Modeling the Impact of Inflation on Retirement Savings Portfolios

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Executive Summary

Background: In the wake of COVID-19 in March of 2020, governments across the world shut down large segments of their economies, stressing global supply chains and causing a shortage of key goods. Following 'reopening' in 2021, pent up consumer demand in the U.S., coupled with a relative scarcity of goods, caused a surge in prices that continued into 2022 and have remained so as of this writing. However, far from being an anomaly in American history, there have been seven periods where inflation, as measured by the consumer price index (CPI), surpassed 5%.

While Americans can generally rely on Social Security income in retirement, and some can even count on a defined benefit pension plan, most private sector employers in the U.S. have moved away from defined benefit plans toward defined contribution plans like a 401(k). This shift has put the onus on individual investors to choose asset allocations that allow them to accumulate money while saving for retirement, and also minimizing the chance of outliving their savings in retirement.

Purpose: The primary purpose of this paper is to demonstrate, through a basic stochastic projection model, how inflation might impact savings and investing for retirement. We do this through inputting into the model a sample of representative scenarios and observing how inflation interacts with the other factors that drive the accumulation of funds in selected portfolios. As described in the disclaimer, the objective is not to gauge what the most advantageous investment strategies are. Rather, it is to illustrate how inflation acts as a component in the results of these strategies.

A motivating factor for undertaking this research is the fact that Americans can almost certainly count on periodic episodes of high inflation and must, therefore, prepare to save and invest through periods of high, moderate, and low inflation. This paper first begins with a summary of current research on the impact of inflation on retirement, including a discussion of previous periods of elevated inflation, investment vehicles that were popular at the time, the performance of different asset classes during past periods of inflation (bonds, TIPS, Real Estate, equities), and the differential impact of inflation on retirement preparedness across income groups.

Model: Following this discussion, we introduce the basic stochastic projection model noted above to compare how well different portfolios perform at accumulating and decumulating retirement assets under various inflationary conditions. While different asset classes tend to have different expected returns and variances, they also perform differently depending on inflation levels, with equities for example, historically on average (although conditions can change), showing lower expected real returns when inflation is high than when it is low. This projection model can help to demonstrate to what extent using instruments like Treasury Inflation Protected Securities (TIPS) or real estate might hedge against high inflation at an acceptable cost to expected returns or volatility. We also examine when the sample results of the model show that there may be different results using an aggressive portfolio strategy like equities to pursue higher expected returns or fixed interest investment types to limit volatility.

After describing the model and its assumptions, we use it to demonstrate the expected performance of a sample of six asset strategies while accumulating assets prior to retirement, and while decumulating assets during retirement. We consider conditions of constant low inflation, as well as spikes of high inflation, both before and after

retirement. Finally, we discuss the sample results and the implications of various portfolio strategies that might minimize the risk of outliving wealth in retirement.

Sample Results: During the accumulation phase, for the sample scenarios we ran, assets designed to mitigate periods of high inflation, such as TIPS, tended to cause a portfolio to underperform in the long-run because of their lower expected returns during years when inflation is low. In contrast, while equities under these assumptions did not act as an inflation hedge in the short-run, over long periods of time their higher expected returns made up for short-term underperformance during periods of high inflation. However, after retirement, aggressive portfolios may be subject to a higher chance of running out of money because the increased volatility leads to a higher dispersion of results. During the decumulation phase when low variance matters more than high returns, more conservative assets, such as bonds and TIPS, may help protect against a catastrophic downside as well as inflation.

Using our sample assumptions, the results of our model that were using an aggressive, equity-based portfolio prior to retirement, and then switching to a more conservative allocation immediately after retirement, gave the greatest probability of remaining solvent in retirement compared to other sample strategies examined. Specifically, we observed that, for our selected target date fund assumptions, the funds began transitioning toward conservative allocations too soon in advance of retirement. This caused the fund to accumulate less money by retirement age, leading to a higher likelihood of running out of money in retirement when compared to other sample strategies that remained aggressive longer. This suggests that switching from an aggressive to a conservative portfolio right at retirement, or deliberately selecting target date funds with later dates, could provide the best compromise between wealth accumulation prior to retirement and volatility minimization after retirement under the assumptions in this model.

Context and Disclaimer:

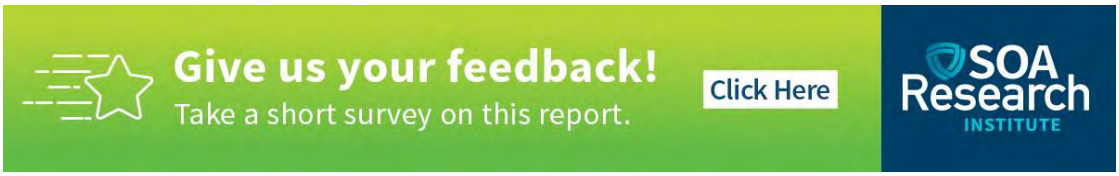
This model and the results included in this paper are neither intended, nor should be used, for an individual's personal financial planning.

This model was developed under a set of simplifying and specific assumptions and is intended for educational purposes only. Rather than being chosen to represent plausible investment portfolios, the allocations shown were instead chosen, for demonstration purposes only, to highlight the differences between the performance of various asset classes and should not be taken as recommended portfolios. For example, while a portfolio of 40% equities, 30% bonds and 30% TIPS makes a good comparison against a portfolio of 40% equities and 60% bonds because the two portfolios only differ by a 30% allocation to TIPS versus bonds, this comparison does not imply that either allocation is optimal or even appropriate for any given investor.

The key value of our model is to demonstrate the dispersion of results that come from selecting and maintaining a particular strategy. However, the projected dispersion of possible results at age 40 is not a guarantee of future returns, or a guarantee that the median projected result will come to pass. It is important to note that a projection made at age 40 may no longer be particularly useful at age 45 since, at age 45, there will be a discreet amount in the investment account, not a dispersion of probabilities. As such, if someone has much more or less in their account at age 45 than the projection expected at age 40, continued adherence to the investment plan decided at age 40 may not make sense. Given the stochastic nature of the model, it is intended for considering the possible future results of implementing portfolio strategies at two separate choice-points: early in saving for retirement and immediately after retiring.

Given its focus on the possible results of pursuing a particular strategy as of age 40, the model we use assumes that investors hold particular portfolios irrespective of market fluctuations, and it, therefore, makes no provision for panic selling or for any investing behavior apart from rigid adherence to a plan. Otherwise, sound strategies might

backfire if, for example, an investor sells after a downturn. Our model assumptions in no way take behavioral finance or the emotional difficulty of implementing particular strategies into account.



Abbreviations and Definitions

In this section, we provide a concise compilation of abbreviations used throughout the report to enhance clarity and streamline communication:

- Central Limit Theorem: The Central Limit Theorem states that the distribution of the sum (or average) of a large number of independent, identically distributed random variables approaches a normal distribution, regardless of the original distribution of the variables. For retirement savings, if we consider the annual returns over many years as independent and identically distributed as our model assumes, the Central Limit Theorem suggests that the distribution of the total portfolio value or average annual return will tend to follow a normal distribution as the number of years increases.

- CPI: The Consumer Price Index is a widely used economic indicator that measures the average change over time in the prices paid by urban consumers for a market basket of consumer goods and services. The Consumer Price Index is often used to gauge inflation or deflation in an economy, providing insight into the cost of living and the purchasing power of a currency. Since the prices of goods do not all fluctuate in tandem, there are different measures of inflation that weigh goods differently. In our model, we use a measure of annual inflation derived from an NYU dataset (Stern School of Business, 2023).

- Law of Large Numbers: The law of large numbers is a fundamental concept in probability and statistics, and it states that as the number of observations or samples in a random experiment increases, the sample mean (average) of the observations converges to the true expected value of the random variable. In simpler terms, as you collect more data, the average of that data becomes more representative of the population or true underlying probability distribution. In the context of retirement savings, this implies that, as the number of years increases, the average annual return on an investment portfolio is likely to approach the expected (average) annual return.

- PPI: The Producer Price Index is an economic indicator that measures the average change over time in the selling prices received by domestic producers for their goods and services. Unlike the Consumer Price Index (CPI), which focuses on prices paid by consumers, the PPI looks at the perspective of producers.

- REIT: Real Estate Investment Trusts are a type of investment vehicle that allow individuals to invest in income-generating real estate properties without having to directly own or manage them. REITs are companies that own, operate, or finance income-producing real estate in various sectors, such as residential, commercial, retail, or industrial.

- TIPS: Treasury Inflation-Protected Securities are a type of U.S. Treasury security designed to protect investors from inflation. These securities are issued by the U.S. Department of the Treasury and are a form of inflation-indexed bonds.

Section 1: Background

Inflation is a pervasive economic phenomenon that affects individuals, businesses, and governments alike. For retirees, the impact of inflation on their portfolios is a critical consideration, as it can erode the purchasing power of their savings over time. Inflation refers to the general increase in the price level of goods and services over time. It is measured by the Consumer Price Index (CPI) or the Producer Price Index (PPI), among other indicators. While moderate inflation is a natural part of a healthy economy, excessive inflation can have a significant negative impact on savers and investors, particularly those relying on fixed-income assets.

1.1 HISTORICAL BACKGROUND - INFLATION

There have been seven periods since World War II where the consumer price index (CPI) surpassed 5%: 1946–48, 1950–51, 1969–71, 1973–82, 1989-91, 2008, and 2021-2022. During the first episode from 1946–48, inflation was primarily caused by the elimination of price controls, supply shortages, and pent-up demand according to researchers at the White House (Rouse et al, 2021). The second episode, during the Korean war, was caused by a jump in demand as households all rushed to purchase goods in anticipation of rationing and supply shortages similar to those in World War II. Inflation during 1969-1971 was caused by a boom in economic growth in the preceding four years, as real GDP growth averaged 4.8% per year during that time. Inflation during the 1970s was caused by two surges in oil prices and was combatted by the Fed Chair, Paul Volcker, dramatically increasing interest rates. The sixth inflationary episode in 2008 was caused by another oil shock due to the First Gulf War and the CPI rose above 5% for just two months, which was primarily due to increased oil prices (Rouse et al, 2021).

In contrast to the last three periods of high inflation in the U.S., which were mainly due to increases in the price of oil, the inflationary event from 2021 to 2023 was caused, in part, by disruptions to the supply chain, in conjunction with increased consumer spending on items as opposed to services, just as supply was contracting (Rouse, 2021) (Paul, 2023).

Some causes of the current period of inflation are similar to the years following WWII, which were disruptions to the supply chain and pent-up demand. Although there are disagreements on all the causes of this inflationary period, economists also point to COVID-19 driving consumers to purchase products, rather than services, and the impact of various relief funds.

1.2 EVOLUTION OF RETIREMENT INVESTMENT VEHICLES

Employer-provided pension plans have been in existence since the 1870's with the first plans offered by the railroad, banking, and public utilities industries. These plans were early versions of defined benefit plans that evolved and grew in popularity into the 1980's. Since then, there has been a shift to defined contribution plans (Seburn, 1991).

From 1980 through 2008, the proportion of private wage and salary workers participating in defined benefit pension plans fell from 38% to 20%. In contrast, from 1980 through 2008, the percentage of private wage and salary workers covered by a defined contribution pension plan increased from 8% to 31% (Butrica, 2009). By 2022, approximately 11% of private industry workers were participating in a defined benefit plan and 48% in a defined contribution plan (Zook, 2023).

Assets held in retirement portfolios have also evolved over time. In the 1950's – 1960's, there was an increased popularity in portfolio-based retirement with the common investment strategy to buy bonds and spend the interest. Inflation in the 1970's eroded the purchasing power of bond interest. This led to a shift in the 1980's of investing in high quality dividend paying stock with the increases in dividends keeping pace with inflation. Investors started to realize that there was too much focus on dividends and not enough on capital gains, which led to a shift in the 1990's of a 'total return' approach, which incorporates interest, dividends, and capital gains (Kitces, 2017).

In 1960, Congress enacted legislation authorizing Real Estate Investment Trusts (REITs), which enabled individual investors to invest in high-quality commercial real estate. In 1986, REITs were given the ability to operate and manage real estate, rather than simply owning or financing it. Over time, REITs have continued to evolve from community shopping malls and railroad real estate to including more types of assets, such as single family rental homes, pipelines, electric transmission lines, and post offices. Currently, approximately 50% of American households own REITs, either directly or indirectly, through mutual funds, exchange traded funds, or target date funds. The availability of REITs has also spread to almost 40 countries (NAREIT, 2023).

The late 1990's saw the emergence of Treasury Inflation-Protected Securities (TIPS) and Target Date Funds (TreasuryDirect). TIPS are bonds with a maturity of 5, 10, or 30 years, a fixed interest rate, and a principal amount that varies with inflation – principal increases with inflation and decreases with deflation. Upon maturity, the investor receives the greater of the original principal or the increased inflation-adjusted price (TreasuryDirect). TIPS holdings have increased since the early 2000's (Treasury.gov).

Target date funds were developed to appeal to individual investors who typically invest in mutual funds. Traditional mutual funds have a set guideline for investment choices based on the fund type, whereas target date funds encompass multiple asset types and the allocation between stocks and bonds becomes more conservative as retirement age approaches. Target date funds have seen fast growth since 2008 due to the Pension Protection Act passed in 2006, creating the need for safe-harbor type Qualified Default Investment Alternatives, which allow for auto-enrollment into target date funds in defined contribution plans (Cross, 2018). In 2008, there was less than $200 billion in assets and, in 2022, target date funds were valued at $2.82 trillion (PR Newswire, 2023).

1.3 ASSET CLASS PERFORMANCE

Protecting wealth from the eroding effects of inflation is a paramount concern for investors. Equities (stocks), TIPS, real estate, and bonds serve as potential hedges against inflation. Each asset class possesses unique characteristics that contribute to its ability to safeguard purchasing power in the face of rising prices.

Equities (Stocks):

Equities, or stocks, are considered one of the most effective long-term inflation hedges. The underlying companies often have the ability to increase prices for their goods and services, thereby maintaining revenue streams that can outpace inflation. Additionally, companies may possess the flexibility to adjust their operations in response to changing economic conditions. While equities can be volatile in the short term, historically, they have demonstrated the potential to provide investors with real returns that exceed inflation rates over extended periods. Since its inception in 1957, the S&P 500 has gained approximately 10.7% annually and has earned approximately 12.4% in the past 10 years (Knueven, 2023). Although the high expected returns of equities, in the long-term, can outpace inflation and individual companies may be able to raise prices to maintain favorable financial results, equities may not prove to be a short-term hedge against inflation because equity returns have often been negatively correlated with inflation.

TIPS (Treasury Inflation-Protected Securities):

TIPS are explicitly designed to protect investors from inflation. The principal value of TIPS adjusts with changes in the Consumer Price Index (CPI), ensuring that investors receive returns that reflect the real rate of inflation. The interest payments on TIPS also increase with inflation, offering a dual layer of protection. This makes TIPS an attractive option for investors seeking a fixed-income instrument that adjusts with the changing economic landscape, providing a reliable defense against the erosive impact of inflation. The attractiveness of TIPS as an investment depends on how users evaluate and view the trade-off of inflation protection against potentially lower returns. Since their inception in the 1990's, TIPS have earned an average annual return of 4.0%. TIPS perform best when inflation rises and underperform other options when inflation decreases (Forbes, 2022).

Real Estate:

Real estate, particularly tangible assets like residential and commercial properties, has historically demonstrated a degree of resilience against inflation. Property values and rental income often have the potential to increase in response to rising prices. Real estate investments can act as a hedge, as they are tied to physical assets that possess intrinsic value. However, the effectiveness of real estate as an inflation hedge can vary based on factors such as location, property type, and overall economic conditions. Historically, REIT's have outperformed the broader stock market during periods of moderate and high inflation. In 2021, with inflation at 7% as measured by the CPI, REITs outperformed the S&P by 12.6% (Funari, 2022).

Bonds:

Bonds are issued by corporations, municipal governments, and the federal government. Bonds are considered a fixed-income security and typically have a defined maturity date and interest rate. Bonds generally do not provide a hedge against inflation. An exception would be if someone intentionally employed a strategy of purchasing short-term bonds with the expectation that interest rates would increase in response to inflation, thereby increasing the yield of the bonds.

1.4 IMPACT OF INFLATION ON VARIOUS DEMOGRAPHIC GROUPS

The impact of inflation affects people's retirement differently, depending on demographic characteristics such as income level, age, and how people spend their money.

Typically, retirees spend less money on food, transportation, clothing and entertainment, but more on healthcare, charitable contributions and services than during pre-retirement, particularly at younger ages. Food, energy and transportation are significant drivers of inflation, so increased costs in these areas may affect retirees less than those still in the work force (Carosa, 2022). The increasing housing costs of both homeowners and renters during inflationary periods can have a significant impact on the amount of income available to cover all expenses. For retirees on a fixed income, increasing expenses may force them to either cut spending or sell assets (Carosa, 2022).

For those on a fixed income, inflation is particularly impactful. Without a cost-of-living adjustment that keeps up with inflation, multiple years of inflation can drastically reduce the purchasing power of retirees. If inflation averaged 2.5%, then someone who needs $50,000 per year to live would need about $80,000 in 20 years' time.

Section 2: Model and Assumptions

In this section, we describe the stochastic retirement finance model that we developed to test the effects of inflation on different asset allocations. We also list the assumptions used in the model along with justifications for the assumption values we chose.

Our hypothetical examples of investment portfolios and analysis focus on the sector of the population who are able to save for retirement, although we recognize there is a percentage of the population who rely completely on Social Security and do not have the resources available to save and invest retirement funds. We are assuming that, prior to retirement, the cohort that we are modeling is continuously employed with wages adjusted for inflation, investing in a 401(k) plan with investment options, and is receiving a company match of contributions.

Also, for the purposes of focusing the modeling on the impact of inflation on portfolios, we do not take into account non-liquid assets such as home ownership, although recognize this may be the largest asset for many retirees. In addition, we realize that a segment of the retired population rents and, therefore, does not have the option of using equity in their home to cover expenses or invest. We also do not take into account rental income or other types of individual investments in real estate.

During retirement, there are required minimum distributions from retirement plans. In the interest of simplicity and, due to our focus on inflation's effect on various asset portfolios, this model assumes a fixed percentage withdrawal from the retirement portfolio. While accumulations are typically pre-tax and distributions are typically taxable, the tax implications are not included in this model or analysis.

2.1 DESCRIPTION OF MODEL

Our stochastic retirement finance model uses assumptions about salary, savings rate, annual raises, Social Security income, post-retirement expenses, and inflation, and uses them to generate a series of expected annual cash flows into or out of a retirement investment portfolio. Details about each of the assumptions is given in subsection 2.2. Then, given assumptions about portfolio allocation and the inflation rate, the model generates 1,000 Monte Carlo simulations of how a given portfolio will perform in accumulating assets before retirement, as well as decumulating assets after retirement, and graphs the 20th percentile, median and 80th percentile simulation in each year to show the dispersion of possible results of the retirement plan and portfolio allocation implicit in the assumptions.

Monte Carlo simulation is a mathematical technique used to model the probability of different outcomes in a process that cannot easily be predicted due to the intervention of random variables. It is used to understand the impact of risk and uncertainty in prediction and forecasting models. It relies on the quality of the input data and the assumptions used in the model.

The Monte Carlo simulations assume that future returns are normally distributed, and the distribution is characterized by an expected return and variance that is derived from historical data about the performance of each asset class during previous periods of high, medium, and low inflation, as well as the historical covariances among asset classes.

All 1,000 of the Monte Carlo simulations begin in year 0 with the same value based on the assumed starting savings. Then, in the years prior to retirement, each simulation is increased by the product of the assumed savings rate and the participant's salary in that year. That result is then multiplied by a randomly generated asset return value based on a normal distribution of possible returns that is dictated by the asset allocation in that year, along with the inflation rate, as we assume that each asset class has different average returns based on the inflation rate, as laid out in subsection 2.2.3.

For example:

1. Simulation 1 below begins with $32,000 at year 0.
2. Then, at year 1, simulation 1 deposits $5,715 (9% savings rate times a salary of $63,500) to reach the value of $37,715.
3. Next, the model assigns an asset return to simulation 1 using the following two-step process:
    a. First, the model assumes a normal distribution of possible annual returns characterized by a mean expected return and standard deviation that it generates based on the inflation rate and asset allocation in that year. In this case, with a 2% inflation rate and an asset allocation of 80% stocks and 20% bonds, the expected return is 10.19% and the standard deviation is 15.67%.
    b. Second, the model randomly generates a number between 0 and 1, in this case 0.2746, which is used to select the 27.46th percentile value of that normal distribution, which is 0.803%. This value is then used as the annual return for simulation 1 in year 1.
4. After generating the annual return, the value for simulation 1 is increased by that amount (0.803%), taking it from $37,715 to $38,018.
5. The following year, simulation 1 is credited with $5,801 ($5,715 adjusted for the assumed annual 1.5% raise), and a new return is chosen based on a new random number, but using the same normal distribution because the inflation rate and asset allocation remain the same.

Figure 1

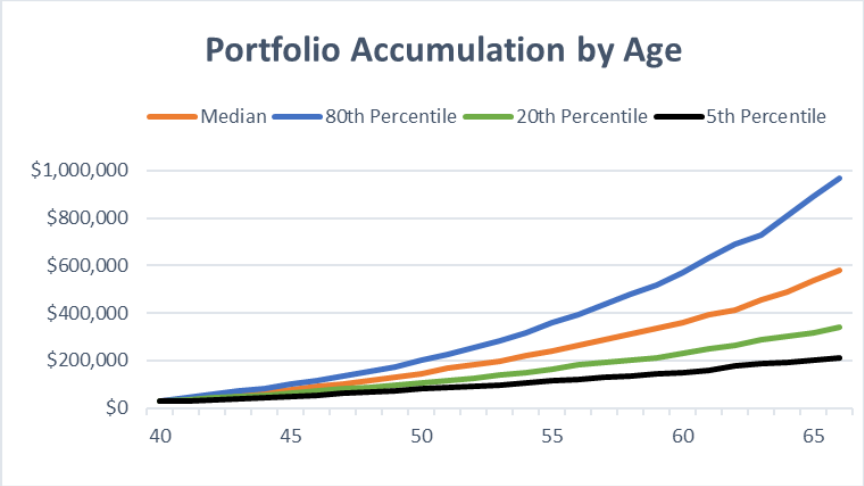
SAMPLE OF THE MODEL AND SEVERAL SIMULATIONS

Time		0	1	2	3	4	5	6	7	8
Age		40	41	42	43	44	45	46	47	48
Year		2023	2024	2025	2026	2027	2028	2029	2030	2031
Cash Flow into Portfolio		$5,715	$5,801	$5,888	$5,976	$6,066	$6,157	$6,249	$6,343	$6,438
Stocks		80%	80%	80%	80%	80%	80%	80%	80%	80%
Bonds		20%	20%	20%	20%	20%	20%	20%	20%	20%
Real Estate		0%	0%	0%	0%	0%	0%	0%	0%	0%
TIPS		0%	0%	0%	0%	0%	0%	0%	0%	0%
Inflation Rate		2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%	2.0%
Expected Return		10.19%	10.19%	10.19%	10.19%	10.19%	10.19%	10.19%	10.19%	10.19%
Standard Deviation		15.67%	15.67%	15.67%	15.67%	15.67%	15.67%	15.67%	15.67%	15.67%
Mean		$32,000	$40,818	$50,312	$60,292	$71,209	$83,007	$95,732	$109,239	$124,399
Median		$32,000	$40,442	$49,800	$59,102	$69,659	$81,405	$91,849	$104,991	$118,014
0.95		$32,000	$50,372	$67,073	$85,251	$104,629	$125,204	$151,196	$171,211	$196,912
0.8		$32,000	$45,630	$58,329	$71,091	$84,623	$99,493	$115,573	$135,319	$156,941
0.2		$32,000	$36,245	$42,268	$48,525	$56,073	$63,704	$73,287	$79,944	$89,177
0.05		$32,000	$31,846	$35,410	$39,102	$45,357	$49,630	$56,342	$63,784	$68,664
Simulations:										
	1	$32,000	$38,018	$46,361	$59,066	$65,519	$76,489	$110,650	$119,576	$147,319
	2	$32,000	$37,141	$39,689	$46,395	$54,559	$56,343	$54,785	$58,782	$76,029
	3	$32,000	$44,788	$66,674	$73,928	$92,552	$97,289	$92,859	$119,045	$141,976
	4	$32,000	$49,005	$61,543	$64,781	$73,669	$91,289	$98,994	$99,234	$100,187
	5	$32,000	$41,897	$44,346	$59,930	$84,101	$86,424	$81,503	$104,253	$102,287
	6	$32,000	$46,034	$49,015	$51,077	$78,483	$80,651	$70,339	$89,832	$123,079
	7	$32,000	$43,931	$50,444	$47,901	$87,254	$91,897	$110,986	$121,624	$194,787
	8	$32,000	$46,796	$63,618	$62,813	$89,734	$100,674	$129,270	$145,610	$191,015
	9	$32,000	$42,050	$55,273	$70,881	$80,723	$83,337	$100,333	$111,144	$146,874
	10	$32,000	$40,257	$60,286	$74,086	$110,351	$109,156	$121,546	$143,188	$200,815
	11	$32,000	$37,787	$50,545	$65,807	$64,254	$76,579	$81,842	$96,813	$106,212
	12	$32,000	$34,890	$49,905	$57,036	$84,934	$107,913	$122,546	$142,314	$191,319

Because each simulation results from a different set of randomly generated returns, the accumulated values of the simulations diverge over time. For each year, the model also takes the mean, median, 5th percentile, 20th percentile, 80th percentile and 95th percentile values from each year. It is important to emphasize that the 80th percentile simulation in year 4 may not be the same as the 80th percentile simulation in year 5 or 6. Rather, the 80th percentile value in each year indicates that 80% of the simulated values are below that amount. Interpreting the output above, we might say that, as of age 40, this model predicts that there is a 50/50 chance of having less than $104,991 by age

47, or that, by age 48, there is a 90% chance of having between $68,664 and $196,912. By plotting these percentiles as a graph, we can get a sense of the dispersion of possible account amounts starting at age 40 up until retirement.

Figure 2
EXAMPLE OF MODEL OUTPUT, SHOWING THE DISPERSION OF ACCUMULATED AMOUNTS



Beginning in retirement, the model stops crediting each simulation with part of the participant's salary and, instead, credits it based on Social Security income, which increases each year according to a cost-of-living adjustment (COLA). The model also begins withdrawing money each year based on a retirement expense assumption, and the amount withdrawn increases each year according to inflation. As a result, the simulations tend to decrease after retirement, or to 'decumulate,' as annual expenses outweigh annual investment returns and Social Security income.

Figure 3
SAMPLE OF MODEL FOLLOWING RETIREMENT AGE

Time to Retirement	0	-1	-2	-3	-4
Time	26	27	28	29	30
Age	66	67	68	69	70
Year	2049	2050	2051	2052	2053
Cash Flow into Portfolio	$0	$0	$0	$0	$0
Cash Out of Portfolio	$87,018	$88,758	$90,533	$92,344	$94,191
Social Security Income	$55,089	$55,916	$56,754	$57,606	$58,470

To chart the decumulation of retirement assets, the model continues where the accumulation graph leaves off, with each of the 1,000 simulations beginning with different amounts based on their dispersion from age 40 to retirement as shown in the Accumulation and Decumulation graph below. However, at the time of retirement, someone might want to change their portfolio allocation and, at that point, they will have a definite amount saved up, not a dispersion of possible results. Therefore, the model can also begin with all 1,000 simulations having the same value (in this case the median accumulated value at age 66) and focus specifically on portfolio performance after retirement, as shown below in the Portfolio Decumulation by Age graph. Note that because the Accumulation and Decumulation graph starts retirement with a dispersion of fund amounts, while the Decumulation by Age graph begins with a single value, the former shows a greater dispersion in outcomes overall. It is best to think of the Accumulation and Decumulation graph as a tool for planning the dispersion of possible results beginning at age 40, while the Decumulation by Age graph shows the dispersion of possible results given a definite starting point at age 66.

Figure 4
OUTPUTS OF MODEL BEGINNING AT AGE 40 AND AT AGE 66 (RETIREMENT AGE)

Because the model relies on a number of assumptions, it can isolate the effect of any particular change in a retirement plan under various inflationary conditions from increasing or decreasing savings rate to altering portfolio allocation.

2.2 DESCRIPTION OF ASSUMPTIONS

2.2.1 DEMOGRAPHIC

- **Starting Age:** Individuals can begin saving for retirement as early as they like. However, to be conservative in our estimates, and to avoid an overly long projection period, our model begins at age 40.

- **Retirement Age:** We assume that our participant will retire at age 66, although we tested alternative scenarios with retirement ages of 62 and 70. To receive full Social Security benefits, a U.S. taxpayer must retire at their Full Retirement Age, which differs depending on birth year. For those born between 1943 and 1954, their Full Retirement Age is 66, but this age increases in two-month increments per year until the Full Retirement Age is 67 for those born in 1960 and later. We chose a retirement age assumption that accords with the Full Retirement Age for retirees as of the time of writing this paper. We also assume that our participant begins receiving Social Security benefits upon retirement.

2.2.2 ECONOMIC

- **Income Before Retirement:** We assume that our participant earns a salary of $63,500 per year beginning at age 40. This assumption is based on median earnings by age in the United States showing that, for those between 35 and 44 years of age, the average salary in the U.S. was $63,596 (Haan, 2023). This same source indicates that, for those aged 45 to 54, the median salary is $64,428 and, for those aged 55 to 64, the average salary is $63,336, indicating a fairly flat median wage from the mid-thirties through the mid-sixties.

- **Savings Rate:** We assume that, from age 40 until retirement, our participant will save 9% of their salary in a retirement fund, and we tested alternate scenarios with a 3% savings rate and a 15% rate. In the United States, 56% of employers offer a 401(k) plan for their employees. Of the employers who offer a 401(k) plan, 86% offer to match employee contributions, with the most common matching arrangement being a 50% match for up to 6% of the employee's salary (Benz, 2020). Therefore, our 9% assumption is based on an

employee taking advantage of the most common 401(k) match arrangement by making the minimum contribution necessary to receive the full match by contributing 6% of their salary to their 401(k), while receiving an additional 3% from their employer.

- Starting Savings: We assume that our participant has just over half their annual salary, or $32,000, saved by age 40. This assumption is difficult to set because of the heavy right-skew of savings amounts in the U.S. For example, a dataset collected from 2019 and 2020 shows that, while the average retirement savings for someone aged between 40 and 44 years was $101,899, the median saved was just $6,950, while the amount saved in the top percentile was $1,097,000 (PK). The average savings is skewed up by considering the high savings amounts of a small number of Americans, while the median is skewed downward by the 22%-25% of Americans aged 30-44 who have no retirement savings at all (Statista).
  According to a report by U.S. News, the financial firm, Fidelity, recommends that by age 30, someone should aim to have 1x their annual salary saved for retirement, and 3x their annual salary by age 40. Financial planners at Rowley recommend that someone should aim to save 1x their annual salary saved by age 35. Relative to these suggested goals, our model makes the relatively conservative assumption that our participant will have 0.5x their annual salary saved by age 40 (LaPonsie, 2023).

- Average Raise: We assume that raises are 0.5% per year less than inflation. We chose a value close to inflation based on the previously mentioned fact that the median salary in the U.S. remains stable within 2% from age 45 through 64 (Haan, 2023). This simplifying assumption also weights earlier contributions more heavily within the model, lending more weight to differences in asset returns across portfolios. This helps to accentuate differences in portfolio performance for easier analysis.

- Social Security Income: We assume that, upon retirement, our participant will begin receiving an income from Social Security equal to 40% of their final salary before retirement, taking into account all the annual raises between age 40 and retirement. We based this assumption on the average replacement rate for Social Security, which is 40% (Holmes, 2023). A 2022 analysis by Social Security actuaries also showed a similar replacement of 40.7% to be typical for medium average earning individuals, or those with annual incomes of $60,024 per year (Clingman et al, 2022).

- Cost of Living Adjustment (COLA): Similar to the average raise, we assume that the Social Security COLA is 0.5% per year less than the inflation rate in that year. While Social Security's COLA is meant to adjust for inflation, from 1975 through 2022, the geometric mean annual COLA for Social Security has been about 3.41% (SSA, 2023) while, over that same time period, the geometric mean of annual inflation has been about 3.70% per year (Stern School of Business NYU, 2023), or about 0.29% per year higher than the COLA. Similarly, a new analysis found that, from 2000 to 2022, Social Security benefits had lost 36% of their buying power (Luhby, 2023). In order to account for these effects, and to place an increasing emphasis on the performance of the retirement portfolio for modeling purposes, we assumed a COLA that was 0.5% less than inflation each year. Also, the COLA adjustment, for simplification purposes, is not broken out between Medicare and Non-Medicare expenses.

- Inflation Rate: Our base assumption is a 2% inflation rate, with variations including a spike to 8% annual inflation for the five years before retirement, a spike to 8% for the five years following retirement, and a spike to 8% for between ages 50 and 55.

- Expenses After Retirement: We assume that, in the year our participant retires, they will have annual expenses of $52,000 adjusted for cumulative inflation from age 40 to retirement age, and then each subsequent year these expenses will increase by the inflation rate. Data from the Bureau of Labor Statistics

indicate that, on average, people over the age of 65 had annual expenses of $52,141 in 2021 (Simmons & Chowdhury, 2023).

2.2.3 ASSETS

Our model considers six possible investment categories: stocks, bonds, treasury inflation-protected securities (TIPS), real estate investment trusts (REITs), Target Date funds, and single-premium annuities purchased at the time of retirement. We calculated the expected returns for bonds, stocks and REITs, along with their variances and covariances based on historical data. We then used data from Target Date Fund allocations over time across those asset classes to construct assumptions for the expected return and variance for target date funds over time.

We calculated the expected returns and variance of equities and bonds using a dataset from NYU that catalogues the annual returns of the S&P 500 (including dividends) and 3-month Treasury bills, along with annual inflation rates from 1928 to 2022 (Stern School of Business NYU, 2023). Using this dataset, we sorted the years into three buckets based on their inflation level: years with <2% inflation, years with >5% inflation, and those in between. Within each bucket corresponding to years with high, medium and low inflation, we calculated the average return for 3-month Treasury bills and the S&P 500.

While the NYU dataset contained data on real estate returns, it focused primarily on residential real estate, whereas the REITs that investors can access today tend to focus on commercial real estate. As such, we developed our expectation for REIT returns from a dataset that tracks REIT index returns from 1972 through 2022 (Nareit, data), following a similar procedure of sorting years into high, medium and low inflation to gain an expectation of REIT returns under various inflationary environments, of course understanding that, while this may be a relatively small dataset, it is in the model for demonstration purposes.

Upon further analysis, we found that while equities performed poorly during years with high inflation, they outperformed in subsequent years. However, our method of dividing years into buckets based on inflation did not consider that pattern and might slightly overestimate the negative effects of inflation on equities. However, as we will see in later sections, even given this caveat the model still favors equities.

Developing a return assumption for TIPS is challenging because, similar to REITs, historical data on TIPS is limited due to their recent invention. Moreover, because the market value of TIPS is responsive to fluctuating interest rates and changing expectations of future inflation, people can achieve very different returns to TIPS depending on whether they hold to maturity or sell prior to maturity. For example, suppose someone decides to purchase a long-duration TIPS and, after they purchase it, inflation goes up. Because the Federal Reserve tends to combat high inflation by increasing interest rates, the market price of the TIPS will be affected both by the changed inflation rate and the changed interest rate. To avoid the need to speculate about the extent of the Fed response, which falls outside the scope of this paper, we assume that investors will purchase short-term TIPS and hold them to maturity, and that they will achieve low, positive real returns over time. Within the model, we assume that the return for any TIPS is 0.5% in excess of inflation for that year.

The assumption of short-term bonds and TIPS could be seen as biasing the results of the model toward equities given that short-term bonds are less risky and, therefore, have the lowest returns. However, we found that all the bond ETFs we examined had near zero or even negative annualized returns as of 2022 because the Fed had increased interest rates, causing their long-duration bond holdings to lose value. As our paper deals with inflation, we chose an assumption of short-term bonds held to maturity in order to guarantee a positive return from bonds year-on-year.

Table 1
AVERAGE ANNUAL RETURNS

	Stocks	Bonds	Real Estate
All Years	11.51%	3.32%	11.26%
<2% Inflation	12.25%	1.92%	8.17%
2-5% Inflation	13.78%	3.82%	15.53%
>5% Inflation	5.38%	5.02%	4.44%

We then constructed a variance-covariance matrix (see below). The variances of each asset class are listed on the diagonal and highlighted, while the covariances between different asset classes can be seen off the diagonal. For instance, the covariance between stocks and REITs can be seen by looking at the cell in the Stocks column and the REITs row, or vice versa. The variance and covariance of equities, bonds and TIPS were calculated using the NYU data for 3-month Treasury bills, the S&P 500 and inflation rates from 1928 to 2022, respectively, whereas the variance of REITs and their covariances to the other asset classes were calculated by comparing the NYU data to the Nareit data from 1972 to 2022 (NAREIT, 2023).

Table 2
VARIANCE-COVARIANCE MATRIX

	Stocks	Bonds	Real Estate
Stocks	3.84%	-0.02%	2.11%
Bonds	-0.02%	0.09%	0.22%
REITs	2.11%	0.22%	4.25%

Target date funds change their composition over time relative to a particular anticipated retirement date called the target date, beginning with an aggressive portfolio allocation tilted toward stocks and gradually shifting toward a more conservative stance by deemphasizing equities in favor of bonds and TIPS. Because of this, establishing a static expected return for target date funds based on historical data would neglect their changing composition over time.

Figure 5
THE CHANGING COMPOSITION OF TARGET DATE FUND COMPOSITION RELATIVE TO TARGET RETIREMENT DATE

Target Date	Years to Retirement	Equities	Bonds	Real Estate	TIPS	Cash	Other
2050	27	84.77%	9.60%	3.10%	0.00%	2.47%	0.05%
2045	22	80.23%	14.03%	3.10%	0.00%	2.60%	0.05%
2040	17	73.21%	21.33%	3.10%	0.00%	2.31%	0.05%
2035	12	66.28%	28.22%	3.10%	0.00%	2.36%	0.04%
2030	7	59.14%	35.51%	3.10%	0.00%	2.21%	0.04%
2025	2	50.09%	39.88%	3.11%	4.60%	2.29%	0.04%
2020	-3	37.13%	46.44%	3.11%	11.38%	1.90%	0.03%
2015	-8	25.51%	50.41%	3.76%	16.61%	3.13%	0.58%

To develop our return assumptions for our target date fund, we gathered data on the portfolio allocations of a sampling of target date funds, with target dates ranging from 2015 to 2050, to see the percentage allocated to equities, bonds, REITs and TIPS. From this, we developed an assumption of how target date funds change their allocation as a function of the time until the listed retirement date. Because we already had assumptions about the returns and variances of equities, bonds, REITs and TIPS, we then calculated the expected return and variance of a

target date fund based on the return and variance of a portfolio with a composition that mirrored that of a target date fund allocation at a similar length of time until retirement.

2.2.4 PORTFOLIOS

Using the above assumptions, we tested each of the following investment portfolios:

- Portfolio 1: Provides a point of comparison and has an aggressive allocation of 20% bonds, 80% equities.
- Portfolio 2: Tests how effectively inflation-protected bonds hedge against inflation by altering the portfolio allocation to 30% TIPS, 30% bonds, and 40% equities. Using this method, we can see how well TIPS protect against inflation when it is high and how much they cost when inflation is low.
- Portfolio 3: Tests how effectively bonds on their own protect against inflation by altering the portfolio allocation to 60% bonds, 40% equities.
- Portfolio 4: Tests how effectively REITs protect against inflation by altering the portfolio allocation to 40% REITs, 40% bonds, and 20% equities.
- Portfolio 5: Converts 50% of the portfolio into a 30-year fixed annuity upon retirement. Portfolio 1 will be assumed during the accumulation phase.
- Portfolio 6: Creates a portfolio allocation mirroring sample Target Date Funds, slowly transitioning from an aggressive to a conservative allocation over time.

Section 3: Output and Analysis

In this section, we examine the output of our model under various sets of assumptions to see the effects of inflation on the portfolios laid out in subsection 2.2.4. We first examine the accumulation phase and then the decumulation phase, in turn, to arrive at an optimal overall strategy.

3.1 ACCUMULATION

The task of accumulating retirement assets differs significantly from decumulation because, during the accumulation phase, there is cash flow into savings each year irrespective of asset returns. Because of this, there is less pressure to achieve a positive asset return in any given year as long as the expected returns remain high over time. In more actuarial terms, if someone saves and invests money over the course of several decades, and if the returns in any given year are independent from the returns of other years, then the law of large numbers and the central limit theorem will apply, and the longer the timespan over which a person saves, the more their expected return in each year will matter and the less the variance of their returns will matter.

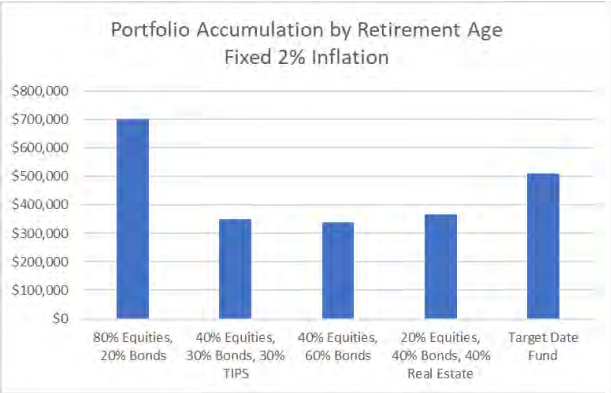
Given the assumptions laid out in subsection 2.2.2 of this report and changing only the portfolio allocation (as shown in the figure below) and the inflation assumption from a fixed 2% inflation per year to a fixed 2% inflation rate with a spike to 8% per year from ages 50 to 55, we observed a difference in the mean accumulated retirement wealth across portfolios, as shown in the figure below. In particular, during the assumed low inflation environment, portfolios with a higher percentage of equities tended to perform the best, with bonds and TIPs leading to less accumulated wealth on average. Under conditions of low inflation, the portfolio of 80% equities and 20% bonds accumulated $700,508, which is 37% more money than the second best performing portfolio, the target date fund. All three portfolios with high proportions of bonds or TIPS accumulated less than half the money that the high equity portfolio generated, with none of them exceeding $370,000 at retirement age.

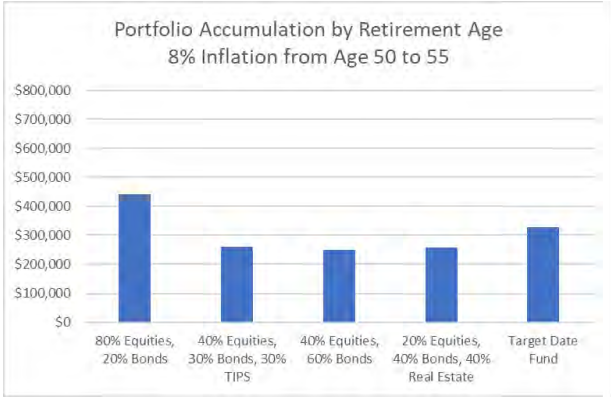
Figure 6

AVERAGE PORTFOLIO ACCUMULATION FROM AGE 40 TO AGE 66

Portfolio at Retirement Age	
80% Equities, 20% Bonds	$700,508
40% Equities, 30% Bonds, 30% TIPS	$349,414
40% Equities, 60% Bonds	$338,314
20% Equities, 40% Bonds, 40% Real Estate	$366,776
Target Date Fund	$509,667

Portfolio at Retirement Age	
80% Equities, 20% Bonds	$442,280
40% Equities, 30% Bonds, 30% TIPS	$259,751
40% Equities, 60% Bonds	$248,770
20% Equities, 40% Bonds, 40% Real Estate	$257,311
Target Date Fund	$328,623





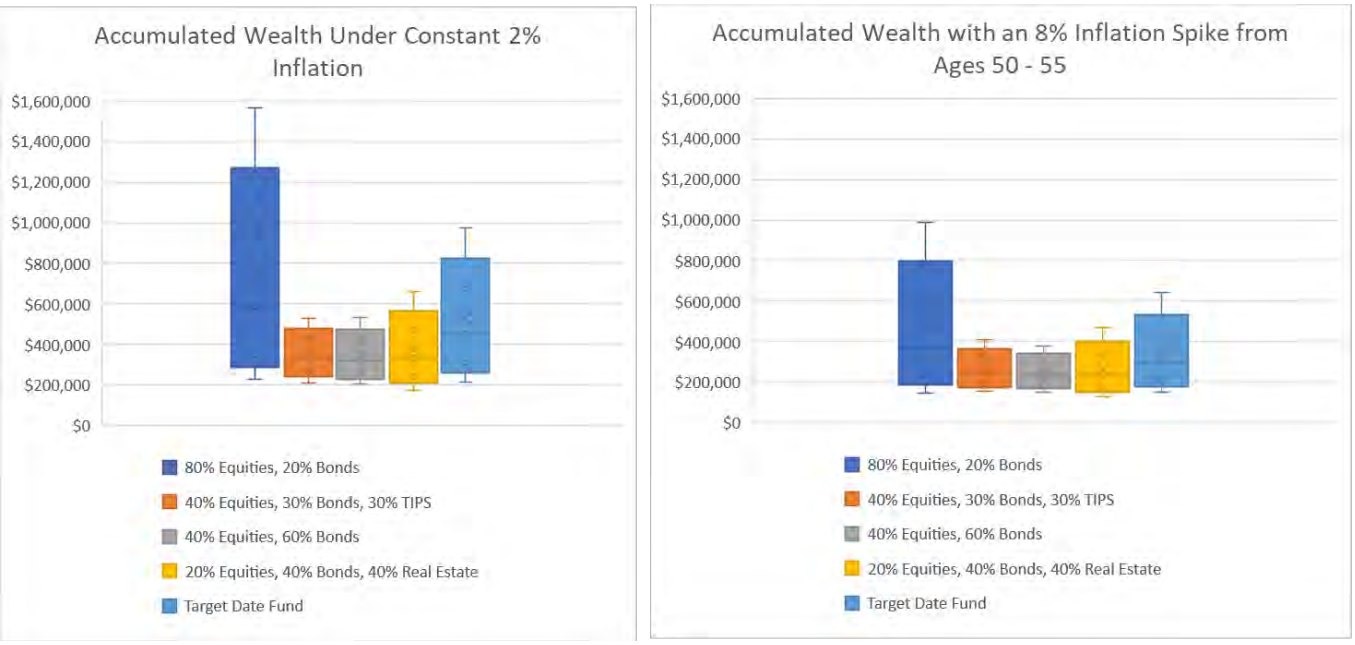
* See subsection 2.2.2 for the economic assumptions used to generate this figure.

When comparing the results from the low inflation condition to the inflation spike condition, we can see that inflation generally had a deleterious effect on real portfolio accumulation across the board, with high inflation being especially devastating to portfolios high in equity exposure and least affecting the portfolio with 30% TIPS. The 80% equity portfolio accumulated $700,508 by retirement age under conditions of low inflation and $442,280 in real terms under the inflation spike condition, a decrease of 36.8%. This poor performance reflects low historical equity returns during past periods of high inflation in the U.S., which tend to occur when underlying macroeconomic conditions are poor and not conducive to equity growth. In contrast, the portfolio with 30% TIPS, decreased just 25.7% (from $349,414 to $259,751). In fact, while in the low inflationary environment, the portfolio of 40% equities and 60% bonds performed materially better than the portfolio of 40% equities, 30% bonds and 30% TIPS (accumulating $338,314 vs. $248,770); in the inflation spike condition, the portfolio with TIPS performed slightly better, suggesting that TIPS can provide meaningful inflation protection during asset accumulation.

However, the most striking finding when looking at the relative portfolio performance under the inflation spike condition is how well the high equity portfolio performs relative to every other asset allocation, including the target date fund, which is supposed to be relatively aggressive prior to retirement. While equities may not be a hedge against inflation in the short-term, over long periods of time, their higher expected returns can make up for their relative underperformance during periods of high inflation. Under the inflation spike condition, the high equity portfolio accumulates $442,280, which is 34.6% more than the next best portfolio. All the remaining portfolios, apart from the target date fund, accumulate somewhere between $248,000 and $260,000, meaning there is a less than 5% difference in their performance relative to one another. However, this view may not fully reflect risk because the model assumes a normal distribution of possible equity returns. If equity returns are not normally distributed, and especially if they have a fat downside tail, then a high equity portfolio may lose significant value before retirement in the case of a sudden market downturn. This effect may not be fully captured by this model given the purposes of the model as described in the disclaimer and throughout this report. Further to this risk, more conservative allocations, such as the target date fund, have less exposure to such downside events.

Looking at our return assumptions from subsection 2.2.3, we can see the reason for the consistent out-performance of equities stems from their high expected returns. During the accumulation phase, asset allocations with bonds or TIPS are relatively ineffective because, based on our historical data, their expected returns do not exceed those for stocks or real estate by very much even when inflation is quite high, and lag far behind when inflation is low. The high expected returns from equities during individual years of low inflation will more than make up for their slight underperformance during individual years when inflation is high, so long as the saving window is sufficiently long.

Figure 7
BOX PLOT OF PORTFOLIO ACCUMULATION FROM AGE 40 TO AGE 66



Given the approach of the sample target date funds to gradually switch from a more aggressive to a more conservative asset allocation over time, we might expect a sample target date fund that begins with 85% equities to outperform a static 80% equity portfolio. However, our model demonstrates that a portfolio of 80% equities and 20% bonds outperforms sample target date funds in accumulating retirement wealth both in high and low inflation environments. This possibly indicates that the sample target date funds' gradual shift towards conservative asset allocations prior to retirement mean that they may fail to fully capture the outsized average returns from equities during times of low inflation, while also underperforming more conservative portfolios during periods of high inflation.

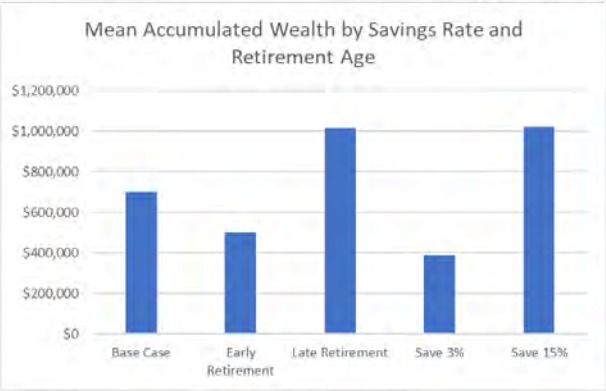
As such, these specific sample model results suggest that, if someone begins saving up for retirement at a sufficiently early age (40 years of age or younger), hedging against possible inflation with instruments like TIPS may, under some situations, be counterproductive to the goal of maximizing assets at retirement age. Rather, under the assumptions of the model results, high allocations in diversified equities may be the most effective strategy under certain circumstances, such as when the long time horizon will allow for the high expected returns of equities to counteract the negative effects of even prolonged periods of high inflation. Similarly, placing money in diversified equities could be a better strategy than putting money in a select target date fund because some target date funds may tend to be overly conservative prior to retirement.

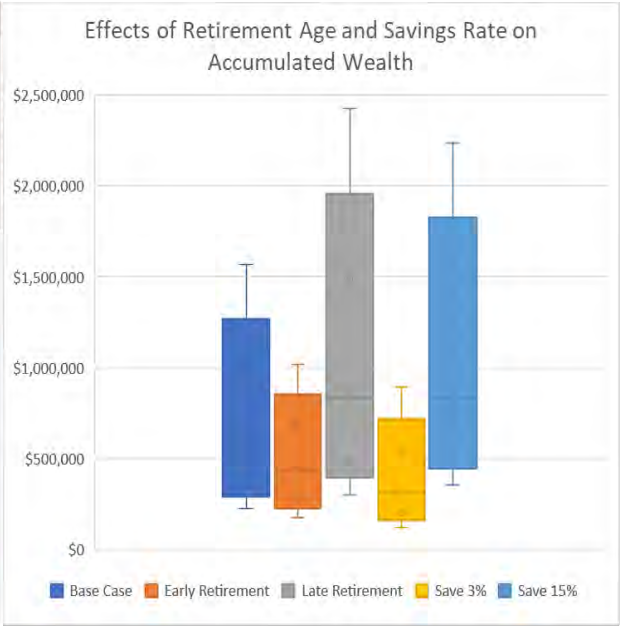
While these results compare the differential results of asset allocation and inflation conditions, they also assume a 9% savings rate and a savings period of 26 years, beginning at age 40 and ending with retirement at age 66. However, the savings rate and retirement age are similarly important in determining the amount accumulated at retirement. As we can see in the figure below, assuming 80% equity and 20% bond allocation and under conditions of a flat 2% inflation, while the average accumulated wealth given a 9% annual savings rate is $700,508, increasing that savings rate to 15% or delaying retirement until 70 increased that amount to $1,017,999 and $1,014,816, respectively. Similarly, decreasing the savings rate to 3% or lowering the retirement age to 60 years of age each decreased average wealth by around $200,000, or around 28.5%, compared to our base case.

Figure 8

EFFECTS OF RETIREMENT DATE AND SAVINGS RATE ON PORTFOLIO ACCUMULATION

Mean Portfolio at Retirement Age	
Base Case	$700,508
Early Retirement	$501,416
Late Retirement	$1,014,816
Save 3%	$390,324
Save 15%	$1,017,999





In the following section, we examine the effects of portfolio selection on the probability of running out of money in retirement, but similarly assume a uniform starting portfolio value. It should be noted that the total amount accumulated prior to retirement has a significant impact on that outcome as well, with larger sums of money allowing for a wider range of successful portfolio allocations and lower sums of money, all but guaranteeing that a retiree will run out of money no matter their asset allocation. For example, under our set of assumptions, above a certain threshold of wealth, a retiree can pursue the most aggressive equity strategy while riding out market downturns. Yet, someone with less than their annual expenses in assets are nearly certain not to make their resources last. In the following sections, we restrict our analysis to moderate levels of accumulated wealth to highlight the cases where asset allocation matters the most.

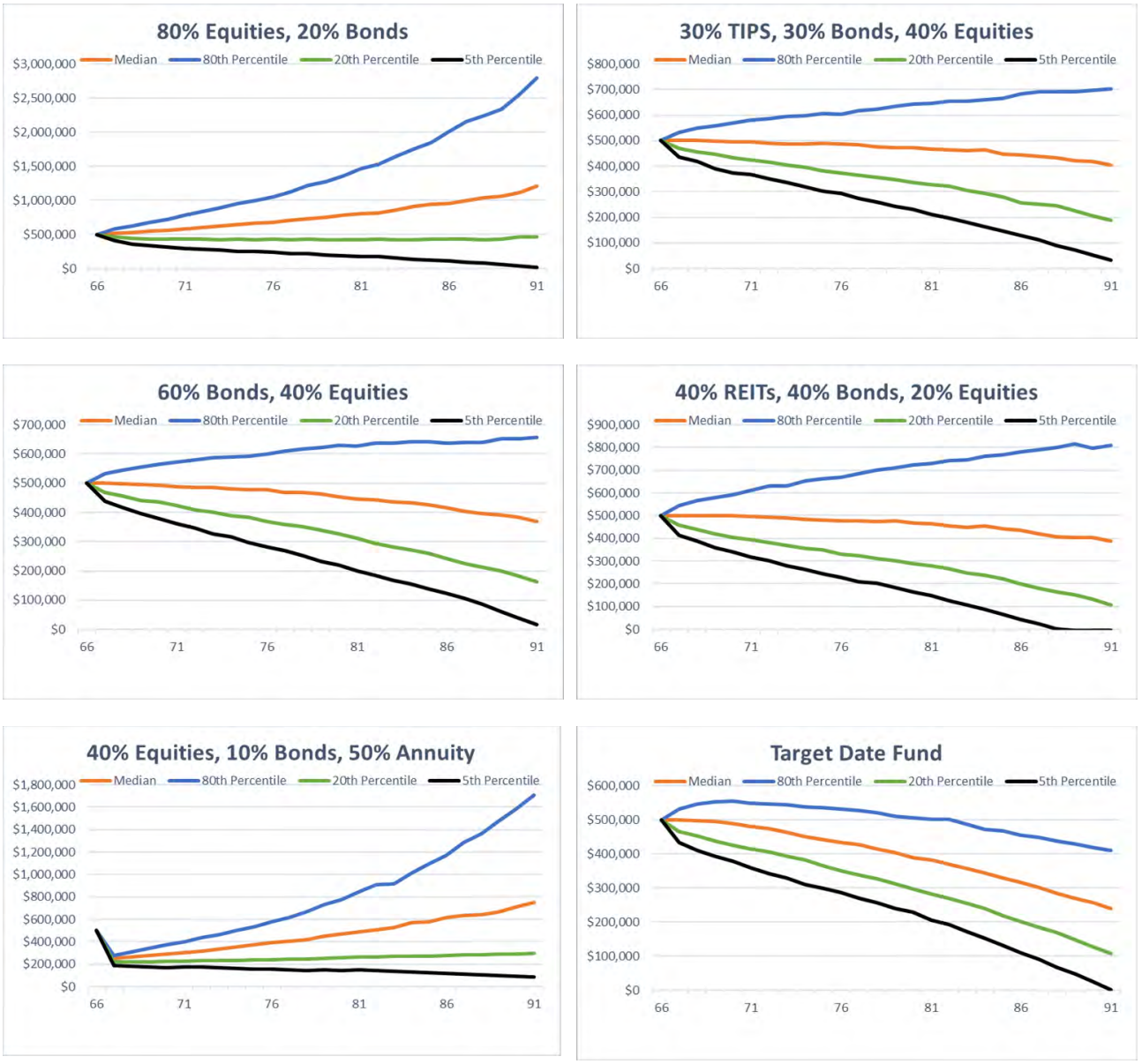
3.2 DECUMULATION

Decumulation, the phase of retirement planning where individuals begin drawing down their accumulated assets to fund their retirement lifestyle, represents a critical and nuanced aspect of financial strategy. There are several different spending rules that a retiree can implement, from something as simple as an annual percentage withdrawal strategy to something more complicated like an annually recalculated virtual annuity approach. For the purposes of this model, we assume that a retiree spends enough money to meet their post-retirement expenses as laid out in subsection 2.2.2, adjusted for inflation. As for allocation, unlike the accumulation phase, where the primary goal is to grow wealth, decumulation requires careful consideration of sustainable income, risk management, and ensuring that retirement savings last throughout one's lifetime.

During the decumulation phase, a common strategy is to shift towards a more conservative asset mix. While stocks may offer growth potential, they also come with higher volatility. A conservative allocation, with a greater emphasis on fixed-income assets, aims to provide stability and preserve capital, especially when retirees are relying on their investments to generate income. To test this assumption, we considered the decumulation performance of each of the portfolios laid out in subsection 2.2.4, beginning with $500,000 at age 66, first under conditions of steady 2% inflation, and then with a spike of 8% inflation for the first five years of retirement.

Figure 9

DECUMULATION OF PORTFOLIO BY ASSET ALLOCATION, ASSUMING 2% INFLATION



Under the conditions of steady 2% inflation shown above, we can see that nearly all portfolios maintain a positive balance until at least age 91, even in their 5th percentile outcome. The exception is portfolio 4, containing 40% REITs, 40% bonds and 20% equities. For this portfolio, at least 5% of simulated outcomes run out of money before age 88½. The median cases for portfolios 2, 3, 4 and 6 all show steady decreases in wealth throughout retirement, while the median case for portfolio 1, consisting of 80% equities and 20% bonds, shows a steady wealth increase throughout retirement. After the cost to purchase an annuity, portfolio 5 shows an increase in wealth over time similar to portfolio 1, although with a less potential upside.

While the portfolios that put a greater emphasis on bonds, TIPS or REITs tend to exhibit greater risk of wealth decline throughout retirement, they also exhibit significantly less dispersion in possible outcomes. For example, at age 85, 75% of the projected outcomes (those between the 5th and 80th percentiles) for portfolios 2, 3 and 6 fall between $100,000 and $700,000. Portfolio 4, with 40% REITS, has a slightly wider range of $50,000 to $900,000, while portfolio 1 has a range extending up to nearly $2,000,000. Based on these model results, the more aggressive portfolio 1 may offer the chance of a significant upside without any greater chance of running out of money under conditions of low steady inflation provided the starting wealth is high enough that average returns tend to outstrip retirement spending.

However, when we consider the performance of the six portfolios under conditions of high inflation, a different picture emerges. By altering the inflation rate from a fixed 2% rate per year to 8% for the five years following retirement, we can see a portfolio of 80% equities and 20% bonds fares significantly worse than it does under conditions of low, steady inflation. While the portfolio maintains its high dispersion of outcomes and an 80th percentile outcome that still passes the million dollar threshold, the median scenario shifts from over $1,000,000 at age 90 adjusted for inflation to less than $400,000. Looking at the 5th and 20th percentiles, we can see that, in low inflation, the 5th percentile still has money at age 90 but, under the inflation spike scenario, the 5th percentile runs out of money by age 80 and the 20th percentile by age 87. While the median of the 80/20 portfolio outperforms all other allocations in this inflation scenario, it carries significantly more downside risk, highlighting why target date strategies move away from equities after retirement age.

Figure 10

DECUMULATION OF PORTFOLIO BY ASSET ALLOCATION, ASSUMING A SPIKE TO 8% INFLATION FOR 5 YEARS FOLLOWING RETIREMENT

In contrast, while portfolios more heavily invested in bonds or TIPS still fare worse under high inflationary conditions than they do under steady low inflation, the effect of inflation is far less, especially on the worst-case scenarios. For example, under high inflation, the 5th percentile outcome of the portfolio with 30% TIPS runs out of money at age 85 and the 20th percentile runs out at age 90. These outcomes are five and four years better than those for the 5th and 20th percentile outcomes for the high equity portfolio.

There is not much difference in the downside protection afforded by the target date fund, 60% bonds portfolio and the 30% TIPS portfolio. All three have a 5th percentile that runs out of money around age 86, the 20th percentile of the target date fund runs out of money around age 88, while the 60% bond portfolio and 30% TIPS portfolio hang on until ages 89 and 90, respectively. However, while all three have similar downside protection, the bonds and TIPS

portfolios have significantly better median and 80th percentile outcomes compared to the target date fund, with their 80th percentiles both ending between $300,000 and $400,000 at age 91 and the target date fund ending well below $200,000. In contrast, the 40% REIT portfolio and the 50% annuity portfolio have similarly bad downside protection as the high equity portfolio, but without as much of a possible upside. The 40% REIT portfolio performs especially badly, with a median case similar to the target date fund, an 80th percentile on par with the 60% bond portfolio, along with the 5th and 20th percentiles scarcely better than the high equity portfolio. Looking to our return assumptions in subsection 2.2.3, this situation develops because real estate has the highest expected returns under conditions of moderate inflation, with lower expected returns than equities under conditions of high and low inflation. Real estate also has a higher variance than equities. Because this scenario tests low inflation with a spike to high inflation, it will tend to make REITs look bad, whereas under another set of assumptions, they might perform quite well, such as in a scenario with prolonged moderate inflation.

Finding a clear take-away from these decumulation model results is more difficult than the accumulation phase because there are two competing considerations at play: minimizing downside risk (i.e., the chance of running out of money before you die) and capitalizing on a possible upside. Pursuing an aggressive, high-equity strategy affords the chance of generating capital with less real additional risk of running out of money in a low inflation environment. However, an aggressive allocation presents a 20% chance under these model results of the risk of running out of money. Thus, in light of this trade-off, if the goal is to minimize the chance of outliving wealth, then as of their retirement, the model results indicate that it may be prudent to adopt a conservative portfolio more heavily weighted towards bonds and TIPS. Exposure to real estate could be incorporated to protect against moderate inflation, but the model results indicate it is insufficient on its own to protect against high inflation. While under these model assumptions, a target date fund can perform reasonably well, a simple 60% bonds, 40% equity portfolio outperforms it across the board, whereas a portfolio with 30% bonds, 40% equities, and 30% TIPS improves inflation protection without adversely affecting outcomes in a low inflation environment.

3.3 OVERALL STRATEGY

In the prior two sections, after comparing various hypothetical portfolio results using our specific model assumptions, we established that, while a high-equity portfolio may be optimal for accumulating retirement funds, a portfolio with greater exposure to bonds and TIPS may help to minimize the chances of outliving savings in retirement. However, the question remains whether the transition from an aggressive to a conservative asset allocation should be performed slowly over time, or whether it is best to mark the shift from accumulation to decumulation with a sudden rebalancing of assets away from equities and toward bonds. In this section, we examine this question by comparing the performance of a sample target date fund that begins with an aggressive portfolio and slowly changes the asset mix to become more conservative with a ‘hybrid portfolio,’ that transitions from an asset allocation of 80% equities and 20% bonds from ages 40 to 66 to an asset allocation of 30% TIPS, 30% bonds and 40% equities immediately upon retirement at age 66. We will compare their performance using our specific modeling assumptions under three inflation conditions: constant low inflation, low inflation with a spike to 8% from ages 50-55 and low inflation with a spike to 8% for the five years following retirement at age 66.

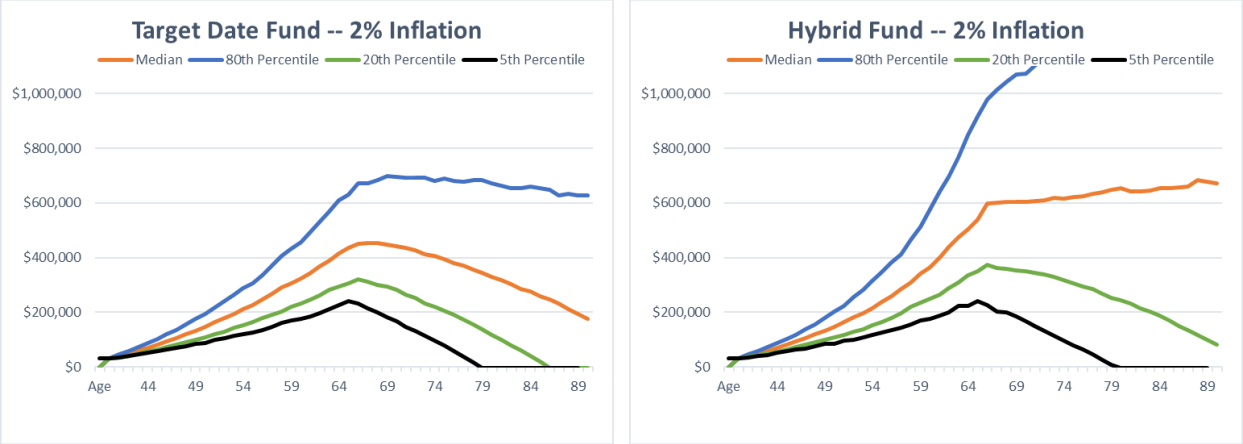
Figure 11

WEALTH ACCUMULATION OF TARGET DATE FUND VS. HYBRID FUND FROM AGE 40 TO 66

Portfolio at Retirement Age				
	Target Date Fund	Hybrid Fund	Difference	% Difference
Mean	$501,142	$694,781	$193,639	38.64%
Median	$449,532	$576,957	$127,425	28.35%
95th percentile	$933,849	$1,480,503	$546,653	58.54%
80th percentile	$651,987	$973,420	$321,433	49.30%
20th percentile	$311,864	$354,511	$42,647	13.67%
5th percentile	$228,994	$234,547	$5,554	2.43%

Figure 12

PERFORMANCE OF TARGET DATE FUND VS. HYBRID FUND ASSUMING 2% INFLATION

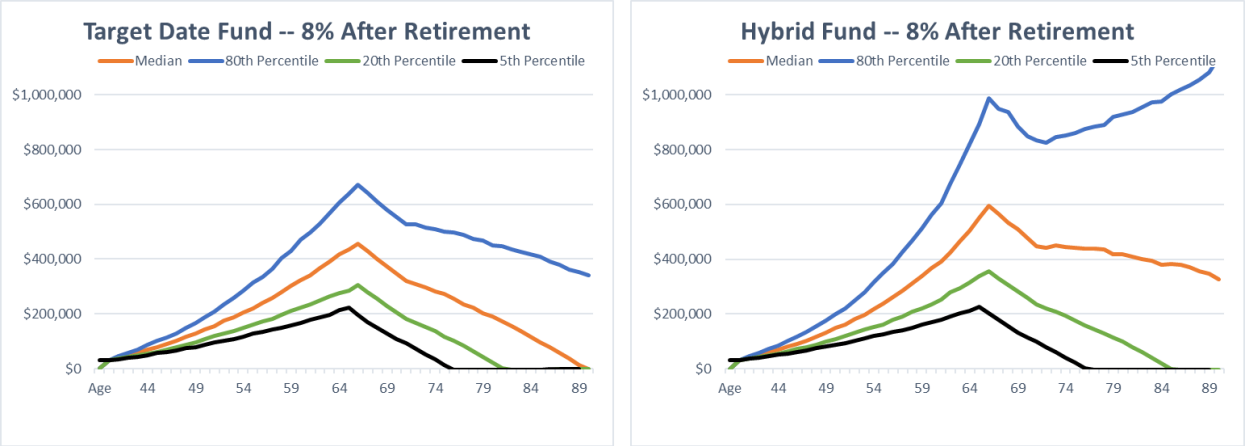


To begin, consider the figures above, representing the respective performance of the target date and hybrid portfolios under conditions of constant 2% inflation. As we can see, the hybrid fund outperforms the target date fund in virtually every respect. First, the hybrid fund accumulates more money across every scenario percentile, with 2.43% more than the target date fund in the 5th percentile of simulations, and 13.67%, 28.35%, and 49.3% more wealth accumulated for the 20th percentile case, median, and 80th percentile case, respectively. During the decumulation phase, while the median case for the hybrid fund gradually increases after retirement to settle just below $700,000 at age 90, the median case for the target date fund gradually slopes downward to below $200,000. The target date fund does not offer better downside protection either, with the 5th percentile scenario running out of money two years before the corresponding 5th percentile scenario for the hybrid fund. Moreover, while the 20th percentile scenario for the target date fund runs out of money by age 86, the 20th percentile scenario for the hybrid fund still has money past age 90.

The better performance of the hybrid fund could be attributed solely to its higher equity allocation during the accumulation phase. However, comparing the median case of the hybrid portfolio with the 80th percentile scenario for the target date fund, we can see that, while the 80th percentile for the target date fund begins retirement with more money ($651,987 compared to $576,957), it decreases after retirement, while the median case for the hybrid fund increases over time. This indicates, under these assumptions, that the sample target date fund is possibly conservative prior to retirement and thereafter as well.

Figure 13

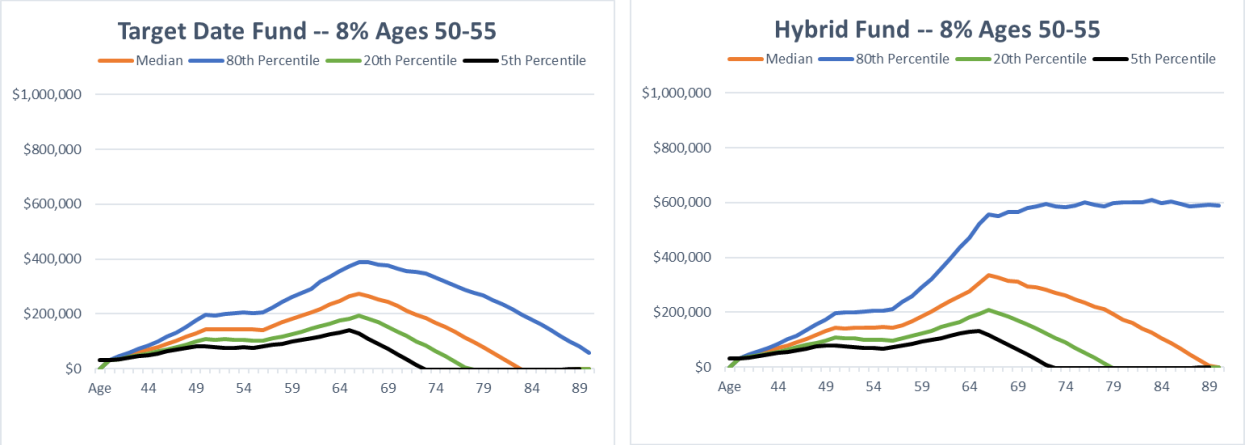
PERFORMANCE OF TARGET DATE FUND VS. HYBRID FUND ASSUMING 8% INFLATION SPIKE FOR 5 YEARS FOLLOWING RETIREMENT



Examining the performance of the two approaches under conditions of high inflation immediately following retirement, as well as under conditions of high inflation from ages 50 through 55, we can see a similar pattern of less downside protection offered by the sample target date fund, along with a poorer performing median result, and less upside in the 80th percentile result compared to the hybrid portfolio.

Figure 14

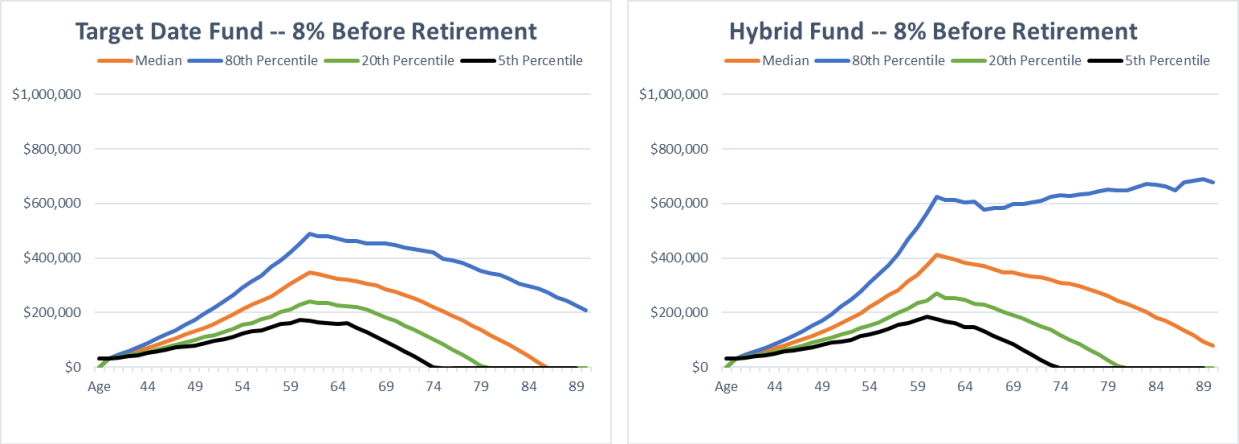
PERFORMANCE OF TARGET DATE FUND VS. HYBRID FUND ASSUMING 8% INFLATION SPIKE FROM AGE 50 - 55



Finally, where the target date fund becomes more conservative prior to retirement, we might expect it to perform better assuming a spike in inflation just prior to retirement that dampened returns to equities. However, even in this case of a spike to 8% inflation for the five years prior to retirement, we see the 20th percentile, median and 80th percentile outcomes for the hybrid fund outperform those of the target date fund, while the 5th percentile of the target date fund runs out of money one year after the hybrid fund. Thus, it seems that the case of inflation just prior to retirement gives a slight advantage to the target date fund during the worst-case scenarios while, for the 20th percentile outcome and above, the hybrid fund performs better.

Figure 15

PERFORMANCE OF TARGET DATE FUND VS. HYBRID FUND ASSUMING 8% INFLATION SPIKE FOR 5 YEARS BEFORE RETIREMENT



Together, these modeling scenarios indicate that, across the examined inflationary conditions, the hybrid portfolio outcomes were better than the sample target date fund at accumulating retirement assets and that this head-start carried over into the decumulation phase, where the hybrid portfolio continued to outperform. These modeling results demonstrate the effect of slowly transitioning toward a more conservative portfolio prior to retirement and that this may decrease overall portfolio accumulation under conditions of low and spiked high inflation with no additional downside protection. These scenarios also suggest that the results may be better when the assumptions include an aggressive, equity-based investment asset allocation prior to retirement, and then suddenly rebalance to a more conservative portfolio when the model begins to spend down savings. Another approach may be with target date funds that have target dates after planned retirement dates, so the fund allocation remains more aggressive until closer to the actual retirement date. In terms of future research, it would be interesting to run additional scenario analyses to find potentially more optimal target date fund allocation transition paths.

Section 4: Conclusion

Although the Federal Reserve generally aims to keep inflation in the U.S. near 2%, since World War II there have been seven periods where the consumer price index (CPI) surpassed 5%. In the future, those preparing for retirement now can anticipate saving and investing through periods of high, moderate, and low inflation. In this report, we used a stochastic retirement savings scenario model to compare the efficacy of different asset allocations under inflationary conditions. Employing certain assumptions described in the report and running a sample of hypothetical scenarios, we found different asset allocations interact with inflation in a variety of ways both before and after retirement.

During the accumulation phase, when the main goal is to achieve the largest savings possible, our model results suggested optimal asset allocations under the conditions of low inflation or a five-year spike to high inflation were identical – an aggressive portfolio high in equities. This result can be explained by considering that, with an investment time horizon spanning multiple decades, expected returns tend to matter more than variance. The historical data we used to derive our asset return assumptions indicated that under low inflation, equities had much higher expected returns, both nominal and real, than bonds or TIPS and even somewhat higher than real estate. Alternatively, during periods of high inflation, equities had only slightly lower returns than the other asset classes. As a result of these factors, equities tend to outperform any other asset class over sufficiently long periods of time, unless inflation remains high for prolonged periods of time, as shown in our analysis.

However, while equities have much higher expected returns, the primary advantage of bonds and TIPS comes from their low variance. During the decumulation phase when the goal is to minimize the probability of outliving your wealth, the significantly lower variance of bonds and TIPS decreases the dispersion of possible outcomes, thereby decreasing the probability of running out of money in retirement. Combining the concern for accumulating as much wealth as possible prior to retirement, along with the imperative to lower the variance of returns in retirement, these results suggest a portfolio strategy that takes an aggressive approach until near retirement and then becomes more conservative post-retirement.

While this approach is fairly boilerplate, perhaps the most novel results from our model came from comparing a sample target date fund to a hybrid fund that transitioned from an aggressive asset allocation to a more conservative allocation immediately upon retirement. Under our assumptions and hypothetical scenarios, the hybrid portfolio consistently produced greater returns than the target date fund across all inflationary conditions. This suggests that the modeled sample target date funds using our assumptions may shift towards conservatism too soon. Our model results suggest that more aggressive equity-based strategies up until retirement, followed by a transition to a moderately conservative portfolio during the decumulation phase, may perform best. However, given the limitations of our model and what it was designed to do, we were only able to test a few allocations and did not test the possibility of transitioning to a more conservative portfolio a few years after retirement, or only after going below a certain level of wealth. It is possible that a strategy of gradual transition similar to a target date fund, but with a longer period of aggressive allocation, could perform even better. However, as discussed earlier, these results may not fully reflect risk because the model assumes a normal distribution of possible equity returns. If equity returns are not normally distributed, and especially if they have a fat downside tail, then a high equity portfolio may lose significant value at any time in the case of a sudden market downturn. This effect may not be fully captured by this model given the purposes of the model as described in the disclaimer and throughout this report. Further to this risk, more conservative allocations, such as target date funds, have less exposure to such downside events.

Future research incorporating an expanded set of assumptions and scenarios may help to shed further light on the interaction of these approaches with inflation and illustrate how results may differ.

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