Monitoring Retirement Portfolio Sufficiency

by Patrick J. Collins, Ph.D., CLU, PFP, Kristor J. Lawson, CFP, and Jon C. Chambers

In designing a retirement portfolio, the prudent financial advisor conducts a thorough analysis of the client's needs and objectives. This analysis generally includes

- Determination of the client's projected retirement income needs, on a current dollar (inflation-adjusted) basis
- Identification of assets earmarked for the retirement portfolio and any expected future additions to the portfolio
- Identification of the client's preferred retirement date and pattern of expected post-retirement distributions, to determine the time period available for asset accumulation and growth
- Assumptions regarding future inflation rates
- Estimation of the client's post-retirement life expectancy, to determine the period over which the retirement portfolio must provide an income stream

TABLE 1

Year	Investment	Rate of Return
1	$5,000	-7%
2	$10,000	-10%
3	$15,000	+4%
4	$20,000	+32%
5	$25,000	+16%
5-year total	$75,000 investment	$104,507 ending dollar value

TABLE 2

Year	Investment	Rate of Return
1	$25,000	-7%
2	$20,000	-10%
3	$15,000	+4%
4	$10,000	+32%
5	$5,000	+16%
5-year total	$75,000 investment	$106,985 ending dollar value

Based on this information, the advisor estimates how well the projected asset accumulation will support targeted retirement income needs. If this analysis indicates a future shortfall, the advisor generally suggests revisions to the client's retirement portfolio, such as

- Changing asset allocation strategies to increase expected return
- Increasing the rate of savings
- Postponing the planned retirement date
- Reducing retirement income expectations

Paradoxically, this traditional approach to retirement planning often fails, even when assumptions about inflation and return prove accurate. Even a well-designed portfolio, operating within expected parameters, and approximating over the long run its statistically expected return, runs the risk that its actual dollar value at some critical juncture will differ widely from the projected value.

This two-part article will examine how this paradox is often overlooked by financial advisors and advocates the need for regular monitoring of the portfolio to determine whether corrective actions need to be taken to ensure a sufficient end wealth. In Part I, we illustrate how the ending dollar value can vary significantly, positively or negatively, from the targeted dollar accumulation, despite an annual rate of return that may fall well within portfolio parameters. In Part II, which will appear in the April 1997 issue of the *Journal*, we will discuss how to implement a retirement portfolio sufficiency monitoring program loosely based on the Financial Accounting Standard Board's ruling number 87, used for monitoring defined-benefit pension plans.

The Retirement Portfolio Sufficiency Paradox

The portfolio sufficiency paradox springs from a variety of sources. Most obvious is the pernicious and unpredictable effect of inflation on the purchasing power of accumulated wealth. Second, there may be a confusion between the compounding of investment returns over time and the compounding of investment wealth. A simple example may suffice to illustrate possible sources of confusion: suppose that over a five-year period you made a series of investments at the beginning of each year. The pattern of investment dollars and returns is as shown in Table 1.

Over the five-year period, a total investment of $75,000 grows to $104,507. The internal rate of return—that is, the measure that best characterizes how your real wealth grows—was 14.55 percent. However, if you had reversed the pattern of investments over the five-year period, your results would have looked quite different, as seen in Table 2.

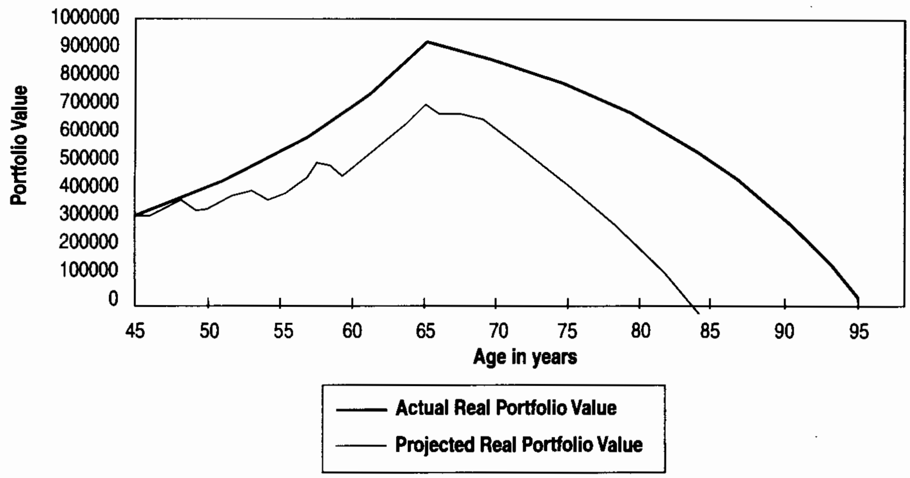
The aggregate investment of $75,000 grows to $106,985. Although the dollar value of the portfolio is greater under the second cash flow pattern, the dollar-weighted internal rate of return of 9.97 percent is less. If your expected return had been, say, ten percent, you might (paradoxically) have been pleased with the result of the first return series, even though you had built less wealth. Despite the fact that $75,000 grows to a larger sum in the second pattern of cash flows, the compound return is less because, in this case, the larger sums of money were committed at an earlier period and, initially, suffered a decline in value. Additional confusion may arise if a client tracks the underlying investment performance of the portfolio. The time-weighted rate of return calculates how an investment performed, irrespective of the timing of cash flows:[1]

In this case, we are interested in evaluating how well the investment performed as opposed to how fast the dollars accumulated in the account. In Table 3, the investment, independent of the amount and timing of cash flows, earned only a 5.92-percent rate of return.

Although the example illustrates how the vagaries of investment cash flows can mask mediocre performance,

CHART 1

Projected and Actual Retirement Income Portfolio (with no Sufficiency Monitoring Adjustment)a



Projected and Actual Retirement Income Portfolio

Age	Actual Portfolio Return	Actual Inflation	Actual Real Portfolio Value	Projected Real Portfolio Value
45	N/A	N/A	300,000	300,000
46	7.00%	4.50%	307,177	317,308
47	12.00%	5.20%	327,033	335,614
48	21.00%	5.90%	373,663	354,976
49	-11.00%	3.50%	321,314	375,456
50	4.00%	2.10%	327,294	397,117
51	13.00%	3.90%	355,959	420,027
52	14.50%	6.00%	384,503	444,259
53	12.50%	7.20%	401,720	469,890
54	-3.00%	8.40%	359,473	496,999
55	14.00%	9.50%	374,246	525,672
56	11.80%	5.20%	397,725	555,999
57	18.40%	7.40%	438,460	588,076
58	17.40%	5.10%	489,774	622,023
59	-5.60%	3.80%	445,420	657,888
60	12.30%	4.10%	480,506	695,843
61	14.00%	3.20%	530,792	735,988
62	11.00%	3.90%	567,064	778,449
63	14.00%	4.50%	618,615	823,359
64	9.00%	5.10%	641,570	870,861
65	13.00%	2.70%	705,914	921,103
66	7.50%	4.10%	663,970	909,244
67	14.20%	3.20%	669,742	896,700
68	12.50%	4.10%	658,785	883,433
69	13.80%	5.20%	647,740	869,400
70	12.10%	6.40%	617,335	854,557

Age	Actual Portfolio Return	Actual Inflation	Actual Real Portfolio Value	Projected Real Portfolio Value
71	6.20%	2.30%	575,870	838,859
72	7.40%	4.20%	528,555	822,255
73	8.10%	3.40%	487,580	804,692
74	11.80%	7.10%	443,977	786,117
75	12.00%	2.30%	421,075	766,470
76	8.10%	3.20%	376,067	745,689
77	7.40%	4.10%	322,989	723,710
78	12.30%	3.70%	284,775	700,462
79	9.40%	3.50%	236,008	675,874
80	7.50%	4.20%	178,483	649,864
81	14.90%	5.10%	130,125	622,359
82	23.80%	1.50%	93,714	593,264
83	9.40%	3.40%	34,152	562,491
84	7.20%	4.10%	N/A	529,942
85	14.80%	5.20%	N/A	495,916
86	11.20%	6.10%	N/A	459,103
87	9.40%	4.10%	N/A	420,590
88	8.70%	2.80%	N/A	379,854
89	13.40%	3.40%	N/A	336,769
90	14.80%	4.20%	N/A	291,198
91	8.20%	5.20%	N/A	242,998
92	9.50%	4.10%	N/A	192,017
93	12.50%	3.80%	N/A	138,095
94	8.40%	5.10%	N/A	81,062
95	14.80%	3.40%	N/A	20,739

the converse is also true—good investment performance can be hidden because of the timing of contributions and withdrawals. Depending on what performance measure is being tracked by the client or the client's advisor, the portfolio may seem woefully off track or marvelously ahead of schedule.

A third source of possible confusion lies in the fact that, often, it is the *arithmetical* average (expected average) investment return that is compounded in order to project ending wealth over multi-period horizons. However, the accumulation of dollars within the nest egg is determined by the *geometric* compounding of actual returns. Obviously, it is no good telling an investor he has averaged +25 percent a year when he did so by losing 50 percent the first year and gaining 100 percent the second, to end up where he started. Less obvious is the fact that the multi-period compounding of arithmetic averages may raise the performance measurement bar too high for real-world portfolios, which compound geometrically. A portfolio that experiences, for example, a 10-percent loss in a year must achieve a return of approximately 11 percent in the following year just to recoup those losses.

A final source of confusion regarding measurement of retirement portfolio sufficiency lies in the fact that the longer the investment horizon, the further the portfolio can wander from its expected dollar value despite the fact that it is approaching its expected return. Buffeted by market volatility, many investors have taken comfort that the Law of Large Numbers ensures that, over time, average annual returns will approach ever more closely the returns they expect. That this supposition is true (so far, as Samuelson[2] points out, we have only one history of capitalism to go on) does not mean anyone should take comfort in it. The Law of Large Numbers may pan out for all investors, but not for every investor. The future dollar value of each portfolio is determined by the unique and unpredictable *pattern* of compounded returns and inflation it suffers. The longer the period over which this pattern can exercise its effects, the greater the potential divergence of the portfolio from its expected—that is, its required—future value. This fact, if unattended, can destroy a retirement.

TABLE 3

Year	Investment	Rate of Return
1	$5,000	-7%
2	$10,000	-10%
3	$15,000	+4%
4	$20,000	+32%
5	$25,000	+16%
5-year total	$75,000 investment	+5.92%

Consider the following hypothetical portfolio, established for a 45-year-old planning to retire at age 65:

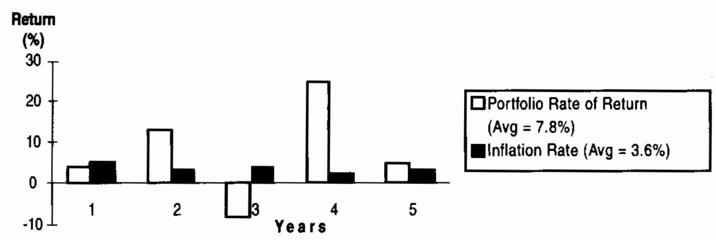
1. Current investment assets earmarked for the retirement income portfolio is $300,000.
2. Upon retirement, systematic annual distributions from the portfolio will provide the majority of spendable income.
3. Current health condition, family history, age of spouse and so forth indicate that it is reasonable to plan for a 20- to 30-year payout horizon.
4. Portfolio allocation is based on the expectation of a long-term rate of return of ten percent at the selected level of risk.
5. Inflation is expected to average four percent.
6. At retirement, the investor will withdraw $65,000 a year (before tax) on an inflation-adjusted basis from the portfolio.

The investor has engaged a financial advisor who explains that real ("nominal" or "reported" returns, net of the current inflation rate) rates of return are most important when building a portfolio for generating retirement income. The advisor demonstrates that a $300,000 portfolio returning a real 5.77 percent a year (this is the real rate of return assuming 10-percent nominal returns and 4-percent inflation[3] will grow to $921,000 in constant dollars over the next 20 years. The advisor also demonstrates that a $921,000 portfolio at age 65 will permit withdrawals of $65,000 a year for a period of 30 years if it continues to earn a real rate of return of 5.77 percent a year. The advisor's projections are listed in Chart 1, in the column titled "Projected Real Portfolio Value." The investor implemented the portfolio in accordance with the advisor's recommendations, and carefully tracked both nominal portfolio returns and actual inflation rates over time.

The investor was fortunate that the actual rates of both return and inflation were extremely close to the advisor's projections. Over the 50-year period, inflation was slightly higher than expected, averaging 4.2 percent a year. However, portfolio rates of return were also slightly better than expected, averaging 10.6 percent a year, thus providing an average real rate of return of 6.14 percent a year. Thus, the investor expected that his portfolio would support a constant dollar distribution of $65,000 a year from the portfolio. Unfortunately, as indicated in the following table and graph, the portfolio was entirely depleted 18 years after retirement.

What went wrong? The portfolio experienced worse-than-expected performance in the fourth and fifth years, from which it never recovered. Although the portfolio's *average* real performance exceeded both the advisor's projections and the investor's expectations, the *pattern* of the portfolio's real performance generated a gap between the portfolio's projected and actual value that was neither detected nor corrected.

CHART 2
Actual Porfolio Performance



Portfolio sufficiency monitoring provides a structured methodology for determining how well a portfolio is performing relative to projections. Sufficiency monitoring also includes several approaches for corrective action if the retirement portfolio's variance from projections becomes sufficiently large.

After some further discussions and examples outlining the academic and accounting rationale behind the portfolio sufficiency monitoring concept, we will return to this example to investigate how a sufficiency monitoring program could have identified and corrected the shortfall in this hypothetical portfolio.

Monitoring Retirement Portfolio Sufficiency

An effective retirement portfolio sufficiency monitoring system provides clients with the information necessary to determine how well their retirement portfolios are doing relative to their specific *personal* objectives. It is a method that periodically tests whether the money on hand will be enough to fund projected future expenses. It therefore differs from investment performance monitoring.

Performance Monitoring Versus Sufficiency Monitoring

In contrast to portfolio sufficiency monitoring, we define investment performance monitoring as

- Tracking and reporting the rates of return of each specific investment for a given period (year-to-date, annually, return from portfolio inception.)
- Tracking and reporting the rates of return for the aggregate portfolio (each investment's return weighted for the proportion of the portfolio that the investment represents)
- Tracking and reporting the rates of return according to the most appropriate calculation formats (annualized average returns, compounded internal rate of return, time-weighted rate of return)
- Tracking and reporting com-

parative data for investment performance (performance relative to comparable investments, indexes, composites, benchmarks, and so forth)

While investment performance monitoring provides important insights, it does not address the question that lies at the heart of the entire investment process: namely, is my portfolio doing well enough that, after inflation, I will have the money to pay taxes and buy the goods and services I will need to support my retirement lifestyle objectives? The key components of portfolio sufficiency monitoring are

- Adjusting nominal performance results for inflation
- Establishing benchmarks for performance objectives
- Setting triggers for reevaluation of the portfolio when it wanders too far from established benchmarks
- Monitoring and adjusting portfolio risk to maximize the probability of meeting retirement portfolio objectives

In summary, investment performance monitoring answers the question: *Is my retirement portfolio performing well relative to other portfolios?* Portfolio sufficiency monitoring answers the question: *Will I have sufficient assets to meet my retirement income needs?*

To further illustrate the issue of portfolio sufficiency monitoring, consider the following example:

1. Investor, age 60, plans to retire in five years.
2. Current investment assets earmarked for the retirement income portfolio amount to $1 million.
3. Upon retirement in five years, systematic annual distributions from the portfolio will provide the majority of spendable income.
4. Current health condition, family history, age of spouse, and so forth indicate that it is reasonable to plan for a 25-year payout horizon.
5. Portfolio allocation is based on the expectation of a long-term rate of return of ten percent at the selected level of risk.
6. Allocation is based on expected yearly variability in portfolio returns between -20 percent to +40 percent at the 95-percent confidence level (that is, a standard deviation of ±15 percent).
7. Inflation is expected to average four percent.
8. At retirement, the portfolio owner will withdraw $80,000 a year (before tax) on an inflation-adjusted basis from the portfolio.

Measuring Success

The answer to the question, "How well is the client doing?" is traditionally addressed by comparing the targeted return with the actual return. Let us assume that, five years from inception, our sample portfolio has experienced exactly the expected ten-percent average annual return. Will this knowledge suffice?

Perhaps—but only if inflation has matched the expected four percent throughout the five-year period. The chance that inflation will remain constant over 60 months is, of course, nil. Thus, it is shortsighted to examine only nominal returns. Prudence dictates the analysis of real returns, that is, returns net of inflation.

Interpreting Performance Results

Suppose this sample investor's portfolio experiences performance results over the five-year period, as illustrated in Chart 2:

A number of queries may be reasonably made:

- Should the investor be concerned about the underperformance of the portfolio relative to its expected long-term return?
- Does the fact that inflation has averaged a full ten percent less than expected make up for the shortfall in nominal returns? Is the investor better off on a relative basis because inflation was less than expected?
- Given the year-to-year performance results, the actual dollar value at the end of five years amounts to $1,419,054 instead of the originally expected $1,610,510. How large must the shortfall become before it threatens the investor's ability to retire at the targeted income level?
- When yearly withdrawals are made from the portfolio, how can the investor ensure that the remaining funds will be sufficient for the full 25-year distribution period?
- If the portfolio is off track, should the investor simply give it more time? If so, how much more time? At what point should the portfolio be reevaluated? What are the options for corrective action?

Although the correct answers to these questions are not usually apparent, they are crucial. A lifetime of work and savings could unravel because the investor did not receive portfolio sufficiency monitoring data specific to his or her unique economic situation and objectives.

Why Not Annuitize?

After contemplating the complexity of constructing a retirement portfolio, the rational investor might question

CHART 3
Distribution of Rate of Return on S&P 500 Porfolio

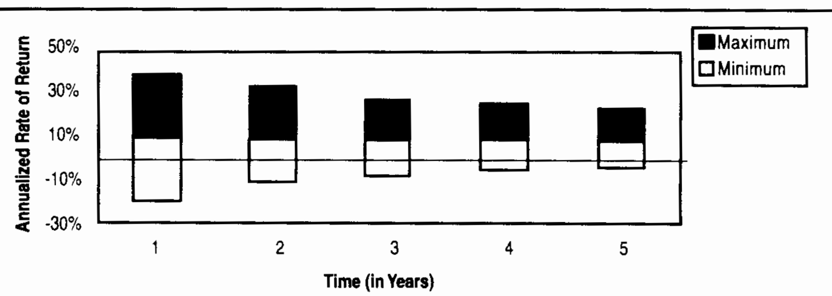
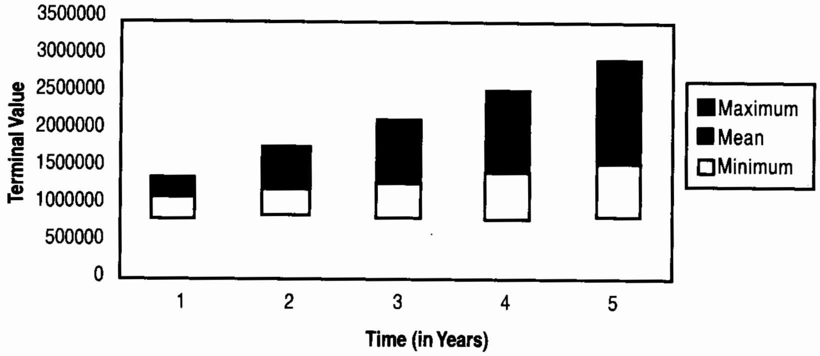


CHART 4
Distribution of Terminal Value of S&P 500 Porfolio



whether it might be preferable to purchase a life annuity from an insurance company. The annuity offers several apparent advantages, including

- Guaranteed lifetime income during the distribution phase (including benefits payable to the investor's beneficiary, if this option is selected)
- Guaranteed fixed rates of return during the accumulation phase

However, the annuity imposes numerous costs and risks. Costs include sales charges and loads and investment management fees. Risks include

- The risk that future inflation will erode the purchasing power of the fixed monthly annuity distribution payment
- The risk that the rate of return on the annuity will be insufficient to generate adequate assets to fund the investor's retirement income objectives
- The risk that the insurance company may default on its obligation to pay annuity benefits

For investors with sufficient accumulated assets to fund their retirement income needs, with enough of a cushion to cover expected future inflation during the distribution phase, an annuity may be a rational approach to minimizing risk in the portfolio. However, for investors requiring real growth in their investment portfolio, purchase of a fixed annuity is not a viable option.

Monitoring Portfolio Risk

Risk has many definitions for investment management. In a retirement portfolio, the investor's primary risk is that the portfolio will not last through retirement. That is to say, he defines risk as the possibility that he will either attain his desired retirement age with fewer (inflation-adjusted) dollars than expected, or deplete his funds earlier in the retirement period than he had anticipated.

Defining Portfolio Risk: Time and Volatility

This risk is inherent in portfolios of risky assets.[4] The value of risky assets is necessarily uncertain at any given time—including retirement age. Although it is possible to determine a portfolio's statistically expected return, its actual value at any time is a function of the expected return and chance (sometimes expressed as standard deviation).

How large is the chance error likely to be? The mathematics of the answer depend on two inputs: (1) the amount of time over which the portfolio operates and (2) the degree of variability in year-to-year investment returns. The first input is the investor's planning horizon, and the second input is the portfolio's spread of possible returns (standard deviation) around its expected return (mean).

Additional Time Increases Risk

According to the law of averages, the size of the chance error (the amount of a shortfall or windfall of dollars in the portfolio) increases with the planning horizon, even if the standard deviation remains constant. Fortunately, the increase in the chance error increases only by the square root of time. Thus, the possible chance error grows slowly over time. Lengthening the time horizon from 1 year to 100 years increases error by a factor of 10, ($\sqrt{100}$) rather than by a factor of 100.[5]

Nevertheless, it is important to remember the following:

1. The probability that the actual dollar value of a portfolio will deviate from projected dollar value either positively or negatively *increases* over time.
2. This is the case, even though the portfolio's average long-term rate of return converges with the expected rate of return established when the portfolio was originally implemented.
3. This is the case, even though the portfolio is well designed and operates within expected parameters.

If the investor monitors portfolio performance solely by determining whether the investments stay within certain rate-of-return guidelines, he or she may well miss some troubling storm clouds on his retirement horizon.[6] Alternatively, if the investor simply compares actual portfolio values with projected nominal values, the investor may mistake the forces operating upon the portfolio and take inappropriate structural (asset allocation) actions.[7] In any event, informed portfolio sufficiency monitoring is the key to assuring the integrity of the investor's retirement.

Rate of Return Convergence Versus Terminal Value Divergence

Consider the case of our sample investor, who has a somewhat risky portfolio, with returns and year-to-year volatility comparable with an investment in the S&P 500. Despite the fact that the expected range for the annualized rate of return narrows over time, the expected range for the terminal value (the assets available to fund retirement income needs) diverges over time (the variability *increases*). Charts 3 and 4 illustrate ranges for portfolio rates of return and terminal portfolio value, both reported at the 95-percent confidence level.

Note that the range of expected returns narrows over time, while the range of terminal values increases over time. After five years, there is roughly a 2.5-percent chance that the actual portfolio value could be as high as $3,022,815 and a 2.5-percent chance that it could be as low as $858,063.

Thus, although the *relative* deviation of terminal wealth from expected wealth increases with the length of the investment period and with the variability of investment returns, the *absolute* dollar uncertainty of risky assets diminishes greatly over lengthy horizons. After a sufficiently long planning horizon, the question becomes not if an equity portfolio will outperform a risk free asset, but rather, by how much it will surpass the risk free return. ■

Endnotes

1. Specifically, the percentage returns of the investment are multiplied together and then raised to the power of $1/n$, where n is the number of measurement periods.
2. The fallacy of using the Law of Large Numbers as a justification for an all-equity portfolio to maximize the geometric mean of terminal wealth is discussed in a more comprehensive manner in "The Long-Term Case for Equities (And How it Can Be Oversold)," Paul A. Samuelson, *The Journal of Portfolio Management* (Fall 1994), pp. 15–24.
3. The formula for calculating real rates of return is

$$i_r = \left(\frac{[1+.i_n]}{[1+CPI]}-1\right)100$$

where i_r = real rate of return and i_n = nominal rate of return

4. See, for example, "What Practitioners Need to Know...About Time Diversification," Mark Kritzman, *Financial Analysts Journal*, January/February, 1994: "The notion that above-average returns tend to offset below-average returns over long horizons is called time diversification. Specifically, if returns are independent from one year to the next, the standard deviation of annualized returns diminishes with time. The distribution of annualized returns consequently converges as the investment horizon increases...Although it is true that the annualized dispersion of returns converges toward the expected return with the passage of time, the dispersion of terminal wealth also diverges from the expected terminal wealth as the investment horizon expands."
5. Investment in risky assets makes uncertain the actual number of dollars that will be available to spend in the future. As an example, we can examine a portfolio with a 10-percent expected return and a standard deviation of 15 percent. Statistically, there is a 95-percent probability that, at the end of year one, the actual investment results will encompass a two standard deviation range (15% x 2) of -20 percent to +40 percent. If we invested $100,000, our expected return after one year is $100,000 (1.10) or $110,000. However, the possible upper and lower values are

upper value =
$$\$100{,}000[1+.10][1+2(.15)] = \$143{,}000$$

lower value =
$$\$100{,}000\frac{[1+.10]}{[1+2(.15)]} = \$84{,}615$$

Note that the lower value is 23 percent less than expected value ($84,615 ÷ $110,000). The percentage value 23 percent is substantially higher than the 15-percent standard deviation of annual returns. What happens if we project possible results over a 20-year planning horizon? From the law of averages, we know that the average deviation of the rate of return will decrease with the square root of time. Specifically:

Standard Deviation of the average rate of return =

$$\frac{\pm 15}{\sqrt{20}} = 3.35$$

For our $100,000 investment the expected return after 20 years equals $\$100{,}000(1.10)^{20}$ or $672,750. The limits of the range of values at the 95-percent probability level equals

upper value =
$$\$100{,}000[1+.10]^{20}[1+2(0.0335)_{20}]^{20} = \$2{,}461{,}172$$

lower value =
$$\$100{,}000\frac{[1+.10]}{[1+2(0.335)]^{20}} = \$183{,}892$$

Time *decreased* risk in the sense that no money was lost—$100,000 worst case became $183,892 after 20 years, despite the fact that the worst one-year case projected a possible loss of more than 15 percent. Time *increased* risk in the sense that the worst-case long-term return is only 27.3 percent of the amount of dollars that we expected to have in the portfolio. After 20 years of compound growth in the portfolio, we have approximately 73-percent fewer dollars to spend than the amount we anticipated. For a discussion of chance error, see *Statistics* by D. Freedman, R. Pisani, R. Purves and A. Adhikare, Second Edition (New York: W.W. Norton & Company, 1991). For a discussion of how the Law of Large Numbers applies to risk and investment portfolios, see "The Long-Term Case for Equities," Paul A. Samuelson, *The Journal of Portfolio Management* (Fall 1994), pp. 15–24.

6. It is sometimes suggested that investment portfolios that tend to produce year-to-year returns equal to or in excess of the investor's required long-term return may be preferred to investments that have a greater propensity in any given year to drop below the required return. The measurement of investment risk considers only deviations in performance that are below the targeted long-term return. "Shortfall" is, therefore, measured not in terms of the ongoing accumulation of inflation-adjusted wealth, but rather in terms of the number of times a portfolio's returns fall below the minimum acceptable return (with the severity of each of the shortfalls weighted by squaring the deviation). In actuality, the "shortfall" measurement gauges the likelihood for and severity of interim tracking errors. It does not provide insight into the probability (ex ante) of achieving required returns over the investor's planning horizon [see, for example, A. Dimarzio, T. Ritter and D. Haire, "An Alternative Perspective on Investment Performance," *Journal of Financial Planning* (July 1993), pp. 129–133.] Conversely, much useful research has been done in the interrelationships between the mathematics of statistical distributions based on ex-post data and the probability of achieving future returns equal to or in excess of specified targets [see, for example, an especially valuable methodology for calculating, at various confidence levels, cumulative shortfall probabilities over a multi-period planning horizon developed by C. Garcia, F. Gould and D. Mitchell, in the appendix to "The Historical Validity of Shortfall Estimates," *The Journal of Portfolio Management* (Summer 1992), p. 41. For additional insight into the probability of distributions of multi-year returns and the implications for investors who pursue strategies to increase wealth in worst-case scenarios—maximize the minimum—over various holding periods, see W. Reichenstein and D. Dorsett, *Time Diversification Revisted* (The Research Foundation of the Institute of Chartered Financial Analysts: Charlottesville, Virginia, 1995)].
7. We assume that the asset allocation decision at the time the portfolio is established reflects the mix of risk-free and risky assets that optimized the portfolio—that is to say, that enabled the portfolio owner to achieve the rate of return necessary to produce targeted income at the level of risk appropriate for the investor's economic objectives and personal circumstances. If the variability (risk) of Treasury bills is zero and their expected return exceeds the rate of return required to generate cash for the retiree, then the optimal position of the portfolio is 100-percent T-bills. If the portfolio's required rate of return exceeds the expected return from T-bills, then the owner must risk some percentage exposure (from 1 percent to 100 percent of the portfolio) to risky assets (equities). This model stands in direct contrast to the "life-cycle" investment model which has received great play in the popular press. Effective portfolio monitoring helps the investor quantify the required risk/return tradeoffs as time unfolds, not according to formulas derived from the popular press, but according to his actual economic circumstances. Without this type of specific information, ongoing investment decisions are likely to be ad hoc. For further discussion on this topic, see "Asset Allocation, Life Expectancy and Shortfall," Kwok Ho, M.A. Milevsky, and Chris Robinson, *Financial Services Review* (Fall 1994), pp. 109–126.

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