Data Dependence and Sustainable Real Withdrawal Rates

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"The only certainty is that nothing is certain."
— Gaius Plinius Secundus

Executive Summary

- Past research on sustainable real withdrawal rates has been overwhelmingly based on past market returns. Such research ignores the possibility, and consequently the implications, that future market conditions will vary from those in the past.
- This paper will explore the impact of varying returns and standard deviations on a distribution portfolio in order to provide the reader with information on appropriate sustainable real withdrawal rates for various market conditions.
- Experts predict that the future market return for a balanced 60/40 portfolio is likely to be 1–2 percent less than historical averages.
- Over longer distribution periods the return of a portfolio becomes increasingly important in maintaining the likelihood of success of a distribution portfolio. A 1 percent decrease in portfolio return is likely to result in an increase in the probability of failure that is approximately 4 times greater than a 1 percent increase in portfolio standard deviation.

In an effort to determine the sustainable withdrawal rate for any distribution portfolio, many assumptions need to be made, such as life expectancy, inflation, market returns, and spending levels. Each of these assumptions is going to affect the results of a distribution analysis to varying degrees. Previous research on sustainable real withdrawal rates has been overwhelmingly based on the assumption that past market conditions are reasonable proxies for future market conditions (or those that will be experienced by retirees). While this assumption is far from unreasonable, it ignores the possibility, and consequently the implications, that future market conditions will vary from those in the past. This paper will explore the impact of varying returns and standard deviations on a distribution portfolio in order to provide the reader with information on appropriate sustainable real withdrawal rates for various market conditions.

Past Research

There is an increasing body of literature dedicated to distribution planning. Bengen (1994) is widely regarded as the first to formally address the issue of sustainable real withdrawal rates from a retiree's perspective. In his piece "Determining Withdrawal Rates Using Historical Data," Bengen found that a "first year withdrawal rate of 4 percent, followed by inflation-adjusted withdrawals in subsequent years, should be safe. In no past case has it caused a portfolio to be exhausted before 33 years." While the safety of a 4 percent real withdrawal rate has been noted in countless other studies, the title of his original research paper explicitly states one of its key limitations ("… Using Historical Data"): its reliance on past data.

A review of other distribution studies, such as those by Cooley, Hubbard, and Walz (1998); Bengen (2001); Tezel (2004); Cassaday (2006); Guyton and Klinger (2006); Robinson (2007); as well as those by one of this article's authors, Blanchett (2007), are all based on historical data. While historical data provides useful insight into what returns a retiree may experience, there is no certainty that the

distribution period will look anything like the test historical period of past research.

While the historical time periods used in past studies have varied, the two most common periods used have been the last 35 years and the last 80 years. The last 35 years is a common span in distribution research because a wider array of asset category returns are available with which to construct portfolios (versus longer historical periods). Because limited data is available on more precise asset categories going back 80 years (for example, domestic real estate), it would be difficult, if not impossible, to test the efficiency of more precise portfolio allocations over the last 80 years. The authors would caution readers, though, from relying too heavily on precise historical allocations (such as Cassaday (2006)), due to the implications of hindsight bias.

The last 80 years is also a common time period in distribution research because it represents a longer period with which to gauge the potential returns a retiree will experience in retirement. Using the last 80 years also allows a researcher to determine how a portfolio would have actually performed for a client had it been implemented during the historical period (for example, from 1973 to 2002). But the limited number of test periods that exist because of the few years available (80 or so) limit the robustness of these types of tests.

Table 1 includes information on the different nominal and real rates of return for a variety of asset categories and portfolios over the last 35 and 80 calendar years. Data definitions are included in endnote 1 and the underlying portfolio allocations are listed in endnote 2. The historical data in Table 1 has been adjusted into "real" terms by subtracting the increase in the Consumer Price Index for All Urban Consumers (CPI-U) for the respective period.[3] However, the CPI-U has been included in Table 1 for each period as a reference.

As the reader can see from Table 1, while the two periods were similar, there were notable differences. The returns were uniformly higher over the last 35 years versus the last 80 years, and the standard deviations tended to be lower for the 35-year period. This creates a misleading scenario when determining the sustainable real withdrawal rate, since studies based on higher portfolio returns and lower portfolio variability (for example, the last 35 years) are likely to suggest higher sustainable withdrawal rates than those based on lower portfolio returns and higher portfolio variability (for example, the last 80 years). Note, though, that the historical periods for distribution studies are always being updated as more

Table 1: Historical Return Comparison

Historical Annualized Real Returns: 1927 – 2006 (Last 80 Calendar Years)						
	Real Return			Nominal Return		
	Geometric Average	Arithmetic Average	Standard Deviation	Geometric Average	Arithmetic Average	Standard Deviation
Cash	0.72%	0.81%	4.10%	3.87%	3.91%	3.18%
Intermediate-term Bond	2.97%	3.11%	5.37%	6.18%	6.25%	3.89%
Large Blend Equity	7.33%	9.45%	20.96%	10.66%	12.85%	21.23%
International Equity	5.16%	7.25%	21.59%	8.43%	10.50%	21.72%
20/80 Portfolio	3.09%	3.23%	5.55%	6.30%	6.40%	4.76%
40/60 Portfolio	4.24%	4.57%	8.28%	7.48%	7.78%	7.92%
60/40 Portfolio	5.30%	5.94%	11.62%	8.58%	9.20%	11.48%
80/20 Portfolio	6.28%	7.35%	15.21%	9.58%	10.66%	15.21%
CPI (Inflation)	3.09%	3.18%	4.27%			
Historical Annualized Real Returns: 1972 – 2006 (Last 35 Calendar Years)						
	Real Return			Nominal Return		
	Geometric Average	Arithmetic Average	Standard Deviation	Geometric Average	Arithmetic Average	Standard Deviation
Cash	1.43%	1.46%	2.68%	6.15%	6.20%	3.07%
Intermediate-term Bond	4.30%	4.44%	5.44%	9.16%	9.23%	4.03%
Large Blend Equity	8.10%	9.35%	16.28%	13.15%	14.32%	16.30%
International Equity	6.75%	8.92%	22.00%	11.75%	13.83%	21.97%
20/80 Portfolio	4.01%	4.14%	5.20%	8.85%	8.93%	4.18%
40/60 Portfolio	5.09%	5.36%	7.51%	9.99%	10.19%	6.71%
60/40 Portfolio	6.11%	6.61%	10.16%	11.06%	11.47%	9.59%
80/20 Portfolio	7.06%	7.86%	12.95%	12.06%	12.77%	12.60%
CPI (Inflation)	4.65%	4.70%	3.21%			
Difference in Periods: 80–Year Real Returns Minus 35–Year Real Returns						
	Real Return			Nominal Return		
	Geometric Average	Arithmetic Average	Standard Deviation	Geometric Average	Arithmetic Average	Standard Deviation
Cash	-0.71%	-0.66%	1.43%	-2.29%	-2.28%	0.11%
Intermediate-term Bond	-1.33%	-1.33%	-0.06%	-2.98%	-2.98%	-0.14%
Large Blend Equity	-0.76%	0.09%	4.69%	-2.49%	-1.47%	4.93%
International Equity	-1.59%	-1.67%	-0.41%	-3.32%	-3.33%	-0.26%
20/80 Portfolio	-0.92%	-0.90%	0.36%	-2.56%	-2.53%	0.58%
40/60 Portfolio	-0.85%	-0.80%	0.77%	-2.51%	-2.41%	1.21%
60/40 Portfolio	-0.81%	-0.67%	1.46%	-2.48%	-2.28%	1.89%
80/20 Portfolio	-0.78%	-0.51%	2.26%	-2.48%	-2.11%	2.61%
CPI (Inflation)	-1.56%	-1.52%	1.05%			

recent return data is being added on when it becomes available (for example, data for 2007). Because there is not one uniform test period, results of different studies will invariably be affected by different historical test periods.

Rolling 20-Year Historical Periods

While an 80-year average return provides useful information about the likely long-term return that will be experienced by a retiree, each retiree is going to experience a different average return based on his or her unique distribution period. Because there is no one set distribution period, different investors will inevitably experience different market returns. Those lucky enough to experience above-average returns will likely be able to enjoy a higher-than-average sustainable real withdrawal rate, while those who experience below average returns will likely need to decrease their sustainable real withdrawal rate in order to avoid portfolio ruin.

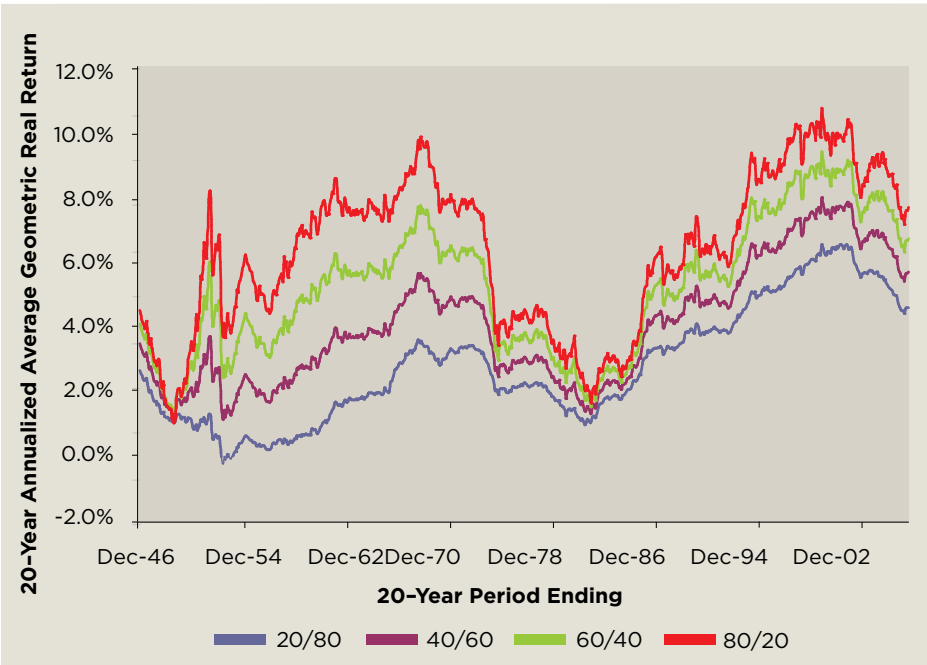
Figure 1 includes 20-year rolling annualized geometric real returns for four balanced portfolios (20/80, 40/60, 60/40, and 80/20). The allocations of the portfolios are included in note 2, while the data definitions are included in note 1.

The range of 20-year returns for the balanced portfolios over the last 80 years was significant: 5.86 percent (–.52 percent to 6.38 percent) for the 20/80 portfolio, 6.99 percent (.87–7.86 percent) for the 40/60 portfolio, 8.29 percent (1.00–9.28 percent) for the 60/40 portfolio, and 9.88 percent (.77–10.64 percent) for the 80/20 portfolio. These differences highlight the importance of considering various return scenarios when determining the sustainable real withdrawal rate for a retiree.

Similar to Figure 1, Figure 2 includes information for four balanced portfolios over the last 80 years. But instead of including information on the 20-year annualized average geometric real returns, Figure 2 includes information on the 20-year annualized standard deviations for the portfolios.

The 20-year standard deviations in Figure 2 exhibit a greater degree of relative stability when compared with the 20-year returns in Figure 1. Following the steep decrease in standard deviations in the initial periods, standard deviations showed a high level of consistency, despite the large variation in portfolio returns.

Figure 1: 20-Year Rolling Annualized Average Geometric Real Returns: 1927 – 2006



What About the Future?

As we all know, future market conditions are anything but certain, and accurately predicting the future is a difficult task. Despite this, forecasting the future is an essential component of any financial plan. These estimates typically are based on both what happened in the past and what is expected to happen in the future. In an attempt to estimate future market conditions, the authors reviewed predictions from a variety of experts. While the forecasted period varied among experts, the average was for approximately the next 20 years. This information is included in Table 2.

While the experts differed in their precise opinions, the consensus was that future market returns are likely to be lower than historical averages. The average future expected real return for equities, according to the forecasts included in Table 2, was 5.2 percent. Based on an average expected equity premium of 2.6 percent, the implicit real rate of return for fixed income was 2.6 percent. This suggests a future real return of 4.1 percent for a 60/40 portfolio. If these forecasts hold, the future return for a balanced 60/40 portfolio is likely to be somewhere between 1 to 2 percent less than historical averages.

The distribution of future market returns (that is, variability) is much more difficult to forecast than returns. While short-term definitions to approximate future market volatility exist, such as the Chicago Board Options Exchange's Volatility Index (or VIX), the authors were not able to find suitable long-term market variability projections. But as the reader will see in the "Analysis" section of this paper, returns have a much greater impact on the sustainability of a distribution portfolio than variability (standard deviation).

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Figure 2: 20-Year Rolling Annualized Standard Deviations: 1927 – 2006

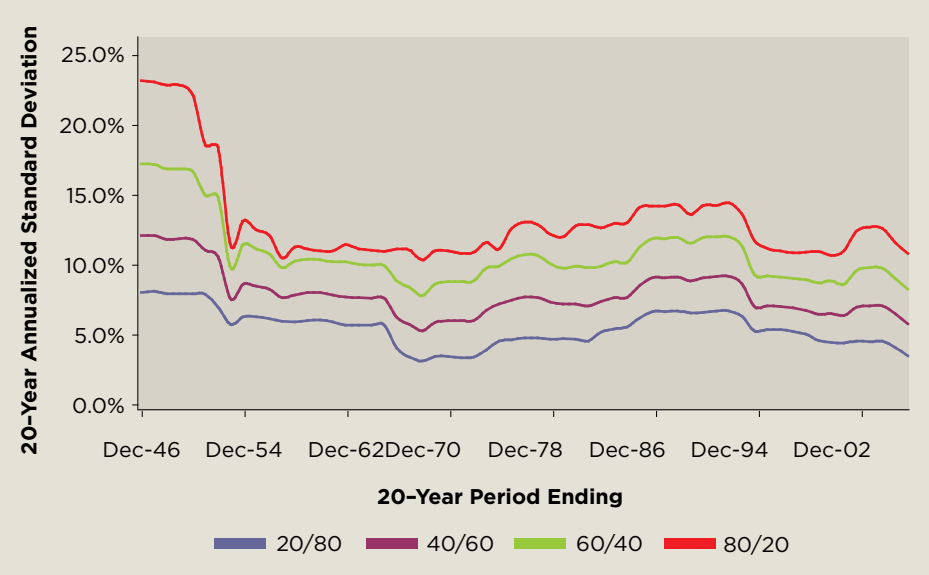

Table 2: Future Forecasted Equity Returns by a Variety of Experts

Study	Real Equity Returns	Equity Risk Premium
O'Shaughnessy (2007) – Historical	3.0–5.0%	
O'Shaughnessy (2007) – Various Models	4.0–7.0%	
Seigel (2006)	6.0%	4.0%
Neiderhoffer and Castaldo (2004)	6.3%	
Dimson, Marsh, and Staunton (2004)	5.0%	3.0%
Ibbotson and Chen (2003)*	2.36%	0.24%
Ibbotson and Chen (2003)**	6.29%	3.97%
Arnott and Bernstein (2002)	2.0–4.0%	0.0%
Welch (2001)		5.5%
Campbell, Diamond, and Shoven (2001) – Campbell[g]	5.0–5.5%	1.5–2.5%
Campbell, Diamond, and Shoven (2001) – Campbell[a]	6.5–7.0%	3.0–4.0%
Campbell, Diamond, and Shoven (2001) – Diamond	6.0–6.5%	1.0–1.5%
Campbell, Diamond, and Shoven (2001) – Shoven	6.0–6.5%	2.5–3.0%
Approximate Average	**5.2%**	**2.6%**

	Real Returns
Implicit Bond Return Based on the Equity Premium	2.6%
Estimated Return of a 60/40 Portfolio	4.1%

* Using forward-looking earnings
** Using forward-looking dividends
g = geometric
a = arithmetic

Analysis

The analysis focused on two key assumptions necessary for any type of distribution analysis: portfolio return and portfolio variability. To test the impact of changing these two variables on a distribution portfolio, a 10,000-run Monte Carlo simulator was built in Microsoft Excel, where returns and standard deviations could be adjusted to test different potential scenarios.

For the analysis, returns are considered to be in "real" terms, such that the annual distribution rate remains constant over time and the impact of inflation can therefore be ignored. Each run is considered successful if it did not run out of money during the distribution period. Ending portfolio balance was not considered. Taxes and rebalancing costs were also ignored (more on taxes later).

In the interest of simplicity, it is assumed that the returns followed a normal distribution. While numerous studies have shown that market returns are non-normal (exhibiting both skewness and kurtosis to varying degrees), assuming a normal distribution better enables practitioners to recreate this analysis. Also, the purpose of this analysis is not to create concrete rules regarding distribution rates (as an infinite number of combinations exist and the future is unknown); rather, it is to provide insight regarding the sensitivity of the assumptions when determining a sustainable withdrawal rate from a distribution portfolio.

Importance of Using Geometric Averages

A key assumption in this analysis is the use of the geometric average return (versus the use of the arithmetic average return).[4] The differences between the two averaging methods can have serious implications when considering a wide array of potential returns and standard deviations. For example, if an investment had a 10 percent average return with a 10 percent standard deviation, the return one standard deviation above the mean (or average) would be 20 percent and the return one standard deviation below the mean would be 0 percent. Both of these returns are equally probable based on a normal distribution. The arithmetic average of the two returns is 10 percent ((20% + 0%) / 2), while the geometric average is 9.54 percent ((1.2 * 1.0)-.5).

To continue the example, if the standard

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deviation of the investment increased to 20 percent (assuming the same mean return of 10 percent), the geometric mean would decrease to 8.17 percent, while the arithmetic average return would stay the same (10 percent). Therefore, the higher the standard deviation, the greater the difference between geometric and arithmetic averages.

> "Over longer periods, returns will have a much greater impact on the probability of success for a distribution portfolio versus the standard deviation."

If one were to do a distribution study with varying standard deviations based on the arithmetic mean, those tests with higher standard deviations would also be accompanied by lower geometric average returns. This would make it difficult to determine whether the resulting success probabilities were a result of higher standard deviations or lower geometric real returns. Because this analysis is based on geometric returns, changing the standard deviation of a portfolio does not affect the portfolio's return, only its standard deviation (thereby eliminating the confounding effects when using arithmetic average returns).

Results

Different geometric real returns and annualized standard deviations had a considerable impact on the sustainable real withdrawal rate available from a distribution portfolio. Table 3 includes a variety of scenarios based on a 4 percent real withdrawal rate. A 4 percent rate has widely been considered the "safe" real withdrawal rate; however, its safety is highly dependent on underlying returns and variability of portfolio. Appendices 1–4 include the results for real distribution rates of 3, 5, 6, and 7 percent, respectively.

Based on the information in Table 1, a 60/40 portfolio has historically had an approximately 6 percent geometric real return and an 11 percent annualized standard deviation (highlighted yellow in Table 3). This corresponds to a 3.53 percent probability of failure for a 4 percent real withdrawal rate. If the geometric return were to decrease by 1 percent from the historical average (6 percent real to 5 percent real), the probability of failure would increase from 3.53 percent to 7.35 percent. If the standard deviation were to increase by 1 percent (from 11 percent to 12 percent) the probability of failure would increase from 3.53 percent to 4.92 percent.

After reviewing the information in Table 3, as well as Appendices 1–4, a trend should become relatively clear to the reader: a 1 percent decrease in real return tends to have a much greater impact on the probability of failure than a 1 percent increase in standard deviation. In fact, the average magnitude of the difference between a 1 percent return reduction and a 1 percent increase in standard deviation was approximately four. Stated differently, a 1 percent decrease in return is likely to

Table 3: Probability of Failure for a Variety of Scenarios Based on a 4% Real Distribution Rate and a 30-Year Distribution Period

Annual Standard Deviation	Geometric Real Return										
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	Range
3.00%	97.89%	67.80%	15.35%	0.68%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**97.89%**
4.00%	93.31%	63.87%	21.89%	3.20%	0.14%	0.00%	0.00%	0.00%	0.00%	0.00%	**93.31%**
5.00%	88.42%	61.31%	26.90%	6.77%	0.92%	0.10%	0.00%	0.00%	0.00%	0.00%	**88.42%**
6.00%	84.13%	59.68%	30.66%	10.59%	2.53%	0.40%	0.06%	0.00%	0.00%	0.00%	**84.13%**
7.00%	80.60%	58.63%	33.25%	14.60%	4.76%	1.09%	0.19%	0.05%	0.00%	0.00%	**80.60%**
8.00%	77.68%	57.78%	35.47%	18.09%	7.08%	2.30%	0.59%	0.13%	0.04%	0.00%	**77.68%**
9.00%	75.34%	57.16%	37.18%	20.55%	9.41%	3.88%	1.29%	0.34%	0.10%	0.04%	**75.30%**
10.00%	73.25%	56.64%	38.55%	22.97%	12.19%	5.64%	2.27%	0.80%	0.23%	0.08%	**73.17%**
11.00%	71.30%	56.24%	39.84%	25.18%	14.77%	7.35%	3.53%	1.43%	0.53%	0.15%	**71.15%**
12.00%	70.05%	56.01%	40.84%	27.36%	17.11%	9.12%	4.92%	2.30%	0.97%	0.36%	**69.69%**
13.00%	68.73%	55.75%	41.76%	28.99%	19.12%	11.04%	6.23%	3.23%	1.56%	0.67%	**68.06%**
14.00%	67.71%	55.49%	42.54%	30.53%	20.84%	13.28%	7.68%	4.41%	2.34%	1.11%	**66.60%**
15.00%	66.84%	55.42%	43.28%	31.92%	22.33%	15.18%	9.16%	5.62%	3.17%	1.71%	**65.13%**
Range	**31.05%**	**12.38%**	**27.93%**	**31.24%**	**22.33%**	**15.18%**	**9.16%**	**5.62%**	**3.17%**	**1.71%**	

Historical Balanced Portfolios

20/80 Portfolio | 60/40 Portfolio | 40/60 Portfolio | 80/20 Portfolio

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result in a change in the probability of failure that is four times greater than the change that would result from a 1 percent increase in the standard deviation. This relationship is one that Brayman (2007) noted previously.

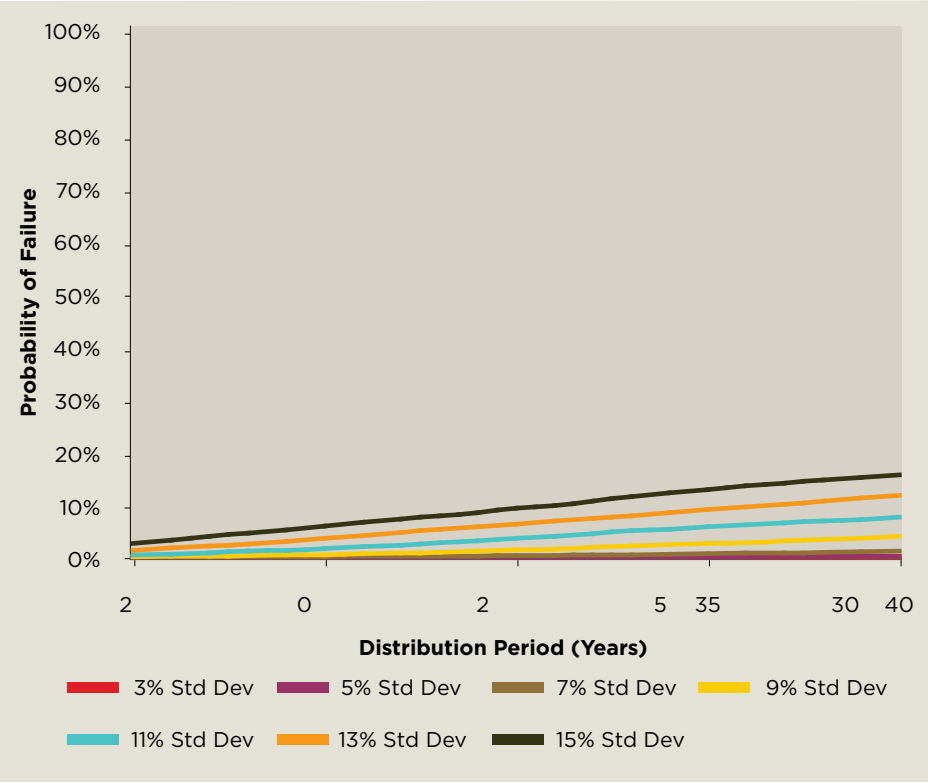
Returns Matter Even More than Standard Deviation over Longer Periods

The information in Table 3 as well Appendices 1–4 is based on a 30-year distribution period. But over longer distribution periods, the portfolio return becomes increasingly important relative to standard deviation. Figure 3 includes information on the probabilities of failure for a variety of distribution periods with varying standard deviations with a 4 percent real withdrawal rate and a 6 percent geometric real return (the long-term average of the 60/40 portfolio) for distribution periods of 20 to 40 years (in one-year increments).

Notice that over longer distribution periods the difference in the probability of failure across different standard deviations increases slightly, although at a constant rate. Contrast the impact of varying standard deviations in Figure 3 with Figure 4, which includes the probabilities of failure for a variety of distribution periods with real returns with a 4 percent real withdrawal rate and an 11 percent annualized standard deviation (the long-term average of the 60/40 portfolio) for distribution periods of 20 to 40 years (in one-year increments).

Figures 3 and 4 demonstrate that the relative importance of a portfolio's standard deviation and return clearly change over time. Over longer periods, returns will have a much greater impact on the probability of success for a distribution portfolio versus the standard deviation. Chopra and Ziemba (1991) noted this effect when conducting research on the out-of-sample benefits of mean optimization (MVO). They found that of the three MVO inputs (returns, standard deviations, and correlations), risk tolerance errors in forecasted means were about 11 times more damaging than errors in forecasted variances (and over 20 times as damaging as errors in covariances). Returns are clearly the primary "drivers" behind the probability of success for a distribution portfolio and need to be cautiously approached when conducting a distribution analysis for a client.

Figure 3: Probabilities of Failure for a Variety of Distribution Periods: 4% Real Distribution Rate and 6% Geometric Real Return



Don't Forget Fees and Taxes

An additional consideration that must be incorporated into the sustainable withdrawal rate decision, even by "market optimists" (that is, those investment professionals who believe that unadjusted past market returns are good proxies for future returns) is the impact of investment fees and expenses on net returns of a portfolio. These costs will reduce the net return experienced by an investor. For example, if the total investment fees and expenses are 1 percent of assets, the return reduction experienced by a retiree is going to end up being 1 percent lower than the historical averages. The authors are not suggesting that financial planning professionals should not charge a reasonable fee for their services—far from it. But ignoring these costs will lead to an overly optimistic estimate of the probability of success for a distribution portfolio.

Taxes are also an important consideration when working with clients to determine a sustainable real withdrawal rate. For example, if a retiree has a $1 million portfolio and needs $40,000 in annual real income yet will be taxed at 20 percent for any distributions, the actual portfolio withdrawal would need to be $50,000, not $40,000 (since $10,000 will be lost to taxes). But while a 5 percent real distribution rate may not seem "dangerous," since a 5 percent real withdrawal from a 60/40 portfolio over 30 years has only a 13.40 percent probability of failure as shown in Appendix 2, once you subtract a 1 percent

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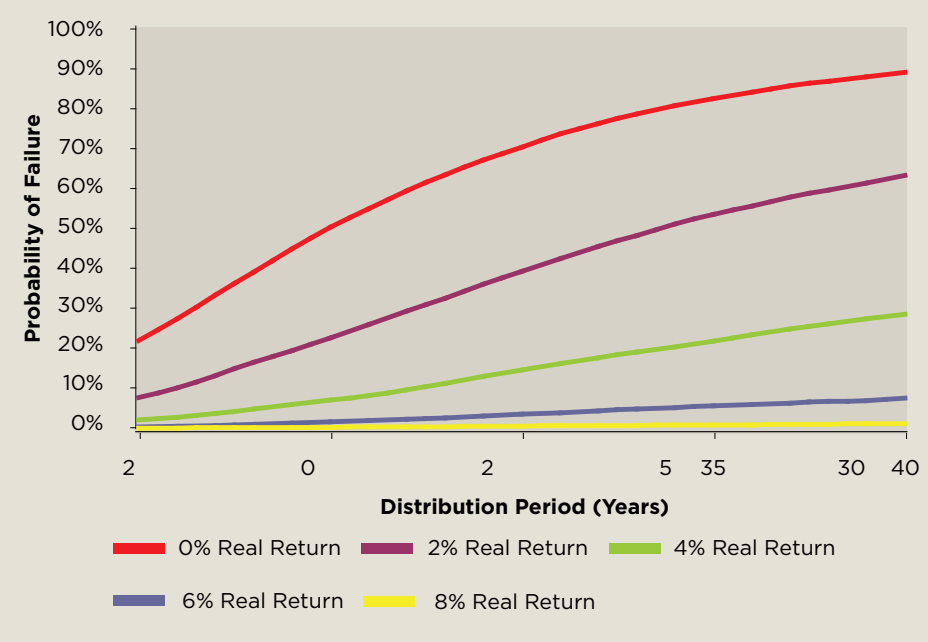
Figure 4: Probabilities of Failure for a Variety of Distribution Periods: 4% Real Distribution Rate and 11% Standard Deviation



advisor fee and combine that with an assumed reduction in future real return, the probability of failure dramatically increases over 30 years at the 5 percent withdrawal rate. For example, if you project a future return decline of 1–2 percent (for a total return reduction of 2–3 percent below historical averages when combined with the advisor fee), the probability of failure increases to 36.68 percent or 52.86 percent.

Pye (2001) noted that after fees and taxes a 4 percent withdrawal will likely only result in approximately 2.8 percent of income available to a retiree for spending purposes. While the exact impact of fees and taxes is going to differ considerably across investors, ignoring the potential impact of fees and taxes is a recipe for disaster for any distribution plan.

Conclusion

The acceptable probability of failure (or success) has varied in past distribution studies. Some authors use 90 percent, while others use 95 percent or even 99 percent. These levels of "certainty" can provide retirees with a false sense of security should future market conditions differ from those in the past. Experts predict that the future return for a 60/40 portfolio is likely to be between 1 and 2 percent less than historical return. Add advisor fees and mutual fund expenses, and the total return reduction realized by retirees is likely going to be between 1 and 4 percent.

The impact of lower potential future returns can have a considerable impact on the probability of success of a distribution portfolio. The possibility that future market returns will exhibit higher variability must also be considered, although the research conducted for this paper suggests that returns have a much greater impact on the probability of success for a distribution portfolio than standard deviation (by an approximate magnitude of four). In summary, recognizing that the future may differ from the past is an essential part of any distribution plan.

Endnotes

1. Data definitions:
   A. Cash: defined as the yield on the 3-month Treasury bill: secondary market rate, data obtained from Tradetools.com (1927–1933) and the St. Louis Federal Reserve (1934–2006): http://research.stlouisfed.org/fred2/.
   B. Intermediate-term bond: defined as the return on the Moody's Seasoned Aaa Corporate Bond Yield, assuming a ten-year duration. Data obtained from the St. Louis Federal Reserve Web site: http://research.stlouisfed.org/fred2/.
   C. Domestic large blend equity: defined as the return on the "Big Neutral" portfolio based on the 2 × 3 portfolio return information publicly available on Kenneth French's Web site: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.
   D. International equity: defined as the return on the Global Financial Data World ex-USA Return Index, data obtained from Global Financial Data.
2. For the portfolio allocations, the equity portion is assumed to be two-thirds domestic large equity and one-third international equity. For the non-equity portion, the allocation is split evenly between cash and intermediate-term bond. For example, a 60/40 portfolio would have a 40 percent allocation to domestic large blend equity and 20 percent to international, and a 20 percent allocation to cash and 20 percent to intermediate-term bond.
3. Data obtained from the Bureau of Labor Statistics: http://data.bls.gov/cgibin/surveymost?bls.
4. For readers not familiar with the difference between the averaging methods, the arithmetic average is the simple average of returns (the total number of returns divided by the number of returns considered), while the geometric average represents the average compounded return of the

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Appendix 1: Probabilities of Failure for a Variety of Scenarios Based on a 3% Real Distribution Rate and a 30-Year Distribution Period

Annual Standard Deviation	Geometric Real Return										
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	Range
3.00%	14.10%	0.57%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**14.10%**
4.00%	20.55%	2.79%	0.13%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**20.55%**
5.00%	25.79%	5.98%	0.75%	0.07%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	**25.79%**
6.00%	29.57%	9.78%	2.11%	0.29%	0.05%	0.00%	0.00%	0.00%	0.00%	0.00%	**29.57%**
7.00%	32.62%	13.65%	4.18%	0.92%	0.14%	0.02%	0.00%	0.00%	0.00%	0.00%	**32.62%**
8.00%	34.53%	16.94%	6.38%	1.96%	0.48%	0.12%	0.01%	0.00%	0.00%	0.00%	**34.53%**
9.00%	36.43%	19.63%	8.73%	3.39%	1.00%	0.26%	0.09%	0.00%	0.00%	0.00%	**36.43%**
10.00%	37.90%	21.98%	11.25%	5.04%	1.89%	0.61%	0.17%	0.06%	0.00%	0.00%	**37.90%**
11.00%	39.26%	24.38%	13.77%	6.74%	2.98%	1.08%	0.38%	0.13%	0.06%	0.00%	**39.26%**
12.00%	40.35%	26.55%	16.14%	8.43%	4.33%	1.93%	0.70%	0.26%	0.11%	0.05%	**40.30%**
13.00%	41.25%	28.37%	18.22%	10.26%	5.70%	2.77%	1.21%	0.55%	0.21%	0.10%	**41.15%**
14.00%	42.05%	29.85%	19.85%	12.24%	7.06%	3.88%	1.97%	0.88%	0.38%	0.16%	**41.89%**
15.00%	42.86%	31.22%	21.52%	14.21%	8.42%	5.07%	2.73%	1.35%	0.66%	0.29%	**42.57%**
Range	**28.76%**	**30.65%**	**21.52%**	**14.21%**	**8.42%**	**5.07%**	**2.73%**	**1.35%**	**0.66%**	**0.29%**	

Historical Balanced Portfolios

20/80 Portfolio | 60/40 Portfolio | 40/60 Portfolio | 80/20 Portfolio

Appendix 2: Probabilities of Failure for a Variety of Scenarios Based on a 5% Real Distribution Rate and a 30-Year Distribution Period

Annual Standard Deviation	Geometric Real Return										
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	Range
3.00%	100.00%	99.88%	94.51%	54.70%	9.10%	0.35%	0.00%	0.00%	0.00%	0.00%	**100.00%**
4.00%	99.94%	99.24%	88.31%	53.74%	16.18%	2.01%	0.11%	0.00%	0.00%	0.00%	**99.94%**
5.00%	99.75%	97.12%	83.03%	53.31%	21.11%	5.19%	0.69%	0.07%	0.00%	0.00%	**99.75%**
6.00%	99.20%	94.20%	78.97%	53.04%	25.31%	8.26%	1.95%	0.30%	0.06%	0.00%	**99.20%**
7.00%	97.87%	90.94%	75.62%	52.88%	28.59%	12.01%	4.00%	0.98%	0.15%	0.05%	**97.82%**
8.00%	96.04%	87.97%	72.99%	52.88%	31.19%	15.67%	6.11%	1.95%	0.54%	0.11%	**95.93%**
9.00%	94.21%	85.22%	70.67%	52.80%	33.22%	18.58%	8.37%	3.47%	1.16%	0.34%	**93.87%**
10.00%	92.02%	82.90%	69.14%	52.87%	35.06%	20.88%	10.74%	5.25%	2.02%	0.70%	**91.32%**
11.00%	90.06%	80.85%	67.76%	52.86%	36.68%	23.12%	13.40%	6.81%	3.23%	1.32%	**88.74%**
12.00%	88.25%	78.91%	66.56%	52.78%	37.94%	24.76%	15.78%	8.48%	4.57%	2.15%	**86.10%**
13.00%	86.28%	77.31%	65.56%	52.77%	38.97%	26.87%	17.84%	10.39%	5.93%	3.16%	**83.12%**
14.00%	84.48%	75.70%	64.78%	52.76%	40.12%	28.49%	19.62%	12.27%	7.38%	4.30%	**80.18%**
15.00%	83.10%	74.28%	64.04%	52.79%	41.09%	29.99%	21.45%	14.33%	8.69%	5.51%	**77.59%**
Range	**16.90%**	**25.60%**	**30.47%**	**1.94%**	**31.99%**	**29.64%**	**21.45%**	**14.33%**	**8.69%**	**5.51%**	

Historical Balanced Portfolios

20/80 Portfolio | 60/40 Portfolio | 40/60 Portfolio | 80/20 Portfolio

series over time. The geometric average is always going to be less than or equal to the arithmetic average due to the effects of compounding.

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Appendix 3: Probabilities of Failure for a Variety of Scenarios Based on a 6% Real Distribution Rate and a 30-Year Distribution Period

Annual Standard Deviation	Geometric Real Return										
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	Range
3.00%	100.00%	100.00%	99.99%	99.46%	84.15%	33.24%	3.52%	0.09%	0.00%	0.00%	**100.00%**
4.00%	100.00%	99.99%	99.84%	96.87%	77.24%	37.42%	8.31%	0.87%	0.06%	0.00%	**100.00%**
5.00%	99.99%	99.90%	99.30%	93.02%	72.68%	39.87%	13.92%	2.94%	0.33%	0.05%	**99.94%**
6.00%	99.95%	99.73%	97.88%	89.18%	69.24%	41.91%	18.35%	5.80%	1.21%	0.15%	**99.80%**
7.00%	99.85%	99.26%	95.62%	85.68%	67.00%	43.38%	21.85%	8.42%	2.68%	0.59%	**99.26%**
8.00%	99.67%	98.24%	93.15%	82.60%	65.28%	44.38%	24.80%	11.65%	4.64%	1.46%	**98.21%**
9.00%	99.25%	96.75%	90.84%	80.03%	63.93%	45.25%	27.32%	14.77%	6.66%	2.66%	**96.59%**
10.00%	98.49%	95.12%	88.60%	77.61%	62.76%	45.76%	29.48%	17.47%	8.58%	4.14%	**94.35%**
11.00%	97.50%	93.47%	86.35%	75.72%	61.93%	46.41%	31.26%	19.78%	10.99%	5.84%	**91.66%**
12.00%	96.22%	91.67%	84.39%	73.88%	61.00%	46.91%	33.01%	21.88%	13.10%	7.28%	**88.94%**
13.00%	95.04%	90.08%	82.61%	72.43%	60.56%	47.41%	34.64%	23.61%	15.54%	8.89%	**86.15%**
14.00%	93.66%	88.46%	81.04%	71.18%	60.12%	47.85%	35.92%	25.25%	17.40%	10.89%	**82.77%**
15.00%	92.33%	86.97%	79.51%	70.16%	59.59%	48.12%	37.11%	27.01%	19.25%	12.43%	**79.90%**
Range	**7.67%**	**13.03%**	**20.48%**	**29.30%**	**24.56%**	**14.88%**	**33.59%**	**26.92%**	**19.25%**	**12.43%**	

Historical Balanced Portfolios

20/80 Portfolio | 60/40 Portfolio | 40/60 Portfolio | 80/20 Portfolio

Appendix 4: Probabilities of Failure for a Variety of Scenarios Based on a 7% Real Distribution Rate and a 30-Year Distribution Period

Annual Standard Deviation	Geometric Real Return										
	0%	1%	2%	3%	4%	5%	6%	7%	8%	9%	Range
3.00%	100.00%	100.00%	100.00%	100.00%	99.90%	95.77%	62.06%	14.37%	0.84%	0.01%	**99.99%**
4.00%	100.00%	100.00%	100.00%	99.94%	99.32%	89.97%	59.13%	20.92%	3.62%	0.22%	**99.78%**
5.00%	100.00%	100.00%	99.96%	99.75%	97.16%	84.90%	57.70%	25.98%	7.30%	1.32%	**98.68%**
6.00%	100.00%	99.98%	99.89%	99.21%	94.24%	80.61%	56.66%	29.56%	11.34%	3.21%	**96.79%**
7.00%	99.99%	99.90%	99.69%	97.93%	91.14%	77.11%	55.95%	32.47%	15.37%	5.69%	**94.30%**
8.00%	99.92%	99.81%	99.18%	96.02%	88.35%	74.43%	55.53%	34.76%	18.68%	7.94%	**91.98%**
9.00%	99.86%	99.59%	98.18%	93.95%	85.75%	72.14%	55.03%	36.56%	21.34%	10.74%	**89.12%**
10.00%	99.75%	99.18%	96.80%	91.77%	83.35%	70.40%	54.81%	38.27%	23.75%	13.41%	**86.34%**
11.00%	99.53%	98.42%	95.48%	90.00%	81.20%	68.83%	54.50%	39.45%	25.78%	15.92%	**83.61%**
12.00%	99.18%	97.45%	93.92%	88.06%	79.25%	67.60%	54.41%	40.50%	27.68%	18.40%	**80.78%**
13.00%	98.57%	96.39%	92.33%	86.23%	77.53%	66.61%	54.36%	41.39%	29.39%	20.22%	**78.35%**
14.00%	97.83%	95.15%	90.93%	84.47%	75.98%	65.64%	54.30%	42.32%	30.84%	21.91%	**75.92%**
15.00%	96.86%	93.95%	89.42%	83.01%	74.72%	64.84%	54.26%	42.97%	32.25%	23.42%	**73.44%**
Range	**3.14%**	**6.05%**	**10.58%**	**16.99%**	**25.18%**	**30.93%**	**7.80%**	**28.60%**	**31.41%**	**23.41%**	

Historical Balanced Portfolios

20/80 Portfolio | 60/40 Portfolio | 40/60 Portfolio | 80/20 Portfolio

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