Vanguard research

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Rational rebalancing: An analytical approach to multiasset portfolio rebalancing decisions and insights

- Investors' portfolios should align with their goals and risk preferences, which makes the rebalancing of the asset allocation in a portfolio an important practice. Among the numerous rebalancing methods, is one more risk-return-efficient and cost-effective than others?
- In this paper, we present a novel approach for determining an optimal multiasset portfolio rebalancing method by maximizing the *utility of post-transaction-cost portfolio wealth*. Rather than analyzing just one historical period, we simulate a distribution of asset returns and a distribution of dynamic transaction costs, which is vital in assessing the rebalancing policy. The utility-based approach enables the determination of a risk-return-efficient, cost-effective rebalancing method while quantifying how much better it is than other alternatives.
- We find that optimal methods involve rebalancing that is neither too frequent, such as monthly or quarterly calendar-based methods, nor too infrequent, such as rebalancing every two years. Implementing an annual rebalancing strategy is optimal for investors who don't participate in tax-loss harvesting or maintain tight tracking to a benchmark portfolio, such as passive funds-of-funds. Most of the efficiency of these rebalancing strategies is generated by harvesting equity risk premium, while allowing reasonable portfolio drifts.

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Introduction

Why rebalance?

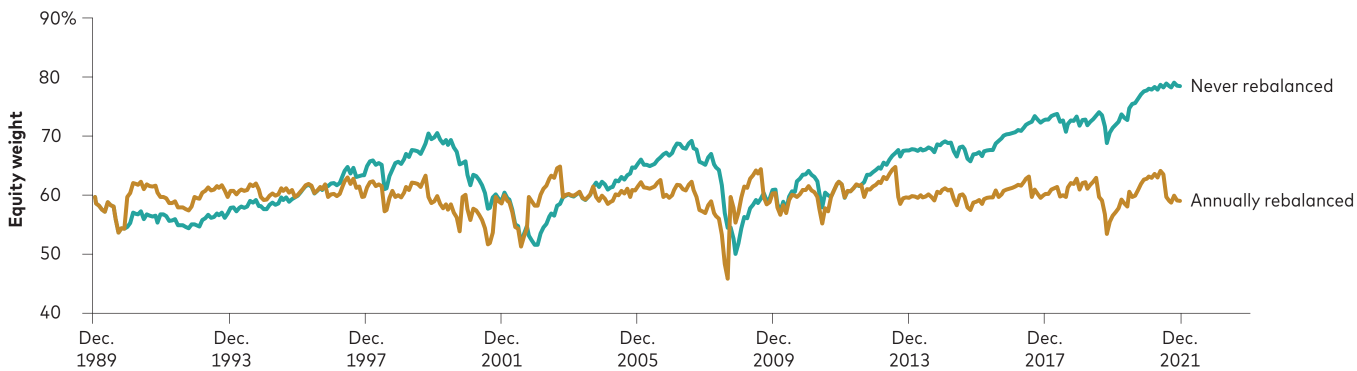
Vanguard believes that the asset allocation decision—which takes into account an investor's risk tolerance, time horizon, and financial goals—is the most important decision in the portfolio-construction process.

The primary function of portfolio rebalancing is to keep portfolio risk in alignment with the investor's risk tolerance.

Absent rebalancing, portfolio allocations will drift from their intended target as the returns of its assets diverge, leading to much higher portfolio risk. For instance, a portfolio with 60% equities and 40% fixed income at the end of 1989, if never rebalanced, would have had 80% in equities at the end of 2021, as shown in **Figure 1**—in stark contrast to an annually rebalanced portfolio.

FIGURE 1.

Asset allocation of never rebalanced versus annually rebalanced 60/40 portfolio



Notes: The 60% equity/40% bond portfolio return data are from December 31, 1989, through December 31, 2021. This figure compares the equity weights for never-rebalanced portfolios and portfolios rebalanced at the end of every year. The equity weight for the 60%/40% portfolio could drift between roughly 50% and 80% if never rebalanced. U.S. bonds are represented by the Bloomberg U.S. Aggregate Bond Index, non-U.S. bonds by the Bloomberg Global Aggregate ex-U.S. Index, U.S. equities by the Dow Jones Wilshire 5000 Index from the beginning of 1990 through April 2005 and the MSCI US Broad Market Index thereafter, and non-U.S. equities by the MSCI All Country World Index ex USA.

Sources: Vanguard calculations, based on data from DataStream.

Figure 2 illustrates the additional amount of risk inherent in an 80% stock/20% bond portfolio relative to the intended allocation of 60% stocks/40% bonds.

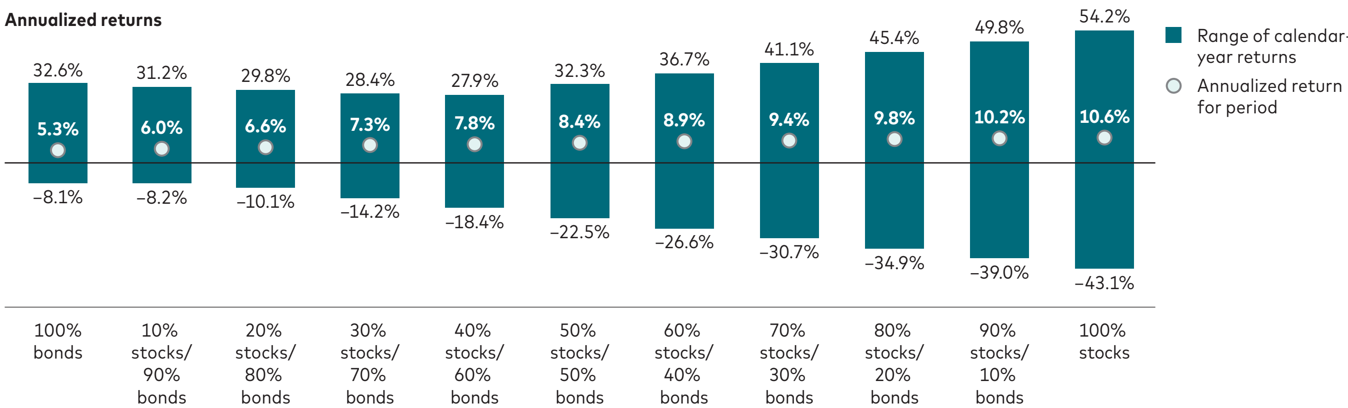
Meaningful deviations during periods of heightened volatility may cause investors to abandon their portfolio because of a misalignment with their risk tolerance, leading them to lock in their losses. From a behavioral perspective, rebalancing also plays a vital role in helping an investor maintain discipline in the investing strategy and aims to remove emotions from decision-making during market turmoil. This makes rebalancing an important part of investing.

When it comes to rebalancing, there are several methods to choose from. A rebalancing strategy is composed of *frequency*, *threshold*, and *destination* decisions.

- **Frequency** refers to how often the portfolio allocation should be monitored. Monitoring frequency can be daily, weekly, monthly, quarterly, semiannually, annually, and so on.
- **Threshold** dictates how far the asset allocation is allowed to deviate from the target. For example, a threshold of 1%, or 2%, and so on.
- Finally, **destination** informs how far back toward the target the portfolio will be rebalanced; that is, one can choose to trade all the way back to the target allocation, halfway back between the target and the threshold, or back to the edge of the threshold.

FIGURE 2.

The mixture of assets defines the spectrum of risk



Notes: Return data are from January 1, 1926, through December 31, 2021. The figure shows maximum and minimum annual returns for a given asset allocation portfolio over the time horizon. The portfolios were rebalanced monthly. Results are displayed on a pretax basis. U.S. bonds are represented by the Standard & Poor's High Grade Corporate Index from 1926 to 1968; the Citigroup High Grade Index from 1969 to 1972; the Lehman Brothers U.S. Long Credit AA Index from 1973 to 1975; Barclays U.S. Aggregate Bond Index from 1976 to 2009, and the Spliced Barclays U.S. Aggregate Float Adjusted Bond Index thereafter. U.S. equities are represented by the Standard & Poor's 90 from 1926 to 1957; the Standard & Poor's 500 Index from 1957 to 1974; the Wilshire 5000 Index from 1975 to 2005; the MSCI US Broad Market Index through 2013, and the CRSP US Total Market Index thereafter.

Source: Vanguard calculations.

Investors, advisors, and asset managers employ three popular methods for rebalancing portfolios that incorporate choices on frequency, threshold, and destination. **Figure 3** describes the rebalancing methods that are analyzed in this paper.

1. **Calendar-based rebalancing:** A calendar-based rebalancing approach designates a frequency for rebalancing portfolio exposures back to the target asset allocation. The more-frequent calendar rebalancing methods result in low tracking error and higher transaction costs, absent cash flows to aid in rebalancing.
2. **Threshold-based rebalancing:** This method allows portfolio allocations to drift within a tolerance threshold, with rebalancing triggered only when the threshold is breached. One major drawback of threshold-based rebalancing is that it requires that the portfolio be monitored daily and is thus not practical for investors who manage their own portfolios. The smaller the threshold, the lower the tracking error and the higher the transaction cost.
3. **Calendar- and threshold-based rebalancing:** This combines the calendar-based and threshold-based rebalancing approaches. The asset allocation weights are monitored according to calendar frequency, though trading in the portfolio takes place only if the asset weights in the portfolio exceed a rebalancing threshold.

Given the numerous rebalancing strategies that could be implemented, is one strategy more risk-return-efficient and cost-effective than others?

In this paper, we present a novel approach for determining an optimal multiasset portfolio rebalancing strategy. Rather than analyzing just one historical period, we simulate a distribution of asset returns (in a way similar to the Vanguard Capital Markets Model®, or VCMM) that encompasses multiple periods and a distribution of dynamic transaction costs that captures the important feature of these costs—that they increase with market volatility, a vital consideration in selecting the rebalancing policy. The utility-based optimization approach enables the determination of a risk-return-, cost-efficient rebalancing method, while also quantifying how much better it is than other rebalancing options.

This paper has four parts. In the first section, we provide a brief review of the literature. In the second section, we offer an overview of our return and transaction-cost forecasting model. In the third section, we describe the utility-based decision-making framework. In the fourth section, we highlight important insights obtained via the quantitative approach and analytics.

FIGURE 3.

Common rebalancing methods and their characteristics

Components	Calendar-based	Threshold-based	Combination rule (calendar and threshold)
Frequency	Calendar-based monitoring frequency	Daily monitoring	Calendar-based monitoring frequency
Threshold	0%	Various thresholds tested	Various thresholds tested
Destination	Back to target	Back to target	Back to target
Strategies tested	Daily, weekly, biweekly, monthly, quarterly, semiannual, annual, biennial, every 2.5 years, no rebalancing	1% threshold to 15% threshold in 1% increments	• Monthly and 1% threshold to monthly and 15% in 1% increments • Quarterly and 1% threshold to quarterly and 15% in 1% increments • Semiannual and 1% threshold to semiannual and 15% in 1% increments • Annual and 1% threshold to annual and 15% in 1% increments

Source: Vanguard.

Improving the analysis behind rebalancing decisions

There is a vast variation in literature on rebalancing research. In general, research correctly highlights the importance of rebalancing a portfolio. However, deeper insights and conclusions about rebalancing vary quite a bit and can be classified as:

- Research that concludes there is no optimal method, such as Zilbering et al. (2015) and Czasonis, Pradhan, and Turkington (2020).
- Research that recommends an optimal rebalancing method based on one specific period of returns, such as Harjoto and Jones (2006), De Juan et al. (2018), and Plaxco and Arnott (2002).
- Research that recommends an optimal rebalancing method based on simulation-based returns but static transaction costs, like Buetow et al. (2002), Masters (2003), Donohue and Yip (2003), Sun et al. (2006), and Kritzman, Myrgren, and Page (2009).
- Research that recommends an optimal rebalancing method based on simulation-based returns and dynamic transaction costs, such as Jones and Stine (2010), Chan and Ramkumar (2011), and Norges Bank Investment Management (2012). Our research falls into this category.

Below are a few disadvantages of first three approaches:

1. **No optimal method:** When there is no decision-making framework or historical-period-dependent analysis, there sometimes is no specific recommendation. We find that this approach fails to identify inefficient rebalancing methods and is not ideal.

2. **One-specific-period-dependent analysis:** History provides very few samples for assessing rebalancing. Anchoring conclusions to just one return path, with only a few volatile events, could lead to erroneous decisions. Instead, the analysis should incorporate the uncertainty of future returns, making a distribution of capital market assumptions an important input. In this paper, we use a smaller-scale version of the VCMM to create a distribution of daily asset returns, because threshold-based methods require daily return simulations. The important features of this probabilistic model are highlighted in the following section.

3. **Ignoring transaction costs or assuming static transaction costs:** Most studies omit transaction costs or assume that transaction costs are static. Neither is a reasonable approach, especially for a portfolio of ETFs or individual securities, whose costs are likely to include bid-ask spreads and brokerage commissions.[1] First, we find that transaction costs are not static through time but are sensitive to market volatility and can increase tenfold during periods of market turmoil. Thus, it is vital to include dynamic transaction costs in the rebalancing analysis. Rather than assuming static transaction cost, we model the costs as a function of market volatility, which is an important predictive factor. Second, we forecast a bell curve of transaction costs, as we would asset returns.

IMPORTANT: The projections and other information generated by the VCMM regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. Distribution of return outcomes from VCMM are derived from 10,000 simulations for each modeled asset class. Simulations as of June 2022. Results from the model may vary with each use and over time.

1 For mutual funds, transaction costs are paid by all investors implicitly because of the purchase or sale of securities within the fund.

A simulation-based analytical approach can offer deeper insights than a historical single-path-based analysis. As discussed later in the paper, the probabilistic approach offers richer insights into how well rebalancing approaches perform in different environments and quantifies the attribution of rebalance benefit among transaction costs and market-driven factors.

The forecasting engine

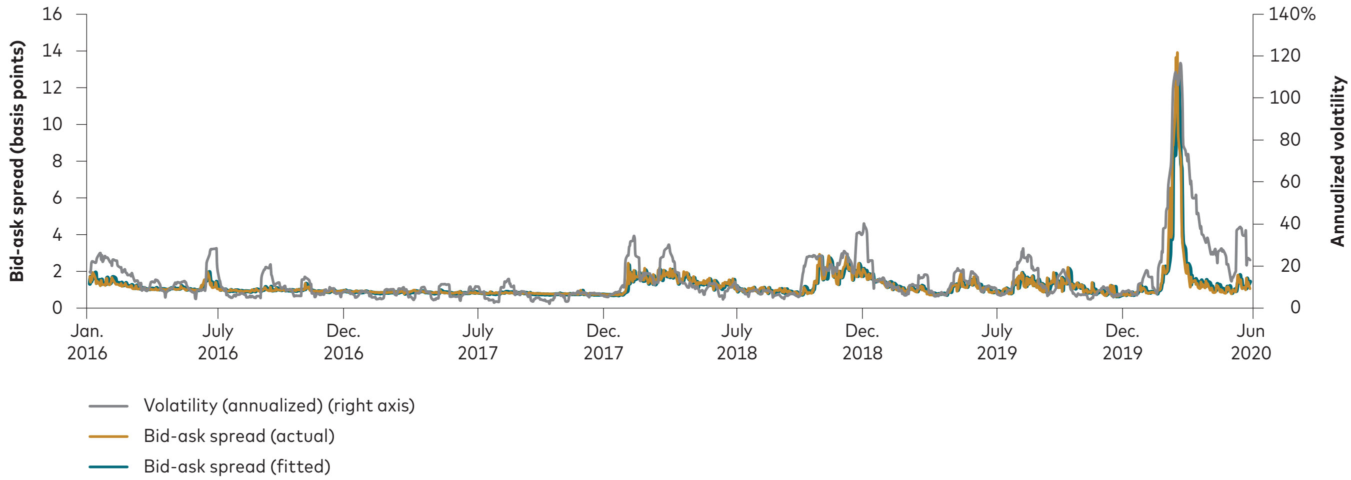
In this paper, we take a probabilistic approach to forecasting asset returns and transaction costs. In doing so, we leverage more than a decade-long body of research at Vanguard, vis-à-vis the proprietary VCMM, to forecast returns, volatilities, and correlations. The key features of the asset return forecasting model we used are described below:

1. **Distributional framework:** Forecasting a *range* of possible asset returns, volatilities, and correlations allows for a deeper assessment of risk-return trade-offs relative to forecasting a *single* value. It enables investors to make objective decisions about rebalancing.
2. **Nonnormal distributions:** It's well known that asset returns are nonnormal, with tail returns more likely than a normal distribution would suggest. This useful characteristic is captured in our simulations.
3. **Forecasting fundamental factors:** As a first step, the model forecasts the drivers of asset returns, such as interest rates, inflation, economic growth, equity price/earnings (P/E) ratio, and market volatility. These forecasts are dynamic, because the evolution of one fundamental affects another.
4. **Return forecasts are fundamentals-driven:** As a second step, asset returns and transaction costs are modeled as functions of the fundamental factors described above. For instance, equity return is a sum of dividend yield, percentage change in P/E ratio, and earnings growth, which can be expressed in terms of P/E ratio forecasts.
5. **Volatility clustering:** The model incorporates the volatility clustering feature of equities, because periods of high equity volatility tend to be clustered together. This vital feature is embedded using a GARCH (generalized autoregressive conditional heteroskedasticity) model.
6. **Forecasting jointly:** The model forecasts asset returns and transaction costs jointly via a regression-based Monte Carlo approach, thereby preserving any cross-correlation between them.
7. **Transaction costs:** Transaction costs are modeled as a function of bid-ask spreads, which are sensitive to market volatility. In times of market turmoil, bid-ask spreads spike, as illustrated in **Figure 4**. Rather than assuming static bid-ask spreads and transaction costs, we model them as sensitive to market volatility and other macro-economic variables. This results in an adjusted-R^2 of more than 87%. (R^2 is a measure of how much of the transaction cost variability can be explained by the above-mentioned independent variables.)

For a detailed overview of the VCMM, refer to Davis et al. (2014) and Davis et al. (2022).

FIGURE 4.

Transaction costs are sensitive to market volatility



Notes: Bid-ask spread data are from January 1, 2016, through June 30, 2020. The figure shows the actual and the fitted, or predicted, bid-ask spread over the time horizon. Volatility is the 10-day trailing volatility of the daily returns based on the closing price of the Standard & Poor's 500 Index. A basis point is one-hundredth of a percentage point.

Sources: Vanguard calculations, based on data from FactSet.

The decision-making framework

When rebalancing methods are compared, a qualitative assessment requires judgment on the trade-offs, which can be difficult when higher-return assets have higher volatility. In other words, if one rebalancing rule provides a higher return, although with greater volatility, should it be preferred? One of the benefits of a utility-based approach is that it allows us to compare utility across different rebalancing rules, in an objective way, instead of through inconclusive risk-return comparisons.

Similar to the Vanguard Asset Allocation Model[2] (VAAM) (Aliaga et al., 2019), we implement a utility-based optimization framework to help evaluate different rebalancing strategies and determine the optimal strategy. Our framework selects the rebalancing strategy that maximizes the expected utility of an investor's after-transaction-cost wealth at the end of a given investment period (10 years, for example).

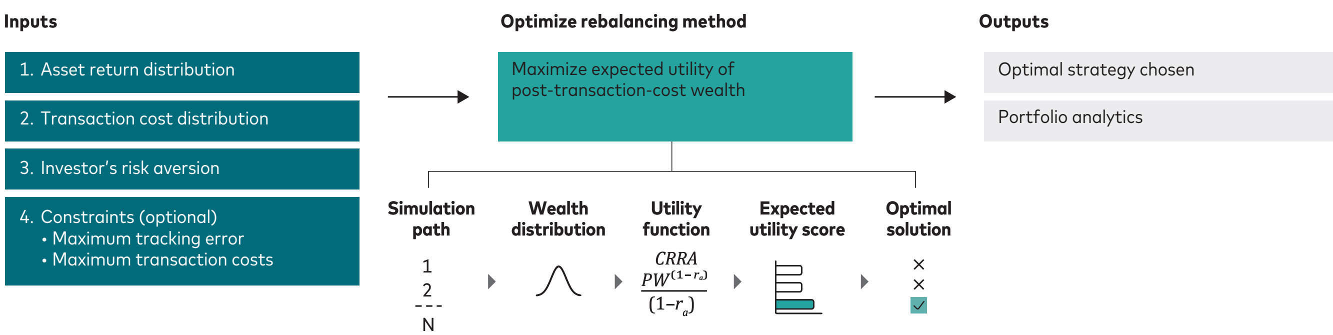
That is, for a given asset allocation, the rebalancing strategy that has the highest utility score is the optimal strategy.

The overview of the framework is illustrated in **Figure 5**, while the technical details of the utility function are discussed in the **Appendix** section **A-1**. In addition to the optimal choice, several interesting portfolio analytics are produced, such as distribution of return, volatility, Sharpe ratios, transaction costs, tracking error, number of rebalancing events, event size, and turnover.

The optimization framework requires the following inputs: 1) asset return distribution, 2) transaction cost distribution, 3) the investor's risk aversion, and 4) constraints (optional). The utility-based optimization framework also allows for embedding constraints, if needed. For instance, a constraint on the maximum expected transaction costs or a maximum allowable tracking error can easily be implemented within this framework.

FIGURE 5.

The optimization process for assessing rebalancing strategies



Source: Vanguard.

2 U.S. patent pending.

Insights

Using our novel framework, we determine which rebalancing strategy is most risk-return- and cost-efficient. While doing so, we are also able to quantify how much better one strategy is than another. Additionally, we decompose how much of the benefit is achieved from lower transaction costs versus how much is market-driven. Finally, we discuss whether the optimal rebalancing methods gain most of the advantage in highly volatile market environments or in normal environments.

Before discussing our findings, we briefly discuss a few considerations that we have not accounted for and how those factors would affect the direction of the results.

- **Cash flows:** Guiding cash flows from periodic contributions into assets that are underweighted is a great way to rebalance a portfolio naturally and efficiently. Similarly, withdrawals from portfolios can be used to rebalance. Therefore, accounting for cash flows in the analysis would lead to even less-frequent rebalancing or wider thresholds than the optimal ones.
- **Tax-loss harvesting:** For investors engaging in tax-loss harvesting, one would expect more-frequent portfolio monitoring. Harvesting tax losses can reduce one's tax liabilities. This advantage is expected to make up for the slightly higher transaction costs from frequent rebalancing. Thus, our findings would not be applicable when tax-loss harvesting is being implemented, where rebalancing decisions are more personalized.
- **Taxes:** Rebalancing a portfolio typically results in the sale of assets that have appreciated in value; this increase in value leads to an overweighting in their allocation, thereby triggering a rebalancing event. During such events, capital gains would be taxable if the assets are held in taxable accounts. Broadly speaking, we expect a similar or even a less-frequent rebalancing strategy to be optimal, because accounting for taxes would result in a higher tax burden, thereby increasing the cost of rebalancing.

Calendar-based rebalancing

Calendar-based methods are simple and easy to implement. Among calendar-based rebalancing rules, we find that a portfolio rebalanced annually is optimal for various stock/bond allocations. For instance, annual rebalancing scores the highest on an optimality scale for a 60% stock/40% bond portfolio, as shown in **Figure 6**, compared with other calendar-based methods.

In general, too-frequent or too-infrequent rebalancing is not risk-return- and cost-efficient, as indicated by the hump shape in Figure 6. Too-frequent rebalancing strategies incur higher transaction costs and have larger tax implications within taxable accounts. Indeed, our framework identifies daily calendar-based rebalancing as the most inefficient.

On the other hand, rebalancing too infrequently, such as once every 2.5 years or never rebalancing, causes the portfolio to drift too far from the target allocation over time, resulting in a disconnect with the investor's risk tolerance.

A utility-based decision-making framework forestalls this disconnect. Annual rebalancing hits the sweet spot in terms of cost versus benefit, while staying in line with the investor's risk preference.

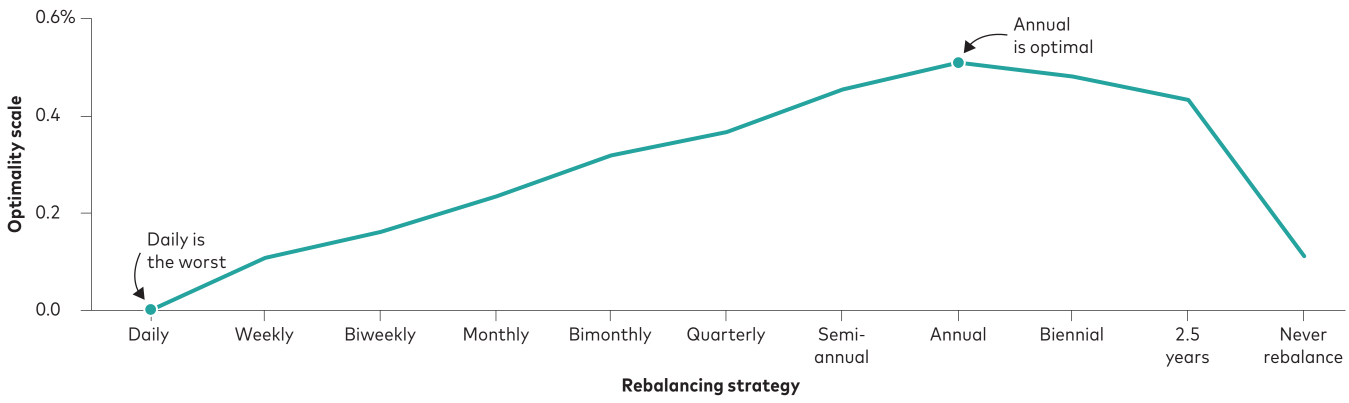
The benefit of one rebalancing rule over another can be quantified in terms of certainty fee equivalent (CFE), which is the optimality scale in Figure 6. The CFE is the fee that would make the investor indifferent if given a choice between the optimal solution with a fee and a sub-optimal one without any fee. In other words, it's the benefit of an optimal strategy. For example, we find that the CFE of annual rebalancing is 51 basis points (0.51%) when compared with daily rebalancing.

Threshold-based rebalancing

Threshold-based rebalancing is sometimes used by asset managers of multiasset funds where maintaining low tracking error is an objective. For instance, if an expected tracking error less than or equal to 20 basis points is desired, then a threshold-based rebalancing of 3% is optimal for a 60/40 portfolio.

FIGURE 6.

Calendar-based rebalancing methods



Notes: Results are based on simulations from our forecasting engine and maximization of post-transaction-cost wealth for a 60/40 portfolio under various rebalancing strategies shown above. The optimality index is the "certainty fee equivalent," or the benefit of selecting the optimal rebalancing strategy relative to daily rebalancing or, conversely, the fee an investor would be willing to pay relative to daily rebalancing. U.S. bonds are represented by the Bloomberg U.S. Aggregate Bond Index, non-U.S. bonds by the Bloomberg Global Aggregate ex-U.S. Index, U.S. equities by the MSCI US Broad Market Index, and non-U.S. equities by the MSCI All Country World Index ex USA. Data are as of June 2022.

Source: Vanguard.

Calendar- and threshold-based rebalancing

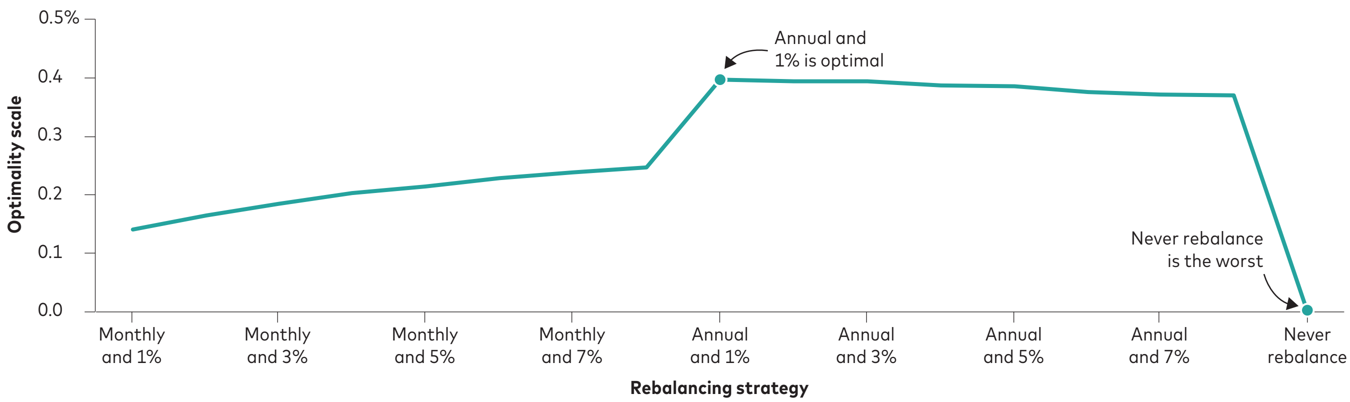
Figure 7 shows that under calendar- and threshold-based rules, less-frequent rebalancing, such as annually with a 1% threshold strategy, is the most efficient. Note that there is no material difference in using any threshold between 1% or 2% along with the annual frequency. We observed that monthly with threshold rebalances are less efficient, but still are better than never rebalancing. Less-frequent calendar and threshold methods are also relatively easy for investors to implement.

Rebalancing in a constrained case

In some cases, a constrained rebalancing solution, such as one with a maximum expected tracking error, is required to meet certain investment objectives.

FIGURE 7.

Calendar- and threshold-based rebalancing without constraints



Notes: Results are based on simulations from the forecasting engine and maximization of post-transaction-cost wealth for a 60/40 portfolio under various rebalancing strategies shown above. The optimality index is the "certainty fee equivalent," or the benefit of selecting the optimal rebalancing strategy relative to never rebalancing or, conversely, the fee an investor would be willing to pay relative to never rebalancing. U.S. bonds are represented by the Bloomberg U.S. Aggregate Bond Index, non-U.S. bonds by the Bloomberg Global Aggregate ex-U.S. Index, U.S. equities by the MSCI US Broad Market Index, and non-U.S. equities by the MSCI All Country World Index ex USA. Data are as of June 2022.

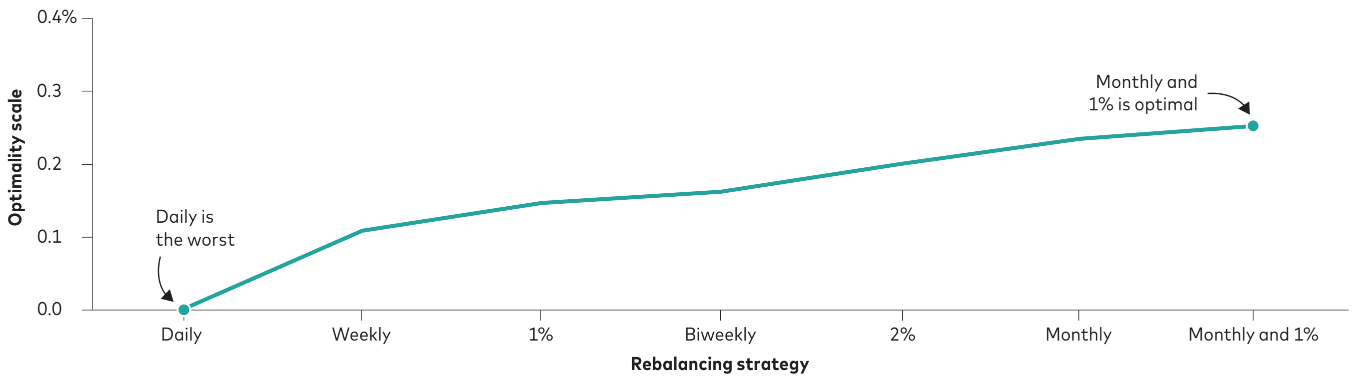
Source: Vanguard.

For instance, **Figure 8** shows that among all rebalancing strategies *with an expected tracking error of less than 15 basis points*, monthly and 1% is optimal. Note that there is no material difference among monthly and 1%, monthly, and 2% threshold rebalancing. Our framework is flexible enough to incorporate other types of constraints.

Figure 9 highlights the relationship between the tracking error and the transaction cost in this constrained scenario. The 2% threshold-based rebalancing is expected to have a lower transaction cost than monthly and 1% and monthly rebalancing strategies.

FIGURE 8.

Constrained case

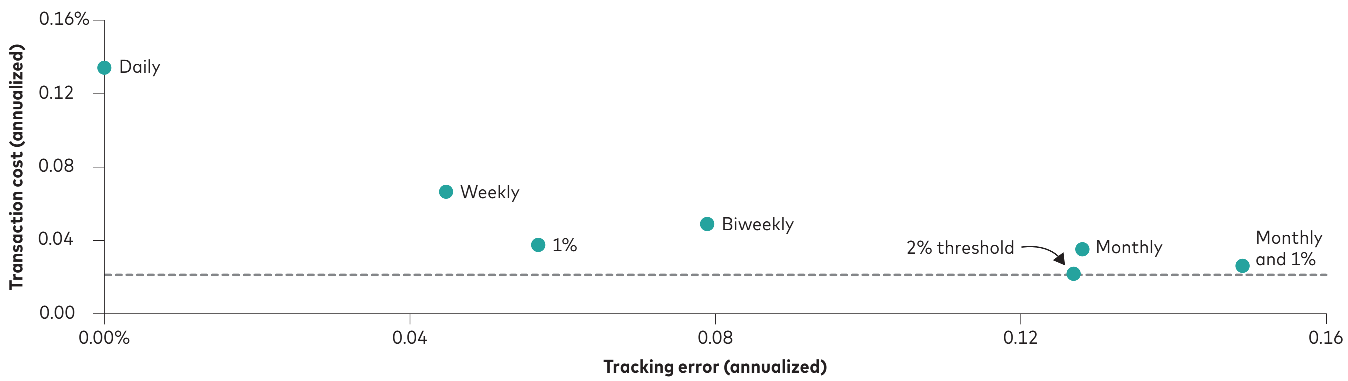


Notes: Results are based on simulations from the forecasting engine and maximization of post-transaction-cost wealth for a 60/40 portfolio under various rebalancing strategies shown above. The optimality scale is the "certainty fee equivalent," or the benefit of selecting the optimal rebalancing strategy relative to daily rebalancing or, conversely, the fee an investor would be willing to pay relative to daily rebalancing. U.S. bonds are represented by the Bloomberg U.S. Aggregate Bond Index, non-U.S. bonds by the Bloomberg Global Aggregate ex-U.S. Index, U.S. equities by the MSCI US Broad Market Index, and non-U.S. equities by the MSCI All Country World Index ex USA. Data are as of June 2022.

Source: Vanguard.

FIGURE 9.

The relationship between transaction cost and tracking error in the constrained case



Notes: Results are based on simulations from the forecasting engine for a 60/40 portfolio. Daily, Weekly, Biweekly, and Monthly refer to frequency; the percentages refer to threshold; and monthly and 1% is the measure under the calendar and threshold method. U.S. bonds are represented by the Bloomberg U.S. Aggregate Bond Index, non-U.S. bonds by the Bloomberg Global Aggregate ex-U.S. Index, U.S. equities by the MSCI US Broad Market Index, and non-U.S. equities by the MSCI All Country World Index ex USA. Data are as of June 2022.

Source: Vanguard.

Which method is optimal overall?

Which rebalancing method is the optimal one among the various calendar, threshold, and calendar-and-threshold choices? Is the optimal choice consistent across various ranges of asset allocation? **Figure 10** shows that annual rebalancing (or annual rebalancing with a threshold of 1% or 2%) is the optimal strategy for various asset allocations tested. From an ease-of-implementation perspective, annual rebalancing is a reasonable recommendation. It also results in lower transaction costs, and it aligns with an investor's risk tolerance.

We also compared the optimal rebalancing strategy with popular rebalancing strategies, such as quarterly with a 5% threshold, quarterly calendar-based, and monthly calendar-based. Annual rebalancing outperforms the popular strategies when it comes to statistical significance. Its benefit over quarterly rebalancing with a 5% threshold is between 6 and 14 basis points, its benefit over quarterly rebalancing (with no threshold) is between 10 and 16 basis points, and its benefit over monthly rebalancing (with no threshold) is between 21 and 28 basis points.

To sum up, our recommendation for most investors—those who aren't participating in tax-loss harvesting or don't require minimal tracking error to a benchmark portfolio—is to follow the annual rebalancing method.

FIGURE 10.

Optimal rebalancing methods

Equity allocation	The optimal rebalancing method and those not materially different (CFE<=2bps)	CFE (annual relative to quarterly–5% rebalance)	CFE (annual relative to quarterly rebalance)	CFE (annual relative to monthly rebalance)
35%	Annual; annual and 1/2/3/4/5%	6 bps	11 bps	25 bps
40%	Annual; annual and 1/2/3%	9 bps	10 bps	21 bps
50%	Annual; annual and 1/2/3%	12 bps	11 bps	22 bps
60%	Annual; annual and 1/2/3/4/5%	12 bps	14 bps	27 bps
70%	Annual; biennial; annual and 1/2/3/4/5/6%	14 bps	16 bps	28 bps
80%	Annual; biennial; annual and 1/2/3/4/5/6/7%	14 bps	16 bps	27 bps
90%	Annual; biennial; annual and 1/2%	11 bps	14 bps	21 bps

Notes: Results are based on simulations from the forecasting engine and maximization of post-transaction-cost wealth for various portfolios and rebalancing strategies shown above. The "certainty fee equivalent" is the benefit of selecting the optimal rebalancing strategy relative to another rebalancing method or, conversely, the fee an investor would be willing to pay relative to another rebalancing method. "Bps" equals basis points. U.S. bonds are represented by the Bloomberg U.S. Aggregate Bond Index, non-U.S. bonds by the Bloomberg Global Aggregate ex-U.S. Index, U.S. equities by the MSCI US Broad Market Index, and non-U.S. equities by the MSCI All Country World Index ex USA. Data are as of June 2022.

Source: Vanguard.

The advantage of less-frequent rebalancing

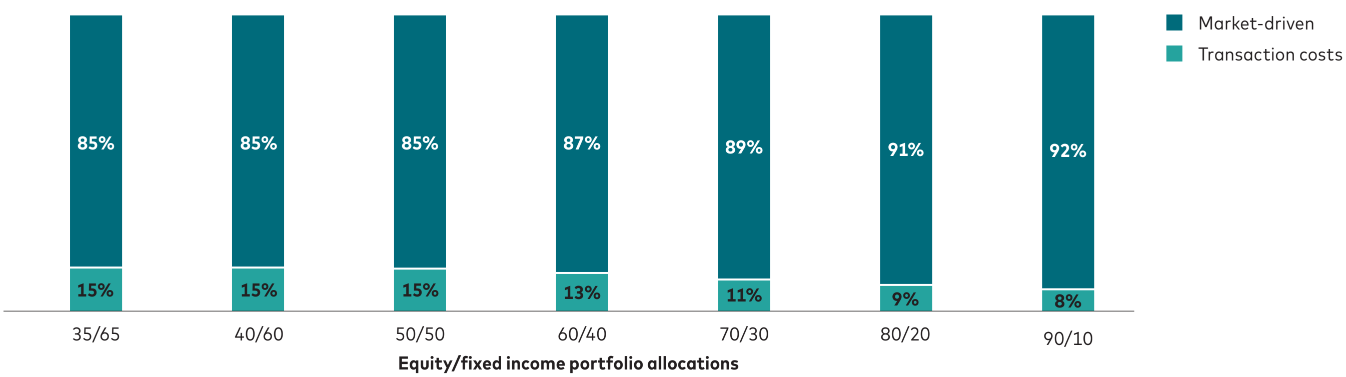
How much of the benefit of annual rebalancing comes from a lower transaction cost, compared with a more-frequent calendar-based model such as monthly rebalancing? **Figure 11** shows that 10% to 20% of the benefit can be attributed to lower transaction costs. The remaining 80% to 90% can be attributed to market-driven reasons such as harvesting the equity risk premium by rebalancing less frequently. As noted before, annual rebalancing is optimal even taking into account the allocation drift that may be experienced, as our framework ensures it is in line with the investor's risk tolerance.

Rebalancing during volatile environments

Should a portfolio be rebalanced during periods of high equity market volatility? That is, should fixed income be sold and proceeds be used to purchase equities? To answer this question, we group simulations into quintiles of equity market volatility and assess whether annual rebalancing is more efficient than a monthly rebalancing approach.

FIGURE 11.

Benefit attribution of optimal rebalancing methods



Notes: Results are based on simulations from the forecasting engine and maximization of post-transaction-cost wealth for various portfolios and rebalancing strategies shown above. The analysis decomposes how much of the expected benefit arises from lower transaction cost versus the benefit from market returns between annual rebalancing versus a monthly rebalancing rule. U.S. bonds are represented by the Bloomberg U.S. Aggregate Bond Index, non-U.S. bonds by the Bloomberg Global Aggregate ex-U.S. Index, U.S. equities by the MSCI US Broad Market Index, and non-U.S. equities by the MSCI All Country World Index ex USA. Data are as of June 2022.

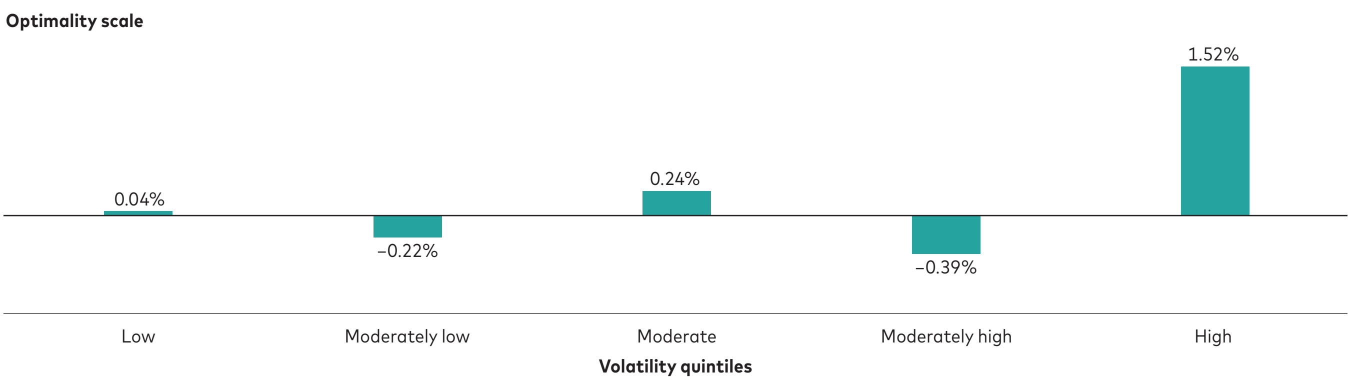
Source: Vanguard.

Figure 12 shows the CFE of annual rebalancing versus monthly rebalancing observed during the five quintiles based on volatility. We find that the less-frequent rebalancing is efficient during periods of market turmoil, as shown by the high 1.52% CFE (indicated by the optimality scale) for the annual rebalancing strategy. While one may get lucky in occasionally timing a monthly rebalance when the equity markets recover right after the rebalancing event, our analysis shows that, on average, it's not efficient to rebalance frequently, especially during periods of high volatility. As we have illustrated in Figure 4, transaction costs rise during volatile environments, which makes rebalancing an expensive action.

Second, one may rebalance in one direction and then have to reverse the transaction because the market fluctuated in the opposite direction, which can happen during these periods of turmoil. Using a less-frequent rebalancing strategy is instead quite efficient because it avoids high transaction costs and unnecessary trades.

FIGURE 12.

Benefits of less-frequent rebalancing during volatile markets



Notes: Results are based on simulations from the forecasting engine and maximization of post-transaction-cost wealth for a 60/40 portfolio by grouping the simulations according to the volatility of the portfolio returns. U.S. bonds are represented by the Bloomberg U.S. Aggregate Bond Index, non-U.S. bonds by the Bloomberg Global Aggregate ex-U.S. Index, U.S. equities by the MSCI US Broad Market Index, and non-U.S. equities by the MSCI All Country World Index ex USA. Data are as of June 2022.

Source: Vanguard.

Conclusions

We propose a framework for determining a risk-return-, cost-efficient rebalancing strategy by maximizing the expected utility of post-transaction-cost wealth. The framework requires forecasting a distribution of asset returns and transaction costs, which are critical factors in assessing rebalancing.

We find that optimal rebalancing methods are neither too frequent, such as monthly or quarterly calendar-based methods, nor too infrequent, such as rebalancing only every two years. Implementing an annual rebalancing is optimal for investors who don't participate in tax-loss harvesting or for whom maintaining tight tracking to the multiasset benchmark portfolio is not a concern.

Most of the efficiency of the optimal rebalancing strategies is generated by market-driven reasons such as harvesting the equity risk premium. Our analysis models ETF transaction costs and can be directly applied to ETF-based portfolios. Applications of our analysis to mutual funds or funds-of-funds may not be exact, as they do not incur explicit transaction costs, but they do include implicit transaction costs incurred from trading individual securities and futures and may also include purchase and redemption fees.

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Appendix

IMPORTANT: The projections and other information generated by the simulations (similar to VCMM) regarding the likelihood of various investment outcomes are hypothetical in nature, do not reflect actual investment results, and are not guarantees of future results. The model's results will vary with each use and over time.

The projections are based on a statistical analysis of historical data. Future returns may behave differently from the historical patterns captured in the model. More important, the model may be underestimating extreme negative scenarios unobserved in the historical period on which the model estimation is based.

The model is a proprietary financial simulation tool. The model forecasts distributions of future daily returns for a wide array of broad asset classes. Those asset classes include U.S. and international equity markets, several maturities of the U.S. Treasury and corporate fixed income markets, and international fixed income markets. The theoretical and empirical foundation for the model is that the returns of various asset classes reflect the compensation investors require for bearing different types of systematic risk (beta).

At the core of the model are estimates of the dynamic statistical relationship between risk factors and asset returns, obtained from statistical analysis based on available daily financial and economic data. Using a system of estimated equations, the model then applies a Monte Carlo simulation method to project the estimated interrelationships among risk factors and asset classes as well as uncertainty and randomness over time. The model generates a large set of simulated outcomes for each asset class over several time horizons. Forecasts are obtained by computing measures of central tendency in these simulations. Results produced by the tool will vary with each use and over time.

Appendix A-1: The utility-based decision-making framework

The model uses a Constant Relative Risk Aversion (CRRA) utility function as specified below.

$$Utility(w) = \frac{w^{(1-r)}}{(1-r)}$$

w = End portfolio wealth (after-transaction costs)

r = Risk aversion coefficient

The CRRA utility function outlined above is a power utility function that considers an investor's risk aversion, defined as an investor's aversion to an uncertainty of outcomes. A risk-averse investor prefers a degree of certainty. An investor with low risk aversion tolerates the uncertainty for a better outcome. Our model can generate results with any user-inputted risk aversion coefficient. Resulting utility scores in our analysis are negative because we assume that end portfolio wealth is always positive (wealth intuitively doesn't go below zero) and the investor's risk aversion coefficient is greater than 1.

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