Life-Cycle Investing in Theory and Practice
Zvi Bodie

Life-cycle investing, especially investing for retirement, is today a matter of intense concern to millions, perhaps billions, of people around the world. In the past three decades, many respected finance theorists and behavioral scientists have studied how people should and actually do make investment decisions. Theorists have produced optimization models that capture important features of reality, such as changing investment opportunities, unpredictable labor income, habit formation, and transaction costs. And at the same time, scientific studies of actual financial behavior have revealed that people consistently make certain mistakes because of lack of knowledge, faulty logic, cognitive dissonance, and biased statistics.

The new science of finance has had a profound impact on the practice of institutional risk management.\(^1\) Sophisticated enterprisewide risk-management systems are widely used today by financial service firms and a growing number of nonfinancial companies (DeLoach 2000). In comparison, applications of this new science to the important life-cycle issues households face have been limited. Online financial planning “tools” and “optimizers” lag far behind the best theory. Contemporary theory uses multiperiod hedging techniques and contingent-claims analysis, but the quantitative models routinely used by professional financial planners appear to be \textit{ad hoc} blends of trial-and-error Monte Carlo forecasting and Markowitz’s static mean–variance model of efficient portfolio diversification.\(^2\)

The aim of this article is to suggest ways to align the practice of life-cycle investing with the latest scientific knowledge. Among the important insights of modern financial science are the following:

- A person’s welfare depends not only on her end-of-period wealth but also on the consumption of goods and leisure over her entire lifetime.
- Multiperiod hedging (rather than “time diversification”) is the way to manage market risk over time.
- Portfolio managers can and should make greater use of the information about the term structure of interest rates and implied volatilities embedded in the prices of derivatives, such as swaps and options.
- The value, riskiness, and flexibility of a person’s labor earnings are of first-order importance in optimal portfolio selection at each stage of the life cycle.
- Habit formation can give rise to a demand for guarantees against a decline in investment income.
- Because of transaction costs, agency problems, and limited knowledge on the part of consumers, dynamic asset allocation will and should become an activity performed by financial intermediaries, rather than by their retail customers.

\textbf{Exhibit 1} summarizes and compares the old paradigm of life-cycle finance and the new one proposed here. The rest of the discussion will explain this exhibit.

\(^{1}\)See Bodie (1999), Merton (1998), and Meulbroek (2002).
\(^{2}\)See Markowitz (1952).
### Exhibit 1. Paradigms of Life-Cycle Finance

<table>
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<tr>
<th>Feature</th>
<th>Old Paradigm</th>
<th>New Paradigm</th>
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<tr>
<td>Measure of welfare</td>
<td>Wealth</td>
<td>Lifetime consumption of goods and leisure</td>
</tr>
<tr>
<td>Time frame</td>
<td>Single period (stocks seems safe in</td>
<td>Many periods (stocks are risky in short and long run)</td>
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<td></td>
<td>long run)</td>
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<tr>
<td>Risk management</td>
<td>Precautionary saving</td>
<td>Precautionary saving</td>
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<td></td>
<td>Diversification</td>
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<td>Hedging</td>
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<tr>
<td>Retail investment products</td>
<td>Mutual funds</td>
<td>Structured standard-of-living contracts</td>
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<tr>
<td></td>
<td></td>
<td>Targeted accounts (e.g., tuition-linked CDs)</td>
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<tr>
<td>Quantitative model</td>
<td>Mean–variance efficiency and</td>
<td>Dynamic programming and</td>
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<td></td>
<td>Monte Carlo simulation</td>
<td>contingent-claims analysis</td>
</tr>
<tr>
<td>Capital market expectations</td>
<td>Estimated from historical statistics</td>
<td>Inferred from current prices of financial instruments (swap</td>
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<td></td>
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<td>curves and implied volatilities)</td>
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</table>

### Theory of Life-Cycle Investing

The seminal work on the theory underlying this article is the “state preference” theory of optimal resource allocation under uncertainty of Arrow and Debreu (1954). In that hypothetical world of complete markets for all contingencies, every individual chooses the combination of elementary time–state claims that maximizes that individual’s expected utility.

As we know, many of those contingent claims do not exist in reality. Merton’s theory of continuous-time finance provides a link, however, from the Arrow–Debreu world to the real world through the technology of dynamic replication.3

Merton’s continuous-time model is much more general than the older Markowitz mean–variance model of portfolio choice that is at the core of most of today’s online asset-allocation tools. The Markowitz model assumes that individuals make decisions in a static single-period framework. Merton’s framework contains several distinct time horizons. The planning horizon is the total length of time for which one plans. Thus, for a 25-year-old who expects to live to age 85, the retirement planning horizon would be 60 years. As one ages, the planning horizon typically gets shorter and shorter.

The decision horizon is the length of time between decisions to revise the portfolio. The length of the decision horizon is controlled by the individual within certain limits. Some people review their portfolios at regular intervals—once a month (when they pay their bills) or once a year (when they file income tax forms). People of modest means with most of their wealth invested in bank accounts may review their portfolios infrequently and at irregular intervals determined by some triggering event, such as getting married or divorced, having a child, or receiving a bequest. A sudden rise or fall in the price of an asset a person owns may also trigger

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a review of the portfolio. People with substantial investments in stocks and bonds may review their portfolios every day or even more frequently.

The shortest possible decision horizon is the trading horizon, defined as the minimum time interval over which investors can revise their portfolios. The length of the trading horizon is not under the control of the individual. Whether the trading horizon is a week, a day, an hour, or a minute is determined by the structure of the markets in the economy (for example, when the securities exchanges are open or whether organized off-exchange markets exist).

To add realism to Merton’s model, Bodie, Merton, and Samuelson (1992) added a third choice variable—the amount of work people choose to do. In this model, individuals start out with an initial endowment of financial wealth and earning power from labor (their human capital). The market values of both components of wealth—financial and human capital—change continuously and stochastically. The wage rate (the return on human capital) is perfectly positively correlated with the market return on traded assets. Consumption, wealth, and rates of return are all denominated in units of the consumption good. At each point in time, individuals determine the amount of their consumption, the proportion of their financial wealth to invest in risky assets (versus the safe asset), and the fraction of their maximum possible labor income that they will “spend” on leisure so as to maximize their discounted lifetime expected utility.

The model’s results indicate that the fraction of an individual’s financial wealth optimally invested in equity should “normally” decline with age for two reasons. The first stems from the fact that human capital is usually less risky than equity and that the value of human capital usually declines as a proportion of an individual’s total wealth as one ages. For example, in an individual’s early years of work, his wealth is often dominated by relatively safe human capital, so to get sufficient risk in his total wealth, a large share of his financial wealth should be in risky assets.

Second, at any given age, the greater the flexibility an individual has to alter her labor supply, the greater the amount she will invest in risky assets. Individuals may be able to offset changes in the value of their financial wealth by changing the amount they work. They may have the opportunity to work longer hours, take on extra jobs, or delay retirement. If younger workers have more opportunity to alter their labor supply than older workers, the share of assets held as risky equity should decline with age.

The opposite result, however, is also possible. For people with risky human capital, such as entrepreneurs or stock analysts, the optimal path may be to start out early in life with no stock market exposure in one’s investment portfolio and increase that exposure as one ages.

Other continuous-time life-cycle models have incorporated the important effects of habit formation. Habit formation provides a strong rationale for financial products that guarantee that future consumption will not fall below a level established by prior consumption as a minimum acceptable standard of living.

Finally, transaction costs, agency costs, and cognitive limitations provide important theoretical justifications for financial intermediaries to supply user-friendly, guaranteed retail investment products that have only a small number of well-understood options. A guarantee of a minimum rate of return is a good substitute for a course in statistics.

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4 For a listing of papers, see Detemple, Garcia, and Rindishbacher (forthcoming 2002).
Beyond Mutual Funds

Most guides to personal finance recommend beginning the process of financial planning by defining goals (e.g., a comfortable retirement, paying for a child’s education). This approach suggests that a consumer demand should exist for targeted investment products that assure achieving the specific goals. An example is a college tuition account that hedges future tuition expenditures. Yet, currently, the money invested in special accounts earmarked for tuition payments is mostly in mutual funds that hold portfolio mixes of stocks, bonds, and cash. Perhaps, people do not understand the risks to which they are exposed.

For many people, the most important goal of financial planning is an adequate retirement income. In the past, one institutional response has been defined-benefit pension plans. In a typical DB plan for salaried employees, those who work for the organization sponsoring the plan their whole career receive a guaranteed life annuity that replaces 70–80 percent of their final salary. The employee “pays” for this annuity by working for the organization for a certain minimum number of years. The plan participant does not worry about the risk of a shortfall; that is the concern of the sponsor and, in the United States, the Pension Benefit Guarantee Corporation.

Traditional DB pension plans have been on the decline in the United States, eclipsed by cash-balance plans and defined-contribution (DC) plans. From a social welfare perspective, this development might actually be a step backward. Risk is being transferred to those who are least qualified to manage it. For the average participant in an employer-sponsored plan, this switch may cause a decline in welfare, even when offset by other benefits of greater monetary value.

The tendency in the last several years has been to offer participants in self-directed DC retirement plans more and more investment options. Economists generally believe that people are made better off when offered more choices, as long as they can always choose what they had before. But when people do not have the knowledge to make choices that are in their own best interests, increasing the number of choices does not necessarily make them better off. In fact, it may make them more vulnerable to exploitation by opportunistic salespeople or by well-intentioned but unqualified professionals.

An analogy with medical care might help to clarify this point. Most of us look to physicians and other medical professionals to guide our choices about health maintenance practices and treatments for illnesses. We would not be made better off if the number of alternatives increased without our understanding enough about them to make rational choices. Like surgery, asset allocation is a complex procedure requiring much knowledge and years of training. No one would imagine that you or I could perform surgery to remove our own appendix.

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6 Indeed, the College Savings Bank in New Jersey has been offering this type of product since 1987 (collegesavings.com).
7 In the United States, these accounts are called “529 accounts.” Named after the federal Internal Revenue Code section that gave these accounts special tax status, 529 accounts were specifically created for college savings. Some investment firms, such as Fidelity Investments, “age-based” portfolios for these plans. The younger the plan beneficiary, the higher the fraction invested in equities.
8 This guarantee is capped by the PBGC. Above the cap, the employee is at risk of default by the plan sponsor. For plans terminated in 2001, the cap was $40,704.60 a year. It is adjusted annually.
10 Even economists acknowledge that there are exceptions—for example, when people have problems with self-control. Adding whiskey to the choice of beverages available to a recovering alcoholic does not increase that person’s welfare.
after reading an explanation in a brochure published by a surgical equipment company. Yet, we seem to expect people to choose an appropriate mix of stocks, bonds, and cash after reading a brochure published by an investment company. Some people are likely to make serious mistakes.

Inspection of the educational materials distributed to consumers by financial service firms confirms these fears. Consumers are led to believe that stocks are not risky in the long run.\textsuperscript{11} Online asset-allocation tools are heavily biased toward equity investment. Rarely is mention made of safe inflation-protected investments such as I-bonds or TIPS (Treasury Inflation-Indexed Securities).

**New Measures of Risk and Reward.** A major side benefit of the emergence of markets for new financial instruments, such as swaps and options, is the new information these markets provide investors.\textsuperscript{12} Important examples are the term structure of interest rates that can be derived from swap curves and the term structure of implied volatilities that can be determined from option prices. This information is rarely (if ever) used in today’s online asset-allocation tools.

**Life-Cycle Financial Products.** The modern theory of contingent-claims analysis provides the framework for the production and pricing of new and improved life-cycle contracts.\textsuperscript{13} In Exhibit 2, I have identified several financial products that offer interesting new opportunities for people to achieve financial security. Some of these products are currently marketed around the world; others have yet to be brought to market.

**Exhibit 2. New Life-Cycle Products**

<table>
<thead>
<tr>
<th>Accumulation Phase</th>
<th>Retirement</th>
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<tbody>
<tr>
<td>Occupational funds</td>
<td>Escalating annuities</td>
</tr>
<tr>
<td>College account</td>
<td>Bundled-risk annuities</td>
</tr>
<tr>
<td>Real estate account</td>
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</table>

I would like to focus on the two “Retirement” opportunities—escalating annuities and bundled-risk annuities.

**Escalating life annuities.** Traditional annuities in the United States, including those provided by DB plans have a glaring defect—namely, they are not protected against inflation. Today, financial intermediaries can efficiently produce annuities that are protected fully or partially against inflation by hedging the liability with TIPS (Bodie 1990, 1997). Moreover, annuities can be combined with upside participation in the performance of various stock market indexes. As an example, consider an escalating life annuity with a minimum benefit linked to the cost of living. Payments increase with inflation and with the performance of a market index, and increases are locked in for life.

Escalating annuities conform to the new paradigm laid out in Exhibit 1. They are designed to provide a guaranteed minimum standard of living defined in terms of a flow of lifetime consumption (rather than a stock of wealth). They allow retirees to gradually increase their consumption if the stock market performs well without jeopardizing the standard of living.

\textsuperscript{11} See Bodie (1995).
\textsuperscript{12} On the informational role of financial market prices, see Bodie and Merton (1995).
\textsuperscript{13} See Merton (1992) for a detailed analysis of the connection between contingent-claims analysis and optimal lifecycle consumption and portfolio policies.
to which the retirees have become accustomed. Note that this approach is very different from a **variable** annuity benefit, which can go either up or down over time, depending on market performance.

To make the example more concrete, let’s assume that a typical customer reaches age 65 with $1 million in his self-directed retirement account. He wants to retire and live off his income from Social Security (say $15,000 a year) and the income generated by his $1 million retirement account. How would a hypothetical escalating annuity work in this case?

One simple design would be to allow the annuitant to choose the fraction of his $1 million that would go into the guaranteed real annuity. Assume he chooses 90 percent, which establishes a guaranteed real floor of $55,000 a year. Together with his Social Security income, this annuity gives him a real income floor of $70,000 a year. The other $100,000 in his retirement account he could invest in equities or equity derivatives to produce growth in real income. Each year, part of this risky fund would be used to purchase additional guaranteed real annuity income.

The upside leverage of the escalating annuity could be increased by investing the $100,000 at risk in a series of equity call options maturing in each of the next 10 years. If, on the annual expiration date, the call is in the money, the proceeds would be used to increase the guaranteed income floor. If it is out-of-the-money, the floor would remain unchanged for another year.

Currently, exchange-traded options have maturities as long as three years. Firms that sell structured equity participation securities, such as Merrill Lynch & Company’s Market Index Target Term Securities (known as “MITTS”), have issued notes with maturities of 10 years. It is not hard to imagine that innovative firms might issue even longer-dated index call options over the counter.

**Bundled risk annuities.** Research shows that retired people do not voluntarily annuitize much of their wealth. One reason may be that they believe they need to hold on to assets in case they need nursing home care. Annuities, once bought, tend to be illiquid, so buyers cannot readily access the cash if they need to pay for nursing home bills. In fact, increased life expectancies in the United States have coincided with increased health care costs near the end of peoples’ lives, so the specter of needing two to three years of long-term care figures prominently in many discussions of retirement planning.

An integrated instrument could help solve this problem by combining a life annuity with long-term care insurance. Combining the coverage mitigates the adverse selection that occurs in the demand for each of the two products on a stand-alone basis.

**Changing Delivery Systems.** As products and services for addressing the financial risks of retirement change, so also do the varieties of institutions available to provide support to the elderly. Today, many diverse retirement income systems coexist around the world, each relying in varying proportions on one or more of the following institutional forms:

- support from family or community,
- pension plans sponsored by employers and/or labor unions,
- social insurance programs run by governments,
• personal savings in the form of real and financial assets—equity in one’s home or business, savings accounts, insurance contracts, mutual funds, and so on.

Many experts agree, however, that the mix of these institutional forms will change significantly in the next few years. Change is particularly to be expected in the industrialized countries, such as the United States, the United Kingdom, Australia, Western Europe, and Japan, where the rapid aging of the population reflects both that people are living longer and that they are having many fewer children. In these economies, people will find they can rely less on family and government support than in the past and must, instead, turn to financial markets and related institutions by saving and investing for their own retirement. Even in emerging markets, new demographic and economic realities have prompted the beginning of widespread retirement system reforms, as seen in the pension reform movements of Latin America, Eastern Europe, and more recently, Asia.

In response to global population aging and financial deregulation, governments and financial firms are seeking to create new institutions and services that will provide the desired protection against the financial consequences of old-age, illness, and disability and will insulate people against both inflation and asset price fluctuations. New opportunities are to be expected for older persons to continue employment, perhaps on a part-time basis, and to convert their assets, particularly housing wealth, into spendable income.

For better or for worse, these developments mean that people are being given more individual choice over their own asset accumulation and drawdown processes. As these new financial instruments transfer more responsibility and choice to workers and retirees, the challenge is to frame risk–reward trade-offs and cast financial decision making in a format that ordinary people can understand and implement.
References


