors face real interest rate (or reinvestment risk), while human wealth considerations give rise to horizon effects in asset allocation. However, this theory also makes a number of suggestions about how life-style and life-cycle funds should be structured, and shows for which types of investors these funds are appropriate investment choices. Thus, modern portfolio theory provides only *qualified* support for these funds. Nevertheless, the paper argues that properly designed life-cycle funds are better default investment choices than money market funds in defined-contribution pension plans. The paper also argues for the creation of life-cycle funds that allow for heterogeneity in risk tolerance, and for the creation of life-cycle funds specific to defined-contribution plans that can better account for the correlation between human capital and stock returns. It also suggests that investors who expect to receive Social Security benefits and pension income after retirement should choose a target retirement date for their funds based on their life-expectancy, not their expected retirement date.

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1. Introduction

The U.S. retirement system has experienced a substantial transformation in recent years. It has evolved from a system in which employees relied mainly on Social Security and professionally managed defined-benefit (DB) pension plans sponsored by their employers to provide for their retirement, to a system in which employees must rely on their own saving and investment decisions to fund their own retirement.

In 1983 about 86% of workers with pension coverage were covered by a DB pension plan; 61.6% were covered exclusively by a DB plan, 24.4% were covered by both a DB plan and a defined contribution (DC) plan, and 14% were covered exclusively by a DC plan. DC plans, which were created by the Employee Retirement Income Security Act (ERISA) of 1974, were conceived as tax-efficient saving instruments to provide individuals with incentives to save and thus obtain a complementary source of income in retirement. By 2004, DC plans no longer played a secondary role in financing retirement: almost 63% of workers with pension coverage were covered exclusively by a DC plan (See **Figure 1**).[2]

The dramatic decline of DB plans and the simultaneous rise of DC plans are illustrated in **Figure 2** and **Figure 3**.[3] Figure 2 reports the evolution of the number of private DB plans and DC plans between 1979 and 2001, and Figure 3 reports the evolution of active participants in those plans for the same period. The number of private DB plans has declined from a peak of about 180,000 plans in 1981 to less than 50,000 plans by 2001, while the number of participants has declined from about 30 million to about 22 million over the same period. This decline does not reflect the full impact of disappearing plans on employees. A large fraction of the plans which have not been terminated have been closed to new employees, and have stopped accruing benefits for their current participants.

By contrast, the number of DC plans and the number of participants in those plans has have exploded. The number of private DC plans has grown from about 325,000 plans in 1979 to almost 700,000 in 2001, and the number of active participants in them has grown from about 18 million to more than 50 million. Companies that close or freeze their plans tend to offer employees a DB plan. Younger companies choose to offer DC plans to their employees instead of DB plans.

This dramatic transformation of the retirement landscape has enormous implications for the way investors save and invest for retirement, and consequently for the money management industry that serves those investors. In 1990, professionally managed DB plans accounted for more than 50% of the $4 trillion assets in the U.S. retirement system

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[2] This figure is based on Munnell, A. and A. Sunden, 2006, "401(k) Plans Are Still Coming Up Short," Brief No. 43, Center for Retirement Research at Boston College.

[3] These figures are based on data from the Department of Labor Form 5500 Pension Plan Bulletins, Table E1 and Table E8.

(excluding Social Security), but by 2004, individually managed DC plans and individual retirement accounts (IRAs) were the ones that accounted for more than 50% of the $14.5 trillion in retirement assets.

One of the major beneficiaries of this change in the retirement market landscape has been the mutual fund industry, since most assets in DC plans and IRAs are invested in mutual funds. While employees decide how much to contribute (up to a legally established maximum limit) to their plan, and how to invest their contributions and the contributions that their employer might make on their behalf, DC plan sponsors are responsible for both the design of the plan and for its administration and recordkeeping. Current regulations grant sponsors considerable freedom in their selection of the number and type of investment options available to participants. In practice, most plan sponsors have chosen to offer a menu of plain vanilla mutual funds plus company stock, thus making mutual funds the main retirement investment vehicle in the U.S.

In recent years plan sponsors have started including mutual funds geared towards offering "one-stop" solutions to retirement investment needs in their menu of investment options (Viceira 2007).[4] These funds have originated in response to what numerous sponsors, mutual fund industry executives and pension and investment experts consider a disappointing experience with the way in which many participants in DC plans and IRAs manage their plan investments. There is concern that many employees might not be making saving and investment decisions conducive to maximizing the probability of getting adequate retirement income.

In fact, there is evidence that a large number of DC plan participants, particularly among those with lower levels of education, wealth, and income, show a considerable degree of inertia in their contribution and investing decisions. They tend to adopt the default contribution and investment option chosen by the plan sponsor, which is typically either no contribution or a small contribution that is entirely invested in a money market fund. Those who actively move away from the plan default investment option tend to adopt naïve diversification strategies, such as allocating equally among all the investment options in the plan, regardless of whether there are substantially more options in a particular asset class than in another. They also tend to invest heavily in company stock. For example, in 2004 company stock represented 34% of all assets in 401(k) plans with 5000 participants or more.[5] They also fail to rebalance regularly.

In response to this concern, plan sponsors have begun adopting mutual funds that try to tackle for investors the tasks of allocating their assets appropriately and rebalancing their portfolios. These funds are concentrated in two categories, balanced or "life-style" funds and "life-cycle" funds. This paper explores how the structure of these funds, the scientific

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[4] Viceira, L. M., 2007, "The Vanguard Group, Inc., in 2006 and Target Retirement Funds," HBS Case study, Harvard Business School.

[5] Holden, S. and Venderhei, J., 2005, "401(k) Plan Asset Allocation, Account Balances, and Loan Activity in 2004," EBRI Issue Brief, No. 285, September 2005, Investment Company Institute and Temple University.

foundations of long-term investing, and what modern theories of long-term investing have to say about the design of these funds and the type of investors for whom these funds are appropriate.

2. Life-Style Funds and Life-Cycle Funds

Balanced or life-style funds have a long tradition in the mutual fund industry, while life-cycle funds are relatively new to the industry. Life-style funds are mutual funds built on the idea of "risk-based investing," or the notion that the fraction of savings allocated to stocks should be a function of investors' risk tolerance, and independent of their investment horizon. Life-cycle funds are a variant of life-style funds built on the idea of "age-based investing," or the notion that investors should allocate a larger share of their long-term savings to stocks when they were young and have long retirement horizons, and decrease this allocation as they approach retirement.

Life-style funds automatically rebalance their holdings, typically a portfolio of underlying funds representing different asset classes and investment styles, as to keep a constant asset target mix over time. These funds provide investors with diversified portfolios whose risk exposure does not change over time. For example, Vanguard Balanced Index Fund tracks the investment performance of a portfolio 60% invested in the U.S. stock market and 40% in the U.S. bond market.[6] Mutual fund companies typically offer several of these funds, and use words such as "aggressive," "moderate," or "conservative" in the fund name to indicate the fund's tilt towards equities.

Similar to balanced funds, life-cycle funds automatically rebalance the investments in the underlying funds to keep the overall portfolio composition of the fund in line with a pre-specified asset target mix. Unlike balance-funds, however, life-cycle funds do not keep their target mix constant over time; instead, they change their target mix according to a predefined "rolldown" schedule until they reach a date called the target date or target maturity date of the fund. This rolldown schedule becomes more conservative over time, in the sense that it tilts the target mix away from equities towards bonds and cash. After their target date, these life-cycle funds are typically folded into a life-style fund that keeps its target asset allocation constant. **Table 1** and **Table 2** show the life-cycle fund offerings, including asset allocation glide paths and returns, of the two largest life-cycle fund families ranked by assets managed in 2006, Vanguard's Target Retirement Funds and Fidelity's Freedom Funds, respectively.

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[6] Specifically, with 60% of its assets, the fund seeks to track the investment performance of the Morgan Stanley Capital International (MSCI) US Broad Market Index, which represents 99.5% or more of the total market capitalization of all the U.S. common stocks regularly traded on the New York and American Stock Exchanges, and the Nasdaq over-the-counter market. With 40% of its assets, the fund seeks to track the investment performance of the Lehman Brothers Aggregate Bond Index, which measures a wide spectrum of public, investment-grade, taxable, fixed income securities in the United States—including government, corporate, and international dollar-denominated bonds, as well as mortgage-backed and asset-backed securities, all with maturities of more than 1 year.

Life-cycle mutual funds are one of the fastest growing segments in the mutual fund industry. Assets under management in these funds were about $120 billion at year-end 2006, from about $1 billion in 1996, when Fidelity, the industry leader in this segment, launched its own version of these funds. This growth has accelerated in recent years with inflows of $15 billion in 2004, from less than $5 billion in 2001 and 2002 (Gordon, 2005).

This growth has taken place mostly through both individual retirement accounts and DC plans, as sponsors of DC plans have added these funds to their plan offerings. In the future, industry experts expect numerous plans to adopt these funds as the plan default investment option as a result of the enactment of the Pension Protection Act of 2006, which gives sponsors more flexibility guiding participants in their fund selection.

The main characteristic of life-style funds is that they change the stock exposure of the fund as a function of investors' risk tolerance. Life-cycle funds reduce the stock exposure of the fund as their target maturity date approaches. Both approaches to asset allocation are in line with both the advice that financial planners traditionally give to their clients and with conventional investing wisdom.

A different question, however, is whether these allocation strategies have any fundamental scientific basis. This is an important question given the relevance of asset allocation decisions to investors' welfare. Poor investment and savings decisions can seriously undermine the long-term welfare and wealth accumulation of investors. Thus, providing investors with sound portfolio advice is of first-order importance. What does academic finance have to say about the investment decisions of long-term investors? What are the prescriptions of the theory of long-term investing for the design of life-style and life-cycle funds? I explore these questions in the remaining sections of this paper.

3. Asset allocation in a mean-variance framework

The analysis of portfolio decisions has a great academic tradition in finance. In fact, modern finance is often thought to have started with the mean-variance analysis that Harry Markowitz developed more than fifty years ago.[7] Markowitz showed how investors should pick assets if they care only about the mean and variance—or equivalently, the mean and standard deviation—of portfolio returns over a single period.

Mean-variance analysis has transcended its academic origins to become the basic paradigm guiding portfolio advice. Mean-variance usefully emphasizes portfolio diversification, the principle that investors should eliminate exposure to risk that is not rewarded. Mean-variance analysis, however, also makes asset allocation recommendations which are often at odds with conventional wisdom.

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[7] H. Markowitz, "Portfolio Selection", *Journal of Finance* 7, 77-91 (1952).

One of the most famous results in mean-variance analysis is the mutual fund theorem of portfolio choice first formulated by the late James Tobin.[8] According to this theorem, all investors should combine cash with a single portfolio or "mutual fund" of risky assets. Consider the basic problem of allocating a portfolio amongst three broad asset classes: stocks, long-term bonds ("bonds"), and short-term bonds or money market funds ("cash"). The mutual fund theorem directs all investors, conservative or aggressive, to hold the *same* portfolio of stocks and bonds, mixing the portfolio with more or less cash depending on the investor's tolerance to risk.

Figure 4 illustrates this principle using the familiar mean-variance diagram. Consistent with long-term historical experience, the diagram plots stocks having higher expected return and greater short-run return volatility than bonds, and bonds having higher expected return and volatility than cash. In fact, cash is assumed in this diagram to be riskless, defined as zero short-run return volatility.[9] The curved line describes the expected return and return volatility of all possible portfolios combining stocks and bonds. The curvature of the line reflects the fact that, unconditionally, stocks and bonds have a low positive correlation. The horizontal line (the "mean-variance efficient frontier") shows the expected return and short-run volatility of all portfolios combining stocks, bonds, and cash which have minimum short-run portfolio return volatility for each expected portfolio return ("mean-variance efficient portfolios").

A common characteristic of all mean-variance portfolios is that they all combine the same portfolio of stocks and bonds (the "tangency portfolio") with cash. Portfolios on the mean-variance frontier located southwest of the tangency portfolio combine this portfolio with a long position in cash, and consequently have lower expected return and volatility than the tangency portfolio. Portfolios on the frontier located northeast of this portfolio are levered positions on this portfolio, and consequently have higher expected return and volatility than the tangency portfolio.

Mean-variance analysis thus delivers a crucial insight: By combining cash with the stock-bond tangency portfolio one can achieve a higher expected return for the same price (i.e., short-run volatility) than by combining only stocks and bonds. If a high expected return is needed, levering up the stock-bond tangency portfolio is a better choice than simply allocating more and more wealth to stocks only.

This insight has an important implication for asset allocation. All investors should hold the tangency stock-bond portfolio, and combine this portfolio with a cash position to achieve the risk that best fits their risk tolerance. Thus if the tangency portfolio is 75% stocks and 25% bonds, an investor who is willing to assume more risk than the risk represented by this portfolio should lever this portfolio up and hold, for example, a 90%-30% levered portfolio of stocks and bonds, financed with his wealth and additional

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[8] J. Tobin, "Liquidity Preference as Behavior Towards Risk", *Review of Economic Studies* 25, 68-85 (1958).

[9] This is literally incorrect, since short-term bonds such as Treasury bills are subject to short-term inflation risk. However, in developed economies such as the U.S. economy, short-term inflation volatility is very small.

borrowings equal to 20% of his wealth. An investor who is more conservative might perhaps hold 60% stocks, 20% bonds, and 20% cash. All investors, however, should maintain the same ratio 3:1 of stocks to bonds.

This portfolio advice is at odds with conventional investing wisdom, as well as the way that life-style funds allocate assets between "aggressive" and "conservative" funds. In practice, both conservative investors and conservative life-style funds favor bonds relative to equities, so the ratio of bonds to stocks increases as portfolios become more conservative. In the previous example, the more conservative investor might be advised to hold a portfolio consisting of 40% equities, 40% bonds, and 20% cash, with a 2:1 ratio of stocks to bonds.

Another implication of mean-variance analysis is that it directs investors to maintain the same asset allocation regardless of their age or investment horizon. This advice is at odds with the advice that financial planners traditionally give their clients and with the asset allocation patterns embedded in life-cycle funds, all of which suggest that the allocation to equities should be directly related to investment horizon.

Thus traditional mean-variance analysis does not seem to provide scientific support for the "risk-based investing" approach and the "horizon-based investing" approach to asset allocation that characterizes life-style funds and life-cycle funds, respectively. However, the asset allocation advice that emerges from mean-variance analysis is based on two critical assumptions. First, mean-variance analysis assumes that investors live in a parsimonious world of constant risk and return. In such a world, it is optimal for long-term investors to act as short-term investors, ignoring the long-term (Merton 1969, 1971, Samuelson 1969, 1991).[10] Second, mean-variance analysis treats financial wealth independent of income.

For decades, the assumption of constant investment opportunities constituted a good approximation of reality to academics and practitioners alike. But in recent years, both academic research and industry research has shown through careful empirical analysis that changes in investment opportunities are quantitatively important. Long-term investors typically receive a stream of income and use it, along with financial wealth, to support their standard of living. In recent years, academic finance has explored the impact of these considerations on long-horizon investing, building on the early theoretical insights on dynamic portfolio choice of Merton (1969, 1971) and Samuelson (1969). In particular, it has shown that they provide a *qualified* support for "risk-based investing" and "age-based investing." This issue is explored next in greater detail.

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[10] Merton, R. C., 1969, "Lifetime portfolio selection under uncertainty: the continuous-time case," *Review of Economics and Statistics* 51, 247-257. Merton, R. C., 1971, "Optimum consumption and portfolio rules in a continuous-time model," *Journal of Economic Theory* 3, 373-413. Samuelson, P. A., 1969, "Lifetime portfolio selection by dynamic stochastic programming," *The Review of Economics and Statistics* 51, 239-246. Samuelson, Paul A., 1991, "Long-run risk tolerance when equity returns are mean regressing: pseudopara-doxes and vindication of 'businessman's risk,'" in William C. Brainard, William D. Nordhaus and Harold W. Watts, eds.: *Money, Macroeconomics, and Economic Policy: Essays in Honor of James Tobin*, MIT Press, Cambridge, Mass.

4. The case for "risk-based investing:" Interest rate risk and the optimal bond allocation of long-term investors

A traditional idea in investment theory and practice is that cash (e.g., short-term default-free bonds or bills) is the safe asset for all investors. Traditional mean-variance analysis treats cash as the riskless asset, and considers bonds as another risky asset like stocks. Bonds are valued only for their potential contribution to the expected short-run excess return, relative to risk, of a diversified risky portfolio.

This idea is rooted in the perception that real interest rates are constant. In reality, real interest rates change over time, and future real interest rates are far from certain. In such circumstances, cash is safe for short-term investors, provided that short-term inflation risk is small, but it is not safe for long-term investors. If future real interest rates eventually decline, these investors need to worry about the impact of constantly reinvesting wealth in short-term instruments on their long-term welfare.

A strategy of constantly reinvesting wealth in short-term bonds will preserve investors' initial wealth, but not necessarily their ability to spend out of this wealth. If real interest rates decline, investors will have to either reduce their spending to accommodate this reduction in the yield on their wealth, or deplete part of the principal to maintain their spending, with the subsequent impact that this reduction in wealth might have on their future well being.

An article in The Wall Street Journal on July 7, 2003, provides a vivid example of the importance of reinvestment risk for long-term investors. The article recounts the stories of several people in Florida who retired during the last twenty years and followed the conventional strategy of continuously investing their retirement assets in certificates of deposit and other short-term fixed-income instruments, and living off the interest income produced by these investments. As nominal interest rates fell faster than the prices of services and goods they consume—that is, as real interest rates declined—during the 1980's, 1990's and early 2000's, these retirees were forced to substantially reduce their standard of living. The title of the article says it all, "As Fed Cuts Rates, Retirees Are Forced To Pinch Pennies—With Interest Income Down, Seniors in Florida Complex Are Facing Tough Choices—A $1.63 Splurge at Burger King."

In contrast to a strategy of constantly reinvesting wealth in short-term bonds, a strategy of investing in long-term bonds will protect spending, since these bonds will increase in value as real interest rates decline, thus providing the extra cushion they need to maintain their spending plans without depleting the initial principal.

This analysis, while enlightening and helpful, is still incomplete. In practice, the coupons and principal payments of long-term bonds such as Treasury bonds are typically fixed in nominal terms. This means that the value of these bonds is also affected by an additional factor: inflation. If inflation is volatile, the ability of long-term bonds to protect spending plans on an inflation-adjusted basis can be seriously undermined. Larger than expected inflation rates will erode the purchasing power of these bonds, even if real interest rates

do not move at all. By contrast, inflation-indexed bonds, which the U.S. Treasury started issuing in 1997 under the denomination of TIPS (Treasury Inflation Protected Securities), are immune to the potentially devastating effects of unexpected inflation. Thus investors need to be aware that regular Treasury bonds are safe investments only when inflation risk is low.

Establishing the extent to which real interest rate risk and inflation risk are important is of key importance to investors, because it determines which financial instruments are safest at long horizons. Campbell and Viceira (2001, 2002) [11] apply the tools of modern finance to the analysis of inflation and interest rates, and find that real interest rates vary enough over time to make cash a risky investment at long horizons, and that, except for the Volcker-Greenspan period of the last twenty years, inflation risk is large enough to make long-term Treasury bonds poor substitutes for inflation-linked TIPS.

Campbell and Viceira (2001, 2002) explore the optimal allocation to cash, long-term bonds, and stock of long-term investors under this environment of changing real and nominal interest rates. They show that, in the presence of real interest rate risk and inflation risk, long-term investors optimally allocate a larger fraction of their wealth to long-term inflation-indexed bonds as they become more conservative. The ratio of bonds to stocks increases with risk aversion and in the limit when investors' risk tolerance approaches zero, long-term investors allocate all their financial wealth to long-term inflation indexed bonds, not cash.

Extremely conservative long-term investors prefer long-term inflation-indexed bonds to cash because, while T-bills help investors preserve capital, they do not necessarily preserve long-term standards of living. Long-term inflation-indexed bonds, not cash instruments, are the riskless asset for conservative investors who care about financing their long-term spending plans or liabilities.

The analysis in Campbell and Viceira (2001, 2002) has significant implications for the design of investment vehicles for long-term investors. First, this analysis provides support for the idea of "risk-based investing," i.e., the idea that the portfolio share of bonds should be larger in conservative portfolios than in aggressive portfolios. However, this support is qualified. These bonds should be inflation-indexed bonds (or TIPS). Nominal bonds play an important role in conservative portfolios only when inflation risk is low, and they are close substitutes of inflation-indexed bonds.

Table 3, which reproduces selected columns from Table 3.3 in Campbell and Viceira (2002), illustrates this result. The table shows the optimal percentage allocation to stocks, bonds, and cash of investors with different degrees of risk aversion. The left columns in the table consider a problem in which investors can choose between cash, stocks, and inflation-indexed long-term bonds. The right columns consider a problem in which

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[11] Campbell. J. Y. and L. M. Viceira, 2001, "Who Should Buy Long-Term Bonds?" *American Economic Review* 91, 99-127. Campbell, J. Y. and L. M. Viceira, 2002, *Strategic Asset Allocation: Portfolio Choice for Long-Term Investors*, Oxford University Press, Chapter 3..

inflation-indexed bonds are not available, and instead investors can choose between cash, stocks, and nominal long-term bonds. Panel A shows optimal allocations to each asset class implied by the dynamics of real interest rates and inflation in the post-World War II period, which was characterized by significant inflation risk. Panel B shows the allocations implied by the dynamics of real interest rates during the last two decades of the 20th century, which was characterized by much lower inflation risk than the rest of the postwar period.[12]

The first row in each panel shows the optimal allocations of investors with the coefficient of relative risk aversion equal to one. These are aggressive investors which value bonds only for their short-run properties (i.e., the contribution they make to their portfolio expected excess return and short-run volatility) and not for their long-term properties. As we move down the columns, the rows show the optimal allocations for increasingly conservative long-term investors.

Table 3 shows that the portfolio share of inflation-indexed bonds relative to the portfolio share of stocks increases with risk aversion, and is basically 100% for investors with extremely high risk aversion coefficients. By contrast, the allocation to nominal bonds in Panel A is very small for all investors, including those who are extremely conservative. These investors prefer to move away from equities and into cash, because nominal bonds in this period are subject to considerable inflation risk and in practice are poorer substitutes for inflation-indexed bonds than cash itself. This picture changes completely in Panel B, where low inflation risk makes nominal bonds close substitutes of inflation-indexed bonds.

Second, the mutual fund industry has designed life-cycle funds so that they are folded into a balanced "retirement fund" at or shortly after their target maturity date. These balanced funds tend to have very small allocations to equities and inflation-indexed bonds, and large allocations to nominal bonds and cash (See **Table 1** and **Table 2**). The allocations shown in Table 1 suggest that these retirement funds and in general all balanced funds except the most conservative ones should contain a considerable allocation to equities. They also suggest that balanced funds, particularly conservative balanced funds, should contain significant allocations to inflation-indexed bonds. Substitution of nominal bonds for inflation-indexed bonds makes an implicit bet that inflation risk will stay low in the future, which might or might not happen.

Third, this analysis suggests that the long standing practice of sponsors of defined-contribution pension plans choosing a money-market fund as the default option for plan participants might not be appropriate if the goal is to choose for them a safe investment. Instead, under that goal the choice should be a portfolio of long-term bonds, preferably inflation-indexed. Of course, plan sponsors might be simply responding to a legal and regulatory environment that is mistakenly focused on preservation of initial principal as the "safe choice." If so, this analysis suggests that there should be a discussion of what the regulatory concept of a safe long-term investment should be.

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[12] These are allocations where the weight of each asset class is constrained to be between 0% and 100%.

Fourth, this analysis also suggests that the issuance of inflation-indexed bonds by the Treasury has a significant impact on welfare, as it provides long-term investors with a truly riskless long-term investment vehicle.

5. The case for "age-based investing"

5.1. Mean-reversion in stock returns

The standard theory of asset allocation treats equities as a risky asset class whose high historical average returns represent compensation for commensurately high risk. In recent years, however, it has become commonplace to argue that equities are actually relatively safe assets for investors who are able to hold them for the long term. This view is based on evidence that stock returns are less volatile when they are measured over long holding periods.[13] As illustrated in **Figure 5**, the annualized volatility of real (or inflation-adjusted) U.S. stock returns appears to decline with holding horizon, from about 16% per annum at a 1-year horizon, to about 8% per annum at horizons of 25 years or longer.[14] Similarly, the range of U.S. stock returns experienced by investors since 1926 changes depending on the holding horizon, with short horizons exhibiting a much wider spread than long horizons, as shown in **Figure 6**. Similar patterns are visible in some international markets (Dimson, Marsh, and Stauton, 2002). [15]

Siegel (1998) [16] presents evidence of this sort to promote an aggressive strategy of buying and holding equities for the long-term. Similarly, some mutual fund industry experts use this evidence to support the horizon-based allocations of life-cycle funds (Greer 2004, Ren and Shelon, 2004).[17] Indeed, Campbell and Viceira (2005) [18] show that these findings

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[13] J. Campbell and R. Shiller, "Valuation Ratios and the Long-Run Stock Market Outlook", *Journal of Portfolio Management* (Winter 1998). Earlier work on mean-reversion includes E. Fama and K. French, "Permanent and Temporary Components of Stock Prices", *Journal of Political Economy* 96, 246-73 (1988) and "Dividend Yields and Expected Stock Returns", *Journal of Financial Economics* 22, 3-27 (1988); J. Campbell and R. Shiller, "Stock Prices, Earnings, and Expected Dividends", *Journal of Finance* 43, 661-76 (1988); and J. Poterba and L. Summers, "Mean Reversion in Stock Returns: Evidence and Implications", *Journal of Financial Economics* 22, 27-60 (1988).

[14] The line shows the volatility (or standard deviation) of stock returns at different holding horizons properly scaled by dividing by the square root of the number of years in the holding horizon.

[15] Dimson, Elory, Paul Marsh, and Mike Staunton, 2002, *Triumph of the Optimists: 101 Years of Global Investment Returns*, Princeton University Press.

[16] J. Siegel, 1998, *Stocks for the Long Run*, 2nd ed., McGraw-Hill.

[17] Greer, Boyce, 2004, "The Case for Age-Based LifeCycle Investing," Viewpoint Investment Concepts White Paper, Fidelity Investments. Cheng, Ren and Jonathan Shelon, 2004, "Putting Lifecycle Investing Theory into Practice," Investment Report, Fidelity Investments.

imply that buy-and-hold long-term investors should hold more equities in their portfolios than buy-and-hold short-term investors.

A different question, however, is whether a strategy of aggressively buying and holding stocks for the long-term, or the deterministic rebalancing strategy implemented in life-cycle funds are desirable long-run investment strategies if stock returns behave the way the data suggest. The key to answer this question resides in understanding what makes stock market risk decrease significantly at long horizons.

In a world of time-invariant risk and return, risk per period (measured as the annualized variance of holding period returns) is constant across all investment horizons. Thus, if expected returns were constant, the line shown in Figure 5 would be horizontal, not decreasing.[19] Therefore, the evidence for reduced risk of stocks at long horizons is inconsistent with constant expected returns. In fact, it is indirect evidence for predictable variation in stock returns.

Empirically, times of unusually high stock prices relative to dividends or earnings appear to be followed by periods of low average stock returns, and conversely, times of low stock prices relative to dividends or earnings tend to be followed by periods of high average stock returns. **Figure 7** illustrates this evidence. It plots 10-year real returns on the S&P 500 when stocks are purchased at different initial price-to-earnings multiples and dividend-to-price ratios.[20] This figure is constructed from Robert Shiller's annual dataset for the period 1871-2004.

Figure 7 shows that when stock market valuations relative to earnings or dividends were in their lowest quintile in this period, real returns over the following ten years were about 10%-11% per annum on average. This average return was more than twice as large as the average return in 10-year periods following times in which stocks relative to earnings or dividends were in their highest quintile. Thus stock returns appear to revert towards a long-run average or mean, and stocks are said to be mean-reverting.

But, if returns are predictable, then why would long-term investors want to pursue a buy-and-hold investment strategy, or a strategy of mechanically rebalancing away from equities as their investment horizon shortens? Should they not instead change their allocation to stocks as a function of prevailing market conditions? For example, they

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[18] See Campbell, J. Y., and L. M. Viceira, 2005, "The Term Structure of the Risk-Return Tradeoff," *Financial Analysts Journal*, Vol. 61, No. 1; and Jurek, J. and L. M. Viceira, 2005, "Optimal Value and Growth Tilts in Long-Horizon Portfolios," *NBER* working paper 12017.

[19] In a world of constant expected return and risk, the volatility of K-holding period returns is precisely equal to the volatility of 1-period returns times the square root of K, the number holding periods. Since the line shown in Figure X is the volatility of K-holding returns divided by the square root of the number of holding periods, this line should be flat in that world.

[20] Earnings and dividends in these ratios are averages over the previous 10 years, to smooth out seasonal and business cycle variation in these variables.

might want to decrease their allocation to stocks when expected future stock returns are low (e.g., at times when stock prices are high relative to earnings of dividends), and conversely increase it when expected future stock returns are high (e.g., when stock prices are low relative to earnings or dividends).

Campbell and Viceira (1999, 2002, and 2003)[21] and others have studied this question in depth using a formal model of long-term portfolio choice under time-varying expected stock returns. They show that long-horizon investors should indeed vary their allocation to stocks in response to changes in expected stock returns. However, these changes are only gradual, not the type of volatile high-frequency trading that is often recommended by "tactical asset allocation" programs. The reason for this gradual approach is that empirically expected stock returns seem to change slowly. The variables that proxy for expected returns, such as dividend yields, smoothed price-earnings ratios, interest rates, etc. are highly persistent, slow-moving variables.

This research also finds that, at the same time, it is optimal for long-term investors to introduce a strategic tilt toward equities in their portfolios, even as they vary their actual allocation at shorter horizons. This strategic tilt reflects a positive intertemporal hedging demand for stocks and it is relatively insensitive to changes in expected returns. If stocks mean-revert, realized stock returns are high at times of low expected future stock returns. It is in this sense that stocks provide a good hedge against a deterioration in their own expected future return, and are relatively safer assets for long-term investors.

Stock return predictability also affects the composition of equity portfolio. Jurek and Viceira (2006)[22] show that growth stocks—stocks with high prices relative to earnings or dividends—tend to deliver higher realized returns at times when expected aggregate stock returns are low than value stocks—stocks with low prices relative to earnings or dividends—do. This makes growth stocks less risky than value stocks from the perspective of long-horizon investors, since they provide a better hedge against market downturns. Thus the strategic tilt towards equities in long-horizon portfolios should be itself biased toward growth stocks.

Therefore, this research suggests that long-term equity investors should invest more on average in equities than their short-horizon counterparts, but they should also consider periodic revisions of this allocation as market conditions change. It is logically inconsistent to count on reduced long-term risk while ignoring the variation in returns that produces it. This market-sensitive allocation policy is very different from the asset

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[21] Campbell, J. Y. and L. M. Viceira, 1999, "Consumption and Portfolio Decisions when Expected Returns are Time Varying", *Quarterly Journal of Economics* 114, 433-495. Campbell, J. Y., Y.L. Chan, and L. M. Viceira, 2003, "A Multivariate Model of Strategic Asset Allocation", *Journal of Financial Economics*. Campbell, J.Y. and L. M. Viceira, 2002, *Strategic Asset Allocation: Portfolio Choice for Long-Term Investors*, Oxford University Press. See also J. Y. Campbell, J. Cocco, F. Gomes, P. J. Maenhout and L. M. Viceira, 2001, "Stock Market Mean-Reversion and the Optimal Equity Allocation of a Long-Lived Investor," *European Finance Review* 5, 269-292.

[22] Jurek, J. W., and L. M. Viceira, 2006, "Optimal Value and Growth Tilts in Long-Horizon Portfolios," NBER Working Paper 12017, National Bureau of Economic Research, Cambridge, Mass.

allocation policy of life-cycle funds, whose target mix moves mechanically away from stocks as an inverse function of investment horizon, regardless of market conditions. Thus mean-reversion arguments provide, if anything, only a partial justification for the rolldown schedule characteristic of life-cycle funds.

The idea of age-based investing focused on mean-reversion is further challenged by the ongoing debate in empirical finance about the robustness of the statistical evidence on stock return predictability. Some research disputes this evidence (Goyal and Welch, 2007),[23] while other claims that the observed time series variability in dividend yields and the lack of empirical evidence that aggregate dividend growth is predictable are consistent with stock return predictability (Campbell and Thompson 2007, Cochrane 2007, Lewellen 2004).[24]

A body of research has explored the implications of uncertainty about the existence of mean-reversion in stock returns on asset allocation.[25] This research finds that this uncertainty should make investors more cautious when changing their equity allocation in response to changes in market conditions than investors who take the estimated stock return processes at face value. However, they are still willing to engage in market dependent asset allocation strategies. This uncertainty also dampens, but does not eliminate, the long-term strategic tilt toward equities induced by mean-reversion. Of course, the magnitude of these effects depends on investors' initial uncertainty. In a model with fixed underlying parameters, the learning effect is transitional and will eventually disappear as investors become more and more confident about the true data generating process.

5.2. Human capital and asset allocation

I have noted that mean-variance analysis ignores that investors have additional sources of wealth besides their financial wealth. One of these sources, arguably the most important for most individual investors, is human capital or the present discounted value of their expected future labor earnings.

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[23] Goyal, A. and I. Welch, 2007, "A Comprehensive Look at the Empirical Performance of Equity Premium Prediction," Manuscript," forthcoming *Review of Financial Studies*.

[24] Campbell, J. Y. and S. Thompson, 2007, "Predicting Excess Stock Returns Out of Sample: Can Anything Beat the Historical Average?" forthcoming *Review of Financial Studies*. Cochrane, J. H., 2007, "The Dog That Did Not Bark: A Defense of Return Predictability," forthcoming *Review of Financial Studies*. Lewellen, J., 2004, "Predicting Returns with Financial Ratios," *Journal of Financial Economics* 74, 209-235.

[25] See N. C. Barberis, "Investing the Long Run When Returns Are Predictable," *Journal of Finance* 55, 225-264 (2000). M. J. Brennan, "The Role of Learning in Dynamic Portfolio Decisions," *European Finance Review* 1, 295-306 (1998). Y. Xia, "Learning about Predictability: The Effects of Parameter Uncertainty on Dynamic Asset Allocation," *Journal of Finance* 56, 205-246 (2001). J. A. Wachter and M. Warusawitharana, 2007, "Predictable Returns and Asset Allocation: Should a Skeptical Investor Time the Market?, working paper, Wharton School at the University of Pennsylvania.

Unlike other types of capital, human capital is not tradable. Investors cannot sell claims against their future labor earnings, but they can extract value from their human capital through the earnings it produces over time, which they can then use either to finance their current spending, or to save and thus increase their financial wealth.

Just because human capital is not tradable does not mean that investors should ignore it when deciding how to invest their financial wealth (or savings). In fact, financial economics has shown that human capital considerations should lead investors to change the target asset allocation for their financial portfolios over time (Bodie, Merton and Samuelson, 1991).[26] This is because as investors age, their human capital gets depleted as it is transformed into consumption and savings.

The relation between human capital and asset allocation is easiest to see if we consider an investor who knows his income in advance with perfect certainty. For this investor, human capital is equivalent to an implicit investment in bonds. When the investor is young and has many years of earning labor income ahead of him, but little wealth saved, human capital represents a large share of his total wealth. The investor should then tilt his financial portfolio towards risky assets to offset the large bond position he already holds through his human capital.

As the investor ages, the value of his human wealth declines (he has less years left to earn labor income) while his financial wealth grows. Thus the bond investment represented by his human wealth becomes less important relative to his total wealth, and the investor will want to attenuate the tilt towards risky assets in his financial portfolio.

Figure 8 illustrates this principle using a stylized example. This figure plots the asset allocation of a life-cycle investor along the expected path of labor earnings and expected returns during the investor's working years. The figure is built under the following assumptions. First, it assumes that the investor wishes to hold a 60%-40% stock-bond portfolio. Second, the investor works for 35 years. He starts with an initial salary of $60,000 per annum which grows at a real (or inflation-adjusted) rate of 4% per annum. Third, the investor starts with initial financial wealth of $75,000. This wealth grows through the returns he obtains on his investments, and through the savings he adds every year. The figure assumes that he saves 15% of his salary every year, and that equities return 6% per annum on average, and bonds 2.3% per annum in real terms. The real riskless rate is also 2.3%.[27]

Under these assumptions, when the investor still has 35 years left until retirement, his human capital is worth $2.864 million. This is the present value of all his future earnings discounted at the riskless rate of 2.3%. Since he also has $75,000 in savings, his total

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[26] Z. Bodie, R. Merton, and W. Samuelson, "Labor Supply Flexibility and Portfolio Choice in a Life Cycle Model", Journal of Economic Dynamics and Control 16, 427-449 (1991).

[27] This is approximately the current yield on long-term inflation-indexed bonds. Note that the implied equity premium (around 3.7%) is low relative to the historical average equity premium, which is around 6.5%.

wealth equals $2.939 million. Given his target mix, this investor would like to hold $1.764 million in stocks, and $1.175 in bonds. But he has already an implicit investment in bonds through his human capital worth $2.864 million, which is well above his target allocation. Thus this investor will opt to invest the entirety of his financial wealth ($75,000) in stocks in an effort to get as close as possible to his 60% target allocation to stocks.

Interestingly, this investor will appear to an outside observer as a very aggressive investor because he allocates 100% of his financial wealth to stocks. In practice, however, his overall wealth portfolio is actually heavily tilted towards bonds: 97.4% of his total wealth is invested in bond-like wealth.

As he grows older and approaches retirement, the value of his human capital declines, and his financial wealth grows. However, the ratio of financial wealth to human capital does not grow fast enough for the investor's desired bond holdings to be larger than the value of his human capital until year 31. At that point his financial wealth has grown to $1.6 million, and his human capital is still worth $1.022 million. Thus his total wealth is $2.6022 million, of which he would like to hold $1.050 million in bonds. Since his bond-like human wealth is worth less than his desired allocation to bonds, at this point he starts investing part of his financial wealth in bonds, and moves away from stocks. The investor starts investing 2% of his financial wealth in bonds, which grows to 34% the last year of his working life.

Figure 8 shows a path for asset allocation in which the share of financial wealth allocated to equities declines as the investor approaches retirement. Thus human capital considerations provide support for "age-based investing." However, there are some important caveats to this conclusion.

First, Figure 8 shows an asset allocation path which is much more aggressive than the asset allocation path typical of life-cycle funds (see Table 1 and Table 2). Despite the fact that the investor aims at a relatively conservative target allocation for his total wealth (60% stocks-40% bonds), the resulting asset allocation path for financial wealth is fully invested in stocks for 30 years of his 35 years of his retirement horizon. In the remaining five years, the allocation to equities is always above 65%. This suggests that the asset allocation path of life-cycle funds is perhaps too conservative.

Of course, one could argue that this example is unrealistic. In practice, future labor income is uncertain for most investors, which makes human wealth a risky non-tradable asset. This might make investors wish to invest their financial wealth more conservatively than in the case with perfectly safe human capital. However, this conclusion does not hold for plausible representations of labor income risk.

Viceira (2001)[28] examines optimal asset allocation with labor income uncertainty. He finds that investors with risky labor income should still tilt their portfolios toward stocks when they are young, provided that labor earnings are not too volatile, and are uncorrelated with the stock market. For these investors, the risk in their human capital is largely idiosyncratic and as such is more similar to an investment in bonds than to an investment in stocks. The resulting asset allocations for investors with typical earnings volatility (around 10% per annum) and low correlation with stock returns are still more aggressive than the asset allocations typical of life-cycle funds. Labor earnings must be highly volatile to significantly reduce the investors' willingness to hold equities in their portfolios.

Second, while idiosyncratic risky labor income might ameliorate the pronounced tilt toward stocks that riskless labor income suggests, there are other considerations which actually work in the opposite direction. Most investors receive Social Security benefits, and many receive other pension benefits when they retire. Pension income is also bond-like, and should make investors even more willing to tilt their portfolios toward equities.[29]

Another consideration is the ability of many working investors to influence the value of their human wealth by varying how hard they work. The ability to vary work effort allows individuals to hold riskier portfolios because they can work harder if they need extra labor income to compensate for losses in their financial portfolios. Bodie, Merton and Samuelson (1991) emphasize that the tilt towards risky financial investments with riskless labor income is strengthened if investors have the ability to adjust their labor supply. Chan and Viceira (2000) have shown that this result carries over when labor income is idiosyncratically risky.[30]

Third, recent research on portfolio choice with risky labor income shows that realistic calibration of labor earnings profiles lead to asset allocation paths in which stock portfolio shares are not necessarily monotonically decreasing with retirement horizon. Cocco, Gomes and Maenhout (2005)[31] have show empirical evidence which, unlike the stylized example I have just presented, assumes that earnings grow at a steady rate over the working life of the investor, the earnings profile of a typical working investor exhibits a hump shape. Labor earnings grow at increasingly higher rates until employees are about 45 years old, at which point they stop growing or even decrease until they retire.

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[28] Viceira, L.M., 2001, "Optimal Portfolio Choice for Long-Horizon Investors with Nontradable Labor Income," *Journal of Finance*, 433-70. See also Chapter 6 of J. Y. Campbell and L. M. Viceira, *Strategic Asset Allocation: Portfolio Choice for Long-Term Investors*, Oxford University Press (2002).

[29] However, uncertainty about future pension benefits can make investors less willing to take equity risk (Kotlikoff, L., F. J. Gomes and L. M. Viceira, 2006, "The Excess Burden of Government Indecision," manuscript, Harvard University).

[30] Chan, Y.L. and L. M. Viceira, 2000, "Asset Allocation with Endogenous Labor Income: The Case of Incomplete Markets," manuscript, Harvard University.

[31] Cocco, J. F., F. J. Gomes, and P. J. Maenhout, 2005, "Consumption and Portfolio Choice over the Life Cycle," *The Review of Financial Studies* 18, 491-533.

They next note that this also implies a hump shape for the value of human wealth, which in turn implies a hump shape for the optimal asset allocation path for equities as investors age. That is, investors should hold portfolios which are more conservative early in their working lives, become more aggressive as they approach middle-age, and then become increasingly more conservative. However, they find that the share of human capital on total wealth at young ages for a typical working investor is so large relative to financial wealth that these investors still want to hold almost if not all of their financial wealth in equities. Thus their findings suggest that life-cycle funds should perhaps exhibit a slightly hump shaped equity allocation path instead of a monotonically declining path.

Fourth, asset allocation is highly sensitive to the correlation of labor earnings with stock returns. Viceira (2001) shows that small correlations significantly reduce the portfolio tilt towards equities in financial portfolios, and large correlations might even reverse this tilt, and make younger investors less willing to hold equities in their financial portfolios than older investors. In fact, Benzoni, Collin-Dufresne, and Goldstein (2007)[32] argue that aggregate labor income and dividends exhibit a large, positive long-run correlation, even though they exhibit a low short-term correlation. This positive long-run correlation implies a hump-shaped allocation to stocks over the working life of the investor.

This is so because in this case human capital is more stock-like than bond-like, and young investors should compensate by tilting their financial portfolios toward bonds, and away from stocks. In the extreme case where labor income is perfectly positively correlated with the return on stocks, human wealth is in fact an implicit investment in stocks. Thus life-cycle funds will not be appropriate for investors whose labor earnings are highly correlated with the stock market.

Correlation considerations are important in other aspects of the design of DC plans. Current regulations allow corporate sponsors to include company stock as part of the menu of investment options available to plan participants. Arguably, employees' labor income is likely to be highly correlated with the fortunes of the company they work for. They should not only avoid holding an undiversified position in their employer's stock, but they should actually underweight the company stock relative to its weight in an index fund. If employees fail to understand this point, or mistakenly think they have superior information about company stock, they might allocate too large a fraction of their retirement savings to company stock. The recent bankruptcy of Enron and the subsequent negative effect on employee retirement benefits has made some investors painfully aware of the risks of investing in company stock.

Finally, it is important to note that while all these models support the notion that retirement horizon matters for asset allocation, they do not prescribe a unique asset allocation path for all investors with identical human capital characteristics. This asset

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[32] Benzoni, L., P. Collin-Dufresne, and R. S. Goldstein, 2007, "Portfolio Choice over the Life-Cycle when the Stock and Labor Markets are Cointegrated," forthcoming *Journal of Finance.*

allocation path is a function of both human capital and the investor's risk tolerance. Thus they imply that life-cycle funds should be both "age-based" and "risk-based."

6. The design of life-cycle funds

6.1. General considerations

Section 4 and Section 5 have explored what modern financial economics has to say about long-run asset allocation strategies, and its implications for the design of life-cycle funds and the life-style or balanced funds in which these funds fold once they reach their target maturity date. In general, the findings of modern financial economics provide support for a notion of age-based investing where age (or retirement horizon) is a proxy for human capital, but they provide a weaker support for a notion of age-based investing that builds on the idea of mean-reversion in stock returns.

Research on long-run investing suggests that life-cycle funds should adopt an asset allocation path heavily tilted toward equities until they are fairly close to their target date. This asset allocation path is based on the typical labor earnings profile, which exhibits low volatility and low correlation with stock returns, and is more aggressive than the asset allocation path of most life-cycle funds currently available to investors. However, employees whose earnings are highly volatile or exhibit significant correlation with stock returns should adopt life-cycle investment strategies with a much less pronounced tilt towards equities.

This research also suggests that the retirement horizon of the investor (a proxy for his human capital) should not be the only variable that determines the asset allocation path of life-cycle funds. Market conditions should induce low-frequency adjustments to the path, as expected returns change over time.

Risk tolerance should also influence this allocation path. To the extent that investors systematically differ in their risk tolerance, it makes sense to consider creating "aggressive, "moderate" and "conservative" life-cycle funds instead of offering a single life-cycle fund per target date. For example, simulations in Poterba, Rauh, Venti and Wise (2005)[33] suggest that the asset allocation of a typical life-cycle fund can produce lower expected utility (or welfare) than a 100% stock allocation for aggressive investors.

These "risk-based" life-cycle funds should have different target asset allocations at maturity. However, they should all share similar large allocations to equities at inception and in the early part of their asset allocation paths, because bond-like human capital accounts for most of the total wealth of a typical young and middle-aged working investor.

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[33] Poterba, J., J. Rauh, S. Venti, and D. Wise, 2005, "Lifecycle Asset Allocation Strategies and the Distribution of 401(k) Retirement Wealth," working paper, MIT.

It is also important to give consideration in life-cycle fund design to the term structure of target maturity dates. Long maturity dates that match current life-expectancy projections instead of expected retirement dates should probably be considered. Investors who expect to receive pension income from other sources such as Social Security or traditional DB pension plans should probably choose life-cycle funds with target dates well beyond their expected retirement date, to account for the fact that their pension income represents a bond-like investment just as their labor earnings do. Of course, investors with no significant pension income should choose target dates that match their expected retirement date.

The findings of modern financial economics also have clear suggestions about the assets that should be included in these funds. First, modern financial economics shows that long-term inflation-indexed bonds, not cash, are the safest asset for long-term investors. Long-term nominal bonds are subject to inflation risk and are safe only when this risk is low; otherwise they are risky assets, and poor substitutes for inflation-indexed bonds. This strongly suggests that long-term inflation bonds should play an important role in these funds, particularly conservative funds, while cash should probably not play a role. In fact, simulations in Poterba, Rauh, Venti and Wise (2005) show that all investors would consistently experience a gain in welfare if they adopted life-cycle funds which replace nominal bonds with TIPS. This is in sharp contrast with the allocations of most if not all of the life-cycle funds available to investors, where inflation-indexed bonds play only a marginal role.

Second, the equity allocations of life-cycle funds and life-style funds are typically heavily biased toward U.S. stocks. They typically define the "stock market" as the U.S. stock market, and include only small allocations to international stocks, which are typically defined as being riskier than U.S. stocks. However, it is hard to see why the stock of GM or Ford is inherently safer than the stock of Toyota or Honda. The empirical evidence available suggests that a well diversified portfolio of equities should include a healthy allocation to international equities (French and Poterba, 2001).[34] Campbell, Serfaty-de Medeiros and Viceira (2007)[35] show evidence that such portfolio should have its currency exposure fully hedged, except for the European and Swiss component of the portfolio, which should be left unhedged.

Third, the equity allocations of life-cycle funds should probably be tilted toward growth stocks and away from value stocks at long-horizons. This tilt should decrease as they approach their target maturity date. Growth stocks appear to be safer than value stocks at long-horizons (Jurek and Viceira, 2006). This tilt should be more pronounced for moderate and conservative life-cycle funds.

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[34] See French, Kenneth R. and James M. Poterba, 1991, "Investor Diversification and International Equity Markets," the *American Economic Review*, 81, no. 2, pp. 222-226.

[35] Campbell, J. Y., K. Serfaty-de Medeiros, and L. M. Viceira, 2007, "Global Currency Hedging," NBER Working Paper 13088, National Bureau of Economic Research, Cambridge, Mass.

These design considerations for life-cycle funds are all based on three premises: first, that investors are homogeneous in their human capital characteristics and in their risk tolerance; second, that they use these funds as their only long-term saving vehicle; third, that tax considerations are irrelevant. Under those premises, one single life-cycle fund per retirement horizon is enough. I explore next the implications of relaxing these premises.

6.2. Heterogeneity in human capital characteristics and risk tolerance

Arguably there is considerable heterogeneity among investors with respect to their risk tolerance and the characteristics of their human capital. Therefore, individually managed accounts would be more appropriate than a single asset-allocation fund, since they can take into account these individual-specific characteristics when making asset allocation recommendations.

It is important to note that this approach is different from the "interior decorator approach" to investing described in Bernstein (1992).[36] Bernstein uses this terminology to describe the practice among some financial advisors of building investor-tailored portfolios of individual stocks instead of a well-diversified stock portfolio, thus exposing their clients to considerable idiosyncratic risk. Here the goal is to use asset allocation to help investor hedge systematic risk through asset allocation risk. Investors should still hold a well diversified portfolio of equities.

Ultimately, separate managed accounts might be the right approach in an ideal world. In practice, however, managing separate accounts is an expensive process which currently becomes cost effective only at sizable account balances. This cost is driven by the need of human intervention, which technological advances will likely reduce in the future. Thus in considering adopting an individual approach, investors need to weigh the cost of these accounts against the cost of adopting a fund whose asset allocation path might not fit exactly their human capital characteristics and risk tolerance.

It is also an open question how much personalization is needed to provide investors with reasonable asset allocation advice. It is possible that heterogeneity in human capital risk and risk tolerance is such that a relatively small number of model asset allocation portfolios suffice to serve most investors needs.

There are also ways that can help capture more investor diversity at a relatively lower cost than full personalization. One is the suggestion already mentioned above of creating "aggressive," "moderate" and "conservative" life-cycle funds to capture disparity in risk tolerance. Another is for sponsors of DC pension plans to consider adopting life-cycle funds specifically designed for their firms. These funds might be able to better capture

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[36] Bernstein, Peter L., 1992, *Capital Ideas: The Improbable Origins of Modern Wall Street*, Free Press, New York.

the human capital risk characteristics of their typical employee, particularly the correlation of wages with stock returns. For example, these company-tailored funds might consider investing in stock portfolios which under weigh the exposure to stocks in the industry where the company competes and avoid exposure to company stock altogether. They might also adopt asset allocation paths whose equity tilts take into account the correlation of wages in the industry with aggregate stock returns.

6.3. Wealth heterogeneity and tax efficiency

Life cycle funds are designed to provide investors with a one-stop solution to their investment needs. Many investors, particularly small investors, do not typically save outside their retirement account, except to own a home and perhaps to hold some precautionary savings. Thus it might make sense for these investors to simply allocate their DC plan contributions to a life-cycle fund which appropriately reflects their risk tolerance and retirement horizon—or their life expectancy if they expect to receive traditional pension benefits in retirement. Sponsors can allow this practice by including life-cycle funds in their plan investment options and, more importantly, encourage it by making these funds the default allocation of the plan.

An interesting question is how home ownership should affect asset allocation decisions. A home is both an asset and a durable consumption good, since it provides its owner with a stream of housing services. Since a home provides its owner with insurance against fluctuations in the cost of housing services, one can view a home as a real (or inflation-indexed) consol bond that pays coupons in the form of housing services. As such, home ownership might make long-horizon investors more willing to hold equities in their financial portfolios.

At short-horizons, however, home prices fluctuate, and these fluctuations might be positively correlated with investors' labor earnings. This makes residential housing a risky asset and can make home owners less willing to take equity risk in their financial portfolios. However, empirically home price volatility and its correlation with labor earnings does not seem large enough to significantly impact asset allocation in practice (Cocco 2005, Yao and Zhang 2005).[37]

There are a number of investors, particularly employees in the upper levels of the wage distribution, who have the ability to save outside their retirement accounts. Tax efficiency considerations make life-cycle funds an inappropriate investment vehicle for these investors, even though age-based investing is still an appropriate asset allocation strategy for them to follow.

Instead, these investors should use regular funds to build their own tax-efficient life-cycle allocation strategy. Tax regulations typically tax fixed-income assets more heavily than

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[37] Cocco, J. F., 2005, "Portfolio Choice in the Presence of Housing," *Review of Financial Studies*, 18, 535-567. Yao, R. and H. H. Zhang, 2005, "Optimal Consumption and Portfolio Choices with Risky Housing and Borrowing Constraints," *Review of Financial Studies*, 18, 197-239.

equities. From this perspective, investors should place as much of their fixed-income asset allocation in their tax-exempt retirement accounts, and equities in their taxable account (Dammon, Spatt, and Zhang 2004).[38]

For this reason, life-cycle funds should probably not be the only investment option available to investors within a DC plan, even if they are appropriately designed to match the human capital characteristics and risk tolerance of plan participants. Tax efficiency considerations suggest that plan participants who have the ability to save outside the plan should have plain vanilla funds available to them, particularly fixed-income investment options, so they can make their own asset allocation plan and, given this plan, locate these assets in their tax-exempt and taxable accounts in a tax efficient manner.

7. Conclusions

This paper has reviewed recent advances in academic models of asset allocation for long-term investors, and explored their implications for the design of investment products that help investors save for retirement, particularly life-cycle funds and life-style funds. The modern theory of long-term asset allocation shows that the type of "risk-based" and "age-based" asset allocation strategies that characterize life-style funds and life-cycle funds respectively are conceptually sound under specific circumstances relating to investment opportunities and investors' wealth. Simultaneously, it also offers a number of suggestions about both the design of these funds and the types of investors for whom these funds are appropriate.

Real interest rate risk (or reinvestment risk) can give rise to "risk-based" asset allocation strategies. This risk makes short-term bonds (or cash) risky assets and long-term inflation-indexed bonds (or TIPS in the U.S.) the riskless asset at long horizons. Thus it is optimal for long-term investors to increase their allocation to these bonds as they become increasingly risk averse.

Long-term nominal bonds are subject to inflation risk, and they are safe assets at long-horizons only to the extent that this risk is low, in which case they become close substitutes for inflation-indexed bonds. Life-style and life-cycle funds should therefore consider increasing substantially their allocation to inflation-indexed bonds at the expense of their current allocations to nominal bonds, unless of course one has the view that inflation risk will be insignificant in the foreseeable future.

The interaction of human wealth (the capitalized value of expected future labor earnings) with financial wealth can give rise to "age-based" asset allocation strategies of the sort used by life-cycle funds. However, these strategies are appropriate only for working investors whose labor earnings exhibit low volatility and low correlation with equity

[38] See Dammon, Robert M., Chester H. Spatt, and Harold H. Zhang, 2004, Optimal Asset Location and Allocation with Taxable and Tax-Deferred Investing,, *Journal of Finance* 59.

returns. It is optimal for these investors to allocate a large fraction of their savings to equities when they have long retirement horizons and their "bond-like" human wealth accounts for most of their wealth, and to decrease this allocation as their retirement horizon shortens and their human wealth is depleted.

However, modern portfolio choice models also show that working investors whose labor earnings are more volatile or more correlated with stock returns than the average should invest in life-cycle funds with a less pronounced tilt towards equities, or even avoid them. For these investors, human wealth is less "bond-like" and more "equity-like" and thus they already have exposure to equities through their human wealth.

The existing empirical evidence suggests that the labor earnings profile of a typical employee exhibits low volatility and low correlation with stock returns. Calibrations of asset allocation models based on this profile suggest that the asset allocation path of life-cycle funds is too conservative and should allocate more to equities, particularly at long horizons.

However, a word of caution is necessary here. It is extremely hard to measure accurately the returns to human capital from aggregate data, and consequently to estimate their correlation with stock returns. Employees considering investing in life-cycle funds, or employers considering adopting these funds for their DC pension plans should carefully examine the degree of correlation between their labor earnings and the stock market, and consider adjusting the equity tilt of the life-cycle fund they offer to their employees accordingly.

Mutual fund companies offering these funds might want to consider offering life-cycle funds that exhibit different equity tilts. That is, they might want to offer "conservative," "moderate" and "aggressive" life-cycle funds. These funds will help capture diversity in risk tolerance and correlation between human wealth and the stock market across investors.

Stock return predictability, or mean-reversion, makes optimal for investors to strategically tilt their portfolios towards equities at long horizons. However, it also suggests that investors should tactically change the equity tilt of their portfolios based on market conditions. It is logically inconsistent to invest more in equities because of mean-reversion, but then ignore the short-term implications of holding such a view of the world.

These considerations do not mean that mutual fund companies should discard their current life-cycle fund offerings, or that DC plan sponsors should ignore them. Instead, they offer useful suggestions on how to modify the current design. In evaluating the merit of an investment vehicle, one needs consider the alternatives which are realistically available.

One alternative is the status quo. The U.S. retirement system is moving towards a system fundamentally based on DC pension plans. In that system, employees are responsible for

financing their own retirement. The existing empirical evidence indicates that many of DC plan participants, particularly those on the low end of the education and income distribution, appear to make suboptimal saving and investing decisions. In particular, they exhibit a significant degree of inertia in their decisions, and they disproportionately tend to adopt the default investment option offered in their plans, which very often is cash in the form of a money market account.

Thus the status quo for many investors is investing in a money market account. One can argue that life-cycle funds, even if imperfectly designed, are a better investing choice for long-term investors than a money market account. As such, employers could use the inertia that overwhelms so many investors positively, and adopt life-cycle funds, possibly tailored to their own needs, as default investment options.

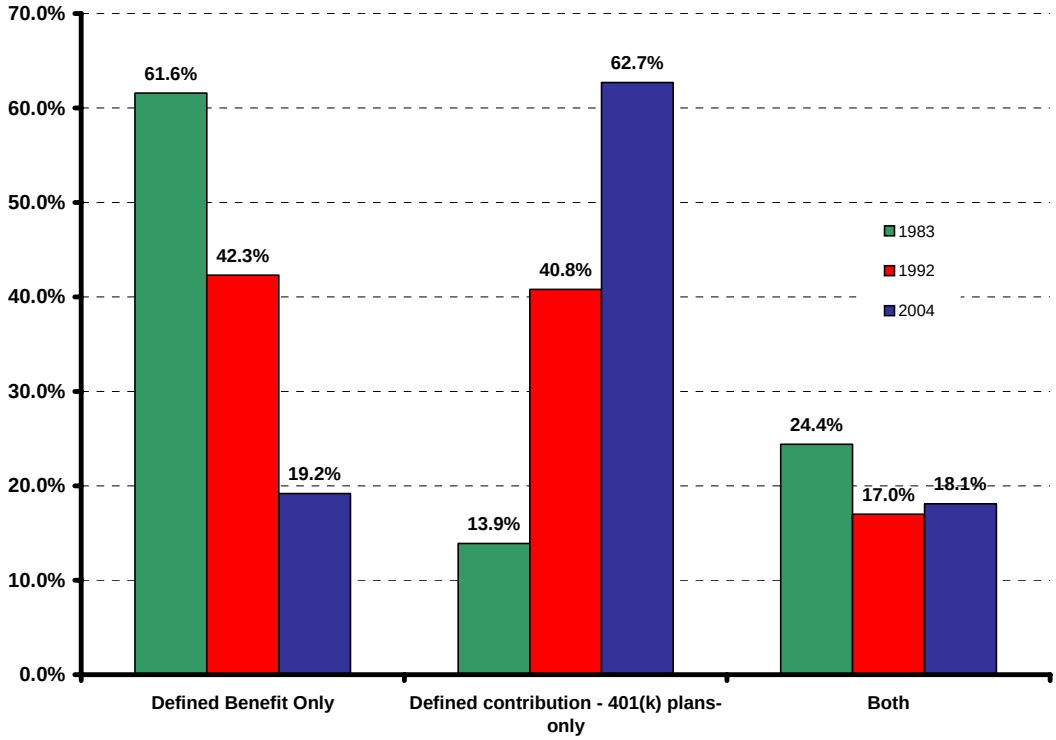
One could argue that a better alternative would be to implement individually managed accounts. While this might be the best approach to capture individual characteristics regarding risk tolerance, human wealth, tax status, and other types of wealth, these accounts are costly to manage. This cost is high enough at this point that they are not a plausible alternative for the vast majority of working investors. Life-cycle funds, on the other hand, are inexpensive to manage, and most mutual companies do not charge fees on top of the fees they already charge to the underlying funds.

A third alternative would be to educate investors so they can make their own choices, adapted to their own personal characteristics. However, the existing empirical evidence suggests that it is investors in the low end of the income and education distribution the ones that tend to make more mistakes. There is also evidence that the common man has difficulty understanding relatively simple financial concepts and ideas. Thus one has to wonder to what extent it is cost effective to try to educate people to become sophisticated investors.

Instead, perhaps a more viable option would be to design products that help individuals meet their financial goals, and educate them to become sophisticated consumers of financial products, such as life-cycle funds, life-style funds, or annuities. Financial engineering is in many ways conceptually and practically as difficult as other types of engineering. Just as we do not ask people to become engineers and build their own personal computers or electronic devices, we should probably not ask them to become financial engineers. And just as people can become highly discriminating buyers of electronic products, despite the fact that they are not engineers, they might also become discriminating buyers of financial products.

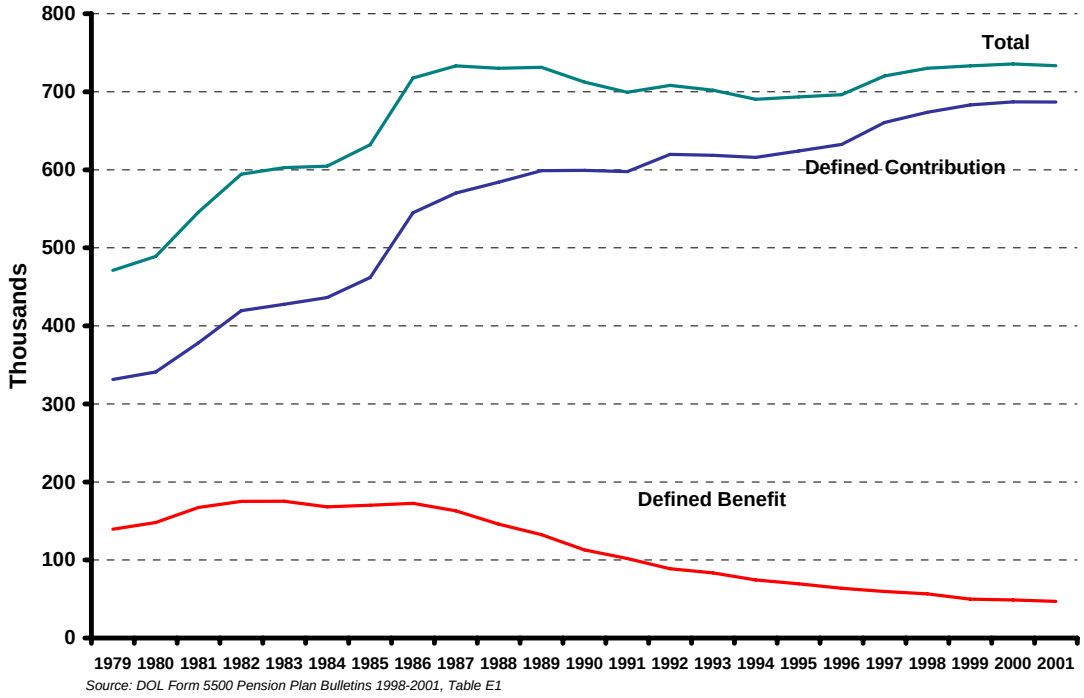
While more sophisticated investment products, individually managed accounts for everyone, and widespread investment education become a reality, we need to evaluate whether life-cycle funds can improve on the current status quo. Arguably they do, and as such, adopting them as default investment options in DC pension plans might help a significant number of individuals. Doing nothing just because these funds are not perfect might be a worse solution than adopting them, and one might end up falling in the trap of the old aphorism “the best is the enemy of the good.”

Figure 1. Percent of workers with pension coverage by type of plan.



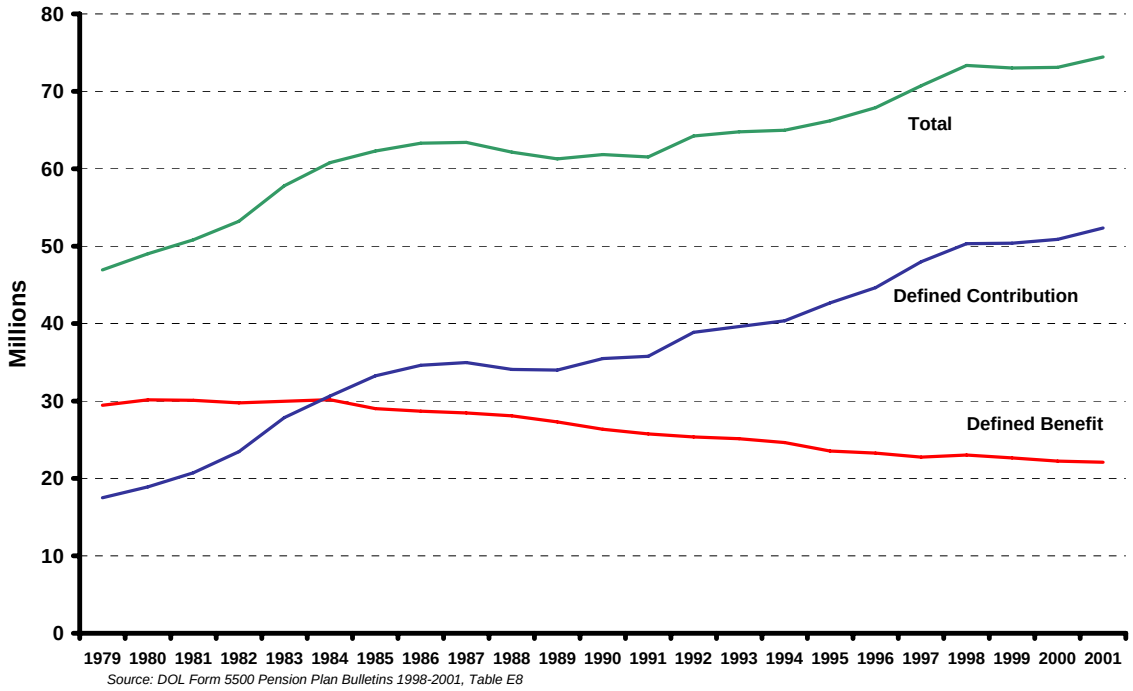
Source: Munnell, A. and A. Sunden, 2006, "401(k) Plans Are Still Coming Up Short," Brief, Center for Retirement Research at Boston College, no. 43.

Figure 2. Number of private pension plans (1979-2001).



Source: DOL Form 5500, Pension Plan Bulletins 1998-2001, Table E1.

Figure 3. Number of active participants in private pension plans (1979-2001).



Source: DOL Form 5500, Pension Plan Bulletins 1998-2001, Table E8.

Figure 4. Mean-variance diagram.

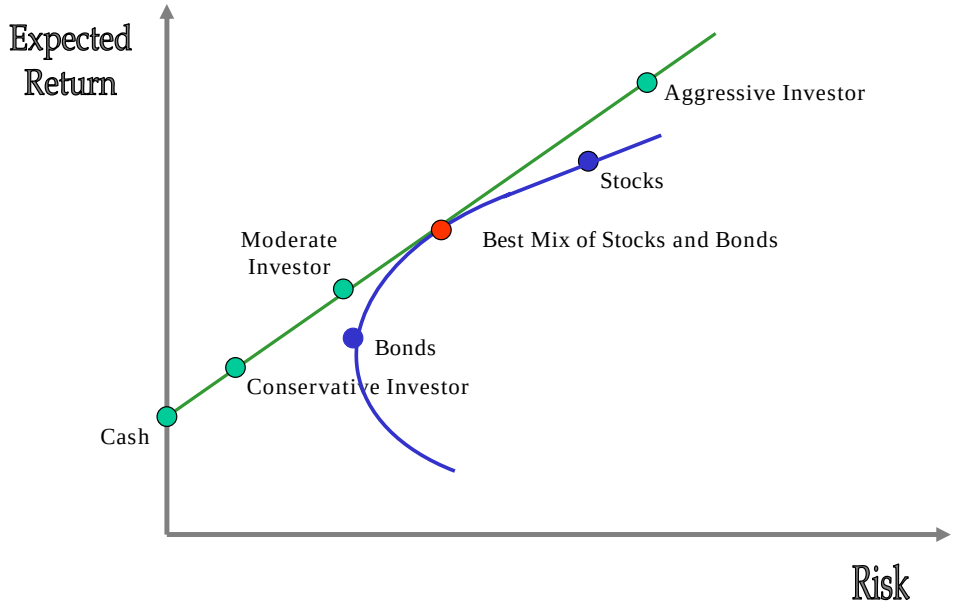


Figure 5. Annualized percent standard deviation of monthly real returns on U.S. stocks, 1959.01-2004.12.

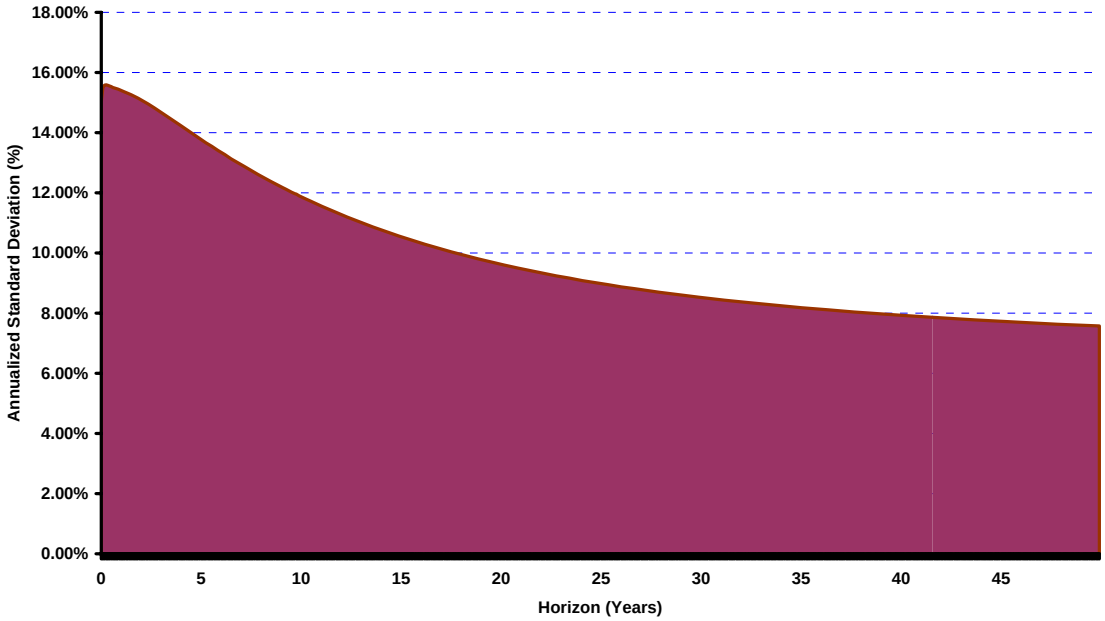


Figure 6. Spread of annualized returns at different horizons, 1926-2005. This figure plots annualized mean returns on U.S. stocks, bonds, and T-bills at horizons of 5, 10, and 20 years.

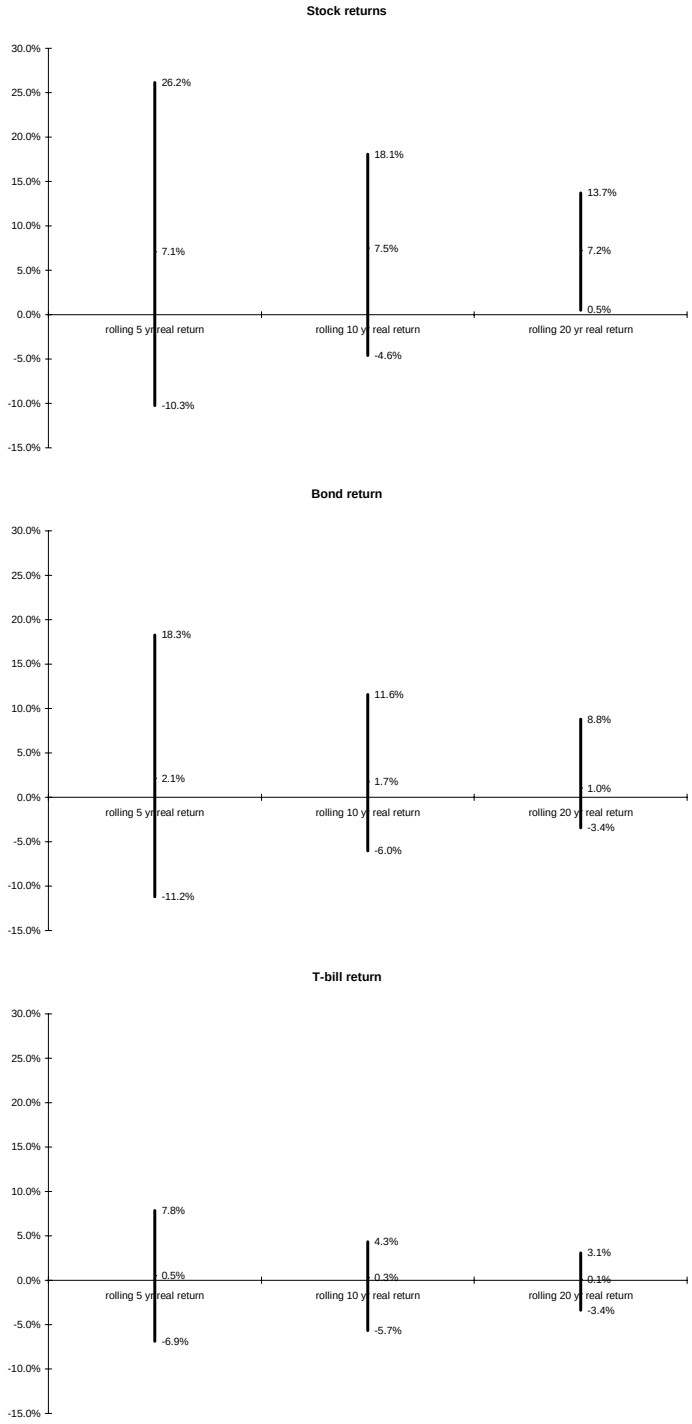
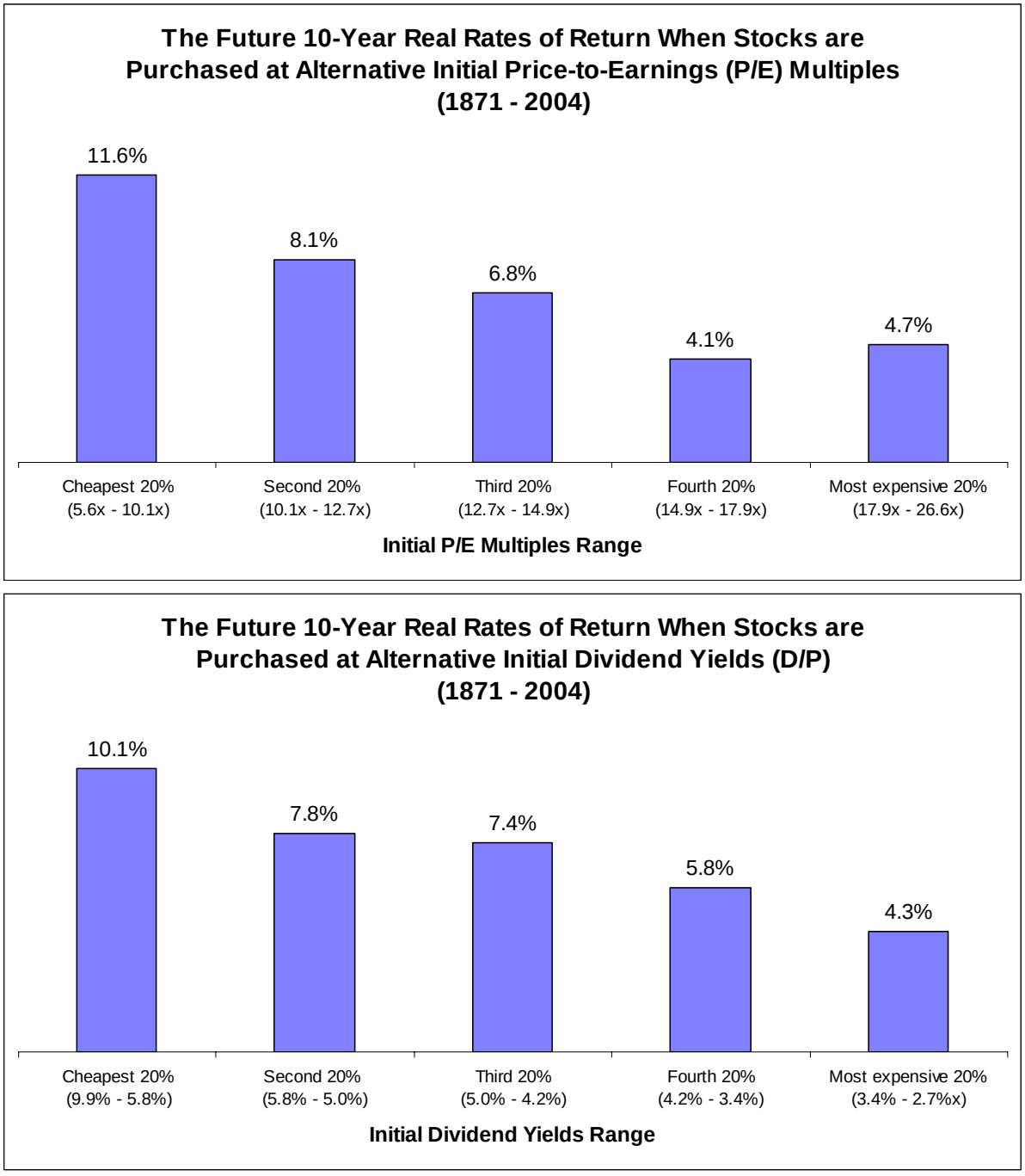


Figure 7. The empirical relation between smoothed price-to-earnings (P/E) multiples and dividend yields (D/P) and future 10-year real returns on the S&P 500, 1871-2004. P/E multiples are based on 10-year moving averages of earnings.



Source: Stock market annual data from Prof. Robert Shiller.

Figure 8. Life-cycle allocation to stocks and bonds when human wealth is riskless.

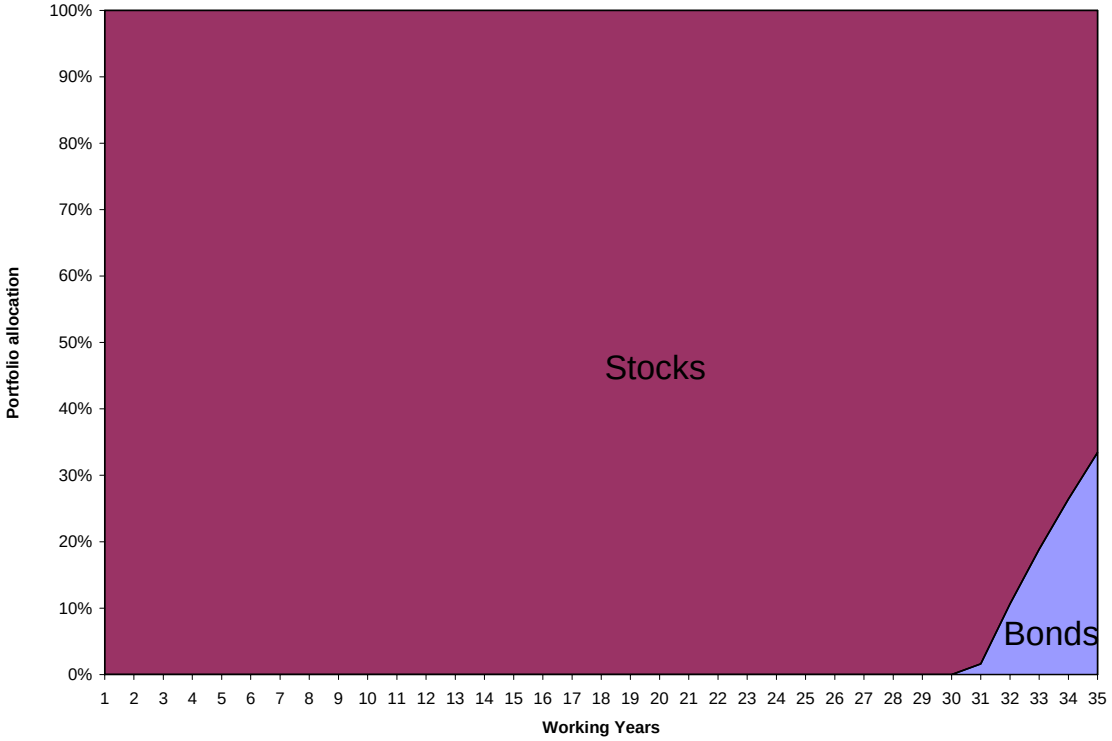


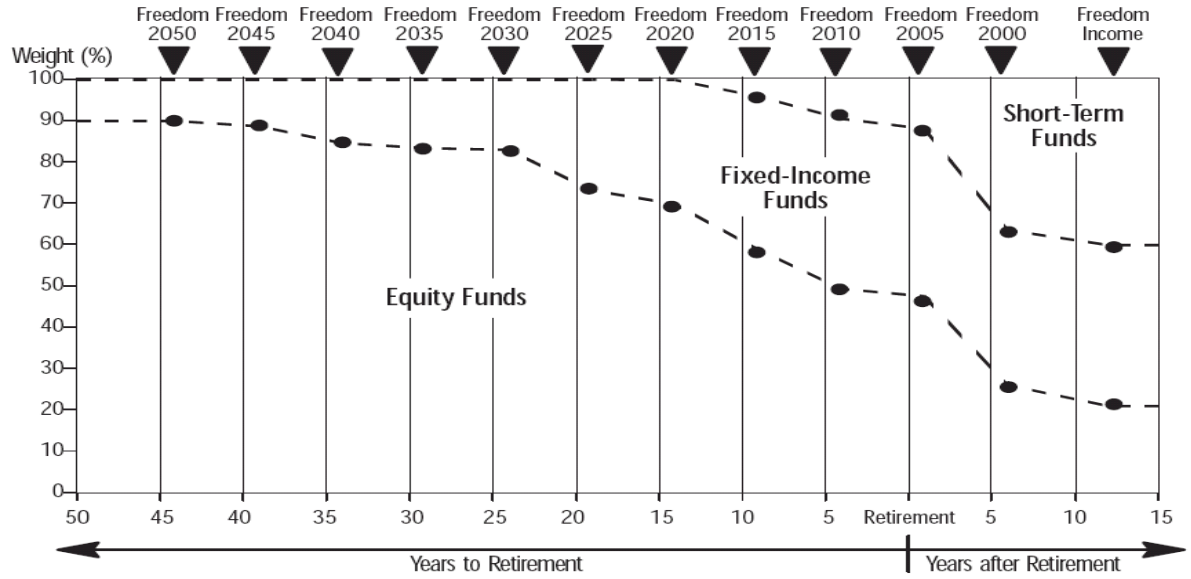
Table 1a. Fidelity Freedom Funds Asset Allocation (May 30, 2006)

		Freedom Fund										
Underlying Fidelity Fund	**Income**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Domestic Equity Funds												
Blue Chip Growth	3.0%	3.6%	5.8%	5.8%	7.2%	8.1%	8.9%	9.7%	10.0%	10.0%	10.4%	10.5%
Disciplined Equity	3.1	4.0	5.9	6.0	7.1	8.2	8.9	9.8	10.2	10.0	10.4	10.5
Equity-Income	3.1	4.0	5.9	6.0	7.1	8.3	8.9	9.8	10.1	10.0	10.4	10.5
Fidelity Fund	1.6	1.7	1.9	3.5	2.1	4.9	2.5	5.2	2.5	3.5	0.0	0.0
Growth & Income Portfolio	3.2	3.9	6.5	6.5	7.9	9.0	9.9	10.8	11.3	11.1	11.8	11.9
Fidelity Growth	2.0	2.6	3.7	3.9	4.6	5.2	5.6	6.2	6.3	6.4	6.7	6.8
Company Fund	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mid-Cap Stock	2.1	2.7	3.8	4.1	4.6	5.5	5.7	6.3	6.6	6.4	6.7	6.8
OTC Portfolio	1.6	1.9	2.9	3.0	3.6	4.1	4.5	4.9	5.0	5.1	5.3	5.4
Small Cap Growth	0.1	0.1	0.2	0.2	0.2	0.3	0.3	0.3	0.4	0.3	0.4	0.4
Small Cap Independence	0.3	0.2	0.8	0.7	1.0	1.1	1.2	1.3	1.4	1.4	1.4	1.4
Small Cap	0.1	0.1	0.2	0.2	0.3	0.3	0.3	0.4	0.4	0.4	0.4	0.4
Value Fund	0.9	0.7	2.3	1.9	2.8	2.9	3.4	3.5	3.9	3.8	5.3	5.4
Total	*21.1*	*25.5*	*39.9*	*41.8*	*48.5*	*57.9*	*60.1*	*68.2*	*68.1*	*68.4*	*69.2*	*70.0*
International Equity Funds												
Diversified International	0.0	0.2	1.9	1.9	2.6	3.0	3.3	3.7	3.9	4.1	4.9	5.0
Europe	0.0	0.2	2.7	2.6	3.6	4.2	4.4	5.1	5.2	5.5	6.8	7.0
Japan	0.0	0.1	0.8	0.8	1.1	1.2	1.4	1.5	1.6	1.7	1.9	2.0
Overseas	0.0	0.1	1.9	1.9	2.6	3.0	3.3	3.7	3.8	4.1	4.9	5.0
Southeast Asia	0.0	0.0	0.4	0.4	0.5	0.6	0.7	0.8	0.8	0.8	1.0	1.0
Total	*0.0*	*0.6*	*7.7*	*7.6*	*10.4*	*12.0*	*13.1*	*14.8*	*15.3*	*16.2*	*19.5*	*20.0*
Investment Grade Fixed Income Funds												
Government Income	13.5	13.0	12.1	12.8	10.2	7.9	6.4	3.4	2.9	1.8	5.0	5.0
Intermediate Bond	8.8	8.6	8.3	8.6	7.1	5.4	4.5	2.3	2.0	1.2	5.0	5.0

	Freedom Fund											
Underlying Fidelity Fund	**Income**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Investment Grade Bond	13.9	13.4	13.1	13.4	11.2	8.5	7.1	3.7	3.1	1.9	0.4	0.0
Strategic Real Return	1.0	0.9	2.0	1.2	2.0	1.0	1.3	0.4	0.6	0.3	0.3	0.0
Total	37.2	35.9	35.5	36.0	30.5	22.8	19.3	9.8	8.6	5.2	10.7	10.0
High Yield Fixed Income Funds												
Capital & Income	0.9	0.8	2.5	2.6	3.3	3.6	3.8	3.6	4	5.1	0.5	0
High Income	0.8	0.8	2.5	2.5	3.2	3.6	3.7	3.6	4	5.1	0.1	0
Total	*1.7*	*1.6*	*5*	*5.1*	*6.5*	*7.2*	*7.5*	*7.2*	*8*	*10.2*	*0.6*	*0*
Short Term Funds												
Retirement Money Market Portfolio	26.3	25.6	7.5	5.8	2.6	0.1	0	0	0	0	0	0
Short-Term Bond	13.7	10.8	4.4	3.7	1.5	0	0	0	0	0	0	0
Total	*40*	*36.4*	*11.9*	*9.5*	*4.1*	*0.1*	*0*	*0*	*0*	*0*	*0*	*0*

Source: Fidelity Freedom Funds Prospectus, May 30, 2006.

Table 1b. Fidelity Freedom Funds Asset Allocation Change Over Time (May 30, 2006)



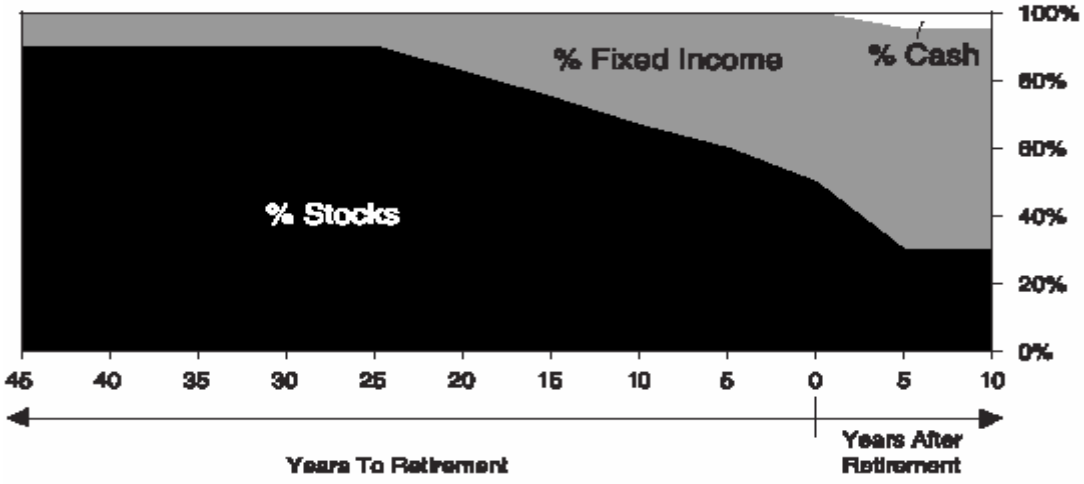
.Source: Fidelity Freedom Funds Prospectus, May 30, 2006.

Table 2a. Vanguard Target Retirement Funds Asset Allocation (June 7, 2006)

	Target Retirement Fund										
Underlying Vanguard Fund	**Income**	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Total Stock Market Index	24.0%	40.0%	48.0%	53.3%	60.0%	66.0%	72.0%	72.0%	72.0%	72.0%	72.0%
European Stock Index	3 5	5.9	7.1	7.9	8.8	9.7	10.6	10.6	10.6	10.6	10.6
Pacific Stock Index	1.7	2.8	3.3	3.7	4.2	4.6	5.0	5.0	5.0	5.0	5.0
Emerging Markets Stock Index	0.8	1.3	1.6	1.8	2.0	2.2	2.4	2.4	2.4	2.4	2.4
Total Bond Market Index	45.0	40.0	40.0	33.3	25.0	17.5	10.0	10.0	10.0	10.0	10.0
Inflation-Protected Securities	20.0	10.0	0	0	0	0	0	0	0	0	0
Prime Money Market	5.0	0	0	0	0	0	0	0	0	0	0

Source: The Vanguard Group.

Table 2b Vanguard Target Retirement Funds Asset Allocation Change Over Time (June 7, 2006)



Source: Vanguard.

Table 3. Optimal percent allocation to stocks, bonds and cash for investors with different degrees of relative risk aversion.

Relative risk aversion	Equity	Indexed	Cash	Equity	Nominal	Cash
(A) 1952-99						
1	100	0	0	100	0	0
2	100	0	0	100	0	0
5	65	35	0	73	6	21
10	32	68	0	35	8	57
5,000	0	94	6	0	10	90
(B) 1983-99						
1	100	0	0	100	0	0
2	86	14	0	87	13	0
5	38	62	0	36	64	0
10	22	78	0	19	81	0
5,000	0	93	7	1	98	1

Source: Campbell and Viceira (2002), Table 3.3.