



Optimal Retirement Income Solutions in DC Retirement Plans
Phase 2: Enable delay of Social Security benefits
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 Analyses

- 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: Determine if projected outcomes can be improved over results in Phase 1 by using retirement savings to enable delaying Social Security benefits.
- Phases 3 and 4 will analyze more complex retirement income solutions, to determine if additional complexity improves projected outcomes and can be justified by delivering more effective results.
 - Phase 3: Combine longevity annuities with systematic withdrawals.
 - Phase 4: Protect retirement income in the period leading up to retirement with deferred income annuities and GLWBs.
- This is the interim report for Phase 2. When the analyses for all phases have been completed, a final report will integrate all four phases.

Summary of Analyses

- Analyze various retirement income solutions for three hypothetical retirees:
 1. Single female retiring at age 65 with \$250,000 in assets.
 2. Married couple both age 65, retiring with \$400,000 in assets.
 3. Married couple both age 65, retiring with \$1,000,000 in assets.
- 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.
- 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.

Summary of Analyses (continued)

- Phase 1: All cases include estimated Social Security benefits that start at the same time as the retirement income solution (parallel Social Security claiming strategy).
- Phase 2: All cases assume Social Security benefits for the primary worker are delayed until age 70 but retirement still starts at age 65 (serial Social Security claiming strategy). For married retirees, nonworking spousal benefits are delayed until age 66. Retirement savings are tapped to replace the Social Security benefits for both the primary worker and nonworking spouse that could have been paid from age 65 to 70.
- This report displays the values graphically. For a table of the values underlying the graphs, visit: <http://longevity3.stanford.edu/phase2.htm>

Executive Summary of Results and Conclusions

- Using retirement savings to enable delaying Social Security benefits increases projected average retirement incomes for all retirement income solutions studied. Average annual income for solutions on the efficient frontier increased by 2% to 6%. These findings are consistent with other analyses (see the *Next Evolution* report previously mentioned).
 - When risk is defined as minimizing the shortfall of retirement income relative to target income, the above increase in average annual income can be realized with roughly the same amount of risk.
 - When access to wealth is an important goal, the above increase in annual income could be realized with the same average amount of accessible wealth.
- Solutions not on the efficient frontier were closer to the efficient frontier when retirement savings were used to delay Social Security benefits.
 - Using retirement savings to enable delaying Social Security benefits is more effective than other methods of generating retirement income – it's an efficient use of savings.

Retirement Income Solutions

Investigated in Phase 2

- Description of Phase 2 solutions:
 - Use a portion of retirement savings to enable delaying Social Security benefits to age 70 for the primary worker, to maximize their value. Until age 70, withdraw amounts from savings equal to Social Security benefits that could have started at age 65. For married couples, assume a nonworking spouse starts Social Security benefits at age 66, and retirement savings are tapped to replace spousal benefits from age 65 to age 66.
 - Use the remaining savings to generate retirement income starting at age 65, using the same RIGs and combinations of RIGs that were analyzed in Phase 1.
- Determine if the Phase 2 retirement income solutions described above improve projected results and extend the efficient frontiers that were developed in Phase 1 analyses.

Phase 1 Retirement Income Solutions That Are Repeated In Phase 2

Stand-alone systematic withdrawal plans (SWPs) (Stock allocations: 0%, 25%, 50%, 75%, 100%):

- Annual retirement income equals 3% of remaining assets at the beginning of each year (roughly equal to investment income, preserving principal).
- Retirement income equals 5% of remaining assets, approximating a “middle of the road” strategy that draws down principal.
- Retirement income equals 7% of remaining assets, approximating an aggressive strategy that draws down principal.
- Withdrawals based on IRS required minimum distribution (RMD) rules, which calculate retirement income each year by dividing remaining assets by remaining life expectancy at each age, using mortality tables specified by the IRS. Qualified retirement plans must comply with this rule once the retiree attains age 70-1/2.

Stand-alone annuities

- Inflation-adjusted single-premium immediate annuity (SPIA)
- Fixed SPIA
- SPIA with 3% growth factor
- VA/GLWB (Asset allocation: 60% equities/40% fixed income)

Phase 1 Retirement Income Solutions That Are Repeated In Phase 2 (continued)

Packaged solutions

- 70% of savings to each systematic withdrawal approach with all previous asset allocations, 30% of savings to each annuity approach.
- GLWB annuities were not included in packaged solutions.

Note #1: The classic “four percent” rule – withdrawing a fixed dollar amount regardless of investment returns – was not included. The prior SOA/SCL report showed this method failed in unfavorable investment scenarios.

Note #2: SWPs based on 3%, 5%, and 7% withdrawal rates will violate the IRS RMD rules at age 70 for a 3% SWP, age 79 for a 5% SWP, and age 86 for a 7% SWP. At these ages, retirees would need to withdraw the RMD and invest the excess of the RMD over the withdrawal strategy.

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 (same as in Phase 1).
 - Efficient frontier #1: Emphasize retirement income.
 - Efficient frontier #2: Illustrate tradeoff between amount of expected retirement income and accessible savings.
- 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): Average annual amount of real income shortfall throughout retirement relative to an inflation-adjusted SPIA under the unfavorable economic scenario, adjusted for survival probabilities.
- Rationale: An inflation-adjusted SPIA represents a guaranteed lifetime income with inflation-protection. Analyze if another solution can be expected to generate a higher amount of annual income by assuming some additional risk compared to the SPIA.

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.
- Note that with the measure of risk used in this analysis, there are two ways that a particular SWP can develop shortfalls compared to an inflation-adjusted annuity. If withdrawals are too conservative, then the annuity will produce higher amounts of income. If the withdrawals are too aggressive, then eventually the assets will decline significantly and resulting income will also fall short relative to the inflation-adjusted annuity.
- 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
- \$250,000 of assets
- Social Security @ 65 = \$16,895/year
- Social Security @ 70 = \$23,903/year

- Annuity product pricing (annual income as percent of assets at beginning of retirement):
 - Inflation-adjusted SPIA: 4.82%
 - Fixed SPIA: 6.76%
 - SPIA with 3% growth rate: 4.88%
 - GMWB: 5%
 - Above rates in effect during April, 2014 for institutionally priced GLWB products and using competitive annuity bidding for SPIAs.
- Capital market assumptions for SWP pricing shown in Appendix B.

Commentary on Efficient Frontier #1

Comparing Phase 1 and 2 Results

- Consistent with Phase 1, solutions on the efficient frontier are single premium immediate annuities (SPIAs).
- Using a portion of retirement savings to enable delaying Social Security benefits improves outcomes for all retirement solutions analyzed, even for solutions not on the efficient frontier.
- Solutions not on the efficient frontier are closer to the efficient frontier in Phase 2 compared to Phase 1. For these solutions, higher average income is delivered with less risk.
- Rationale:
 - Savings are being used more efficiently to “purchase” higher Social Security benefit at very favorable rate.
 - In Phase 2, fewer assets are deployed into solutions that are considered to be less efficient.

Commentary on Efficient Frontier #1

Comparing Phase 1 and 2 Results (continued)

- On the efficient frontier, Phase 2 produces a slightly higher average annual retirement income for the 3% growth SPIA, by \$495 (1.6%) compared to Phase 1, with roughly the same (or very slightly higher) levels of risk.
- The partial annuitization strategy producing the highest average income is the 7% SWP with 100% allocation to equities, combined with a 3% growth SPIA. For this strategy, the average annual income increases from \$29,126 to \$30,217, an increase of \$1,091 (3.7%). The measure of risk improves from 88% to 96%.

Commentary on Efficient Frontier #1

Comparing Phase 1 and 2 Results (continued)

- Off the efficient frontier, results are improved further. For the pure RMD SWP strategy with 100% allocation to stocks, the average annual income increases from \$27,265 in Phase 1 to \$28,953 in Phase 2, an increase of \$1,688 (6.2%). The measure of risk (percentage of income compared to inflation-adjusted annuity) improves from 78% to 90%.
- For the pure RMD SWP strategy with 50% allocation to stocks, the average annual income increases from \$25,709 in Phase 1 to \$27,982 in Phase 2, an increase of \$1,688 (8.8%). The measure of risk (percentage of income compared to inflation-adjusted annuity) improves from 80% to 91%.
- For the GLWB strategy, the average annual income increases from \$27,111 in Phase 1 to \$28,881 in Phase 2, an increase of \$1,770 (6.5%). The measure of risk (percentage of income compared to inflation-adjusted annuity) improves from 90% to 95%.

Commentary on Efficient Frontier #1

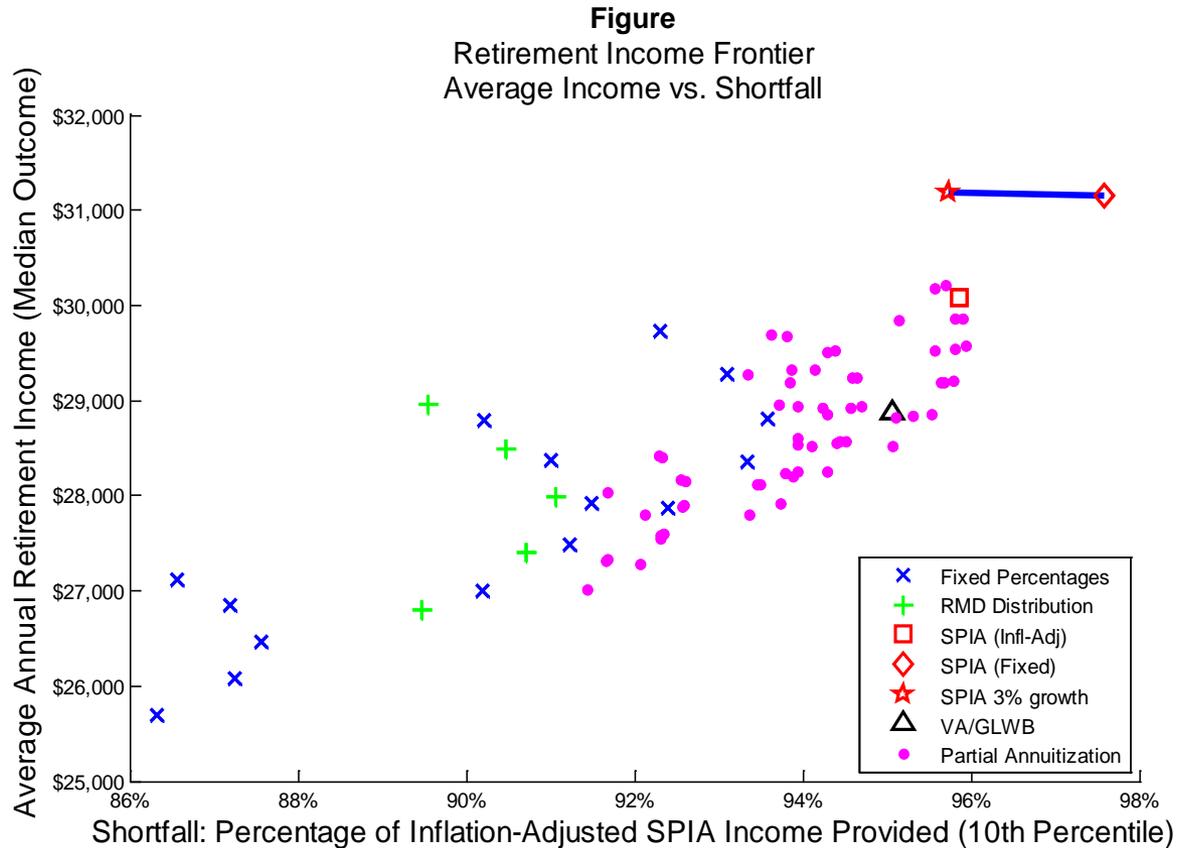
Comparing Phase 1 and 2 Results (continued)

- For retirement income solutions using invested assets, Phase 2 entails taking money that might have been invested in stocks and using it to delay taking Social Security. As a result, investing solutions with a high allocation to stocks show a lower improvement between Phases 1 and 2, compared to investing solutions with a low allocation to stocks.
- As a result, the farther off the efficient frontier a particular solution is in Phase 1, the more it makes sense to use retirement savings to enable delay taking Social Security benefits. Conservative retirees who are not comfortable with high allocations to stocks may have more to gain by a strategy that uses retirement savings to delay Social Security benefits.

Efficient Frontier Analysis #1: Emphasize Retirement Income

Hypothetical Retiree #1: Single female age 65 with \$250,000

Phase 2: Use Retirement Savings to Delay Social Security to Age 70



Average income increases

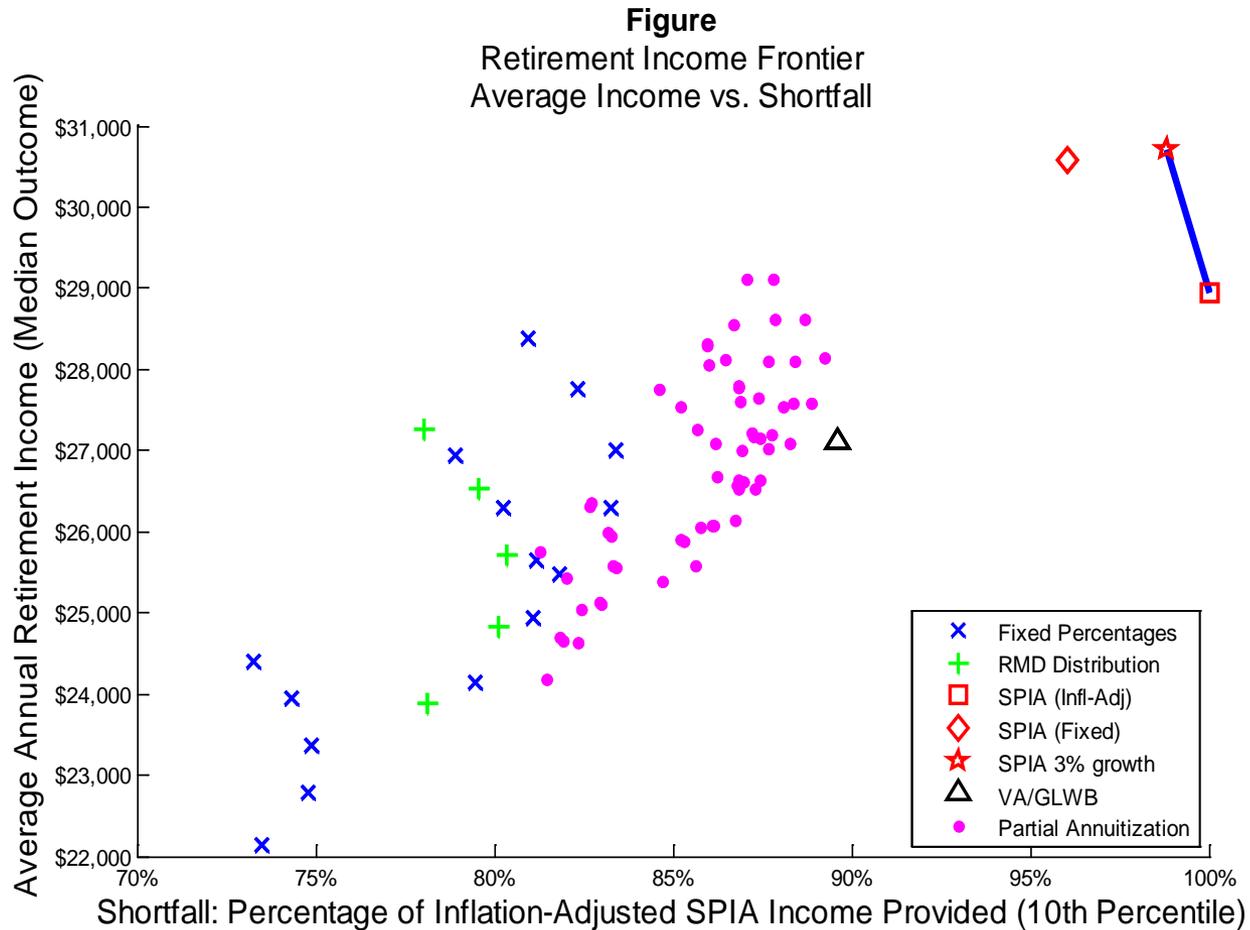
Risk decreases

Efficient Frontier Analysis #1: Emphasize Retirement Income

Hypothetical Retiree #1: Single female age 65 with \$250,000

Phase 1 Analysis For Comparison Purposes

Social Security Starts at Age 65

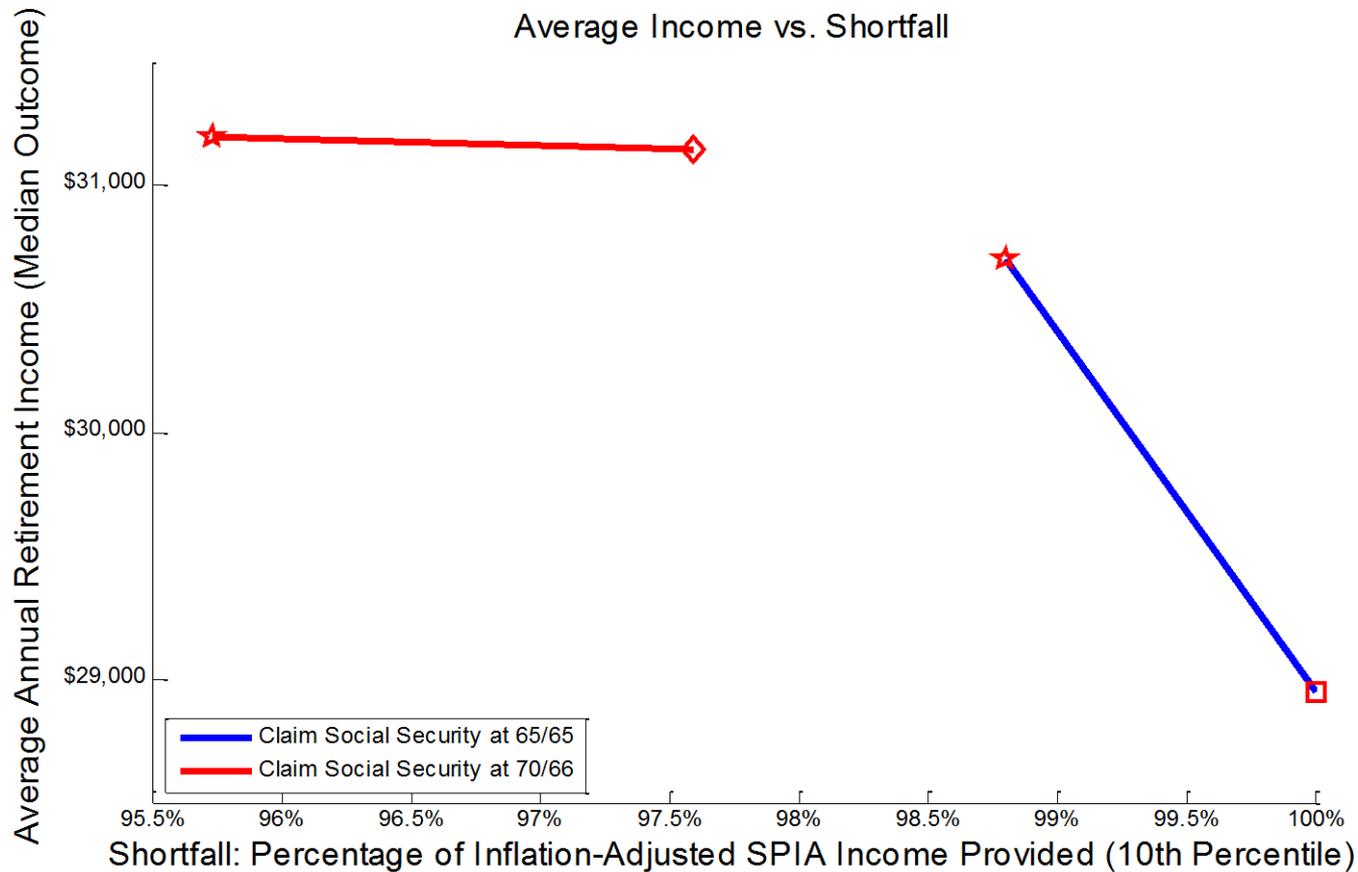


Efficient Frontier Analysis #1: Emphasize Retirement Income

Hypothetical Retiree #1: Single female age 65 with \$250,000

Comparison of Efficient Frontiers Phases 1 and 2

Figure
Retirement Income Frontier
Average Income vs. Shortfall



Commentary on Efficient Frontier #1

Comparing Phase 1 and 2 Results

(continued)

- The conclusions about optimal retirement income solutions under Phase 1 are virtually the same as conclusions for optimal retirement income solutions that are used for remaining savings under Phase 2.
- SPIAs produce highest amount of income with lowest amount of risk, defined as shortfall of expected income relative to an inflation-adjusted SPIA under the 10th percentile stochastic forecast.
- The next best solutions are partial annuitization strategies.
 - Partial annuitization strategy producing highest amount of average income is 30% of assets to SPIA increasing 3% and 70% to SWP using 7% withdrawal strategy with 100% allocation to equities. Partial annuitization strategy using RMD SWP is very close behind.

Commentary on Efficient Frontier #1

Regarding Other Retirees

- Efficient frontier analyses for other hypothetical retirees show similar patterns (See Appendix C for results).
 - Delaying Social Security increases retirement income for all solutions, and solutions not on the efficient frontier are closer to the frontier with Social Security delay.
- Additional retirees:
 - Married couple both age 65, retiring with \$400,000 in assets. The solution on the efficient frontier – fixed SPIA -- increased average annual retirement income from Phase 1 to Phase 2 by \$1,896 (3.6%).
 - Married couple both age 65, retiring with \$1,000,000 in assets. The solution on the efficient frontier – fixed SPIA -- increased average annual retirement income from Phase 1 to Phase 2 by \$2,413 (2.6%).

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

Comparing Phase 1 and 2 Results for Retiree #1

Single Female with \$250,000 in Assets

For each retirement income solution, Phase 2 solutions produce higher average annual retirement incomes, but less accessible wealth.

Hypothetical retiree #1	Phase 1 Start SS age 65	Phase 2 Delay SS	Difference
Partial annuitization strategy*			
- Ave income	\$28,324	\$29,696	\$1,372
- Ave accessible wealth	\$150,276	\$105,053	(\$45,223)
SWP RMD/75% equities			
- Ave income	\$26,537	\$28,498	\$1,961
- Ave accessible wealth	\$199,856	\$137,243	(\$62,613)
SWP 3% WR/75% equities			
- Ave income	\$23,942	\$26,846	\$2,904
- Ave accessible wealth	\$233,154	\$159,001	(\$74,153)

*30% of savings to 3% growth SPIA, 70% to RMD SWP with 100% stock allocation

Commentary on Efficient Frontier #2

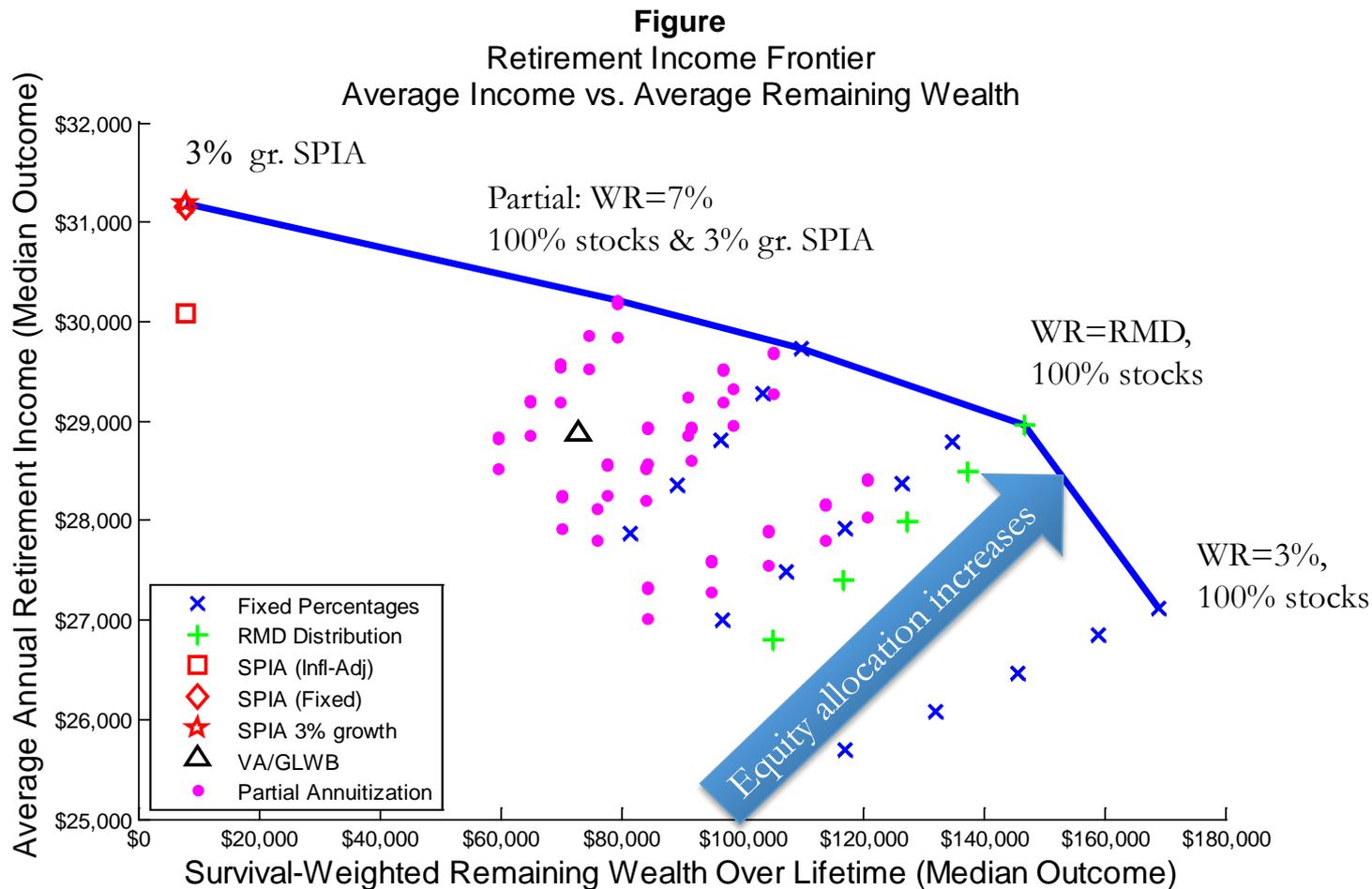
Comparing Phase 1 and 2 Results

- For each specific retirement income solution, Phase 2 solutions produce higher average annual retirement incomes, but less accessible wealth.
- Rationale: Devoting retirement savings in the first five years of retirement to replace Social Security benefits consumes savings, but this use of savings to increase Social Security benefits can be viewed as a very favorable “annuity purchase rate” that boosts average annual income.

Efficient Frontier Analysis #2: Tradeoff Between Income and Access

Hypothetical Retiree #1: Single female age 65 with \$250,000

Phase 2: Use Savings to Delay Social Security



Efficient Frontier Analysis #2: Tradeoff Between Income and Access

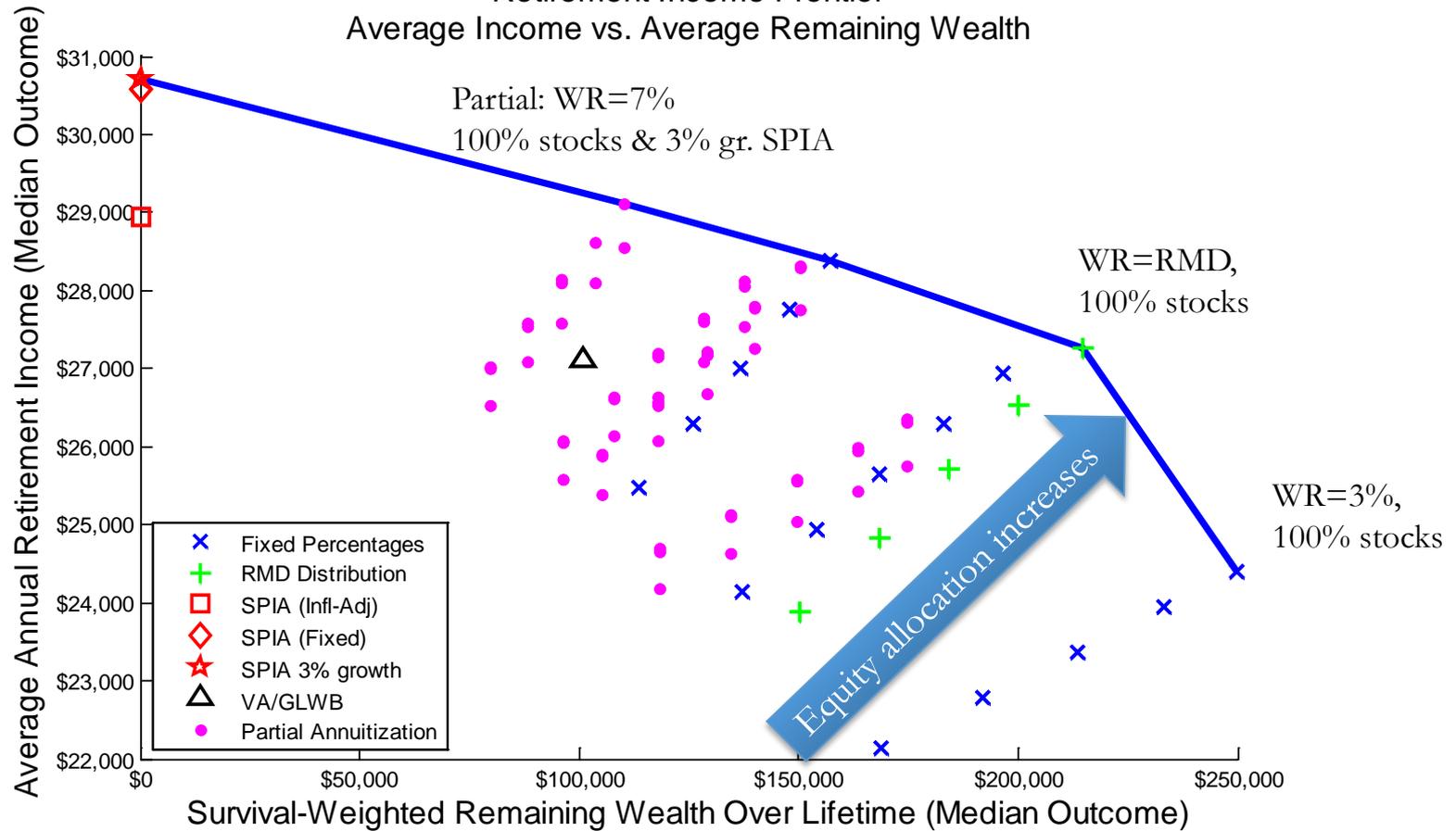
Hypothetical Retiree #1: Single female 65 with \$250,000

Phase 1 Analysis for Comparison Purposes

Start Social Security at age 65

3% gr. SPIA

Figure
Retirement Income Frontier
Average Income vs. Average Remaining Wealth



Commentary on Efficient Frontier #2

(Continued)

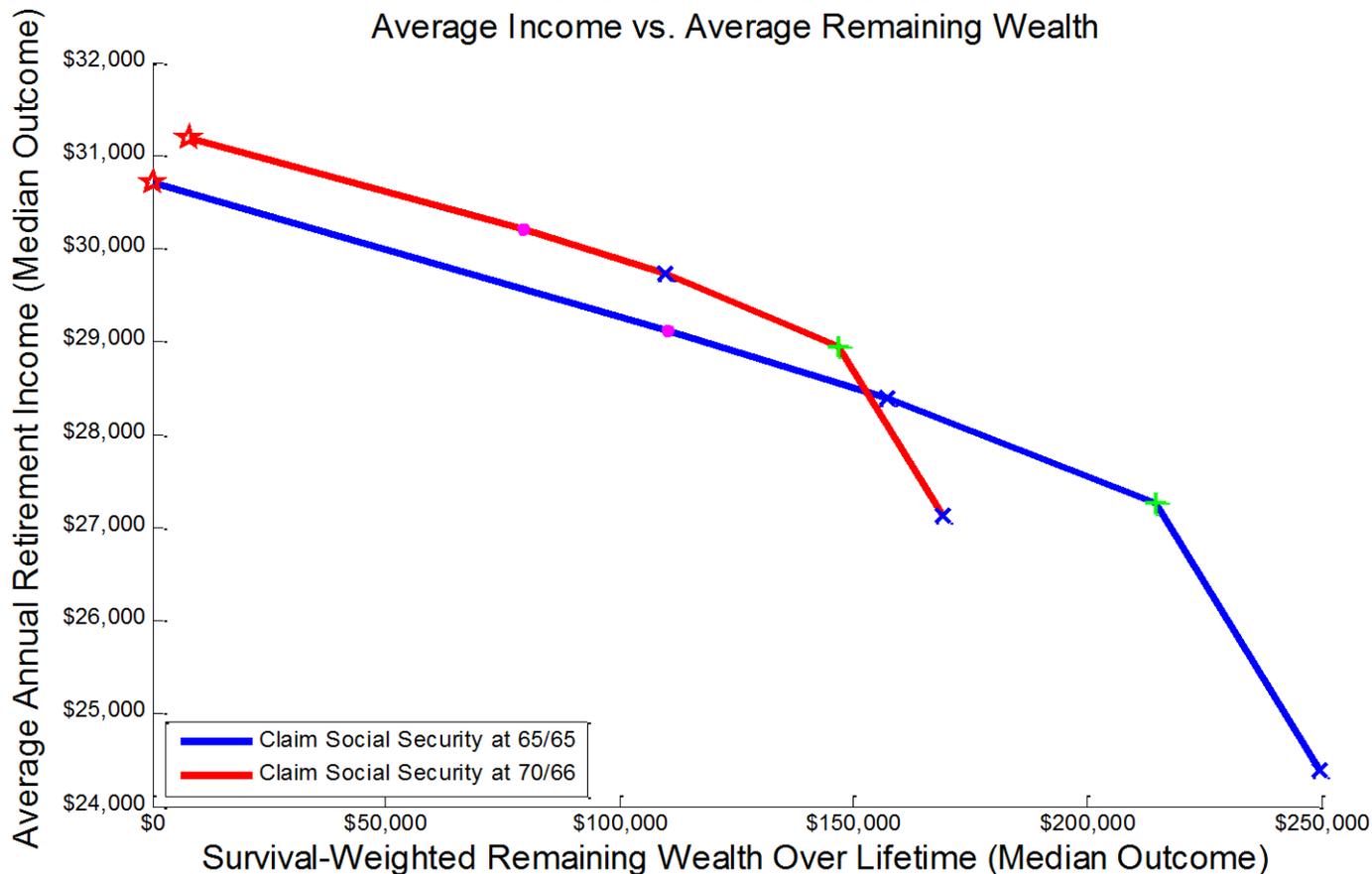
- A close look at the comparison of efficient frontiers under Phases 1 and 2 (on the next page) shows that a Phase 2 strategy can increase average annual income with the same approximate average amount of accessible wealth. For example:
 - Phase 2: 7% SWP with 100% stock allocation (blue cross on red line)
 - Average income: \$29,739
 - Average accessible wealth: \$109,865
 - Phase 1: Partial annuitization strategy (pink dot on blue line)
 - Average income: \$29,127
 - Average accessible wealth: \$110,086
 - In this example, average annual income is increased by \$612 (2.1%), with only a \$221 decrease in average accessible wealth.
- In other words, using retirement savings to enable a higher Social Security income is like “buying” an annuity from Social Security at a very favorable rate.

Efficient Frontier Analysis #2: Tradeoff Between Income and Access

Hypothetical Retiree #1: Single female age 65 with \$250,000

Comparison of Phases 1 and 2 Efficient Frontiers

Figure
Retirement Income Frontier
Average Income vs. Average Remaining Wealth



Annual income increases

Accessible wealth increases

Commentary on Efficient Frontier #2

(Continued)

- Another benefit to the Phase 2 strategy is that the “insurance company” from which a retiree is “buying” the annuity is the federal government. This avoids the commonly expressed concern about insurance company bankruptcy. (A concern considered by many analysts to be unfounded due to the low level of insurance company bankruptcies and existence of guarantees by state guaranty associations, but nevertheless is often cited as a reason not to buy an annuity).
- As with the first efficient frontier analysis, retirement income solutions that are well below the efficient frontier show higher increases in expected retirement income by using savings to enable delaying Social Security benefits, compared to retirement income solutions close to the efficient frontier. Conservative retirees who are not comfortable with high allocations to stocks benefit more from the strategy to use savings to enable delaying Social Security benefits.

Commentary on Efficient Frontier #2

Regarding Other Retirees

- Efficient frontier analyses for other hypothetical retirees show similar patterns with same conclusion. See Appendix D for results.
 - The Social Security delay strategy enables the retiree to increase average annual income with the same approximate average accessible wealth or higher.

Additional retirees

- Married couple both age 65, retiring with \$400,000 in assets. Pure 7% SWP strategy with SS delay compared to partial annuitization strategy without SS delay increases average annual retirement income from \$52,351 to \$54,201 (3.5% higher), with slight increase in average accessible wealth from \$176,138 to \$185,924.
- Married couple both age 65, retiring with \$1,000,000 in assets. Pure 7% SWP strategy with SS delay compared to partial annuitization strategy without SS delay increases average annual retirement income from \$90,325 to \$92,250 (2.1% higher), with an increase in average accessible wealth from \$440,345 to \$544,223.

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

- 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.
- 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.

Appendix A

Definitions

- Single premium immediate annuity (SPIA) is an insurance product that guarantees a lifetime retirement income. 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.
- 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.

Appendix B: Assumptions

Table C.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	-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

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
- SPIA 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

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 #1

- Single 65-year old female with \$250,000 of assets at age 65
- Start Social Security benefit at age 70
- Use enough savings at age 65 to replace Social Security benefit that would have started at age 65, payable from age 65 to age 70
 - Social Security @ 65 = \$16,895/year
 - Social Security @ 70 = \$23,903/year
- Use remaining savings to generate retirement income at age 65.
- Annuity product pricing at age 65 (annual income as percent of assets at beginning of retirement):
 - Inflation-adjusted single life SPIA: 4.82%
 - Fixed single life SPIA: 6.76%
 - Single life SPIA with 3% growth rate: 4.88%
 - GLWB: 5%
 - Above rates in effect during April, 2014 for institutionally priced products. Retail products would produce lower payout rates resulting in lower retirement incomes.

Appendix B: Hypothetical Retiree #2

- Married 65-year old couple with \$400,000 of assets at age 65
- Start worker's Social Security benefit at age 70, start spouse's benefit at age 66.
- Use enough savings at age 65 to replace worker's Social Security benefit that would have started at age 65, payable from age 65 to age 70, and to replace spouse's benefit that would have started at age 65, payable until age 66.
- Social Security @ 65
 - \$22,493/year for primary earner
 - \$11,054/year for spouse
- Worker's Social Security @ 70: \$31,823
- Spouse's Social Security @ 66: \$12,054

Appendix B: Hypothetical Retiree #2 (continued)

- Use remaining savings to generate retirement income at age 65.
- Annuity product pricing at age 65 (annual income as percent of assets at beginning of retirement):
 - Inflation-Adjusted SPIA: 4.06%
 - Fixed SPIA: 6.02%
 - SPIA with 3% growth rate: 4.29%
 - GLWB: 4.5%
 - Above rates in effect during April, 2014 for institutionally priced GLWB products and using competitive annuity bidding for SPIAs.

Appendix B: Hypothetical Retiree #3

- Married 65-year old couple with \$1,000,000 of assets at age 65
- Start worker's Social Security benefit at age 70, start spouse's benefit at age 66.
- Use enough savings at age 65 to replace worker's Social Security benefit that would have started at age 65, payable from age 65 to age 70, and to replace spouse's benefit that would have started at age 65, payable until age 66.
- Social Security @ 65
 - \$29,042/year for primary earner
 - \$14,272/year for spouse
- Worker's Social Security @ 70: \$41,089
- Spouse's Social Security @ 66: \$15,564

Appendix B: Hypothetical Retiree #3 (continued)

- Use remaining savings to generate retirement income at age 65.
- Annuity product pricing at age 65 (annual income as percent of assets at beginning of retirement):
 - Inflation-Adjusted SPIA: 4.06%
 - Fixed SPIA: 6.02%
 - SPIA with 3% growth rate: 4.29%
 - GLWB: 4.5%
 - Above rates in effect during April, 2014 for institutionally priced GLWB products and using competitive annuity bidding for SPIAs.

Appendix C

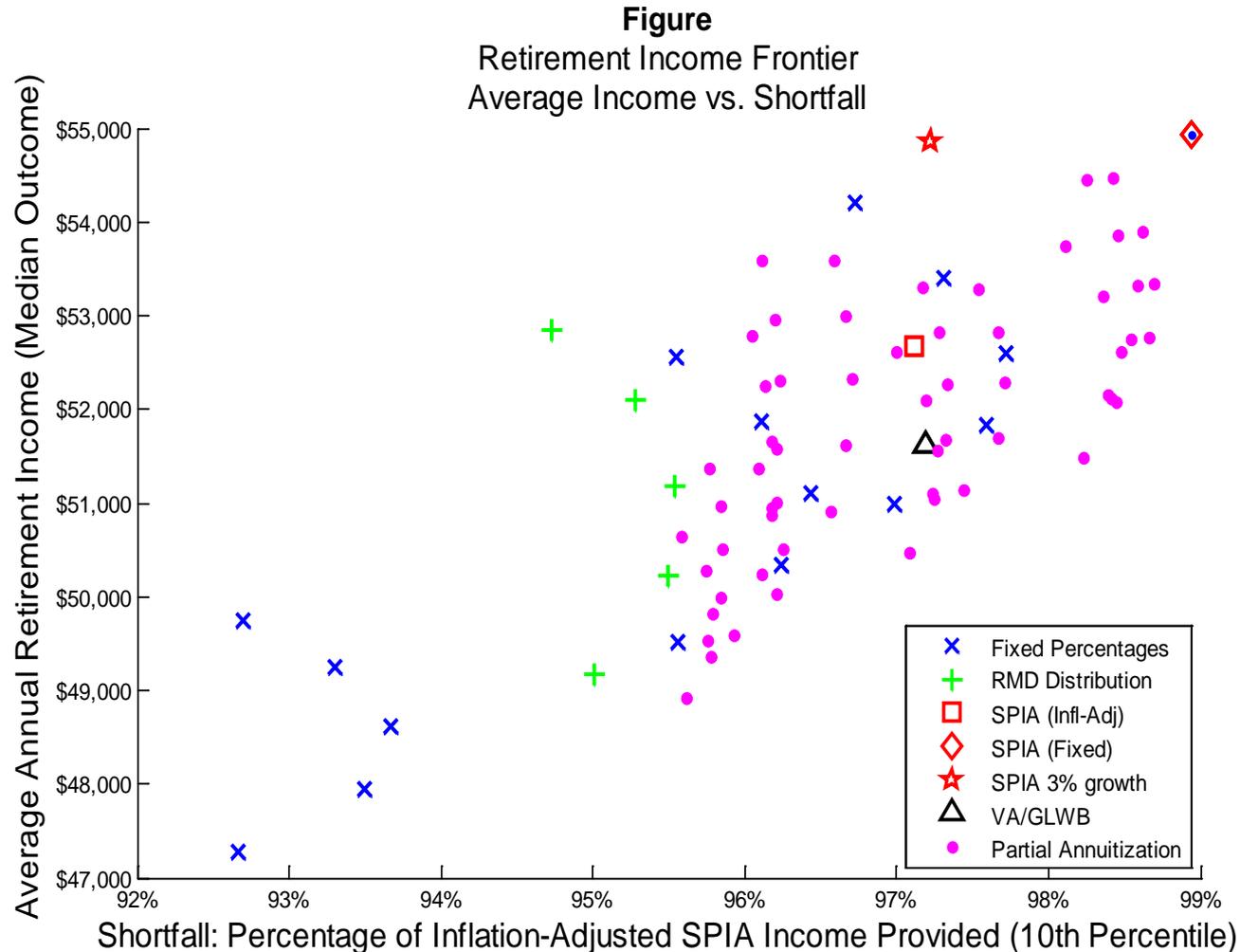
Efficient Frontier #1 Results for Additional Hypothetical Retirees

- Married couple both age 65, retiring with \$400,000 in assets
- Married couple both age 65, retiring with \$1,000,000 in assets
- Note: For the graphs on the following pages, the axis scales change for different hypothetical retirees.

Efficient Frontier Analysis #1: Emphasize Retirement Income

Hypothetical Retiree #2: Married couple age 65 with \$400,000

Phase 2: Use Retirement Savings to Delay Social Security



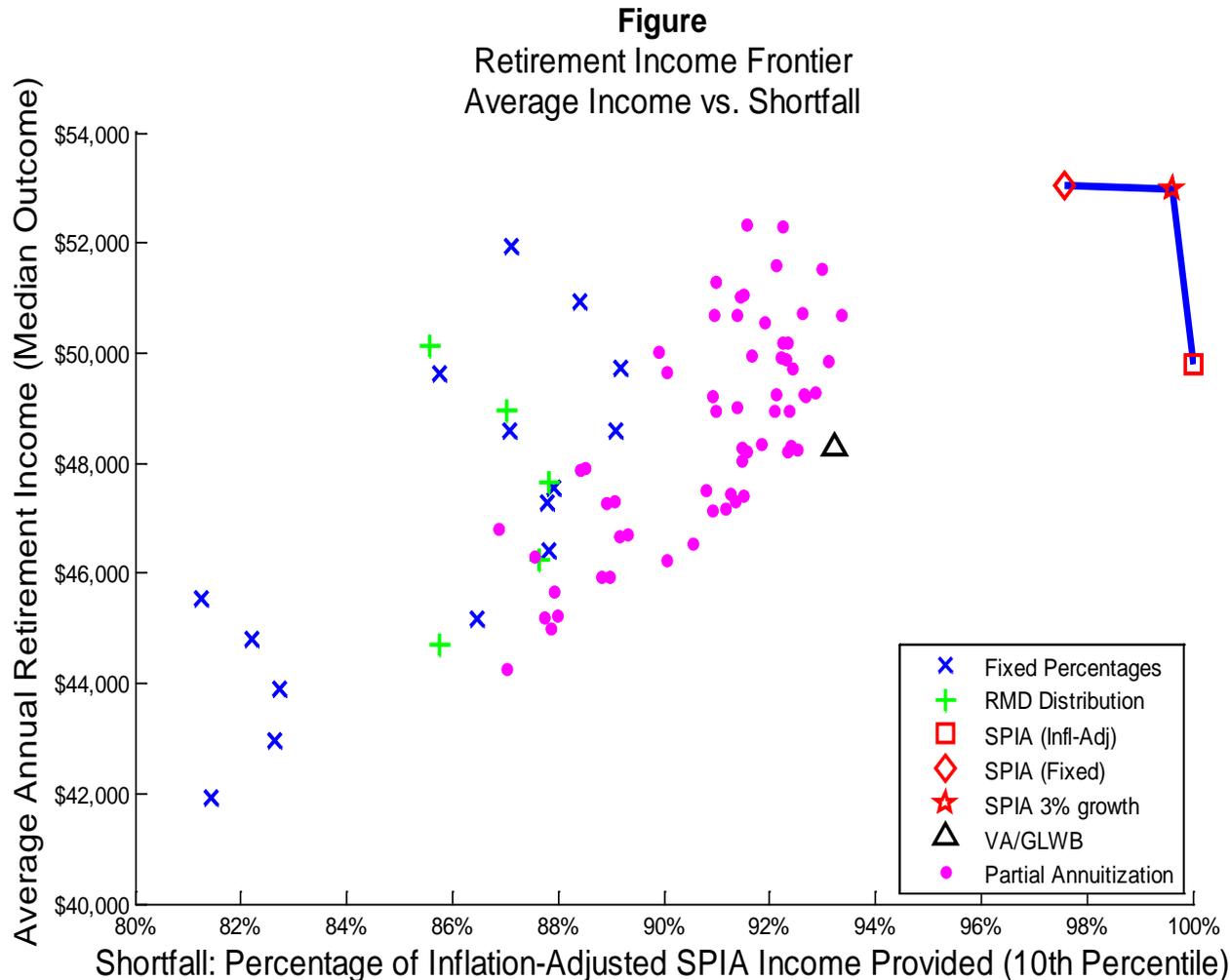
Appendix C

Efficient Frontier Analysis #1: Emphasize Retirement Income

Hypothetical Retiree #2: Married couple age 65 with \$400,000

Phase 1 for Comparison Purposes

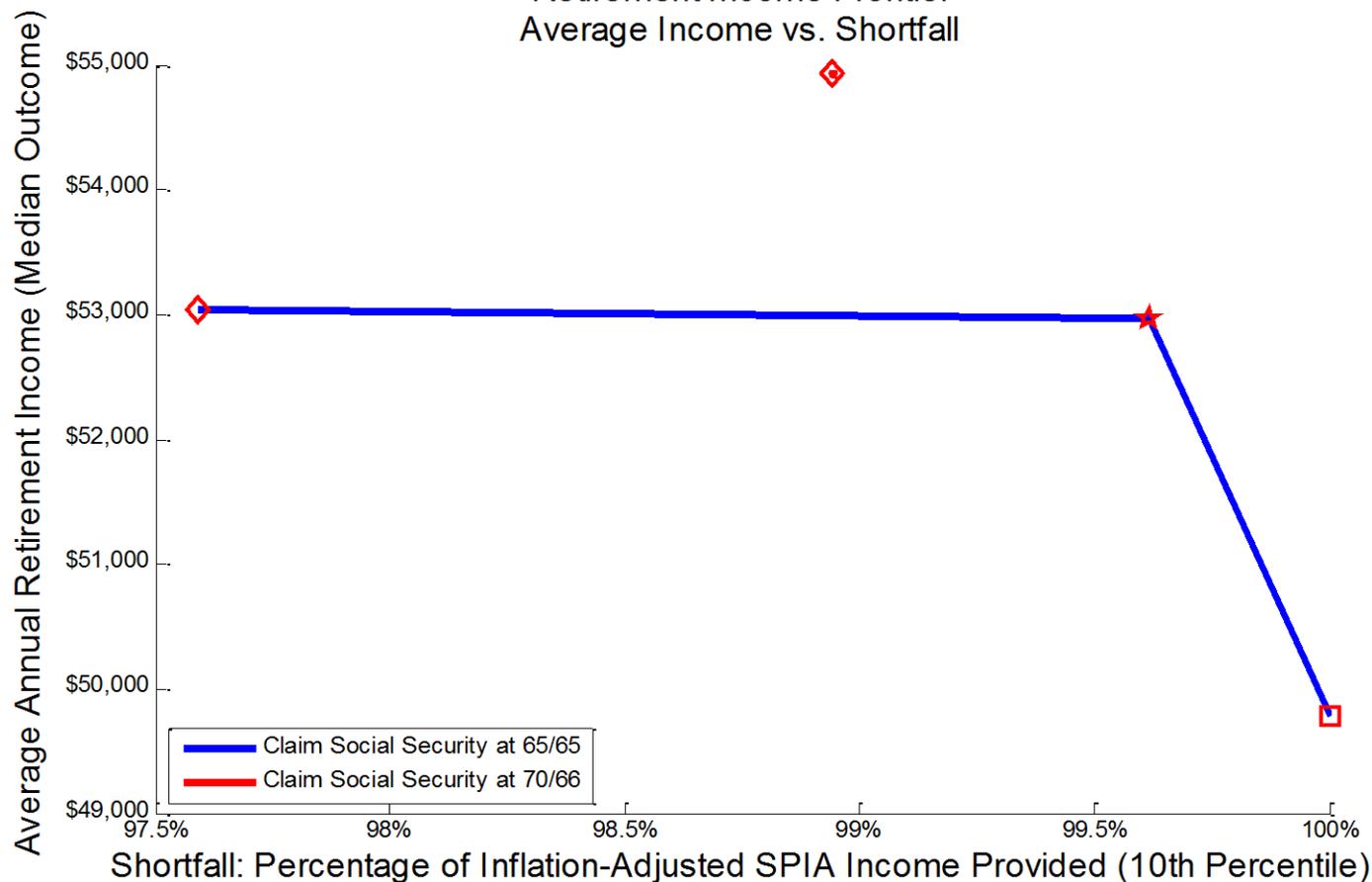
Start Social Security at age 65



Appendix C

Efficient Frontier Analysis #1: Emphasize Retirement Income Hypothetical Retiree #2: Married couple age 65 with \$400,000 Comparison of Efficient Frontiers for Phases 1 and 2

Figure
Retirement Income Frontier
Average Income vs. Shortfall



Efficient Frontier Analysis #1: Emphasize Retirement Income Hypothetical Retiree #3: Married couple age 65 with \$1,000,000

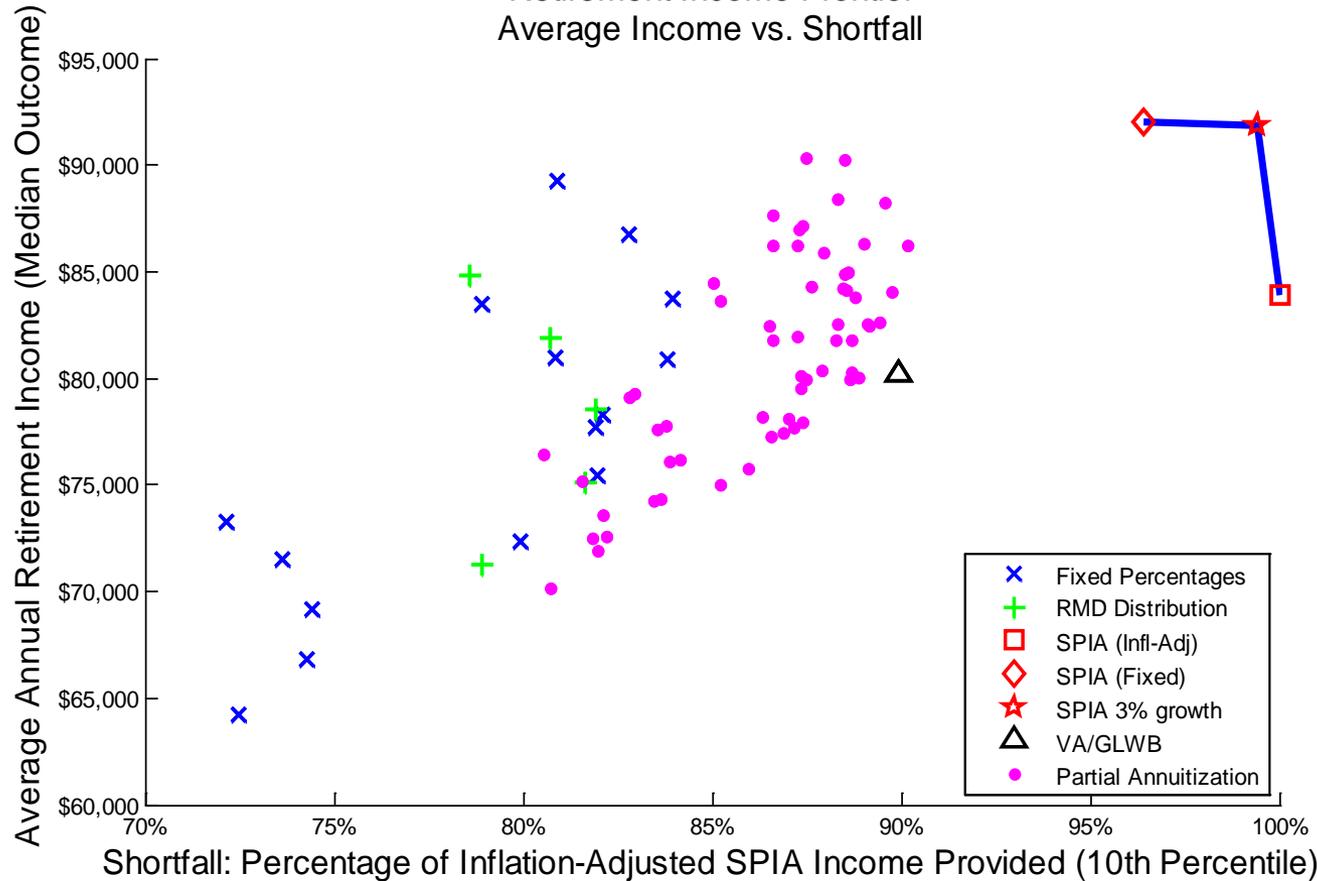
Phase 2: Use Retirement Savings to Delay Social Security



Appendix C

Efficient Frontier Analysis #1: Emphasize Retirement Income
Hypothetical Retiree #3: Married couple age 65 with \$1,000,000
Phase 1 for Comparison Purposes
Start Social Security at age 65

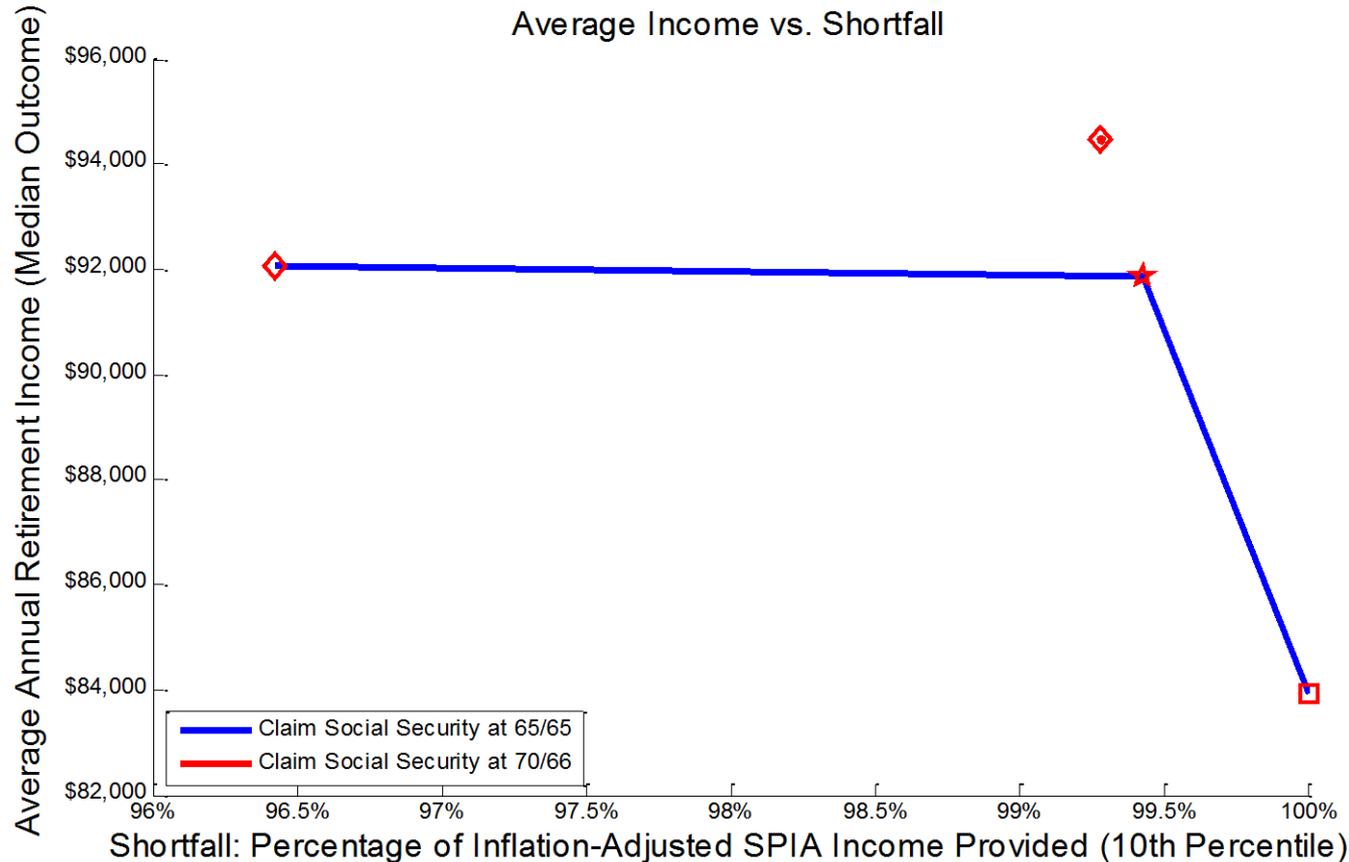
Figure
Retirement Income Frontier
Average Income vs. Shortfall



Appendix C

Efficient Frontier Analysis #1: Emphasize Retirement Income Hypothetical Retiree #3: Married couple age 65 with \$1,000,000 Comparison of Efficient Frontiers for Phases 1 and 2

Figure
Retirement Income Frontier
Average Income vs. Shortfall



Appendix D

Efficient Frontier #2 Results for Additional Hypothetical Retirees

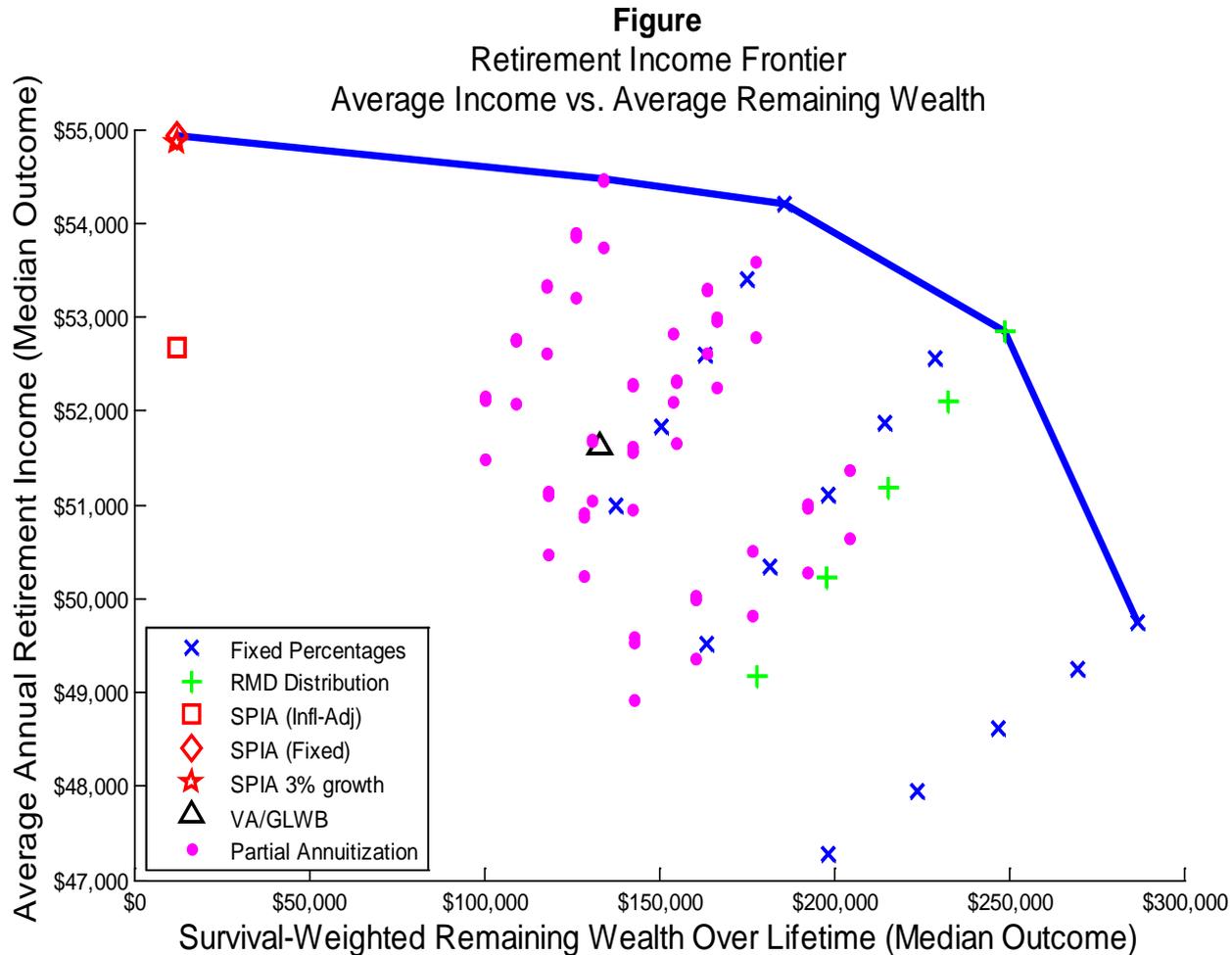
- Married couple both age 65, retiring with \$400,000 in assets
- Married couple both age 65, retiring with \$1,000,000 in assets
- Note: For the graphs on the following pages, the axis scales change for different hypothetical retirees.

Appendix D: Efficient Frontier Analysis #2

Tradeoff Between Income and Accessible Wealth

Hypothetical Retiree #2: Married couple age 65 with \$400,000

Phase 2: Use retirement savings to delay Start Social Security



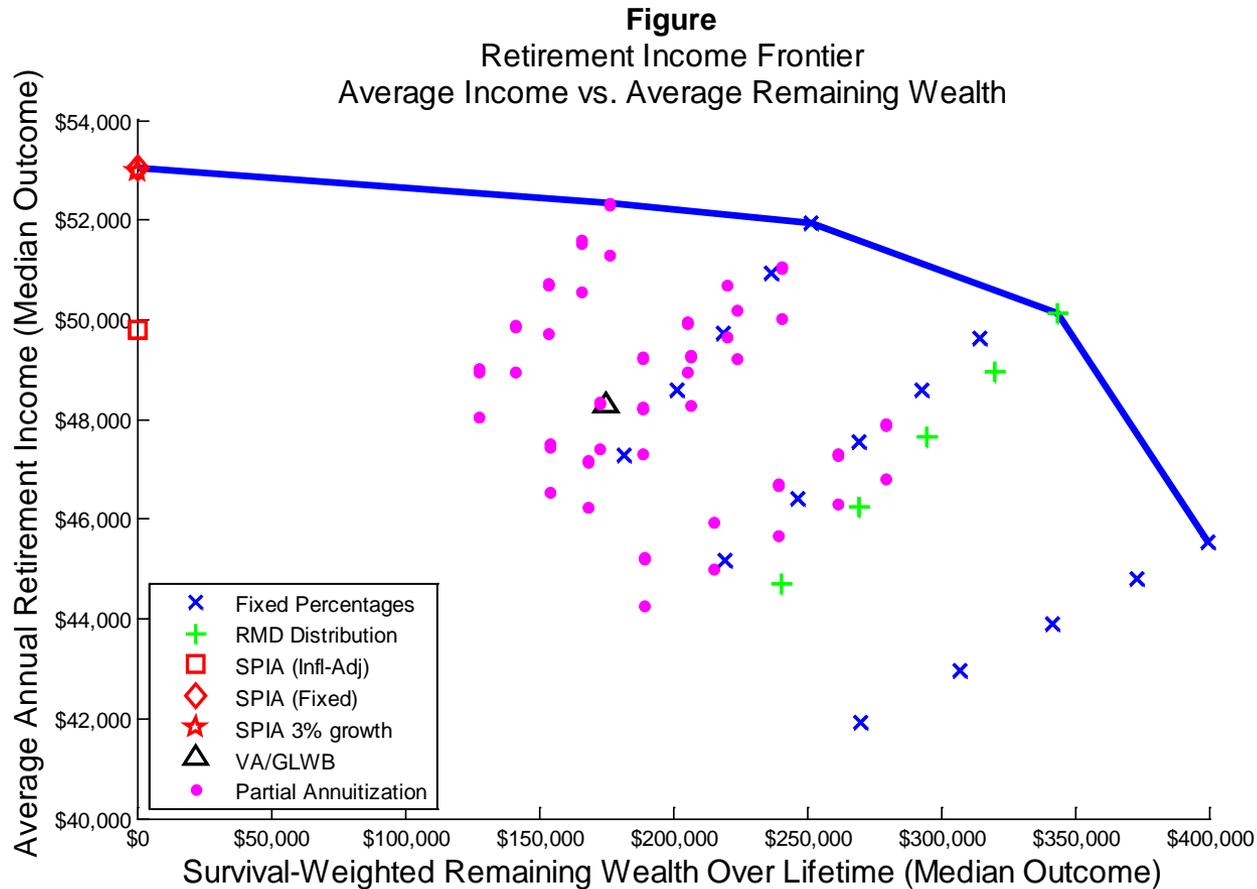
Appendix D: Efficient Frontier Analysis #2

Tradeoff Between Income and Accessible Wealth

Hypothetical Retiree #2: Married couple age 65 with \$400,000

Phase 1 for Comparison Purposes

Start Social Security at age 65

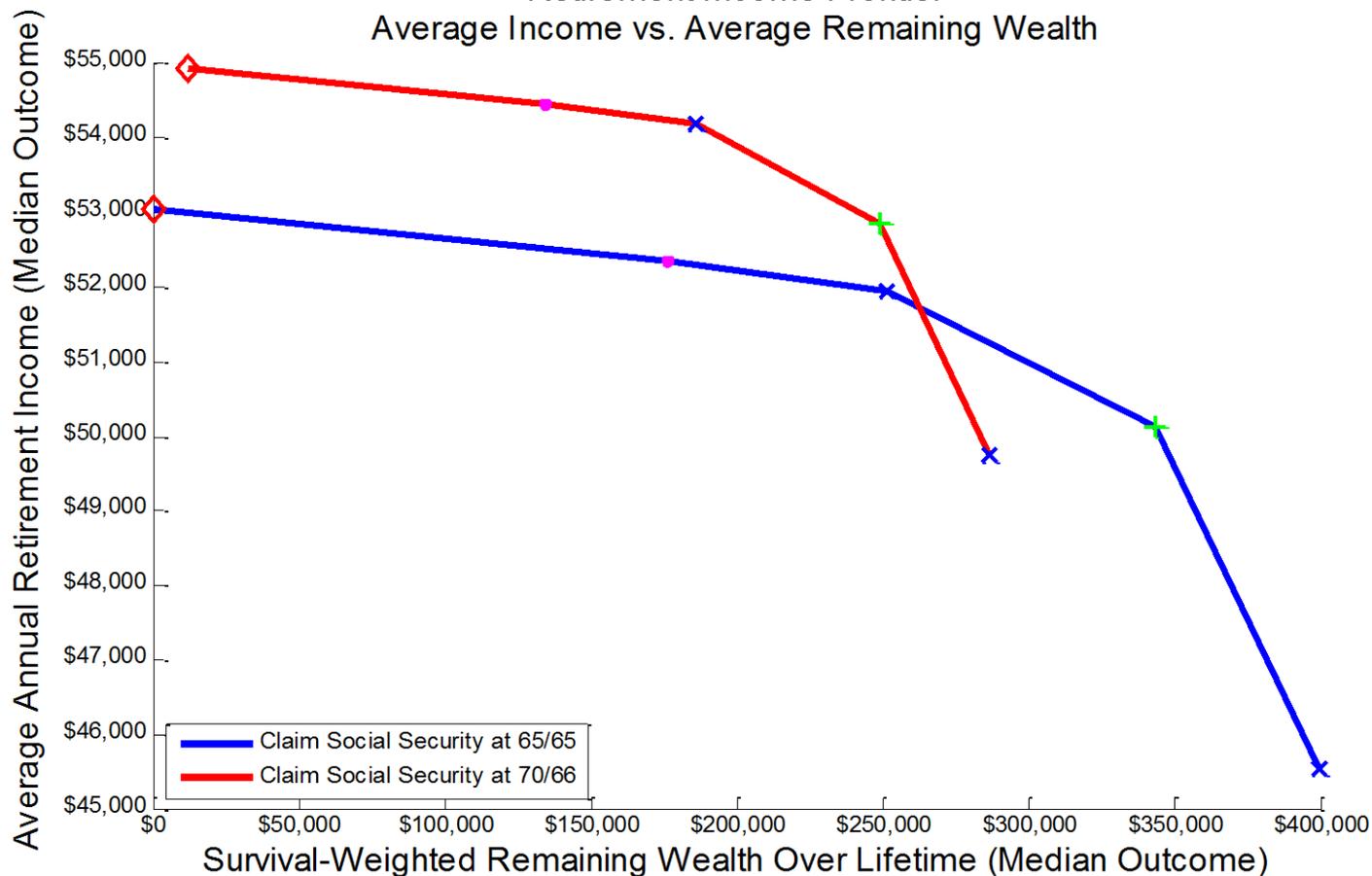


Efficient Frontier Analysis #2: Tradeoff Between Income and Access

Hypothetical Retiree #2: Married couple age 65 with \$400,000

Comparison of Phases 1 and 2 Efficient Frontiers

Figure
 Retirement Income Frontier
 Average Income vs. Average Remaining Wealth



Annual income increases

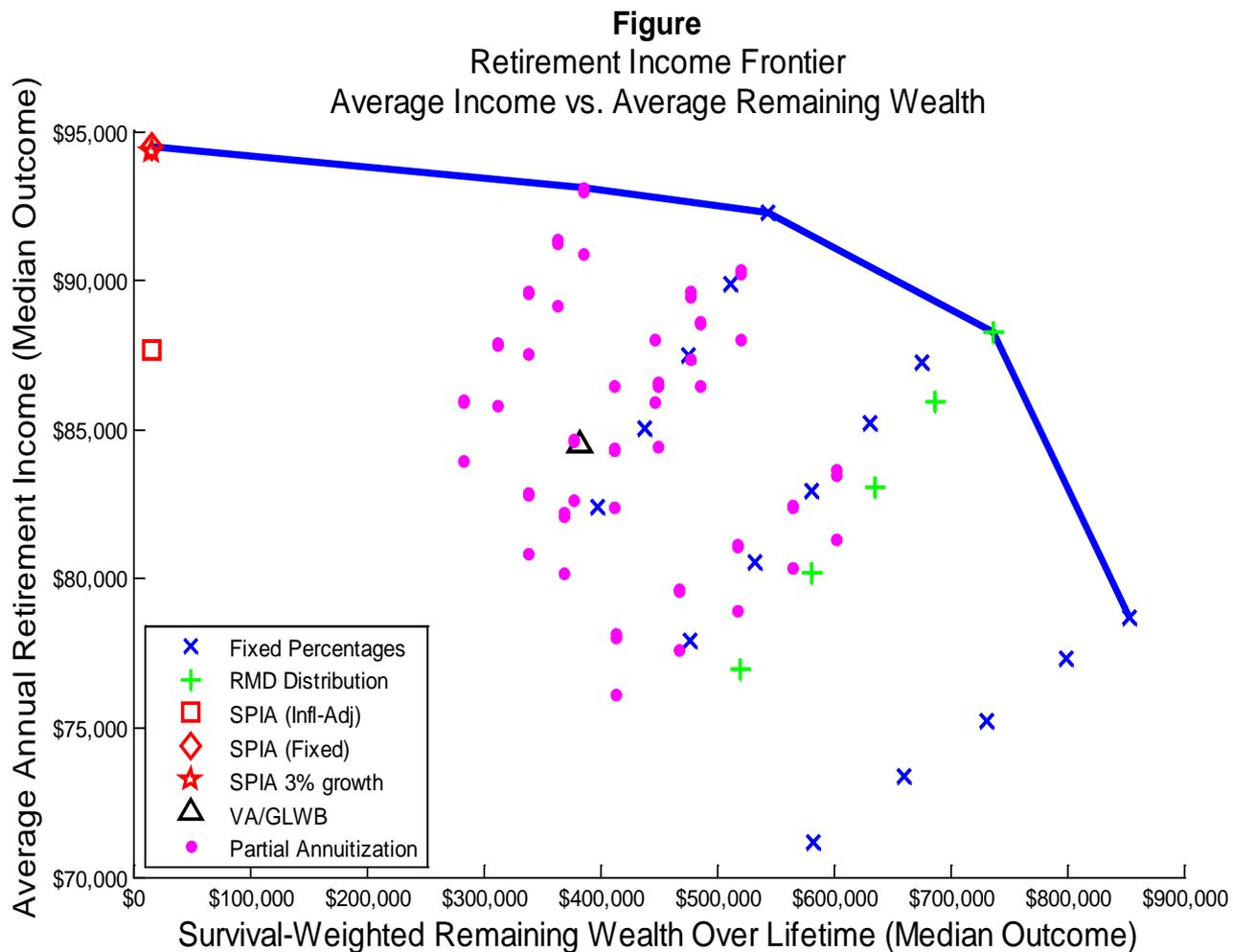
Accessible wealth increases

Appendix D: Efficient Frontier Analysis #2

Tradeoff Between Income and Accessible Wealth

Hypothetical Retiree #3: Married couple age 65 with \$1,000,000

Phase 2: Use retirement savings to delay Start Social Security



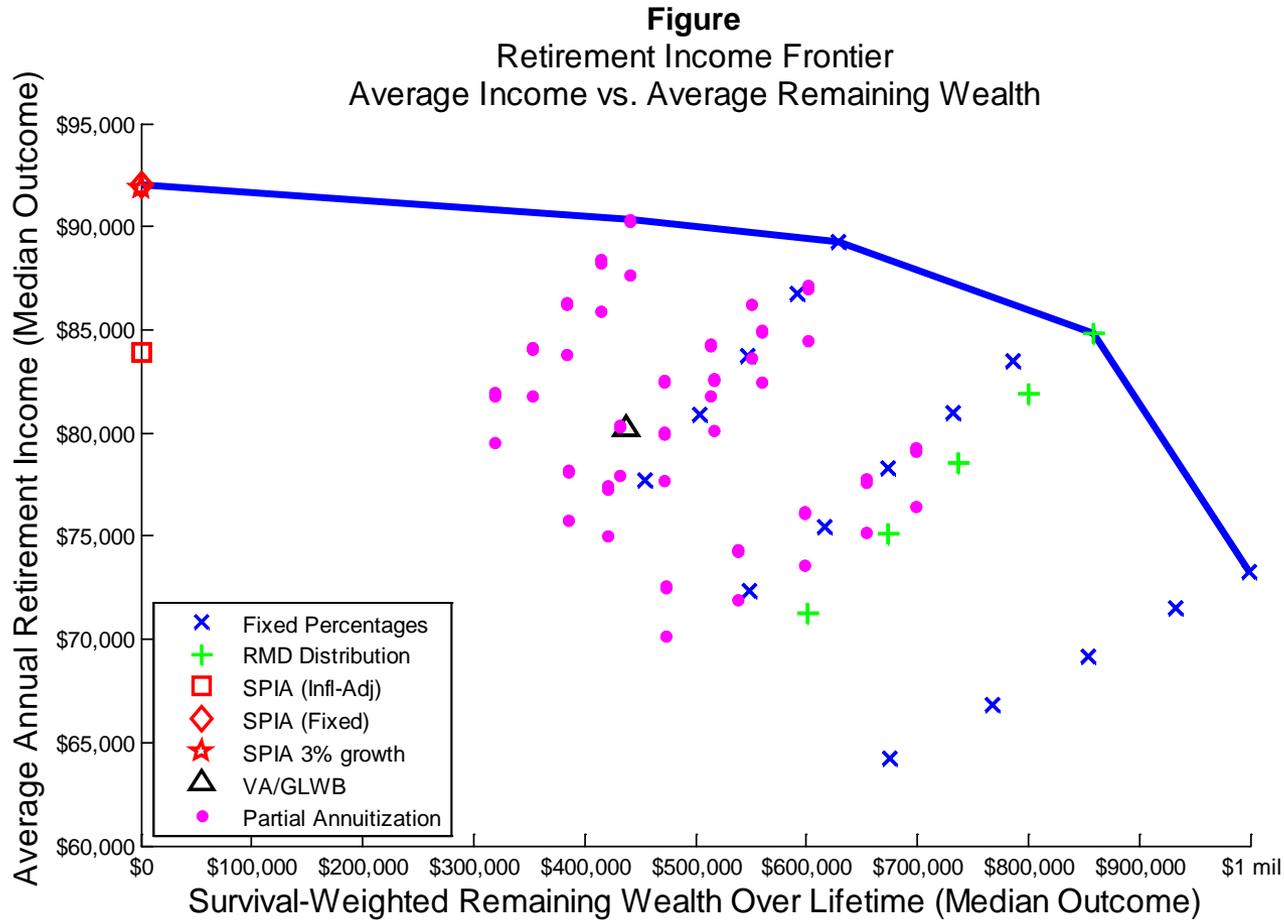
Appendix D: Efficient Frontier Analysis #2

Tradeoff Between Income and Accessible Wealth

Hypothetical Retiree #3: Married couple age 65 with \$1,000,000

Phase 1 for Comparison Purposes

Start Social Security at age 65

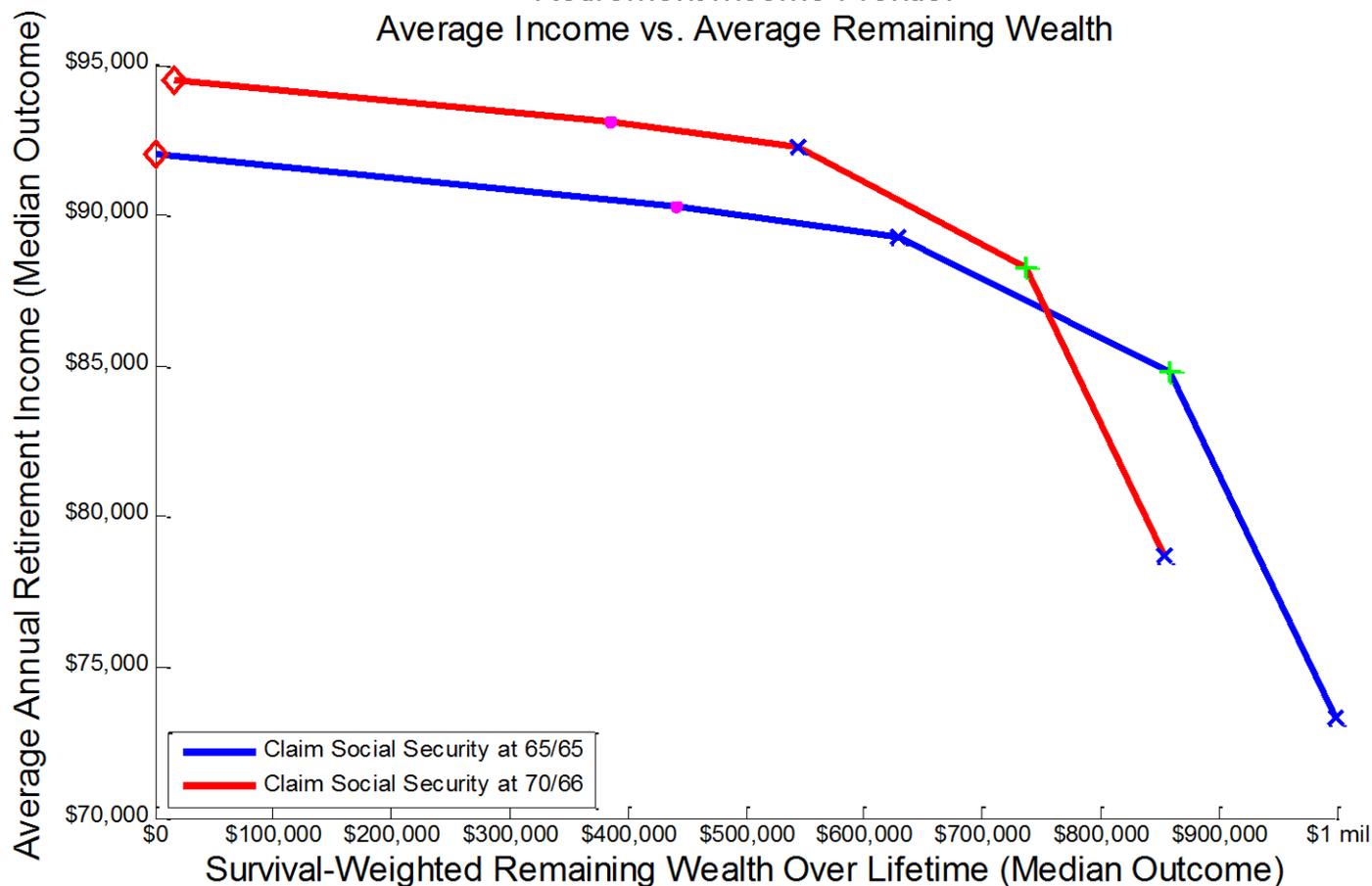


Efficient Frontier Analysis #2: Tradeoff Between Income and Access

Hypothetical Retiree #3: Married couple age 65 with \$1,000,000

Comparison of Phases 1 and 2 Efficient Frontiers

Figure
Retirement Income Frontier
Average Income vs. Average Remaining Wealth



Annual income increases

Accessible wealth increases