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# Portfolio rebalancing in theory and practice

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**Executive summary.** The primary goal of a rebalancing strategy is to minimise risk relative to a target asset allocation, rather than to maximise returns. A portfolio's asset allocation is the major determinant of a portfolio's risk-and-return characteristics<sup>1</sup>. Yet, over time, asset classes produce different returns, so the portfolio's asset allocation changes. Therefore, to recapture the portfolio's original risk-and-return characteristics, the portfolio should be rebalanced.

In theory, investors select a rebalancing strategy that weighs their willingness to assume risk against expected returns net of the cost of rebalancing. Our findings indicate that there is no optimal frequency or threshold when selecting a rebalancing strategy. This paper demonstrates that the risk-adjusted returns are not meaningfully different

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#### Important information

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<sup>1</sup> Assuming a well-diversified portfolio that engages in limited market-timing.

whether a portfolio is rebalanced monthly, quarterly or annually; however, the number of rebalancing events and resulting costs (taxes, time, and labour) increase significantly. (For instance, monthly rebalancing with no threshold would require 1,008 rebalancing events, while annual rebalancing with a 10% threshold would require only 15 rebalancing events.) As a result, we conclude that for most broadly diversified stock and bond fund portfolios (assuming reasonable expectations regarding return patterns, average returns, and risk), annual or semi-annual monitoring, with rebalancing at 5% thresholds, is likely to produce a reasonable balance between risk control and cost minimisation for most investors. Annual rebalancing is likely to be preferred when taxes or substantial time/costs are involved.

Vanguard believes that the asset allocation decision – which takes into account each investor’s risk tolerance, time horizon, and financial goals – is the most important decision in the portfolio-construction process.<sup>2</sup> This is because asset allocation is the major determinant of risk and return for a given portfolio. Over time, however, as a portfolio’s investments produce different returns, the portfolio will likely drift from its target asset allocation, acquiring risk-and return characteristics that may be inconsistent with an investor’s goals and preferences. Portfolio rebalancing is extremely important because it helps investors to maintain their target asset allocation. By periodically rebalancing, investors can diminish the tendency for ‘portfolio drift,’ and thus potentially reduce their exposure to risk relative to their target asset allocation.

As part of the portfolio-construction process, it is therefore important for investors to develop a rebalancing strategy that formally addresses ‘how often, how far, and how much’: that is, how frequently the portfolio should be monitored; how far an asset allocation can be allowed to deviate from its target before it is rebalanced and whether periodic rebalancing should restore a portfolio to its target or to a close approximation of the target. While each of these decisions has an impact on a portfolio’s risk-and-return characteristics; the differences in results among the strategies are not very significant. Thus, the how often, how far, and how much are mostly questions of investor preference. The only clear advantage for any of these strategies, as far as maintaining a portfolio’s risk-and-return characteristics, and without factoring in rebalancing costs, is that a rebalanced portfolio more closely aligns with the characteristics of the target asset allocation than a portfolio that is never rebalanced.

2 Assuming a well-diversified portfolio that engages in limited market-timing.

This paper's discussion begins with a review of the significant rebalancing opportunities into equities over the past 80 years. We then establish a theoretical framework for a rebalancing strategy, which is that investors should select a rebalancing strategy that balances their willingness to assume risk against expected returns net of the cost of rebalancing. In several scenarios, we explore the trade-off between various potential rebalancing decisions and a portfolio's risk-and-return characteristics. Finally, we review practical rebalancing considerations, emphasising rebalancing for risk control, not return maximisation.

### Costs of rebalancing

Throughout this paper, the term costs of rebalancing refers to:

- Taxes (if applicable): If rebalancing within taxable registrations, capital gains taxes may be due upon the sale if the asset sold has appreciated in value.
- Transaction costs to execute and process the trades: For individual securities and exchange-traded funds (ETFs), the costs are likely to include brokerage commissions and bid-ask spreads. For mutual funds, costs may include purchase or redemption fees.
- Time and labour costs to compute the rebalancing amount: These costs are incurred either by the investor directly or by a professional investment manager.

The costs may include administrative costs and/or management fees, if a professional manager is hired.

Keep in mind that in addition to these costs there may be trading restrictions that could limit the frequency of transacting on the accounts. Finally, since there is little difference in the results between the frequencies analysed, these costs would suggest that less-frequent rebalancing (i.e., annually or semi-annually, rather than daily) would be preferred.

Return data for Figures 1 through 8 and Appendices A-1 and A-2 of this paper are based on the following stock and bond benchmarks, as applicable: Stocks are represented by the Standard & Poor's 90 from 1926 through March 3, 1957; the S&P 500 Index from March 4, 1957, through 1974; the Wilshire 5000 Composite Index from January 1, 1975, through April 22, 2005; and the MSCI® US Broad Market Index from April 23, 2005, through December 31, 2009. Bonds are represented by the S&P High Grade Corporate Index from 1926 through 1968; the Citigroup High Grade Index from 1969 through 1972; the Lehman Long- Term AA Corporate Index from 1973 through 1975; and the Barclays Capital US Aggregate Bond Index from 1976 through 2009.



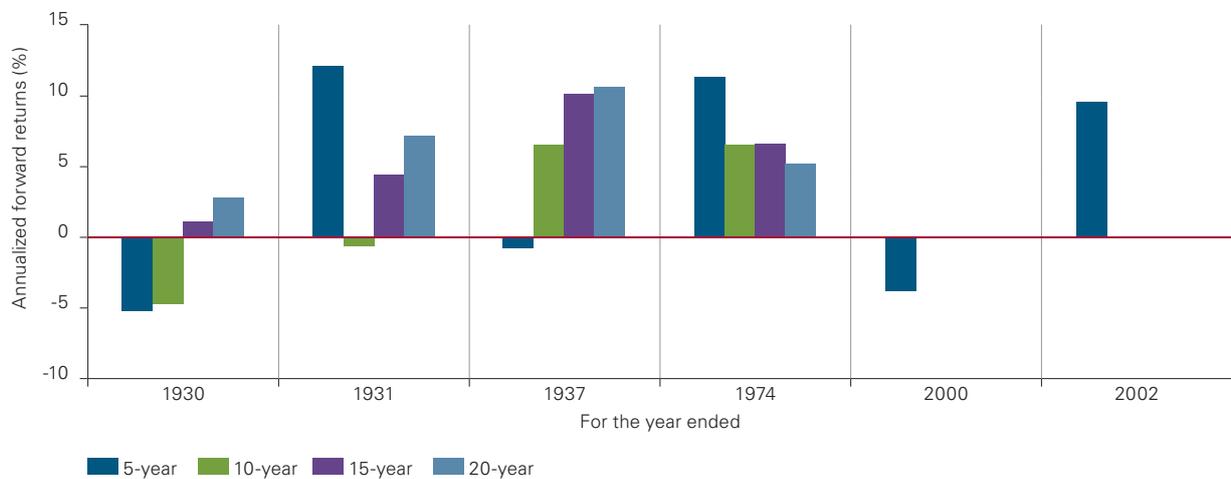
Figure 3 shows the average annualised returns for the 5, 10, 15, and 20 years following six of those rebalancing events into equities (note that only the 5-year return is shown for 2002). As expected, the only occasions when the average annualised returns for fixed income securities exceeded the returns for equities for the same time period were in the shorter time horizons. Over longer time horizons, investors expect to be compensated for the additional risks associated with investing in equities. For each of the 15- and 20-year periods, the annualised returns for equities exceeded the comparable returns for bonds over the same period. (See Appendix A, for the underlying return data.) As for the forward-looking returns for 2008, time will tell; however, we are off to a good start, considering that the US equity market returned more than 28% in 2009.

**Figure 2.** Figure 2: Equity returns during rebalancing opportunities: 1926 through 2009

For the year ended	1-year trailing	3-year trailing	Equity allocation prior to rebalancing
1930	-24.8%	-0.4%	48.0%
1931	-43.1	-26.7	46.3
1937	-34.7	8.8	48.7
1974	-26.3	-9.2	47.9
2000	-10.9	10.8	54.5
2002	-20.9	-14.4	46.9
2008	-37.0	-8.4	47.0

Notes: All returns are in nominal US dollars. Figure assumes a 60% stock/40% bond portfolio and annual rebalancing with a threshold of 5%. For benchmark data, see box on page 2. Sources: Vanguard calculations, using data from Standard & Poor's, Wilshire, MSCI, Citigroup, and Barclays Capital.

**Figure 3.** Excess return of equities over fixed income securities following selected rebalancing events: 1926 through 2009



Notes: This illustration does not represent the return on any particular investment. All returns are in nominal US dollars. For benchmark data, see box on page 2. See Appendix A, for underlying return data. Sources: Vanguard calculations, using data from Standard & Poor's, Wilshire, MSCI, Citigroup, and Barclays Capital.

It is important to recognise that the goal of portfolio rebalancing is to minimise risk (tracking error) relative to a target asset allocation, rather than to maximise returns. If an investor’s portfolio can potentially hold either stocks or bonds, and the sole objective is to maximise return regardless of risk, then the investor should select a 100% equity portfolio.<sup>5</sup> This is not the case for most investors, however. Typically, an investor is more concerned with downside risk (or the risk that the portfolio will drop in value) than with the potential to earn an additional 0.50 percentage point to 0.75 percentage point for each 10% increase in equity allocation, as shown in Figure 4’s market risk data for various hypothetical asset allocations. Times of distress in the equity markets are not the only times that investors are reluctant to rebalance their portfolios. Despite their loss-aversion tendency, many investors are equally loath to rebalance during bull markets for equities. They seem to fall prey to ‘it’s different this time,’ and they hesitate to sell asset classes that have had exceptional performance in order to purchase assets that have had even ‘average’ or ‘expected’ performance. These investors, however, can end up with a portfolio that is overweighted to equities and therefore more vulnerable to equity-market corrections, putting the investors’ portfolios at risk of larger losses compared with their target portfolios. We next discuss the trade-off between rebalancing decisions and a portfolio’s risk-and-return characteristics.

**Figure 4.** Market-risk data for various hypothetical asset allocations: 1926 through 2009

Asset allocation	Nominal average annual return	Real average annual return
100% bonds	5.5%	2.4%
20% stocks/80% bonds	6.7	3.6
30% stocks/70% bonds	7.3	4.1
40% stocks/60% bonds	7.8	4.6
50% stocks/50% bonds	8.2	5.1
60% stocks/40% bonds	8.7	5.5
70% stocks/30% bonds	9.0	5.9
80% stocks/20% bonds	9.4	6.2
100% stocks	9.9	6.7

Notes: This illustration does not represent the return on any particular investment. All returns are in nominal US dollars. For benchmark data, see box on page 2. Sources: Vanguard calculations, using data from Standard & Poor’s, Wilshire, MSCI, Citigroup, and Barclays Capital.

### Trade-offs in the rebalancing decision

Similar to the selection of a portfolio’s target asset allocation, a rebalancing strategy involves a trade-off between risk and return. The more risk an investor is willing to assume, the higher the expected return over the long term (known as the risk premium). If a portfolio is never rebalanced, it tends to gradually drift from its target asset allocation as the weight of higher-return, higher-risk assets increases. Compared with the target allocation, the portfolio’s expected return increases, as does its vulnerability to deviations from the return of the target asset allocation.

Consider two hypothetical portfolios, each with a target asset allocation of 60% stocks/40% bonds for the period 1926 through 2009; the first portfolio is rebalanced monthly, and the second portfolio is never rebalanced. Consistent with the risk premium theory, the never-rebalanced portfolio’s stock allocation gradually drifts upward (see Figure 5), to a maximum of approximately 99% stocks and 1% bonds. As the never-rebalanced portfolio’s equity exposure increases, the portfolio displays higher risk (a standard deviation of 14.4% versus 12.1% for the monthly rebalanced portfolio) and a higher average annualised return (9.1% versus 8.5%, respectively).

**Figure 5.** Comparing results for monthly versus never rebalancing for two 60% stock / 40% bond portfolios: 1926 through 2009

1926 through 2009	Monthly rebalanced	Never rebalanced
Maximum Stock Weight	68.4%	98.7%
Minimum Stock Weight	51.5	36.0
Final Stock Weight	61.1	97.5
Average Annualized Return	8.5%	9.1%
Annualized Standard Deviation	12.1	14.4

Notes: This illustration does not represent the return on any particular investment. Assumes a portfolio of 60% stocks/40% bonds. All returns are in nominal US dollars. For benchmark data, see box on page 2. Sources: Vanguard calculations, using data from Standard & Poor’s, Wilshire, MSCI, Citigroup, and Barclays Capital.

5 Assuming a portfolio of equity and fixed income investments; allocations to alternative asset classes or investments were not considered.

A rebalancing strategy measures risk and return relative to the performance of a target asset allocation (Leland, 1999; Pliska and Suzuki, 2004). The decisions that can determine the difference between a portfolio's actual performance and that of the portfolio's target asset allocation include how frequently the portfolio is monitored, the degree of deviation from the target asset allocation that triggers a rebalancing event; and whether a portfolio is rebalanced to its target or to a close approximation of the target.

First we address ways an investor can determine when to trigger a rebalancing event. Although various triggers can be used, we focus primarily on the following three:

- A 'time-only' strategy, which triggers a rebalancing event based on a set time schedule such as monthly, quarterly, annually, and so on.
- A 'threshold-only' strategy, which triggers a rebalancing event when a portfolio deviates from its target asset allocation by a predetermined minimum percentage, such as 1%, 5%, 10%, and so on. Note that the nature of this strategy requires daily monitoring, because otherwise investors cannot determine how often a rebalancing event should occur.

- A 'time-and-threshold' strategy, which combines the 'time-only' and 'threshold-only' strategies. In other words, the portfolio is monitored on a set time schedule, but is rebalanced only if the allocation deviates from the target by the predetermined minimum rebalancing threshold at that time.

### Strategy 1: 'Time-only'

When using the 'time-only' strategy, the portfolio is rebalanced every day, month, quarter, or year, and so on, regardless of how much or how little the portfolio's asset allocation has drifted from its target. As the strategy's name implies, the only variable taken into consideration is time. Determining the frequency with which to rebalance the portfolio largely depends on the investor's risk tolerance, the correlation of the portfolio's assets, and the costs involved in rebalancing.

The data in Figure 6, compare results for the 'time-only' rebalancing strategy using several different frequencies: monthly, quarterly, annually, and never.<sup>6</sup> The target asset allocation used in the figure is 60% stocks/40% bonds, and the time period is 1926 through 2009. The figure assumes that each portfolio is rebalanced at the

**Figure 6.** Comparing portfolio rebalancing results for 'time-only' strategy: Various frequencies, 1926 through 2009

Monitoring frequency	Monthly	Quarterly	Annually	Never
Minimum rebalancing threshold	0%	0%	0%	0%
Average Equity Allocation	60.1%	60.2%	60.5%	84.1%
Costs of Rebalancing				
Annual turnover	2.7%	2.2%	1.7%	0.0%
Number of rebalancing events	1008	335	83	0
Absolute framework				
Average annualized return	8.5%	8.6%	8.6%	9.1%
Volatility	12.1%	12.2%	11.9%	14.4%

Notes: This illustration does not represent the return on any particular investment. Assumes a portfolio of 60% stocks/40% bonds. All returns are in nominal US dollars. For benchmark data, see box on page 2. There were no new contributions or withdrawals. Dividend payments were reinvested in equities; interest payments were reinvested in bonds. There were no taxes. All statistics were annualised. Sources: Vanguard's calculations, using data from Standard & Poor's, Wilshire, MSCI, Citigroup, and Barclays Capital.

<sup>6</sup> Although daily rebalancing is certainly an option, we excluded this option from the chart because of the limited availability of daily return data.

predetermined interval, regardless of the magnitude of deviation from the target asset allocation. As the figure shows, the portfolio that was rebalanced monthly had an average equity allocation of 60.1% (and an average return of +8.5%); similarly, the portfolio that was rebalanced annually had an average equity allocation of 60.5% (and an average return of +8.6%) – not a substantial difference in either respect.

The question then becomes: Which frequency is preferred? The answer depends primarily on investor preference – the amount of deviation from the target that the investor is comfortable with, as well as the costs the investor is willing to incur, given the degree of variation. The number of rebalancing events was significantly higher for monthly rebalanced than for annually rebalanced portfolios (1,008 versus 83, respectively, in Figure 6), which would result in higher trading costs for the monthly rebalanced portfolio. In addition, the quarterly rebalanced portfolio provided the same average annualised return as the annually rebalanced portfolios (+8.6%); however, the quarterly rebalanced portfolio had significantly more rebalancing events (335 versus 83), the cost of which would likely result in a lower total return for the portfolio.

As stated previously, while there is little difference among the results for the rebalanced portfolios using this strategy, a significant difference does exist between the results of the portfolios that were rebalanced and the never-rebalanced portfolio. The never-rebalanced portfolio in Figure 6 drifted to an average equity allocation of about 84%. Here again, as the portfolio's equity exposure increased, the portfolio displayed higher risk (a standard deviation of 14.4%, versus 11.9% for the annually rebalanced portfolio, 12.2% for the quarterly balanced portfolio and 12.1% for the monthly rebalanced portfolio) and a higher average annualised return (+9.1% for the never-rebalanced, versus +8.5% and +8.6% for the monthly and quarterly rebalanced portfolios, respectively).

## Strategy 2: 'Threshold-only'

The second strategy, 'threshold-only,' ignores the time aspect of rebalancing. Investors following this strategy rebalance the portfolio only when the portfolio's asset allocation has drifted from the target asset allocation by a predetermined minimum rebalancing threshold such as 1%, 5%, or 10%, regardless of the frequency. The rebalancing events could be as frequent as daily or as infrequent as every five years, depending on the portfolio's performance relative to its target asset allocation. To analyse the impact of threshold-only rebalancing strategies, we conducted a historical analysis for rebalancing thresholds of 1%, 5%, and 10%, assuming daily monitoring. If the hypothetical portfolio's allocation drifted beyond the threshold on any given day, it would be rebalanced back to the target allocation. Due to the limited availability of daily data (and therefore lack of comparability to the other figures in the body of this paper), the details of the analysis are included in Appendix B (see Figures B-1, B-2, B-3, and B-4).

Again with this strategy, the magnitude of the differences in the average equity allocation, in the average annual return, and in the volatility may not warrant the additional costs associated with a 0% threshold (5,323 rebalancing events) versus a 10% threshold (4 rebalancing events). The primary drawback to the threshold-only strategy is that it requires daily monitoring, which investors can either perform themselves or pay an advisor to do for them (which ultimately lowers the portfolio's total return because of the additional cost). The preferred strategy depends primarily on investor preference.

**Figure 7.** Comparing portfolio rebalancing results for ‘time-and-threshold’ strategy: Various frequencies and thresholds, 1926 through 2009

Monitoring frequency	Monthly				Quarterly			Annually			Never
Minimum rebalancing threshold (%)	0	1	5	10	1	5	10	1	5	10	0
Average Equity Allocation (%)	60.1	60.1	61.2	61.6	60.2	60.9	62.6	60.5	60.7	63.0	84.1
<b>Costs of Rebalancing</b>											
Annual turnover (%)	2.7	2.3	1.7	1.3	2.2	1.7	1.5	1.7	1.6	1.4	0.0
Number of rebalancing events	1,008	389	58	20	210	50	21	72	28	15	0
<b>Absolute framework</b>											
Average annualized return (%)	8.5	8.5	8.6	8.8	8.7	8.8	8.9	8.6	8.6	8.7	9.1
Volatility (%)	12.1	12.1	12.2	12.2	12.2	12.1	12.3	11.9	11.8	12.1	14.4

Notes: This illustration does not represent the return on any particular investment. Assumes a portfolio of 60% stocks/40% bonds. All returns are in nominal US dollars. For benchmark data, see box on page 2. There were no new contributions or withdrawals. Dividend payments were reinvested in equities; interest payments were reinvested in bonds. There were no taxes. All statistics were annualised. Sources: Vanguard’s calculations, using data from Standard & Poor’s, Wilshire, MSCI, Citigroup, and Barclays Capital.

### Strategy 3: ‘Time-and-threshold’

The final strategy discussed here, ‘time-and threshold,’ calls for rebalancing the portfolio on a scheduled basis (e.g., monthly, quarterly, or annually), but only if the portfolio’s asset allocation has drifted from its target asset allocation by a predetermined minimum rebalancing threshold such as 1%, 5%, or 10%. If, as of the scheduled rebalancing date, the portfolio’s deviation from the target asset allocation is less than the predetermined threshold, the portfolio will not be rebalanced. Likewise, if the portfolio’s asset allocation drifts by the minimum threshold or more at any intermediate time interval, the portfolio will not be rebalanced at that time.

To analyse the impact of time-and-threshold rebalancing strategies, we conducted a historical analysis over the period 1926 through 2009 on the performance of several hypothetical portfolios. Figure 7 summarises the results for monthly, quarterly, and annual monitoring frequencies with 1%, 5%, and 10% minimum rebalancing thresholds, as well as the results for a never-rebalanced portfolio. Using this strategy, for example, if a portfolio is monitored monthly with a 1% threshold, it will be rebalanced if its actual

asset allocation differs from its target asset allocation by 1% or more on the monthly rebalancing date.

We compared the risk-and-return characteristics produced by the time-and-threshold strategy relative to a target asset allocation of 60% equities/ 40% bonds. The target allocation was rebalanced monthly regardless of the magnitude of the allocation drift (0% minimum rebalancing threshold). A portfolio that was rebalanced more frequently, either because it was monitored more frequently or because it had tighter rebalancing thresholds, tracked the target asset allocation more closely. However, the magnitude of the differences in the average annualised returns and volatility was relatively insignificant.

As Figure 7 demonstrates, a rebalancing strategy that included monthly monitoring and 1% thresholds was more costly to implement (an average of 389 rebalancing events, with annual portfolio turnover of 2.3%) than one that included annual monitoring and 10% rebalancing thresholds (an average of 15 rebalancing events and annual portfolio turnover of 1.4%).

Although this simulation implies that portfolios that are rebalanced more frequently track the target asset allocation more closely, it also suggests that the cost of rebalancing may place upper limits on the optimal number of rebalancing events. Transaction costs and taxes detract from the portfolio's return, potentially undermining the risk-control benefits of some rebalancing strategies. In our simulation, the number of rebalancing events and the annual turnover were proxies for costs; the actual costs depend on a portfolio's unique transaction costs and taxes.

After taking into consideration reasonable expectations regarding return patterns, average returns, and risk, we concluded that for most broadly diversified stock and bond fund portfolios, annual or semi-annual monitoring, with rebalancing at 5% thresholds, produces a reasonable balance between risk control and cost minimisation.

There are two important qualifications to this conclusion. First, this analysis assumes that some approximation of the stock and bond markets' historical return patterns, average returns, volatility, and low return correlation can be expected to persist in the future. Second, our analysis assumes that a portfolio holds a broadly diversified group of liquid assets with readily available market prices.<sup>7</sup>

### Implementing a rebalancing strategy

In translating this conceptual rebalancing framework into practical strategies, it's important to recognise two real-world limitations to the framework's assumptions. First, conventional wisdom among financial practitioners suggests that investor preferences may be less precise than theory assumes. Investors' target asset allocations are typically flexible within 5% to 10% ranges, indicating that they are mostly indifferent to small risk-or-return deviations. Second, some costs of rebalancing – time, labour, and market impact – are difficult to quantify. Such costs are often included indirectly in advisory fees or reflected as trading restrictions, making it difficult to explicitly consider rebalancing costs. Several practical strategies discussed next aim to capture

the risk-control benefits illustrated by our theoretical framework while minimising the costs of rebalancing.

#### Rebalance with portfolio cash flows.

Rebalancing a portfolio with dividends, interest payments, realised capital gains, or new contributions can help investors both exercise risk control and trim the costs of rebalancing. Typically, investors can accomplish this by sweeping their taxable portfolio cash flows into a money market or checking account and then redirecting these flows to the most underweighted asset class as part of their scheduled rebalancing event.<sup>8</sup>

Figure 8 illustrates how dividend and interest payments can be used to reduce potential rebalancing costs for several hypothetical portfolios. The 'Income' column shows a 60% stock/40% bond portfolio that was rebalanced by investing the portfolio's dividend and interest payments in the underweighted asset class from 1926 through 2009. An investor who had simply redirected his or her portfolio's income would have achieved most of the risk-control benefits of more labour- and transaction-intensive rebalancing strategies at a much lower cost.

For example, a portfolio that was monitored monthly and rebalanced at 5% thresholds had 58 rebalancing events and annual portfolio turnover of 1.7% (see Figure 8). The portfolio that was rebalanced by simply redirecting income had no rebalancing events and portfolio turnover of 0%. For taxable investors, this strategy was also very tax-efficient. The differences in risk among the various rebalancing strategies were very modest. One caution: The high levels of dividends and interest rates during this 84-year period may not be available in the future. An effective approach independent of the level of dividends and bond yields is to use portfolio contributions and withdrawals to rebalance the portfolio. However, the potential tax consequences of these transactions may require more customised rebalancing strategies.

<sup>7</sup> A concentrated or aggressive, actively managed portfolio of stocks and bonds may also behave differently from our illustrated examples. Such portfolios tend to be more volatile than broadly diversified stock and bond portfolios (Tokat, 2005), requiring more frequent rebalancing to maintain similar risk control relative to the target asset allocation.

<sup>8</sup> The sweep process just described can improve the after-tax return of the portfolio at the margin; however, investors should weigh the time and effort required against the potential increased returns.

**Figure 8. Impact of rebalancing with portfolio cash flows: 1926 through 2009**

Monitoring frequency	Monthly	Monthly	Quarterly	Annually	Never	Income
Minimum rebalancing threshold	0%	5%	5%	5%	None	None
Average Equity Allocation	60.1%	61.2%	60.9%	60.7%	84.1%	61.0%
<b>Costs of Rebalancing</b>						
Annual turnover	2.7%	1.7%	1.7%	1.6%	0.0%	0.0%
Number of rebalancing events	1,008	58	50	28	0	0
<b>Absolute framework</b>						
Average annualized return	8.5%	8.6%	8.8%	8.6%	9.1%	8.5%
Volatility	12.1%	12.2%	12.1%	11.8%	14.4%	11.3%

Notes: This illustration does not represent the return on any particular investment. All returns are in nominal US dollars. For benchmark data, see box on page 2. There were no new contributions or withdrawals. Except in the 'Income' column, dividend payments were reinvested in equities; interest payments were reinvested in bonds. The 'Income' column shows a 60% stock/40% bond portfolio that was rebalanced by investing the portfolio's dividend and interest payments in the underweighted asset class from 1926 through 2009. There were no taxes. All statistics were annualised. Sources: Vanguard's calculations, using data from Standard & Poor's, Wilshire, MSCI, Citigroup, and Barclays Capital.

### Rebalance to target asset allocation or some intermediate asset allocation.

Finally, the decision to rebalance either to the target asset allocation or to some intermediate allocation (an allocation short of the target allocation) depends primarily on the type of rebalancing costs. When trading costs are mainly fixed and independent of the size of the trade – the cost of time, for example – rebalancing to the target allocation is optimal because it reduces the need for further transactions. On the other hand, when trading costs are mainly proportional to the size of the trade – as in commissions or taxes, for example – rebalancing to the closest rebalancing boundary is optimal, minimising the size of the transaction. If both types of costs exist, the optimal strategy is to rebalance to some intermediate point.

### Conclusion

Just as there is no universally optimal asset allocation, there is no universally optimal rebalancing strategy. The only clear advantage as far as maintaining a portfolio's risk-and-return characteristics is that a rebalanced portfolio more closely aligns with the characteristics of the target asset allocation than with a never-rebalanced portfolio.

As our analysis shows, the risk-adjusted returns are not meaningfully different whether a portfolio is rebalanced monthly, quarterly, or annually; however, the number of rebalancing events and resulting costs increase significantly (monthly rebalancing with no threshold would require 1,008 rebalancing events, whereas annual rebalancing with a 10% threshold would require only 15 rebalancing events). As a result, we conclude that a rebalancing strategy based on reasonable monitoring frequencies (such as annual or semi-annual) and reasonable allocation thresholds (variations of 5% or so) is likely to provide sufficient risk control relative to the target asset allocation for most portfolios with broadly diversified stock and bond holdings.

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## Appendix A

**Figure A-2.** Equity returns following rebalancing events: 1926 through 2009

For the year ended:	5-year return (annualised)	10-year return (annualised)	15-year return (annualised)	20-year return (annualised)
1930	3.2%	1.8%	6.6%	7.4%
1931	22.4	6.4	10.1	11.7
1937	4.5	9.5	12.7	12.9
1974	18.6	16.4	17.3	15.1
2000	2.1	tbd	tbd	tbd
2002	14.0	tbd	tbd	tbd
2008	tbd	tbd	tbd	tbd

Notes: All returns are in nominal US dollars. Figure assumes a 60% stock/40% bond portfolio and annual rebalancing with a threshold of 5%. All returns are in nominal US dollars. For benchmark data, see box on page 2. Sources: Vanguard calculations, using data from Standard & Poor's, Wilshire, MSCI, Citigroup, and Barclays Capital.

**Figure A-2.** Fixed income returns following rebalancing events: 1926 through 2009

For the year ended:	5-year return (annualised)	10-year return (annualised)	15-year return (annualised)	20-year return (annualised)
1930	8.4%	6.5%	5.5%	4.6%
1931	10.3	7.0	5.7	4.5
1937	3.8	3.0	2.6	2.3
1974	7.3	9.9	10.7	9.9
2000	5.9	tbd	tbd	tbd
2002	4.4	tbd	tbd	tbd
2008	tbd	tbd	tbd	tbd

Notes: Figure assumes a 60% stock/40% bond portfolio and annual rebalancing with a threshold of 5%. All returns are in nominal US dollars. For benchmark data, see box on page 2. Sources: Vanguard calculations, using data from Standard & Poor's, Wilshire, MSCI, Citigroup, and Barclays Capital.

## Appendix B. 'Threshold-only' rebalancing analysis

To analyse the impact of 'threshold-only' rebalancing strategies, we conducted a historical analysis for minimum rebalancing thresholds of 0%, 1%, 5%, and 10%, assuming daily monitoring of a hypothetical 60% stock/40% bond hypothetical portfolio. If the portfolio's allocation drifted beyond the rebalancing threshold on any given day, it would be rebalanced back to the target allocation.

As shown in Appendix Figure B-1, the portfolio that is rebalanced daily with no threshold over the period 1989 through 2009 had an average equity allocation of 60.0% (and an average return of +8.9%), whereas the portfolio that was monitored on a daily basis with a 10% threshold had an average equity allocation of 62.2% (and an average return of +9.0%).

Once again the magnitude of the differences in the average equity allocation, the average annual return, and the volatility may not warrant the additional costs associated with a 0% threshold (5,323 rebalancing events) versus a 10% threshold (4 rebalancing events). The preferred strategy depends primarily on investor preference.

Appendix Figures B-2, B-3, and B-4 have been included for comparison purposes and are based on data from 1989 through 2009 (the same return data used in the body of this paper).

## Limited availability of daily return data

It is important to note that the average annualised returns for the 60% stock/ 40% bond portfolio in Figure B-1, which incorporates daily returns, are higher than those of tables in the body of this paper, owing to the fact that the returns here are based on the period 1989 through 2009, whereas all the other returns in the paper (except where noted) are based on data from 1926 through 2009. The shorter time period was necessitated due to the limited availability of reliable daily data. Accompanying this appendix are comparable tables for monthly, quarterly, and annual rebalancing statistics for the period 1989 through 2009. These tables have been added for comparison purposes. We believe that incorporating the longer time series provides more valuable insight and have only included the 1989 through 2009 results because of the limited availability of daily returns.

**Figure B-1.** Comparing daily portfolio rebalancing results for ‘threshold-only’ strategy: Various thresholds, 1989 through 2009

Monitoring frequency	Daily	Daily	Daily	Daily	Never
Minimum rebalancing threshold	0%	1%	5%	10%	None
Average Equity Allocation	60.0%	60.1%	61.7%	62.2%	69.2%
Costs of Rebalancing					
Annual turnover	12.5%	7.9%	3.1%	1.8%	0.0%
Number of rebalancing events	5,323	270	14	4	0
Absolute framework					
Average annualized return	8.9%	8.9%	8.9%	9.0%	8.6%
Volatility	12.9%	12.9%	13.0%	13.0%	10.9%

Notes: This hypothetical illustration does not represent the return on any particular investment. Assumes a portfolio of 60% stocks/40% bonds. Stocks are represented by the Wilshire 5000 Composite Index from January 1, 1989, through April 22, 2005; and the MSCI US Broad Market Index from April 23, 2005, through December 31, 2009. Bonds are represented by the Barclays Capital US Aggregate Bond Index from 1989 through 2009. There were no new contributions or withdrawals. Dividend payments were reinvested in equities; interest payments were reinvested in bonds. There were no taxes. All statistics were annualised. Sources: Vanguard calculations, using data from Wilshire, MSCI, and Barclays Capital.

**Figure B-2.** Comparing monthly portfolio rebalancing results for ‘threshold-only’ strategy: Various thresholds, 1989 through 2009

Monitoring frequency	Monthly	Monthly	Monthly	Monthly	Never
Minimum rebalancing threshold	0%	1%	5%	10%	None
Average Equity Allocation	60.0%	60.1%	61.5%	62.2%	69.2%
Costs of Rebalancing					
Annual turnover	5.6%	4.4%	2.8%	1.9%	0.0%
Number of rebalancing events	252	79	12	4	0
Absolute framework					
Average annualized return	8.8%	8.8%	8.9%	9.1%	8.6%
Volatility	9.5%	9.5%	9.6%	9.6%	10.9%

Notes: This hypothetical illustration does not represent the return on any particular investment. Assumes a portfolio of 60% stocks/40% bonds. Stocks are represented by the Wilshire 5000 Composite Index from January 1, 1989, through April 22, 2005; and the MSCI US Broad Market Index from April 23, 2005, through December 31, 2009. Bonds are represented by the Barclays Capital US Aggregate Bond Index from 1989 through 2009. There were no new contributions or withdrawals. There were no taxes. Dividend payments were reinvested in equities; interest payments were reinvested in bonds. Sources: Vanguard calculations, using data from Wilshire, MSCI, and Barclay’s Capital.

**Figure B-3. Comparing quarterly portfolio rebalancing results for 'threshold-only' strategy: Various thresholds, 1989 through 2009**

Monitoring frequency	Quarterly	Quarterly	Quarterly	Quarterly	Never
Minimum rebalancing threshold	0%	1%	5%	10%	None
Average Equity Allocation	60.1%	60.1%	61.4%	62.3%	69.2%
Costs of Rebalancing					
Annual turnover	4.2%	4.0%	2.9%	2.0%	0.0%
Number of rebalancing events	83	43	11	4	0
Absolute framework					
Average annualized return	8.9%	8.9%	9.0%	9.1%	8.6%
Volatility	9.5%	9.5%	9.5%	9.6%	10.9%

Notes: This hypothetical illustration does not represent the return on any particular investment. Assumes a portfolio of 60% stocks/40% bonds. Stocks are represented by the Wilshire 5000 Composite Index from January 1, 1989, through April 22, 2005; and the MSCI US Broad Market Index from April 23, 2005, through December 31, 2009. Bonds are represented by the Barclays Capital US Aggregate Bond Index from 1989 through 2009. There were no new contributions or withdrawals. There were no taxes. Dividend payments were reinvested in equities; interest payments were reinvested in bonds. Sources: Vanguard calculations, using data from Wilshire, MSCI, and Barclay's Capital.

**Figure B-4. Comparing annual portfolio rebalancing results for 'threshold-only' strategy: Various thresholds, 1989 through 2009**

Monitoring frequency	Annually	Annually	Annually	Annually	Never
Minimum rebalancing threshold	0%	1%	5%	10%	None
Average Equity Allocation	60.2%	60.2%	61.2%	61.2%	69.2%
Costs of Rebalancing					
Annual turnover	2.8%	2.8%	2.8%	2.0%	0.0%
Number of rebalancing events	20	16	8	4	0
Absolute framework					
Average annualized return	9.0%	9.0%	9.1%	9.0%	8.6%
Volatility	9.4%	9.4%	9.4%	9.5%	10.9%

Notes: This hypothetical illustration does not represent the return on any particular investment. Assumes a portfolio of 60% stocks/40% bonds. Stocks are represented by the Wilshire 5000 Composite Index from January 1, 1989, through April 22, 2005; and the MSCI US Broad Market Index from April 23, 2005, through December 31, 2009. Bonds are represented by the Barclays Capital US Aggregate Bond Index from 1989 through 2009. There were no new contributions or withdrawals. There were no taxes. Dividend payments were reinvested in equities; interest payments were reinvested in bonds. Sources: Vanguard calculations, using data from Wilshire, MSCI, and Barclay's Capital.

