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Improvements in Age-Based Asset Allocation Strategies for College Savings and Retirement Plans

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Executive Summary

During any 17-year period, the stock market suffers at least three corrections and at least one bear market, involving stock market drops of at least 10% and 20%, respectively. Thus, the risk of a market downturn is unavoidable when one is saving for a child's college education.

However, one can minimize the impact of the risk of investment losses by using an age-based asset allocation strategy. An age-based asset allocation strategy starts with an aggressive mix of investments when the child is young and shifts to a more conservative mix of investments as college approaches.

Aggressive investments include high-risk, high-return investments like stocks. Conservative investments include low-risk, low-return investments like bonds, CDs, money market funds and cash. As the return on an investment increases, the risk of investment loss also increases.

Delaying the onset of a shift in age-based asset allocation by as much as 10 years can increase the return on investment by as much as a percentage point without significantly increasing risk.

An age-based asset allocation reduces the impact of market downturns by changing the percentage of the portfolio that is invested in high-risk investments each year from birth to college. When the child is young, the portfolio is invested more in high-risk investments, when less money has been saved and there is more time to recover from losses. When the child approaches traditional college age (e.g., age 17), the portfolio is invested in lower-risk investments to lock in the gains.

Traditional age-based asset allocation strategies for college savings may shift from high-risk, high-return asset classes to low-risk, low-return asset classes too quickly.

This paper presents a systematic way of improving the performance of age-based asset allocation strategies by delaying the onset of the shift to a more conservative mix of investments by up to 10 years. This increases the return on investment by increasing the duration of the initial investment in high-risk, high-return asset classes, but without significantly increasing the overall risk of investment loss. The age-based asset allocation is then compressed to fit the remaining investment horizon.

A similar change to the investment glide path (the change in asset allocation over time) for retirement savings may also lead to performance improvements for retirement plans without significantly increasing the overall risk of investment loss.

This approach can help maximize the amount of money available to pay for college, retirement and other major life-cycle events. It should yield about an 8% increase in total college savings and about a 23% increase in total retirement savings by age 65.

Balancing Investment Risk and Investment Return

During any 17-year period, the stock market will drop by at least 10% at least three times and as many as seven times, as shown in the *Corrections and Bear Markets* section of this paper. At least one of these stock market downturns will involve a drop of 20% or more.

Thus, stock market downturns are unavoidable when saving for a child's college education. One cannot avoid all risk of loss when investing in stocks.[1] But, one can manage the risk of loss and minimize the impact of investment losses by using an age-based asset allocation strategy.

The overall goal is to maximize the asset value of the college savings plan so that there is as much money as possible to pay for college.

Asset Allocation

An asset allocation specifies the proportion of an investment portfolio's assets that are invested in two or more asset classes or investment options.

Some asset classes, such as stocks, offer a higher rate of return on investment, but at a higher risk of financial loss. Other asset classes, such as bonds, cash, CDs and money market accounts, offer a lower rate of return at lower risk. Typically, the lower the risk associated with an asset class, the lower the rate of return.

An asset allocation tries to balance risk and return by mixing high-risk and low-risk investments.

When one investment appreciates faster than the others, it may be necessary to periodically rebalance the portfolio so that the investments maintain the same asset allocation.

Research has shown that most of an investment portfolio's long-term returns can be attributed to the asset allocation, as opposed to the specific investments. If the risks associated with each asset class are not correlated, an asset allocation can also reduce the overall volatility of the investment portfolio.

Age-Based Asset Allocation

With an age-based asset allocation, the asset allocation changes over time.[2] Generally, an age-based asset allocation shifts from an aggressive, high-risk mix of investments to a more conservative, low-risk mix of investments as the child gets older and approaches college age. This usually involves reducing the proportion of the investment portfolio's assets that are invested in stocks. For example, a college savings plan might start off with 80% of the money invested in stocks and gradually reduce this percentage to 20% as college approaches.

When the child is young, the investor's risk tolerance is higher because less money is at risk and because there is a longer investment horizon to recover from market downturns.

Thus, an age-based asset allocation not only rebalances the portfolio to maintain the asset allocation, but also changes the asset allocation based on the child's age or the number of years remaining until enrollment in college.

More than two-thirds of investors in 529 college savings plans are invested in age-based asset allocations.

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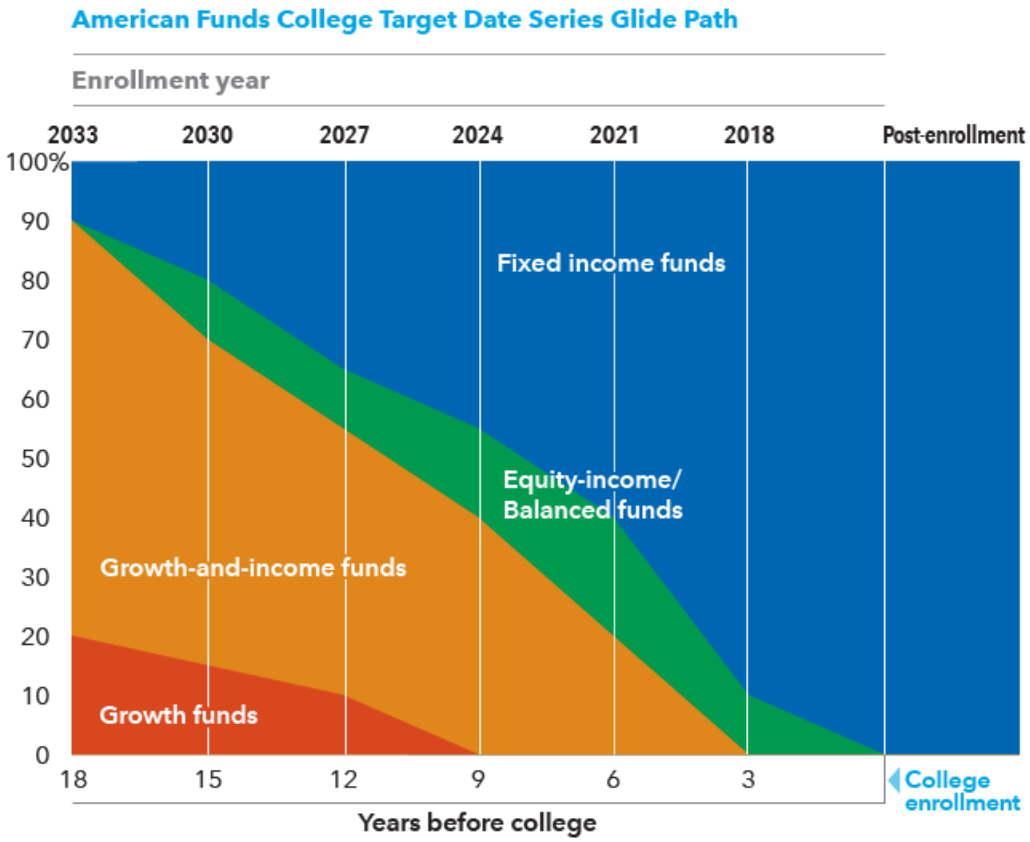
[1] Technically, one could periodically buy "put options" to lock in gains and thereby limit the impact of market downturns. But, buying put options comes at a cost and may reduce the net return on investment.

[2] The focus of this paper is on the use of age-based asset allocations for college savings. Similar concepts may be applied in other contexts, such as saving for retirement. In the context of saving for retirement, age-based asset allocations are often implemented through target-date funds, sometimes called life-cycle funds.

Investment Glide Path

An investment glide path specifies how the percentage of the investment portfolio that is invested in each asset class changes over time in an age-based asset allocation. For example, a popular rule of thumb suggests setting the percentage of stocks in a retirement savings plan at 100 minus the employee's age.

This chart provides an example of an investment glide path from American Funds, which manages the CollegeAmerica 529 college savings plan, one of the largest 529 plans. The chart was retrieved from the AmericanFunds.com web site on January 22, 2018.[3] Notice how the percentage invested in stock funds immediately starts decreasing after the first year, even for newborn children, without a delayed onset.



This paper evaluates the investment risk and the return on investment for several investment glide paths for college savings plans using all six hundred 204-month (17-year) periods from January 1950 through December 2017. The total savings for a glide path, where GP_i is the percentage high risk investments at month i in the glide path, C is the monthly contribution and n is the date of the start month, is based on the following equation:

$$\sum_{m=1}^{204}\left(C_{m+n}\times\prod_{i=m}^{204}(1+GP_i\times HighRiskROI_{n+i}+(1-GP_i)\times LowRiskROI_{n+i})\right)$$

[3] https://www.americanfunds.com/individual/products/target-date-college-series.html

Although past performance is not predictive of future results, the historical risk and return may provide insights into the typical performance of an age-based asset allocation strategy.

In particular, this paper demonstrates that delaying the onset of an age-based asset allocation by up to 10 years may yield an improvement in the return on investment without significantly increasing the risk of financial loss. The investment glide paths of college savings plans often flatten out at ages 15-17 and after the student enrolls in college, but do not sustain a flat asset allocation at the start of the college savings plan.[4] This paper demonstrates that these age-based asset allocation strategies may move out of an aggressive asset allocation too soon.

Thus, this paper proposes an investment glide path that begins with a static asset allocation followed by a declining asset allocation. The static asset allocation involves investing a high percentage of the portfolio in high-return, high-risk investments like stocks for several years before transitioning to an age-based asset allocation that becomes more conservative as college approaches. Sustaining a static asset allocation for several years at the start of the investment glide path differs from most investment glide paths, which change the asset mix at every point on the path. The design of an investment glide path often considers whether the trajectory should be steep or more gradual, instead of keeping the asset allocation unchanged.

This analysis assumes a fixed $250 monthly contribution from birth to age 17, with total contributions of $51,000.[5] The aggressive investment option is based on the performance of the S&P 500. The conservative investment option is assumed to have a fixed risk-free rate of return of 1.0%.[6]

Corrections and Bear Markets

Stock market downturns are inevitable when one is investing for the long term.

There are three main types of market downturns:

- A *pullback* is defined as a drop of 5% or more in the stock market.
- A *correction* is defined as a drop of 10% or more.
- A *bear market* is defined as a drop of 20% or more.

This table shows periods of one or more months from 1950 to 2017 during which the S&P 500 decreased by 10% or more. The average duration of a correction was 5 months and the average duration of a bear market was 10 months. If the 1969-70 and 1973-74 bear markets are excluded due to the anomalous duration, the average duration of a bear market was 6 months.

Start of Period	End of Period	Drop in S&P 500	Duration in Months
January 1953	August 1953	12.7%	8
August 1956	February 1957	12.9%	7

[4] Before the creation of 529 college savings plans in 1996, families would sell investments before the start of the base year (around age 15) so that the capital gains would not reduce eligibility for need-based financial aid.
[5] The amount of the fixed monthly contribution does not affect this paper's conclusions. The impact is proportional to the amount of the monthly contribution.
[6] A risk-free investment is defined as having no risk of financial loss.

August 1957	December 1957	16.5%	5
January 1962	June 1962	25.7%	6
February 1966	September 1966	18.8%	8
May 1969	June 1970	20.1%	14
January 1973	September 1974	59.1%	21
July 1975	September 1975	12.3%	3
February 1980	March 1980	10.6%	2
April 1981	September 1981	15.4%	6
December 1981	July 1982	16.1%	8
September 1987	November 1987	32.7%	3
June 1990	October 1990	10.1%	5
July 1998	August 1998	15.7%	2
February 2001	March 2001	15.6%	2
June 2001	September 2001	18.2%	4
April 2002	September 2002	32.7%	6
December 2002	February 2003	10.5%	3
November 2007	March 2008	15.5%	5
June 2008	February 2009	60.6%	9
May 2010	June 2010	13.6%	2
May 2011	September 2011	15.4%	5

During any 204-month (17-year) period from 1950 to 2017, there were 3-7 corrections (including bear markets) and 1-3 bear markets. This demonstrates that market downturns are largely unavoidable when one is saving for a child's college education.

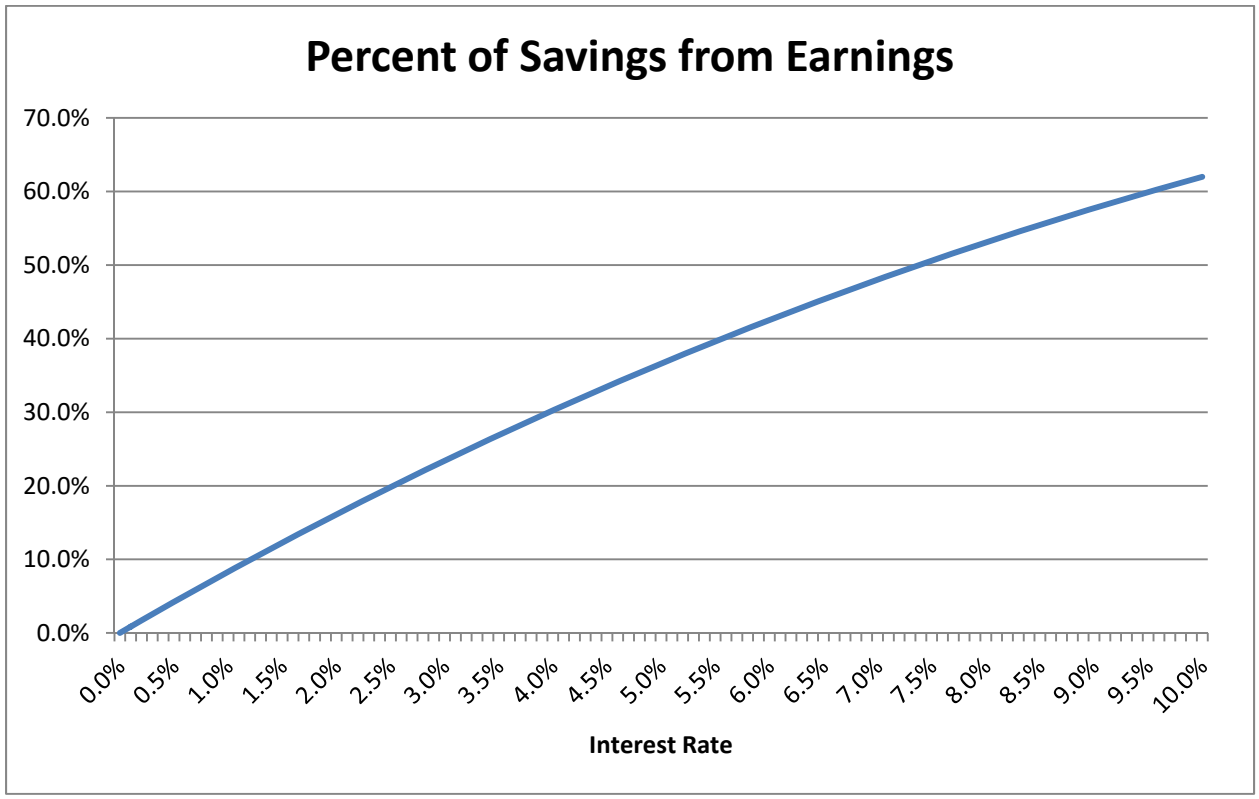
Trying to time the market by exiting after a cumulative drop of 10% or more and re-entering after a one-month increase is not effective. Remaining invested is a more effective strategy, because timing the market is like closing the barn door after the horse has already escaped, often missing out on the economic recovery that follows an economic downturn.

This table shows all corrections from 1950 to 2017 during which the S&P 500 decreased by 10% or more in a single month.

Month	Drop in S&P 500
November 1973	11.4%
September 1974	11.9%
March 1980	10.2%
October 1987	21.8%
August 1998	14.6%
September 2002	11.0%
October 2008	16.9%
February 2009	11.0%

Percent of Savings from Earnings

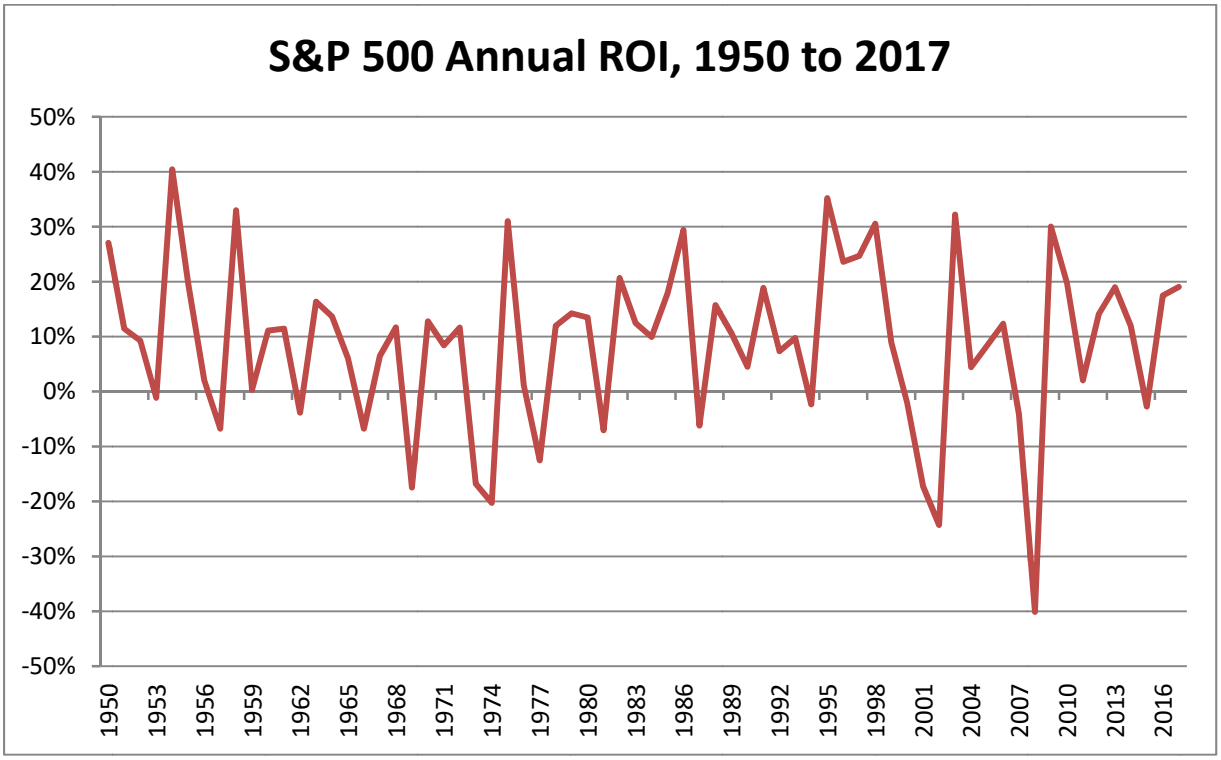
This table and chart are used to determine the equivalent interest rate based on the percent of total savings that are attributable to earnings. The table and chart assume equal monthly contributions and a fixed return on investment for all 17 years.



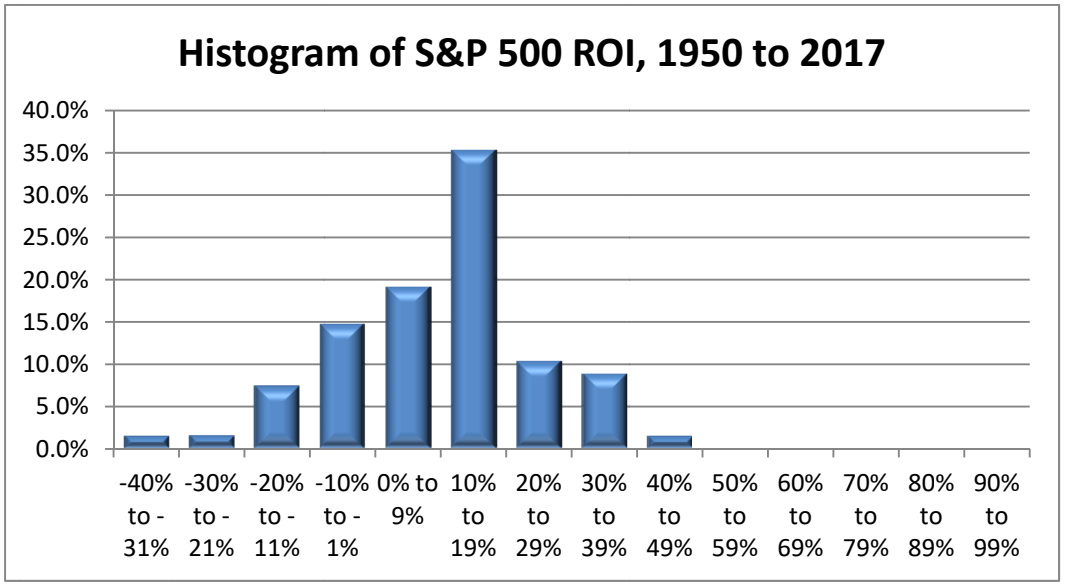
Interest Rate	Percent of Savings from Earnings
0%	0.0%
1%	8.3%
2%	16.1%
3%	23.4%
4%	30.2%
5%	36.6%
6%	42.5%
7%	48.0%
8%	53.1%
9%	57.7%
10%	62.0%

S&P 500 Return on Investment (ROI)

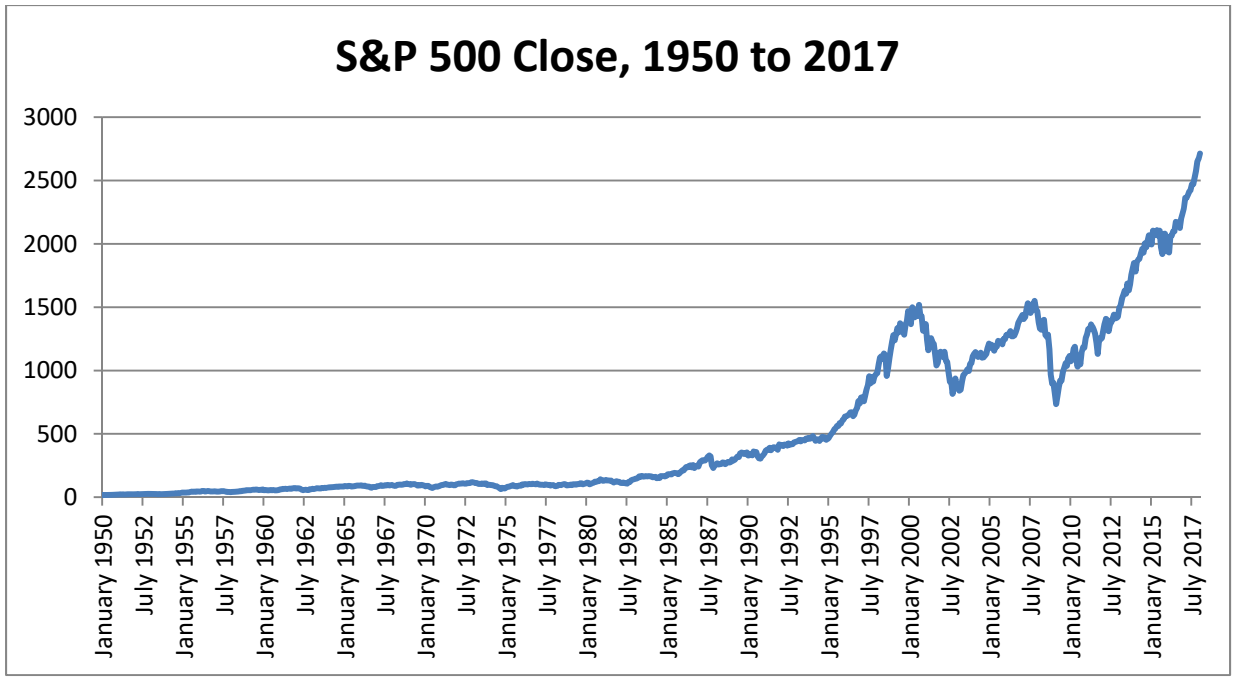
This chart shows the annual return on investment for the S&P 500 from 1950 to 2017. It ranged from a maximum loss of 40.1% to a maximum gain of 40.5%, with an average return on investment of 8.9%.



This chart shows the distribution of the annual return on investment for the S&P 500 from 1950 to 2017.



This chart shows the monthly closing price of the S&P 500 from 1950 to 2017. The bear markets that ended in 2002 and 2009 are visibly evident in this chart.



Evaluating Investment Glide Paths

This section of the paper evaluates the risk and return of several investment glide paths.

Level Asset Allocation

A level asset allocation uses a flat investment glide path that sets a fixed percentage of the investment portfolio that is invested in stocks for all 17 years.

Parents are often tempted to remain 100% invested in stocks for all 17 years, despite the risk of financial loss, because of the potential for high earnings.

This table shows the return on investment for various level asset allocation strategies, assuming a $250 monthly contribution ($51,000 total) for all 17-year periods from 1950 to 2017. As the table demonstrates, the average earnings for a Level 100% investment glide path are $50,790, almost the same as the total contributions. This corresponds to having 42.5% of the total savings come from earnings. It is the equivalent of having a no-risk, fixed annual return on investment of 6.0%.

Asset Allocation	Min	Max	Average	Standard Deviation	Equivalent Fixed Annual ROI	Average Earnings
Level 100%	-18.9%	77.3%	42.5%	20.1%	6.0%	$50,790
Level 80%	-11.7%	69.9%	38.1%	17.3%	5.2%	$38,708
Level 75%	-10.1%	67.7%	36.8%	16.5%	5.0%	$35,948
Level 50%	-2.9%	54.1%	29.4%	12.2%	3.8%	$23,549
Level 25%	3.2%	34.9%	20.0%	6.9%	2.5%	$13,204
Level 20%	4.3%	30.2%	17.8%	5.6%	2.2%	$11,350
Level 0%	8.2%	8.2%	8.2%	0.0%	0.9%	$4,567

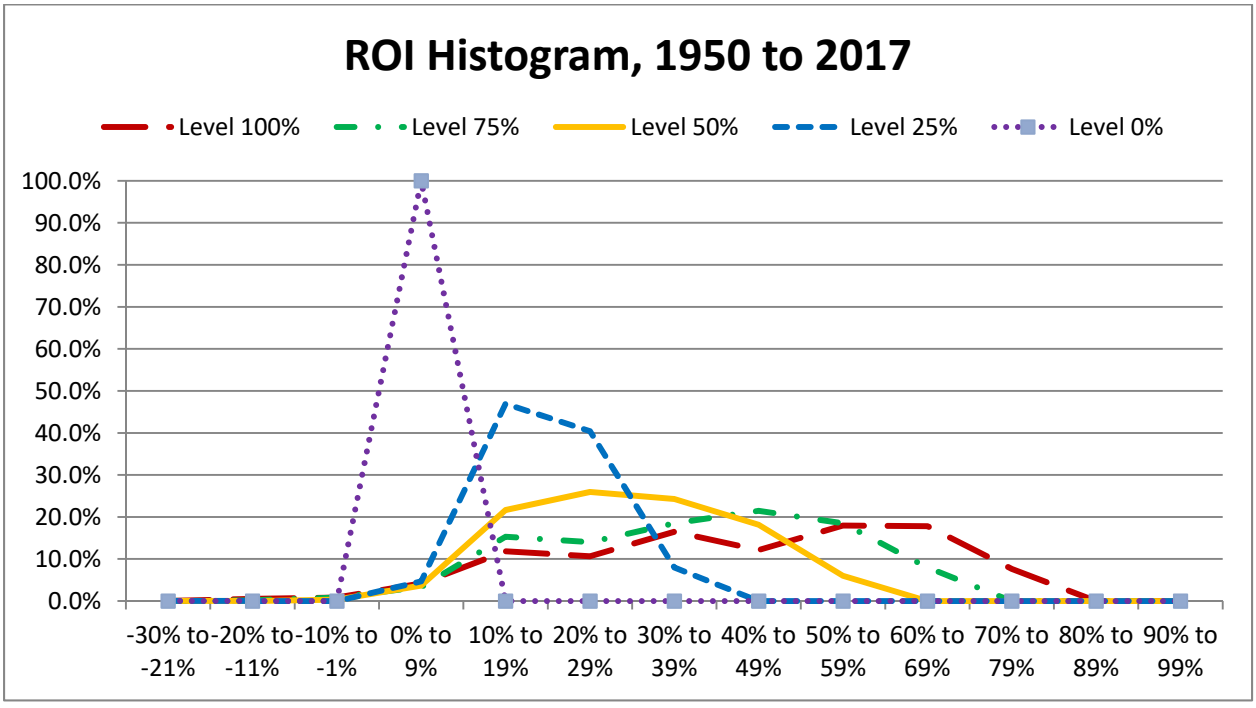
This table also shows that the no-risk strategy of having none of the money invested in stocks (Level 0%) yields average earnings of $4,567, with 8.2% of the total savings coming from earnings. That is a useful baseline performance for comparison with the other investment glide paths.

Investing 100% in stocks for the entire 17-year period comes with some risks, as shown in this table. From 1950 to 2017, 10 of the 600 (1.7%) 17-year periods involved a net loss. The worst performance involved an 18.9% loss. In some cases, this very aggressive investment strategy underperformed the safe investment strategy that does not invest any money in stocks, with 24 of the 600 (4.0%) 17-year periods earning less. This asset allocation did not earn enough to have at least 25% of total savings from earnings in 140 of the 600 (23.3%) 17-year periods.

Asset Allocation	Min	% Negative	% < Safe (8.2%)	% Earnings < 25%
Level 100%	-18.9%	1.7%	4.0%	23.3%
Level 80%	-11.7%	1.2%	2.8%	26.1%
Level 75%	-10.1%	1.0%	2.8%	27.0%
Level 50%	-2.9%	0.5%	2.3%	37.1%
Level 25%	3.2%	0.0%	1.8%	73.0%
Level 20%	4.3%	0.0%	1.8%	90.8%
Level 0%	8.2%	0.0%	0.0%	100.0%

Note that this table shows that the level investment glide paths can yield a net loss when at least half of the portfolio is invested in stocks.

This chart shows the distribution of the return on investment for each level investment strategy for all 17-year periods from 1950 to 2017. As the percentage of the portfolio invested in stocks increases, the maximum potential return on investment increases, but the distribution also flattens out.



Age-Based Asset Allocation

An age-based asset allocation starts off with an aggressive mix of investments when the child is young and gradually shifts it to a more conservative mix of investments as the child approaches college age. If there are losses when the child is young, the losses will be small because not much money has been saved yet and there are many years available to recover from the losses. As college approaches, it is more important to protect the investment from potential losses.

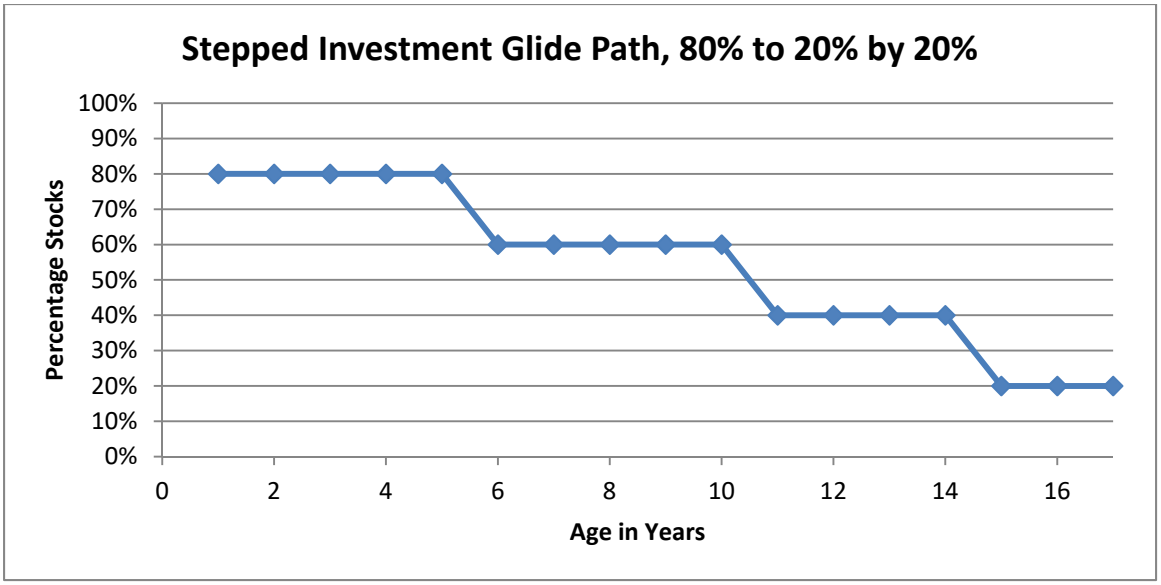
The investment glide path for an age-based asset allocation strategy generally involves annual incremental adjustments to the percentage invested in stocks. Often, the annual increment is fixed, leading to a linear investment glide path. These linear age-based asset allocations decrease monotonically with increasing age, albeit in a step fashion. Here are several common examples:

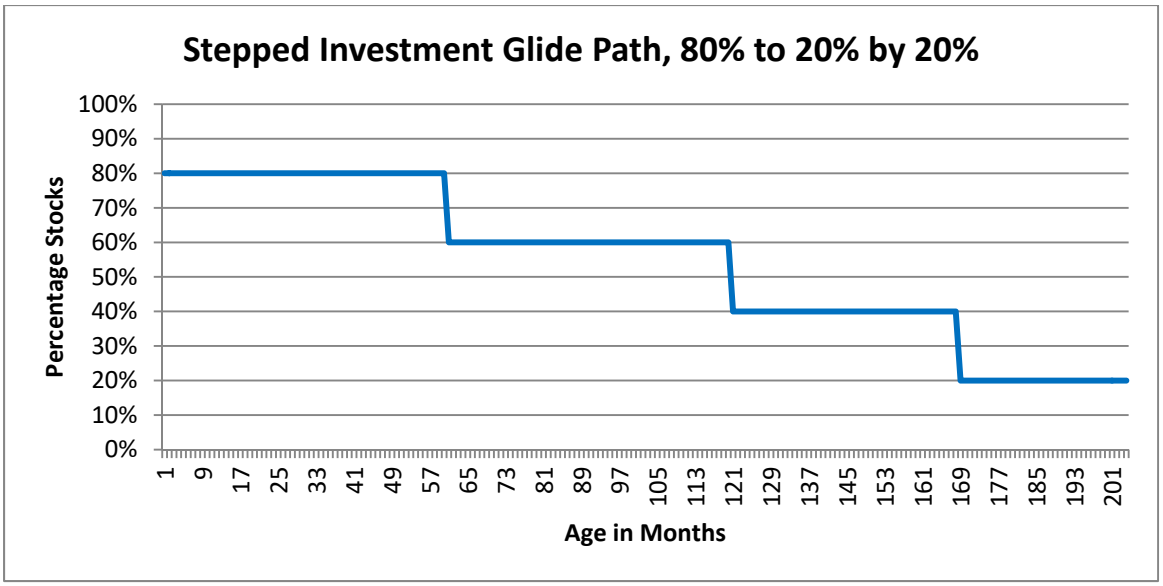
- 80% to 20% (3.75% increment)
- 80% to 30% (3.13% increment)
- 100% to 20% (5.00% increment)
- 100% to 30% (4.38% increment)
- 75% to 25% (3.13% increment)

More than two decades ago, I introduced the concept of an age-based asset allocation for college savings. One of my original proposals for an age-based asset allocation started off with 80% of the investment in stocks at birth, and reduced the percentage by 20% with the transition to a new age bracket (typically every five years or so):

- 80% - birth through age 5
- 60% - age 6 to age 10 (start of 1st grade)
- 40% - age 11 to age 14 (start of 6th grade)
- 20% - age 15 to age 17

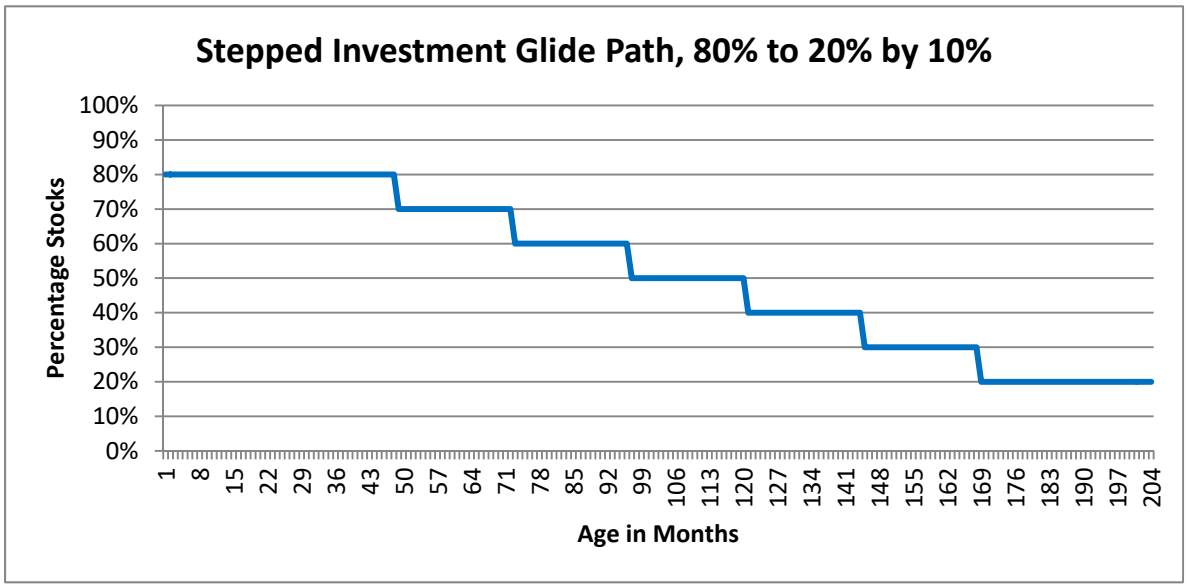
This investment glide path is illustrated in these charts, one measured in years and the other in months.





A variation on this stepped investment glide path used increments of 10% instead of 20% every two years or so after age 5:

- 80% - birth through age 4
- 70% - age 5 to age 6
- 60% - age 7 to age 8
- 50% - age 9 to age 10
- 40% - age 11 to age 12
- 30% - age 13 to age 14
- 20% - age 15 to age 17



Other variations start with an initial stock percentage of 75% or 100% and increments of 25%, terminating with either 0% or 25% of the money invested in stocks. For example, here is the Stepped 100% to 25% by 25% investment glide path:

- 100% - birth through age 5
- 75% - age 6 to age 10
- 50% - age 11 to age 14
- 25% - age 15 to age 17

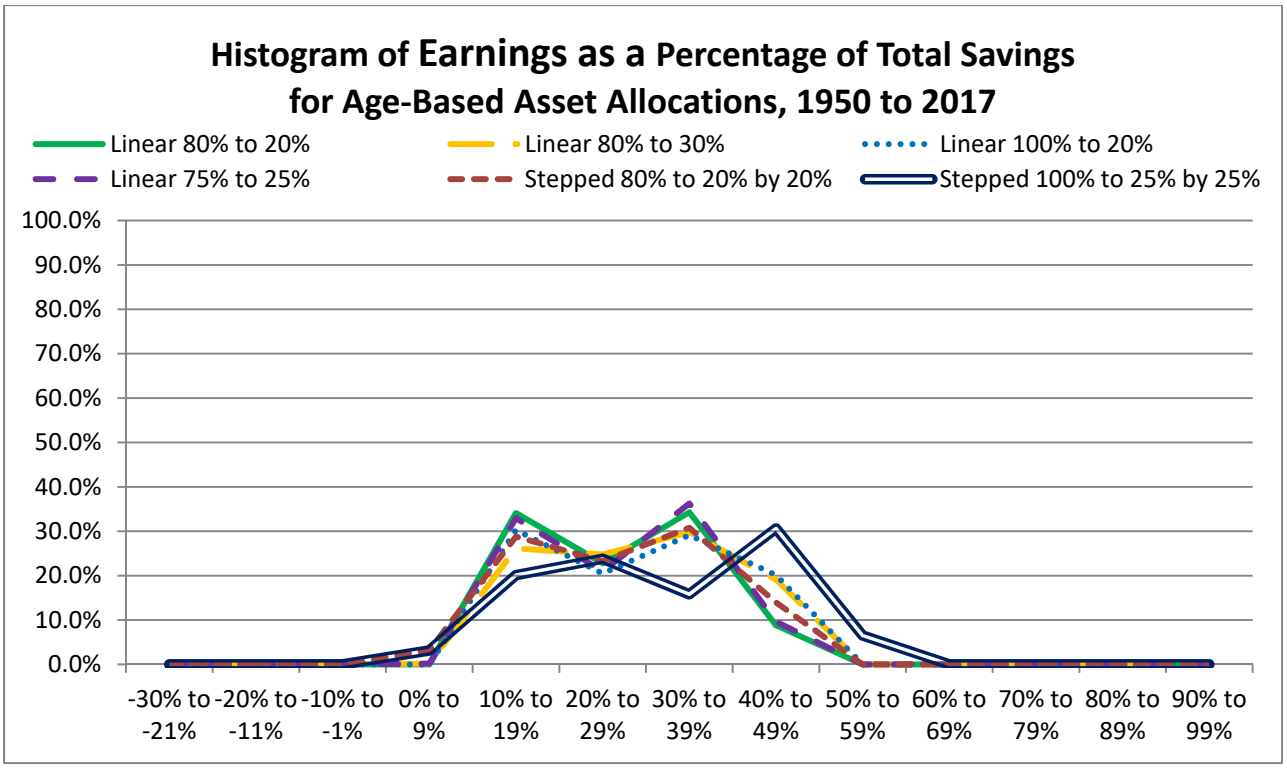
This table shows the return on investment for these investment glide paths. Increasing the initial or final percentage stocks in the asset allocation increases the average earnings and the percentage of total savings that comes from earnings, as does sustaining the initial percentage for a longer period of time.

Asset Allocation	Min	Max	Average	Standard Deviation	Equivalent Fixed Annual ROI	Average Earnings
Linear 80% to 20%	11.1%	44.3%	26.5%	9.6%	3.4%	$19,642
Linear 80% to 30%	8.4%	49.8%	28.9%	10.9%	3.8%	$22,487
Linear 100% to 20%	11.3%	48.5%	29.1%	11.0%	3.8%	$22,795
Linear 100% to 30%	10.9%	53.6%	31.4%	12.1%	4.1%	$25,790
Linear 75% to 25%	9.5%	46.1%	27.1%	9.9%	3.5%	$20,275
Stepped 80% to 20% by 20%	6.7%	46.5%	27.6%	10.6%	3.6%	$21,022
Stepped 80% to 20% by 10%	10.2%	44.2%	26.6%	9.7%	3.4%	$19,757
Stepped 75% to 0% by 25%	3.6%	36.2%	22.0%	8.7%	2.8%	$15,156
Stepped 100% to 25% by 25%	5.9%	53.6%	31.5%	12.7%	4.1%	$26,179

This table shows the risks associated with each investment glide path. The investment risk does not appear to vary much, except for the Stepped 75% to 0% by 25% investment glide path.

Asset Allocation	Min	% Negative	% < Safe (8.2%)	% Earnings < 25%
Linear 80% to 20%	11.1%	0.0%	0.0%	48.1%
Linear 80% to 30%	8.4%	0.0%	0.0%	44.9%
Linear 100% to 20%	11.3%	0.0%	0.0%	41.6%
Linear 100% to 30%	10.9%	0.0%	0.0%	39.6%
Linear 75% to 25%	9.5%	0.0%	0.0%	47.8%
Stepped 80% to 20% by 20%	6.7%	0.0%	0.8%	44.1%
Stepped 80% to 20% by 10%	10.2%	0.0%	0.0%	46.6%
Stepped 75% to 0% by 25%	3.6%	0.0%	5.7%	58.1%
Stepped 100% to 25% by 25%	5.9%	0.0%	1.5%	38.4%

This chart shows the distribution of these investment glide paths by the percentage of total savings attributable to earnings for all 17-year periods from 1950 to 2017. The distributions are similar, except that the Stepped 100% to 25% by 25% investment glide path is shifted toward higher percentage earnings, albeit also with a slight increase in the investment glide paths at the low percentage earnings end of the distribution. Besides the better performance of stepped glide paths over linear glide paths, glide paths that begin at 100% also seem to perform better without affecting risk significantly.



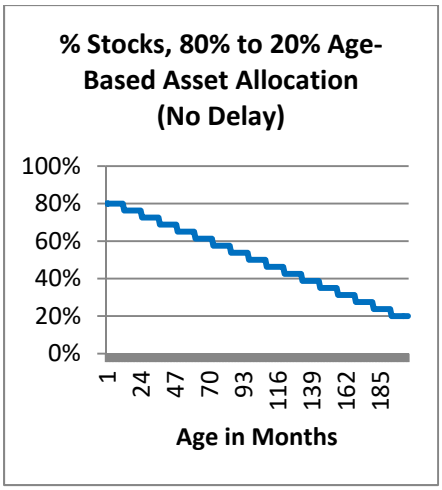
The stepped investment glide paths seem to perform better because they sustain an initial high percentage stocks for longer than the linear investment glide paths. The stepped investment glide paths maintain an aggressive investment posture for the first five years, instead of just one year. The linear investment glide paths move away from investments in stocks too soon.

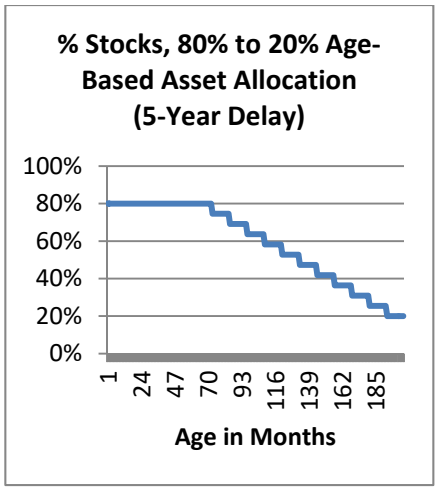
This suggests that one should explore the impact of delaying the onset of a linear age-based asset allocation on the performance of the investment glide path.

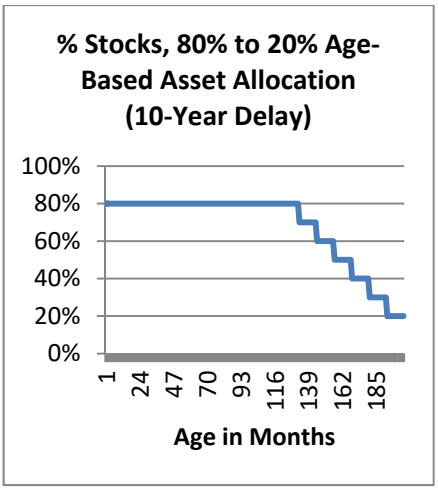
Delayed Onset of Age-Based Asset Allocation

Delaying the start of a shift from the initial percentage stocks by up to 10 years can increase the equivalent fixed annual ROI by as much as a percentage point without appreciably increasing the risk. This can add thousands of dollars to the investment returns.

These charts illustrate the investment glide paths for a Linear 80% to 20% age-based asset allocation with a delayed onset of 0, 5 and 10 years.







This table shows the impact on investment performance of a delayed onset of the shift to a more conservative investment allocation. It presents data for a delayed onset of 0, 5 and 10 years.

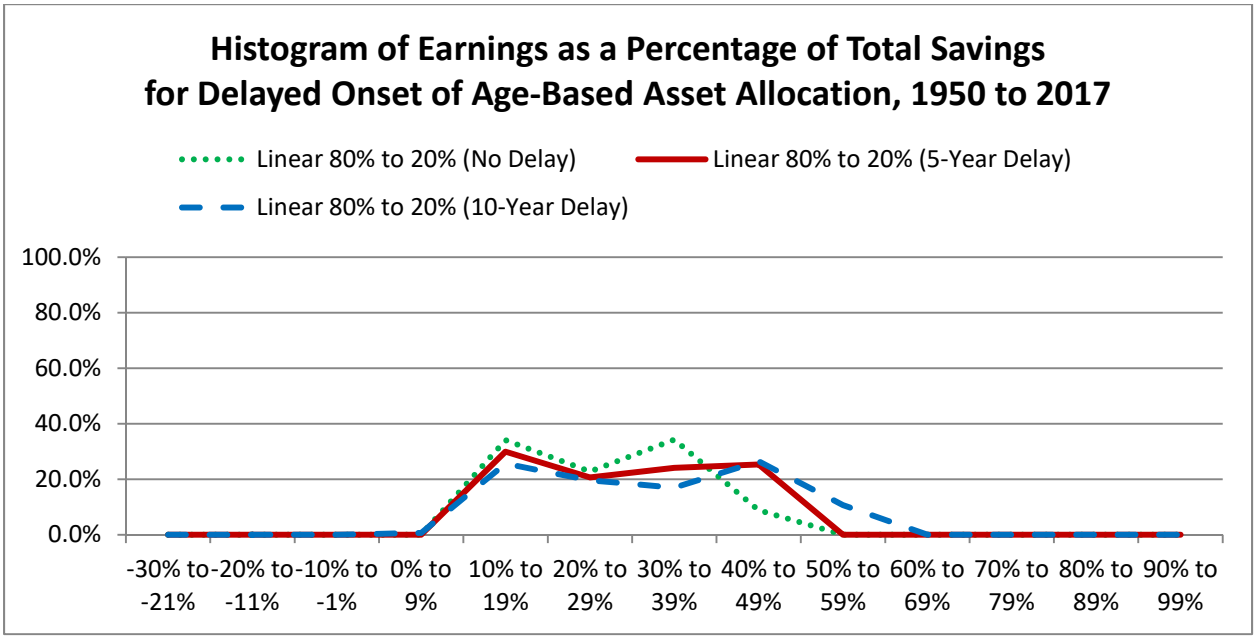
Asset Allocation	Delayed Onset	Min	Max	Average	Standard Deviation	Equivalent Fixed Annual ROI	Average Earnings
Linear 80% to 20%	**No Delay**	11.1%	44.3%	26.5%	9.6%	3.4%	$19,642
Linear 80% to 20%	**5 years**	10.9%	49.0%	29.5%	11.4%	3.9%	$23,302
Linear 80% to 20%	**10 years**	8.9%	55.9%	32.8%	14.0%	4.4%	$28,438
Linear 80% to 30%	**No Delay**	8.4%	49.8%	28.9%	10.9%	3.8%	$22,487
Linear 80% to 30%	**5 years**	10.8%	53.3%	31.2%	12.2%	4.1%	$25,662
Linear 80% to 30%	**10 years**	9.5%	58.4%	33.9%	14.3%	4.5%	$30,057
Linear 100% to 20%	**No Delay**	11.3%	48.5%	29.1%	11.0%	3.8%	$22,795
Linear 100% to 20%	**5 years**	10.8%	54.2%	32.8%	13.4%	4.3%	$28,045
Linear 100% to 20%	**10 years**	7.5%	62.6%	36.6%	16.5%	5.0%	$35,522
Linear 100% to 30%	**No Delay**	10.9%	53.6%	31.4%	12.1%	4.1%	$25,790
Linear 100% to 30%	**5 years**	11.0%	58.1%	34.4%	14.0%	4.6%	$30,569
Linear 100% to 30%	**10 years**	8.4%	64.6%	37.6%	16.7%	5.1%	$37,284
Linear 75% to 25%	**No Delay**	9.5%	46.1%	27.1%	9.9%	3.5%	$20,275
Linear 75% to 25%	**5 years**	11.0%	49.9%	29.5%	11.4%	3.8%	$23,330
Linear 75% to 25%	**10 years**	9.5%	55.4%	32.3%	13.5%	4.3%	$27,572

As this table demonstrates, the investment performance of the Linear 80% to 20% investment glide path improves as the delayed onset increases. A 5-year delay increases the equivalent fixed annual interest rate by 0.5% and the return on investment by $3,660. A 10-year delay increases the equivalent fixed annual interest rate by 1.0% and the return on investment by $8,796. The Linear 80% to 20% investment glide path with a 5-year delayed onset has superior performance to the Stepped 80% to 20% by 20% glide path, with a 0.3% higher equivalent fixed annual interest rate and a $2,280 higher return.

This table shows the change in the risks associated with delayed onset. It demonstrates that the change in risk is negligible. The risks associated with a 5-year delay in the Linear 80% to 20% investment glide path are also lower than for a Stepped 80% to 20% by 20% investment glide path.

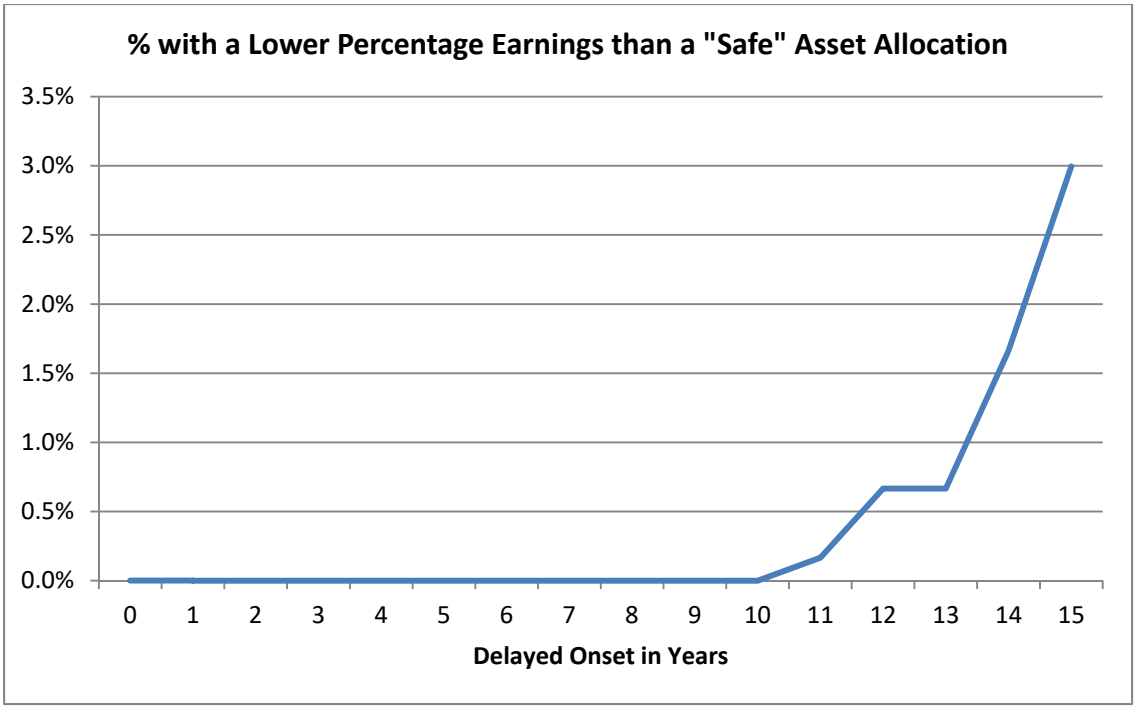
Asset Allocation	Delayed Onset	Min	% Negative	% < Safe (8.2%)	% Earnings < 25%
Linear 80% to 20%	**No Delay**	11.1%	0.0%	0.0%	48.1%
Linear 80% to 20%	**5 years**	10.9%	0.0%	0.0%	41.8%
Linear 80% to 20%	**10 years**	8.9%	0.0%	0.0%	37.3%
Linear 80% to 30%	**No Delay**	8.4%	0.0%	0.0%	44.9%
Linear 80% to 30%	**5 years**	10.8%	0.0%	0.0%	39.8%
Linear 80% to 30%	**10 years**	9.5%	0.0%	0.0%	36.4%
Linear 100% to 20%	**No Delay**	11.3%	0.0%	0.0%	41.6%
Linear 100% to 20%	**5 years**	10.8%	0.0%	0.0%	36.4%
Linear 100% to 20%	**10 years**	7.5%	0.0%	0.5%	32.3%
Linear 100% to 30%	**No Delay**	10.9%	0.0%	0.0%	39.6%
Linear 100% to 30%	**5 years**	11.0%	0.0%	0.0%	33.9%
Linear 100% to 30%	**10 years**	8.4%	0.0%	0.0%	31.6%
Linear 75% to 25%	**No Delay**	9.5%	0.0%	0.0%	47.8%
Linear 75% to 25%	**5 years**	11.0%	0.0%	0.0%	42.6%
Linear 75% to 25%	**10 years**	9.5%	0.0%	0.0%	38.1%

This chart shows the impact of 0-year, 5-year and 10-year delayed onsets on the distribution of investment glide paths by the percentage of total savings attributable to earnings on a Linear 80% to 20% investment glide path for all 17-year periods from 1950 to 2017. It demonstrates that a 5-year delay performs better than no delay, and a 10-year delay performs better than a 5-year delay.



The risk associated with an investment glide path can be approximated by reporting the percentage of 204-month periods (17-year periods) from 1950 to 2017 in which the investment glide path had a lower return on investment than a safe Level 0% asset allocation.

This chart shows the impact of the delayed onset of a Linear 80% to 20% investment glide path on the percentage of 17-year periods with a return on investment that is less than that of the safe Level 0% asset allocation. As the chart demonstrates, the risk starts increasing with a delayed onset of 11 or more years.



Graphs of the impact of delayed onset on other investment glide paths are similar, with performance on all 17-year periods exceeding that of a safe Level 0% investment glide path up until 9-11 years of delayed onset.

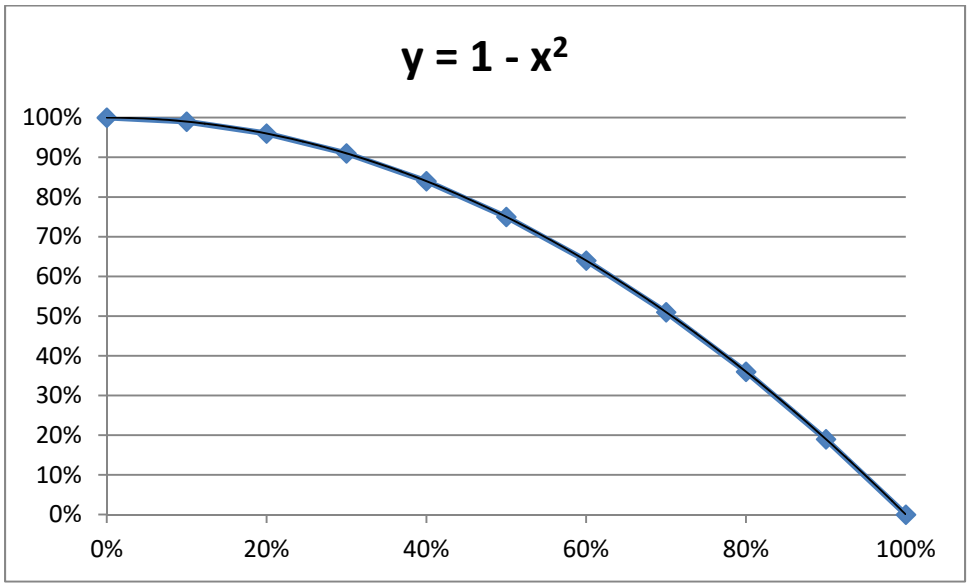
Other Age-Based Asset Allocations

There are several other investment glide paths that could be considered:

- $y = 1 - x^2$ is a convex curve that starts off at 100% stocks and gradually decreases to 0% stocks
- $y = 80\% - 60\% * x^2$ is a convex curve that starts off at 80% and gradually decreases to 20% stocks
- Inverse 20% to 80% is like the Linear 80% to 20% age-based asset allocation, but starts off at 20% and increases to 80%, instead of decreasing from 80% to 20%
- PPY[7] 100% to 20% remains at 100% aggressive investments from birth to age 14, then switches to 100% conservative investments for ages 15-17

[7] PPY stands for prior-prior year, which bases the income and assets on financial aid application forms on the federal income tax returns from two years ago. Accordingly, when applying for financial aid for the freshman year in college, one wants to avoid realizing capital gains after January 1 of the sophomore year in high school. This

This chart illustrates the $y = 1 - x^2$ curve.



This table shows the return on investment for these four investment glide paths.

Asset Allocation	Min	Max	Average	Standard Deviation	Equivalent Fixed Annual ROI	Average Earnings
$y = 1 - x^2$ [100% to 0%]	10.3%	50.5%	30.5%	12.8%	4.0%	$25,022
$y = 80\% - 60\% * x^2$ [80% to 20%]	11.0%	51.3%	30.3%	11.9%	4.0%	$24,370
Inverse 20% to 80%	-24.8%	62.1%	31.4%	16.1%	4.1%	$27,721
PPY 100% to 20% (0-14 / 15-17)	-14.4%	67.0%	36.7%	18.6%	5.0%	$37,220

This table shows the risks associated with these investment glide paths. The inverse and PPY glide paths demonstrate significant risks, while the convex curves demonstrate performance that is similar to linear age-based asset allocations.

Asset Allocation	Min	% Negative	% < Safe (8.2%)	% Earnings < 25%
$y = 1 - x^2$ [100% to 0%]	10.3%	0.0%	0.0%	37.9%
$y = 80\% - 60\% * x^2$ [80% to 20%]	11.0%	0.0%	0.0%	41.4%
Inverse 20% to 80%	-24.8%	3.2%	7.7%	32.6%
PPY 100% to 20% (0-14 / 15-17)	-14.4%	2.5%	6.3%	29.5%

investment glide path sells all investments prior to this year to avoid artificially increasing income with capital gains.

Innovations

This paper introduces several innovations that can be applied to saving for college, retirement and other life-cycle events.

- It increases the return on investment for an investment glide path without significantly increasing the investment risk by transforming the investment glide path.

- It transforms an investment glide path by delaying the onset of the shift to a less aggressive mix of investments by a number of years and compressing the original glide path to fit into the remaining available investment horizon.

- It demonstrates that a delayed onset of 5 years yields the equivalent of a 0.5% percentage point increase in the average return on investment.

- It demonstrates that a delayed onset of 10 years yields the equivalent of a 1.0% percentage point increase in the average return on investment.

- It demonstrates a monotonic increase in return on investment for a 17-year age-based asset allocation for each year of delayed onset from 0 to 10 years.

- It demonstrates that the investment risk starts to increase significantly with 11 or more years of delayed onset.

- It develops a computer model for developing, evaluating and validating investment glide paths by evaluating the return on investment for a glide path on all available historical stock market performance data. It then analyzes the distribution of the return on investment for all time periods to identify likely, best-case and worst-case performance thresholds, as well as the percentage of the trials that fall below certain desirable performance thresholds. These thresholds include those associated with investment losses (e.g., below a zero return on investment) and those associated with a risk-free return on investment. Although past performance is not necessarily predictive of future performance, the distribution of performance on all past time periods may represent a reasonable indication of the range of likely future performance.

- This paper analyzes a variety of investment glide paths using 600 trials based on all 17-year (204-month) contiguous periods from 1950 to 2017. It identifies several investment glide paths that demonstrate superior investment performance when compared with the most popular investment glide paths without significantly increasing investment risk.

- It demonstrates that starting an age-based asset allocation at 100% stocks when the child is young instead of a smaller percentage (e.g., 80%) yields superior investment returns without significantly affecting investment risk.

Recommendations

The following recommendations can improve investment performance within an age-based asset allocation in college savings plans without significantly increasing risk.

> **Recommendation:** Delay the onset of the age-based asset allocation strategy by as many as 10 years, maintaining a static aggressive asset allocation until the transition to an age-based asset allocation. A 5-year delay will increase the equivalent rate of return by as much as half a percentage point. A 10-year delay will increase the equivalent rate of return by as much as a full percentage point.
>
> **Recommendation:** Begin the asset allocation with 100% of the portfolio invested in stocks, instead of a lower percentage like 80%. Starting off at 80% stocks is too conservative, without significantly reducing the risk of loss.
>
> **Recommendation:** Consider ending the asset allocation with 30% of the portfolio invested in stocks, instead of a lower percentage like 20%. There is some concern that this may yield too high a risk as college approaches. After all, a bear market in which the stock market drops by 40% will contribute an 8% net loss with 20% of the portfolio invested in stocks and a 12% net loss with 30% of the portfolio invested in stocks. But, historical stock market data suggests that the risk is rare.

Similar strategies should also be effective for optimizing the performance of target date funds for retirement savings and other life-cycle events.