Optimal Retirement Income Solutions in DC Retirement Plans
Phase 4: Strategies to Protect Retirement Income Before Retirement

Interim results and commentary
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SOCIETY OF ACTUARIES

Acknowledgments

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Project Goals

- Illustrate an analytical framework using stochastic forecasts and efficient frontiers for hypothetical retirees, for determining retirement income generators (RIGs) that could be offered in a DC retirement plan.
- Determine the RIGs or combination of RIGs that could be considered optimal according to specified criteria.
- Encourage plan participants, plan sponsors, and advisors to adopt a portfolio approach to developing retirement income strategies.
- Follow up prior SOA/SCL report that analyzed the characteristics of stand-alone RIGs:
  - *The Next Evolution in Defined Contribution Retirement Plans: A Guide for DC Plan Sponsors to Implementing Retirement Income Programs*
- See Appendix A for definition of certain terms, and see above report for additional definition of terms and descriptions of RIGs.

Summary of Four-Phase Project on Optimal Retirement Income Strategies

- Phase 1 analyzes RIGs that are currently available in DC retirement plans and are straightforward to implement. Phase 1 establishes a baseline for comparing to future phases.
- Phase 2 determines if projected outcomes can be improved over results in Phase 1 by using retirement savings to enable delaying Social Security benefits.
- Phase 3 analyzes qualified longevity annuity contracts (QLACs) in combination with systematic withdrawals.
- Phase 4 examines strategies to protect retirement income in the period leading up to retirement.
- This is the interim report for Phase 4. A final report will integrate all four phases.

Executive Summary of Phase 4 Results and Conclusions

- There has been considerable interest in strategies to protect retirement income from decreasing in the five to ten years preceding retirement, as a result of the stock market crash of 2008-2009 and subsequent decline in interest rates and economic activity.

- Many older workers experienced substantial declines in their account balances, and found that their reduced account balances generated retirement income at reduced rates compared to the period immediately before the economic downturn, due to lower rates of interest and dividend payments on stocks. Many of these workers were forced to delay their retirement, while others who were laid off may have had no choice but to retire on reduced retirement incomes.

- In October, 2014, the Treasury Department issued guidance intended to enable plan sponsors to offer deferred annuities to older participants within target date funds (TDFs) without violating nondiscrimination requirements. This guidance increased interest in strategies to protect retirement income in the period leading up to retirement.

Executive Summary of Phase 4 Results and Conclusions (continued)

- This report analyzes key questions:
  - What strategies can older workers adopt to protect their retirement incomes in the period leading up to retirement?
  - Can plan sponsors offer investing and retirement income solutions to help their older workers achieve this goal?

- We examine the following strategies to protect retirement income in the period leading up to retirement:
  - Invest in target date funds that reduce exposure to stocks as the worker ages, then employ a systematic withdrawal program (SWP) to generate retirement income
  - Buy deferred income annuities (DIAs)
  - Invest in guaranteed lifetime withdrawal benefit (GLWB) annuities
  - As noted in our *Next Evolution* report, the above solutions are readily available to employer-sponsored retirement plans

- We use stochastic forecasts together with efficient frontiers to analyze these strategies.

Executive Summary of Phase 4 Results and Conclusions (continued)

- Many TDFs remain vulnerable to stock market crashes and may not offer satisfactory protection in the period leading up to retirement.
  - According to one study[1], the vast majority of assets in TDFs employ a "through" methodology, with an average allocation to stocks of 49% at age 65.
  - With such a TDF, a stock market decline of 50% could result in roughly a 25% decline in the value of the TDF.
  - During the 2008-2009 stock market crash, many TDFs targeting near-retirees experienced losses in the above order of magnitude[2].
  - Many systematic withdrawal schemes, such as the IRS required minimum distribution (RMD) or four percent rule, apply a target percentage to the amount of retirement savings at retirement. In this case, a drop in the value of savings has a one-to-one corresponding decrease in the amount of initial income at retirement. As a result, a 25% decline in savings at retirement translates into a 25% drop in retirement income.
  - Our projections verify this continued vulnerability of many TDFs.

[1]"To" versus "through: The great glidepath debate, by TIAA-CREF Asset Management, May, 2015

[2]The global financial crisis and the performance of target date funds in the United States, by Laurence Booth and Bin Chang

Executive Summary of Phase 4 Results and Conclusions (continued)

- Our projections show that fixed DIAs offer the best protection against the possibility that an unfavorable economic scenario will result in retirement income being much less than expected, compared to the other RIGs and strategies that we analyzed. DIAs deployed at age 55 offer the most protection, although a laddered approach (purchasing small amounts of a DIA each year) produces projected results that are almost as favorable as buying the DIA at age 55.
  - However, most workers will not want to invest all their savings in a DIA, since a DIA results in reduced upside potential when market returns are favorable, compared to using TDFs with SWPs.
  - In addition, deferred annuities do not have liquidity throughout retirement, a desirable feature of SWPs.
- These results support the potential desirability of a strategy discussed in our Phase 1 report:
  - Cover nondiscretionary retirement living expenses with guaranteed sources of retirement income, such as Social Security, and deferred, immediate, or GLWB annuities purchased with a portion of retirement savings.
  - Cover discretionary living expenses by investing remaining savings and using a SWP to generate retirement income.

Executive Summary of Phase 4 Results and Conclusions (continued)

- We also modeled a fund with a constant 65% allocation to stocks throughout retirement as an alternative to a TDF that reduces the allocation to stocks over time. Our analyses show that such a fund projects slightly higher retirement incomes with slightly less risk or slightly higher liquidity than investing in a typical TDF.

- Our report suggests that ideally older workers should not defer retirement income decisions until they retire. Instead, it's recommended that older workers start planning for the types of RIGs they will deploy to generate retirement income five to 10 years before retirement. Part of their planning would include deciding whether to deploy strategies to protect their retirement income and assets during this period.

- We acknowledge that DIAs and GLWBs are not widely offered within employer-sponsored retirement plans, and that when they are offered, the take-up rate by retirees has been low. DIAs and GLWBs are available at some financial institutions through IRAs, although most likely using retail instead of institutional pricing. Our goal for this project is to further understanding about retirement income strategies to help plan sponsors design retirement income options to be deployed in their DC plans, and to help financial advisors develop retirement income strategies for their clients.

Summary of Phase 4 Analyses

- Analyze various retirement income solutions for two hypothetical near-retirees:
  1. Single female age 55 with $180,000 in assets, will retire at age 65.
  2. Married couple both age 55 with $300,000 in assets, will retire at age 65.

- Above asset values were chosen to be consistent with assumed age 65 asset values for Phases 1, 2, and 3, assuming average investment returns after age 55. Above asset values are assumed to be dedicated to generating retirement income, and do not include separate assets devoted to a safety cushion for unexpected emergencies. No additional contributions are assumed to be made after age 55.

- At ages 55 or 60, use a portion of retirement savings to protect retirement income from capital market downturns. Assume retirement income starts at age 65.

- Prepare stochastic forecasts and efficient frontiers of retirement income generated at age 65, using various strategies to protect retirement income before age 65. We did not include income from Social Security to isolate the impact of strategies to protect retirement income (this is different from the analyses for Phases 1, 2, and 3).

Summary of Phase 4 Analyses (continued)

- See Appendix B for details on methods, assumptions for hypothetical retirees, and capital market assumptions. Assumptions regarding expected returns and inflation reflect the low-interest rate environment prevalent in 2014 and 2015.
  - Arithmetic mean real return: 5.1% for stocks, 0.3% for bonds.
  - Arithmetic mean inflation rate: 2.1%.
  - Annuity purchase rates in April, 2014.

- Note that this report assumes institutional pricing of annuity products and investing solutions, as described in Appendix B. If a retiree experiences higher expenses with either annuity products or investing solutions, results might be less favorable than shown in this report.

- This report displays the values graphically. For a table of the values underlying the graphs, visit: http://longevity3.stanford.edu/phase2.htm

Retirement Income Solutions Investigated in Phase 4

- Invest 100% of assets in a target date fund (TDF) at age 55, and use systematic withdrawals to generate retirement income beginning at age 65. The withdrawal method is the IRS required minimum distribution (RMD-SWP). Repeat for a balanced fund with a constant 65% allocation to stocks. These serve as baselines to compare to other strategies. Most TDFs are constructed assuming the retiree will remain invested throughout retirement and use a SWP to generate retirement income.

- Invest 100% of assets at age 55 in a fixed deferred income annuity (DIA) commencing at age 65.

- Invest 100% of assets at age 60 in a fixed DIA commencing at age 65. From age 55 to 60, assets are invested in a TDF. Repeat for a balanced fund with a constant 65% allocation to stocks.

- Assets are invested in a TDF until age 65, then purchase a fixed single premium immediate annuity (SPIA) at age 65 with 100% of assets at that time. Repeat for investing from age 55 to 65 in a balanced fund with a constant 65% allocation to stocks.

Retirement Income Solutions Investigated in Phase 4 (continued)

- Assume 100% of assets are invested in a guaranteed lifetime withdrawal benefit (GLWB) annuity at age 55. At age 65, the contract provisions determine the annual income (assumed payout rates are 5% for a single retiree, 4.5% for a couple). Assume 60% of savings invested in stocks.

- Assume 10% of assets at each age between 55 and 64 are used to purchase a fixed DIA starting at age 65 (laddered DIA). Remaining assets are invested in a TDF until age 65. Repeat for a balanced fund with a constant 65% allocation to stocks.

- Assets are invested in a TDF until age 65, then purchase a fixed SPIA at age 65 with 30% of assets at that time (partial annuitization). Use RMD-SWP to generate retirement income with remainder of assets. Repeat for a balanced fund with a constant 65% allocation to stocks.

Retirement Income Solutions Investigated in Phase 4 (continued)

- Assume 30% of assets at age 55 are used to purchase a fixed DIA starting at age 65 (partial annuitization). Remaining assets are invested in a TDF until age 65. Use RMD-SWP with remaining assets at age 65 to generate income at age 65. Repeat for a balanced fund with a constant 65% allocation to stocks.

- Assume 30% of assets at age 60 are used to purchase a fixed DIA starting at age 65 (partial annuitization). Remaining assets are invested in a TDF until age 65. Use RMD-SWP with remaining assets at age 65 to generate income at age 65. Repeat for a balanced fund with a constant 65% allocation to stocks.

- Note that the DIAs, SPIAs, and GLWBs modeled in this project are described in Appendix A. Appendix B describes assumed pricing for these products, and the expenses and asset allocation for GLWBs. There can be many variations among these products with respect to features, pricing, and asset allocation that might differ from the products modeled in this report.

Defining Optimal with Retirement Income Efficient Frontiers

- For a particular retirement income solution, efficient frontiers illustrate the tradeoff between two retirement income objectives.

- Many different retirement income solutions are plotted as points on an X/Y graph, and the two retirement objectives are expressed as two dimensions on the graph.

- The efficient frontier is the set of highest points on the Y axis (vertical axis) for a given value on the X axis (horizontal axis).

Defining Optimal with Retirement Income Efficient Frontiers

- We used two types of efficient frontiers.
  - Efficient frontier #1: Emphasize retirement income (Phase 4 uses a different measure compared to Phases 1, 2, and 3, as described on page 18 of this report).
  - Efficient frontier #2: Illustrate tradeoff between amount of expected retirement income and accessible savings (same measure as used in Phases 1, 2, and 3).
- Stochastic forecasts produce retirement income projections under a range of expected, unfavorable and favorable scenarios.

Defining Optimal with Retirement Income Efficient Frontiers

- "Optimal" is in the eye of the beholder
  - Different definitions of optimal will produce different solutions that could be considered optimal.

- Other possible analyses of optimal could consider:
  - Volatility in retirement income amount from year to year.
  - The chance that savings will be exhausted.
  - The chance that retirement income could fall below a specified threshold.

- Plan sponsors should define criteria for optimal solutions that best meet their participants' goals and characteristics.

Details on Efficient Frontier #1

- Participant's most important goal: Maximize lifetime income that maintains purchasing power.
  - Tradeoff: Return vs. risk, defined in terms of retirement income.

- Measure of return (Y-axis): Average annual real retirement income from the retirement income solution under the median stochastic forecast throughout retirement. This average is calculated using the projected amount of income at each future age, multiplied by the probability of survival to each future age and adjusted for projected inflation.

- Measure of risk (X-axis): Same as Y-axis, only the average annual amount of real income is calculated under the unfavorable scenario (10^{th} percentile), to compare the potential shortfall of retirement income under an unfavorable economic scenario to the expected amount of income.

- Rationale: Retirees will want to balance the retirement income that is expected by a particular strategy vs. the amount of retirement income that's possible under an unfavorable scenario.

Details on Efficient Frontier #1 (continued)

- Note that there are other measures of risk that may be reasonable to use, such as the probability of running out of money. This report purposely analyzes RIGs that have no chance of running out of money – annuities and systematic withdrawal strategies where the annual withdrawal is a percentage of remaining assets. With such systematic withdrawal strategies, however, it is possible that the amount of withdrawal can decrease substantially, a risk that is addressed in this report.

- See Appendix B for details on the methods used for the efficient frontiers and stochastic forecasts.

Hypothetical Retiree #1

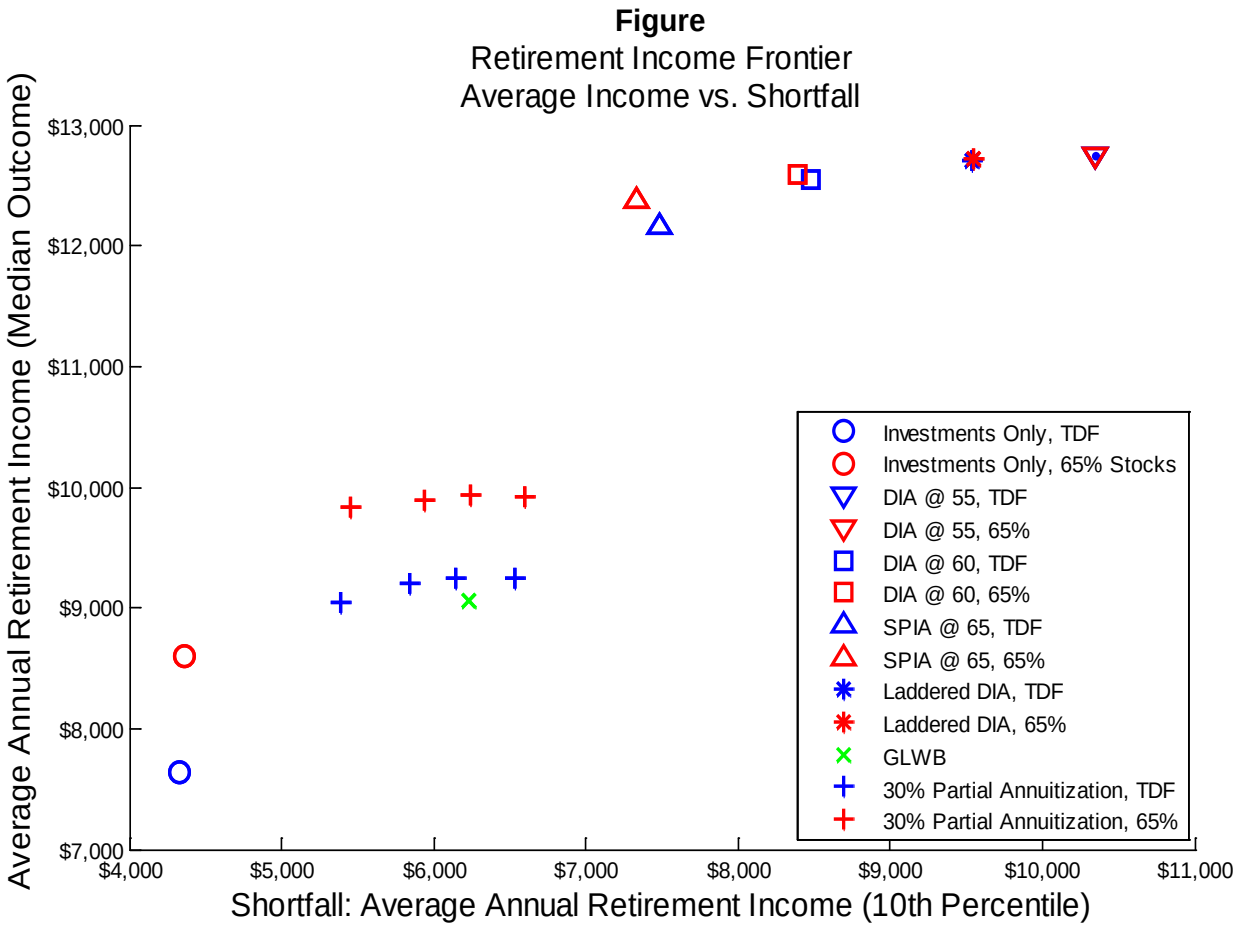
- Single female retiring at age 65
- $180,000 of assets at age 55
- No contributions assumed after age 55

- Product pricing for life annuity at age 65 (annual income as percent of assets at beginning of retirement):
  - Fixed SPIA: 6.76%
  - Sample rates for DIA commencing at age 65:
    - Purchase age 55: 10.43%
    - Purchase age 60: 8.39%
  - GMWB: 5%
  - Above rates in effect during April, 2014 for institutionally priced GLWB products and using competitive annuity bidding for SPIAs and DIAs.
- Capital market assumptions for SWP pricing shown in Appendix B.

Commentary on Efficient Frontier #1

- The graph on the next page shows that for the solutions we analyzed, buying a fixed DIA at age 55 produces the highest amount of average annual real income expected at age 65, with also the highest amount of average annual income under the unfavorable scenario. This DIA also produced the lowest drop in income between the expected and unfavorable scenarios, measured on a percentage basis, as shown later in this report.
- The next most favorable solutions are, in order:
  - Laddered approach to buying a DIA between age 55 and 64 (roughly 10% of assets are used to purchase a DIA at each age)
  - Invest in a TDF or balanced fund until age 60, then buy a DIA with 100% of assets
  - Invest in a TDF or balanced fund until age 65, then buy a SPIA with 100% of assets
- Partial annuitization solutions project higher average real retirement incomes than RMD-SWP solutions, both under the expected and unfavorable scenarios.
- For all solutions that invest savings, either before or during retirement, the balanced fund invested 65% in stocks projects slightly higher retirement incomes than the TDF, due to the higher allocation to stocks compared to the TDF allocation.

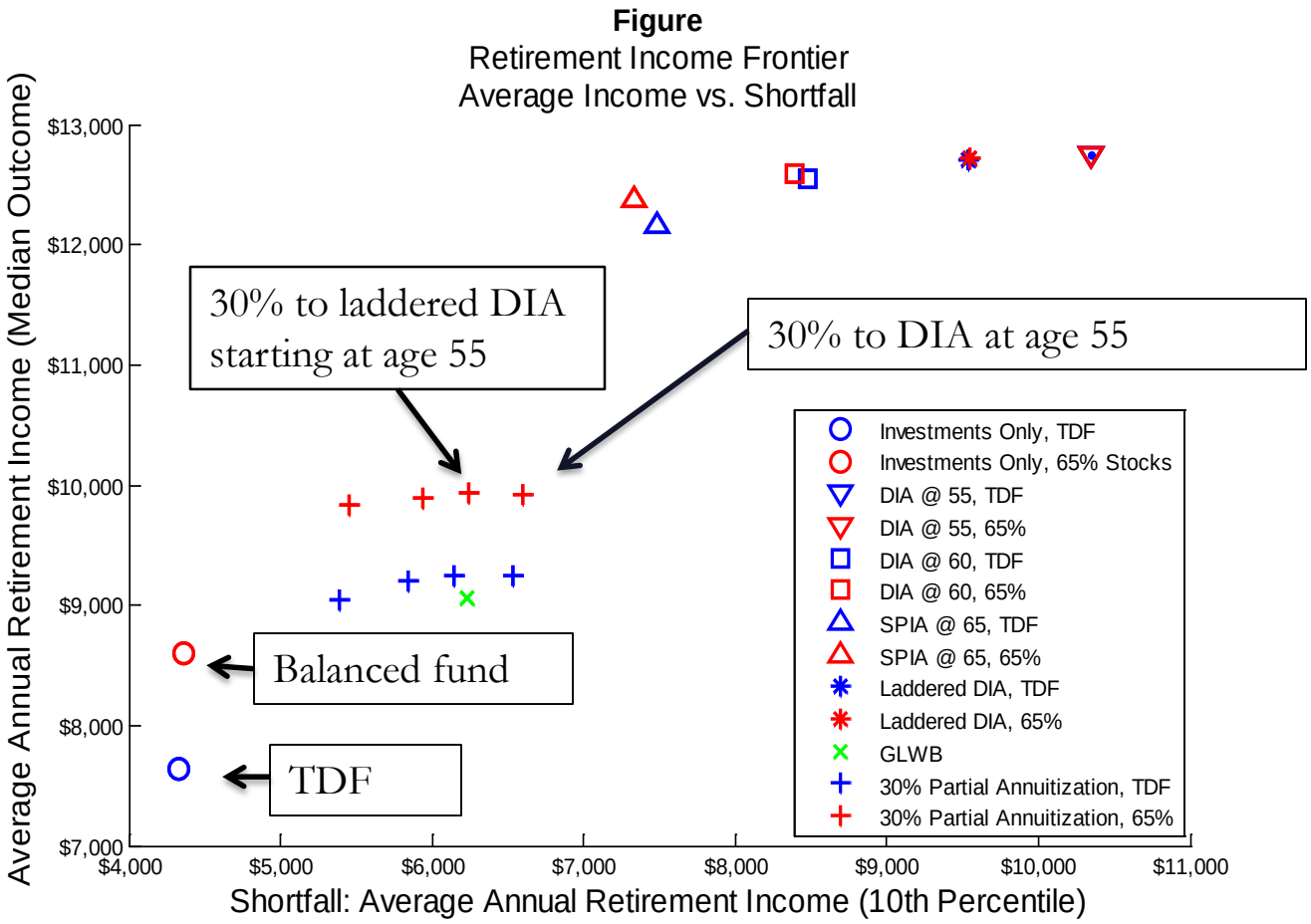
Efficient Frontier Analysis #1: Emphasize Retirement Income
Hypothetical Retiree #1: Single female age 55 with $180,000 in Savings



Commentary on Efficient Frontier #1 (continued)

- The graph on the next page shows that for the partial annuitization solutions that devote 30% of assets to an annuity, purchasing the DIA at age 55 projects the highest amount of average annual income under both the expected and unfavorable scenarios.
- The laddered approach to partial annuitization devotes approximately 3% of assets at each age between 55 and 64 to buy a DIA that starts at age 65. Remaining assets are invested in a TDF, and use the RMD-SWP to generate income at age 65. This solution represents one possible implementation of the Treasury guidance described earlier in this report regarding TDFs. This solution projects the second-highest amount of average annual income under both the expected and unfavorable scenarios.
- For the partial annuitization solutions, projected retirement incomes were higher using a balanced fund with 65% of assets devoted to stocks, compared to investing in a TDF.
- Partial annuitization solutions with DIAs project higher retirement incomes than a GLWB. This helps quantify the cost of liquidity, a feature of GLWBs but not of DIAs.

Efficient Frontier Analysis #1: Emphasize Retirement Income
Hypothetical Retiree #1: Single female age 55 with $180,000 in Savings



Commentary on Efficient Frontier #1 (continued)

- A laddered approach to purchasing DIAs has a few advantages:
  - From a behavioral perspective, it allows an older worker to make a series of incremental decisions, rather than one "all or nothing" decision.
  - It allows the older worker to dollar-cost-average their annuity purchases, which mitigates vulnerability to interest rate swings.
- Ideally an older worker would decide the amount of income they ultimately want to receive from an annuity at retirement, and prorate the annuity purchases each year until their target retirement age to end up with the targeted amount of annuity income.
- Note that laddered purchases of DIAs within retirement plans are relatively uncommon at the writing of this report, but that the Treasury guidance referenced on page 5 enables such a feature.

Commentary on Efficient Frontier #1 Regarding Other Retiree

- The efficient frontier analysis for the other hypothetical retiree shows similar patterns.
  - Married couple both age 55 with $300,000 in assets at age 55.
- See Appendix C for results.

Details on Efficient Frontier #2

- Goal is to balance amount of expected retirement income with amount of expected accessible savings throughout retirement.

- Measure of return (Y-axis): Average annual real retirement income from retirement income solution, adjusted for the probability of survival to each future age (same as efficient frontier #1).

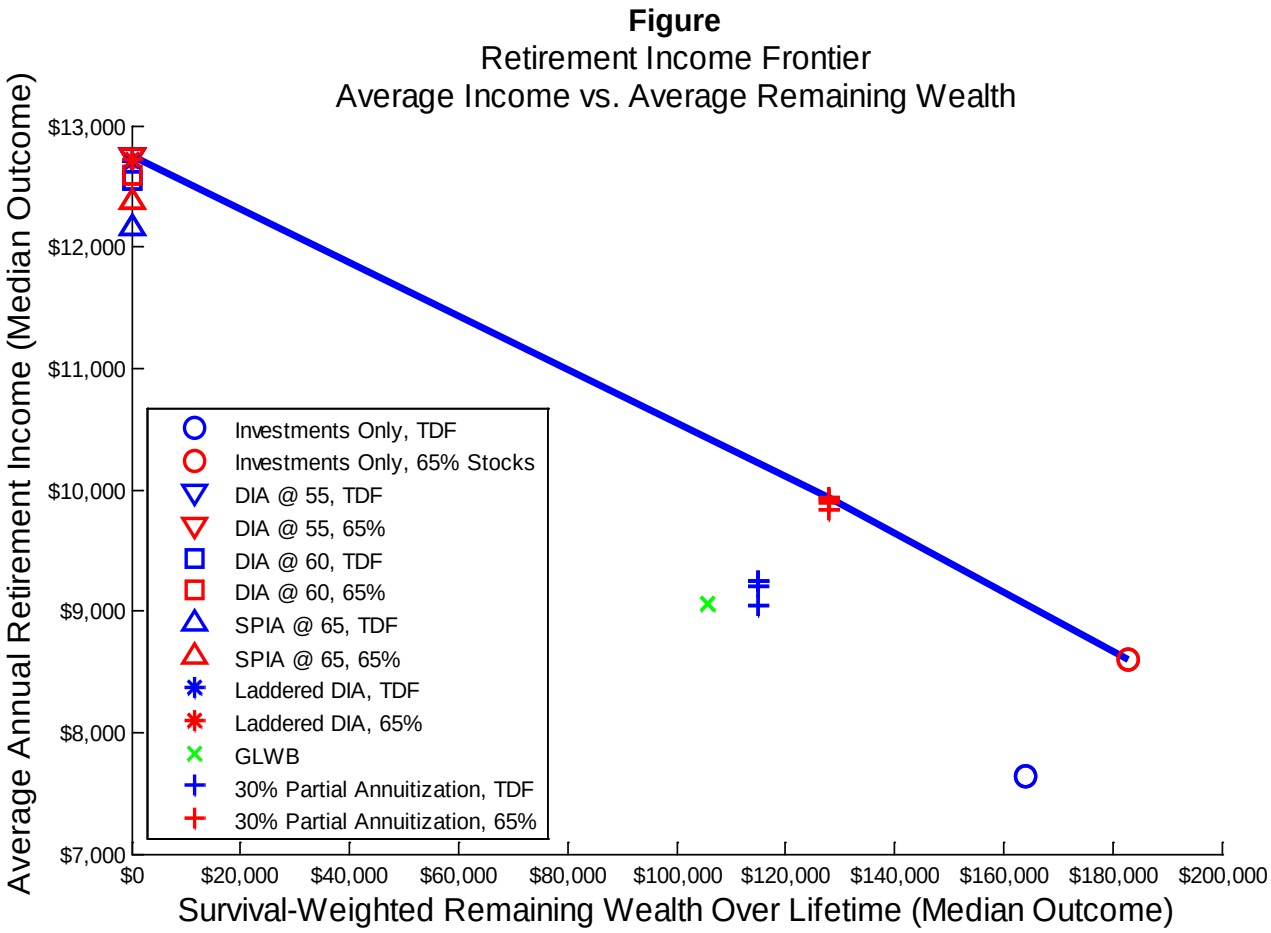
- Measure of accessible wealth (X-axis): Average amount of real accessible savings throughout retirement under the median stochastic forecast, adjusted for the probability of survival to each future age.

- Rationale: Many participants are hesitant to devote substantial resources to irrevocable annuities, and desire some access to savings and/or legacy. These participants may be willing to accept reduced retirement income in exchange for access to savings.

Commentary on Efficient Frontier #2

- The graph on the next page shows that all of the solutions that annuitize all assets by age 65 produce higher average annual retirement incomes than partial annuitization or SWP solutions, but there is no accessible wealth beyond age 65. This helps quantify the cost of liquidity, and was addressed in our Phase 1 report.
- Partial annuitization solutions produce higher average annual retirement incomes than pure SWP solutions, but lower accessible wealth.
- Solutions that use the balanced fund invested 65% in stocks project higher retirement incomes than solutions that use TDFs.
- Partial annuitization solutions project higher retirement incomes and higher accessible wealth over retirement than the GLWB.

Efficient Frontier Analysis #2: Tradeoff Between Income and Access
Hypothetical Retiree #1: Single female age 55 with $180,000 in assets at age



Annual income increases

Accessible wealth increases

Commentary on Efficient Frontier #2 Regarding Other Retiree

- The efficient frontier analysis for the other hypothetical retiree shows similar patterns.
  - Married couple both age 55 with $300,000 in assets at age 55.
- See Appendix D for results.

Measuring Predictability with Projection of Retirement Incomes

- Projection of retirement incomes provides insights into the possible range of retirement incomes. In particular, a significant decrease between the income expected by a worker at the anticipated retirement age and the income realized under an unfavorable economic scenario can result in delayed retirement or retiring under undesirable circumstances.
- The table on the next page compares projected retirement income at age 65 for four retirement income solutions under the 50th percentile (representing the expected retirement income) and the 10th percentile (representing the unfavorable scenario).
- The projections are for hypothetical retiree #2, the 55 year-old couple with $300,000 in assets.
- The table shows that DIAs result in more projected predictability and less uncertainty in retirement incomes, and result in the greatest protection in income in the period leading up to retirement, compared to using investing solutions with TDFs during this period.

DIAs Reduce the Potential Decrease in Retirement Income at Age 65 Due to Unfavorable Economic Scenarios

Projected annual real retirement income at age 65

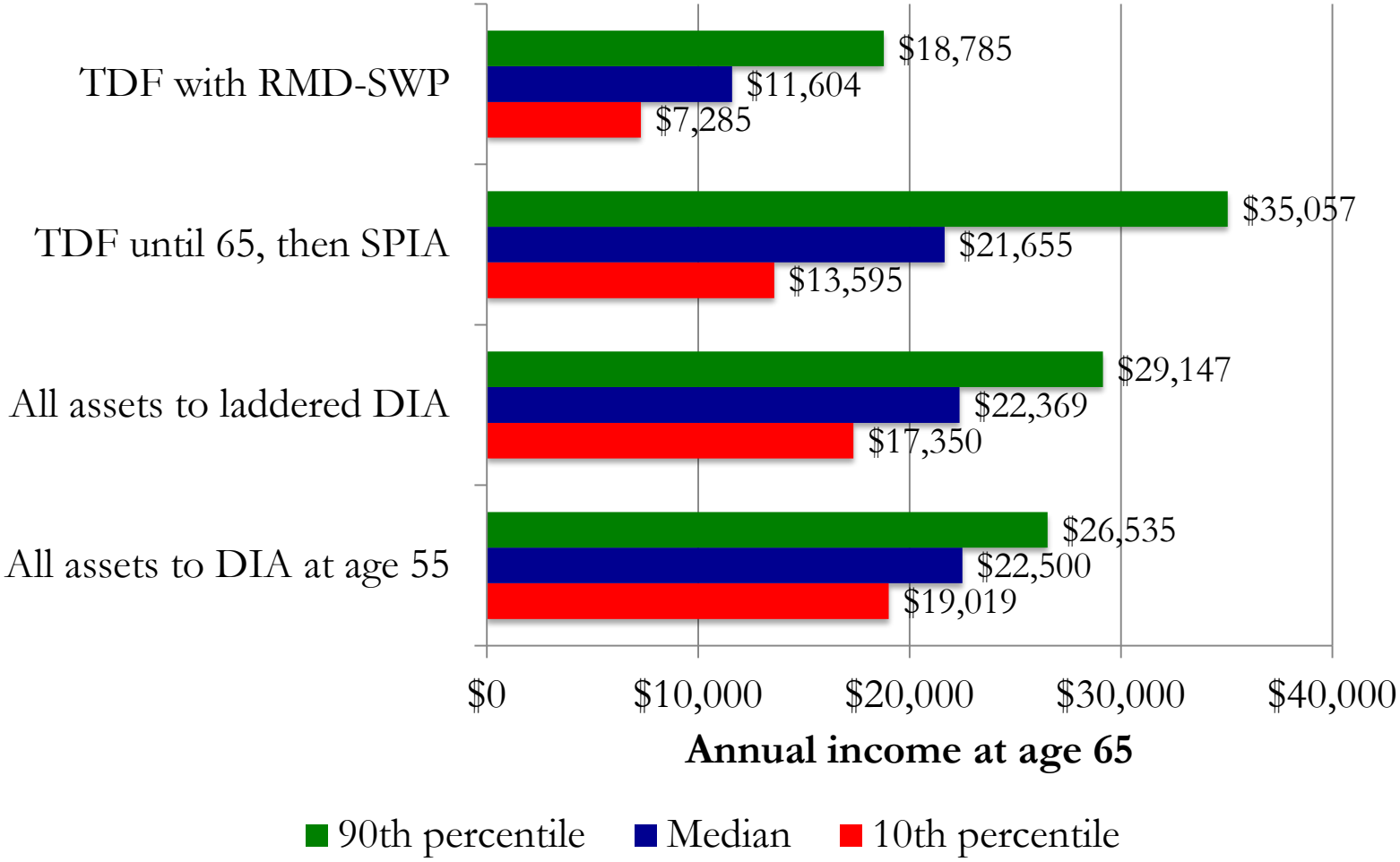
Retirement income strategy	Expected (50th percentile)	10th percentile	Percentage Difference
TDF with RMD-SWP at age 65	$11,604	$7,285	-37.2%
100% of savings to purchase DIA at age 55	$22,500	$19,019	-15.5%
TDF until age 60, then 100% of savings to purchase DIA	$22,010	$15,226	-30.8%
TDF until age 65, then 100% to purchase SPIA	$21,655	$13,595	-37.2%
All savings to laddered DIA between ages 55 and 64	$22,369	$17,350	-22.4%

Married couple with $300,000 in assets at age 55

Assessing Both Downside and Upside Potential in Retirement Income

- The graph on the next page shows the range of possible initial retirement incomes at age 65 for various retirement income solutions, under the 10th, 50th, and 90th percentiles of the stochastic forecasts. This graph is for the married couple at age 55 with $300,000 in assets.
- This shows that investing in a TDF until age 65, and then using either an RMD-SWP or SPIA to generate retirement income, produces the widest percentage range between the favorable and unfavorable outcomes.
- DIAs result in the narrowest range between the highest and lowest amounts of real annual retirement incomes, expressed in percentage terms. Most or all of the differences in real incomes for the fixed annuities result in different scenarios for inflation.
- This result supports a strategy where older workers approaching retirement consider the minimum amount of retirement income for which they need relative certainty, and deploy a program of purchasing DIAs to secure that income. They could then invest their remaining assets to cover discretionary living expenses that require less certainty, and for which they may be willing to accept investing risk for upside potential.

Investing all assets in TDF until age 65 shows widest range of possible outcomes in retirement incomes at age 65 when expressed as percentage



Married couple age 55 with $300,000 in savings

Projection of Retirement Incomes Throughout Retirement

- Appendix E contains graphs showing projected retirement incomes for 30 years of retirement for selected Phase 4 strategies. The results show the retirement incomes under the 10th, 25th, 50th, 75th, and 90th percentiles of a stochastic forecast, to illustrate the potential range of retirement incomes over the course of retirement. The analyses for these graphs were also used to produce the table and graph on the previous pages.
- Projections are for hypothetical retiree #2, the 55 year-old couple with $300,000 in assets.
- These forecasts can be used to determine the general pattern of retirement income (level or decreasing on a real basis, after adjusting for inflation). A level line keeps pace with projected inflation, while a declining line does not.
- These forecasts can also be used to assess the potential volatility of a specific retirement income solution. Retirement income solutions with wider variation between the 10th and 90th percentiles are more likely to have retirement incomes that fluctuate, compared to solutions with narrower variation between these extreme outcomes.

Projection of Retirement Incomes Throughout Retirement (continued)

- The graphs in Appendix E demonstrate that solutions using an RMD-SWP with TDF start with lower retirement income compared to solutions that use annuities, and they have the widest range in possible outcomes, but they are more likely to keep up with inflation.
- Note that the DIA solutions projected in this report are fixed in nominal terms. It is possible to buy DIAs that increase after the age the annuity starts according to a fixed rate or a measure of inflation such as the Consumer Price Index. For the fixed DIA solutions illustrated in Appendix E, any variance in projected real retirement incomes after the monthly income has started is due to differences in stochastic projections for inflation.
- An older worker would need to achieve a rate of return exceeding 4.43% between ages 55 and 65 to realize higher income at age 65 from a strategy to invest assets until age 65 and then purchase a SPIA, compared to purchasing a DIA at age 55. In the interest rate environment prevalent in 2014-2015, stock market or interest rate risk is needed to achieve this rate, exposing the worker to potential uncertainty in retirement incomes at age 65.

Commentary on Analyses

- The results presented in this report reflect the specific circumstances of the hypothetical employees and the assumptions used to produce the stochastic forecasts. Different employees and alternative assumptions will produce different results. For example:
  - Higher assumed real rates of return generally produce more favorable projections, and vice versa.
  - Higher returns of stocks relative to bonds and annuity purchase rates will show more favorable projections for investing solutions, while lower returns of stocks relative to bonds and annuity purchase rates will show more favorable projections for insured solutions.
  - For both investing and insured solutions, low-cost institutionally priced solutions were assumed. Retail solutions would produce less favorable results than shown in this report.
- As such, the results from this report may or may not be generalized to other situations. Nevertheless, important insights may be gained from this report, and in particular, the methods used in this report can be used with alternative assumptions and the circumstances of other retirees.

Commentary on Analyses (continued)

The analyses in this report assume no risk of insurance company default. Retirees and advisors who want to address this risk should consider insurance company ratings and the limits of state guaranty associations. Consistent with the goal of developing a diversified portfolio of retirement income, retirees may want to consider diversifying annuity purchases among more than one insurance company.

One method to increase guaranteed retirement income from a source commonly assumed to be riskless is to increase Social Security benefits by delaying benefits, and Phase 2 addresses this strategy.

Appendix A: Definitions

- Deferred income annuity (DIA) is an insurance product that guarantees a lifetime retirement income beginning at an age specified in the future. Amount of income can be fixed in dollar terms, adjusted for inflation, or adjusted at a specified rate (such as 3% per year). Joint and survivor annuities continue income as long as one beneficiary is alive. The DIAs priced in this project are irrevocable after purchase.

- Guaranteed lifetime withdrawal benefit (GLWB) is an insurance product that acts like a systematic withdrawal plan that determines annual income as a specified percentage of assets and guarantees income for life. Future retirement income may increase with favorable investment performance but is guaranteed not to decrease with unfavorable performance. Retirees may also have access to remaining funds. Also called guaranteed minimum withdrawal benefit (GMWB).

- Retirement income generator (RIG) is a stand-alone mechanism that converts savings into retirement income.

Appendix A: Definitions (continued)

- Retirement income solution can be a stand-alone RIG or a packaged combination of RIGs, where retirement savings are allocated among two or more RIGs.

- Single premium immediate annuity (SPIA) is an insurance product that guarantees a lifetime retirement income beginning immediately. Amount of income can be fixed in dollar terms, adjusted for inflation, or adjusted at a specified rate (such as 3% per year). Joint and survivor annuities continue income as long as one beneficiary is alive. The SPIAs priced in this project are irrevocable after purchase.

Appendix A: Definitions (continued)

- Systematic withdrawal plan (SWP) invests retirement savings and uses a method for determining periodic retirement income; there is no lifetime guarantee and it is not an insurance product.
  - Endowment SWP calculates the annual retirement income as a fixed percentage of remaining assets at each future year.
  - RMD-SWP uses the IRS required minimum distribution to calculate retirement income, and equals remaining assets divided by remaining life expectancy at each future age. The RMD requirements start at age 70-1/2, with an initial payout rate of 3.65%. For the analyses in this report, we assumed a 3.5% payout between ages 65 and 70.

- Target date funds (TDFs) are mutual funds containing both equities and bonds. As a participant nears the target age, the asset allocation gradually shifts from equities to bonds. The pattern of this shift over time is called the "glide path." Among different financial institutions offering TDFs, there is considerable variation in the glide paths and the allocation between stocks and bonds at retirement. The glide path for the TDF modeled in this report is described in Appendix B. TDFs by themselves are not a retirement income generator (RIG); a SWP program combined with a TDF constitutes a RIG.

Appendix B: Assumptions

Table B.1. Assumptions Used for Stochastic Forecasts

	Real Returns			Correlation Coefficients		
	Arithmetic Mean	Geometric Mean	Standard Deviation	Stocks	Bonds	Inflation
Stocks	5.1%	3.1%	20.0%	1.0	0.1	-0.2
Bonds	0.3%	0.2%	7.0%	0.1	1.0	-.6
Inflation	2.1%	2.0%	4.2%	-0.2	-0.6	1.0

Note: Above rates are lower than historical averages. Bond returns reflect low-interest rate environment, and stock returns reflect lower-than-historical premium over bond returns.

Mortality table for survival probabilities: Society of Actuaries' RP-2014 Mortality Tables Draft for Healthy Annuitants. Note that this table excludes annuitants who are classified as disabled; it may include annuitants who are somewhat unhealthy but not disabled.

Appendix B: Notes on Assumptions

- Assumptions for payout rates are representative of institutional pricing.
- SWP investment expenses: 50 bps
- GLWB investment and insurance expenses: 150 bps.
- GLWB asset allocation is 60% stocks, 40% bonds.
- SPIA and DIA rates based on sex distinct pricing.

For the purpose of this report, annuity payout rates were sampled in April, 2014, using the Income Solutions annuity bidding platform. A sampling of annuity purchase rates in December, 2014, for Retiree #1, showed decreases in payout rates for immediate annuities resulting in dollar amount decreases in retirement incomes ranging from 2.7% to 4.3% compared to the rates used in this report. This was the result of interest rates declining from April to December of 2014. We sampled annuity purchase rates again in July, 2015, and the change in payout rates for immediate annuities compared to April, 2014 resulted in changes in the dollar amount of retirement incomes ranging from a decrease of 3.9% to an increase of 0.2%. This is the result of slight increases in interest rates during 2015.

Many analysts forecast additional increases in interest rates during 2015, which could result in annuity purchase rates increasing back to levels in April, 2014 or higher. The authors decided not to chase a moving target and retained the April, 2014 annuity purchase rates.

Appendix B
Notes on Assumptions (continued)

Assumed asset allocation and glide path for the TDF is based on the averages across fund families from the 2013 Morningstar Report on target date funds, as follows:

Age	Equity allocation	Age	Equity allocation
55	66.34%	65	47.86%
56	64.26%	66	46.04%
57	62.18%	67	44.22%
58	60.10%	68	42.40%
59	58.38%	69	41.98%
60	56.66%	70	41.56%
61	54.94%	71	41.14%
62	53.22%	72	40.72%
63	51.50%	73 and after	40.30%
64	49.68%		

Appendix B
Notes on Assumptions (continued)

For the purpose of this report, annuity payout rates were not modeled stochastically after age 55, due to programming limitations. To the extent that annuities are purchased after age 55, there could be some drift between annuity purchase rates and the particular economic scenario being modeled.

Note that this is not an issue for the pure SWP solutions and solutions that purchase a DIA at age 55. It's less of an issue for the laddered DIA and more of an issue for the solution that defers purchase of the SPIA until age 65.

Note that for economic scenarios where interest rates rise, there's a partial offsetting effect in the projected amounts of retirement income generated by annuities. Assets invested in bonds or stocks may depreciate due to rising interest rates, but annuity payout rates should increase for the same reason. (This phenomenon is illustrated by the example on the next two pages).

This issue creates a level of inconsistency in the modeling for some of the solutions modeled. Nevertheless, the authors believe that valuable insights can still be gained from these analyses.

Appendix B
Notes on Assumptions (continued)

One of the coauthors prepared the following example to illustrate the potential impact of rising interest rates on annuity purchases.

Suppose a single female age 60 has $100,000 in savings. If she deploys this amount to purchase a DIA with retirement income starting at age 65, using the annuity purchase rates assumed in this study (8.39% payout rate), her annual income at age 65 would be $8,390 per year. If interest rates increase after she purchases the DIA, her eventual income does not change.

Suppose instead she invests her $100,000, interest rates immediately rise by 1%, and then she purchases a DIA. The annual payout rate is estimated to increase from 8.39% to 9.74%. The net result on her retirement income at age 65 depends on how she has invested the $100,000.

Appendix B
Notes on Assumptions (continued)

(Example continued to illustrate the potential impact of rising interest rates on annuity purchases.)

If she owned $100,000 of 10-year Treasury bonds and interest rates went up by 1% (from current 2.20% to 3.20%) the value of those Treasuries would drop to about $91,500. At a 9.74% payout rate, $91,500 would generate an annual income of $8,912 -- an increase from the original $8,390.

If she owned 30-year Treasuries, the value of her $100,000 would drop to about $80,807, which would produce $7,871 of annual income—a decrease from the original $8,390.

If she owned $100,000 in stocks, it's hard to predict the resulting appreciation or depreciation in stocks resulting from a 1% increase in interest rates. If her stocks depreciated at a rate under 13.9%, her eventual retirement income would increase (the net result of the depreciation in assets together with the increased payout rate). Stock market depreciation of more than 13.9% would result in a decrease in her retirement income. Obviously, if her stocks appreciated, her eventual retirement income would increase.

Appendix B
Details on Efficient Frontier Calculations

The Y axis of both efficient frontiers is the average real retirement income weighted by the survival probability to each future age, labeled the average expected retirement income. This method starts by stochastically projecting the retirement income under a specific RIG to each future year, using a range of potential outcomes in capital markets and adjusted for projected inflation. As a result, the average income amounts are expressed in today's dollars.

For the purpose of calculating the average real retirement income, the median projected retirement income for each year was used. The median income amount for each future year is then multiplied by the probability that the retiree will survive from the initial retirement date to that future year. The resulting values are averaged over the retirement period to determine the average real retirement income weighted by survival probability.

One result of this methodology is that greater weight is placed on income received in earlier years of retirement compared to later years.

Appendix B
Details on Efficient Frontier Calculations (continued)

There was no discounting of future income amounts to the initial year of retirement. The rationale is that personal discount rates are difficult to define; even if it's possible to define such rates, they are most likely close to zero under the current interest rate environment.

The average real accessible wealth in Efficient Frontier #2 was calculated in the same manner as described above, except that remaining wealth under each RIG was projected stochastically to each future year. Again, greater weight is placed on accessible wealth in earlier years of retirement compared to later years.

Note that average accessible wealth as calculated here is different from average legacy at death. While the projected remaining wealth amounts would be the same, the average legacy at death would be weighted by the probability of dying at each future year. As a result, the average legacy at death would weight later years more than earlier years. For middle income retirees, it was assumed that average accessible wealth would be more important than average legacy at death.

Appendix B: Hypothetical Retiree #2

- Married 55-year old couple with $300,000 of assets
- No contributions assumed after age 55

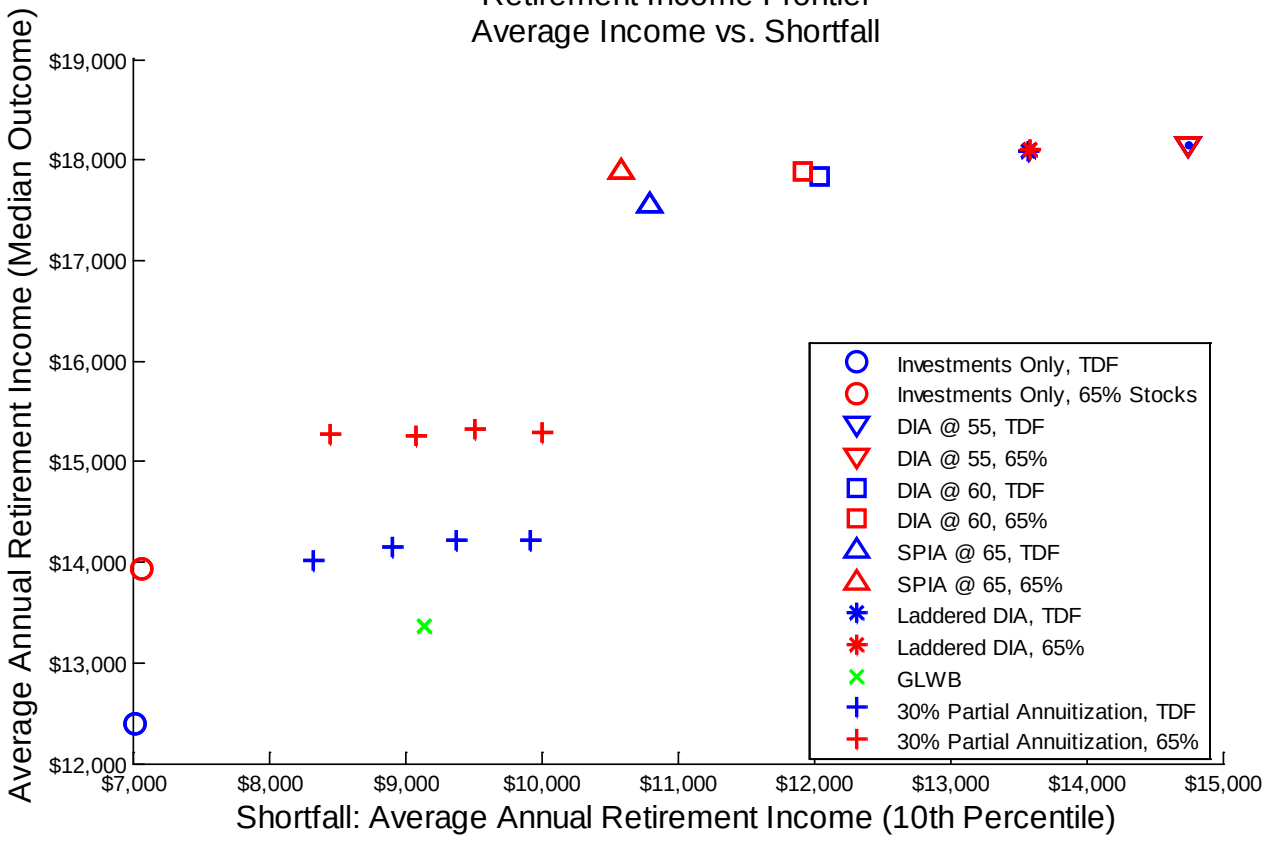
- Product pricing at age 65 for 100% joint and survivor annuity (annual income as percent of assets at beginning of retirement):
  - Fixed SPIA: 6.02%
  - Sample rates for DIA commencing at age 65:
    - Purchase age 55: 9.16%
    - Purchase age 60: 7.35%
  - GLWB: 4.5%
  - Above rates in effect during April, 2014 for institutionally priced GLWB products and using competitive annuity bidding for SPIAs and DIAs.

Appendix C
Efficient Frontier #1 Results for Additional Hypothetical Retiree

- Married couple both age 55 with $300,000 in assets
- Note: For the graph on the following page, the axis scales change for different hypothetical retirees.

Appendix C
Efficient Frontier Analysis #1: Emphasize Retirement Income
Hypothetical Retiree #2: Married couple age 55 with $300,000 in savings

Figure

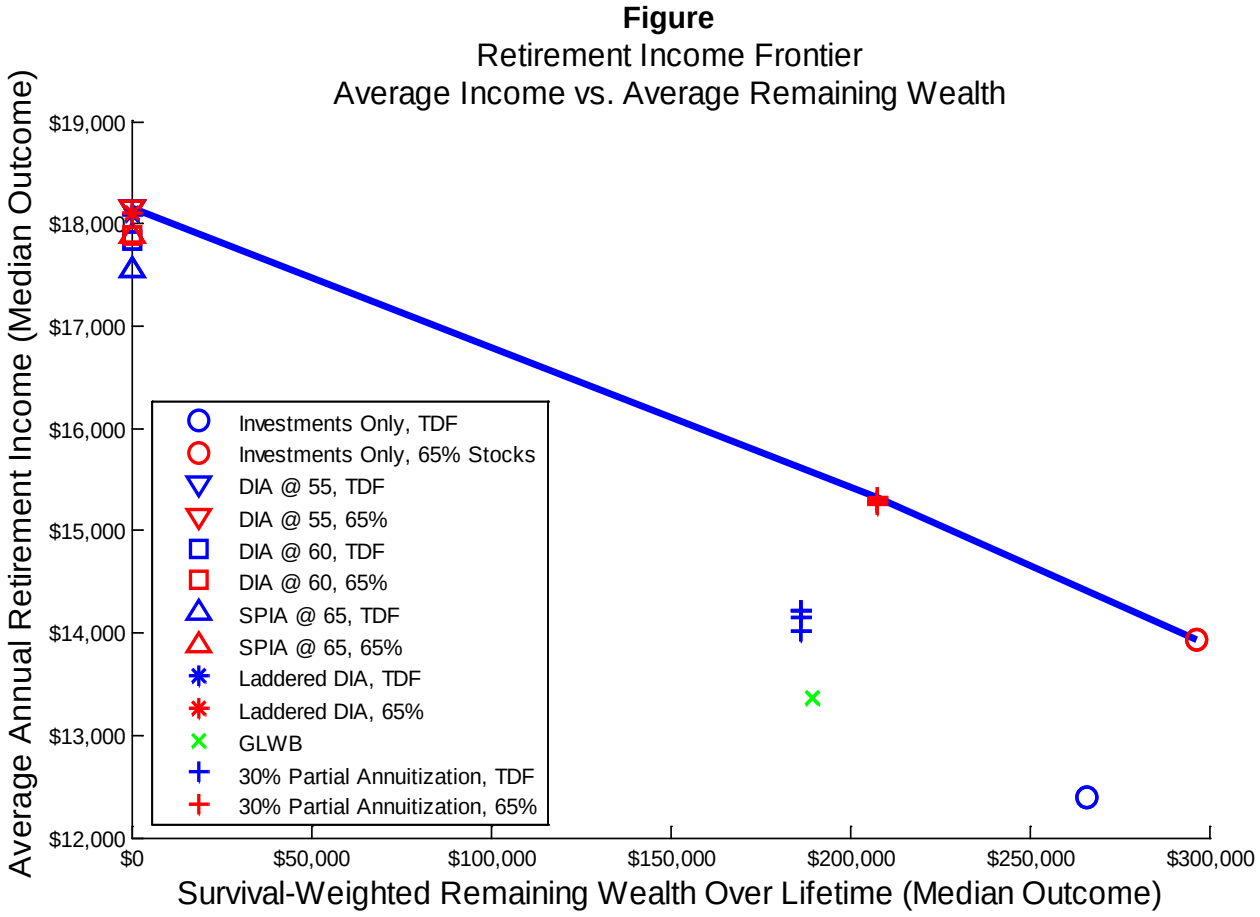


Appendix D
Efficient Frontier #2 Results for Additional Hypothetical Retiree

- Married couple both age 55 with $300,000 in assets
- Note: For the graph on the following page, the axis scales change for different hypothetical retirees.

Appendix D: Efficient Frontier Analysis #2 Tradeoff Between Income and Accessible Wealth Hypothetical Retiree #2: Married couple age 55 with $300,000 in assets

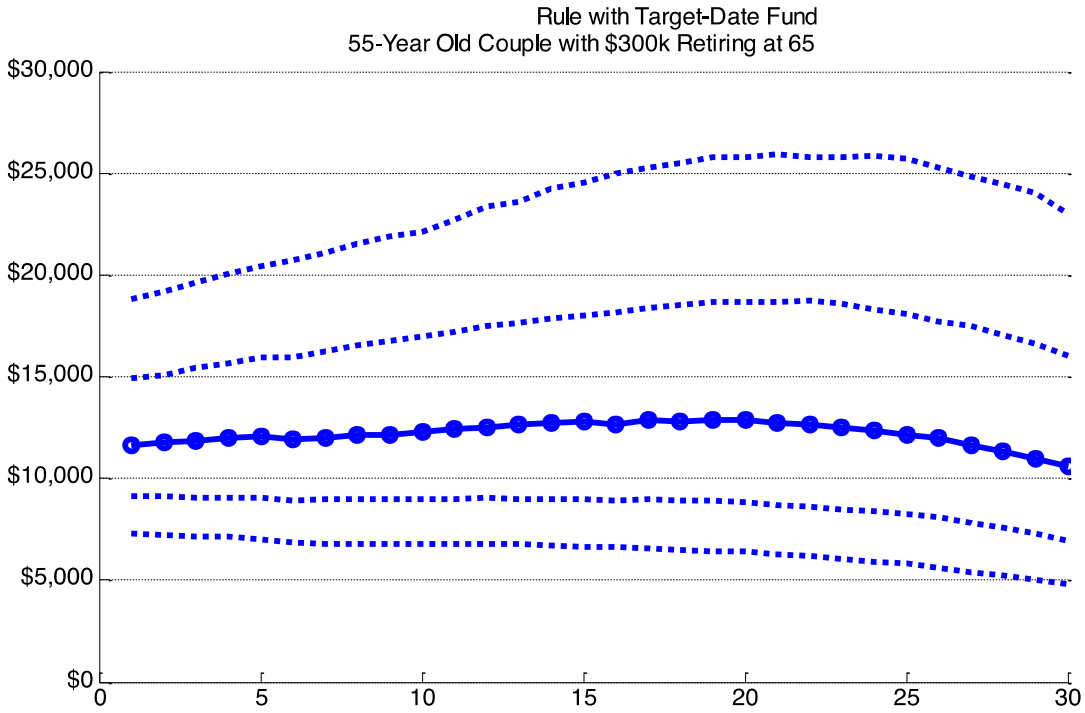
Figure



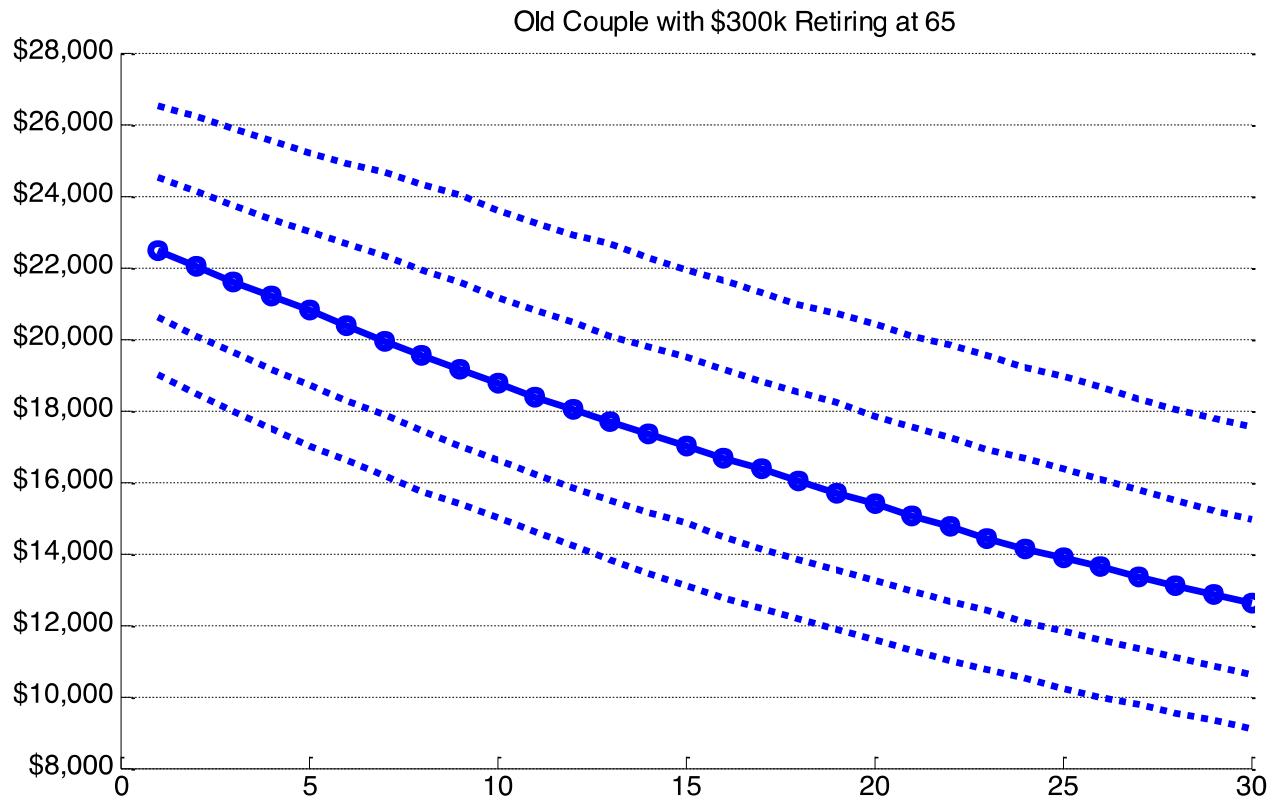
Appendix E
Projection of Retirement Incomes for Selected Retirement Income Solutions

- The pages that follow show the projected retirement incomes for each year over 30 years for Hypothetical Retiree #2 (couple age 55 with $300,000 in savings) under the following percentiles under the stochastic forecast: 10th, 25th, 50th, 75th, 90th.
- The lines show the amounts of retirement income beginning at age 65 and continuing for a 30 year retirement.
- These graphs illustrate the following six different retirement income solutions (Social Security income is not included):
  - Invest all assets in TDF at age 55, then use RMD-SWP to generate retirement income at age 65.
  - At age 55, use all assets to buy a DIA beginning at age 65.
  - Invest in a TDF until age 60, then use all assets to buy a DIA beginning at age 65.
  - Invest in a TDF until age 65, then use all assets to buy a SPIA.
  - Begin laddered DIA purchase at age 55 such that all assets devoted to an annuity by age 65. Until age 65, invest remaining assets in TDF.
  - Partial annuitization; use 30% of assets at age 55 to purchase DIA, then invest remaining assets in TDF and use RMD-SWP to generate retirement income at age 65.
- Note the scale of the vertical axis changes (showing amount of income).

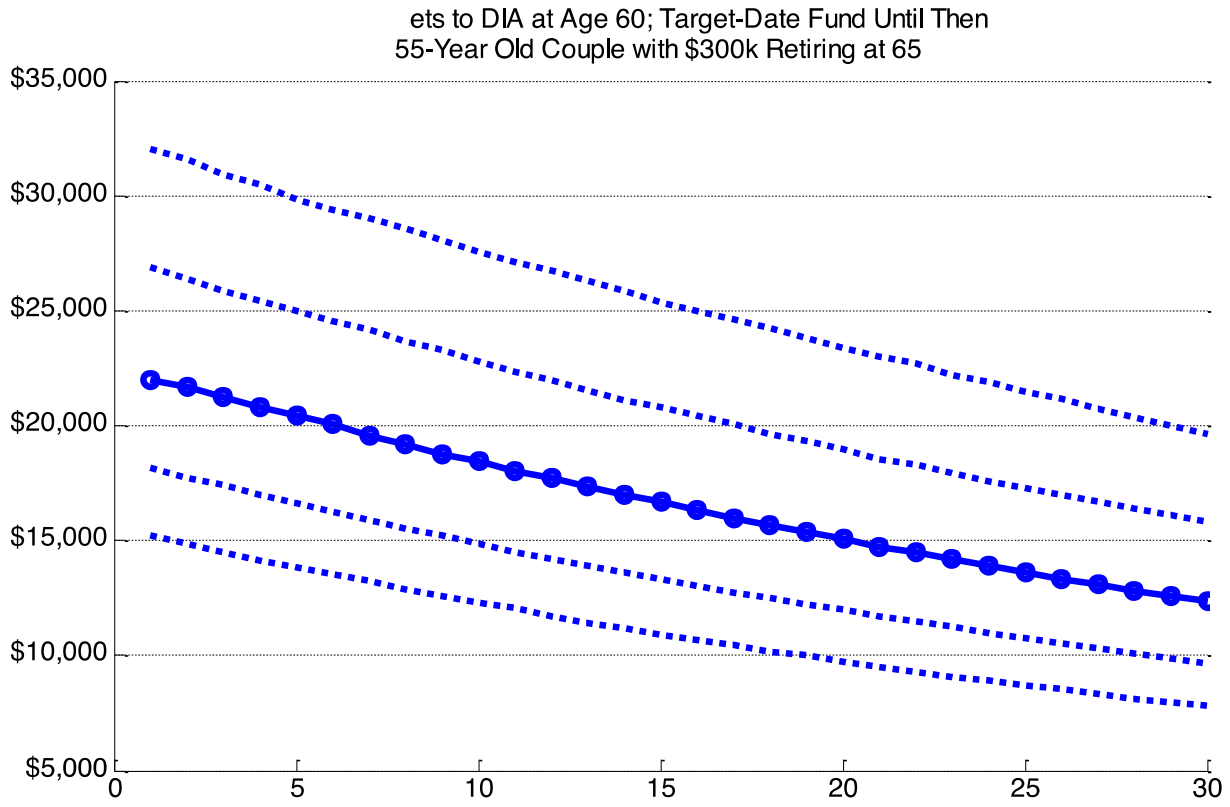
Appendix E
Expected Pattern of Real Retirement Income
Hypothetical Retiree #2: Married couple age 55 with $300,000
RMD-SWP with TDF



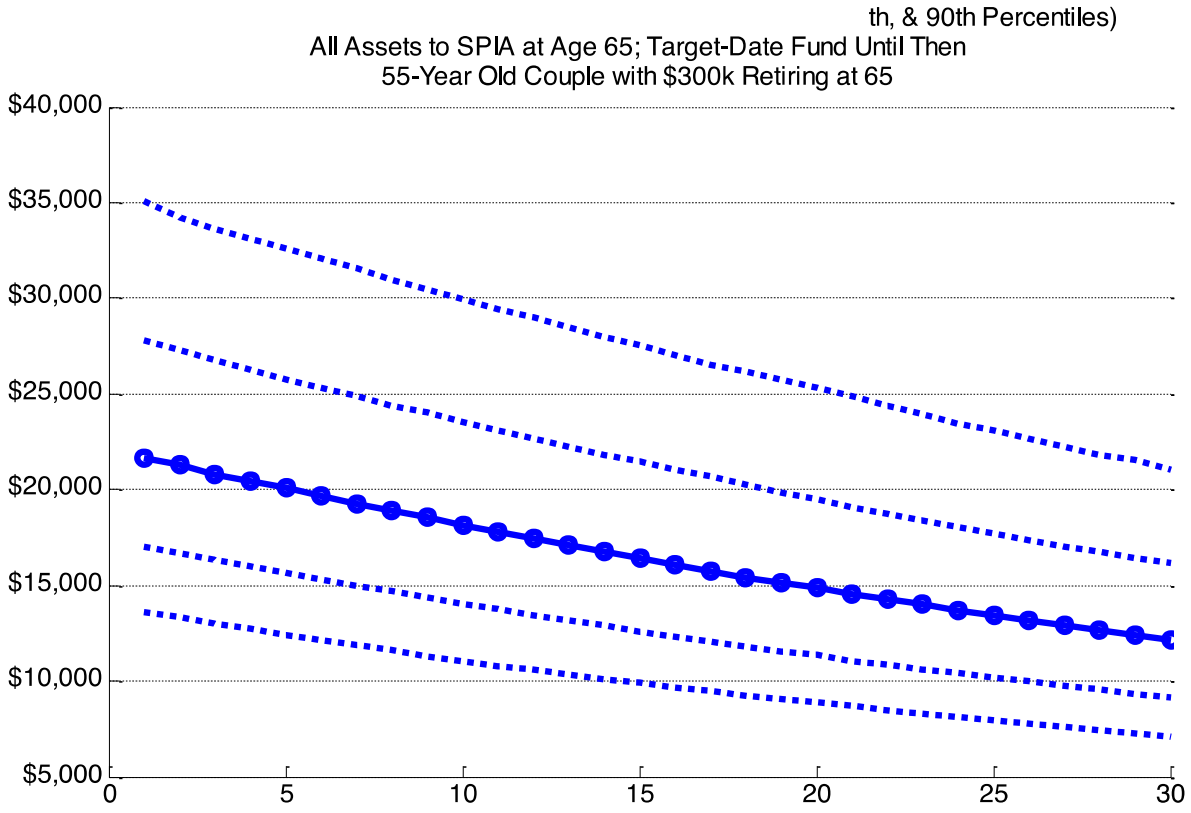
Appendix E
Expected Pattern of Real Retirement Income
Hypothetical Retiree #2: Married couple age 55 with $300,000
Purchase DIA with all assets at age 55



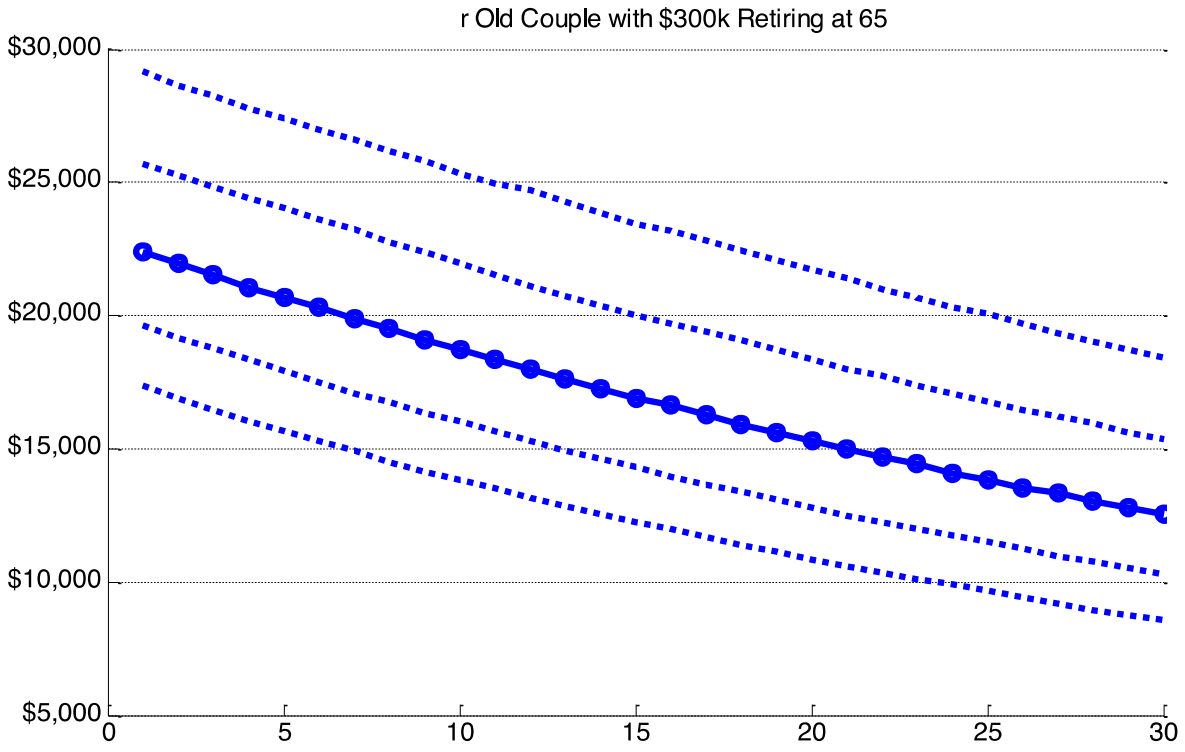
Appendix E
Expected Pattern of Real Retirement Income
Hypothetical Retiree #2: Married couple age 55 with $300,000
Invest in TDF until age 60, then purchase DIA with all assets



Appendix E
Expected Pattern of Real Retirement Income
Hypothetical Retiree #2: Married couple age 55 with $300,000
Invest in TDF until age 65, then purchase SPIA with all assets



Appendix E
Expected Pattern of Real Retirement Income
Hypothetical Retiree #2: Married couple age 55 with $300,000
Begin laddered DIA purchase at age 55, invest remaining assets in TDF



Appendix E

Expected Pattern of Real Retirement Income

Hypothetical Retiree #2: Married couple age 55 with $300,000

Purchase DIA with 30% of assets at age 55. Invest remaining assets in TDF and use RMD-SWP