Penny saved, penny earned

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Executive summary. Several long-term trends—including financial shortfalls facing public benefit programs such as Social Security and Medicare, low returns on equities over the past decade, very low yields on bonds and money market instruments, and overall longer life expectancies—suggest the need for higher individual retirement savings. Committing to a disciplined investment program clearly involves trade-offs, at any age or life stage. When it comes to retirement planning, each investor must define his or her willingness to forgo current consumption (which can thus result in higher savings rates) to improve his or her prospects of providing for future spending.

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Although investors continue to be concerned about the adequacy of their retirement savings overall, we see some positive trends, including an increase in the personal savings rate. Since its recent low in mid-2005 of less than 1%, the personal savings rate has been trending upward, to 5.5% in mid-2011, according to the U.S. Bureau of Economic Analysis.

This paper examines three retirement-investing criteria—age at the start of investing (or time horizon), contribution rates, and portfolio asset allocation—using a case study of a hypothetical investor who starts saving at three different ages, to illustrate how these investing "levers" can influence one's retirement outlook. Our conclusions reinforce that the two levers an investor can directly control—savings time horizon and savings rate—will, independently or together, generally provide a higher probability of success, rather than relying on the possibility for higher portfolio returns (by, for instance, increasing one's stock exposure). We further illustrate how investment fees, which have often been overlooked, can significantly erode a portfolio over long time horizons.

An essential first step in any retirement plan is for an investor to understand the key factors that influence a portfolio's prospective wealth at retirement. An awareness of how these factors interact, and which factors you can directly control, can greatly influence long-term wealth creation, which ultimately defines the retirement decision.

This paper studies three factors that influence retirement investing: age at the start of investing (or time horizon), contribution rates, and portfolio asset allocation. Specifically, we assume the investor begins saving at three different ages (25, 35, and 45) as a percentage of salary (a $30,000 salary at age 25; $51,372 at age 35; and $64,090 at age 45—based on an adjusted Social Security Administration [SSA] wage index, with retirement at age 65). We illustrate median portfolio balances assuming the following allocations: conservative (20% stock/80% bond), moderate (50% stock/50% bond), and aggressive (80% stock/20% bond).[1] (Please see the Appendix, for further explanation of our assumptions.)

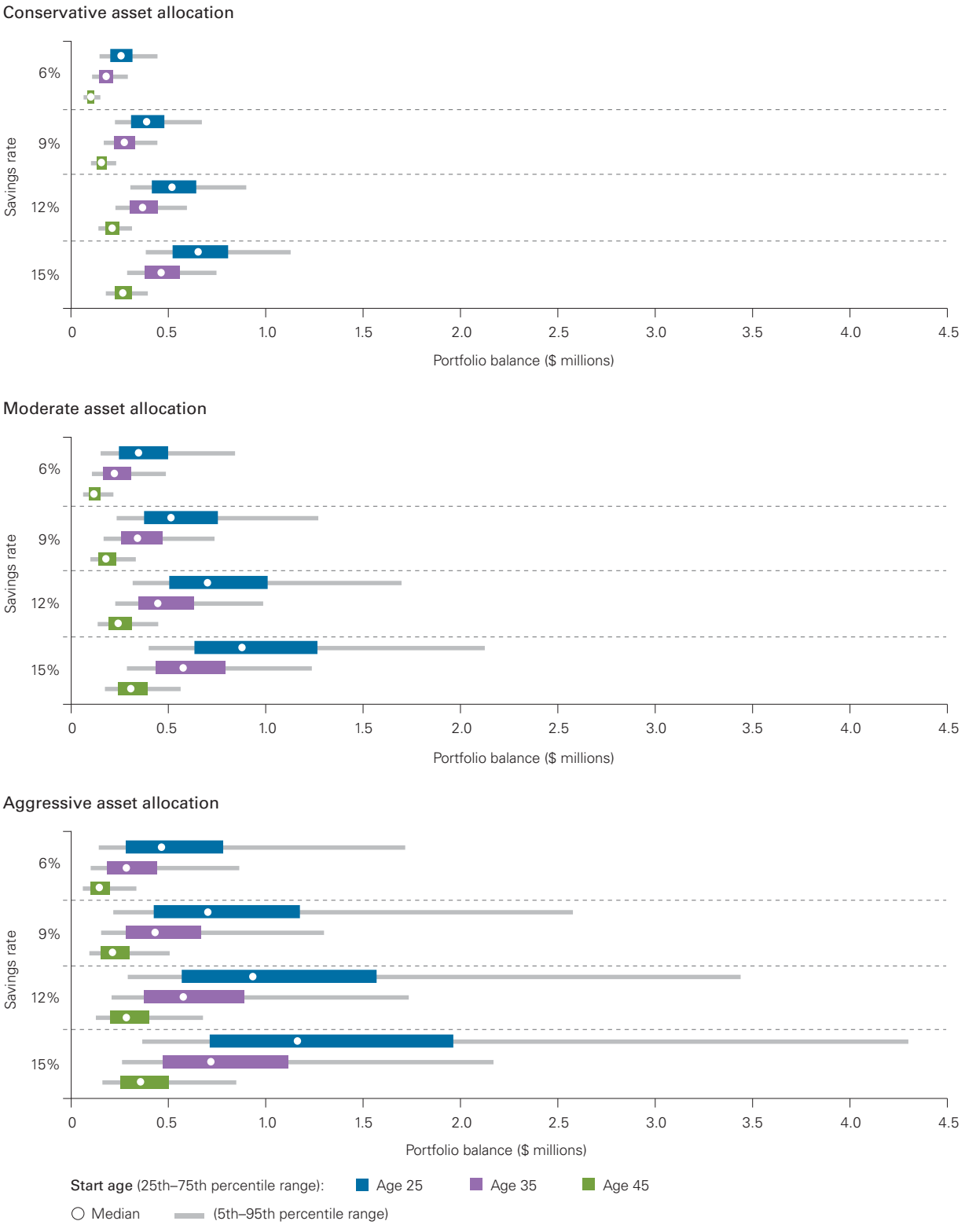
Figure 1 illustrates the range of portfolio values at the hypothetical retirement age of 65. The range represents the 95th and 5th percentile balances, with the bars showing the 75th- and 25th-percentile balances and the median values noted within each bar. Furthermore, Figure 2, on page 4, translates the inflation-adjusted median portfolio's balance at retirement into income, assuming a 4% initial withdrawal. We then calculate the percentage of income replacement (of ending salary) that this would provide, in addition to Social Security.

Notes on risk: All investments are subject to risk. There is no guarantee that any particular asset allocation or mix of funds will meet your investment objectives or provide you with a given level of income. Diversification does not ensure a profit or protect against a loss in a declining market.

IMPORTANT: The illustrations in this paper are hypothetical and do not represent the return on any particular investment. All results are in U.S. dollars as of December 31, 2010. The projections or other information generated by the Vanguard Capital Markets Model® regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. VCMM results will vary with each use and over time. Please see page 15 for more information on the VCMM.

1 For purposes of our analysis, we assume that the asset allocation does not change throughout the investing period. Investors, however, generally switch to a more conservative allocation as they approach retirement.

Figure 1. Range of portfolio balances at retirement, inflation-adjusted

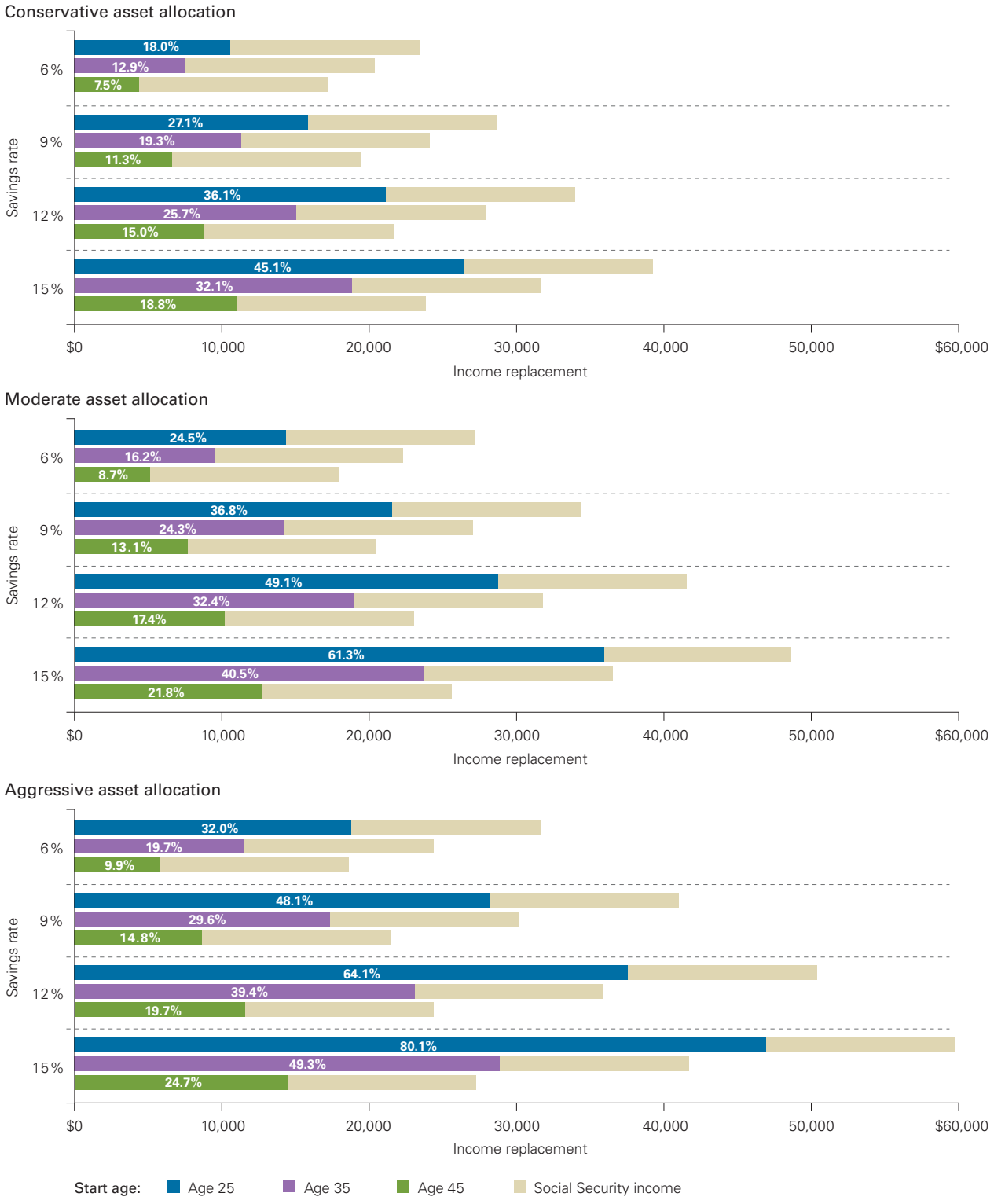


Notes: **This hypothetical illustration does not represent the return on any particular investment.** See Appendix for detailed assumptions, including asset allocation and indexes represented.

Sources: Vanguard, based on Social Security Administration (SSA) estimates using the Quick Calculator at ssa.gov.

Figure 2. Income replacement supported by median portfolio balances, inflation-adjusted

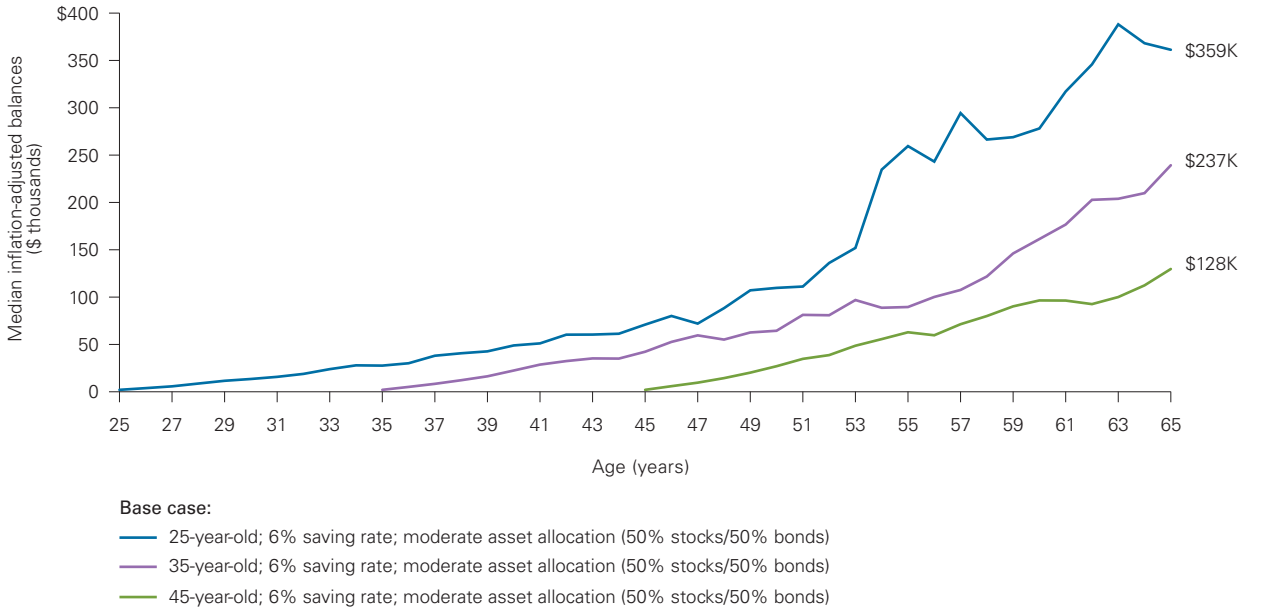
We assume a starting salary of $30,000 at age 25 and model just one wage scale with increasing age. As such, Social Security income is $12,800 at retirement, representing a 22% income replacement in all scenarios.



Notes: Inflation-adjusted ending salary upon retirement at age 65 for all scenarios is about $58,600. See Appendix for detailed assumptions, including asset allocation and benchmark representation.

Sources: Vanguard, based on Social Security Administration (SSA) estimates using the Quick Calculator at ssa.gov.

Figure 3. Benefits of starting to save early: Median portfolio balances at retirement (inflation-adjusted)



Notes: The three median ending balances shown in this figure are based on simulations run for each savings scenario. The return streams leading to the median ending balances may differ. See Appendix for assumptions on benchmark representation.

Source: Vanguard.

Committing to savings can have a big impact

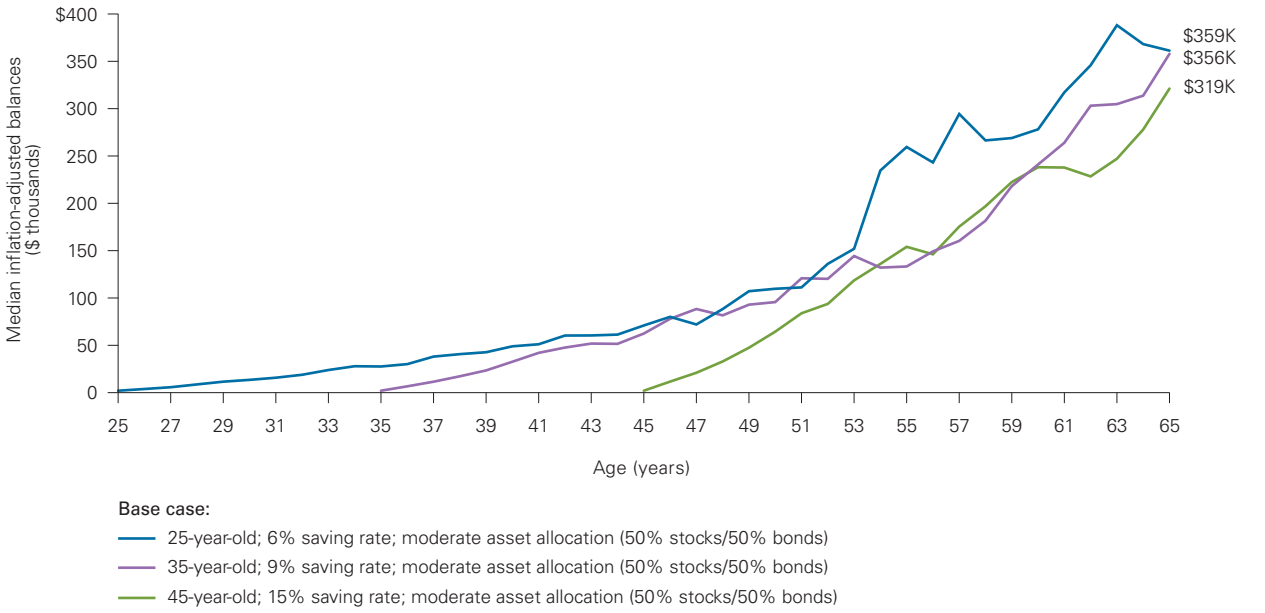
Not surprisingly, this analysis highlights the importance of two variables. First, the most obvious conclusion is that, across all asset allocations and time horizons, portfolios with higher savings rates resulted in higher outcomes. At any given level of risk–return choice (or asset allocation), higher contribution levels resulted in better outcomes, due to higher levels of capital committed by the investor. Second, this reinforces the importance of early and disciplined savings.[2] In all of the scenarios, the median portfolio balances were significantly higher for investors who started saving at an early age (i.e., 25), versus later at age 35 or 45.

Time horizon: Benefits of an early start can be astounding

Figure 3 illustrates the benefit at retirement of starting to save early. In our analysis, if an investor starts contributing 6% of his or her salary at age 25 in a moderate allocation, the median portfolio balance at retirement is roughly $359,000. If, however, the investor's contribution rate remains the same but is deferred until age 35, the median portfolio balance would be approximately $237,000, or 34% lower. Furthermore, if starting to save is deferred until age 45, then the median portfolio balance is about $128,000, or 64% lower.

2 For simplicity, we assumed the savings rate is a constant percentage of income. The theory of consumption smoothing, on the other hand, assumes that savings will vary with income, meaning that saving rates will be lower in years with lower income and adjusted higher as income levels increase, with the hope of optimizing the overall standard of living.

Figure 4. An alternative look at benefits of starting to save early: Median portfolio balances at retirement (inflation-adjusted)



Notes: The three median ending balances shown in this figure are based on simulations run for each savings scenario. The return streams leading to the median ending balances may differ. See Appendix for assumptions on benchmark representation.

Source: Vanguard.

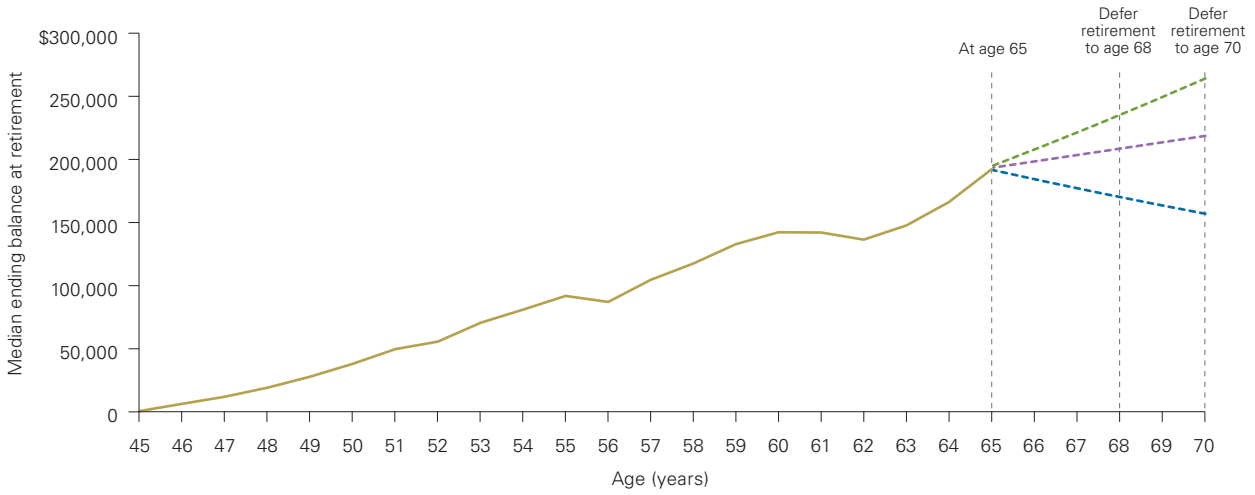
Looking at this analysis another way, if this same investor doesn't start investing until age 35, to achieve a similar median retirement balance, he or she would have to increase contributions to 9% of salary. A more extreme situation exists when savings are deferred until age 45, in which a savings rate exceeding 15% of the investor's salary would be required to achieve similar outcomes (see **Figure 4**). Although this is just one example, the conclusions generally apply across this paper's scenarios and illustrate how powerful compounding can be over longer time horizons.

Time horizon: If facing a shortfall, delaying retirement can help bridge the gap

Although the recent market environment has admittedly been challenging for many investors, those nearing retirement may be facing shortfalls and forced to make tough decisions. In these cases, the option to delay retirement, even for a few years, may provide a meaningful opportunity to close the shortfall. This may seem like an obvious conclusion, but if you can work longer and defer retirement for a while, we show here how continued savings coupled with no spending from the portfolio can materially increase a portfolio's balance and, thus, later provide for higher income replacement.

Figure 5 illustrates results for a hypothetical investor whose saving horizon was 20 years, saving 9% of salary starting at age 45 in a moderate allocation. Although this scenario may likely have resulted in a savings shortfall, the near-retiree could help close the gap by deferring retirement. The figure shows how both the median ending balances would change (and thus the supporting income) if retirement were deferred for either three years or five years. A savings shortfall can certainly be

Figure 5. Deferring retirement can help to narrow savings shortfalls for median ending balances



	At age 68		At age 70	
	Balance	Income (4% real)	Balance	Income (4% real)
Base case: Retire at age 65 and withdraw 4% per year	$169,400	$6,800	$156,100	$6,200
Defer retirement: 0% annual return and 0% annual inflation	207,300	8,300	217,800	8,700
Defer retirement: 6.9% annual return and 2.5% annual inflation	233,100	9,300	263,300	10,500

Notes: The three median ending balances shown in this figure are based on simulations run for each savings scenario. The return streams leading to the median ending balances may differ. See Appendix for assumptions on benchmark representation.

Source: Vanguard.

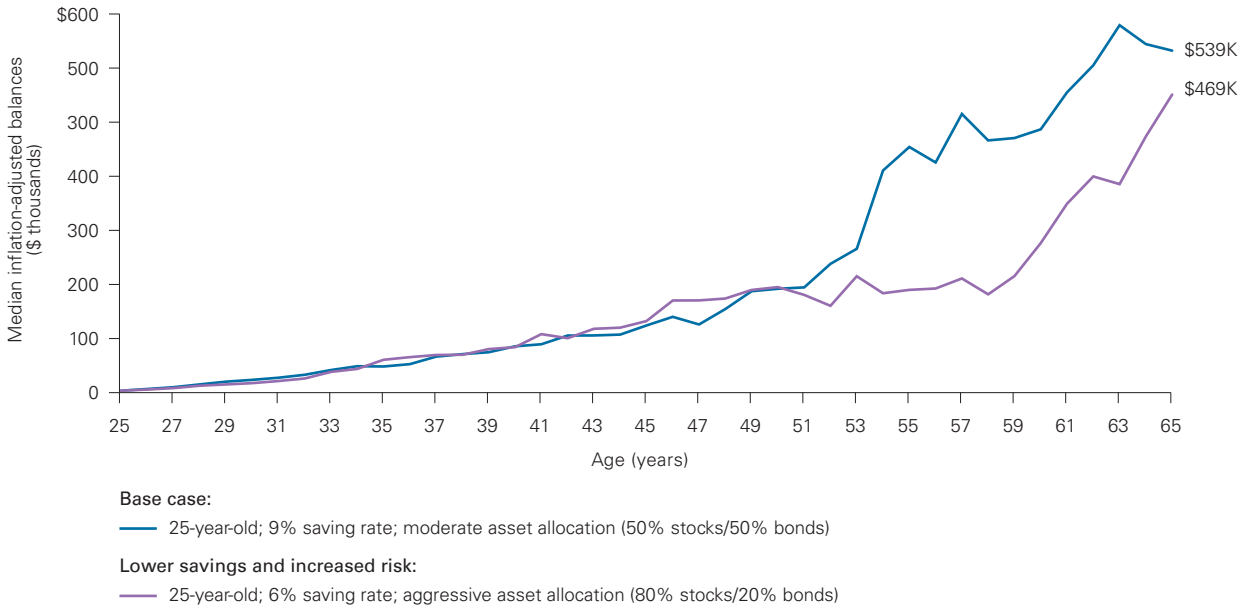
daunting, but Vanguard's view is that it's important to be aware that, when faced with a shortened time horizon, extending the savings period by delaying retirement—or, alternatively, increasing your saving rate, as we discuss next—may often be viable options to help bridge the gap.

Savings rate: More reliable than portfolio returns

Increasing the savings rate can have a substantially more positive impact on wealth accumulation than shifting to a more aggressive portfolio. For example, **Figure 6**, on page 8, demonstrates how saving 9% starting at age 25 in a moderate allocation resulted in a higher median ending balance (about $539,000) than saving 6% in a more aggressive allocation (about $469,000). Saving 12% starting at age 25 in a moderate allocation resulted in a median portfolio balance of about $718,000, versus about $704,000 in a more aggressive allocation with a savings rate of 9% (not shown in Figure 6; see Appendix **Figure A-1**, on page 12).

This type of relationship (in which a higher contribution rate has more positive influence than a more aggressive allocation) generally exists throughout the case study, including scenarios with starting ages of 35 or 45. This reinforces that a higher contribution rate can be a more reliable and more powerful contributor to wealth accumulation across a range of starting ages than increasing the risk–return potential through more aggressive portfolio construction strategies.

Figure 6. Benefit of increased saving versus increased portfolio risk for median portfolio balances at retirement (inflation-adjusted)



Notes: The three median ending balances shown in this figure are based on simulations run for each savings scenario. The return streams leading to the median ending balances may differ. See Appendix for assumptions on benchmark representation.

Source: Vanguard.

Dealing with 'worst-case' scenarios

Much of our case study to this point has illustrated savings scenarios based on median scenarios. It is natural, then, to ask how the conclusions might differ in a "worst-case" scenario, defined for our purposes as a scenario with poor capital market returns.

Using the same example as in Figure 6, but looking at the 5th-percentile income balances instead of median income balances, the 25-year old investor saving 9% in a moderate portfolio would have accumulated roughly $246,000 (see Appendix Figure A-1, on page 12). On the other hand, had that investor instead opted to save less (6%) in a more aggressive portfolio, his or her ending balance would have been roughly $149,000, or about 40% less than that of the moderate portfolio. In terms of income replacement, the first example would have provided an income replacement ratio of about 17%, whereas the second example would have resulted in a much lower income replacement (described more in the paper's next section) of about 10% (see Appendix **Figure A-2**, on page 13). Both of these income replacements, even factoring in Social Security benefits, would likely be insufficient to meet a typical retiree's spending needs.

We use this illustration to reinforce that the financial markets are cyclical and that the timing of return patterns can have a significant impact, positive or negative, on one's actual financial outcomes. With long-term financial planning, it can be very dangerous to rely on high or "average" portfolio returns, since this can lead to insufficient income replacement over the long-term.

Translating portfolio balances at retirement into income replacement

Generally, a retiree may require less income at retirement, so his or her income replacement ratio will likely be less than 100%.[3] In the absence of a personalized financial plan, Vanguard generally suggests targeting a replacement range of 75%–85% of preretirement income. Certain expenses, such as employment-related expenses, income taxes, and savings, will likely be lower (or eliminated altogether). But, on the other hand, the rising costs of health care may add to a retiree's budget. Of course, income needs are highly individualized, and will vary among retirees. However, using a rule of thumb such as a retirement income replacement ratio helps an investor to determine how much he or she needs to save to supplement fixed income sources, such as Social Security, in retirement.

We thus analyzed what the retirement portfolio balances would support in terms of a retiree's income replacement ratio. For each scenario, we translated the inflation-adjusted median portfolios balance at retirement into income, assuming a 4% initial withdrawal.[4] We then calculated the percentage of income replacement this would provide, in inflation-adjusted dollars, using the median portfolio balance and terminal salary. Figure 2 (on page 4) shows the median initial income produced by the portfolio at retirement in both dollars (the blue, purple, and green bars) and as a percentage of income replacement (indicated in white inside each of those bars). We also illustrate what Social Security would represent in additional income replacement.[5]

For example, continuing the earlier discussion of the investor who started contributing 9% at age 25 and assuming a moderate allocation, the median portfolio balance at retirement was about $539,000. Assuming a 4% initial withdrawal rate, the first year's portfolio spending would be approximately $21,500 (in today's dollars). This would result in a retirement income replacement ratio of 59% (22% from Social Security[6] and about 37% from investment assets). If the investor assumed a more aggressive asset allocation, the median income replacement would increase to about $28,200 for a total income replacement ratio of 70% (of that, about 48% would come from investment assets). But again, increasing the contribution rate proved to be a much more powerful strategy than a more aggressive allocation. By raising the contribution rate to 12%, the median income increased to about $28,700, or a 71% total income replacement ratio. And increasing the contribution rate to 15% resulted in a median income of about $35,900, or an 83% income replacement rate. (See Appendix Figure A-2.)

For higher-income earners, portfolio needs to support higher income replacement

Our case study has examined just one general range of income replacement for retirement savings. This need becomes more magnified for higher-income earners, as Social Security represents a smaller percentage of income replacement. According to Aon Consulting (2008), income replacement for income levels between $80,000 and $250,000 ranges from 78% to 88%, with Social Security representing only 39 to 14 percentage points, respectively.[7] The implication is that higher-income earners will generally need to generate a greater level of income from their retirement savings. Although lower-income earners may be comfortable saving more modestly—since Social Security may constitute a greater percentage of income replacement—higher-income earners will likely stand to benefit from increased savings rates.

3 See also Aon Consulting's *2008 Replacement Ratio Study*, which analyzes the replacement ratio necessary for individuals to maintain their preretirement standard of living, at different income levels.

4 Several studies support a general 4% initial retirement withdrawal rate for a balanced stock/bond portfolio (see Bruno and Jaconetti, 2009, for additional discussion and references).

5 Social Security estimates from ssa.gov Quick Calculator, assuming age 65 retirement; see salary assumptions outlined in the Appendix.

6 Because we assume a salary of $30,000 at age 25 and model just one wage scale with increasing age, Social Security is assumed to represent 22% income replacement in all scenarios.

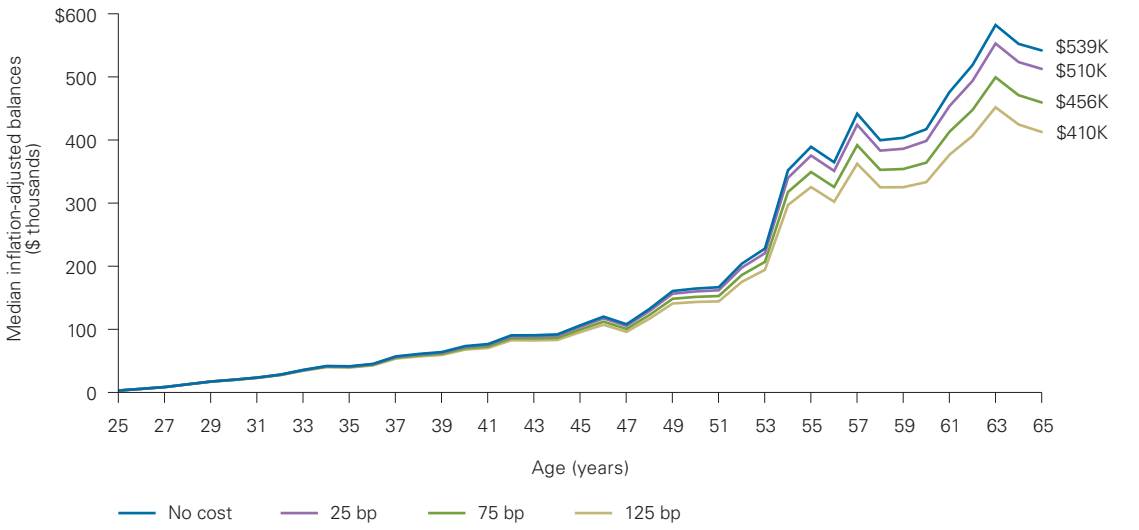
7 We recognize that Aon Consulting's 2008 assumptions differ from those used here; however, we also recognize that Social Security income represents a smaller percentage of income replacement for those with higher incomes.

Understanding long-term impact of investment costs

External factors such as portfolio returns and inflation clearly cannot be controlled or accurately predicted over the long term. On the other hand, investors can directly control their personal savings contribution rate. Investment costs, which can also have major consequences for a long-term portfolio's balance, are an often-neglected variable that investors can also directly influence.

To illustrate how costs can significantly reduce portfolio balances, consider our previous scenario in which a 25-year-old investor contributes 9% annually to a portfolio that is moderately invested in stocks and bonds. **Figure 7** illustrates a range of hypothetical portfolio balances at retirement, using benchmark returns as proxies for the asset-class returns and first assuming no costs. We then ran the same scenario, changing the annual investment costs to 0.25%, 0.75%, and 1.25%. Over a 40-year savings period for this hypothetical investor, the figure shows a striking potential impact on the portfolio balances at retirement. For instance, if this hypothetical investor were in a very high-cost investment at 1.25% versus a low-cost program at 0.25%, the difference in the median ending balance would be nearly $100,000, or a loss of roughly 20% in the portfolio's value.

Figure 7. Long-term impact of investment costs on portfolio balances



Note: This hypothetical illustration does not represent the return on any particular investment.

Source: Vanguard.

Conclusion

Committing to a disciplined invested program clearly involves trade-offs, at any age or life stage. An important aspect of the retirement-planning process for all investors is to define their willingness to forgo current consumption (potentially resulting in higher savings rates) to improve their overall prospects of providing for spending in the future. A higher savings rate will likely provide a higher probability of success due to the partial shift in responsibility for accumulation from the less certain return stream of risky assets to a more certain savings stream.

References

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Appendix. Background data and assumptions

Figure A-1. Portfolio balances at retirement, inflation-adjusted

Conservative asset allocation

Savings rate	Age	5%	25%	Median	75%	95%
6%	25	$158,252	$213,345	$264,127	$327,413	$455,815
	35	119,944	155,747	188,151	228,209	303,486
	45	76,194	94,270	109,998	129,235	162,446
9%	25	$237,378	$320,018	$396,191	$491,119	$683,723
	35	179,916	233,621	282,227	342,313	455,229
	45	114,291	141,405	164,996	193,853	243,670
12%	25	$316,504	$426,690	$528,254	$654,826	$911,630
	35	239,888	311,495	376,303	456,418	606,972
	45	152,388	188,540	219,995	258,471	324,893
15%	25	$395,630	$533,363	$660,318	$818,532	$1,139,538
	35	299,860	389,369	470,378	570,522	758,714
	45	190,485	235,674	274,994	323,089	406,116

Moderate asset allocation

Savings rate	Age	5%	25%	Median	75%	95%
6%	25	$164,025	$257,682	$359,218	$509,493	$852,146
	35	119,462	177,975	237,231	320,105	498,023
	45	74,417	101,793	127,654	161,989	229,440
9%	25	$246,038	$386,523	$538,828	$764,239	$1,278,219
	35	179,193	266,962	355,846	480,158	747,035
	45	111,625	152,690	191,481	242,984	344,161
12%	25	$328,050	$515,364	$718,437	$1,018,986	$1,704,292
	35	238,924	355,950	474,461	640,211	996,046
	45	148,833	203,586	255,308	323,979	458,881
15%	25	$410,063	$644,205	$898,046	$1,273,732	$2,130,365
	35	298,655	444,937	593,077	800,263	1,245,058
	45	186,042	254,483	319,135	404,973	573,601

Aggressive asset allocation

Savings rate	Age	5%	25%	Median	75%	95%
6%	25	$148,910	$287,511	$469,201	$788,078	$1,723,147
	35	107,333	190,595	288,567	448,311	870,688
	45	67,008	104,559	144,408	204,091	342,139
9%	25	$223,365	$431,266	$703,801	$1,182,117	$2,584,720
	35	160,999	285,893	432,850	672,467	1,306,032
	45	100,511	156,838	216,612	306,136	513,209
12%	25	$297,820	$575,021	$938,402	$1,576,156	$3,446,293
	35	214,666	381,190	577,133	896,623	1,741,377
	45	134,015	209,118	288,815	408,182	684,279
15%	25	$372,275	$718,777	$1,173,002	$1,970,195	$4,307,867
	35	268,332	476,488	721,417	1,120,778	2,176,721
	45	167,519	261,397	361,019	510,227	855,348

Source: Vanguard.

Figure A-2. Median portfolio balances at retirement, inflation-adjusted: Initial annual income and replacement ratios (from investment assets).

5th percentile income

		Conservative		Moderate		Aggressive	
Savings rate	Age	Income	Ratio	Income	Ratio	Income	Ratio
6%	25	$6,330	10.8%	$6,561	11.2%	$5,956	10.2%
	35	4,798	8.2	4,778	8.2	4,293	7.3
	45	3,048	5.2	2,977	5.1	2,680	4.6
9%	25	$9,495	16.2%	$9,842	16.8%	$8,935	15.3%
	35	7,197	12.3	7,168	12.2	6,440	11.0
	45	4,572	7.8	4,465	7.6	4,020	6.9
12%	25	$12,660	21.6%	$13,122	22.4%	$11,913	20.3%
	35	9,596	16.4	9,557	16.3	8,587	14.7
	45	6,096	10.4	5,953	10.2	5,361	9.2
15%	25	$15,825	27.0%	$16,403	28.0%	$14,891	25.4%
	35	11,994	20.5	11,946	20.4	10,733	18.3
	45	7,619	13.0	7,442	12.7	6,701	11.4

Median income

		Conservative		Moderate		Aggressive	
Savings rate	Age	Income	Ratio	Income	Ratio	Income	Ratio
6%	25	$10,565	18.0%	$14,369	24.5%	$18,768	32.0%
	35	7,526	12.9	9,489	16.2	11,543	19.7
	45	4,400	7.5	5,106	8.7	5,776	9.9
9%	25	$15,848	27.1%	$21,553	36.8%	$28,152	48.1%
	35	11,289	19.3	14,234	24.3	17,314	29.6
	45	6,600	11.3	7,659	13.1	8,664	14.8
12%	25	$21,130	36.1%	$28,737	49.1%	$37,536	64.1%
	35	15,052	25.7	18,978	32.4	23,085	39.4
	45	8,800	15.0	10,212	17.4	11,553	19.7
15%	25	$26,413	45.1%	$35,922	61.3%	$46,920	80.1%
	35	18,815	32.1	23,723	40.5	28,857	49.3
	45	11,000	18.8	12,765	21.8	14,441	24.7

95th percentile income

		Conservative		Moderate		Aggressive	
Savings rate	Age	Income	Ratio	Income	Ratio	Income	Ratio
6%	25	$18,233	31.1%	$34,086	58.2%	$68,926	117.7%
	35	12,139	20.7	19,921	34.0	34,828	59.5
	45	6,498	11.1	9,178	15.7	13,686	23.4
9%	25	$27,349	46.7%	$51,129	87.3%	$103,389	176.5%
	35	18,209	31.1	29,881	51.0	52,241	89.2
	45	9,747	16.6	13,766	23.5	20,528	35.1
12%	25	$36,465	62.3%	$68,172	116.4%	$137,852	235.4%
	35	24,279	41.5	39,842	68.0	69,655	118.9
	45	12,996	22.2	18,355	31.3	27,371	46.7
15%	25	$45,582	77.8%	$85,215	145.5%	$172,315	294.2%
	35	30,349	51.8	49,802	85.0	87,069	148.7
	45	16,245	27.7	22,944	39.2	34,214	58.4

Note: Because our analysis uses just one salary assumption, Social Security represents 22% income replacement in all scenarios, and can be added to the income replacement in this figure to derive the total income replacement.

Source: Vanguard

Simulation results: The simulation results displayed in this paper are based on the Vanguard Capital Markets Model (VCMM). For a more detailed description of the VCMM, see page 15 as well as Wallick, Aliaga-Díaz, and Davis (2009). Our analysis uses various standard assumptions about asset allocations, contributions, and replacement ratios. All results are inflation-adjusted.

Wage scale: Investor salary growth is modeled here after the Social Security Administration's (SSA's) wage index, which is based on reported wages for workers across the 25–65 age spectrum for low-, medium-, and high-income earners. This wage scale allows us to trace the earnings progression of an average earner over a 40-year working career, accounting for factors such as career development. Therefore, as modeled, the average worker reaches a peak salary at age 55 (in real terms) and experiences a decline in real salary through age 65. Our simulations also allow for 1.1% annual salary growth, on a real basis, in addition to the cross-sectional increase in the wage scale, which reflects the historical average productivity growth of the U.S. economy.

Our analysis assumes a starting salary at age 25 of $30,000; at age 35, a salary of $51,372; and at age 45, a salary of $64,090. At retirement age 65, the final salary is $58,563.

Social Security: Estimates taken from the ssa.gov website, assuming $30,000 earnings at current age of 25 and retirement at age 65. This analysis assumes a reduced benefit, since the retirement age is lower than "normal retirement age" for full Social Security benefits.

Asset allocation and return assumptions: The asset-return distributions are based on 10,000 simulations from the VCMM. The VCMM uses a statistical analysis of historical data to create forward-looking expectations for the U.S. and international capital markets. The model uses index returns, with no fees or expenses, to represent asset classes. Taxes are not factored into the analysis. Inflation is modeled based on historical data and simulated going forward, with the median and volatility displayed in Appendix Figure A-3.

For all the figures in this paper, U.S. stocks are represented by the Wilshire 5000 Composite Index; U.S. bonds are represented by the Barclays Capital U.S. Aggregate Bond Index (a former Lehman Brothers index); international stocks are represented by the Morgan Stanley Capital International Europe, Australasia, Far East (MSCI EAFE) plus Emerging Markets Index; inflation is calculated from the Consumer Price Index; and intermediate TIPS (Treasury Inflation-Protected Securities) and cash are derived from underlying U.S. Treasury yield data from the Federal Reserve Board.

A conservative asset allocation in this paper is considered to be 20% stock/80% bond; a moderate asset allocation is 50% stock/50% bond; and an aggressive asset allocation is 80% stock/20% bond. For stock allocations, we assume 70% allocation to U.S. stocks and 30% allocation to international stocks.

Contributions: Contributions are made at the end of the year, based on a percentage of salary. We recognize that an investor in an employer-sponsored retirement plan makes contributions throughout the year through payroll deductions.

Replacement ratio: We assume a 4% initial withdrawal of portfolio balance to estimate the dollar withdrawal. The percentage is determined by taking the dollar amount as a percentage of the ending year salary.

Figure A-3. Annualized 40-year asset-return distribution

	40-year horizon							
	5th percentile	10th percentile	25th percentile	Median	75th percentile	90th percentile	95th percentile	Standard deviation
Domestic equity	3.80%	5.00%	7.00%	9.20%	11.50%	13.60%	14.80%	19.20%
International equity	3.40	4.70	7.00	9.50	12.00	14.30	15.80	22.30
U.S. nominal bonds	3.00	3.40	4.10	4.80	5.60	6.30	6.70	7.00
Inflation	0.60	1.10	2.00	3.00	4.00	4.90	5.40	2.70

Source: Vanguard.

About the Vanguard Capital Markets Model

The Vanguard Capital Markets Model (VCMM) is a proprietary financial simulation tool developed and maintained by Vanguard's primary investment research and advice teams. The model forecasts distributions of future returns for a wide array of broad asset classes. Those asset classes include U.S. and international equity markets, several maturities of the U.S. Treasury and corporate fixed income markets, international fixed income markets, U.S. money markets, commodities, and certain alternative investment strategies.

The theoretical and empirical foundation for the Vanguard Capital Markets Model is that the returns of various asset classes reflect the compensation investors require for bearing different types of systematic risk (beta). At the core of the model are estimates of the dynamic statistical relationship between risk factors and asset returns, obtained from statistical analysis based on available monthly financial and economic data from as early as 1960.

Using a system of estimated equations, the model then applies a Monte Carlo simulation method to project the estimated interrelationships among risk factors and asset classes as well as uncertainty and randomness over time. The model generates a large set of simulated outcomes for each asset class over several time horizons. Forecasts are obtained by computing measures of central tendency in these simulations. Results produced by the tool will vary with each use and over time.

The projections or other information generated by the Vanguard Capital Markets Model regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. VCMM results will vary with each use and over time.

The VCMM projections are based on a statistical analysis of historical data. Future returns may behave differently from the historical patterns captured in the VCMM. More important, the VCMM may be underestimating extreme negative scenarios unobserved in the historical period on which the model estimation is based.

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