Social Security

Policy Brief

Portfolio Theory, Life-Cycle Investing, and Retirement Income

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There has been much discussion recently about life-cycle funds and their role in providing a secure retirement income for older Americans. These funds, which gradually shift account assets from broad-based stock funds to bond funds as a participant ages, are becoming an important vehicle for retirement savings. This policy brief explores the economic rationale behind the life-cycle approach and the advantages and limitations of life-cycle funds.

Introduction

Life-cycle funds are a relatively new approach to retirement investing and have gained popularity in recent years. Although the characteristics of these funds vary, the general life-cycle proposition calls for investment portfolios that hold a decreasing proportion of assets in equities (associated with higher risk) and a greater proportion in fixed-return investments (associated with lower risk) as an individual ages. Those types of plans seek to limit potential losses from market fluctuations as an individual approaches retirement. The building blocks of life-cycle funds are typically broad-based index funds, such as a stock fund tied to the S&P 500 or to a corporate bond fund that tracks the Lehman Brothers Corporate Bond Index. Broad-based index funds lower risk to retirement income that would arise from undiversified investments in individual companies.

Life-cycle funds are an increasingly important topic in discussions about retirement income. Vanguard (2004) reports rapid growth in the number of private-sector retirement plans that offer life-cycle funds. In addition, the defined contribution plan offered to federal employees (the Thrift Savings Plan) now includes life-cycle funds. Some Social Security reform proposals call for the creation of personal retirement accounts. Such accounts would allow individuals to invest in equities, corporate bonds, and government securities and could incorporate life-cycle funds.

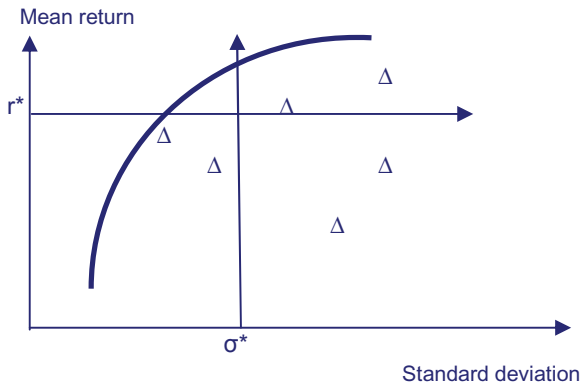
This brief explores some of the theoretical and empirical foundations for life-cycle funds by reviewing the finance literature on optimal portfolio theory. It also discusses actual life-cycle plans and the advantages and disadvantages of these types of funds.

Portfolio Theory

Modern portfolio theory originated with the work of Markowitz (1952), who recognized that by combining assets that are not perfectly correlated (for example, assets whose returns do not move in complete unison with each other) an investor could reduce his or her investment risk without reducing expected returns. It is theoretically possible to derive a portfolio of risky assets that returns the smallest amount of risk for a given return.

Repeating this procedure many times for different levels of expected return produces the *Mean-variance* or *Markowitz* efficient frontier (Chart 1). Intended solely for illustrative purposes, the chart shows individual stocks with their respective ex-ante expected mean returns and standard deviations. The standard deviation, which measures how much a stock's annual return deviates from its long-term historical average, is used as an estimate of risk or variability of investment outcomes (the standard deviation is the square root of the variance). The curved line denotes the

Chart 1.
Mean-variance efficient frontier



SOURCE: Author's derivation.

efficient frontier, which is derived by combining the individual stocks and taking into account the degree of covariation between them. In reality, thousands of triangles and a very large number of computations would be needed to determine the efficient frontier.

The implications of the efficient frontier are quite significant. All portfolios falling on this frontier will provide the highest return for a given level σ* of risk (vertical line) and, conversely, the lowest risk for a given level r* of return (horizontal line). The efficient frontier does not eliminate risk but reduces it to the lowest level possible for a given expected rate of return. Investors wanting a portfolio of stocks with low risk could choose one from the bottom left portion of the efficient frontier; those wishing to seek higher returns by taking on more risk could choose a portfolio from the upper right portion of the frontier. All points below the efficient frontier are suboptimal in the sense that investors could increase their expected rate of return without assuming any additional risk.

Although the discussion up to this point has focused on stock portfolios, the concept of an efficient frontier can be generalized to incorporate other asset types, including bonds. Bonds typically have both lower returns and lower standard deviations than stocks. Thus, in Chart 1, a bond-heavy portfolio would be located on the lower left portion and a stock-heavy portfolio on the upper right portion of the frontier. Life-cycle funds can be thought of as moving along the frontier (from the upper right to the lower left) as one ages.

Life-Cycle Funds

The life-cycle funds described here create portfolios that are heavily concentrated in stocks at the beginning of the work life and gradually shift holdings to bonds as retirement nears. While this brief primarily focuses on the decision of how to invest accumulated savings, it is important to note that investors, in reality, face a set of complex and interrelated decisions over the life-cycle. The discussion here abstracts from many of those decisions (such as how much schooling to acquire, when to begin working, how much to save each period).

Several demographic and economic factors provide some rationale for life-cycle funds. The first deals with how the value of human capital varies over time as a fraction of total wealth. Human capital is composed of elements that are fixed (innate ability), that are largely fixed after a certain point (formal schooling), and that vary with time (experience). A good proxy for measuring the value of human capital is the present value of wages over an individual's remaining working life. This is generally considered much less variable or "stochastic" than equity returns because its determinants are, to some extent, fixed. Therefore, to maintain a constant level of variability (risk exposure) over the life-cycle, relatively more of one's total financial assets should be held in stocks when young and less as one gets older (Bodie, Merton, and Samuelson 1992).

To illustrate the constant risk of exposure approach, consider someone who wishes to hold 60 percent of total wealth at any given age in riskless assets (for example, inflation-protected bonds) and 40 percent in risky assets (for example, stocks). Suppose, further, the person's human capital at a young age is equivalent to a riskless asset valued at $300,000. If the person has $200,000 in financial assets, they should all be held in risky assets (such as stocks) so that the 60/40 balance is achieved. As the person ages, the value of human capital falls (because only a few working years remain) but the financial assets grow. To maintain the 60/40 balance, financial assets must increasingly be shifted out of risky assets.

Although human capital is a determinant of the present value of lifetime earnings, it is not the only factor. Individuals have discretion over whether to work and how much to work. This issue—labor supply flexibility—is also important in discussions of life-cycle funds. Intuitively, because younger workers

have greater labor supply flexibility and have just begun their working lives, their age can act as a buffer against market downturns since additional work can make up for lost wealth. Jagannathan and Kocherlakota (1996) argue that labor supply flexibility makes life-cycle funds desirable, but only if equity returns are relatively uncorrelated with labor income. Avenues for future research (Poterba and others 2006) focus on creating life-cycle portfolios that differ for singles as opposed to married couples—an approach that takes into account the added labor supply flexibility married couples have because of the potential of having two earners. Hence, married couples might be more inclined to invest a relatively larger fraction of their wealth in stocks later in life.

The work of Jagannathan and Kocherlakota (1996) and Poterba and others (2006) examines labor supply flexibility in the specific context of life-cycle funds, while other research on the same general topic offers insight into the foundations of life-cycle funds. Bodie (2001) examines labor supply flexibility and portfolio choice in terms of retirement age. He assumes a fixed saving rate and predictable earnings, from which he determines a baseline retirement income assuming retirement at age 65 and investments in riskless Treasury securities. He then considers whether the baseline retirement income could be achieved at an earlier retirement age with alternative portfolios: one invested 50 percent in stocks and 50 percent in riskless Treasury securities and the other invested completely in stocks. If the future risk premium (the expected return on stocks minus the return on riskless Treasury bonds) is assumed to be 4 percent and the standard deviation of stock returns is 20 percent, then the portfolio with half of its assets invested in stocks and the other half invested in Treasury bonds has an expected retirement age of 61, but this comes with a small probability of having to postpone retirement to age 67 to achieve the desired level of retirement income. The all-stock portfolio has an expected retirement age of 57, but again carries a small probability of having to postpone retirement until age 68. Although Bodie's focus is on retirement age, his general point is that labor supply flexibility can offset market losses. With life-cycle funds, market losses will tend to be concentrated at relatively younger ages—ages at which health and labor market opportunities may be more favorable.

Booth (2004) finds support for life-cycle investing using a model that examines replacement rates. He argues that as the investment horizon increases, the distribution of ending wealth becomes more skewed, with the mean ending wealth being significantly greater than the median. Thus, while a younger person may need to hold only 50 percent in stocks to achieve an "expected" ending wealth (the mean distribution) that matches the replacement rate target, such a portfolio would not have a high probability of generating the appropriate ending wealth. In general, Booth argues that if individuals desire a high probability of achieving the target replacement rate, they may need to hold a greater share of their portfolio in stocks when they are younger.

Specific Approaches

This section discusses specific approaches to life-cycle investing as opposed to the general concept of holding a smaller percentage of assets in equities as one ages. Four examples of life-cycle investment approaches are considered:

- a popular rule of thumb known as the "100-minus age" rule;
- the Malkiel approach (1990);
- the Shiller plan (2005); and
- the new "L Fund" plan offered to federal employees through the Thrift Savings Plan, a defined contribution retirement plan similar to a 401(k) plan.

Clearly this is not an exhaustive list of possible life-cycle investment plans or approaches, but specific examples will help sort out ideas and illustrate important concepts.

Table 1 presents the percentage held in stocks at specific ages under the four approaches. The simplest of these approaches is the "100-minus age" rule, which dictates that the percentage invested in the stock market equal 100 minus one's age. For example, at age 55,

Table 1.
Illustrations of life-cycle fund allocations in equities, by age (in percent)

Age	100-minus age	Malkiel approach	Shiller plan	L fund (TSP)
25	75	70	85	85
35	65	60	71	75
55	45	50	26	50

SOURCE: Author's calculation.

45 percent of investments should be in a broad-based stock index fund and 55 percent in bonds. A somewhat more involved approach was suggested in Malkiel (1990). Malkiel's approach suggests stock allocations that are roughly similar to those derived from the "100-minus age" rule. The Shiller plan (2005) has a baseline life-cycle portfolio that is somewhat more aggressive at young ages and less so at later ages than is the "100-minus age" rule or Malkiel's plan.

Recently, the federal Thrift Savings Plan began to offer life-cycle products. These products, which are referred to as L funds, are based on planned retirement age rather than current age. They are composed of combinations from five underlying funds: the S fund (Wilshire 4500 index), the C Fund (S&P 500 index), the I Fund (EAFE international stock index), the G Fund (federal government bond fund), and the F Fund (Lehman Brothers U.S. bond market index). To illustrate, consider an individual born in 1980 who expects to retire after 2035 (such a person would use the L 2040 Fund). At age 25, the worker's portfolio would be composed of 85 percent stocks and 15 percent bonds. By age 55, about 50 percent of the portfolio would be held in stocks. The L Fund plan is comparable with the Shiller plan at the beginning, but the Shiller plan drops the equity component much more quickly at later ages.

Although the specific allocations of the four life-cycle approaches vary, they are roughly comparable. They specify holding a majority of assets in stocks in the early years and then shifting to bonds as retirement nears (Table 1).

Preferences

There is evidence that life-cycle investment strategies reflect people's general preferences. Several researchers have found investment behavior to be broadly consistent with the life-cycle advice. Schooley and Worden (1999), using data from the Survey of Consumer Finances, found that investors with long investment horizons lean more heavily toward stocks. Specifically, those with planning horizons of 5 or more years had roughly 50 percent of their assets invested in equities compared with less than 12 percent for those with horizons of 1 year or less. More generally, one-half of those with planning horizons of less than a year were unwilling to take any financial risk with their assets, in contrast to only 25 percent of those with horizons of over 10 years being unwilling to take any risk. One issue these results cannot address is whether they reflect inherent preferences of individuals or whether they are in response to advice given by financial planners.

Table 2.
Retirement asset allocation, by age group (in percent)

Age group	Cash	Bonds	Stocks
25–44	7	34	60
45–54	6	36	57
55–64	7	43	50
65 or older	9	55	37

SOURCE: Bodie and Crane (1997).

NOTE: Totals may not sum to 100 percent because of rounding.

Bodie and Crane (1997) found similar results for retirement asset categories. Using data from TIAA-CREF, the proportion of retirement assets held in stocks declined with age (Table 2).

The authors found a negative relationship between age and stock market investing roughly consistent with the "100-minus age" rule. To be exact, for each additional year one ages, the fraction invested in stocks declines by 0.6 percent. One caveat to interpreting these results as "age" effects is that investing preferences may change across cohorts or generations (for example, today's younger workers may be willing to accept a greater level of financial risk than previous generations).

Life-cycle products appear to be increasing in popularity. Vanguard (2004) noted that between 2000 and 2003 the number of plans offering specific life-cycle funds has more than doubled.

Limitations

Some researchers, however, have questioned whether life-cycle approaches are appropriate for retirement saving. Several research studies show that these funds still expose investors to significant risk while eliminating most upside potential. Shiller (2005) simulated ending wealth balances of hypothetical life-cycle accounts using historical data for the S&P 500 and bond market returns and found that the life-cycle fund failed to outperform a 3 percent real return in 32 percent of trials, but a 100 percent investment in the S&P 500 would have beaten such a return in 98 percent of trials.

Hickman and others (2001) simulated outcomes under Malkiel's approach, the "100-minus age" rule, and 100 percent investment in the S&P 500 index fund. Using a 30-year holding period, the two life-cycle approaches (Malkiel and "100-minus age" rule) yielded very similar outcomes and produced median wealth at retirement that was approximately one-half that associated with the index fund. However, in about 15 percent of the simulations the life-cycle approaches did outperform the S&P 500, which suggests that occasionally the shift to bonds at later ages will be a correct strategy. However, the authors question whether protection against this relatively rare outcome warrants the large reduction in expected ending wealth.

In a similar fashion, Butler and Domian (1993) simulated ending balances for stocks, bonds, and life-cycle accounts and derived probability distributions for ending wealth. Their conclusion was consistent with Hickman and others in that common stocks are the best vehicle for long-term retirement savings (life-cycle accounts outperformed a portfolio of all stocks in only about 8 percent of their simulations). Ho, Milevsky, and Robinson (1994) also emphasize the importance of stocks, arguing that higher risk/return investments may be necessary to minimize the chances of outliving one's assets in old age.

It is important to emphasize, however, that the literature on the limitations of life-cycle funds is based on historical returns and often uses data from periods when stock returns were strong. While riskless bonds may generally underperform stocks, they also protect against extremely negative outcomes (Bodie 1995). It is questionable whether the historical period for which data are available is long enough to reflect these extreme outcomes. Thus, one rationale for life-cycle funds is that they offer protection against extreme outcomes near retirement that occur with a very low probability.

Finally, some recent work questions the theoretical and intuitive underpinnings of life-cycle funds. Benzoni, Collin-Dufresne, and Goldstein (2005) argue that changes in labor income tend to be more heavily correlated with stock returns over long horizons. In other words, rather than being "bondlike" in its variability, labor income is "stocklike" over long horizons. In this framework, individuals should diversify by holding less risky assets (such as bonds) when young and riskier assets (such as stocks) at later ages. Viceira (2001) and Lynch and Tan (2004) also consider the role of labor income in optimal portfolio holdings.

Conclusion

This policy brief provides policymakers with an overview of portfolio theory and the advantages and disadvantages of a life-cycle investing approach. Portfolio theory suggests life-cycle investing can be optimal in some circumstances. Empirical work has found conflicting results. Life-cycle investing is consistent in many cases with actual portfolio choices individuals make, but some researchers question whether the protection that such funds provide against market downturns is worth the lower average returns produced by shifting assets from stocks to bonds.

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