

The Benefits of Low Correlation

Written by Craig Israelsen

October 01, 2007



A fundamental premise of portfolio construction is to utilize assets that have low correlation with each other. A primary benefit of assembling a portfolio with low correlation among the constituent assets is a reduction in the volatility of the overall portfolio returns, which, in turn, reduces the portfolio's standard deviation of return. While this advantageous domino effect may have intuitive appeal, it may be difficult for many investors to put a specific value on.

It is generally assumed that a reduction in a portfolio's standard deviation of return is compellingly beneficial. To the extent that reducing standard deviation of return is perceived as analogous to reducing risk, this assumption seems reasonable. However, this study is based on the premise that most investors may be unable to quantify the value of that risk reduction, as measured by reduced standard deviation of return. Said more simply, most investors are probably unable to articulate the specific benefits of reducing the standard deviation of their portfolio's returns, though they undoubtedly have a general sense that doing so is a "good thing."

Therefore, this study attempts to quantify the value of volatility reduction achieved by assembling portfolios with progressively lower correlation among the constituent assets. This study also examines several additional benefits accrued from low correlation that may have more intuitive appeal to the general population than the common metric of standard deviation. A more specific segment of the population that stands to particularly benefit from creating low-correlation portfolios are retirees, as they are typically more sensitive to portfolio volatility.

Literature Review

The basic premise underlying diversification and portfolio selection can be summarized by a simple sentence from Harry Markowitz: "To reduce risk, it is necessary to avoid a portfolio whose securities are all highly correlated with each other." (Markowitz, 1991).

It is assumed that Markowitz was equating the term "risk" with volatility of returns. Additionally, William Bernstein observes that "the concept of correlation of assets is central to portfolio theory—the lower the correlation, the better." (Bernstein, 2001).

Reducing the volatility of returns in a portfolio is achieved by combining assets that tend to have low correlation to each other. Countless mean-variance studies have documented the ability of low correlation portfolios to reduce the volatility of a portfolio's returns (i.e., standard deviation of return) while maintaining a level of return that is typically superior to the performance of higher correlation portfolios. Thus, lowering correlation is integral in reducing volatility and enhancing risk-adjusted performance.

This study attempts to add to the body of literature by quantifying additional benefits (beyond the reduction of volatility) achieved by lowering the correlation among the assets in a portfolio. This study specifically examines the benefits of correlation reduction in retirement portfolios during the draw-down phase (or when a retirement portfolio is in "withdrawal mode," as money is being systematically withdrawn). The bulk of the extant mean-variance research literature is based on analysis which has assumed a buy-and-hold portfolio. As

will be shown, a portfolio in withdrawal mode is far more sensitive to portfolio volatility (i.e., account value losses) than a buy-and-hold portfolio.

Description And Justification

This study examines the aggregate correlation among various assets in a variety of portfolios and the corresponding impact on portfolio performance as measured by standard deviation of annual returns, internal rate of return, maximum portfolio drawdown in any single year, frequency of loss and probability of portfolio recovery following a loss.

Maximum portfolio drawdown is a measure of the percentage of change in the portfolio account value from the end of one year to the end of the following year. It takes into account the increasing annual withdrawals which occur at the end of each year. Frequency of loss is a measure of the number of times the portfolio lost 10 percent or more in any one-year, two-year or three-year period as measured by internal rate of return (IRR). The historical probability of recovery from a 10 percent portfolio loss is measured by calculating the portfolio's performance over all contiguous three-year periods to determine if it generated a return sufficient to restore the portfolio account balance to its pre-loss level.

It is proposed that these three measures of portfolio risk—maximum portfolio drawdown, frequency of loss and probability of recovery from a loss—are more intuitively useful to the average investor than is the standard deviation of return.

Analysis

A retirement withdrawal-mode portfolio is studied in this analysis. A starting balance of \$500,000 is assumed, with an initial withdrawal at the end of the first year of 5 percent of the starting portfolio balance (in this case, \$25,000), and an annual increase in the withdrawal of 3 percent to account for annual inflation. Thus, the second-year withdrawal in this analysis was \$25,750, the third-year withdrawal was \$26,523 and so forth.

We first consider a fundamental difference between a buy-and-hold portfolio and a retirement-withdrawal-mode portfolio. As shown in Figure 1, the mathematics of recovery from a loss are much more severe in a retirement-withdrawal-mode portfolio than in a buy-and-hold portfolio. For instance, if a buy-and-hold portfolio sustains a 10 percent loss, it only needs a 3.6 percent average annualized return over the next three years to restore its pre-loss account balance. In a retirement-withdrawal-mode portfolio, the needed annual return to recover from a 10 percent loss within three years is 11.5 percent.

If the loss is 25 percent, the buy-and-hold portfolio must generate a 10.1 percent annualized return over three years, whereas the required annual return in a withdrawal-mode portfolio is nearly double at 19.4 percent. Notice that a withdrawal-mode portfolio is forced into "recovery mode" even if the return that it is recovering from is positive (5 percent, 2 percent, etc.) or flat (zero percent). This is due to the fact that the required return must exceed the withdrawal rate that is increasing each year.

As clearly seen by the required returns to restore losses, recovery is considerably more challenging in a withdrawal-mode portfolio. In light of that, avoiding large losses in a retirement-withdrawal-mode portfolio is the highest priority—as demonstrated by the raw mathematics of recovery.

The time frame covered in this study was the 37-year period from 1970-2006. Assets included in this analysis were large-cap U.S. equities, small-cap U.S. equities, non-U.S. equities, U.S. intermediate-term bonds, cash, REITs and commodities (see Figure 2). The 37-year historical performance of large-cap U.S. equities is

represented by the S&P 500 Index, while the performance of small-cap U.S. equities is captured by using the Ibbotson Small Companies Index from 1970-1978 and the Russell 2000 Index from 1979-2006. The performance of non-U.S. equities was represented by the Morgan Stanley Capital International EAFE Index (Europe, Australasia, Far East) Index. U.S. intermediate-term bonds were represented by the Ibbotson Intermediate Term Bond Index from 1970-1976 and the Lehman Brothers Intermediate Term Bond Index from 1977-2006.

The historical performance of cash is represented by 3-month Treasury Bills. The performance of real estate was measured by using the annual returns of the NAREIT Index (annual returns for 1970 and 1971 were estimated as the NAREIT Index [National Association of Real Estate Investment Trusts] did not provide annual returns until 1972). Finally, the historical performance of commodities was measured by the Goldman Sachs Commodities Index (GSCI). As of February 6, 2007, the GSCI is now known as the S&P GSCI Commodity Index.

The annual returns of each asset from 1970-2006 are provided in Figure 2. Data in red and in parentheses represent negative returns. The primary data source for this study was Morningstar Principia. Raw data were also obtained from "Stocks, Bonds, Bills, Inflation" by Ibbotson Associates. As shown in Figure 2, the 37-year average annualized return for each individual asset is reported, as well as the annualized return of an equally weighted, seven-asset portfolio. Also reported is the 37-year standard deviation of annual returns, the worst one-year percentage return and the worst three-year cumulative percentage return (assuming buy-and-hold). The worst 3-year cumulative return is highlighted in blue for each asset.

The bivariate correlations between each asset are reported in Figure 3. For example, the 37-year average correlation between large U.S. equities and small U.S. equities was 0.738 (or 73.8 percent). The average correlation between U.S. intermediate-term bonds and commodities was -0.213. The aggregate correlation for the entire portfolio (as calculated by computing the average of the 21 bivariate correlations) was 0.128.

As shown in Figure 5, there is a meaningful correlation between two of the data series in Figure 2, namely between the 37-year annualized percentage return in a buy-and-hold portfolio and its worst three-year cumulative percentage return. Also included in Figure 5 are an equally weighted portfolio including all seven assets (shown by the black square), a 40 percent large stock/60 percent fixed bond portfolio (plum square), and a 60 percent large stock/40 percent bond portfolio (bright blue square). The 40/60 portfolio is a common asset allocation model among "conservative allocation" funds, such as the Vanguard Wellesley Income or Franklin Income funds. The 60/40 portfolio is typical among "moderate allocation" funds, such as the Vanguard Wellington or Dodge & Cox Balanced funds. The equal-weighted seven-asset portfolio ends up with an allocation of 42 percent in equities, 29 percent in fixed income and 29 percent in "alternative" assets.

Among the stand-alone assets (the dots), there is a clear pattern between higher annualized return and greater risk of loss. The benefit of creating diversified portfolios is demonstrated by the location of the squares. For example, the seven-asset portfolio (black square) and the 40/60 portfolio (plum square) virtually eliminated large losses over any three-year period during the 37-year time frame of this study, while still maintaining a level of performance that was comparable with the individual equity assets. As expected, the 60/40 portfolio had a higher return than the 40/60 portfolio (by 63 basis points (bps), or 0.63 percent), but at the price of experiencing a much larger three-year loss (-13.9 percent vs. -0.40 percent). As already shown, recovering from losses in a withdrawal-mode portfolio is far more challenging than in a buy-and-hold portfolio. The modest additional return in the 60/40 portfolio (relative to the 40/60 portfolio) comes at a high price.

Even minimally diversified portfolios (such as the "conservative allocation" two-asset 40/60 portfolio) can greatly reduce the likelihood of a large loss. As a general rule, portfolios with higher levels of diversification, and therefore lower levels of aggregate portfolio correlation, can further enhance the likelihood of loss protection as well as overall performance.

With this connection between performance and worst-case three-year loss in mind, the information presented in Figure 1 is more compelling. For example, a 25 percent loss in a withdrawal-mode portfolio will require a 19.4 percent annual return over the subsequent three-year period to restore the loss, compared with "only" a 10.1 percent needed annualized three-year return in a buy-and-hold portfolio. It is important to note that five of the individual assets in this study had three-year cumulative percentage losses in excess of 25 percent (large U.S. equity, small U.S. equity, non-U.S. equity, REITs and commodities). Indeed, three of the individual assets had worst-case three-year cumulative losses of over 37 percent. (And this is assuming a buy-and-hold portfolio. In withdrawal-mode portfolios, market losses are magnified because of money being withdrawn). Recovering from losses of this magnitude is far more problematic in a retirement-withdrawal-mode portfolio than in a buy-and-hold portfolio.

Determining the likelihood of recovering from a loss in a withdrawal-mode portfolio (within three years following the loss) was calculated by analyzing historical performance over 35 unique three-year rolling periods. A total of 37 years of historical performance were examined (from 1970-2006). Thus, the first three-year rolling period was 1970-1972, the second was from 1971-1973 and so on. Unlike a Monte Carlo approach, this technique does not simulate performance hundreds of thousands of times. Rather, this approach uses rolling historical performance to create 1) a set of historical three-year recovery probabilities based on actual returns in the order that they actually occurred, and 2) frequencies of loss over periods of one year, two years and three years. In addition, this analysis took into account the increasing annual withdrawals coming out of a withdrawal-mode portfolio.

Figure 1

Needed Average Annual % Return To Restore Portfolio Balance						
Portfolio Loss	Retirement Withdraw-Mode Portfolio					
	\$500,000 initial balance, First Year End-of-Year Withdrawal of 5% of initial balance, 3% of annual withdrawal					
	Within 1 Year	Within 2 Years	Within 3 Years	Within 4 Years	Within 5 Years	
5%	5.2%	5.2%	5.3%	5.4%	5.9%	
2	8.4	6.9	6.4	6.3	6.2	
0	10.7	8.0	7.2	6.9	6.7	
-2	13.1	9.2	8.0	7.5	7.2	
-5	16.8	11.1	9.3	8.4	8.0	
-10	23.7	14.4	11.5	10.1	9.4	
-15	31.4	18.0	13.9	12.0	10.9	
-20	40.2	22.0	16.5	14.0	12.5	
-25	50.2	26.4	19.4	16.1	14.3	
-30	61.8	31.3	22.6	18.5	16.2	
-35	75.3	36.9	26.1	21.2	18.4	
Portfolio Loss	Buy-and-Hold Portfolio					
	Within 1 Year	Within 2 Years	Within 3 Years	Within 4 Years	Within 5 Years	
-2%	2.0%	1.0%	0.7%	0.5%	0.4%	
5	5.3	2.6	1.7	1.3	1.0	
-10	11.1	5.4	3.6	2.7	2.1	
-15	17.6	8.5	5.6	4.1	3.3	
-20	25.0	11.8	7.7	5.7	4.6	
-25	33.3	15.5	10.1	7.5	5.9	
-30	42.9	19.5	12.6	9.3	7.4	
-35	53.8	24.0	15.4	11.4	9.0	

Results

As shown in Figure 4, the first withdrawal-mode portfolio analyzed consisted of 50 percent large U.S. equities and 50 percent small U.S. equities. Understandably, this portfolio allocation strategy does not represent a

typical retirement portfolio. It is included in this analysis simply as a starting point. The two-asset portfolio was annually rebalanced (as were all the portfolios in Figure 4) to maintain the original equal weighting over the 37-year period. The 37-year correlation of this two-asset withdrawal-mode portfolio was 0.738. Its IRR was 10.74 percent with a standard deviation of annual returns of 18.03 percent. The probability of this two-asset portfolio recovering from a 10 percent loss within three years was 62.9 percent. In other words, this two-asset portfolio generated a three-year annualized return of 11.5 percent or higher (the needed return to recover from a 10 percent loss in a withdrawal-mode portfolio as reported in Figure 1) in 62.9 percent of the three-year rolling periods between 1970 and 2006. The worst-case portfolio loss (i.e., drawdown) in any single year was -30.8 percent.

In this two-asset portfolio, the frequency of a loss of 10 percent or more in any given year was 10.8 percent over the 37-year period being studied. Said differently, in 10.8 percent of the 37 single-year periods this withdrawal-mode portfolio lost 10 percent or more. The frequency of a cumulative loss of 10 percent or more over any of the 36 contiguous two-year periods was 11.1 percent, and 8.6 percent over the 35 rolling three-year periods studied. In other words, in 8.6 percent of the 35 three-year rolling periods the portfolio lost 10 percent or more.

Next, non-U.S. equities were added to the portfolio. The three assets (large U.S. equities, small U.S. equities and non-U.S. equities) were each equally weighted at 33.33 percent of the portfolio. With three asset classes, the aggregate correlation of the portfolio declined from .738 to .599. The 37-year IRR of the portfolio, meanwhile, increased by 20 bps to 10.94 percent, and the standard deviation of return dropped by 85 bps to 17.18 percent. The recovery probabilities and frequencies of loss were similar to the two-asset portfolio. The worst-case one-year drawdown was -29.8 percent, which represents a 100 bps improvement compared with the two-asset portfolio. Compared with the two-asset portfolio, the 139 bps reduction in aggregate portfolio correlation in the three-asset portfolio led to a slight increase in return, a modest reduction in standard deviation of return, a slight reduction in recovery probability, a slight improvement in maximum portfolio drawdown and comparable frequencies of loss over one-, two- and three-year periods.

Figure 2

Total Annual Percentage Returns Of Individual Assets And Equal-Weighted Portfolio (Assuming Buy-And-Hold)								
Year	Large US Equity	Small US Equity	Non-US Equity	Intermed. Term US Bonds	Cash	REIT	Comm.	All7 Assets in Eql-
1970	3.92	(17.40)	(11.66)	16.90	6.80	(4.00)	15.17	1.39
1971	14.14	16.50	29.59	8.70	4.52	15.52	20.15	15.59
1972	19.16	4.40	36.35	5.20	4.23	8.01	42.37	17.10
1973	(14.69)	(30.90)	(14.92)	4.60	7.46	(15.52)	74.90	1.56
1974	(26.47)	(19.90)	(23.16)	5.70	8.35	(21.42)	39.50	(5.34)
1975	37.23	52.80	35.39	7.80	6.08	19.29	(17.22)	20.20
1976	23.64	57.40	2.54	12.90	5.23	47.58	(11.94)	19.62
1977	(7.44)	25.40	18.06	3.00	5.52	22.43	10.38	11.05
1978	6.40	23.50	32.62	2.23	7.67	10.24	31.56	16.33
1979	18.30	43.07	4.75	6.59	10.86	35.86	33.78	21.89
1980	32.22	38.60	22.58	6.65	12.71	24.36	11.06	21.17
1981	(5.08)	2.03	(2.28)	10.79	15.38	6.02	(22.98)	0.58
1982	21.46	24.95	(1.86)	25.42	11.66	21.60	11.57	16.40
1983	22.46	29.13	23.69	8.22	9.24	30.64	16.23	19.94
1984	6.26	(7.30)	7.38	14.29	10.33	20.93	1.03	7.56
1985	31.74	31.05	56.16	18.00	7.97	19.07	10.02	24.86
1986	18.68	5.68	69.44	13.06	6.29	19.17	2.06	19.20
1987	5.26	(8.80)	24.63	3.61	6.13	(3.65)	23.76	7.28
1988	16.61	25.02	28.77	6.40	7.06	13.47	27.92	17.82
1989	31.68	16.26	10.54	12.68	8.67	8.84	38.25	18.13
1990	(3.12)	(19.48)	(23.45)	9.56	7.99	(15.34)	29.13	(2.10)
1991	30.48	46.04	12.13	14.11	5.68	35.69	(6.13)	19.71
1992	7.62	18.41	(12.17)	6.93	3.59	14.58	4.41	6.20
1993	10.06	18.88	32.56	8.17	3.12	19.67	(12.32)	11.45
1994	1.31	(1.82)	7.78	(1.75)	4.45	3.17	5.28	2.63
1995	37.53	28.45	11.21	14.41	5.79	15.25	20.32	18.99
1996	22.94	16.49	6.05	4.06	5.26	35.28	33.90	17.71
1997	33.35	22.36	1.78	7.72	5.31	20.28	(14.09)	10.96
1998	28.57	(2.55)	19.93	8.49	5.01	(17.51)	(35.71)	0.89
1999	21.04	21.26	27.03	0.49	4.87	(4.62)	40.89	15.85
2000	(9.10)	(3.02)	(14.19)	10.47	6.32	26.36	49.71	9.51
2001	(11.88)	2.49	(21.42)	8.42	3.67	13.93	(31.91)	(5.24)
2002	(22.09)	(20.48)	(15.94)	9.64	1.68	3.81	32.03	(1.62)
2003	28.67	47.25	38.59	2.29	1.05	37.14	20.68	25.10
2004	10.71	18.33	20.25	2.33	1.43	31.59	17.28	14.56
2005	4.91	4.55	13.54	1.68	3.34	12.17	25.69	9.41
2006	15.79	18.37	26.34	3.84	4.80	35.06	(15.09)	12.73
37 Yr. Avg. Annualized Rtn.	11.18	12.12	10.85	8.07	6.33	13.48	11.48	11.53
37 Yr. Standard Deviation of Rtn.	16.80	21.83	21.83	5.50	3.11	16.66	24.05	8.67
No. of Yrs. with a Negative Rtn.	8	10	10	1	0	7	9	4
Worst One-Yr % Rtn.	(26.47)	(30.90)	(23.45)	(1.75)	1.05	(21.42)	(35.71)	(5.34)
Worst Three-Yr. Cumulative % Rtn.	(37.59)	(42.22)	(43.32)	6.43	4.22	(28.30)	(26.04)	2.09

When adding bonds to the portfolio (now with four asset classes where each class comprised 25 percent of the annually rebalanced portfolio), the 37-year IRR dropped by a modest 34 bps to 10.60 percent, but the standard deviation of return declined by 414 bps to 13.04 percent. The aggregate portfolio correlation declined considerably, from .599 to .416. The probability of recovery from a 10 percent loss remained the same as the three-asset portfolio (60 percent), but the worst-case portfolio single-year drawdown was only -22 percent compared with -29.8 percent in the three-asset portfolio—an improvement of 780 bps. With bonds added to the portfolio, the frequency of a 10 percent loss occurring in any single year improved dramatically, moving from 13.5 percent to 8.1 percent. The frequency of a cumulative 10 percent loss within two years fell from 8.3 percent to 5.6 percent, and over three years from 8.6 percent to 5.7 percent.

Next, we consider a five-asset portfolio. Adding cash (i.e., T-Bills) to the portfolio lowered aggregate portfolio correlation to .211 and lowered the standard deviation of the portfolio by 259 bps to 10.45 percent. However, the 37-year IRR declined by 64 bps to 9.96 percent. Compared with the original two-asset portfolio, the five-asset portfolio's average IRR was lower by 78 bps, but the standard deviation of annual returns was reduced by 758 bps.

In the five-asset portfolio, the probability of recovery from a 10 percent loss within three years was 54.3 percent, 13.7 percent lower than the 62.9 percent level of the two-asset portfolio. The worst-case one-year drawdown improves significantly to -16.9 percent, a 1,390 bps improvement over the two-asset portfolio. The frequency of a 10 percent or greater loss within one year was only 2.7 percent compared with 10.8 percent in the two-asset portfolio—a 75 percent reduction. Compared with the two-asset portfolio, frequency of a loss of 10 percent or more in a two-year period was 50 percent lower, and 66 percent lower over a three-year period.

Compared with the five-asset portfolio, the six-asset portfolio (which added REITs) increased the 37-year IRR by 42 bps to 10.38 percent, while only raising standard deviation by 16 bps. Aggregate portfolio correlation (.258) is essentially unchanged, as is the probability of recovery from a 10 percent loss within three years. The worst-case one-year drawdown increased slightly to -18.8 percent, and the frequency of loss over one, two and three years were comparable to the five-asset portfolio.

The most dramatic impact in the portfolio comes when adding commodities as the seventh asset class. This multi-asset portfolio was comprised of large U.S. equities, small U.S. equities, non-U.S. equities, U.S. intermediate-term bonds, cash, REITs and commodities—each asset class having a portfolio weighting of 14.3 percent. The seven-asset portfolio had the highest return (11.25 percent), the lowest standard deviation of return (8.67 percent), the lowest aggregate correlation (.128), the smallest maximum one-year drawdown (-10.2 percent) and a zero frequency of a 10 percent loss (as measured by IRR) over one-, two- and three-year periods. (The -10.2 percent maximum portfolio drawdown is, by necessity, calculated differently than IRR).

The probability of recovery from a 10 percent loss within 3 years is lowest in the five-asset and the seven-asset portfolio (54.3 percent), but the margin of difference is slim between the highest probability of 62.9 percent and the lowest at 54.3 percent. The key point here is that highly diversified portfolios with low aggregate correlation tend to avoid losses, which essentially negates the need for a high recovery probability. In sum, the probability of recovery from a 10 percent loss within three years is slightly lower in the more diversified portfolios, but the frequency of 10 percent or higher losses is nearly eliminated.

We have arrived at the heart of the issue: In addition to reducing the volatility of year-to-year performance (as observed by the fact that the seven-asset portfolio had the third-lowest standard deviation of returns of all the assets listed in Figure 2), what are the additional benefits of low correlation in a portfolio?

Figure 3

37-Year Correlations (Using Annual Returns from 1970-2006)						
	Large US Equity	Small US Equity	Non-US Equity	US Bonds	Cash	REIT
Small US Equity	0.738					
Non-US Equity	0.586	0.472				
US Bonds	0.221	0.065	-0.100			
Cash	0.039	0.001	-0.124	0.410		
REIT	0.463	0.760	0.307	0.111	-0.085	
Commodities	-0.275	-0.308	-0.144	-0.213	-0.013	-0.247

Aggregate (Average) Portfolio Correlation with All Seven Assets = 0.128

As shown in Figure 4, as aggregate portfolio correlation decreases, standard deviation of return likewise

declines. But what is the quantifiable value of lower standard deviation of return?

Figure 4

Portfolio Progression In A Retirement Withdrawl Portfolio								
Equally-Weighted Assets in Withdrawal Portfolio (\$500,000 starting balance, 5% withdraw rate, 3% inflation rate of annual withdrawal)	37 Yr. IRR 1970-2006 (%)	37 Yr. Standard Deviation of Annual Rtns. (%)	Aggregate Portfolio Correlation	Probability of Recovery from a 10% Loss Within 3 Yrs. (%)	Worst Case Single Year Portfolio Draw-Down (%) ^a	Frequency of a One Yr. Loss of 10% or Worse (%) ^b	Frequency of a Two Yr. Cumulative Loss of 10% or Worse (%)	Frequency of a Three Yr. Cumulative Loss of 10% or Worse (%)
Two-Asset Portfolio Large US Equity, Small US Equity (50% each)	10.74	18.03	.738	62.9	-30.8	10.8	11.1	8.6
Three-Asset Portfolio Large US Equity, Small US Equity, Non-US Equity (33.33% each)	10.94	17.18	.599	60.0	-29.8	13.5	8.3	8.6
Four-Asset Portfolio Large US Equity, Small US Equity, Non-US Equity, US Int. Term Bonds (25% each)	10.60	13.04	.416	60.0	-22.0	8.1	5.6	5.7
Five-Asset Portfolio Large US Equity, Small US Equity, Non-US Equity, US Int. Term Bonds, Cash (20% each)	9.96	10.45	.211	54.3	-16.9	2.7	5.6	2.9
Six-Asset Portfolio Large US Equity, Small US Equity, Non-US Equity, US Int. Term Bonds, Cash, REIT (16.67% each)	10.38	10.61	.258	57.1	-18.8	5.4	2.8	2.9
Seven-Asset Portfolio Large US Equity, Small US Equity, Non-US Equity, US Int. Term Bonds, Cash, REIT, Commodities (14.3% each)	11.25	8.67	.128	54.3	-10.2	0.0	0.0	0.0
40/60 Conservative Allocation Portfolio 40% Large Stock 60% Intermediate Bond	9.35	8.11	.221	37.1	-12.2	0.0	2.8	0.0
60/40 Moderate Allocation Portfolio 60% Large Stock 40% Intermediate Bond	9.70	10.78	.221	51.4	-18.9	2.7	5.6	2.9

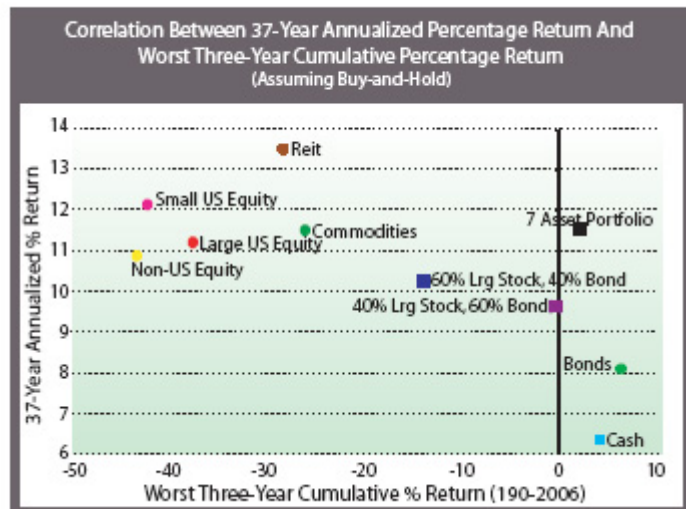
a Worst-case single-year portfolio drawdown is a measure of the percentage change in the ending portfolio value from the end of one year to the end of the next year after considering the annual withdrawal. This measure is dependent on the prior year.

b Frequency of one-year loss is determined by assessing the distribution of 37 one-year IRRs. Hence, each IRR is independent. Thus, while there was a zero frequency of a one-year IRR of -10% or worse, there was one year in which the maximum portfolio drawdown was -10.2%.

With reductions in correlation and standard deviation of return come dramatic reductions in the maximum drawdown within a retirement portfolio. Indeed, the maximum portfolio drawdown is reduced by 67 percent,

from -30.8 percent in a two-asset portfolio to -10.2 percent in the seven-asset portfolio. Moreover, the likelihood of experiencing a portfolio loss is reduced in portfolios with lower aggregate correlation. Both of these issues—reduced magnitude of loss as well as reduced frequency of loss—are important to all investors, but particularly to retirees in withdrawal mode, for whom the "mathematics of recovery" following a portfolio loss are much more demanding.

Figure 5



The raw performance of each successive portfolio in Figure 5 was relatively stable as it was expanded with each additional asset. In fact, given the assets included in this analysis and the sequencing of their inclusion, greater diversification ultimately enhanced performance (particularly when adding the sixth and seventh assets—REITs and commodities) while substantially reducing volatility, maximum drawdown and frequency of loss. At what cost were these benefits accrued?

The "cost" of greater diversification (in this case, a significant reduction in exposure to core U.S. equities) was a modest reduction in the probability of recovery from a 10 percent loss within three years. However, the offsetting benefit of increased portfolio diversification is a marked reduction in the likelihood of experiencing a portfolio loss.

Some may correctly suggest that several of the portfolios in Figure 4 do not represent sensible retirement portfolios because of their modest exposure to bonds. Agreed. To address this issue, consider the last two portfolios in Figure 4—a "conservative allocation" 40/60 portfolio and a "moderate allocation" 60/40 portfolio. Compared with the 40/60 portfolio, the seven-asset portfolio had a 190 bps higher return (11.25 percent vs. 9.35 percent) while only increasing the volatility of return by 56 bps—unlikely to be noticed by even the most fastidious investor. Perhaps more importantly, the probability of recovery from a 10 percent loss is considerably higher in the seven-asset portfolio (54.3 percent vs. 37.1 percent) and the worst-case single-year drawdown is lower (-10.2 percent vs. -2.2 percent). The frequencies of large losses over one-, two- and three-year periods are essentially zero for both portfolios.

The seven-asset portfolio also shines against the 60/40 portfolio as evidenced by a 155 bps higher IRR, a 211 bps lower standard deviation of return, a slightly higher probability of recovery from a 10 percent loss within three years, significantly lower maximum one-year drawdown (-10.2 percent versus -18.9 percent) and superior loss frequencies.

Summary

There are several quantifiable benefits of lowering the correlation of a retirement-withdrawal-mode portfolio's component assets. First, there is a dramatic reduction in the volatility of the portfolio's performance (i.e., lower standard deviation of return). Second, there is a significant reduction in the worst-case portfolio loss, or maximum drawdown. Third, the likelihood (or frequency) of loss is minimized. Fourth, performance does not suffer if sufficient diversification is achieved.

This study suggests that maximum portfolio loss, frequency of loss and probability of recovery following a loss are quantifiable measures of the benefits of low correlation. Furthermore, this study suggests that these three measures may have greater intuitive appeal to investors than standard deviation of return.

As was shown by the mathematics of recovery for portfolios in withdrawal mode, avoiding large losses is of paramount importance. Achieving low correlation among the assets in a portfolio—the key to generating a multitude of benefits—requires the use of a variety of low-correlated assets. Some of the needed assets may not fit the standard paradigm of a traditional retirement portfolio, namely commodities and REITs.

At least one caution is in order. The time frame of this analysis (1970-2006) was a period of robust returns across the board. Equities averaged annual performance in excess of 11 percent, intermediate-term bonds averaged over 8 percent, commodities generated a 37-year average annual return of over 11 percent and REITs had nearly a 13.5 percent annualized return. These levels of performance may not persist. Nevertheless, the benefits derived from building low-correlation portfolios—particularly during retirement withdrawal—will always be in demand regardless of the performance level of various assets.

References

Bernstein, W., 2001, *The Intelligent Asset Allocator*, McGraw Hill.

Markowitz, H., 1991, *Portfolio Selection*, Blackwell Publishing.