"The Portfolio Size Effect and Lifecycle Asset Allocation Funds: A Different Perspective"

by

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Abstract

Basu and Drew (in the *JPM* Spring 2009 issue) argue that lifecycle asset allocation strategies are counterproductive to the retirement savings goals of typical individual investors. Because of the portfolio size effect, most portfolio growth will occur in the years just before retirement when lifecycle funds have already switched to a more conservative asset allocation. In this article, we use the same methodology as Basu and Drew, but we do not share their conclusion that the portfolio size effect soundly overturns the justification for the lifecycle asset allocation strategy. While strategies that maintain a large allocation to stocks do provide many attractive features, we aim to demonstrate that a case for supporting a lifecycle strategy can still be made with modest assumptions for risk aversion and diminishing utility from wealth. Our differing conclusion results from four factors: (1) we compare the interactions between different strategies; (2) we consider a more realistic example for the lifecycle asset allocation strategy; (3) we examine the results for 17 countries; and (4) we provide an expected utility framework to compare different strategies. We find that with a very reasonable degree of risk aversion, investors have reason to prefer the lifecycle strategy in spite of the portfolio size effect.

Journal of Economic Literature Classification Number: D14, D81, G11, G23

Keywords: lifecycle funds, target date funds, retirement planning, asset allocation, portfolio size effect

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Lifecycle or target-date funds (TDFs) have been promoted as a simple solution for retirement savers to invest their savings with a hands-off approach. This investment strategy involves allocating a high proportion of one's assets to equities during the early period far away from the target date, and gradually shifting to more conservative assets, such as bonds and bills, as the target date draws nearer. Confidence in this approach led the US Department of Labor to adopt it as a qualified default investment alternative for corporate defined-contribution pension plans in 2007 as a part of the provisions from the Pension Protection Act of 2006. But as a result of the financial crisis, this investment strategy has received criticism for not being conservative enough. TDFs may confuse investors because there are no clear guidelines about appropriate asset allocations over time, and equity allocations for some TDFs were perceived as being too high for soon-to-be retirees. In 2008, Morningstar reported equity allocations for 2010 TDFs ranging from 29 percent to 65 percent. Noting a 2010 retirement TDF that lost more than 40 percent of its value in 2008, Senator Herb Kohl is leading a push for greater regulation of TDFs to provide more disclosure to investors and to possibly place quantitative restrictions on their equity holdings as the target date approaches (Halonen [2009]).

Meanwhile, Basu and Drew [2009] strongly criticize target-date funds, but for the opposite reason. They argue that TDFs are counterproductive to the retirement savings goals of typical individual investors because they reduce equity allocations at precisely the wrong time. Their conclusion results from the portfolio size effect, an idea they attribute to Shiller [2005], indicating that most of the portfolio growth for individuals will occur late in their careers when they can enjoy capital gains from larger portfolio balances. Basu and Drew [2009] argue that because TDFs have switched to more conservative assets by this time, investors miss their main opportunity for capital gains. Instead, unless an investor has already saved a sufficient amount to finance a comfortable retirement (which does not represent the situation of a typical saver), Basu and Drew argue that a high equity allocation should be maintained in TDFs, a conclusion opposite to the conventional wisdom. They arrive at this conclusion by simulating the results of different investment strategies, in which a lifecycle strategy with a portfolio of all equities that is gradually shifted to a mix of only bonds and bills by retirement, is compared to a contrarian strategy with the opposite approach of holding bonds and bills when young, and gradually shifting to only equities as retirement approaches.

For someone whose goal is to maximize their mean or median wealth accumulation at their retirement date, it is clear from historical trends that the best chance for success is generally to maintain a high equity allocation near retirement, in contrast with the general philosophical approach of TDFs. A risk averse individual, however, may have a different goal, such as minimizing the risk of suffering from extreme hardships in retirement. The question then is how risk averse someone must be to prefer the target-date strategy, and Basu and Drew [2009] conclude that the degree of risk aversion would be extreme and unlikely, writing:

> Only when we compare the 10^{th} percentile (and below) outcomes – whose likelihood of occurrence is 1 in 10 – lifecycle strategies fare slightly better. As a practical matter, it is very unlikely that investors would select a lifecycle asset allocation model with the sole objective of minimizing the severity of these extremely adverse outcomes – should they occur – because the cost of such action is substantial in terms of foregone wealth (p. 69-70).

Here we argue that a solid case can still be made for the lifecycle strategy even when using the same methodological framework as Basu and Drew [2009]. Primarily this is because we take issue with their approach to interpreting the findings and with some of their underlying assumptions. First, Basu and Drew's criticism of TDFs is too strong because they do not consider the interactions between the lifecycle and contrarian investment strategies. They compare percentiles in the cumulative distribution of wealth accumulations for the two investment strategies and show that it is only in the bottom 10 to 15 percent of the distributions for each strategy that lifecycle investing provides more wealth. This approach has theoretical justification, but it is rather abstract, and another equally meaningful way to compare the strategies is to examine the percentage of simulations in which the lifecycle strategy provides larger target-date wealth than the contrarian strategy. For this comparison, the lifecycle strategy tends to provide more wealth about 35 percent of the time. While this is still less than 50 percent, it does make the situation look better for lifecycle funds if they are otherwise able to provide some assurance against bad outcomes.

Second, Basu and Drew stack the deck against the lifecycle strategy by creating an unrealistic lifecycle portfolio that is invested 50 percent in bonds and 50 percent in bills by the target date, with no allocation to stocks. Understandably, they do this in order to better illustrate the portfolio size effect, but this will be confusing to readers who hear their main conclusions without internalizing the *caveat* that the lifecycle portfolio under consideration is not a realistic example. We consider a more realistic example for the lifecycle strategy, which lessens the differences between it and its contrarian counterpart strategy.

Third, Basu and Drew consider only United States data from Dimson, Marsh, and Staunton [2002] updated to account for the period between 1900 and 2004. But of the 17 countries included in this dataset, the United States provides relatively successful results for the contrarian strategies. Only in about four of these countries do the contrarian strategies perform even better. To the extent that the United States in the twentieth century represents a good luck scenario that may be hard to repeat in the future, examining these strategies for the other 16 countries will also be helpful, and this will tend to portray the lifecycle strategy more positively.

Finally, Basu and Drew do not attempt to quantify their conclusion that an unlikely amount of risk aversion would be needed for one to prefer the lifecycle strategy. We will introduce a utility function in order to quantify the degree of risk aversion necessary for an investor to enjoy higher expected utility from the lifecycle strategy. We find that investors with very reasonable degrees of risk aversion may prefer the lifecycle strategy, despite the tendency for the contrarian strategy to produce larger expected wealth. Across 17 countries and for five different sets of comparisons, the maximum degree of risk aversion we find necessary for an investor to reject the contrarian strategy is 3.3, which is well within the bounds of reason for this parameter.

The contrarian strategies of Basu and Drew do tend to provide greater wealth at retirement than the lifecycle strategies more than half the time, and they provide the best chance for tantalizingly large wealth accumulations. But to therefore conclude that TDFs should not reduce their equity holdings as the target date approaches requires making an underlying assumption that the goal of the retirement saver is to maximize their expected wealth at retirement and that investors may not experience a diminishing rate of enjoyment from greater wealth accumulations. We must also explore more about the possibility that retirement savers want protection from bad outcomes. In this case, savers may be willing to forgo chances for additional wealth if it means having a better chance to avoid additional hardships as well. We aim to more carefully consider the potential severity of bad outcomes from each strategy, as well as how the opposite strategy performs when a strategy performs poorly. In doing this, we find that the portfolio size effect is not strong enough to reject the lifecycle strategy for investors with reasonable aversion to risk. We achieve this conclusion considering only the financial wealth of retirement savers, though our findings fit into the literature which uses a more complete model of lifetime assets such as human capital and housing to justify the lifecycle approach (see, for instance, Kyrychenko [2008]; Soto, Triest, Golub-Sass, and Golub-Sass [2008]; and Ibbotson, Milevsky, Chen, and Zhu [2007]).

Methodology

To keep the methodology consistent and comparable with Basu and Drew [2009], we maintain the same hypothetical worker who is saving for retirement. This worker starts with a salary of $25,000 which grows by 4 percent each year during a 41 year career. The worker contributes 9 percent of salary to a retirement savings portfolio at the end of each year for the first 40 years of work. No contribution is made in the 41st year, but this approach allows the initial contribution to grow for 40 years before retirement. The portfolio is rebalanced without considering tax implications or transaction costs at the end of each year to maintain the targeted asset allocation.

For comparison purposes, we also maintain Basu and Drew's four pairs of lifecycle / contrarian portfolio strategies. For Pair A, which is the (20,20) approach, the lifecycle strategy keeps assets allocated 100 percent to stocks for the first 21 years of the worker's career (there are no savings until the end of the first year, so this means 20 years for investments), and then shifts linearly to a portfolio of 50 percent bonds and 50 percent bills by the time of retirement, illustrating the gradual shift to conservative assets found in lifecycle funds. This strategy is paired with a contrarian strategy using the opposition approach: the portfolio starts with 50 percent bonds and 50 percent bills and then moves to 100 percent stocks by the 21st year and maintains this 100 percent stock allocation for the remaining 20 years of the worker's career. The investment strategy is reversed, but both strategies keep the same number of years of investable funds held in different assets. Pairs B, C, and D follow the same idea, but rather than having the lifecycle fund maintain 100 percent stocks for only the first 21 years, these other approaches keep stocks for 26, 31, and 36 years, respectively.

While we maintain this approach so our results are comparable with the previous study, we also note that this treatment of lifecycle funds as being completely divested of stocks by the time of retirement is not realistic, and thus does not provide fair treatment to the idea of the lifecycle investing strategy. For example, the TDFs from T Rowe Price have an asset allocation at retirement of 55 percent stocks, 35 percent bonds, and 10 percent bills. As for 40 years before the target date, these funds hold 90 percent stocks and 10 percent bonds. Thus, we add a fifth category which models the lifecycle strategy after a real example from the T Rowe Price Retirement Funds. These lifecycle and contrarian strategies are illustrated in Exhibit 1. For lack of a better term, we refer to this as the "realistic" approach, though it is just one of many possible realistic TDFs.

// Exhibit 1 About Here //

To maintain comparability, we also use the same procedure to generate simulated investment returns using the same underlying data. This involves creating 10,000 simulations, each of which consists of 41 years of asset returns for equities, bonds, and bills. These asset returns are randomly drawn, with replacement, from the Dimson, Marsh, and Staunton dataset for the United States for 1900 to 2004. The simulations preserve the means, standard deviations, and cross-correlations of the underlying data, which is commercially available from Ibbotson Associates and Morningstar. Any differences in our asset returns result only from the random variation associated with a sample size of 10,000. In each simulation, the lifecycle and contrarian strategy performances are calculated from the same asset returns.

Most of our analysis then consists of comparing the distributions of wealth accumulations for different investment strategies. Essential to this analysis, we estimate the expected utility from different strategies using a standard constant relative risk-aversion utility function:

$$E\left[U\left(w\right)\right]=\sum_{i=1}^{N}\left(\frac{1}{1-\gamma}w_i^{1-\gamma}\right) \tag{1}$$

in which w_i represents the wealth accumulation at retirement in each of N=10,000 simulations. In the case that $\gamma=1$, the utility is defined instead as the natural logarithm of wealth. This is a standard way to evaluate the utility provided by wealth (see, for instance, Ibbotson, Milevsky, Chen, and Zhu [2007]; Milevsky [2006]; Azar [2006]; and Poterba, Rauh, Venti, and Wise [2005]). We calculate the expected utility for each strategy as the mean utility from the 10,000 simulations and then compare the expected utilities from the lifecycle and contrarian strategies. We solve for the value of γ that makes the expected utility from each strategy equal, such that investors with risk aversion coefficients below our estimates will be aggressive enough to appreciate the higher expected returns of the contrarian strategy, while investors with values above our estimates will prefer the lower volatility and downside protection of the lifecycle strategy.

Utility provides a more enriched way to compare investment strategies than does just comparing the accumulated wealth. This is because a useful way to interpret the utility function is that it accounts for the diminishing returns from wealth that people experience. An extra $10,000 of savings will tend to provide more utility to someone with only $50,000 of savings than to someone with $500,000 of savings. In this framework, larger values for γ indicate that the investor experiences relatively less gains in utility as their wealth increases. Another equally important and more fundamental interpretation of γ is that it represents the coefficient of risk aversion, providing a measure of an individual's attitude toward risk taking. A value of zero represents risk neutrality, while increasingly positive values indicate increasing risk aversion. In surveying the literature, Azar [2006] finds general agreement that the realistic range for risk aversion is between one and five. The majority of studies use a value in this range, and where there is disagreement, it is generally among those who believe that risk aversion is even greater.

In choosing the utility function, it is important to acknowledge a potential limitation of these results related to a lack of understanding about the precise way that people may evaluate the utility of their wealth. While our expected utility approach provides a way to account for the diminishing returns from wealth, it may not be suitable for individuals who evaluate the utility or success of their retirement saving strategies in other ways, and other possible utility functions may lead to different conclusions. Investors could view a retirement savings accumulation goal in absolute terms and view as a failure any outcome that does not achieve the goal. Schleef and Eisinger (2007), for instance, implicitly define utility in terms of the shortfall risk of not accumulating as much as a predetermined wealth goal. Not meeting the goal means failure, and the degree to which the goal is not met is irrelevant. As Schleef and Eisinger find, such a utility function will generally lead to recommendations for higher equity allocations as retirement approaches, in contrast with the lifecycle strategy, as this is the way to maximize the probability of success for all but the most modest of retirement accumulation goals. With this view of shortfall risk, the individual does not worry about the distribution of their wealth accumulations and would find the analysis and conclusions of Basu and Drew [2009] to be persuasive.

Results

// Exhibit 2 About Here //

Exhibit 2, which corresponds to Exhibit 2 in Basu and Drew [2009], compares the different pairs of investment strategies at different points in their cumulative distributions for the

United States data. We note here that the results are quite similar to Basu and Drew's, with minor differences resulting from the randomness of the simulations, so that when we subsequently reach the opposite conclusion as Basu and Drew, it is not because the underlying simulations are different. In addition to demonstrating this comparability, Exhibit 2 also adds the realistic lifecycle strategy in Pair E. Unlike in the (20,20) approach where the mean and median contrarian strategy outcomes are 42.3 and 29.7 percent larger, respectively, the differences between the contrarian and lifecycle strategies in the realistic approach are only 12.7 and 8.1 percent. The results for the realistic approach in Pair E should provide the baseline case most worth remembering by the reader.

The final two columns in Exhibit 2 provide two contrasting ways to compare the distributions of the lifecycle and contrarian strategies. To compare strategies, Basu and Drew focus on the cumulative distributions of each strategy in isolation and describe how most percentiles of the distribution for the contrarian strategy are larger than the corresponding percentiles of the lifecycle strategy. This idea is represented in the $LC_{CDF}>C_{CDF}$ column. With this comparison method, our results show that for the (20,20) approach, it is only in the bottom 14.2 percent of each distribution that the lifecycle strategy provides more wealth than the contrarian strategy. As more emphasis is placed on equities in the subsequent pairs, these values decline further, as in Pair D the lifecycle strategy provides more wealth only for 11.2 percent of the corresponding distributions. Meanwhile, for the realistic approach, the lifecycle strategy does do better, though still only the bottom 22.68 percent of the lifecycle distribution has larger wealth accumulations.

Finally, the [P(LC>C)] column presents a different method for comparing strategies, as it shows the percentage of times that the lifecycle strategy provides more wealth than the contrarian strategy across the simulations. For the (20,20) approach, the lifecycle strategy outperforms the contrarian strategy 32.4 percent of the time, and this success rate increases to 35.8 percent for the (35,5) approach. Meanwhile, the realistic lifecycle strategy provides more wealth 36 percent of the time. While the contrarian strategy still provides greater wealth more often than not, these numbers do work to even the odds somewhat and may make the lifecycle strategy more palatable if it can otherwise reduce the chances for particularly bad outcomes.

// Exhibit 3 About Here //

Before focusing only on bad outcomes, Exhibit 3 first provides details about the differences in absolute wealth accumulations for different subsamples of the strategy pairs. Though results are provided for all five pairs of strategies, our description of this exhibit will emphasize the realistic approach in Pair E. We consider the distribution of differences in outcomes for subsets of the results when each strategy provides greater wealth, in order to consider the extent of these differences. We consider both Basu and Drew's preferred comparison of the cumulative distribution functions for wealth, as well as our measure of which strategy provides greater wealth in each of the simulations. The results from this table tend not to make a convincing case for the lifecycle strategies. For instance, in the 22.6 percent of each cumulative distribution when the lifecycle strategy provides more wealth, the median difference is $34,600, which represents just 28.8 percent of the $120,025.52 final salary. Meanwhile, for the portion of the distribution in which the contrarian strategy provides more wealth, the median difference is more substantial at $173,800, which is an extra 1.448 multiple of final salary. We argue that it is more meaningful to consider the pairwise comparisons of the strategies for each simulation, and in this case the median difference in the 36 percent of cases in which the lifecycle strategy outperforms is $97,900, or 81.6 percent of final salary, compared to a median difference of $249,200, or 2.08 times the final salary, when the contrarian strategy outperforms. Similar results can be found throughout Exhibit 3, as it is the case that the contrarian strategies do tend to outperform more frequently and to provide substantially larger wealth when they outperform. Whether an individual values the occasional additional wealth gains, however small, from the lifecycle strategies depends on their risk aversion and how the lifecycle strategies perform in the bad luck cases of negative asset returns near retirement.

// Exhibit 4 About Here //

To provide more understanding about the bad luck cases when the lifecycle strategy tends to offer downside protection, Exhibit 4 plots the paired wealth accumulations for the realistic approach when at least one strategy provides less than $1 million at retirement. This value representing 8.33 times the final salary of $120,025.52. Points above the 45 degree line are situations in which the lifecycle strategy outperforms the contrarian strategy, while the contrarian strategy provides more wealth at points below the 45 degree line. When investment returns are poor, the lifecycle strategy tends to provide more wealth at a time when each additional dollar of wealth will have a more substantial impact on the retiree's living standard. For instance, in the very worse simulation result for both strategies, the contrarian strategy provides about $93,000, compared to more than $150,000 for the lifecycle strategy. This is only visual evidence, but the utility function will allow us to quantify the potential value of this insurance.

// Exhibit 5 About Here //

Before considering the degree of risk aversion necessary for someone to prefer the lifecycle strategy to the contrarian strategy, Exhibit 5 first introduces comparable results for the 17 countries included in the Dimson, Marsh, and Staunton dataset. The historical data represent total returns for assets in local currency from 1900 to 2008 for each country. To be consistent with the other countries, a new set of simulations using data through 2008 was created for the United States as well. For three different approaches, we provide the median wealth accumulations for the lifecycle and contrarian strategies, as well as the $LC_{CDF}>C_{CDF}$ and P(LC>C) calculations.

Australia provides the most successful case for the contrarian strategy relative to the lifecycle strategy for each of the outcome measure comparisons. In the realistic approach, Australia is followed by South Africa, the United Kingdom, Canada and the United States. For other countries, the contrarian strategy does tend to provide greater wealth more often than not, but the differences between the two strategies are narrower with the contrarian strategies enjoying smaller advantages. For the realistic approach, the lifecycle strategy outperforms the contrarian strategy more than 40 percent of the time in 11 of the 17 countries. At the opposite extreme, the contrarian strategy barely outperforms the lifecycle strategy in Norway. Looking forward to the years ahead, we must note from this exhibit that the record for the contrarian strategies in the United States is strong relative to the typical country in the dataset, and decisions about equity allocations for TDFs must consider whether this strong historical performance in the United States can be sustained.

// Exhibit 6 About Here //

Finally, Exhibit 6 provides details about the degree of risk aversion required for an investor to prefer the less volatile lifecycle strategy to the contrarian strategy, using a constant relative risk-aversion utility function for total wealth accumulated at the retirement target date. The contrarian strategy is most volatile for the (20,20) approach and least volatile for the realistic approach, which explains why the risk aversion coefficients decrease along each row. For countries in which the contrarian strategy performs relatively better, the risk aversion coefficient must be higher for an investor to accept the lifecycle strategy. While a coefficient of zero represents risk neutrality, a coefficient of one is typically viewed as an aggressive investor, while values of five and higher are viewed as conservative. As reviewed in Azar [2006], a large number of studies treat five as a baseline risk aversion coefficient.

With these values in mind, a fundamental message from this exhibit is that many investors are likely to prefer the lifecycle strategy. At the most extreme, an Australian with a coefficient below 3.3 would prefer the contrarian (20,20) strategy to its lifecycle counterpart. In the United States, the value is 2.23, and in Norway it is only 1.24. For the realistic approach, the values range from 2.62 in Australia to 0.97 in Norway, with a value of 1.69 for the United States. In all 17 countries an investor with risk aversion of 3 or higher would enjoy greater expected utility from the realistic lifecycle strategy than the realistic contrarian strategy. We conclude that the characteristic noted by Basu and Drew [2009] that much of the cumulative distribution of the contrarian strategy is larger thus does not imply that investors would need to be extremely risk averse to accept the lifecycle strategy. Some of the more aggressive investors would prefer the contrarian strategy in order to take advantage of the portfolio size effect, but the lifecycle strategy still prevails as a better choice for the typical investor.

Summary and Conclusions

Retirement savers may have a certain goal in mind for how much wealth they aim to accumulate by their retirement date. Unless this goal is relatively modest, or the person has otherwise already saved much more than the 9 percent of salary we assume, the contrarian strategies will tend to provide a higher probability for reaching their goal. But this is not the whole story. A saver who cannot otherwise increase their savings rate or delay their retirement may accept that the goal will not necessarily be reached. It is a somewhat arbitrary number anyway. What becomes important is to find an appropriate tradeoff between expected wealth accumulation at the target date and protection against big losses for the already accumulated wealth. Making a “Hail Mary” pass to achieve the goal by keeping a high allocation to equities may not be appropriate for a risk averse investor. Our use of a utility function reflects this point, and we have found that savers with very reasonable amounts of risk aversion will enjoy higher expected utility from using the lifecycle strategies instead of the contrarian strategies. The portfolio size effect examined by Basu and Drew [2009] is not large enough to overturn the general justification for the lifecycle strategy.

References

Azar, Samih A. “Measuring Relative Risk Aversion.” *Applied Financial Economics Letters*, Vol. 2, No. 5 (2006), pp. 341-345.

Basu, Anup K., and M.E. Drew. “Portfolio Size Effect in Retirement Accounts: What Does It Imply for Lifecycle Asset Allocation Funds?” *The Journal of Portfolio Management*, Vol. 35, No. 3 (2009), pp. 61-72.

Dimson, E., P. Marsh, and M. Staunton. *Triumph of the Optimists: 101 Years of Global Investment Returns*. Princeton, NJ: Princeton University Press, 2002.

Halonen, Doug. “Feds taking aim at target-date funds.” *Pensions & Investments*, Vol. 37, No. 11, June 1, 2009, pp. 2, 27.

Ibbotson, Roger G., M.A. Milevsky, P. Chen, and K.X. Zhu. *Lifetime Financial Advice: Human Capital, Asset Allocation, and Insurance*. Charlottesville, VA: The Research Foundation of the CFA Institute, 2007.

Kyrychenko, Vladyslav. “Optimal Asset Allocation in the Presence of Nonfinancial Assets.” *Financial Services Review*, Vol. 17, No. 1 (2008), pp. 69-86.

Milevsky, Moshe A. *The Calculus of Retirement Income: Financial Models for Pension Annuities and Life Insurance*. New York, NY: Cambridge University Press, 2006.

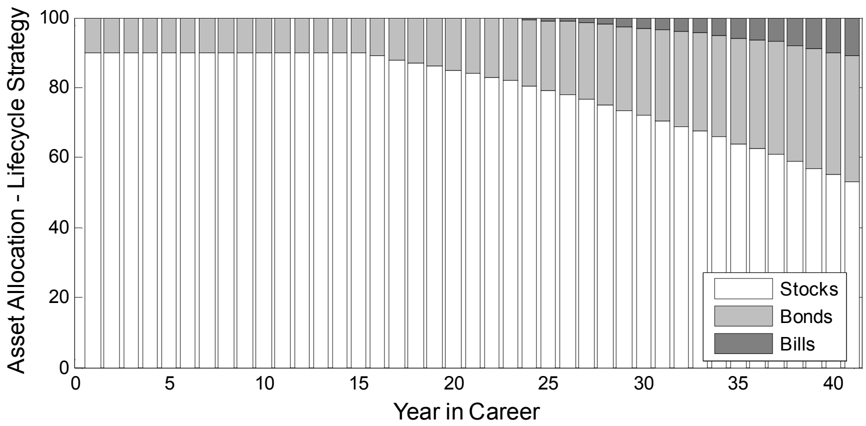
Poterba, J., J. Rauh, S. Venti, and D. Wise. "Utility Evaluation of Risk in Retirement Savings Accounts." In: D. Wise, ed., *Analyses in the Economics of Aging*. Chicago: University of Chicago Press, 2005, pp. 13-52.

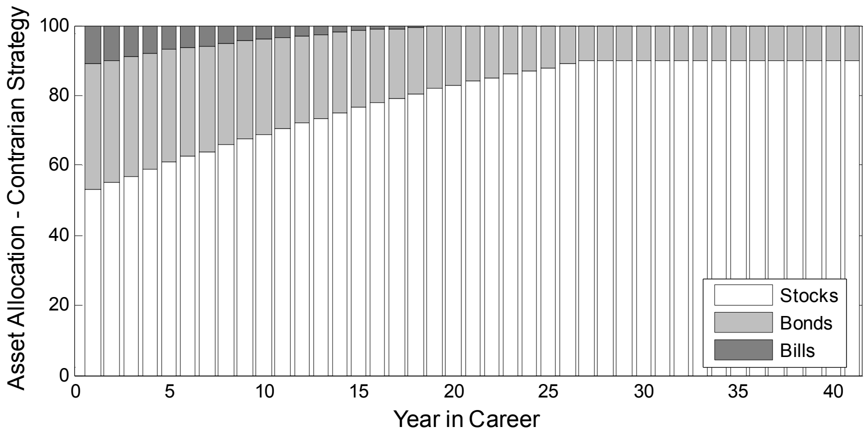
Schleef, H. J., and R. M. Eisinger. "Hitting or Missing the Retirement Target: Comparing Contribution and Asset Allocation Schemes of Simulated Portfolios." *Financial Services Review*, Vol. 16 (2007), pp. 229-243.

Shiller, Robert. “The Lifecycle Personal Accounts Proposal for Social Security: A Review.” National Bureau of Economic Research Working Paper No. 11300, 2005.

Soto, Mauricio, R. Triest, A. Golub-Sass, and F. Golub-Sass. “An Assessment of Life-Cycle funds.” Working paper, Center for Retirement Research at Boston College, 2008.

EXHIBIT 1
Realistic Lifecycle Strategy Based on T Rowe Price Retirement Funds





Source for lifecycle strategy:
http://individual.troweprice.com/public/Retail/Mutual-Funds/Retirement-Funds

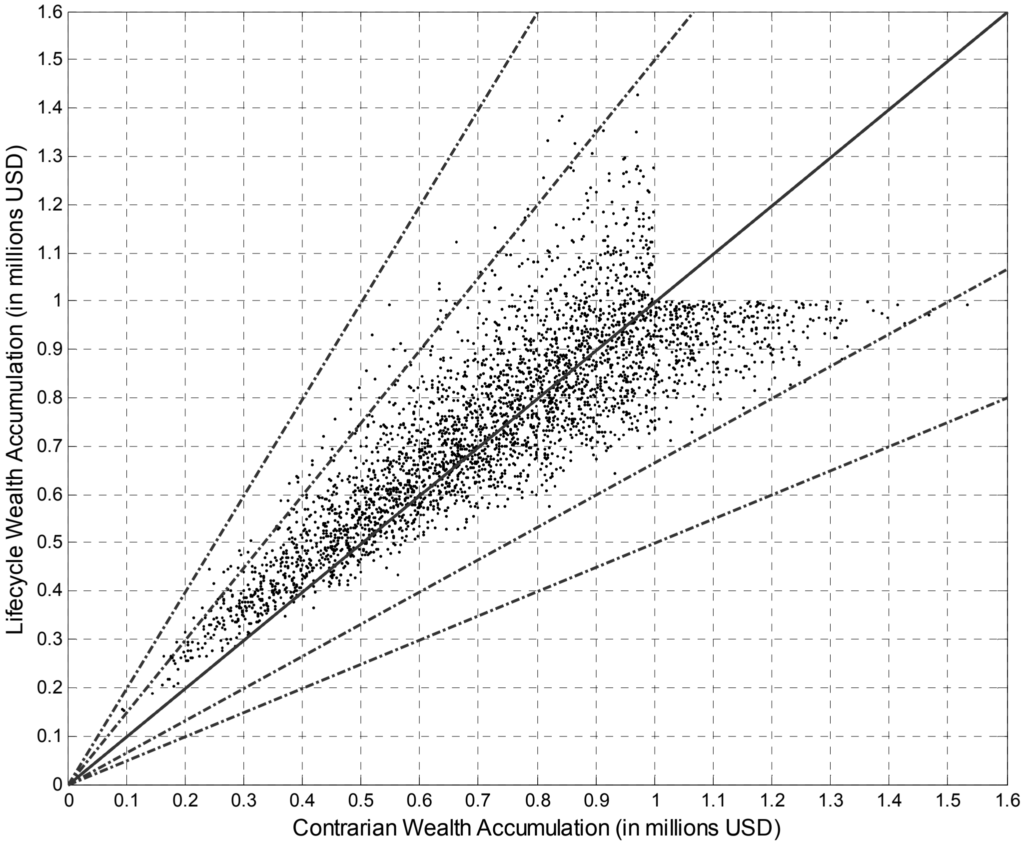
EXHIBIT 2
Portfolio Values at Retirement in Nominal Dollars

Strategy	Mean	Median	25th Percentile	75th Percentile	LC_{CDF}> C_{CDF}	P(LC>C)
Pair A						
Contrarian(20,20)	1,987,202	1,462,367	859,499	2,489,639		
Lifecycle (20,20)	1,396,650	1,127,481	783,093	1,699,455	14.2	32.4
Ratio: Contr / LC	1.423	1.297	1.098	1.465		
Pair B						
Contrarian(25,15)	2,169,721	1,548,218	893,826	2,686,853		
Lifecycle (25,15)	1,614,076	1,248,311	823,125	1,979,197	12.9	32.8
Ratio: Contr / LC	1.344	1.240	1.086	1.358		
Pair C						
Contrarian(30,10)	2,335,808	1,626,323	924,789	2,871,295		
Lifecycle (30,10)	1,877,954	1,393,592	867,718	2,307,533	12.7	34.5
Ratio: Contr / LC	1.244	1.167	1.066	1.244		
Pair D						
Contrarian(35,5)	2,470,113	1,688,906	952,944	3,007,577		
Lifecycle (35,5)	2,188,141	1,546,508	915,945	2,677,686	11.8	35.8
Ratio: Contr / LC	1.129	1.092	1.040	1.123		
Pair E						
Contrarian(Realistic)	1,956,692	1,485,675	903,228	2,440,347		
Lifecycle (Realistic)	1,735,684	1,374,114	898,341	2,142,498	22.6	36.0
Ratio: Contr / LC	1.127	1.081	1.005	1.139		

EXHIBIT 3
Differences in Portfolio Values at Retirement in Nominal Dollars (1000s)

		Difference (Larger value - Smaller value)				
Strategy and Subsample	Proportion of Cases	Mean	Median	25th Percentile	75th Percentile	Maximum
Pair A (20,20)						
$LC_{CDF} > C_{CDF}$	14.2%	$61.1	$57.8	$30.2	$91.2	$156.5
$LC_{CDF} < C_{CDF}$	85.8%	$698.4	$426.6	$169.3	$894.1	$9,430.7
LC>C	32.4%	$368.4	$237.7	$108.3	$472.3	$7,170.5
LC<C	67.6%	$1,050.2	$626.6	$262.3	$1,354.5	$13,790.5
Pair B (25,15)						
$LC_{CDF} > C_{CDF}$	12.9%	$53.1	$53.2	$25.7	$76.8	$137.7
$LC_{CDF} < C_{CDF}$	87.1%	$645.6	$376.4	$140.7	$813.6	$14,025.7
LC>C	32.8%	$366.2	$224.6	$102.9	$456.2	$8,188.7
LC<C	67.2%	$1,005.4	$578.2	$236.1	$1,259.8	$16,123.4
Pair C (30,10)						
$LC_{CDF} > C_{CDF}$	12.7%	$38.0	$37.9	$18.5	$56.2	$116.9
$LC_{CDF} < C_{CDF}$	87.3%	$529.7	$299.8	$101.0	$642.0	$15,911.0
LC>C	34.5%	$344.5	$201.0	$88.9	$424.0	$7,748.3
LC<C	65.5%	$880.8	$504.5	$203.7	$1,083.1	$15,911.0
Pair D (35,5)						
$LC_{CDF} > C_{CDF}$	11.8%	$19.1	$17.0	$9.6	$24.2	$53.2
$LC_{CDF} < C_{CDF}$	88.2%	$322.1	$161.6	$63.4	$379.8	$17,848.2
LC>C	35.8%	$302.5	$169.4	$75.0	$364.0	$6,395.8
LC<C	64.2%	$608.2	$333.0	$134.1	$746.7	$17,848.2
Pair E (Realistic)						
$LC_{CDF} > C_{CDF}$	22.6%	$33.9	$34.6	$16.7	$49.8	$75.5
$LC_{CDF} < C_{CDF}$	77.4%	$295.5	$173.8	$68.4	$398.8	$4,509.6
LC>C	36.0%	$152.2	$97.9	$46.5	$189.3	$3,713.3
LC<C	64.0%	$430.6	$249.2	$99.7	$544.7	$5,878.5

EXHIBIT 4
Adverse Outcomes with the Realistic Approach
Comparing Wealth Accumulations When at Least One Strategy Provides Under $1 Million



Note: $1 million represents 8.33 times final salary

EXHIBIT 5
Portfolio Values at Retirement (1000s)

		(20,20) Approach			(35,5) Approach			Realistic Approach		
		Median	LC_{CDF}> C_{CDF}	P(LC>C)	Median	LC_{CDF}> C_{CDF}	P(LC>C)	Median	LC_{CDF}> C_{CDF}	P(LC>C)
Australia	LC	1,535	6.69	26.87	2,242	4.69	30.71	1,897	13.4	30.65
	C	2,035			2,473			2,082		
Belgium	LC	832	35.13	43.98	933	32.42	44.64	911	42.42	46.35
	C	903			951			922		
Canada	LC	1,049	15.53	33.4	1,352	13.78	37.22	1,216	27.97	36.96
	C	1,287			1,439			1,297		
Denmark	LC	1,130	34.76	44.99	1,258	41.06	44.77	1,229	43.92	47.03
	C	1,206			1,284			1,249		
France	LC	1,488	20.93	37.47	1,976	19.78	40.59	1,878	34.45	42.35
	C	1,829			2,133			1,960		
Germany	LC	6,723	28.32	45.72	9,055	32.35	45.16	7,640	34.64	47.78
	C	8,345			9,914			8,265		
Ireland	LC	970	30.88	40.26	1,136	32.56	41.32	1,080	38.61	42.62
	C	1,092			1,172			1,120		
Italy	LC	1,499	27.16	41.09	1,938	22.99	43.07	1,856	37.74	46.21
	C	1,777			2,038			1,905		
Japan	LC	1,684	21.03	38.79	2,274	22.11	43.35	2,087	32.16	43.14
	C	2,060			2,403			2,186		
The Netherlands	LC	803	26.4	38.14	988	26.52	39.7	928	33.09	41.33
	C	949			1,039			974		
Norway	LC	895	41.3	46.14	985	38.9	46.63	986	47.73	49.37
	C	957			1,010			993		
South Africa	LC	2,000	10.15	32.31	2,850	7.23	36.45	2,411	16.41	35.12
	C	2,559			3,075			2,621		
Spain	LC	1,367	32.78	43.17	1,588	33.32	43.86	1,551	38.76	46.67
	C	1,532			1,664			1,587		
Sweden	LC	1,622	19.45	36.1	2,187	16.78	38.32	1,960	29.79	39.83
	C	2,012			2,351			2,069		
Switzerland	LC	660	30.92	41.13	756	32.99	42.71	749	41.22	45.96
	C	740			786			764		
United Kingdom	LC	1,092	18.15	34.24	1,380	16.02	35.28	1,244	24.84	35.76
	C	1,317			1,472			1,318		
United States	LC	1,060	19.05	34.77	1,381	21.04	37.54	1,269	26.44	39.03
	C	1,301			1,482			1,340		

Exhibit 6
Minimum Risk Aversion Needed for Lifecycle Strategy to Provide Larger Expected Utility

	(20,20) Approach	(25,15) Approach	(30,10) Approach	(35,5) Approach	Realistic Approach
Australia	3.3	3.23	3.19	3.04	2.62
Belgium	1.41	1.38	1.37	1.35	1.16
Canada	2.66	2.57	2.5	2.39	2.09
Denmark	1.49	1.45	1.43	1.39	1.18
France	2.03	1.99	1.94	1.88	1.45
Germany	1.22	1.18	1.15	1.09	1.08
Ireland	1.5	1.46	1.42	1.34	1.25
Italy	1.57	1.55	1.55	1.52	1.16
Japan	1.86	1.81	1.75	1.64	1.41
The Netherlands	1.93	1.88	1.83	1.76	1.5
Norway	1.24	1.22	1.21	1.19	0.97
South Africa	2.76	2.69	2.65	2.63	2.21
Spain	1.59	1.56	1.55	1.54	1.21
Sweden	2.1	2.06	2.03	1.99	1.66
Switzerland	1.8	1.76	1.72	1.68	1.27
United Kingdom	2.3	2.24	2.2	2.15	2.01
United States	2.23	2.17	2.12	2.05	1.69