1-1-2002

An Analysis of Investment Advice to Retirement Plan Participants

Zvi Bodie
Boston University

An Analysis of Investment Advice to Retirement Plan Participants

Abstract

This chapter examines the investment advice currently provided to participants in self-directed retirement plans (401k, 403b, etc.) by financial service firms and investment advisory services. It finds much of the advice to be logically flawed and dangerously misleading. There exists a strong bias in favor of investing retirement savings in the stock market without insurance against a market decline. The paper concludes that in view of the limited ability of the general public to handle the complex task of investing for retirement, financial firms will have to design safer products with a small number of choices that are easily understood.

Disciplines

Economics

Comments

The published version of this Working Paper may be found in the 2003 publication: *The Pension Challenge: Risk Transfers and Retirement Income Security*.

The Pension Challenge

Risk Transfers and Retirement Income Security

EDITED BY

Oliva S. Mitchell and Kent Smetters

OXFORD
UNIVERSITY PRESS

Part I

Plan Sponsors and Retirement Income Risk

Chapter 2

An Analysis of Investment Advice to Retirement Plan Participants

Zvi Bodie

Around the world, the primary responsibility for providing an adequate retirement income has been shifting from governments, employers, and trade unions, to individuals. Pension plans are shifting from the defined benefit form to defined contribution, in which plan participants must make investment decisions. Evidence abounds that people consistently make certain mistakes because of lack of knowledge, faulty logic, cognitive dissonance, and biased statistics. This chapter examines the quality of the online investment education materials and advice offered at websites designed specifically for people planning for retirement. The first section of the chapter titled "Time Horizon and Risk Tolerance: The Trouble with Online Advice" analyzes the content of these websites, and it concludes that much of the advice offered there is misleading and potentially quite harmful. The second section titled "Defined Benefit, Defined Contribution, and Individual Choice" considers what might be done to improve the advice and to develop better investment products.

While there are significant differences in the level of technical sophistication among the websites and optimization tools, their qualitative advice is strikingly uniform.[1] The educational materials at these websites generally agree on the following set of principles for investing money earmarked for retirement:[2]

- Investors should diversify their total portfolio across asset classes, and the equity portion should be well-diversified across industries and companies.
- The longer your time horizon, the more you should invest in equities.

Table 2-1 summarizes some of the key findings from an examination of the major websites.[3]

Time Horizon and Risk Tolerance: The Trouble with Online Advice

In Economic theory provides no necessary connection between a person's time horizon and his risk tolerance. Thus, one can have a horizon of 30 years

TABLE 2-1 Retirement Investment Advice in Websites

Issue	Quicken	Smart Money	mPower (Money Central)	Financial Engines
Does the fraction in stocks automatically increase with time horizon?	Yes	Yes	No	No
Is there a risk-free (e.g. TIPS or I-bonds) option?	No	No	No	No
Is there any mention of different stock market forecasts of experts?	No	No	No	No

Source: Author's survey.

and be extremely averse to risk, or a horizon of 1 year and be very tolerant of risk. Indeed, for utility functions that exhibit constant relative risk aversion (CRRA), Merton (1969, 1971) and Samuelson (1969) have shown that the proportion of total wealth optimally held in risky assets is the same regardless of age. Their models show that very risk-averse people should choose to invest in such a way as to minimize the volatility of their lifetime consumption flow. If a risk-free lifetime annuity is available, then they should purchase it.

AQ: Merton 1971 is not listed

Stocks for the Long Run

Yet the standard advice offered by the financial services industry is that a longer time horizon implies greater risk tolerance.[4] For example, *Smart-Money University* puts it this way:

Where to invest your retirement savings shouldn't be that complicated. It depends largely on a single factor: time. The more time you have before you plan to retire, the more aggressively you should be invested in equities. If, as for many people, the stock market makes you nervous, check out *Time vs. Risk* for an interactive demonstration of why this simple axiom holds true in good times and bad. History shows quite clearly that equities are your best long-term investment option.[5]

A popular rule of thumb says that the fraction of one's portfolio to invest in stocks should be 100 minus one's age. Using this rule, 70 percent of one's investments should be in stocks if one is 30 years old; 30 percent should be in stocks if one is 70. The reasoning behind this advice goes as follows:

stocks' year-to-year volatility make them poor choices to finance short-term goals: For example, stocks' spectacular 1995 return of 37.6 percent (as measured by the S&P 500) compares with the low 1994 return of 1.3 percent. But, over longer periods of

time, fluctuations like these have tended to settle down—as you can see in the chart. Stock returns for twenty-year periods ranged from a low of about three percent to a high of around 17 percent. Over thirty-year periods, stock returns narrowed, ranging from 8.5 to 13.5 percent. That's why, although investing in stocks is hardly risk-free and past results certainly don't guarantee future performance, their historical pattern suggests that stocks may be an appropriate alternative for you to consider if your goal is a longer-term one.[6]

Unfortunately, this reasoning is invalid, and it may also be dangerously misleading. The apparent reduction in risk is a statistical illusion arising from the fact that the measure of return used is an average compound rate. As students of introductory statistics are taught, the dispersion of an n-year average declines, as n grows.[7] But the dispersion of the average compound rate of return is not a relevant parameter for the purpose at hand. For a person investing a lump sum now to have, say, $1 million in 30 years time, the relevant parameter is not the dispersion of the annual rate of return, but the dispersion of the value of the portfolio in 30 years. The dispersion of long-term holdings does not fall with time.

This same mistake is often made in educational materials depicting the trade off between risk and reward (the "efficient portfolio frontier") for different time horizons. Using mean and standard deviation of average compound rates of return, the slope of the curve gets steeper as the time horizon lengthens, implying that equities are a better choice, the longer one's horizon. But this is because the expected annualized risk premium remains fixed, while the annualized standard deviation declines: again, a statistical illusion.[8]

The financial advice in the websites that report probability of success or failure as their summary measure are also misleading, but in a more subtle way. To see why, compare the *probability* of a shortfall with the *cost of insuring* against a shortfall.[9] A shortfall occurs if the value of a stock portfolio at the horizon date is less than the value an investor would have received by investing in safe bonds (e.g. Treasury bonds) maturing on that same date. If, as history suggests, the *expected* average compound return on stocks exceeds the risk-free rate of interest, it is indeed true that the probability of a shortfall declines with the length of the investment time horizon (Figure 2-1). But this fact does not have the favorable implications many investment advisers think it has.

The Truth about the Risk of Stocks in the Long Run

The simple economic fact is that there is no "free lunch" for the long-term investor in the risk-reward department. The probability of a shortfall is a flawed measure of risk because it completely ignores the *severity* of the financial loss should a shortfall occur.[10] A measure that does take proper
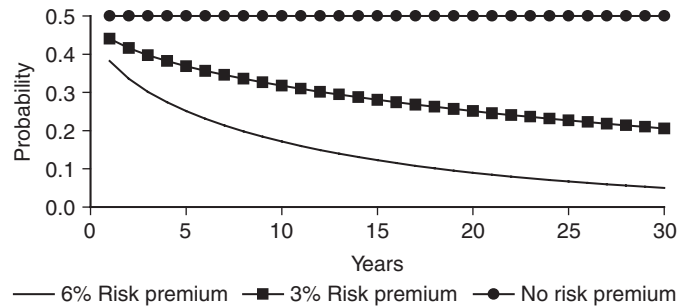
Figure 2-1. Probability of a shortfall. (*Source:* Author's computations.)
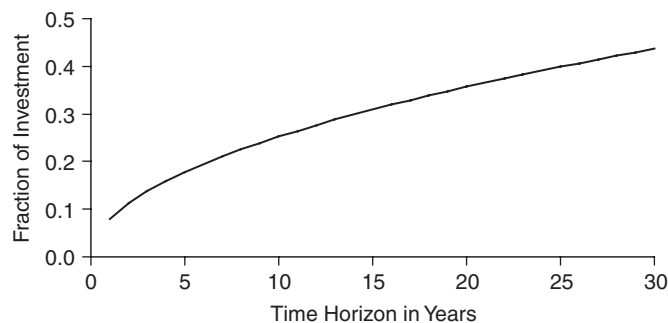
Figure 2-2. Cost of shortfall insurance. (*Source:* Author's computations.)

account of both the likelihood *and* the severity of a potential shortfall is the price an investor would have to pay to insure against it.

If stocks were truly less risky in the long run, then the cost of insuring against earning less than the risk-free rate of interest should decline as the length of the investment horizon increases. But reality is quite the opposite. The structure of insurance against shortfall risk is effectively a put option with maturity equal to the investment horizon and with a strike price set at the forward price of the underlying stock portfolio.[11] According to theory and in actual practice, the put price representing the cost of insuring against a shortfall *increases* as the investment horizon lengthens. (See Figure 2-2.)

This pattern is easily confirmed for maturities up to 3 years by inspection of prices for exchange-traded puts on individual stocks and on broad stock-index portfolios. The same result holds uniformly for proprietary pricing models used by investment and commercial banks to assess their own cost for longer-maturity puts that they sell over the counter. For very long maturity puts, this cost ranges from one-third to a half of the value of the equity portfolio to be insured and so there is typically little commercial interest.

In short, the insurance cost, and hence the risk, of shortfall over long time horizons is anything but small (see Bodie, 1995; LaChance and Mitchell, Chapter 8, this volume).

The Importance of One's Earnings Profile

Clearly the conventional reasoning linking age and equity investing is fundamentally flawed, but there are good reasons for linking age and portfolio mix. A critical, but often overlooked, determinant of optimal asset allocation is the risk profile of the individual's future labor income. Typically the ratio of future labor income to other assets (such as retirement savings) is large when investors are young, and eventually it decreases as they approach retirement.

If one's future labor income is relatively secure, it might be optimal to start out in the early years with a high proportion of one's investment portfolio in stocks, and decrease it over time as suggested by the conventional wisdom. However, this conventional wisdom may *not* apply to those who face substantial risk in their labor income: entrepreneurs or stock brokers, for example, whose income is highly sensitive to stock market risk. For such investors, their human capital already provides a large stock market exposure and the *opposite* policy may be optimal, that is, to start out with a relatively low fraction of the portfolio in stocks and increase it over time.[12]

The Conservative Investor

To assess the strength of the pro-equity bias at websites for retirement plan participants, I performed a simple test by adopting the stance of an ultraconservative investor to see if there was any mention of risk-free investments such as inflation-protected bonds. When asked questions designed to elicit my risk tolerance, I answered them in such a way as to indicate as little tolerance as possible for risk of any kind. In theory, the financial advice should result in a portfolio designed to minimize the volatility of my lifetime consumption. If all post-retirement consumption is to be financed from accumulated savings, then the portfolio should consist entirely of fixed-income securities denominated in units of the consumption good.

Unfortunately, in *none* of the many models I tested did this ever turn out to be the case. Instead, I was always advised to invest a substantial fraction of my portfolio stocks (at least 30 percent). This was true even when I notified the advice program that I was starting my retirement. As shown in the next section, retirees who are drawing down their retirement savings to finance their spending face special risks when they invest in equities.

The Situation of Retirees

Most websites emphasize the fact that people may live a long time after they retire. The average male retiring at 65 can expect to live 19 more years,

TABLE 2-2 Drawdown of Retirement Fund Assuming 10% Per Year Rate of Return

Year	Rate of Return (%)	Amount in Fund ($)	Interest Earned ($)	Amount Withdrawn
1	10	1,000,000	100,000	117,460
2	10	982,540	98,254	117,460
3	10	963,335	96,333	117,460
4	10	942,209	94,221	117,460
5	10	918,970	91,897	117,460
6	10	893,407	89,341	117,460
7	10	865,288	86,529	117,460
8	10	834,358	83,436	117,460
9	10	800,334	80,033	117,460
10	10	762,907	76,291	117,460
11	10	721,739	72,174	117,460
12	10	676,453	67,645	117,460
13	10	626,638	62,664	117,460
14	10	571,843	57,184	117,460
15	10	511,567	51,157	117,460
16	10	445,264	44,526	117,460
17	10	372,331	37,233	117,460
18	10	292,105	29,210	117,460
19	10	203,856	20,386	117,460
20	10	106,781	10,678	117,460
21		0	0	

Source: Author's computations.

to age 84. The average woman retiring at age 65 can expect to live 23 more years, to age 88. Therefore, the reasoning goes, one should remain substantially committed to stocks even after one retires.

This advice is especially problematic, however, because during retirement one is drawing down one's assets. The resultant standard of living will depend not only on the *average* rate of return one earns during retirement, but also on the *time path* of returns. Even if the average rate of return is high, one can run out of money long before one expires. For example, suppose one planned to save a total of $1 million, expecting to live for 20 years after retirement, and assume an average rate of return of 10 percent per year.[13] The annual retirement income to be withdrawn is calculated to be $117,496 per year. Table 2-2 shows that by withdrawing this amount at the end of each year, the original fund will be exhausted in precisely 20 years, *provided that one earns 10 percent in each and every year.*

But suppose that the rate of return varied over the 20 years. Even if the average is 10 percent per year, it makes a big difference whether

TABLE 2-3 DrawDown of Retirement Fund When Rate
of Return during First 10 Years Is Zero

Year	Rate of Return	Amount in Fund ($)	Interest Earned ($)	Amount withdrawn at end of year ($)
1	0	1,000,000	0	117,460
2	0	882,540	0	117,460
3	0	765,081	0	117,460
4	0	647,621	0	117,460
5	0	530,162	0	117,460
6	0	412,702	0	117,460
7	0	295,242	0	117,460
8	0	177,783	0	117,460
9	0	60,323	0	117,460
10	0	−57,137	0	117,460

Source: Author's computations.

the higher-than-average returns occur early or late in the 20-year span. Suppose that during the first 10 years your rate of return is below average and during the last 10 years it is above average. One might not make it past the 10th year. For example, suppose the rate of return is zero in the first 10 years, and 20 percent per year in the last 10 years. Since the fund would earn no interest at all during the first half of the period, one would completely run out of money by the 9th year, as shown in Table 2-3 and in Figure 2-3.

This is not merely a far-fetched hypothetical situation. Suppose that in January 1973 a retiree had a fund of $1 million. The average rate of return on a value-weighted portfolio of all stocks on the NYSE during the 20 years starting in 1973 was a healthy 12.78 percent per year. Suppose the retiree was conservative and assumed only a 10 percent rate of return, thus taking out $117,460 each year. The pattern of actual annual returns and remaining funds is shown in Table 2-4 and depicted in Figures 2-4 and 2-5.

Let's take a detailed look at what could have happened. The stock market declined 14.75 percent in 1973, so at the end of the year only $852,500 was left. After taking out $117,460, only $735,040 was left. In 1974 the market dropped another 26.5 percent, reducing the account balance to $540,990. At the end of 1974, he again took out $117,460, leaving a new account balance of $423,530. In other words, by the end of 1974, he had less than half of the original $1,000,000 left, even though he only took out a total of $234,920. In 1975 the market gained 37.2 percent, lifting his balance to $581,337. After withdrawing $117,460, the balance was $463,878. In 1976
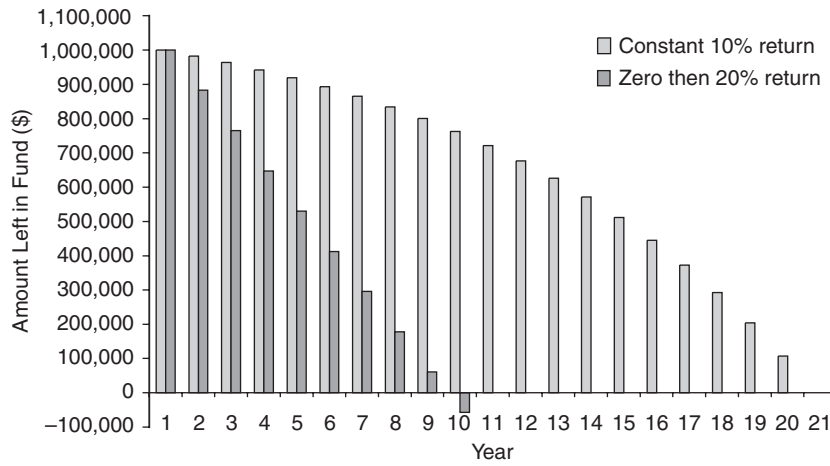
Figure 2-3. How long will $1 million last? (*Source*: Author's computations.)

TABLE 2-4 Actual Values for Retiree Starting in 1973

Year	Rate of Return (%)	Amount in Fund ($)	Interest Earned ($)	Amount Before Withdrawal ($)	Amount Withdrawn ($)
1973	−14.75	1,000,000	−147,500	852,500	117,460
1974	−26.40	735,040	−194,051	540,990	117,460
1975	37.26	423,530	157,807	581,337	117,460
1976	23.98	463,878	111,238	575,116	117,460
1977	−7.26	457,656	−33,226	424,430	117,460
1978	6.50	306,971	19,953	326,924	117,460
1979	18.77	209,464	39,316	248,780	117,460
1980	32.48	131,321	42,653	173,974	117,460
1981	−4.98	56,514	−2,814	53,700	117,460
1982	22.09	−63,760	−14,085	−77,844	117,460

Source: Author's computations.

the market climbed 23.8 percent, raising the balance to $575,116, from which he again took $117,460, leaving a balance of $457,656. The next year, 1977, was a bad year with a market return of −7.2 percent. The account balance declined to $424,430, from which he withdrew $117,460, and so on. By the time he reached 1981, he had only $56,514 left in the fund. That year his return was −4.98 percent and he could no longer take out $117,460 to live on. Thus we see that even though *on average* from 1973 through 1992
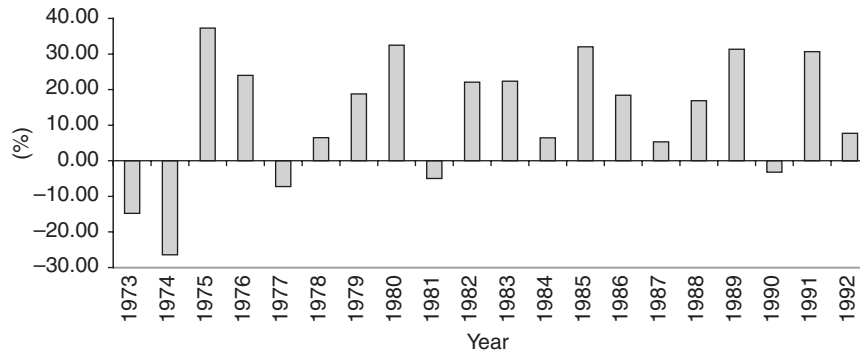
Figure 2-4. Rate of return on New York Stock Exchange. (*Source*: Wharton research data services <http://wrds.wharton.upenn.edu>.)
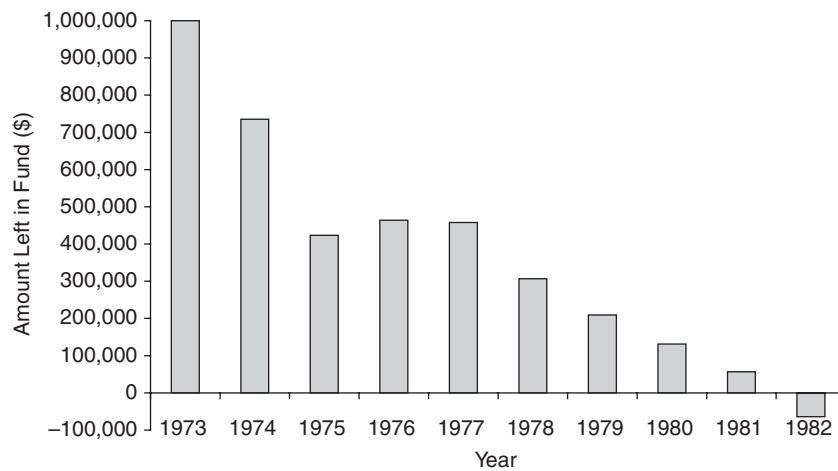
Figure 2-5. Funds remaining for retiree who started withdrawing in 1973. (*Source*: Author's computations.)

the market returned a rate of return of 11.3 percent per year, and he had been counting on only 10 percent per year, he ran out of money before the 10th year.

Matters would have been even worse for a retiree in Japan. The Japanese market reached its peak in 1989, just over 40,000 on the Nikkei 225, its major stock index. It then plunged to about 12,000, and despite temporary recoveries, it has remained depressed ever since.

Differences of Opinion among Expert Forecasters

How will the US stock market perform over the next 10 years? Even the experts cannot agree. The *New York Times* (September 2, 2001) reported that Robert Shiller and Jeremy Siegel, two finance professors who specialize in analyzing the stock market, had strikingly different market forecasts. Shiller argued that the US stock market was vastly overvalued, and he predicted generally poor performance until share prices realign themselves with "fundamental" values. Siegel disagreed. If the experts cannot even agree about the *mean* rate of return on stocks over the next decade, then it is reasonable to conclude that even a well-diversified stock portfolio is a risky investment.

Another piece of conventional wisdom holds that one should invest in stocks because they are a good hedge against inflation. In fact, the evidence is that stocks are not a good hedge against inflation. The decade of the 1970s was the only prolonged period in the past century when the United States experienced significant inflation, and that is precisely the period when stocks did poorly.[14]

Defined Benefit, Defined Contribution, and Individual Choice

One institutional response to the difficulties faced by ordinary people in managing their own retirement funds has been defined benefit (DB) pension plans. In a typical DB plan for salaried employees, those who work for the organization sponsoring the plan over their whole careers receive a guaranteed life annuity that replaces 60–70 percent of final salary.[15] The employee "pays" for this annuity by working for the organization for a certain minimum number of years. Plan participants do not worry about the risk of a shortfall, since this is the concern of the sponsor and in the United States, the Pension Benefit Guaranty Corporation (PBGC).[16]

But traditional DB pension plans have been on the decline in the United States, eclipsed by cash-balance plans and defined contribution (DC) plans, which transfers the risk to those who may be least qualified to manage it.[17] For the average participant in an employer-sponsored plan, the switch to self-directed pension plans might therefore 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 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.[18] But if people do not have the knowledge to make choices that are in their own best interests, increasing the number of choices may not necessarily make them better off.

In fact, it could make them more vulnerable to exploitation by opportunistic salespeople or by well-intentioned, but unqualified, professionals.

An analogy with medical care may 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 probably not be 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 patients could perform surgery to remove their own appendices after reading an explanation in a brochure published by a surgical equipment company. Yet prevailing practice seems to expect employees to choose an appropriate mix of stocks, bonds, and cash after reading a brochure published by an investment company. Some of them are likely to make serious mistakes, and the educational materials distributed to retirement plan participants by financial service firms confirms these fears. Participants are led to believe that stocks are not risky in the long run. Online asset allocation tools are heavily biased toward equity investment. Rarely is mention made of truly safe long-term investments, such as government inflation-protected bonds and real annuities.

Protection Against a Market Decline

Starting with the emergence of exchange-traded options and the discovery of the option pricing model in 1973, a variety of financial service firms have been selling investment products that offer protection against a stock market decline.[19] In Germany it seems likely that insured equity-linked retirement saving products will become the norm, as a result of the pension reform legislation passed in 2001. A key feature of Germany's pension reform is that to qualify for state subsidies, all savings vehicles must carry a guarantee of principal.[20]

Escalating Life Annuities

The modern theory of contingent claims analysis provides the framework for the production and pricing of new and improved retirement income products with protection against both market declines and the risk of outliving one's resources.[21] Let me illustrate using the example of a class of contracts that I call "escalating annuities."[22]

Traditional annuities in the United States, including those provided by DB plans have a glaring defect: they are not protected against inflation. Today it is possible for financial intermediaries to efficiently produce annuities that are protected fully or partially against inflation by hedging the liability with inflation-protected government bonds.[23] Moreover, they can also 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 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 to which they have become accustomed. Note that this is very different from a variable annuity benefit, which can either go up or down over time depending on market performance.

To make the example more concrete, let us assume that a typical customer reaches age 65 with $1 million in his self-directed retirement account. He seeks to retire and live off his income from Social Security (say $15,000 per year) and the income generated by his $1 million retirement account. How would a hypothetical escalating life annuity work? 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, and that this establishes a guaranteed real floor of $55,000 per year.[24] Together with his Social Security income, this gives him a real income floor of $70,000 per year. The other $100,000 in his retirement account would be invested 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.[25]

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, then the proceeds are used to increase the guaranteed income floor. If it is out of the money, the floor remains unchanged for another year.

Currently, exchange-traded options have maturities as long as 3 years. Firms that sell structured equity participation securities 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.

Conclusions

Increasingly, the complex problem of investing so as to provide a secure retirement income is being transferred from governmental institutions and private sector employers to people who lack the knowledge and the training to handle the risk. As we have seen, the educational materials and investment advice provided to those people by financial service firms is often dangerously misleading. One practical solution to the dangers posed

for individuals and for society at large is to design and produce a new generation of investment products that insure people against severe market declines. Advances in the science of finance and market innovations over the past several decades have made this a feasible task.

Notes

[1] A major distinction is between websites that give advice in terms of from three to five generic asset categories and those that give more specific recommendations based upon the user's actual holdings. Some use a Markowitz efficient portfolio frontier analysis. The more sophisticated websites, such as *Financial Engines* or *mPower*, simulate probability distributions of retirement wealth or retirement income.

[2] See Bodie and Crane (1997) for a more complete statement of generally accepted investment principles. Ameriks and Zeldes (2001) report a similar finding.

[3] My survey was done during the month of December 2001.

[4] *Financial Engines* was the only exception.

[5] See <http://university.smartmoney.com/Departments/Investing101/RiskvsReward/index.cfm?story=timevsrisk>.

[6] Taken from TIAA-CREF "Principles of Sound Investing."

[7] The variance of the annualized rate of return declines with the length of the holding period as long as there is no perfect positive serial correlation in stock returns. Empirically stock returns exhibit either no serial correlation or negative serial correlation. See in Bodie, Kane, and Marcus (2002), pp. 254–256

[8] See Merton (1992) for a demonstration that characterizing rates of return solely in terms of mean and variance is valid only when the time interval is extremely short and there are no big "jumps."

[9] See Bodie (1995).

[10] The term *severity* as used here is meant to capture not just the *magnitude* of a shortfall but also its *weight* in terms of its Arrow-Debreu state-claim price. For a detailed discussion of this point see Bodie (2002).

[11] Bodie (1995).

[12] See Bodie, Merton, and Samuelson (1992).

[13] This example is taken from Bodie and Clowes (2003).

[14] See Bodie (1976).

[15] The employer-provided benefit is typically integrated with Social Security benefits, and the combination of the two replaces roughly 70 percent of earnings only for those at the bottom of the income scale.

[16] 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 per year. It is adjusted annually.

[17] The AFL-CIO writes: "Defined benefit plans remain the best and soundest vehicles for building and safeguarding retirement income and security." <www.aflcio.org/publ/estatements/feb2002/governance.htm>.

[18] But even economists acknowledge that there are exceptions, for example, when people have problems with self-control. Offering a shot of whiskey to a recovering alcoholic does not increase his welfare.

[19]For a discussion of such products, see Bodie and Crane (1999) and Maurer and Schlag (Chapter 9 this volume).

[20]Deutsche Bank has already structured principal-guaranteed transactions of funds and mixed equity, and fixed-income portfolios. <www.risk.net/investor/archive/oct01/pension.htm>.

[21]For a discussion of the many other risks of old age that can be addressed with innovative financial products, see Bodie, Hammond, and Mitchell (2002).

[22]Dybvig (1995) uses the term "ratcheting" to describe this time-pattern of consumption.

[23]See Bodie (1990, 1997).

[24]This is an approximation based on quoted rates on Lincoln National Life's Inflation-Proofer annuity.

[25]I am assuming that the worker has no bequest motive.

References

Ameriks, John and Stephen Zeldes. 2001. "How Do Household Portfolio Shares Vary With Age?" TIAA-CREF Institute Working Paper. <www.tiaa-crefinstitute.org>.

Bodie, Zvi. 1976. "Common Stocks as a Hedge against Inflation." *Journal of Finance* May: 459–470.

——. 1990. "Inflation Insurance." *The Journal of Risk and Insurance* 57(4) 634–645.

——. 1995. "On the Risk of Stocks in the Long Run." *Financial Analysts Journal* May–June: 18–22.

——. 1997. "Inflation-Protected Retirement Plans." In *Managing Public Debt: Index-Linked Bonds in Theory and Practice*, eds. Marcello De Cecco, Gustavo Piga, and Lorenzo Pecchi. Edward Elgar Publisher, pp. 33–49.

——. 2002. "Life-Cycle Finance in Theory and in Practice." Boston University School of Management Working Paper.

—— and Michael Clowes. 2003. *Worry-Free Investing: A No-Risk Approach to Achieving Your Lifetime Financial Goals.* New York, NY: Financial Times/Prentice Hall.

—— and Dwight B. Crane. 1997. "Personal Investing: Advice, Theory, and Evidence." *Financial Analysts Journal* 53 (November–December): 13–23.

————. 1999. "The Design and Production of New Retirement Savings Products." *Journal of Portfolio Management* 25 (January–February): 77–82.

——, P. Brett Hammond, and Mitchell, Olivia S. 2001. "New Approaches to Analyzing and Managing Retirement Risks." *Benefits Quarterly* 17(4): 72–83.

——, Alex Kane, and Alan Marcus. 2002. *Investments*, 5th edn. McGraw-Hill Irwin.

——, R. C. Merton, and W. Samuelson. 1992. "Labor Supply Flexibility and Portfolio Choice in a Life-Cycle Model." *Journal of Economic Dynamics and Control* 16: 427–449.

Dybvig, Philip H. 1995. "Dusenberry's Ratcheting of Consumption and Investment Given Intolerance for any Decline in Standard of Living." *Review of Economic Studies* 62: 287–313.

Merton, Robert C. 1969. "Lifetime Portfolio Selection Under Uncertainty: The Continuous-Time Case." *Review of Economics and Statistics* 51 (August): 247–257.

——. 1992. *Continuous-Time Finance*, revised edn. Oxford: Basil Blackwell.

Samuelson, Paul A. 1969. "Lifetime Portfolio Selection by Dynamic Stochastic Programming." *Review of Economics and Statistics* 51 (August): 239–246.