Innovations in Retirement Financing

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Chapter 5

Retirement Planning and the Asset/Salary Ratio

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In this era of individual responsibility for retirement security, interest in retirement income adequacy is at an all-time high. Concern over low U.S. personal savings rates and the possibility of social security system insolvency prompt this interest, in concert with the growth of popular alternatives to traditional defined benefit plans, the introduction of retirement savings education programs, and the development of new individual retirement software products. Such interest has generated a wide array of research studies. A first group asks whether Americans in specific age cohorts, employment situations, pension plans, and income and wealth categories are saving enough for retirement (e.g., Moore and Mitchell 2000; Gale and Sabelhaus 1999; Samwick and Skinner 1998). The second type of research focuses on how retirement savers allocate contributions and accumulations among asset classes and investment vehicles, and the effects of such allocations on future retirement income (e.g., Ameriks and Zeldes 2000). Finally, a third set of studies asks how individual workers or families ascertain whether they are in the retirement savings "ballpark," especially when retirement may be years away (e.g., Bernheim et al., this volume).

This chapter seeks to extend thinking about asset adequacy by constructing and testing a simple measure of retirement savings adequacy that is analogous to (but not identical to) the *funding ratio* concept used in defined benefit pension plans. Our hope is that this measure, which compares required assets-in-hand to salary, will provide retirement savers with a rough indication of where they stand on the path to adequate retirement income.

We call our measure the *Asset/Salary Ratio,* a breakeven number similar to but simpler than tools such as an income replacement ratio, a life cycle consumption model, or a stochastic asset return model. It does not embody the sophistication of these other tools, but it does have the advantage of

enabling individuals to determine at a glance whether they are on track for a faroff retirement. As such, it has the advantages of simplicity, and all attendant caveats associated with simplifying the complexities of nature and finance.

Funding Measures in the Defined Benefit Environment

The Asset/Salary Ratio reflects, but is not identical to, concepts and methods widely used to measure the overall funding status of a defined benefit (DB) pension plan. In the DB world, a plan manager is responsible for ensuring that future annual revenues cover future annual pension payments. In other words, the job of the pension manager is to match required assets to the present value of future liabilities for all covered employees, where the liabilities depend on all employees' eventual credited service, final or final average salary, and an accrual percentage (Leibowitz, Bader, and Kogelman 1996b). There are several ways to define a defined benefit plan's funding ratio (*FR*), but a common one is the current market or actuarial value of a pension fund's assets (i.e., a weighted average of book versus market value) divided by the discounted value of the plan's future liabilities (actuaries often call this the "actuarial accrued liability").[1] For example, a state government DB retirement system might use a variation of the following basic measure to determine funding progress and the overall financial status of the plan:

$$\text{FR}_t = \frac{\text{Assets}_t}{\text{PV Future Liabilities}_t} \,. \tag{1}$$

If FR >1, this could indice that the plan currently enjoys a funding *surplus* (an excess of assets over liabilities). A plan with FR >1 should theoretically be well funded as long as the investment and actuarial assumptions that underlie it continue to be validated by subsequent experience. In contrast, when FR <1, there is a need for incremental funding to bring the required level of assets up to match the estimate of discounted future liabilities.

Over time a plan's funding ratio may change as it is affected by new experience, such as changes in inflation, mortality, retirement rates, salaries, and other actuarial gains and losses, all of which can affect future liabilities. Also, unexpected changes in investment returns could affect the future value of the assets. As a result, the funding ratio should be examined regularly to assess the probability of a shortfall due to investment or actuarial experience differing from the model's initial characterization (Leibowitz, Bader, and Kogelman 1996a). Even at its most basic, this concept can direct a plan manager's attention to a crucial issue associated with pension plan solvency, namely the ability of the plan to meet the obligations it has incurred. The DB funding ratio, as well as expected and unexpected

changes in it, can provide signals for managers, such as the need to consider whether contribution rates and/or investment strategy should be adjusted.

Funding Measures in a Defined Contribution Case

In the defined contribution (DC) pension plan case, we would like to construct a simpler measure of an individual retirement saver's retirement funding adequacy. We suggest that a DC funding ratio can be conceived of, under normal circumstances, as the relationship between assets and a present-value liability measure. A key difference between DB and DC pensions, of course, is that different parties bear responsibility for achieving and maintaining the asset-liability match. Another difference between the plan types is how the liabilities are characterized. Usually, DB plans are characterized by the pooling of investment and actuarial risk, whereas DC plans do so in very limited ways or not at all. DC plans trade off pooling of retirement income certainty for a greater individual investment and actuarial control.

In the DC context, our interest focuses on the role of the individual saver rather than the employer or employer pension plan. This is because, even though DC plan rules apply to all covered employees, any given employee can be thought of as acting as his or her own plan sponsor and provider. As such, the individual takes on certain increased risks in a DC plan, making investment choices and facing market risks associated with those choices (within plan limits). On the other hand, DC participants do retain the choice of whether or not to join the mortality pool by annuitizing their accumulated assets at retirement. If they choose not to annuitize, they face greater mortality risk since the "pool" would then essentially represent a sample of one (Brown et al. 2001 and this volume).

Thus in a DC plan it is the individual rather than his or her employer who must be responsible for and concerned with retirement plan "solvency," i.e., the match between an individual's assets and liabilities at retirement. Therefore, we believe that an individual's DC pension income can be related to a kind of Asset/Salary Ratio. Taking the DB funding ratio relationship in (1) as a starting point, we translate the asset figure or numerator directly into the DC context: the individual's current marked-to-market pension accumulations or assets are equivalent to the DB plan assets. An analogous individual liability figure for the denominator in (1), however, is less transparent. Unlike a DB plan, there is no formula that tells an individual in a DC plan exactly how much income he will receive at retirement, based on service and salary. In the strict sense, the asset-liability ratio in a DC plan, unlike a DB plan, is always inherently equal to 1, since by definition the individual's liabilities are always equal to his or her accumulated assets in the plan. Nevertheless we seek to measure that would indicate whether the individual was "on track" for achieving an adequate retirement income, in the spirit of a DB funding ratio.

Despite the lack of a specific, contractual promise in the DC context,

some well understood and often recommended targets are helpful in projecting retirement income needs. A useful one is the income replacement ratio (RR), or the proportion of preretirement income that a retiree can replace with a payout annuity purchased at the time of retirement (Heller and King 1989, 1994). The replacement ratio is, of course, closely related to the notion of a funding ratio at the point of retirement, in that both are dependent on projections of salary growth, investment returns, annuity purchase costs, contribution rates, and lengths of covered employment. A precise mathematical relationship can be used to calculate the income replacement ratio (see Appendix A). We note that the replacement ratio is particularly sensitive to the difference between investment earnings rate and salary growth rate. For example, with an annual contribution rate of 10 percent of salary and a retirement payout annuity based on a six percent interest rate, a person who spends 30 years in a DC plan where investment returns exceed salary growth by three percent per year will achieve an income replacement ratio of about 40 percent of final preretirement income. This compares to only a 20 percent replacement ratio if salary growth and investment returns were equal to each other.

In addition to its use in making projections, the replacement ratio can be used to set retirement saving and investment goals. For example, the American Association of University Professors and the American Association of Colleges recommend that educational institutions design pension plans to enable employees to replace about two-thirds of their inflation-adjusted annual disposable salary (averaged over the last few full-time work years) through a combination of pension annuity income and social security benefits (American Association of University Professors 1990). This policy was reaffirmed by a National Academy of Sciences committee in 1991 (Hammond and Morgan 1991). This two-thirds clearly is a "one-size-fits-all" approach that overlooks variations in life cycle circumstances, though it does provide a starting point for planning purposes. Slightly higher targets were recommended by Palmer (1993), using tax and social security benefit rules and consumer expenditure data. He proposed that required income replacement ratios for individuals and married couples range from 70 to 80 percent of gross preretirement income.[2]

Building on this work, we take a conservative approach by selecting an overall retirement income target of 75 percent. If we further assume that social security benefits will pick up about 25 percent of the total, then an average individual or couple with a DC plan would need the pension to produce about 50 percent of annual preretirement income. Low income workers might need a lower ratio than the 50 percent target, and very high income workers might require a higher ratio to achieve an overall 75 percent replacement ratio, because social security benefits are progressive. Starting with 50 percent as a target pension replacement ratio, it is then possible to solve for any one of the other variables that go into it—the

needed contribution rate, years of service, or difference between investment earnings and salary growth rates.

Nevertheless, a key challenge facing a retirement planner is to evaluate how alternative circumstances and actions can influence future financial viability. For this reason we propose that the DB plan funding ratio approach could help people develop a sense of whether they are on track for retirement. Accordingly, we recast the DB funding ratio for a participant in a DC plan as follows:

$$\text{ASR}_t = \frac{A_t}{S_t} . \tag{2}$$

This says that the Asset/Salary Ratio (ASR) is the liability (assets) divided by an individual's annual salary S at t years before retirement.[3] This Asset/Salary Ratio can be thought of in two ways: as a person's *current* Asset/Salary Ratio or as the Asset/Salary Ratio *required* to achieve a target income replacement ratio in the future.

What does the Asset/Salary Ratio mean? How can a ratio of assets to salary tell an individual anything about the adequacy of his or her retirement savings? It should be noted that, although the DB Funding Ratio may hover near 1, the required Asset/Salary Ratio (RASR) will increase over time, since the accumulated assets needed to fund future retirement income must grow faster than a person's salary. But a worker who knows his current ASR can roughly estimate the ratio that would be *required* to fund retirement income years into the future and then assess whether the current ratio is "on track" for retirement. Both current salary and current savings can be brought forward through working life to retirement with some assumptions (e.g., an asset growth rate and a salary growth rate). Hence, at any point t years prior to retirement, it can be determined whether current ASR equals the required ASR and thus whether current savings rates might eventually produce assets sufficient to fund an annuity that would provide an income equal to 50 percent of salary at retirement (or whatever target replacement ratio is desired).

The mathematical relationships between the elements making up the RASR include the desired replacement ratio (RR), pension contribution rate, investment rate of return on pension contributions, salary growth rate, investment rate of return on annuity assets, and the respective number of years remaining prior to and following retirement. Using these variables, someone with a current ASR equal to his or her RASR could be said to be "on track" for retirement, other things being equal (see Appendix B). A person whose current ASR is currently higher than the required ratio enjoys a cushion to protect against unforeseen trends or events (unexpected stock market declines, better-than-expected retiree life spans, etc.). And someone with a current ASR lower than required might need to take corrective action

(e.g., increase plan contributions, start other kinds of retirement savings, change investment strategies, or delay retirement).

Implementing the Asset/Salary Ratio

We next illustrate how the RASR works with a few simple assumptions listed in Table 1, all of which will vary depending on an individual's circumstances and appetite for risk.

First, we assume an income replacement ratio target of 50 percent. Second, we use a DC pension plan contribution rate of 10 percent.[4] Third, although the formula for RASR does not require knowing the worker's current income, it does require projecting growth. We use a real rate of percent on top of a 2-percent inflation rate, since aggregate salaries in higher education have grown at about this rate over time (*Academe,* 1998). Fourth, we must project asset returns, and we begin by assuming that assets are invested in either government bonds, long-term inflation-indexed bonds, or a partially guaranteed, fixed income account such as the traditional TIAA account. Fifth, we assume that at retirement the individual purchases a 25-year certain annuity (a date-certain annuity was chosen instead of a life annuity for standardization and ease of replication). In this case, the payout annuity interest rate is similarly set at 6 percent.

The base-case RASR appears in Table 2 for calculations based on assumptions in Table 1. Reading across, it starts with a desired income replacement ratio. It then displays the future value of replacement income (i.e., for the 50 percent income replacement ratio target, half of the future salary of $1.80 or $.90 for every $1.00 of current income). The next column displays the corresponding future cost of an annuity sufficient to provide the replacement income and the following column shows the future value of all future pension contributions. The fifth column is the difference between the cost of the annuity and the future contributions, while the sixth column is the present value of that difference. The final column shows the RASR for the corresponding target replacement ratio.

For example, for an individual 15 years from retirement, the RASR is as follows:[5]

$$\text{RASR}_{15} = \frac{(\text{AC} - \text{FV}_p) / (1 + r)^{15}}{S_{15}}, \tag{3}$$

where

AC = the cost of a 25-year annuity at retirement assuming a 50 percent income replacement ratio,

FV_p = the future value of premium contributions until retirement,

r = investment rate of return, and

S = current salary.

TABLE 1. Baseline Asset/Salary Ratio Modeling Assumptions

Target income replacement ratio RR	50%
Plan contribution rate P	10%
Salary growth w	4%
Pre-retirement rate of return r	6%
Annuity length years K	25
Annuity rate of return r_{AN}	6%

Source: Authors' calculations.

Plugging in the numbers from Tables 1 and 2, we obtain

$$\text{RASR}_{15} = \frac{(\$11.51 - \$2.98) / (1 + .06)^{15}}{\$1.00} = 3.56 \ .$$

(For ease of calculation, salary is set at $1.00. Since we are using the required ASR, salary level does not affect this ratio.)

Figure 1 shows a set of required Asset/Salary Ratios calculated in a similar fashion for several points prior to retirement. For each year, the funding ratio shown is associated with a 50 percent retirement income replacement ratio. For example, a 65-year-old about to retire, who began saving at age 25 with a salary of $30,000, should by now have accumulated about $885,000 ($138,500 times the RASR of 6.39) in order to purchase an annuity with a 50 percent income replacement ratio.[6] Fifteen years prior to retirement, the same individual would have needed about $274,000 ($76,900 times the RASR of 3.56) to be on the pathway to retirement. With 25 years to go, he would have needed about $108,000 ($52,000 times the RASR of 2.08).

Surplus and Deficit Relative to the RASR Curve

The required Asset/Salary Ratio curve defines the Asset/Salary Ratios needed to be on track for meeting a relatively conservative retirement goal using a conservative low risk investment approach. Someone whose circumstances place him or her exactly on the line would deemed to be neither over nor underfunded for retirement. On the other hand, a current ASR that falls below the line implies a projected retirement income shortfall, or an income replacement ratio less than the standard 50 percent target. Note that this is meant to be a crude rather than a precise signal, since circumstances might vary considerably from the assumptions used in the base case. For example, participation in a DB plan and the presence of other personal savings would effectively raise the current ASR. Unusually high temporary income might depress the current ASR for a time, until future income dropped back into line with past income. A person's contribution rate might be over 10 percent, so assets would accumulate more quickly than in the

TABLE 2. Required Asset/Salary Ratios for Various Replacement Ratios 15 Years from Retirement

Target Income Replacement Ratio (%)	*Future Value Replacement Income ($)*	*Annuity Cost ($)*	*Total Premium Payments ($)*	*Future Value Annuity Cost Less Future Value Premiums*	*Present Value Annuity Cost Less Future Value Premiums ($)*	*Required (par) Asset/Salary Ratio*
30	0.54	6.91	3.10	3.81	1.59	1.59
40	0.72	9.21	3.10	6.11	2.55	2.55
50	0.90	11.51	3.10	8.41	3.51	3.51
55	0.99	12.66	3.10	9.56	3.99	3.99
60	1.08	13.81	3.10	10.72	4.47	4.47
70	1.26	16.12	3.10	13.02	5.43	5.43
80	1.44	18.42	3.10	15.32	6.39	6.39
100	1.80	23.02	3.10	19.92	8.31	8.31

Source: Authors' calculations.
Note: Calculations use assumptions in Table 1 and current salary = $1.

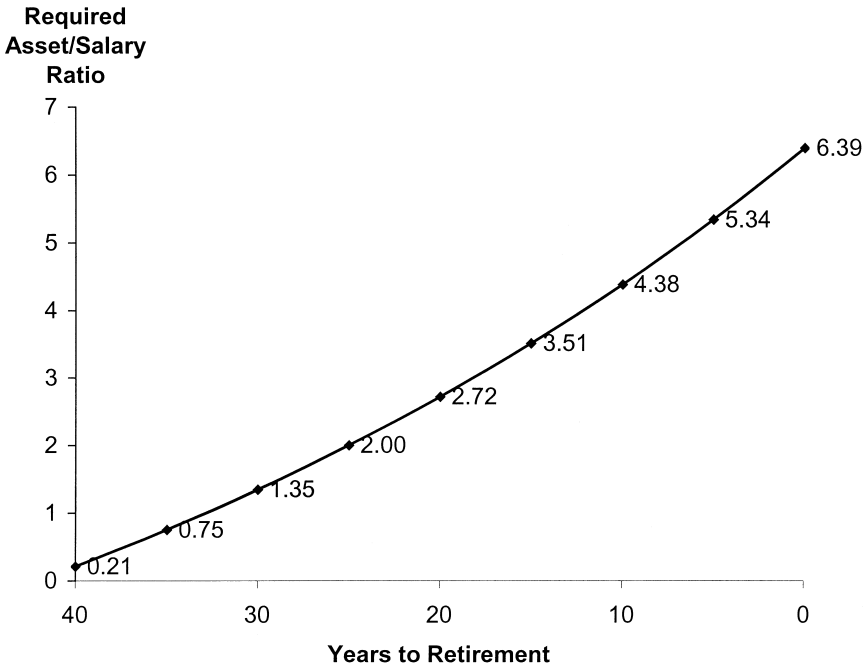

Figure 1. Required asset/salary ratio for 50 percent replacement ratio. Source: Authors' calculations.

base case, and the person's current funding curve would rise more steeply through time. Conversely, a current ASR below the line could provide warning of a future shortfall, a signal to expand the asset base through increased retirement plan contributions or other savings. Of course, having a longer time horizon offers opportunity and can avoid crises that demand precipitous action.

Developing a Risk Cushion

A worker with a current ratio substantially above the RASR curve could expect that assets are in excess of those needed to fund the desired retirement annuity. In essence, he or she would have a *risk cushion* for retirement. This is useful because the ASR as described here is deterministic, while risk will influence retirement planning over an extended period of time. Such uncertainty might be associated with employment (i.e., under- or unemployment risk), investment returns (e.g., allocation choices or market risk), pension contributions, and special needs such as expensive health conditions or unforeseen family expenditures. So a risk cushion could be a luxury

or a necessity, depending on how well the assumptions behind the RASR match an individual's future circumstances.

If a risk cushion exists, it might be used in at least four ways. First, the "extra" assets could be used to project the target income replacement ratio. For example, a drop in future contributions below the 10 percent rate assumed here would cause the current ASR to fall relative to the RASR. The presence of a risk cushion would help to protect against a dip in the current ASR for whatever reason.[7] Second, a risk cushion could permit the replacement target to be raised. Figure 2 displays several families of retirement funding ratio curves that reflect the effect of boosting the target income replacement ratio. It shows that if an individual can sustain a position above the RASR curve over the years (e.g., through a consistently higher contribution rate), then he or she will achieve a higher retirement income replacement ratio.

The risk cushion could also be used to provide a safety net under a higher risk investment strategy. That is, some or all of the assets corresponding to the risk cushion could be invested in riskier assets that hold the possibility of higher returns. Alternatively, having a risk cushion through time might accumulate enough assets to retire earlier while still meeting the 50 percent income replacement goal. Finally, a risk cushion could be used to make gifts or leave legacies to charities or to children, depending on the individual's tax status and predilections.

Portfolio in Hand

Sometimes people stop making DC plan contributions well before retirement, and in this instance it is interesting to examine the future value of what they have already accumulated. Alternatively, we might wish to know the future value of future contributions as a proportion of total accumulations. To see the nonlinear nature of the relationship between required assets and salary, we turn to Table 3, which uses the same numbers as those behind the RASR curve in Figure 1 to show the proportion of final (total) retirement accumulations a person would have in hand for selected years prior to retirement. For example, a low risk RASR 35 years before retirement implies that the accumulated assets, as well as the future earnings on those assets, will represent only about 23 percent of total projected accumulations at retirement. This implies that over 75 percent of a person's final accumulation is associated with future contributions and the earnings on those contributions. This suggests that the young investor may consider the effect of taking on additional risk in his or her portfolio. For example, if current assets experienced a one-time 20 percent loss 35 years from retirement, this would reduce final accumulations by about 4 percent (.23 times .20). This is because most of the final accumulation is represented by *future* contributions.

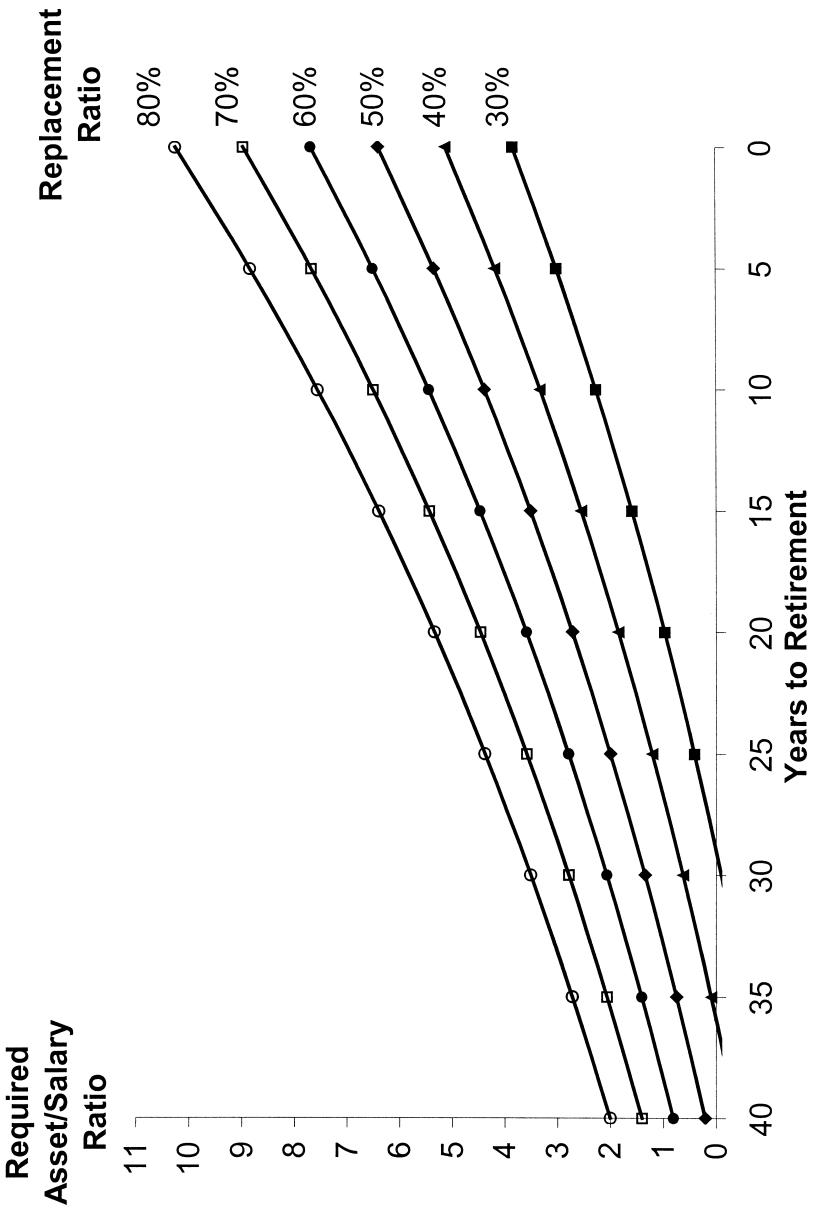

Figure 2. Required asset/salary ratio for alternative replacement rates. Source: Authors' calculations.

TABLE 3. Portfolio in Hand (% of Final Accumulation)

	Years to Retirement								
Returns	*0*	*5*	*10*	*15*	*20*	*25*	*30*	*35*	*40*
6 ("Par")	100	92	83	73	62	50	37	23	7
8	100	92	81	69	54	36	14		
10	100	91	80	64	44	17			

Source: Authors' calculations.

Conversely, someone nearing retirement might be less able to stomach a sharp reduction in assets. An individual 5 years from retirement who is at the RASR would have about 92 percent of his or her final portfolio in hand. If there were a significant market loss—say, the same 20 percent one-time reduction—he or she would end up with 18 percent less assets at retirement (.20 times .92). These numbers suggest that we may need to adjust the familiar admonition that the power of compounding over a long time period makes retirement saving early more valuable than similar contributions later. Although it is important to save early in one's career, it also appears easier to recover from market downturns and other events that cause asset losses. This may explain the finding that young people in recent years have placed a higher percentage of their retirement savings in higher risk equities than did older people (Ameriks and Zeldes, 2000).

Effect of Higher Expected Returns on the ASR

The RASR curve assumes a relatively low risk 6 percent rate of return, but few people in DC plans invest all their savings at or near a risk-free rate. We next explore how investing at higher returns affects the RASR as well as the portfolio in hand. Figure 3 shows that if retirement savings average 10 percent per year, then the RASR or ASR needed to achieve a 50 percent retirement income replacement ratio drops considerably in the early years, as compared to the base percent case. At 25 years from retirement, the RASR would be a little over two times salary, if investment returns average 6 percent. At 10 percent return, the ASR drops to less than 30 percent of current salary. At 15 years from retirement, the 6 percent return par ASR ratio would be 3.5 times salary, while the 10 percent return funding ratio would be only 1.8 times salary.

With higher asset returns, the portfolio in hand calculation shows a similar decline. As shown in Table 3, a 10 percent asset return would imply only about 17 percent of final accumulations in hand 25 years from retirement, compared to 50 percent in the 6 percent return case. This means that asset gains (or losses) on early career savings would have less influence on final accumulations, than in the more conservative case.

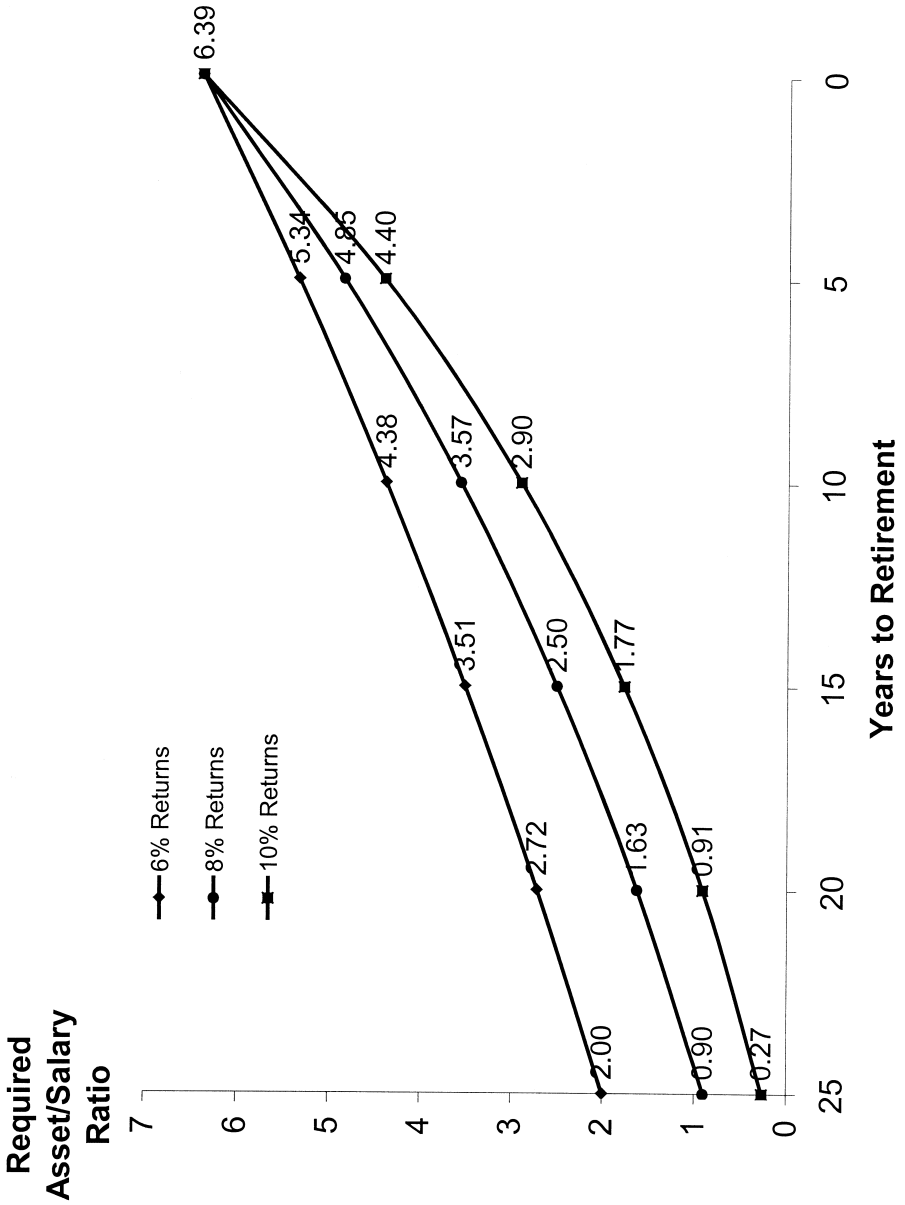

Figure 3. Required asset/salary ratio for alternative rates of return. Source: Authors' calculations.

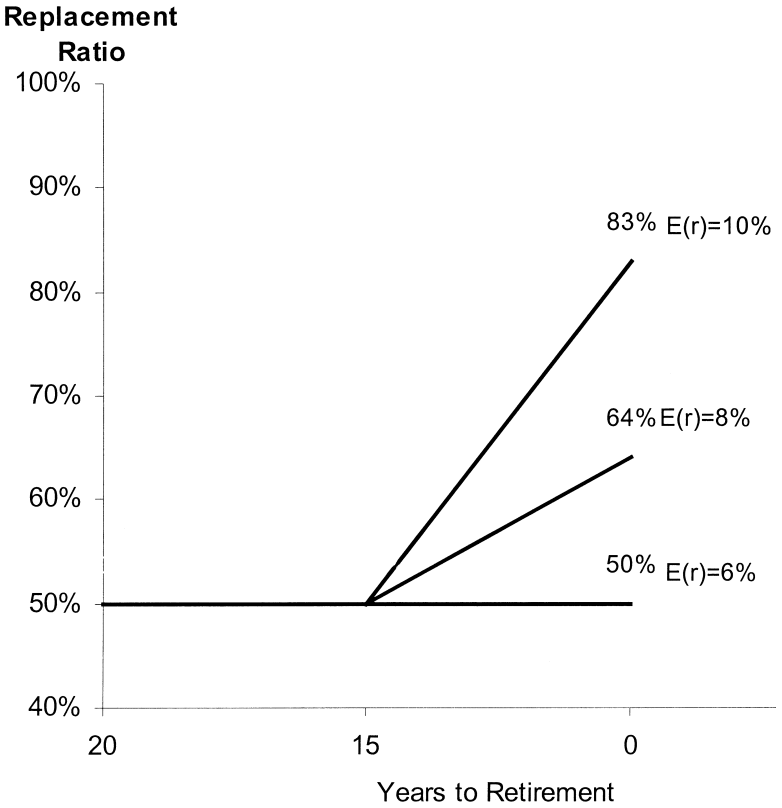

Figure 4. Projected replacement rates with alternative portfolio returns. Source: Authors' calculations. Note: $E(r)$ refers to the expected value of portfolio returns.

Higher asset returns could also be used to get to a higher retirement income replacement ratio. Figure 4 assumes that at 15 years prior to retirement, the individual has achieved a RASR of 3.5 (e.g., prior to that point, assests were invested at the RASR, low risk rate of 6 percent). Thenceforth all assets and future contributions are invested in assets whose expected returns average 10 percent. If assets did provide 10 percent returns, the individual could achieve much higher expected retirement income replacement ratios: over 80 percent in the case of the pure 10 percent return, and over 60 percent in the case of a portfolio that blended riskier and low-risk assets.

Investment Risk Implications of Higher Returns

There is, of course, additional investment risk that could lead to retirement income lower (or higher) than the "expected" result. For example, to boost

expected returns from the six to the 10 percent range, an investor could purchase stocks that have enjoyed historically higher average rates of return than bonds or money market returns. An investor who had held the Ibbotson index of large capitalization U.S. stocks for all (overlapping) 15-year periods since 1926 would have experienced annual returns averaging 10.75 percent, well in excess of our low risk 6 percent rate. Yet about half the time, the Ibbotson large cap stock index return was lower than the 10.75 percent average. And about 15 percent of the time, the Ibbotson return was less than or equal to 6 percent per year, the same annual return as the low risk, fixed income investment used in the previous examples. (For 10 percent of the 15-year returns, the annual return was less than four percent.)

How would this variability of equity returns affect our Asset/Salary Ratio and the individual's chances of achieving his or her retirement income target? To examine this question, we simulated a case in which a worker 15 years from retirement had achieved the par Asset/Salary Ratio of 3.5. If he continued to save and invest at the six percent low risk rate, he or she would achieve the target 50 percent income replacement ratio at retirement in the certainty case. To see what the range of outcomes and probabilities might be if that person selected a riskier portfolio, we undertook Monte Carlo simulations using four different mixes of a low risk fixed-income asset and higher risk equities with a savings and investment period of 15 years.[8] For every individual iteration, each investment year's return was drawn independently from a normal distribution of equity returns with a expected nominal annual return of 10 percent (instead of the 10.75 percent historical return for a large-cap all-equity portfolio) and a standard deviation of 17 percent. Assets were rebalanced at the beginning of each year.

Figure 5 illustrates the resulting Asset/Salary Ratio and target replacement ratio, showing the probability of achieving a range of income replacement ratios using 100 percent equities with a 15-year retirement horizon. Recall that the original target replacement ratio was 50 percent, which was the "expected" outcome for an individual with a par Asset/Salary Ratio investing in assets using six percent. By investing 100 percent in equities, the individual could increase his or her expected replacement ratio from 50 to over 80 percent. Using stochastic simulation, Figure 5 shows that there is a 50 percent chance of attaining at least a 72 percent income replacement ratio at retirement, and a 20 percent chance of reaching nearly 120 percent of preretirement income.[9] However, the figure also shows that there is a 25 percent chance that the replacement income will fall short of the original 50 percent target, and a 10 percent chance that the individual will have to settle for an income replacement ratio of less than 36 percent.

What alternative blend of risky and low risk assets could balance those expected risks and rewards of equity investment? Answering this question depends on the individual's tolerance for shortfall risk, but several alternatives appear in Figure 6 using three mixed portfolios along with the original

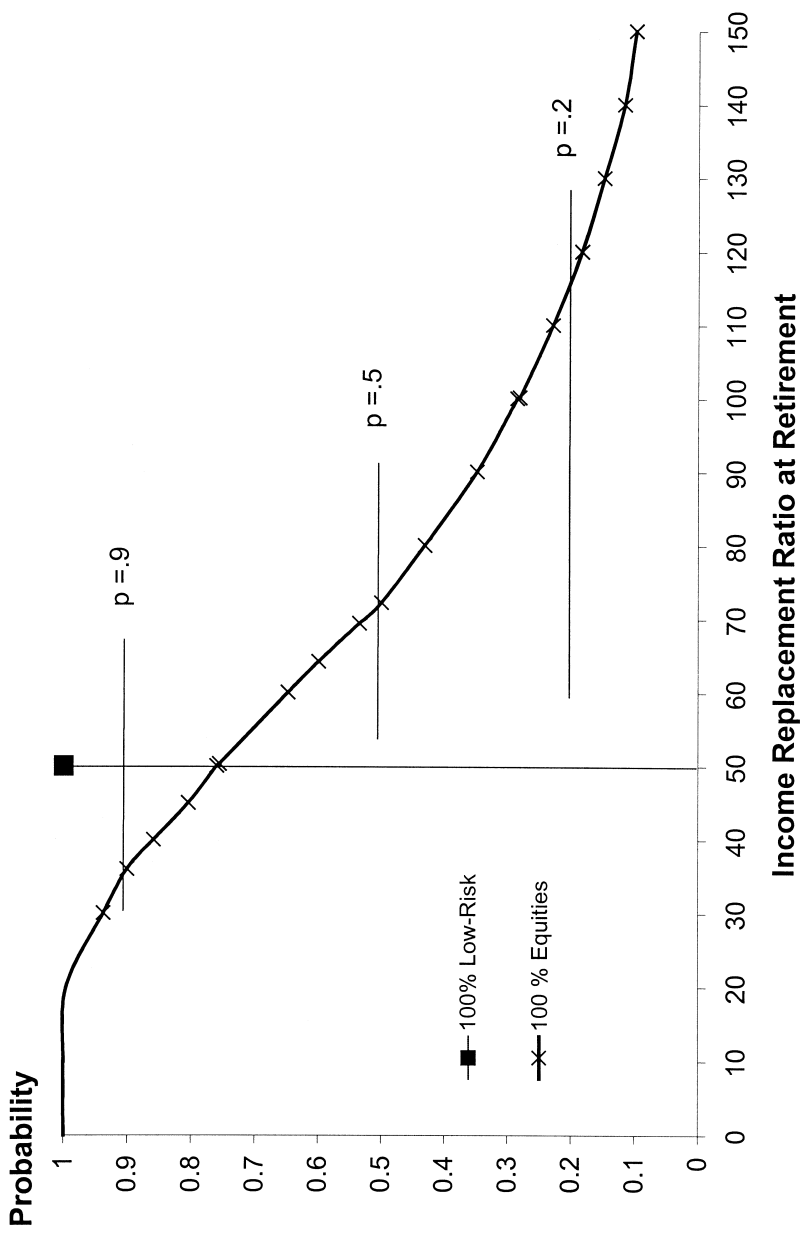

Figure 5. Probability of alternative asset/salary and replacement rate outcomes (stochastic simulation) with 100 percent in equities. Source: Authors' calculations.

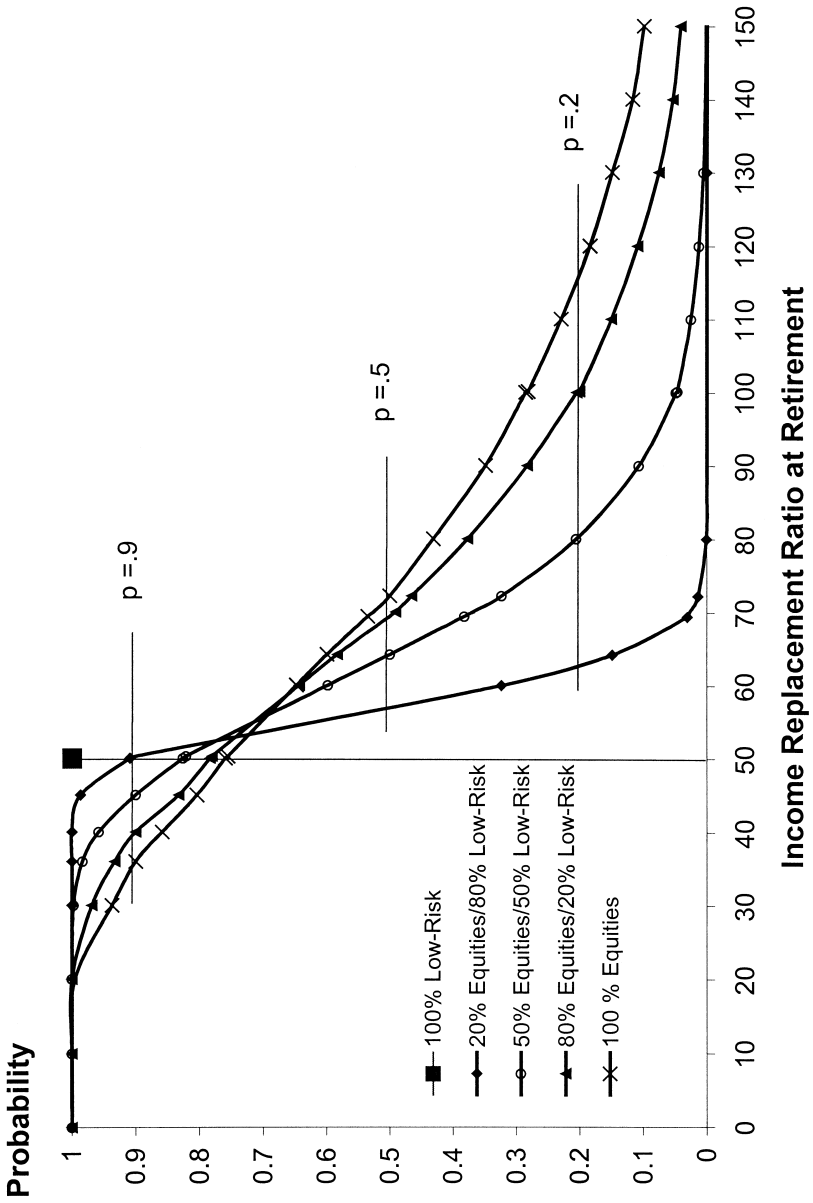

Figure 6. Probability of alternative asset/salary and replacement rate outcomes (stochastic simulation) with alternative investment portfolio. Source: Authors' calculations.

100 percent low risk and 100 percent higher risk portfolios. For example, a mix of 20 percent equities and 80 percent of the fixed-income asset falls short of the 50 percent replacement ratio 10 percent of the time. All the same, this portfolio has limited potential for doing better than the low risk alternative, in that about half the time it would achieve a replacement ratio of 58 percent or less (compared to 72 percent replacement ratio in the 100 percent equity case). A 50-50 mix of equities and the fixed income asset, one which returned 8 percent, would do better. On average, it would achieve a 64 percent replacement ratio and would reach the 45 percent replacement ratio or even better about 90 percent of the time.

Someone who could tolerate a little more risk might wish to adopt an allocation policy that would limit the income risk to a ten percent chance of falling 10 percent below the target income replacement ratio (RR = 40 percent). An 80-20 mix of equities and the low-risk asset would achieve this goal. Such a portfolio would also have a fifty percent chance of achieving at least a 70 percent income replacement ratio, and a 20 percent chance of matching 100 of preretirement income. Such an asset allocation strategy might be a good way of at least partially "immunizing" a portfolio against the chance of a retirement income shortfall, while still participating in the possibility of achieving a retirement income "cushion."

Implications of Other Risks

Of course investment volatility and asset allocation choice are not the only sources of risks facing a retirement saver: others include under or unemployment, health or family consumption needs, and inflation. Even modest inflation, for example, can seriously erode the real value of retirement savings and retirement income (Brown et al. 2001 and this volume). The Asset/Salary Ratio does recognize some inflation effects prior to retirement, in that it assumes a nominal salary growth of four percent, which in current circumstances implies an inflation rate of 2 to 2.5 percent (long-term wage growth for workers in the U.S. has been about one percent in real terms). Similarly, nominal investment returns of 6 percent for the low risk case and 10 percent for the higher risk case incorporate a comparable inflation rate.

Nevertheless the damaging effects of inflation are not built into the retirement payout annuity income, and the impact can be significant. As Figure 7 shows, if inflation remains steady at 2.5 percent, an individual whose first-year retirement income was $40,000 would after 10 years have an inflation-adjusted income of only about $31,000. After 25 years, a little more than the median unisex lifespan for a person age 65, real income would be only $21,500, which is more than a 45 percent decline. If inflation were higher, say 4 percent, then the same $40,000 would be worth only about $27,000 after 10 years and $15,000 after 25 years, a 62.5 percent decline.

To cope with inflation in retirement, the RASR calculation could be ad-

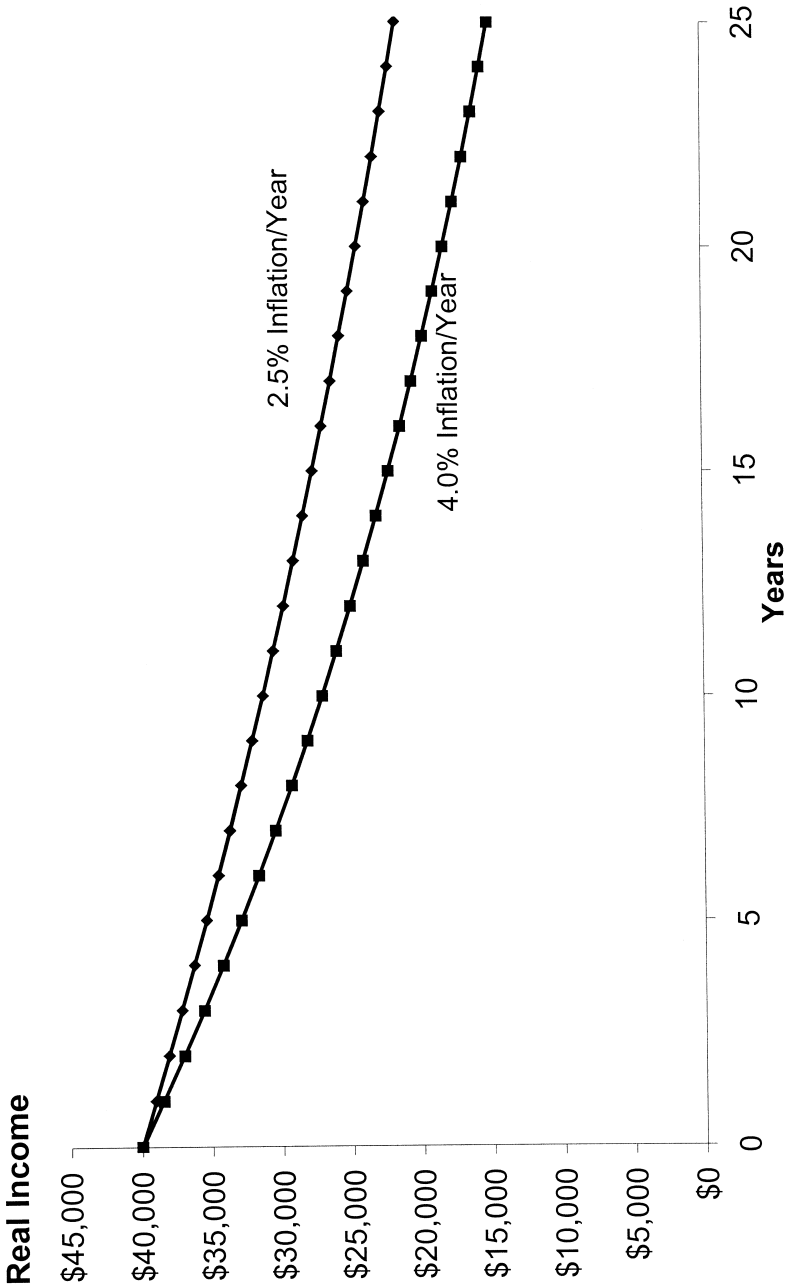

Figure 7. Effect of alternative inflation rates on retirement income. Source: Authors' calculations.

justed to assume a "real" payout annuity interest rate in retirement (for a discussion of the cost of real annuities, see Brown et al., 2000). For example, inflation-linked bonds currently carry a coupon of about four percent with a built-in inflation adjustment. Figure 8 shows the effect on the required Asset/Salary Ratio of purchasing an annuity based on a long-term inflation bond at four percent coupon. The required Asset/Salary Ratio 15 years prior to retirement increases by more than one (from 3.56 to 4.63) as compared to the nominal six percent annuity par ASR curve. In essence, this means that to purchase inflation protection, the saver would need to have 30 percent more assets at that time. Because the Asset/Salary Ratio curve is not linear, the required Asset/Salary Ratio would increase by nearly 50 percent at 25 years prior to retirement. With five years to go before retirement, the required Asset/Salary Ratio would increase by 24 percent. Taking future inflation into account requires more saving or a higher return, higher risk investment strategy that involves a greater probability of not achieving the target income replacement ratio.

Conclusions and Discussion

Knowing years in advance whether one is on track to achieving a retirement goal is one of the most fundamental and, at the same time, most challenging issues any individual or couple faces. Sophisticated efforts have been made to construct better tools for estimating the adequacy of retirement income strategies, some of which are reported elsewhere in this volume (Bernheim et al. this volume; Scott this volume). Our measure, the Asset/Salary Ratio, is less sophisticated than some of these, in that it uses a number of projections and does not attempt to estimate stochastic returns and risk levels from a portfolio of actual assets. Nevertheless, our approach has the advantage of clarity with respect to the assumptions that an individual makes or needs to make in setting goals and achieving an adequate retirement income.

No matter what the approach, assessing retirement income adequacy involves projecting how much annual income people need for retirement; what proportion of that income social security will provide; what other sources of retirement income—such as a spouse's defined benefit plan—they can expect; and what their tolerance is for retirement income shortfall risk. Having ascertained all that, the ultimate question is how much in the way of assets they need to accumulate to produce an adequate retirement. The more years away from retirement, the more uncertain the answers to all these questions can seem.

The Asset/Salary Ratio, when used in conjunction with a target income replacement goal, employs numbers that people commonly have at hand—current salary and assets—to arrive at a rough estimate of current savings adequacy that can be used as a snapshot view for further retirement income planning. An actual Asset/Salary Ratio that is substantially below the

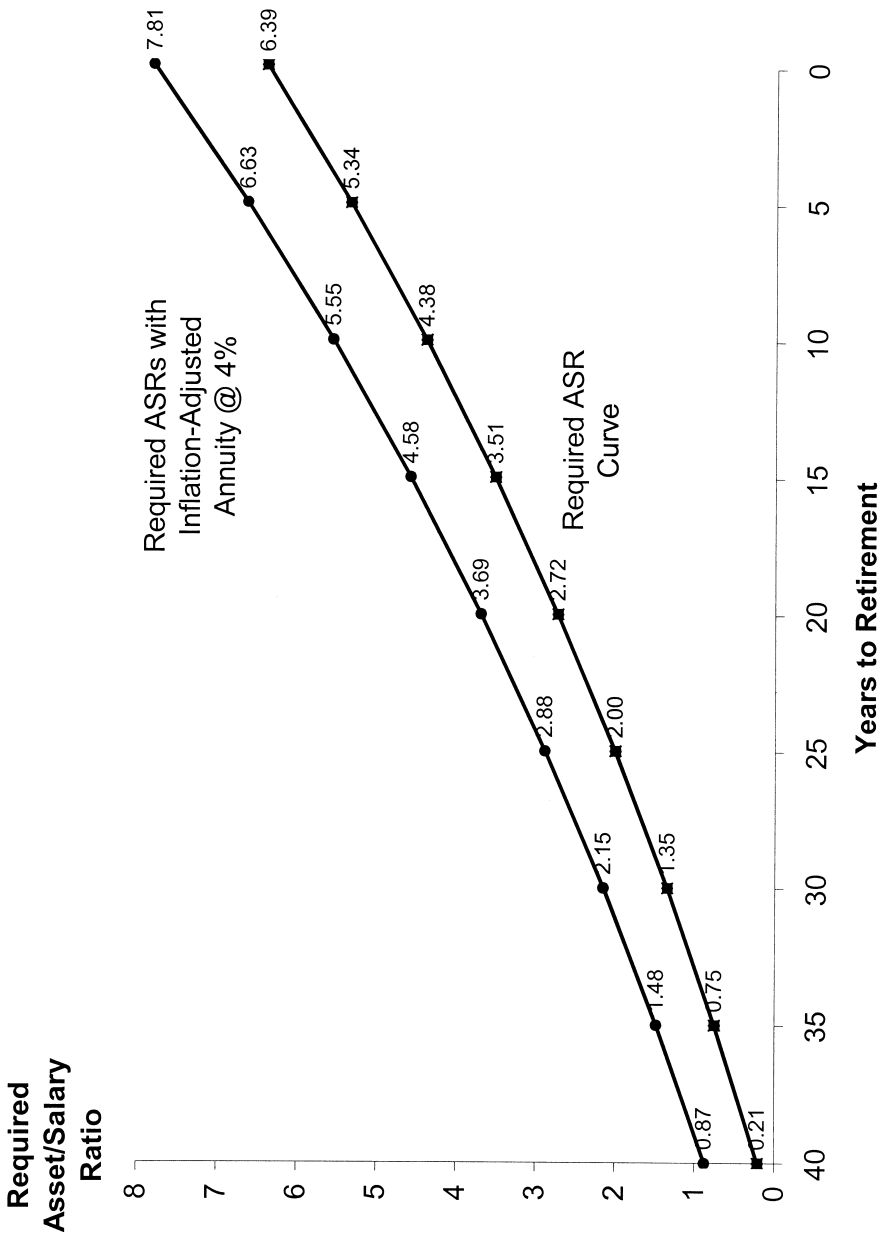

Figure 8. Asset/ salary ratio required to purchase inflation protection. Source: Authors' calculations.

required par ASR curve could provide a signal that the individual or couple should start saving more, examine other sources of retirement income, work longer, or plan lower consumption in retirement. An actual Asset/Salary Ratio that is significantly above the par ASR curve could be a sign of a risk cushion or could permit riskier asset allocations. Finally, the Asset/Salary Ratio can inform investment strategies to reduce the risk of a retirement income shortfall. We could imagine, for example, an electronic Asset/Salary Ratio calculator that allowed people to customize assumptions about target replacement ratios, salary growth, and investment return and risk.

Appendix A: The Income Replacement Ratio

The replacement ratio can be summarized as follows (Heller and King 1989 and 1994):[10]

$$\text{RR} = \frac{P}{\text{AC}} \sum_{n=1}^{N-1} \left[\frac{1+r}{1+w} \right]^n , \tag{A1}$$

where P = plan contribution rate as a percentage of salary,
r = annual preretirement investment earnings rate,
w = annual salary increase rate,
N = total number of years in the DC plan, and
AC = annuity purchase cost, or the cost per $1 of an income for life or for a specified period.
We can rewrite this formula as follows:

$$\text{RR} = \left(\frac{\text{FV}_{\text{Assets}}}{\text{AC}} \right) \frac{1}{S(1+w)^{N-1}} , \tag{A2}$$

where
$\text{FV}_{\text{Assets}}$ = future value of all plan contributions, which depends on a contribution rate (percentage of salary) and an investment return rate,
S = first-year annual salary, and $S(1+w)^{N-1}$ = salary in the final working year before retirement.

Appendix B: The Asset/Salary Ratio

We define the *Asset/Salary Ratio* as the ratio of current retirement assets to current salary at time t years before retirement.

$$\text{ASR}_t = \frac{A_t}{S_t} , \tag{B1}$$

where S is the salary earned over the previous year.

The Asset/Salary Ratio can be thought of in two ways: the existing Asset/Salary Ratio or the asset/salary that would be *required* to achieve a target income replacement ratio. Taking the latter meaning of the Asset/Salary Ratio, we can say that without any future contributions (i.e., pension premiums) beyond the current moment, the *required* current level of assets or initial principal would be equal to the discounted present value of the cost of an annuity at retirement divided by future salary growth.

$$A_t \text{ (no contributions)} = \frac{\text{FV}_A}{(1+r)^t}, \tag{B2}$$

where FV_A = the discounted present value of the cost of an annuity at retirement that would be sufficient to produce the desired replacement ratio and r = the rate of investment return on the existing assets.

If we add future pension contributions and any other incremental savings, then required current assets is reduced accordingly to:

$$A_t \text{ (with contributions)} = \frac{\text{FV}_A - \text{FV}_P}{(1+r)^t}, \tag{B3}$$

where FV_P is the accumulated value of annual premium payments (and any other retirement savings) at retirement. These in turn depend on initial salary, salary growth, and investment return on premiums such that:

$$\text{FV}_p = \sum_{n=1}^{t} \text{PS}_t (1+w)^{n-1} (1+r)^{t-n}, \tag{B4}$$

and w = nominal salary increase rate, including a real salary increase and an inflation component.

Substituting equation (B4) into equation (B3), the required assets size becomes:

$$A_t = \frac{\text{FV}_A - \sum_{n=1}^{t} \text{PS}_t (1+w)^{n-1} (1+r)^{n-t}}{(1+r)^t} \tag{B5}$$

Now the future value of an annuity can be recast in terms of the replacement ratio (RR), salary, salary growth, and an annuity purchase cost:

$$\text{FV}_A = \left[S_t (1+w)^t \text{RR} \right] \text{AC}, \tag{B6}$$

where

$$\text{AC} = \frac{1 - \left(1/(1+r_{\text{AN}})^K\right)}{r_{AN}},$$

r_{AN} = investment rate of return on annuity assets, and K = total number of years in the annuity. Substituting (B6) into (B5) yields

$$\text{(B7)} \qquad A_t = \frac{S_t}{(1+r)^t}\left[[\mathrm{RR}(1+w)^t\mathrm{AC}] - \sum_{n=1}^{t} P\,(1+w)^{n-1}\,(1+r)^{t-n}\right].$$

Simplifying further yields

$$\text{(B8)} \qquad \frac{A_t}{S_t} = \frac{\mathrm{RR}(1+w)^t\mathrm{AC}}{(1+r)^t} - \frac{P\,(1+w)\left[(1+r)^t - (1+w)^t\right]}{(r-w)(1+r)^t},$$

or

$$\text{(B9)} \quad \mathrm{ASR}_t = \frac{A_t}{S_t} = \mathrm{RR} * \mathrm{AC}\left(\frac{1+w}{1+r}\right)^t - \frac{P\,(1+w)}{r-w}\left[1 - \left(\frac{1+w}{1+r}\right)^t\right].$$

There are at least two things to note about this characterization of the Asset/Salary Ratio. First, the annuity value is based on a date certain rather than a life annuity. If a life annuity is used then the annuity cost AC depends on the annuity's interest rate, i, the probability of a person age b at retirement of living to age $b + h$ (hPb), and on the last age in a mortality table, m, as follows:

$$\text{(B10)} \qquad \mathrm{AC}_b = \sum_{h=0}^{m-\mathrm{b}} \frac{hPb}{(1+i)^h}.$$

Second, the preretirement investment return, annuity investment return, and salary growth terms may all be different. If any of them are similar, the Asset/Salary Ratio equation collapses further. For example, if the preretirement investment rate of return and the salary growth rate are equal, then:

$$\text{(B11)} \qquad \mathrm{ASR}_t = \frac{A_t}{S_t} = \mathrm{RR} * \mathrm{AC} - P * t.$$

Notes

We are grateful to Gary Selnow, John Ameriks, Mark Warshawsky, Harry Klaristenfeld, Deanne Shallcross, Yuewu Xu, and anonymous readers for helpful comments and suggestions.

1. FASB 87 requires private pension plan sponsors to report their surplus, or the excess of assets over present-value liabilities, on a marked-to-market basis. GASB 5, on the other hand, does not require public pension plans to measure liabilities with a discount rate that reflects current market conditions.

2. At that time, social security benefits at age 65 replaced about 20 percent of income in the upper income categories ($90,000 in 1990 dollars), about 50 percent of income for the middle income range ($35,000), and about 70 percent of income for those with lower incomes ($15,000).

3. To be precise, S_t is the individual's salary or income over the last year.

4. DC plan contribution rates vary considerably among employers. In higher edu-

cation, many college and university plans are designed so that the employer and employee together contribute 10 percent or more of annual salary.

5. This assumes that salary equals $1 or that the right-hand side of the equation is divided by S_t.

6. These examples assume 4 percent nominal (2 percent real) annual salary growth.

7. One of the limits of the Asset/Salary Ratio should be noted in connection with this first point. Other things being equal, a future salary *decrease* would in fact lead to an *increase* in the actual Asset/Salary Ratio. But in most cases individuals would not prefer to increase their own Asset/Salary Ratio in this manner.

8. Using the @Risk commercial software program, the Latin Hypercube sampling method was used along with expected value recalculation. In repeated simulations, the results converged consistently after about 1,500 iterations.

9. Note that the mean replacement ratio result was 83 percent, consistent with the non-stochastic expected value. However the p=.50 replacement ratio is 72 percent. Repeated simulations produced distributions of replacement ratios that exhibited skewness (1.8) and considerable kurtosis (9.8). Not surprisingly, these distributions resembled a log normal rather than a normal distribution.

10. The following formula follows the Heller and King convention, but it has been reduced to a simplified form that assumes contributions to the plan are made only once each year at year's end.

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