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Withdrawal Patterns and Rebalancing Costs for Taxable Portfolios

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Abstract

This article quantifies the effect of taxes on the magnitude and variability of cash flows from taxable retirement portfolios. While previous research focuses on pretax cash flows, this paper includes taxes associated with rebalancing and withdrawals. We incorporate the differential tax treatment of interest income and capital gains. Taxes have dramatic effects on the size and variability of the after-tax cash flows withdrawn from the portfolio. Financial planners may use our results to determine the ideal equity allocation in taxable retirement portfolios. For withdrawals below 5% and above 8% of initial portfolio value, our results suggest that the 100% equity allocation generally provides the most attractive trade-off between risk and return during the retirement period. Even for withdrawals (as a percentage of initial portfolio value) from 5% to 8%, the 100% equity allocation is an attractive choice because it has substantially higher mean terminal value and similarly higher mean after-tax cash flows. An analysis of inflation-adjusted withdrawal amounts also strongly favors the 100% equity allocation. © 2003 Academy of Financial Services. All rights reserved.

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1. Introduction

Despite the popularity of 401(k)s and IRAs, many investors accumulate substantial assets in fully taxable portfolios that they depend on to provide retirement income. Such portfolios

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often result from the sale of businesses or from inheritances. The management of these funds is complicated because it requires striking a balance between conflicting goals. Retirees want to maximize their income but also want to avoid exhausting their assets before death. Several researchers (Bengen, 1994, 1996, 1997; Cooley, Hubbard, & Walz [hereafter CHW], 1998, 1999) have examined the appropriate size of the sustainable withdrawals from such portfolios of assets. However, these previous studies do not explicitly factor taxes into their analyses.

This paper investigates the impact of taxes on the analysis of sustainable withdrawals from taxable portfolios. Taxes impact the cash flows from such portfolios in several ways. Financial planners typically recommend rebalancing portfolios on a regular basis to a target asset allocation. Maintaining the desired debt/equity mix may create significant tax liabilities on recognized gains. Also, the different treatment of income and capital gains influences the optimal asset allocation.

The results of this study suggest that the 100% equity allocation provides the best return versus risk trade-off for most of the withdrawal amounts as a percentage of initial portfolio value examined. In addition, this allocation always had the highest mean terminal portfolio value of the five asset allocations analyzed in this study. Over all time periods and withdrawals investigated, for noninflation-adjusted data, the median difference between the mean terminal value of the 100% stock allocation and the next highest mean terminal value is over $1.9 million. Even if clients are reluctant to commit to a 100% equity allocation, this paper provides financial planners with guidelines on the magnitude of taxes and the variation in after-tax cash flows associated with the withdrawal pattern and asset allocations studied herein.

2. Literature review

Bengen (1994, 1996, 1997) wrote the seminal research on withdrawals as a percentage of initial portfolio value; additionally, his papers investigate the optimal asset allocation for retirement portfolios. After conducting a portfolio analysis using historical returns, Bengen suggests that retirees place a relatively large proportion of their assets in equities. He recommends a stock allocation between 50% to 75% in the early years of retirement and advises reducing this percentage as one grows older. When adjusting the asset allocation of their taxable portfolios, Bengen advocates that retirees use the following formula: percentage of portfolio in equities = (120 to 150) minus your age. Investors with less tolerance of risk should choose a number closer to 120, and more aggressive investors should choose a number closer to 150.

CHW (1998, 1999) extend Bengen's research by developing a procedure for measuring the tradeoffs between withdrawals, expected years of retirement, and asset allocations. Using historical data provided by Ibbotson Associates, CHW generate an algorithm that grows an initial amount by the total return for a given asset allocation and reduces the portfolio value by a fixed withdrawal amount. CHW (1998) use annual withdrawals and, implicitly, annual rebalancing. A later study (CHW, 1999) uses monthly withdrawals and rebalancing. In both studies, CHW conclude that retirees should invest a minimum of 50% of their portfolio in stocks.

As an example of their methodology, one might start with a retirement portfolio of $100,000, a withdrawal amount of 7% (i.e., $7,000 per year), and an asset allocation of 50% stocks and 50% long-term high-grade corporate bonds. Suppose that in the first year of retirement the total return on stocks is 8% and the total return on bonds is 4%. The portfolio value will grow 6% to $106,000. The retirement income withdrawal of $7,000 is taken from the retirement fund and the remaining $99,000 is invested for the next period. This continues until the end of a predetermined retirement period is reached. Success is defined as having a non-negative value for the portfolio at the end of the retirement period (i.e., not outliving your money).

Jarrett and Stringfellow (2000) extend the research on withdrawal management by analyzing different withdrawal methodologies and portfolio horizon values. The authors provide withdrawal rates (i.e., withdrawals as a percentage of initial portfolio value) that make it highly likely that an individual will have sufficient funds to avoid running out of money before the end of their retirement period. However, they do not indicate the level of success that should occur given the various strategies. According to their results, someone with a 30-year retirement period would be able to withdraw 3.55% of their initial portfolio value each year if the portfolio consists entirely of large company stocks.

Although they have not analyzed the impact of taxes on withdrawals from a retirement portfolio, many researchers have investigated the general effects of taxes on portfolio returns. Siegel and Montgomery (1995) consider the effects of taxes and inflation on the returns of major asset classes. They use marginal tax rates on ordinary income associated with each time period from 1926 to 1993; they also consider effective marginal tax rates on capital gains. They conclude that wealth-maximizing individuals should invest as much as they can and keep it invested so as to minimize the effects of taxes on their portfolio values. Stein (1998) focuses on the valuation of a portfolio that has an imbedded tax liability and on issues associated with determining an appropriate benchmark against which to compare portfolio returns on an after-tax basis. He finds that after-tax returns depend on how the assets grow over time and on when the cost basis of the investments is established.

Opiela (2002) indicates that individuals need to be cognizant of the investments that they are putting into their taxable and tax-deferred accounts. Also, Chincarini and Kim (2001) investigate the three sources of tax losses that individuals face: 1) taxable events generated by turnover in an investment fund; 2) taxes on dividends; and 3) taxes on capital gains. Investors need to consider turnover rates in their mutual funds. They also need to be aware that the extent of tax losses are greater the more short-term gains are realized and the higher one's tax bracket.

Portfolio rebalancing also plays an important role in determining the success rate and the after-tax cash flows available to retirees. Several studies have examined rebalancing issues, particularly the transactions costs of rebalancing; like the research done on withdrawal patterns, these studies do not include the effect of taxes. One of the earliest research projects investigates different rebalancing options with a portfolio invested in common stocks, long-term government bonds and T-bills (Stine and Lewis, 1992). The authors conclude that the optimal approach is to rebalance when an asset class deviates 7% to 10% from its initial allocation.

Using more returns data, asset classes, and asset allocations, Tsai (2001) also analyzes the performance of various rebalancing methods, including never rebalancing, periodic rebalancing, and rebalancing that is contingent on market returns. She finds little difference in the performance of the various strategies. Although her analysis does not include the tax and transactions costs associated with rebalancing, she notes the advantages of rebalancing monthly when a weighting is off by at least five percentage points. This strategy reduces the number of times that rebalancing occurs. Weiss (2001) advocates the use of dynamic rebalancing. This approach uses the coupon payments from bonds to fund cash withdrawals when the inflation-adjusted cumulative equity return is below its projected mean. When returns on stocks are above their projected mean, this strategy rebalances annually to a target allocation. Monte Carlo analysis shows this strategy to be better than annual rebalancing.

Buetow et al. (2002) focus on the effects of portfolio rebalancing on the value of tax-exempt portfolios. They consider both frequency (calendar) and interval (contingent) rebalancing strategies. For frequency rebalancing, they tested daily, monthly, quarterly, and semiannual rebalancing. For interval rebalancing, they tested movements of ±1% to 20% from the target allocation percentages. They find that a disciplined rebalancing strategy can enhance portfolio value. The authors recommend a daily monitoring frequency and a 5% interval rebalancing strategy to optimize the effect on portfolio returns.

3. Data and methodology

Our methodology is based on that of CHW. We start with an initial endowment of $1,000,000 and invest it according to each of five asset allocations. As in CHW, the asset allocations are 100% equity, 75% equity and 25% bonds, 50% equity and 50% bonds, 25% equity and 75% bonds, and 100% bonds. The value of the portfolio is calculated using historical total returns on common stocks and long-term government bonds taken from the Ibbotson Associates Yearbook (2000). On an annual basis, the portfolio is rebalanced to the original asset allocation.

Because the portfolio is intended to provide retirement income, an amount is withdrawn at the end of each year. We test 10 withdrawal rates (i.e., withdrawals as a percentage of initial portfolio value), which range from 3% ($30,000 per year). Success occurs when the portfolio has a positive value at the end of a given time period, which is 20, 25, or 30 years in this study. Two withdrawal strategies are investigated: fixed withdrawal amounts and inflation-adjusted withdrawal amounts. Using pretax withdrawals, our analysis produces success rates consistent with those reported by CHW (1998).

Our study extends the CHW research by including tax effects. Ordinary income, including both coupons from bonds and dividends from stocks, adjusted for capital losses and carryovers as appropriate, is taxed at 28%. Recognized net capital gains are taxed at 20%. In compliance with the current U.S. Tax Code, losses are limited to $3,000 in a taxable year and the losses exceeding this amount are carried forward. To determine the tax basis for capital gains tax calculations, this study uses the specific identification method, and the most recently acquired securities are sold first. In falling markets, this approach recognizes lower losses than the first-in, first-out alternative because securities that were recently purchased at lower prices will be sold before older higher basis securities. In bull markets, our application of the specific identification method produces smaller capital gains than the first-in, first-out method.

For every withdrawal amount/asset allocation combination that has a success rate less than 100%, the minimum after-tax cash flow will at least fall to zero. The minimum after-tax cash flow occasionally is negative because taxes exceed the withdrawal amount, which is expressed on a pretax basis. These tax payments are triggered by annual portfolio rebalancing so only the asset allocations that require rebalancing experience negative minimum after-tax cash flows.

As do CHW, we also study the effects of inflation by incorporating a CPI-based inflation adjustment into a portion of our study. Our CPI values come from the Bureau of Labor Statistics Web site. We adjust for the effects of inflation by increasing or decreasing the withdrawal amount by the change in the Consumer Price Index. Rebalancing occurs annually so we multiply the previous period's withdrawal amount (the initial withdrawal amount if it is the first year of the portfolio's existence) by the ratio of the current year's January CPI number over the previous year's January CPI number. This provides us with the current year's inflation-adjusted withdrawal amount. All other elements of the methodology remain the same as for the noninflation-adjusted cash flows.

This study utilizes returns data from 1926 to 1999. This data contains 55 overlapping 20-year periods, 50 overlapping 25-year periods, and 45 overlapping 30-year periods. For each of these periods, we calculate the cash flows for all of the combinations of withdrawal amounts and asset allocations. We do this both with and without adjusting for inflation. The next section describes the cash flows from these portfolios.

4. Results

4.1. After-tax cash flows, not adjusted for inflation

Tables 1, 2, and 3 provide the analysis of after-tax cash flows for retirement durations of 20, 25, and 30 years, respectively. Because the same relations generally persist across the different time horizons, the tables are discussed together. Each table has two parts; the first part covers withdrawals as a percentage of initial portfolio value from 3% to 7% whereas the second part describes rates from 8% to 12%. The first column in each table lists the withdrawal, the second gives the equity allocation, and the third provides the success rate.

The success rate is the percentage of portfolios that have a positive value when the investment horizon is reached. For withdrawal amounts as a percentage of initial portfolio value of 5% and less, Table 1 provides evidence that there are few failures to provide the withdrawals for the full 20 years. Although the success rates are lower for these withdrawal amounts over 25- and 30-year periods (see Tables 2 and 3), withdrawals of less than 5% seldom exhaust the portfolio regardless of the time horizon or asset allocation used in this study. The success rate for the 100% bond allocation drops dramatically for withdrawals of

Table 1
After-tax cash flows for a 20-year retirement period

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
3%	100%	100%	21,600	25,805	21,637	302	20.0	20	7,189,320
3%	75%	100%	−5,502	22,769	20,412	2,761	20.0	20	5,202,282
3%	50%	100%	−26,777	22,440	19,126	4,693	20.0	20	3,719,490
3%	25%	100%	−12,934	22,740	19,789	3,351	20.0	20	2,621,643
3%	0%	100%	21,600	24,550	21,953	651	20.0	20	1,807,823
4%	100%	100%	28,800	38,195	29,165	1,281	20.0	20	6,427,009
4%	75%	100%	11	33,401	27,567	2,974	20.0	20	4,572,816
4%	50%	100%	−20,080	32,177	26,371	4,689	20.0	20	3,199,184
4%	25%	100%	−3,245	32,786	27,391	3,356	20.0	20	2,188,008
4%	0%	100%	28,800	35,456	31,035	2,161	20.0	20	1,444,731
5%	100%	96%	0	49,810	36,745	4,058	19.8	14	5,672,971
5%	75%	100%	6,356	48,418	35,252	3,744	20.0	20	3,943,232
5%	50%	100%	−11,437	44,861	34,252	5,246	20.0	20	2,677,133
5%	25%	100%	6,443	44,306	36,415	3,545	20.0	20	1,753,512
5%	0%	100%	36,000	48,272	40,698	3,771	20.0	20	1,081,639
6%	100%	95%	0	59,649	44,776	6,742	19.7	11	4,929,144
6%	75%	96%	0	59,952	43,273	6,051	19.9	15	3,320,854
6%	50%	100%	−988	59,074	43,288	6,042	20.0	20	2,155,609
6%	25%	100%	15,882	57,200	46,658	4,289	20.0	20	1,318,907
6%	0%	84%	0	60,080	50,285	7,452	19.8	18	726,662
7%	100%	93%	0	69,486	52,940	10,314	19.4	8	4,198,127
7%	75%	95%	0	69,806	51,849	9,132	19.7	12	2,709,168
7%	50%	96%	0	70,112	53,290	7,836	19.9	16	1,641,198
7%	25%	100%	23,091	70,093	57,572	5,680	20.0	20	884,302
7%	0%	45%	0	70,096	55,264	18,127	18.3	15	460,550
8%	100%	89%	0	80,047	60,937	14,541	19.1	7	3,491,981
8%	75%	89%	0	79,916	60,603	13,396	19.4	10	2,118,228
8%	50%	85%	0	79,934	62,926	12,594	19.5	13	1,150,787
8%	25%	60%	0	80,105	64,916	16,091	19.0	16	517,877
8%	0%	25%	0	80,072	57,222	27,820	16.3	13	281,104
9%	100%	75%	0	89,711	67,034	21,335	18.3	6	2,852,219
9%	75%	73%	0	89,602	67,385	20,648	18.6	8	1,587,952
9%	50%	60%	0	90,091	69,331	21,856	18.4	11	745,588

continued

Table 1
Continued

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
9%	25%	24%	0	89,953	65,970	29,384	16.8	13	302,123
9%	0%	18%	0	90,040	58,549	36,195	14.6	11	145,247
10%	100%	64%	0	100,022	71,611	28,938	17.3	5	2,294,671
10%	75%	53%	0	99,717	71,668	29,477	17.3	7	1,162,006
10%	50%	42%	0	99,629	72,118	32,388	16.8	9	452,115
10%	25%	13%	0	99,698	65,274	39,579	14.7	11	172,674
10%	0%	9%	0	99,718	58,180	43,896	12.8	10	56,892
11%	100%	49%	0	109,581	74,598	36,777	16.2	4	1,820,202
11%	75%	45%	0	109,865	74,722	37,877	16.1	6	819,731
11%	50%	24%	0	109,853	72,861	41,954	15.1	8	246,270
11%	25%	9%	0	109,760	63,822	47,733	12.9	10	91,292
11%	0%	4%	0	109,673	56,207	50,439	11.1	9	24,001
12%	100%	45%	0	119,748	76,905	44,177	15.2	4	1,415,073
12%	75%	33%	0	119,654	75,464	46,305	14.6	5	542,205
12%	50%	9%	0	119,511	70,267	50,900	13.2	7	133,943
12%	25%	4%	0	119,489	61,879	54,467	11.3	9	39,423
12%	0%	2%	0	119,651	54,827	55,816	9.9	8	7,805

The cash flows described in this table are annual after-tax withdrawals from a portfolio with an initial value of $1,000,000. The averages are calculated over 55 overlapping 20-year periods from 1926 to 1999.

Table 2
After-tax cash flows for a 25-year retirement period

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
3%	100%	100%	21,600	25,805	21,633	283	25.0	25	10,919,157
3%	75%	100%	−21,043	22,769	20,202	3,423	25.0	25	7,394,743
3%	50%	100%	−36,362	22,440	18,643	5,711	25.0	25	4,888,177
3%	25%	100%	−13,482	22,740	19,517	3,662	25.0	25	3,149,303
3%	0%	100%	21,600	24,550	21,908	618	25.0	25	1,953,577
4%	100%	100%	28,800	39,900	29,172	1,366	25.0	25	9,527,066
4%	75%	100%	−14,753	33,401	27,373	3,503	25.0	25	6,312,615
4%	50%	100%	−34,967	32,177	25,914	5,523	25.0	25	4,045,879
4%	25%	100%	−13,112	32,786	27,103	3,731	25.0	25	2,483,204
4%	0%	100%	28,800	36,513	31,285	2,225	25.0	25	1,424,603
5%	100%	96%	0	49,810	36,389	5,035	24.6	14	8,170,886
5%	75%	98%	−4,562	49,842	35,001	4,401	25.0	23	5,231,583
5%	50%	100%	−27,944	44,861	33,839	5,824	25.0	25	3,200,549
5%	25%	100%	−1,008	44,143	36,163	3,895	25.0	25	1,817,147
5%	0%	88%	0	50,015	41,110	5,451	24.8	23	903,261
6%	100%	94%	0	59,649	44,106	8,012	24.3	11	6,842,346
6%	75%	96%	0	59,952	42,601	7,258	24.7	15	4,179,207
6%	50%	98%	−19,076	59,533	42,658	7,159	24.9	21	2,357,879
6%	25%	100%	11,095	58,971	47,048	4,433	25.0	25	1,150,446
6%	0%	46%	0	60,111	46,671	16,029	22.6	18	503,329
7%	100%	90%	0	69,486	51,919	11,971	23.9	8	5,555,652
7%	75%	92%	0	69,806	50,819	10,794	24.3	12	3,152,444
7%	50%	92%	−4,832	70,112	52,483	10,010	24.6	16	1,544,134
7%	25%	68%	0	70,145	56,342	13,088	23.9	20	550,021
7%	0%	18%	0	70,075	47,326	26,236	19.3	15	281,924
8%	100%	78%	0	79,882	58,616	17,835	23.1	7	4,365,151
8%	75%	78%	0	79,916	58,528	16,903	23.5	10	2,208,090
8%	50%	60%	0	79,934	60,203	18,585	23.1	13	853,466
8%	25%	18%	0	80,105	56,553	27,425	20.4	16	254,958
8%	0%	14%	0	80,072	47,585	33,938	16.7	13	122,870
9%	100%	68%	0	90,078	63,040	25,616	21.7	6	3,353,453
9%	75%	56%	0	89,602	62,340	26,484	21.5	8	1,477,282

continued

Table 2
Continued

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
9%	50%	46%	0	90,091	63,062	29,727	20.6	11	411,166
9%	25%	8%	0	89,953	54,518	37,499	17.1	13	98,957
9%	0%	6%	0	90,040	47,156	40,742	14.4	11	22,422
10%	100%	48%	0	99,891	64,630	34,193	19.7	5	2,559,787
10%	75%	42%	0	99,717	63,928	35,597	19.3	7	963,233
10%	50%	20%	0	99,629	62,106	40,027	17.8	9	157,977
10%	25%	2%	0	99,698	51,916	44,884	14.4	11	33,681
10%	0%	0%	0	99,718	45,110	46,346	12.2	10	0
11%	100%	42%	0	109,581	65,484	41,739	17.9	4	1,937,953
11%	75%	32%	0	109,865	64,462	43,650	17.3	6	593,462
11%	50%	2%	0	109,853	58,498	48,223	15.0	8	68,213
11%	25%	2%	0	109,760	49,799	50,482	12.4	10	7,227
11%	0%	0%	0	109,673	43,316	50,760	10.6	9	0
12%	100%	34%	0	119,748	66,279	48,335	16.5	4	1,431,283
12%	75%	24%	0	119,654	63,862	50,751	15.4	5	328,731
12%	50%	2%	0	119,511	54,853	54,169	12.7	7	32,944
12%	25%	0%	0	119,489	47,755	55,032	10.8	9	0
12%	0%	0%	0	119,651	42,533	54,697	9.4	8	0

The cash flows described in this table are annual after-tax withdrawals from a portfolio with an initial value of $1,000,000. The averages are calculated over 50 overlapping 25-year periods from 1926 to 1999.

Table 3
After-tax cash flows for a 30-year retirement period

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
3%	100%	100%	21,600	25,805	21,630	271	30.0	30	16,405,143
3%	75%	100%	−15,905	22,769	20,003	3,789	30.0	30	10,534,747
3%	50%	100%	−36,255	22,440	18,141	6,373	30.0	30	6,441,261
3%	25%	100%	−17,683	22,740	19,237	4,065	30.0	30	3,725,208
3%	0%	100%	21,600	24,550	21,885	600	30.0	30	1,979,556
4%	100%	98%	0	39,900	29,019	2,196	29.9	25	14,060,787
4%	75%	100%	−5,133	33,401	27,210	3,693	30.0	30	8,793,449
4%	50%	100%	−33,590	32,177	25,493	5,972	30.0	30	5,151,428
4%	25%	100%	−13,240	32,786	26,880	3,840	30.0	30	2,750,648
4%	0%	100%	28,800	38,701	31,617	2,324	30.0	30	1,238,246
5%	100%	96%	0	49,810	36,033	5,739	29.4	14	11,816,352
5%	75%	98%	0	49,842	34,719	4,920	29.8	23	7,061,508
5%	50%	100%	−13,968	46,121	33,511	5,992	30.0	30	3,855,438
5%	25%	100%	−800	45,214	36,014	3,946	30.0	30	1,775,210
5%	0%	56%	0	50,076	39,270	11,190	28.0	23	600,884
6%	100%	93%	0	59,649	43,387	8,931	29.0	11	9,632,733
6%	75%	96%	0	60,024	42,083	7,951	29.4	15	5,394,215
6%	50%	96%	−3,142	59,533	42,047	7,880	29.7	21	2,577,129
6%	25%	89%	0	60,104	47,334	5,833	29.8	27	807,490
6%	0%	16%	0	60,111	41,222	22,111	23.4	18	221,685
7%	100%	87%	0	69,486	50,565	13,456	28.2	8	7,536,510
7%	75%	89%	0	69,806	49,657	12,272	28.7	12	3,789,170
7%	50%	84%	0	70,112	51,561	12,072	29.0	16	1,362,260
7%	25%	20%	0	69,669	50,918	22,009	25.4	20	200,706
7%	0%	7%	0	69,991	39,747	30,467	19.0	15	98,917
8%	100%	76%	0	80,233	55,659	20,495	26.6	7	5,709,803
8%	75%	71%	0	79,916	55,365	20,371	26.9	10	2,411,744
8%	50%	47%	0	79,934	55,300	24,446	25.4	13	555,797
8%	25%	4%	0	80,105	47,638	33,410	20.2	16	49,092
8%	0%	2%	0	80,072	38,677	36,608	15.9	13	26,301
9%	100%	60%	0	89,711	58,928	28,118	24.7	6	4,224,981
9%	75%	51%	0	89,602	56,943	30,014	23.9	8	1,509,657

continued

Table 3
Continued

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
9%	50%	24%	0	90,091	56,229	34,668	21.9	11	148,230
9%	25%	2%	0	89,953	44,510	40,527	16.4	13	2,598
9%	0%	0%	0	90,040	37,639	41,608	13.5	11	0
10%	100%	49%	0	99,891	59,858	35,944	22.3	5	3,154,960
10%	75%	38%	0	99,717	58,162	37,899	21.4	7	887,426
10%	50%	4%	0	99,629	52,781	43,415	18.0	9	3,084
10%	25%	0%	0	99,698	42,143	45,680	13.8	11	0
10%	0%	0%	0	99,718	36,448	45,687	11.7	10	0
11%	100%	44%	0	109,581	61,273	42,505	20.4	4	2,275,005
11%	75%	27%	0	109,865	58,423	45,135	19.0	6	456,508
11%	50%	0%	0	109,853	48,711	49,390	14.8	8	0
11%	25%	0%	0	109,760	40,542	49,803	12.0	10	0
11%	0%	0%	0	109,673	35,438	49,188	10.3	9	0
12%	100%	31%	0	119,748	60,815	48,845	18.4	4	1,603,487
12%	75%	18%	0	119,654	57,217	51,640	16.6	5	168,024
12%	50%	0%	0	119,511	45,503	53,681	12.6	7	0
12%	25%	0%	0	119,489	39,260	53,350	10.6	9	0
12%	0%	0%	0	119,651	35,000	52,496	9.2	8	0

The cash flows described in this table are annual after-tax withdrawals from a portfolio with an initial value of $1,000,000. The averages are calculated over 45 overlapping 30-year periods from 1926 to 1999.

5%. To maintain a reasonable success rate at these higher withdrawal amounts, it is essential to hold stocks. For all three retirement periods, the 100% equity allocation has the lowest percentage of failures at withdrawals above 7%.

For each withdrawal amount and allocation combination in our study, we conduct one trial for each of the 20-, 25-, or 30-year overlapping periods from 1926 to 1999. The actual returns data over each of these periods is used to calculate the portfolio values and after-tax yearly cash flows. When the assets in a portfolio are exhausted, the cash flows for the remaining years in the retirement period equal zero. Columns four through seven of Tables 1, 2, and 3 contain the minimums, maximums, means, and standard deviations of these after-tax cash flows for each withdrawal amount/asset allocation choice.

First, we examine the minimums. For every withdrawal amount/asset allocation combination that has a success rate less than 100%, the minimum after-tax cash flow will at least fall to zero, and this occurs for all the withdrawals above 7% regardless of the retirement period. The minimum after-tax cash flow occasionally is negative because taxes exceed the withdrawal amount, which is expressed on a pretax basis. These tax payments are triggered by annual portfolio rebalancing so only the asset allocations that require rebalancing experience negative minimum after-tax cash flows. The 50%/50% allocation generates negative cash flows that are of greater magnitude than other allocations. For the 3% and 4% withdrawals as a percentage of initial portfolio value, the 100% stock and 100% bond allocations have substantially higher minimum after-tax cash flows because these allocations do not need to be rebalanced.

The maximum after-tax cash flows are shown in column five of Tables 1–3. Within each of the withdrawals above 6%, there is little difference between the maximum after-tax cash flows for each asset allocation. The largest difference between these maximums is $659, and this occurs at the 7% withdrawal for the 25-year retirement period. However, at lower withdrawals, taxes associated with rebalancing cause larger differences in the maximums. Within each withdrawal of 6% or less, the average difference between the largest maximum and the smallest maximum is $4,366. Either the 100% stock or 100% bond allocation has the highest maximum for these withdrawal amounts.

Because our analysis assumes that retirees have income outside of their retirement portfolios, it is possible that some of the maximum after-tax cash flows exceed the pretax withdrawal amounts. For example, Table 1 shows that the maximum after-tax cash flow for a 7% withdrawal rate and a 50%/50% asset allocation is $70,112, which is greater than the pretax withdrawal rate of $70,000 (7% × $1,000,000). This can occur when a portfolio is close to failure or the end of the retirement period and generates a capital loss that exceeds the amount of interest and dividends. We assume that the retiree uses this excess capital loss to reduce taxable income outside of the investment portfolio; this tax benefit from the retirement portfolio is represented as a positive cash flow in addition to the pretax withdrawal rate.

Column six of Tables 1–3 shows the mean after-tax cash flows generated from various withdrawals and asset allocations. For withdrawals under 6%, the 100% bond allocation provides the highest mean cash flows and the 100% stock allocation provides the second highest mean cash flows. The average difference between the cash flows from the 100% stock and 100% bond allocations is $2,149 at these withdrawals. The 100% stock allocation has the highest average cash flow for the 20-year period when the withdrawal rate is 12%, for the 25-year period when the withdrawal rate is above 9%, and for the 30-year period when the withdrawal rate is above 7%. As expected, equity investments are more attractive as the holding period lengthens. For withdrawals as a percentage of initial portfolio value between 6% and 9%, the results are mixed, and the best allocation depends on the retirement period.

In addition, asset allocation becomes more important at the higher withdrawal amounts. Within each withdrawal above 8%, the average difference between the highest and lowest mean after-tax cash flow produced by the five different asset allocations is $20,250. This is substantially higher than the difference of $2,149 discussed earlier for the lower withdrawals, and it is a result of the higher failure rate of the allocations with significant portions of bonds.

The standard deviations for each withdrawal amount/asset allocation strategy are provided in column seven. At lower withdrawals as a percentage of initial portfolio value, the 100% stock and 100% bond allocations produce lower standard deviations. Using the 3% withdrawal rate for the 20-year retirement period as an example, the 100% equity and the 0% equity allocations have standard deviations of $302 and $651, which are substantially less than the standard deviation of $4,693 for the 50%/50% allocation. In this case, even though the 100% stock and 100% bond allocations have similar minimums, maximums, and means, the 100% equity allocation has the smaller standard deviation of the cash flows.

This result is counterintuitive to our expectation that stocks are generally riskier. This occurs because it is more likely that the coupon stream from the 100% debt allocation will not be sufficient to meet the pretax withdrawal. Dividend yields through the 1950s tended to exceed coupon rates. Thus, for the 0% equity allocation it is more likely that securities must be sold (and capital gains incurred) to meet the withdrawal amount. As our assumed capital gains tax rate is less than that for ordinary income, the average after-tax cash flow for the 0% equity allocation is slightly higher than for the 100% allocation.

Throughout all of the time horizons investigated, the 100% stock allocation has the lowest standard deviation for withdrawals less than 5%, and this allocation generally produces the lowest standard deviation for withdrawals above 8%. The results are mixed for the withdrawals between 5% and 8%.

Columns eight and nine provide data on the number of years that the portfolios survive for various asset combinations. At lower withdrawals, there is little difference between the average years that a portfolio survives. At higher rates (8% and above for the 20-year period, 7% and above for the 25-year period, and 6% and above for the 30-year period), the difference between the mean survival length of the 100% stock and 100% bond portfolios becomes at least approximately four years. The minimum survival length is lower for the 100% stock allocation at lower withdrawal amounts. This occurs because our data includes stock returns during the Great Depression. At higher withdrawals, allocations with significant portions of bonds have the highest minimum survival lengths.

Column 10 provides the mean-adjusted terminal portfolio values, which represent the average amount of money that is left over at the end of the investment horizon after making the withdrawals throughout the retirement period. This amount is labeled the adjusted value because it reflects the negative cash flows that occur during the retirement period due to taxes. The future value of these cash flows is calculated at the end of the retirement period using the overall return on the portfolio during that period and it is subtracted from the unadjusted terminal value.

On average, a substantial amount remains at low withdrawal percentages. Even at the 12% withdrawal, the 100% equity allocation has a mean-adjusted terminal portfolio value of approximately $1.5 million. Regardless of the withdrawal level, the 100% equity allocation dominates all the other allocations by providing higher mean terminal portfolio values.

4.2. *Inflation-adjusted after-tax cash flows*

Tables 4-6 provide inflation-adjusted results. The general interpretation of these tables is similar to that for Tables 1, 2, and 3. As expected, given that more money is being withdrawn, i.e., inflation was generally positive over the period studied, success rates are often lower for the inflation-adjusted data. Also, the terminal portfolio values are smaller. The cash flows themselves are, of course, larger on average with larger standard deviations. The minimum cash flows are now negative in only two instances (25 years and 30 years at 3% withdrawal and 50% equity). This is so because inflation has driven the withdrawal amounts sufficiently high that taxes on recognized gains no longer exceed the pretax cash flows. The overall impression from Tables 4, 5, and 6 is that the 100% equity allocation is, generally, even more attractive with adjustment for inflation than without adjusting for inflation. We discuss this further in the following section.

4.3. *Best asset allocations*

Tables 1–6 provide substantial information on the after-tax cash flows that a retiree should expect to receive based on various withdrawal levels, asset allocations, historical returns, and historical rates of inflation. How should one use this information to decide on a particular asset allocation? Table 7 shows the best stock allocation at each withdrawal rate and retirement period based on three criteria. The first criterion is to choose the asset allocation that produces the highest mean after-tax cash flow. Columns two through four provide the results of applying this criterion. For example, if one has a 30-year retirement period and a withdrawal rate of 8%, Table 7 shows that the 100% stock allocation provides the highest mean after-tax cash flow for both the noninflation-adjusted data and the inflation-adjusted cash flows (the number after the backslash). For noninflation-adjusted data, regardless of the retirement period, an allocation without stocks is preferred at low withdrawals (less than 6%). For the noninflation-adjusted data, at high withdrawals as a percentage of initial portfolio value (greater than 9%), the 100% equity allocation generally results in the highest mean after-tax cash flows. For the inflation-adjusted cash flows, the longer the period the more attractive is the 100% equity allocation, even for low withdrawal rates. This is not too surprising as equities tend to be better inflation hedges than bonds. The main problem with this highest mean after-tax cash flow criterion is that it only focuses on the reward and ignores the risk.

The second criterion in Table 7 is to pick the asset allocation with the lowest risk as measured by the lowest standard deviation of after-tax cash flows. For cash flows that are not adjusted for inflation, regardless of the investment horizon, the 100% stock allocation is

Table 4
After-tax cash flows from an inflation-adjusted withdrawal strategy for a 20-year retirement period

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
3%	100%	100%	15,566	83,121	33,633	13,266	20.0	20	6,304,206
3%	75%	100%	11,638	76,086	31,837	13,037	20.0	20	4,419,305
3%	50%	100%	251	74,445	30,555	13,523	20.0	20	3,025,030
3%	25%	100%	9,980	76,913	31,914	13,239	20.0	20	1,999,397
3%	0%	100%	15,566	83,929	35,447	13,679	20.0	20	1,247,443
4%	100%	100%	20,755	127,232	46,361	19,661	20.0	20	5,246,856
4%	75%	100%	16,633	123,045	43,763	19,172	20.0	20	3,528,689
4%	50%	100%	14,181	123,389	42,847	19,272	20.0	20	2,270,718
4%	25%	100%	15,448	128,027	45,730	19,693	20.0	20	1,357,016
4%	0%	89%	0	132,344	49,787	20,668	19.8	18	703,904
5%	100%	91%	0	165,054	59,147	25,869	19.9	17	4,204,472
5%	75%	95%	0	166,616	56,896	26,262	19.9	18	2,647,485
5%	50%	91%	0	164,195	57,642	27,041	19.9	18	1,530,996
5%	25%	87%	0	164,945	60,555	27,074	19.7	17	752,935
5%	0%	45%	0	161,920	58,896	29,679	18.5	15	307,681
6%	100%	78%	0	197,601	67,429	30,857	19.0	13	3,312,344
6%	75%	78%	0	197,621	66,406	30,691	19.2	14	1,906,360
6%	50%	75%	0	176,120	67,610	31,315	19.1	14	944,951
6%	25%	49%	0	181,395	67,378	33,366	18.3	14	352,682
6%	0%	20%	0	171,689	59,151	37,281	16.1	12	138,557
7%	100%	71%	0	216,392	74,314	36,124	18.1	10	2,555,239
7%	75%	69%	0	191,674	74,476	36,051	18.3	11	1,300,811
7%	50%	55%	0	205,398	74,594	37,639	18.0	11	499,294
7%	25%	25%	0	188,064	67,733	40,903	16.3	11	148,018
7%	0%	15%	0	176,266	57,915	43,001	14.2	11	63,056
8%	100%	58%	0	228,973	80,093	42,656	17.2	9	1,869,208
8%	75%	51%	0	238,168	79,514	43,133	17.1	9	796,058
8%	50%	27%	0	213,685	75,765	45,234	16.3	10	224,482
8%	25%	13%	0	188,137	66,491	47,318	14.5	10	52,880
8%	0%	15%	0	189,324	57,523	48,232	12.7	9	12,259
9%	100%	47%	0	271,624	83,748	49,818	16.1	8	1,310,379
9%	75%	36%	0	229,780	80,514	50,484	15.7	8	446,328

Table 4
Continued

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
9%	50%	20%	0	206,731	73,820	51,844	14.5	8	80,373
9%	25%	5%	0	198,070	63,720	52,970	12.7	9	10,660
9%	0%	0%	0	192,568	55,832	52,696	11.3	8	0
10%	100%	33%	0	253,207	84,516	57,167	14.8	6	872,755
10%	75%	20%	0	236,829	79,435	56,889	14.2	7	214,914
10%	50%	5%	0	216,236	71,027	57,729	12.9	8	11,326
10%	25%	0%	0	200,440	61,015	57,466	11.2	8	0
10%	0%	0%	0	194,905	53,608	56,496	10.0	7	0
11%	100%	27%	0	238,564	83,927	62,925	13.6	5	556,278
11%	75%	16%	0	228,585	76,683	62,577	12.7	6	109,972
11%	50%	2%	0	229,017	67,106	62,599	11.3	7	91
11%	25%	0%	0	212,874	58,710	61,464	10.0	7	0
11%	0%	0%	0	195,668	52,963	60,471	9.1	7	0
12%	100%	20%	0	250,803	81,822	68,337	12.4	5	343,598
12%	75%	7%	0	238,556	73,922	67,628	11.4	6	35,579
12%	50%	0%	0	237,348	64,006	66,710	10.0	6	0
12%	25%	0%	0	236,624	57,383	65,577	9.1	7	0
12%	0%	0%	0	215,002	52,016	64,275	8.2	6	0

The cash flows described in this table are annual after-tax withdrawals from a portfolio with an initial value of $1,000,000. The withdrawal amount is adjusted annually for inflation. The averages are calculated over 55 overlapping 20-year periods from 1926 to 1999.

Table 5
After-tax cash flows from an inflation-adjusted withdrawal strategy for a 25-year retirement period

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
3%	100%	100%	15,566	101,300	37,077	16,912	25.0	25	9,168,951
3%	75%	100%	10,680	92,266	34,872	16,387	25.0	25	5,884,690
3%	50%	100%	−10,336	92,266	33,353	16,896	25.0	25	3,581,789
3%	25%	100%	9,980	94,536	35,076	16,674	25.0	25	2,003,381
3%	0%	100%	0	109,648	39,965	18,290	25.0	24	945,781
4%	100%	100%	20,755	162,169	51,383	25,262	25.0	25	7,193,458
4%	75%	100%	16,633	157,975	48,459	24,792	25.0	25	4,298,329
4%	50%	100%	5,241	158,895	47,660	25,652	25.0	25	2,297,755
4%	25%	100%	0	159,752	51,400	26,887	24.9	22	970,381
4%	0%	88%	0	159,946	49,388	28,698	22.8	18	299,810
5%	100%	90%	0	208,506	62,333	32,225	24.2	17	5,378,740
5%	75%	94%	0	202,326	60,009	32,296	24.3	18	2,860,546
5%	50%	90%	0	202,305	60,020	33,127	24.1	18	1,223,434
5%	25%	86%	0	184,039	58,968	33,634	22.7	17	315,009
5%	0%	40%	0	185,861	49,329	35,628	19.3	15	82,865
6%	100%	76%	0	219,220	66,234	36,307	22.5	13	4,038,915
6%	75%	76%	0	202,507	64,318	35,538	22.5	14	1,879,748
6%	50%	72%	0	180,966	64,462	36,267	22.1	14	592,983
6%	25%	44%	0	207,781	57,338	39,052	19.5	14	106,744
6%	0%	16%	0	171,689	47,243	39,158	16.5	12	30,400
7%	100%	68%	0	220,929	69,796	40,907	20.9	10	2,969,005
7%	75%	66%	0	229,858	68,964	40,866	20.9	11	1,150,618
7%	50%	52%	0	242,460	65,818	43,246	19.7	11	219,320
7%	25%	22%	0	187,442	54,383	43,526	16.8	11	32,361
7%	0%	14%	0	176,266	45,899	43,139	14.4	11	2,051
8%	100%	56%	0	261,624	72,844	46,987	19.5	9	2,074,251
8%	75%	50%	0	276,725	70,286	47,994	18.9	9	604,803
8%	50%	26%	0	213,685	62,633	48,570	17.1	10	71,773
8%	25%	12%	0	188,137	52,399	47,907	14.7	10	1,298
8%	0%	14%	0	187,291	44,585	46,923	12.7	9	0
9%	100%	46%	0	312,585	74,844	54,258	17.9	8	1,342,304
9%	75%	36%	0	229,780	68,922	53,569	16.9	8	286,592

continued

Table 5
Continued

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
9%	50%	20%	0	204,612	59,065	52,947	14.9	8	10,955
9%	25%	6%	0	198,070	49,460	51,654	12.7	9	0
9%	0%	0%	0	192,568	43,563	50,484	11.3	8	0
10%	100%	32%	0	252,857	72,847	59,241	16.1	6	881,485
10%	75%	20%	0	228,171	65,970	58,405	14.9	7	117,474
10%	50%	6%	0	216,236	55,629	56,877	12.9	8	0
10%	25%	0%	0	200,440	47,896	55,224	11.3	8	0
10%	0%	0%	0	194,905	42,321	53,561	10.1	7	0
11%	100%	30%	0	238,564	73,146	64,848	14.9	5	494,932
11%	75%	18%	0	228,585	63,348	62,753	13.3	6	27,473
11%	50%	2%	0	229,017	52,619	60,153	11.4	7	0
11%	25%	0%	0	212,874	46,430	58,335	10.1	7	0
11%	0%	0%	0	193,652	42,087	56,957	9.2	7	0
12%	100%	22%	0	267,587	70,573	69,447	13.4	5	221,092
12%	75%	8%	0	238,556	59,417	65,875	11.7	6	2,957
12%	50%	0%	0	237,348	50,409	63,148	10.1	6	0
12%	25%	0%	0	236,624	45,517	61,650	9.2	7	0
12%	0%	0%	0	215,002	41,564	60,229	8.4	6	0

The cash flows described in this table are annual after-tax withdrawals from a portfolio with an initial value of $1,000,000. The withdrawal amount is adjusted annually for inflation. The averages are calculated over 50 overlapping 25-year periods from 1926 to 1999.

Table 6
After-tax cash flows from an inflation-adjusted withdrawal strategy for a 30-year retirement period

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
3%	100%	100%	15,566	116,747	39,911	19,932	30.0	30	13,572,362
3%	75%	100%	5,579	111,037	37,436	19,352	30.0	30	8,117,826
3%	50%	100%	−10,336	112,555	35,575	19,844	30.0	30	4,378,888
3%	25%	100%	9,980	121,409	37,812	19,986	30.0	30	1,941,143
3%	0%	100%	0	136,527	42,947	24,893	29.1	24	501,450
4%	100%	100%	20,755	189,941	55,014	29,269	30.0	30	10,278,607
4%	75%	100%	0	187,013	52,134	29,402	30.0	29	5,571,342
4%	50%	100%	0	190,222	51,071	31,107	29.8	26	2,419,043
4%	25%	100%	0	187,513	53,090	32,090	28.9	22	572,894
4%	0%	87%	0	173,651	41,368	30,701	23.6	18	122,765
5%	100%	91%	0	208,958	62,706	34,622	28.4	17	7,577,720
5%	75%	93%	0	226,273	60,035	34,318	28.5	18	3,580,368
5%	50%	89%	0	190,875	58,114	34,724	27.6	18	1,162,549
5%	25%	84%	0	180,007	50,926	34,604	24.2	17	188,903
5%	0%	38%	0	185,861	40,481	33,973	19.9	15	30,296
6%	100%	80%	0	235,261	67,246	39,658	26.4	13	5,559,623
6%	75%	80%	0	225,359	63,655	37,880	26.2	14	2,246,736
6%	50%	78%	0	200,742	61,475	39,215	24.8	14	461,052
6%	25%	47%	0	181,395	48,553	38,341	20.5	14	60,001
6%	0%	18%	0	171,689	39,283	37,838	17.0	12	0
7%	100%	73%	0	263,689	70,188	44,195	24.4	11	3,945,084
7%	75%	71%	0	230,174	67,386	43,864	24.0	12	1,245,200
7%	50%	56%	0	223,198	58,614	44,740	21.2	12	152,834
7%	25%	24%	0	187,442	46,260	42,846	17.5	12	2,918
7%	0%	16%	0	176,266	37,889	41,285	14.7	11	0
8%	100%	60%	0	295,758	72,563	51,153	22.4	9	2,637,795
8%	75%	53%	0	271,508	67,121	51,209	21.3	10	584,478
8%	50%	29%	0	189,855	54,301	48,597	18.1	11	29,781
8%	25%	13%	0	188,137	43,876	46,445	15.1	11	0
8%	0%	16%	0	187,291	37,073	44,673	12.9	9	0
9%	100%	49%	0	286,511	71,857	57,385	20.2	8	1,717,594
9%	75%	40%	0	294,831	63,504	56,261	18.4	9	225,809

continued

Table 6
Continued

Withdrawal	Equity %	Success rate	Minimum after-tax cash flow	Maximum after-tax cash flow	Mean after-tax cash flow	Standard deviation of after-tax cash flows	Mean years that portfolio survives	Minimum years that portfolio survives	Mean adjusted terminal portfolio value
9%	50%	22%	0	191,230	50,208	51,847	15.4	10	0
9%	25%	7%	0	190,944	41,469	49,440	13.1	9	0
9%	0%	0%	0	189,095	36,327	47,818	11.5	8	0
10%	100%	36%	0	343,258	71,676	64,449	18.3	6	1,019,170
10%	75%	22%	0	274,966	59,375	59,468	16.1	8	60,380
10%	50%	7%	0	188,819	46,881	54,682	13.4	9	0
10%	25%	0%	0	186,910	40,209	52,519	11.6	8	0
10%	0%	0%	0	185,031	35,371	50,544	10.3	7	0
11%	100%	33%	0	392,036	71,466	69,998	16.8	5	434,598
11%	75%	20%	0	244,628	55,014	61,829	14.0	7	0
11%	50%	2%	0	189,569	44,342	57,259	11.7	8	0
11%	25%	0%	0	187,713	38,986	55,170	10.4	7	0
11%	0%	0%	0	185,840	35,157	53,541	9.4	7	0
12%	100%	24%	0	326,994	65,086	71,318	14.6	5	160,584
12%	75%	9%	0	202,441	50,630	63,305	12.2	7	0
12%	50%	0%	0	194,713	42,489	59,739	10.4	7	0
12%	25%	0%	0	195,229	38,015	57,793	9.4	7	0
12%	0%	0%	0	199,230	34,562	56,228	8.5	6	0

The cash flows described in this table are annual after-tax withdrawals from a portfolio with an initial value of $1,000,000. The withdrawal amount is adjusted annually for inflation. The averages are calculated over 45 overlapping 30-year periods from 1926 to 1999.

Table 7
Best stock allocations under three criteria

Withdrawal	Highest mean after-tax cash flow			Lowest standard deviation of after-tax cash flow			Highest reward-risk ratio		
	20-Year period	25-Year period	30-Year period	20-Year period	25-Year period	30-Year period	20-Year period	25-Year period	30-Year period
3%	0%/0%	0%/0%	0%/0%	100%/75%	100%/75%	100%/75%	100%/0%	100%/100%	100%/100%
4%	0%/0%	0%/25%	0%/100%	100%/75%	100%/75%	100%/100%	100%/0%	100%/100%	0%/100%
5%	0%/25%	0%/100%	0%/100%	25%/100%	25%/100%	25%/0%	0%/100%	25%/100%	25%/100%
6%	0%/50%	25%/100%	25%/100%	25%/75%	25%/75%	25%/0%	25%/100%	25%/100%	25%/100%
7%	25%/50%	25%/100%	50%/100%	25%/75%	50%/75%	50%/0%	25%/75%	50%/100%	50%/100%
8%	25%/100%	50%/100%	100%/100%	50%/100%	75%/0%	75%/0%	50%/100%	75%/100%	75%/100%
9%	50%/100%	50%/100%	100%/100%	75%/100%	100%/0%	100%/0%	75%/100%	100%/100%	100%/100%
10%	50%/100%	100%/100%	100%/100%	100%/0%	100%/0%	100%/0%	100%/100%	100%/100%	100%/100%
11%	75%/100%	100%/100%	100%/100%	100%/0%	100%/0%	100%/0%	100%/100%	100%/100%	100%/100%
12%	100%/100%	100%/100%	100%/100%	100%/0%	100%/0%	100%/0%	100%/100%	100%/100%	100%/100%

This table shows the best stock allocations for various withdrawals as a percentage of initial portfolio value. Columns 2–4 show the stock allocations that provide the highest mean after-tax cash flows. Columns 5–7 show the stock allocations that provide the lowest standard deviations of the after-tax cash flows. The final three columns list the stock allocations that produce the highest reward-risk ratios, defined as the mean after-tax cash flow divided by the standard deviation of the after-tax cash flows. The first number in Columns 2–10 is the equity allocation based on a constant withdrawal amount. The number after the backslash is the equity allocation based on an inflation-adjusted withdrawal amount.

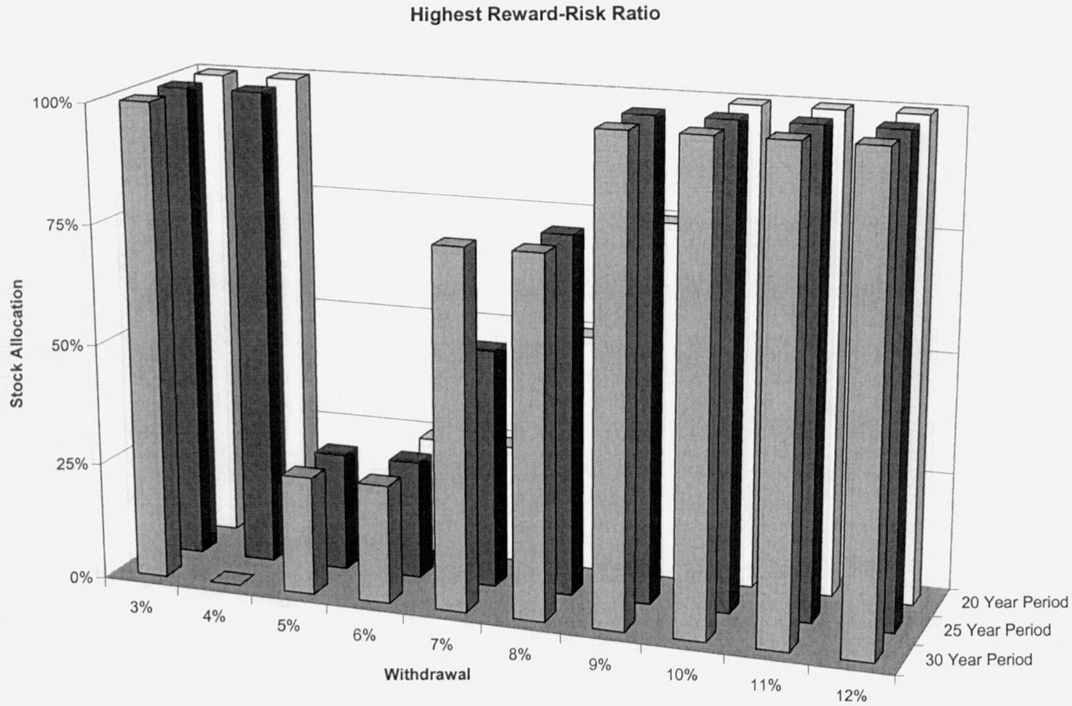

Fig. 1. Stock allocations that produce the highest reward-risk ratios, which equal the mean divided by the standard deviation of the after-tax cash flows, for various withdrawals as a percentage of initial portfolio value.

better at low withdrawals (less than 5%) and high withdrawals (above 9%). The results are mixed in between 5% and 9%. For the inflation-adjusted cash flows, the 0% equity allocation has the lower standard deviation, but this is due to so many of the cash flows being zero because the failure rate at 0% equity is very high. Furthermore, this criterion is perhaps misleading because it doesn't directly reflect the reward of a particular asset allocation (i.e., the level of after-tax cash flows).

The final criterion is to choose the allocation with the highest ratio of the mean and the standard deviation of the after-tax cash flows. This approach is superior because it reflects both the risk and reward of a particular strategy. Without adjusting for inflation, the 100% equity allocation has the highest reward-risk ratio in 16 of the 30 withdrawal amount/retirement period combinations. Using inflation-adjusted cash flows, this ratio rises to 27 of 30. Thus, a 100% equity allocation is generally preferred and is clearly the best allocation when the withdrawal is below 5% or above 8%. Fig. 1 illustrates these results for the noninflation-adjusted data by showing the stock allocation that produces the highest reward-risk ratio for various assumptions.

4.4. *Terminal portfolio values*

One of the weaknesses of the criteria presented in Table 7 is that they ignore the money left over after all the scheduled withdrawals have been made. This amount is important to

Table 8
Terminal portfolio value advantage of 100% equity

Withdrawal	20-Year period		25-Year period		30-Year period	
	Terminal value advantage of 100% equity	Equivalent payment value	Terminal value advantage of 100% equity	Equivalent payment value	Terminal value advantage of 100% equity	Equivalent payment value
3%	1,976,925	22,466	3,521,871	24,421	5,870,396	26,647
4%	1,839,695	20,629	3,206,344	21,961	5,261,998	23,704
5%	1,709,426	19,033	2,918,745	19,957	4,733,297	21,367
6%	1,587,230	17,709	2,649,897	18,205	4,232,219	19,231
7%	1,475,724	16,692	2,398,226	16,575	3,747,340	17,131
8%	1,368,636	15,642	2,151,719	14,946	3,298,059	15,154
9%	1,262,094	14,466	1,874,706	12,842	2,714,112	12,378
10%	1,132,665	12,763	1,596,555	10,744	2,267,534	10,325
11%	1,000,471	11,036	1,344,491	9,013	1,818,497	8,320
12%	872,869	9,498	1,102,552	7,316	1,435,463	6,560

This table shows the mean portfolio terminal value advantage of 100% equity asset allocation relative to the asset allocation that produces the next highest terminal value. This terminal portfolio advantage is computed for each combination of withdrawals as a percentage of initial portfolio value, retirement period lengths, and overlapping periods within our sample data from 1926 to 1999. The values shown below are the averages across the overlapping periods. The equivalent payment value expresses the terminal value advantage of 100% equity as a payment received each year in the retirement period. The equivalent payment value is calculated using an interest rate equal to the total return on equity over the particular time period.

retirees for two reasons. First, they may live longer than the retirement period and need additional cash withdrawals from their portfolios. Second, they may want to leave as much as possible to their heirs.

An examination of Table 8 indicates that the 100% equity allocation has a decided advantage, providing higher average terminal values across all withdrawals as a percentage of initial portfolio value and retirement periods analyzed in this study. In every case, the mean terminal value of the 100% equity portfolio is higher than the other allocations. While this may not be a surprise, the size of the equity advantage is worth noting. Table 8 provides the mean terminal value advantage of 100% equity, which is the average difference between the adjusted terminal value of 100% equity and the asset allocation that produces the next largest adjusted terminal value. This average is provided for each withdrawal amount and time period, and it is calculated using the terminal value advantage for each overlapping period within our sample data, which extends from 1926 to 1999. The median difference computed across all withdrawals and time periods is over $1.9 million. The smallest average terminal value advantage of equity is $872,868. Table 8 uses noninflation-adjusted data. An analogous table based on inflation-adjusted data provides even stronger support for a 100% equity allocation.

Because the focus of this research project is portfolio withdrawals, it is useful to express this terminal value advantage as a cash flow that could be withdrawn in each year over the retirement period. The equivalent payment value expresses the terminal value advantage of 100% equity as a payment received each year in the retirement period. The equivalent payment value is calculated using an interest rate equal to the total return on equity over the particular time period. The median equivalent payment value, which is computed across all withdrawals as a percentage of initial portfolio value and retirement periods, is $16,109 per year. Remember that this represents the annuitized value of just the advantage of the 100% stock allocation; if the entire terminal portfolio value were actually converted to a yearly payment, it would usually be several times larger. When the equivalent payment value is compared to the mean cash flows shown in Tables 1–3 (i.e., the results without adjusting for inflation), it is clear that the terminal portfolio value is too big to be ignored when making a decision on the appropriate asset allocation and withdrawal rate.

5. Summary and concluding remarks

Previous research on withdrawal patterns and portfolio rebalancing has not incorporated tax effects into the analysis. Although individual tax situations vary significantly, our research shows that taxes usually have a dramatic effect on the cash flows from a nonqualified retirement portfolio.

This study is unique in that it serves as a useful guide to financial advisors who want to counsel their clients on the after-tax cash flows (spendable money) that they can expect from their retirement portfolios. In addition to providing the mean after-tax cash flows for various withdrawal amount/asset allocation combinations, this paper also provides the minimums, maximums, and standard deviations. These statistics show that if retirees strictly adhere to a certain pretax withdrawal amount and rebalancing strategy, cash flows will likely exhibit fluctuations too large to ignore.

This occurs even at the lower withdrawal percentages that have perfect success rates. As an example, compare the after-tax cash flows from a 100% equity allocation and a 50%/50% allocation with a withdrawal of 3% and a 20-year retirement period. The 100% equity allocation has a significantly lower standard deviation. Assuming a normal distribution of cash flows, 68% of the cash flows from the 100% equity position would be between $21,435 and $21,939. But the expected range for the 50%/50% allocation would be $14,433 to $23,819, which is considerably larger due to taxes. Previous studies on this subject fail to reflect these tax effects associated with rebalancing.

Planners could use Tables 1–6 to give clients a measure of the tradeoffs involved in managing a taxable retirement portfolio. For example, suppose a client desires a withdrawal amount equal to 6% of the initial value of the retirement portfolio. Our work allows the advisor to show that a 25% equity allocation is generally preferred. Furthermore, the size of the cash flows and their variability is shown for the other allocations as well.

Planners could show clients the counterintuitive results for low withdrawal amounts and asset allocations other than 100% equity or 0% equity. A risk-averse client might want, say, a 3% withdrawal rate and only a 25% equity allocation. The client thinks he must expose some of the portfolio to higher risk equities in order to maintain portfolio value. Using our results, the planner could show the client that, due to the magnitude of the tax consequences of rebalancing, an allocation of 0% equity would actually be preferred, given the client's risk aversion.

Suppose a client with greater risk tolerance has a 30-year time horizon, wants a 12%

withdrawal rate, and is willing to put 100% of her assets into equities. Using our results, the financial planner can show the client that the mean after-tax cash flow from a 7% withdrawal rate, 100% equity allocation is $50,565 versus $60,815 for the 12% withdrawal rate. For a less than 17% reduction in after-tax mean cash flow, your success rate (chance of having the portfolio last for 30 years) moves from 31% to 87%. If you just say to the client, "we think you should consider reducing your withdrawal rate from 12% to 7%," the client might, mistakenly, believe that the planner is asking her to sacrifice 41.67% of her income. But, using our results, the planner can demonstrate that the magnitude of the reduction in expected after-tax cash flows is only on the order of 17%.

Our research finds that the 100% equity allocation generally offers significant advantages over other asset allocations in the presence of taxes. For withdrawals below 5% and above 8%, this asset allocation provides the most attractive trade-off between risk and return for the cash flows during the retirement period. At higher withdrawals (usually above 8%), the 100% equity allocation is the preferred choice under all three criteria investigated in this study (highest mean after-tax cash flow, lowest standard deviation of after-tax cash flow, or highest reward-risk ratio). Even when the 100% equity allocation is not the best choice under one of the criteria, it usually produces results similar to the best choice. Additionally, the terminal portfolio advantage of 100% equity makes this asset allocation an even more attractive choice. On average, the 100% equity allocation provides a higher terminal value across all withdrawals and time horizons studied.

Because expected capital gains are a higher percentage of the total return for most stocks than for most bonds, the recent decreases in capital gains tax rates make stocks even more attractive on an after-tax basis. Under the new law, if an asset is purchased after December 31, 2001 and held for more than five years, the maximum capital gains tax rate (starting with the 2002 tax year) is 18%. This rate is 8% for individuals in the 15% tax bracket.

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