Why Does an Equal-Weighted Portfolio Outperform Value- and Price-Weighted Portfolios?*

Yuliya Plyakha§ Raman Uppal¶ Grigory Vilkov§

This version: October 16, 2012

Abstract

We compare the performance of equal-, value-, and price-weighted portfolios of stocks in the major U.S. equity indices over the last four decades. We find that the equal-weighted portfolio with monthly rebalancing outperforms the value- and price-weighted portfolios in terms of total mean return, four factor alpha, Sharpe ratio, and certainty-equivalent return, even though the equal-weighted portfolio has greater portfolio risk. The total return of the equal-weighted portfolio exceeds that of the value- and price-weighted because the equal-weighted portfolio has both a higher return for bearing systematic risk and a higher alpha measured using the four-factor model. The nonparametric monotonicity relation test indicates that the differences in the *total return* of the equal-weighted portfolio and the value- and price-weighted portfolios is monotonically related to size, price, and idiosyncratic volatility. The higher *systematic return* of the equal-weighted portfolio arises from its higher exposure to the market, size, and value factors. The higher *alpha* of the equal-weighted portfolio arises from the monthly rebalancing required to maintain equal weights, which is a contrarian strategy that exploits reversal in stock returns; thus, alpha depends only on the monthly rebalancing and *not* on the choice of initial weights.

Keywords: stock index, systematic risk, idiosyncratic risk, factor models, contrarian, trend following

JEL: G11, G12

*We gratefully acknowledge comments from Hank Bessembinder, Michael Brennan, Oliver Boguth, Ian Cooper, Victor DeMiguel, Engelbert Dockner, Bernard Dumas, Nikolae Gârleanu, Will Goetzman, Antti Ilmanen, Philipp Kaufmann, Lionel Martellini, Stefan Nagel, Stavros Panageas, Andrew Patton, David Rakowski, Tarun Ramadorai, Bernd Scherer, Eric Shirbini, Mungo Wilson, Michael Wolf, Josef Zechner, and participants of seminars at the EDHEC-Risk Days Europe Conference, Endowment Asset Management Conference at the University of Vienna, European Summer Symposium in Financial Markets at Gerzensee, Edhec Business School (Singapore), Goethe University Frankfurt, Multinational Finance Society Conference (Krakow), Norges Bank Investment Management, S&P Indices, University of Innsbruck, and University of Southern Denmark.

§Goethe University Frankfurt, Finance Department, Grüneburgplatz 1 / Uni-Pf H 25, D-60323 Frankfurt am Main, Germany; Email: plyakha@finance.uni-frankfurt.de and vilkov@vilkov.net.

¶CEPR and Edhec Business School, 10 Fleet Place, Ludgate, London, United Kingdom EC4M 7RB; Email: raman.uppal@edhec.edu.

Why Does an Equal-Weighted Portfolio Outperform Value- and Price-Weighted Portfolios?

This version: October 16, 2012

Abstract

We compare the performance of equal-, value-, and price-weighted portfolios of stocks in the major U.S. equity indices over the last four decades. We find that the equal-weighted portfolio with monthly rebalancing outperforms the value- and price-weighted portfolios in terms of total mean return, four factor alpha, Sharpe ratio, and certainty-equivalent return, even though the equal-weighted portfolio has greater portfolio risk. The total return of the equal-weighted portfolio exceeds that of the value- and price-weighted because the equal-weighted portfolio has both a higher return for bearing systematic risk and a higher alpha measured using the four-factor model. The nonparametric monotonicity relation test indicates that the differences in the *total return* of the equal-weighted portfolio and the value- and price-weighted portfolios is monotonically related to size, price, and idiosyncratic volatility. The higher *systematic return* of the equal-weighted portfolio arises from its higher exposure to the market, size, and value factors. The higher *alpha* of the equal-weighted portfolio arises from the monthly rebalancing required to maintain equal weights, which is a contrarian strategy that exploits reversal in stock returns; thus, alpha depends only on the monthly rebalancing and *not* on the choice of initial weights.

Keywords: stock index, systematic risk, idiosyncratic risk, factor models, contrarian, trend following

JEL: G11, G12

1 Introduction

The *value-weighted* "market" portfolio plays a central role in asset pricing, for instance in the Capital Asset Pricing Model of Sharpe (1964), and it is also the standard benchmark against which performance is measured and portfolio managers are evaluated in both academic studies and in the practitioner literature.[1] On the other hand, the use of *equal-weighted* mean returns is ubiquitous in empirical finance.[2] Our objective in this paper is to compare the performance of the equal-weighted portfolio to that of the value- and price-weighted portfolios, and to understand the reasons for the differences in the performance of these portfolios. Our main contribution is to show that there are significant differences in the performance of equal-, value-, and price-weighted portfolios, and to explain that only a part of the higher return of the equal-weighted portfolio arises from differences in exposure to systematic risk factors, and that a substantial proportion comes from the rebalancing required by the equal-weight portfolio. We also use the methods recommended in Asparouhova, Bessembinder, and Kalcheva (2010, 2012) to show that the differences in performance across these three portfolios are not driven by noise in prices arising from microstructure effects.

To undertake our analysis, we construct equal-, value-, and price-weighted portfolios from 100 stocks randomly selected from the constituents of the S&P500 index over the last forty years. We find that the equal-weighted portfolio with monthly rebalancing outperforms the value- and price-weighted portfolios in terms of total mean return and four-factor alpha from the Fama and French (1993) and Carhart (1997) models. The total return of the equal-weighted portfolio is higher than that of the value- and price-weighted portfolios by 271 and 112 basis points per annum. The four-factor alpha of the equal-weighted portfolio is 175 basis points per year, which is more that 2.5 times the 60 and 67 basis points per year for the value- and price-weighted portfolios, respectively. The differences in total mean return and alpha are significant even after allowing for transactions costs of 50 basis points.

[1] The value-weighted portfolio is used as a benchmark in academic studies such as Carhart (1997) and Chevalier and Ellison (1997), and in practitioner papers such as Amenc, Goltz, Martellini, and Retkowsky (2010), Chow, Hsu, Kalesnik, and Little (2011), and Haugen and Baker (1991).

[2] Equal-weighted mean returns are used in a large number of papers on empirical asset pricing (see, for example, the classical work of Fama and MacBeth (1973), Black, Jensen, and Scholes (1972), and Gibbons, Ross, and Shanken (1989)), almost all event-studies and research that relates mean returns to firm characteristics (for reviews of this literature, see Campbell, Lo, and MacKinlay (1997) and Kothari and Warner (2006)); Asparouhova, Bessembinder, and Kalcheva (2012, p. 2) write "For example, examining papers published in only two premier outlets, *The Journal of Finance* and *The Journal of Financial Economics*, over a recent five year (2005–2009) interval, we were able to identify twenty four papers that report equal-weighted mean returns and compare them across portfolios."

The equal-weighted portfolio, however, has a higher volatility (standard deviation) and kurtosis compared to the value- and price-weighted portfolios. The volatility of the return on the equal-weighted portfolio is 17.90% per annum, which is higher than the 15.83% and 16.46% for the value- and price-weighted portfolios; the kurtosis of 5.53 for the equal-weighted portfolio is also higher than the 4.83 and 5.36 for the value- and price-weighted portfolios. The skewness of the equal-weighted portfolio is less negative than the skewness of the value- and price-weighted portfolios: the skewness of the equal-weighted portfolio is -0.3266, compared to -0.3860 and -0.4996 for the value- and price-weighted portfolios, respectively.

Despite the unfavorable volatility and kurtosis, the Sharpe ratio and certainty-equivalent return of the equal-weighted portfolio are higher than those of the value- and price-weighted portfolios. The Sharpe ratio of the equal-weighted portfolio is 0.4275, while that for the value- and price-weighted portfolios is 0.3126 and 0.3966. The higher return and less negative skewness of the equal-weighted portfolio leads also to a higher certainty-equivalent return, which, for an investor with power utility and relative risk aversion of 2, is 0.0994 per annum for the equal-weighted portfolio, compared to 0.0793 and 0.0930 for the value- and price-weighted portfolios, respectively.

The results described above imply that the source of the superior performance of the equal-weighted portfolio is its significantly higher mean return, along with its less-negatively skewed returns. To understand the reasons for the superior performance of the equal-weighted portfolio, we first use the non-parametric monotonicity relation tests developed by Patton and Timmermann (2010) and Romano and Wolf (2011) to study if there is a relation between a particular characteristic of stocks and the *total return* of the equal-weighted portfolio relative to the value- and price-weighted portfolios.[3] These monotonicity tests indicate that the returns of the equal-weighted portfolios relative to the returns of the value- and price-weighted portfolios are monotonically decreasing with size and price, and monotonically increasing with idiosyncratic volatility. Book-to-market is related to the difference in returns between only the equal- and price-weighted portfolios. Reversal and three-month momentum are not significantly monotonically related to the returns of the equal-weighted portfolio relative to the value- and price-weighted portfolios, although it is the stocks with extremely low and extremely high reversal that contribute to the higher alpha of the equal-weighted portfolio. Liquidity appears

[3]There is a large literature studying the relation between returns and characteristics of sort-based portfolios; see, for example, Conrad, Cooper, and Kaul (2003) and Greene and Rakowski (2011).

to be monotonically related to the difference in returns between the equal- and value-weighted portfolios, but this effect is not significant once returns are corrected for microstructure effects as suggested in Asparouhova, Bessembinder, and Kalcheva (2010, 2012).

Motivated by the findings from the non-parametric monotonicity tests, we use the standard four-factor model (Fama and French (1993) and Carhart (1997)) to decompose the total returns of the equal-, value-, and price-weighted portfolios into a *systematic component*, which is related to factor exposure, and *alpha*, which is not related to factor exposure. We find that of the total excess mean return of 271 basis points per annum earned by the equal-weighted portfolio over the value-weighted portfolio, 42% comes from the difference in alpha and 58% from the excess systematic component. On the other hand, of the total excess mean return of 112 basis points earned by the equal-weighted portfolio relative to the price-weighted portfolio, 96% comes from the difference in alpha and only 4% from the difference in systematic return. The proportional split between systematic return and alpha is similar also after adjusting for transactions costs of 50 basis points. We find that the higher systematic return of the equal-weighted portfolio arises from its higher exposure to the market, size, and value factors; however, the equal-weighted portfolio has a more negative exposure to the momentum factor than the value- and price-weighted portfolios. We also extend the four-factor model by including the systematic reversal factor (constructed by K. French and available on his web site) and find that only 11% of the four-factor alpha of the equal-weighted portfolio can be attributed to the exposure to the reversal factor. However, including the reversal factor does not affect the alphas of the value- and price-weighted portfolios, both of which stay insignificant.

Finally, we demonstrate through two experiments that the higher alpha and less negative skewness of the equal-weighted portfolio are a consequence of the monthly rebalancing to maintain equal weights, which is implicitly a contrarian strategy that exploits the reversal in stock prices at the monthly frequency.[4] In the first experiment, we reduce the rebalancing frequency of the equal-weighted portfolio. We find that as the rebalancing frequency decreases from one month to six months, the excess alpha earned by the equal-weighted portfolio *decreases* and the skewness of the portfolio return becomes more negative; when the rebalancing frequency is further reduced to twelve months, the alpha of the equal-weighted strategy is statistically indis-

[4]For the literature on momentum and contrarian strategies, see Jegadeesh (1990), Conrad and Kaul (1998), Jegadeesh and Titman (1993, 2002), Lo and MacKinlay (1990), DeMiguel, Nogales, and Uppal (2010) and Asness, Moskowitz, and Pedersen (2009).

tinguishable from that of the value- and price-weighted strategies. In the second experiment, we artificially keep the weights of the value- and price-weighted portfolios fixed so that they have the contrarian flavor of the equal-weighted portfolio, and we find that this *increases* their alpha and makes skewness less negative. If we keep the weights of the value- and price-weighted strategies fixed for twelve months, the alpha of these portfolios increases and is statistically indistinguishable from that of the equal-weighted portfolio. An important insight from these two experiments is that it is *not* the initial weights of the equal-weighted portfolio, but the monthly rebalancing that is responsible for the alpha it earns, relative to the alphas for the value- and price-weighted portfolios. This is explained, at least partly, by the theoretical results of Platen and Rendek (2010), who show that with continuous rebalancing the equal-weighted portfolio approaches the optimal growth portfolio of a log-utility investor, and hence, outperforms other portfolios including the value-weighted portfolio.

We check the robustness of our results along a variety of dimensions. When selecting a sample of stocks from the S&P500 index, we consider not just one portfolio with 100 stocks but resample to select 1,000 portfolios, and all the results we report are based on the performance metrics averaged across these 1,000 portfolios. In addition to the results reported for portfolios with 100 stocks, we also consider portfolios with 30, 50, 200, and 300 stocks (again, with resampling over 1,000 portfolios). Besides the stocks sampled from the S&P500 for large-cap stocks, we consider also stocks from the S&P400 for mid-cap, and the S&P600 for small-cap stocks. We also use several methods to correct for potential biases arising from noisy prices and liquidity differences across stocks, as suggested in Blume and Stambaugh (1983), Asparouhova, Bessembinder, and Kalcheva (2010, 2012), and Fisher, Weaver, and Webb (2010).[5] Finally, we test the sensitivity of our results to different economic conditions: we study the performance of the equal-weighted portfolio relative to the value- and price-weighted portfolios if one had invested in the strategy at the peak of the business cycle (March 2001 or December 2007) or the trough (November 2001). We find that our results are robust to these variations.

[5] The four methods we use are: (i) correcting the CRSP end-of-month returns for the bias induced by the bid-ask bounce by using the *previous* period's gross-return weighting to construct the equal-weighted portfolio; (ii) using the midpoint of the closing bid and ask quotes to compute monthly returns; (iii) correcting the end-of month returns by subtracting from the noisy return the square of the ratio of the bid-ask spread to the total of the bid and ask prices; and, (iv) computing returns using the volume-weighted average prices (VWAP) for the last day of each month from the TAQ Database. While the first correction method is implemented for the full dataset, because of limited data availability, the other three methods are implemented for data only from 1995 onwards.

The rest of the paper is organized as follows. In Section 2, we describe the data on stocks that we use to build the portfolios we study, the resampling procedure, and the performance metrics used to compare the performance of equal-, value-, and price-weighted portfolios. In Section 3, we provide evidence on the empirical performance of the three weighting rules. In Section 4, we use the nonparametric monotonicity relation test to identify the stock characteristics that are related to the differences in the returns of the equal-weighted portfolio and the value- and price-weighted portfolios. In Section 5, we study the returns of the equal-, value-, and price-weighted portfolios using the four-factor model; Section 5.1 analyzes the systematic exposure of returns, and Section 5.2 investigates the source of the excess alpha of the equal-weighted portfolio, relative to the alphas of the value- and price-weighted portfolios. The robustness tests we undertake are described in Section 6. We conclude in Section 7 with a short summary of the findings. Appendix A explains the data and the resampling technique used to compute the test statistics; Appendix B gives the details of the construction of the various stock characteristics that we use in our analysis.

2 Data Description and Methodology

In this section, we first describe our data. Next, we describe the resampling procedure used to construct 1,000 portfolios so that the results do not depend on a particular sample of stocks. Finally, we describe the performance metrics used to compare the out-of-sample performance of the equal-, value-, and price-weighted portfolios.

2.1 The Choice of Stocks

We construct equal-, value-, and price-weighted portfolios of $N = 100$ stocks that are in the S&P500 index over the period February 1967 to December of 2009. For robustness, we consider also (i) portfolios with 30, 50, 200, and 300 stocks; and, (ii) stocks belonging to the MidCap S&P400 index from July 1991 to December of 2009, and the SmallCap S&P600 index from November 1994 to December of 2009. The choice of starting month is dictated by the date on which each particular index was initiated. In total, the stocks in our sample cover approximately 90% of the market capitalization of stocks traded in the U.S. stock market. The S&P500 index focuses on the large-cap segment of the market with coverage of more than 75% of U.S. equities.

To identify the composition of the index at any point in time we use the COMPUSTAT Index Constituents file and link it to the CRSP file using the CCM (CRSP/COMPUSTAT Merged Database) Linking Table. For each portfolio with N stocks, we randomly choose N stocks that are constituents of a particular index. If the S&P announces the decision to remove a particular stock that was in our portfolio (the S&P usually makes this announcement five days before removing the stock), then we too remove this stock from our portfolio and randomly choose another stock to replace it.

We use monthly returns in our analysis and the data on returns for stocks is extracted from the CRSP database.[6] The company characteristics used in our analysis, such as size, book-to-market, momentum, reversal, liquidity, and idiosyncratic volatility, are constructed using the monthly and daily CRSP and COMPUSTAT databases. We describe the data filtering steps in Appendix A and the method for constructing each characteristic in Appendix B; summary statistics for these characteristics are provided in Table 1. Note that the three samples for S&P500, S&P400, and S&P600 consist of relatively large and liquid stocks. For instance, compared to the larger sample of 3762 stocks used in Asparouhova, Bessembinder, and Kalcheva (2012), we see that the median firm size in their sample is approximately equal to the median firm size in our S&P600 small-cap sample. Using the reciprocal of the Amihud's liquidity measure as a rough proxy for Amivest's liquidity measure, we also note that even in the S&P600 small-cap sample the stocks are about two times more liquid than in the larger CRSP sample. The large-cap S&P500 sample certainly has much larger and more liquid stocks than the sample consisting of 3762 CRSP stocks.

2.2 Resampling Procedure and Performance Metrics

We study three commonly used weighting rules: equal-weighting (EW), value-weighting (VW), and price-weighting (PW). To ensure that our results are not driven by the choice of stocks that we select from a particular index, rather than studying just one sample of stocks, we use resampling to form $1,000$ randomly chosen portfolios of a given size N from a given stock index, and compute the performance metrics for each portfolio-weighting rule. We then use the resulting empirical distribution of the metrics to compute the p-values to test the null

[6] For robustness, we also construct monthly returns using (i) the bid and ask quotes for each stock at the end of a month from CRSP, and (ii) volume-weighted average prices for all trades reported in the Trade and Quote NYSE database at the end of a month.

hypotheses that there is no difference in the value of each performance metric for the equal-weighted portfolio and the value-weighted portfolio, and for the equal-weighted portfolio and the price-weighted portfolio. We also implement four methods to reduce any potential biases arising from noise in stock prices because of microstructure effects and differences in liquidity across stocks that Asparouhova, Bessembinder, and Kalcheva (2010, 2012) show can influence the return of the equal-weighted portfolio; these robustness tests are discussed in Section 6.3.

We compute a number of performance metrics for the returns on the equal-, value-, and price-weighted portfolios. The performance metrics we compute can be divided into three broad groups. First, for return indicators, we use the mean return on the portfolio, the systematic return on the portfolio based on the four-factor model (Fama and French (1993) and Carhart (1997)), and the alpha with respect to the one-factor market model and the four-factor model. We also compute the *outperformance frequency*, which is the average fraction of times that the equal-weighted portfolio has a higher cumulative return than the value- and price-weighted portfolios within a twelve-month period from the beginning of each period.

Second, for measuring the risk of the portfolio return, we compute the volatility (standard deviation), skewness, and kurtosis of the portfolio return, as well as the average maximum drawdown (MDD), defined as the time series average of the maximum percentage loss of the portfolio value $V(\tau)$ over any period from τ_1 to τ_2 during the last twelve months:

$$\mathrm{MDD} = \frac{1}{T-13} \sum_{t=12}^{T-1} \max_{t-11 \leq \tau_1 < \tau_2 \leq t} \left\{ 0, \frac{V(\tau_1)}{V(\tau_2)} - 1 \right\} \times 100. \quad (1)$$

Third, to measure the risk-return tradeoff we use the Sharpe ratio, Sortino ratio, and Treynor ratio. The Sharpe ratio is measured as the mean return in excess of the risk-free rate divided by the volatility of the portfolio. The Sortino ratio is measured as the mean return in excess of the risk-free rate, divided by the downward semi deviation of the portfolio return from the risk-free rate, where

$$\text{Downward semi deviation} = \sqrt{\frac{1}{T} \sum_{i=1}^{T} (\max\{r_i^f - r_i, 0\})^2}. \quad (2)$$

Compared to the Sharpe ratio, the Sortino ratio penalizes only the downward deviations of the portfolio return from the target risk-free rate. The Treynor ratio (also called the reward-to-volatility ratio), is measured as the mean return in excess of the risk-free rate divided by the portfolio's one-factor market beta, β^{mkt}. According to the Treynor ratio, portfolios with the similar systematic return components will achieve similar rankings. We also report the certainty equivalent return of a myopic CRRA investor for two levels of relative risk aversion: $\gamma = 2$ and $\gamma = 5$.

We report the annual turnover of each portfolio. We define the *monthly* turnover to be the time-series mean (over the $T-1$ monthly rebalancing dates) of the sum of absolute changes in weights across the N available stocks in the portfolio:

$$\text{Turnover} = \frac{1}{T-1} \sum_{t=1}^{T-1} \sum_{j=1}^{N} \left(\left| w_{j,t+1} - w_{j,t^+} \right| \right). \tag{3}$$

To get the annual turnover, we multiply the above quantity by 12. Note that, in contrast to the definition usually used in the mutual-fund industry, our measure includes both sales and purchases; so, compared to the traditional measure, our measure of turnover is twice as large.

To estimate the diversity between two portfolios, we compute the Euclidean distance (2-norm) between the pairs of the portfolio weights, which measures how different are the weights in the equal-weighted portfolio from the weights in the value- and price-weighted portfolios.

$$\text{Distance}_{i,j} \quad = \quad \frac{1}{T} \sum_{t=1}^{T} \sqrt{\sum_{n=1}^{N} (w_n^i - w_n^j)^2}. \tag{4}$$

If two portfolios have almost the same portfolio weights, the distance between their weights will be almost zero; the more portfolios differ from each other, the bigger will be the distance between their weights. Also, the distance between a concentrated and a well-diversified portfolio will be greater than the distance between two less concentrated portfolios.

We compute all the performance metrics described above both, before transactions costs, and net of a proportional trading cost of 50 basis points (0.5%). The annual transactions costs for our portfolio are obtained by multiplying the annual turnover by 50 basis points. The mean return net of transactions costs is then obtained by subtracting these transaction costs from the total mean return before transactions costs.

3 Performance of Equal-, Value-, and Price-Weighted Portfolios

We now analyze how different weighting rules affect portfolio performance. The performance that we report in this section is based on the average metrics from the 1,000 portfolios constructed for each portfolio-weighting rule, as described in Section 2.2. We measure the performance of each of the three weighting rules over the period February 1967 to December 2009 for the stocks constituents of S&P500. We report in Table 2 performance measured in per annum terms. We study performance before transactions costs and also performance net of transactions costs of 50 basis points.[7] We divide our discussion of portfolio performance into three parts, corresponding to the three categories of metrics described above: measures of return, risk, and the risk-return tradeoff.

3.1 Comparison of Portfolio Return Measures

Examining the metrics for returns given in Table 2, we make three observations. First, the equal-weighted portfolio significantly outperforms the price- and value-weighted portfolios, with a mean annual return of 13.19%, compared to 10.48% for the value-weighted portfolio and 12.07% for the price-weighted portfolio. That is, the total return of the equal-weighted portfolio is higher than that of the value- and price-weighted portfolios by 271 and 112 basis points per annum, and the p-values for both these differences are 0.0. This is true also net of transactions costs of 50 basis points: the total return of the equal-weighted portfolio is higher than that of the value- and price-weighted portfolios by 238 and 88 basis points per annum, and the p-values for both these differences are 0.0. Compared to the value-weighted portfolios gains, equal-weighted portfolio gains are higher in 67.7% of cases, and, as compared to the price-weighted portfolio gains – in 64.2% of cases during twelve month. Net of transaction costs these numbers decrease only by 1% and 2%.

Second, the differences in the four-factor alphas are even more striking:[8] the annual alpha for the value-weighted portfolio is 60 basis points and for the price-weighted portfolio is 67 basis points, while that for the equal-weighted portfolio is 175 basis points, which is more than 2.5

[7]The performance of portfolios constructed from the stocks constituents of S&P400 and S&P600 is reported in Tables 7 and 8. Comparing these two tables with Table 2, one can verify that the main insights for the weighting rules are similar across the three indexes; see Section 6.2 for a discussion of this comparison.

[8]The estimates of the beta coefficients for the four-factor model are given in Table 4.

times greater. The systematic component of return for the equal-weighted portfolio exceeds that of the value-weighted portfolio by 156 basis points per year, while it is similar to that of the price-weighted portfolio. Consequently, of the total excess mean return earned by the equal-weighted portfolio over the value- and price-weighted portfolios, the proportions coming from the differences in alphas are 42% and 96%, respectively.

Because of the monthly trading to maintain equal weights, the equal-weighted portfolio has a higher turnover than that of the value- and price-weighted portfolios. The value- and price-weighted portfolios do not require any trading, but they do need to be rebalanced when some stocks enter and others exit the index and when there is a change in the market capitalization or the stock price because of secondary public offerings, stock splits, etc. The turnover of the equal-weighted portfolio is about six times that of the value-weighted portfolio and about three times that of the price-weighted portfolio. Assuming a conservative transaction cost of 50 basis points (in the market today, the transaction cost for non-retail traders is less than 10 basis points), the equal-weighted portfolio incurs transaction costs of about 0.41% per year, while the transactions costs are only 0.07% and 0.16% for the value- and price-weighted portfolios, respectively. Our third observation is that even after adjusting for these transactions costs, the total mean returns and the four-factor alpha are significantly different for the equal-weighted portfolio and the two other weighting rules.

Among the equal-, value- and price- weighted portfolios, the smallest *distance* lies between the price and equal weights and is equal 0.0671. The distance between the value and price weights is more than double, 0.1733; and, the largest difference is between the value and equal weights, 0.1867. Thus, the equal and price weights are more similar; value weights differ more from equal weights than from the price weights.

3.2 Comparison of Portfolio Risk Measures

Examining the various measures of risk in Table 2, we see that the per annum volatility (standard deviation) is 0.1790 for the equal weighted portfolio, 0.1646 for the price-weighted portfolio, and 0.1583 for the value-weighted portfolio, with the difference in volatility between the equal-weighted portfolio and the other two portfolios being statistically significant (the p-values for both differences are 0.0). Thus, total-return volatility is highest for the equal-weighted portfolio, lowest for the value-weighted portfolio, with the volatility for the price-weighted portfolio being in the middle. The effect of transaction costs on volatility is very small (the difference shows up only in the fifth decimal point).

Skewness is higher (less negative) for the equal-weighted portfolio compared to the value- and price weighted portfolios. The difference in skewness for the equal- and price-weighted portfolios is statistically significant (p-value of 0.0), but the difference in skewness for the equal- and value-weighted portfolios is not statistically significant (p-value of 0.43). Transactions costs make skewness slightly more negative.

Kurtosis is highest for the returns on the equal-weighted portfolio at 5.53, lowest for the returns on the value-weighted portfolio at 4.84, with the kurtosis for the price-weighted portfolio being in the middle. The difference in kurtosis between the equal-weighted and value-weighted portfolios is statistically significant with a p-value of 0.01. The kurtosis net of transactions costs is not very different from kurtosis before transaction costs.

A useful metric for any portfolio manager is the maximum drawdown. The equal-weighted portfolio has slightly higher portfolio drawdown compared to both value- and price-weighted portfolios, and this difference is statistically significant. The point estimate of the portfolio drawdown is lowest for the value-weighted portfolio, higher for the price-weighted portfolio, and highest for the equal-weighted portfolio. The reason for this is that when a stock in the portfolio has a drop in its price, the price- and value-weighted portfolios react immediately by allocating *less* weight to this stock and more weight to the other assets in the portfolio. The equal-weighted portfolio, on the other hand, on the next rebalancing date allocates *more* wealth to the stock whose price has dropped, which increases the portfolio drawdown in case the stock price continues to decline.

3.3 Comparison of Risk-Return Tradeoff Measures

The observations regarding the risk-return metrics follow directly from our analysis of the return and risk measures above. The main observation is that the equal-weighted portfolio outperforms the price- and value-weighted portfolios in terms of both Sharpe ratio and certainty equivalent return. From Table 2 we see that the annual Sharpe ratio for the equal-weighted portfolio is 0.4275 and for the value-weighted portfolio is 0.3126, with the difference being statistically significant (p-value of 0.0). The price-weighted portfolio has a Sharpe ratio of 0.3966, which is also significantly different from the Sharpe ratio for the equal-weighted portfolio (p-value of 0.05).

For an investor with risk aversion of $\gamma = 2$, the certainty equivalent return for the equal-weighted portfolio is 0.0994, for the value-weighted portfolio is 0.0793, and for the price-weighted portfolio is 0.0930; the differences between the certainty-equivalent returns for the equal-weighted portfolio and the value- and price-weighted portfolios are statistically significant, and the p-values are 0.0 and 0.01, respectively. These results are similar even after transactions costs. However, for an investor with risk aversion of $\gamma = 5$, the certainty-equivalent return for the equal-weighted portfolio exceeds that for the value-weighted portfolio but is less than that for the price-weighted portfolio; and the differences in these certainty-equivalent returns are not statistically significant.[9]

Our goal in the remainder of the paper is to understand the reasons for the difference in the performance of the equal-, price- and value-weighted portfolios. In Section 4, we investigate if there is a relation between a particular stock characteristic and the *total returns* of the equal-, value-, and price-weighted portfolios using the non-parametric monotonicity tests developed in Patton and Timmermann (2010), which is a nested version of the monotonicity test in Romano and Wolf (2011). Then, in Section 5.1, we use the traditional four-factor model to identify the relation between exposures of portfolios to risk factors and the *systematic component* of total return that is earned by these three portfolios for bearing systematic risk. While the four-factor model is useful for identifying the relation between exposure to risk factors and the systematic component of total return, it leaves unexplained the source of *alpha*. In Section 5.2, we demonstrate that the rebalancing required to maintain equal weights is the source of the difference between the alpha of the equal-weighted portfolio and that of the value- and price-weighted portfolios.

[9] The Sortino and Treynor ratios rank the equal-, value- and the price-weighted portfolio in the same way as the Sharpe ratio and the certainty equivalent: the equal-weighted portfolio has the highest Sortino ratio of 0.6424 and Treynor ratio of 0.0728. These measures are smaller for the price-weighted portfolio and equal to 0.5813 and 0.0662 correspondingly, the smallest for the value-weighted portfolio 0.4534 and 0.0526, correspondingly.

4 Characteristics Related to Outperformance of Equal-Weighted Portfolio

In this section, we study eight characteristics of stocks that could potentially be driving the differences in total returns of the equal-, value-, and price-weighted portfolios. The eight characteristics we consider are: size, book-to-market, 3-month momentum, 12-month momentum, reversal, price, liquidity, and idiosyncratic volatility. The study of size, book-to-market, and price is motivated by the work of Conrad, Cooper, and Kaul (2003). The analysis of momentum and reversal is motivated by the work Jegadeesh (1990) and Jegadeesh and Titman (1993, 2002). The investigation of price is prompted by the work of Miller and Scholes (1982) and Breen and Korajczyk (1995). The study of liquidity is motivated by the work of Amihud (2002); for a review of the recent literature on liquidity, see Goyenko, Holden, and Trzcinka (2009). A good discussion of the recent work on idiosyncratic volatility can be found in Fu (2009).

We describe our analysis of characteristics in two parts. First, in Section 4.1, we explain the methodology used to study the relation between each characteristic and the total returns of the equal-, value, and price-weighted portfolios. Then, in Section 4.2, we report the results of our investigation of each of the eight characteristics.

4.1 Analysis of Characteristics: Methodology

We now analyze the relation between various stock characteristics and the returns on the equal-, value-, and price-weighted portfolios using the nonparametric monotonicity tests developed in Patton and Timmermann (2010), which is a nested version of the tests developed by Romano and Wolf (2011). In particular, we test the hypothesis that there is a monotonic relation between a particular characteristic and the difference in returns between (i) the equal- and value-weighted portfolios, and (ii) the equal- and price-weighted portfolios.

The steps entailed in this analysis are the following. For each of the one thousand portfolios consisting of $N = 100$ stocks, we sort the stocks in each of these thousand portfolios at the end of each month by a particular characteristic. From these 1,000 sorted portfolios we create 100 synthetic assets, where for each asset $j = 1, \ldots, 100$ the characteristic is set equal to the mean characteristic of all stocks across the thousand portfolios with rank j after the sorting procedure, and the return of the synthetic asset j for the next period is equal to the mean return of all the stocks with the same rank j.[10] Then, we group the sorted assets into deciles and compute the return for each decile by applying equal, value, and price weights within each decile. Finally, we compute the relation between the characteristic and the *difference* in the total portfolio return of the value- and equal-weighted decile portfolios, relative to the price- and equal-weighted portfolios; we display this relation in Figures 1–8, and in Table 3 report the results for the test that the relation is monotonic.

To test for an increasing (decreasing) relation we form the pairwise differences of the values of the test series; that is, the value of decile i minus the value of decile $i-1$, where $i = 2, \ldots, 10$, bootstrap the differences in the time series dimension,[11] find the minimum (maximum) of each bootstrapped sample, and compute the probability that the minimum (maximum) of the differences is greater (smaller) than the sample minimum (maximum) of the differences.[12] We also perform a stronger test for a monotonic relation, where we consider not only the pairwise differences of the adjacent data points, but also the differences between *all* possible pairs.

4.2 Analysis of Characteristics: Results

We start by analyzing whether the "size" characteristic plays a significant role in explaining the difference between the returns of the equal-weighted portfolio and the value- and price-weighted portfolios. We start by sorting the assets we have into deciles based on size. We then plot in Figure 1 the difference between the equal-weighted and value-weighted portfolio decile returns, and also the difference between the equal-weighted and price-weighted portfolio decile returns. This figure shows that "size" plays a role in explaining the difference in decile returns. That is, because the equal-weighted portfolio overweights small size stocks compared to the value-weighted portfolio, size is at least partly responsible for the equal-weighted portfolio outperforming a value-weighted portfolio. Table 3 shows that for the differences in returns

[10] We create these synthetic assets to limit the computational burden. Note that monotonicity relation tests use a bootstrap in the time-series dimension, while we use resampling in the cross-sectional dimension to create 1,000 portfolios, and therefore, if we did not create these synthetic assets, the bootstrap would impose a significant computational burden; see Appendix A for additional details. Constructing these synthetic assets also contributes to reducing the noise induced by the bid-ask spread in stock returns used by CRSP to compute the end-of-month returns.

[11] We use $10,000$ bootstrap samples with the length of the stationary bootstrap being six months, as recommended for monthly data by Patton and Timmermann (2010).

[12] Romano and Wolf (2011) highlight a weakness of the monotonicity tests proposed by Patton and Timmermann (2010) because the critical values of these tests are based on an additional assumption that if a relation is not strictly monotonically increasing, it must be weakly monotonically decreasing. In light of this, we test for *both* weakly increasing and weakly decreasing relations, and conclude that a particular relation is weakly increasing only if the null of a weakly increasing relation is not rejected *and* the null of a weakly decreasing relation is rejected.

between the equal- and value-weighted portfolios, and between the equal- and price-weighted portfolios, the tests for a monotonically *increasing* relation with the size characteristic are rejected: the p-values for EW−VW and EW−PW are 0.0 for the test of neighboring pairs and also for the stronger test across all pairs.

Next, we study whether the book-to-market characteristic plays a role in explaining the returns of decile portfolios sorted on the basis of this characteristic. From Figure 2, we see that the higher is the book-to-market characteristic of the stocks in the portfolio, the more the equal-weighted portfolio outperforms the value-weighted portfolio. In Table 3, we see that for the book-to-market characteristic, the hypothesis of a monotonically decreasing relation with EW−VW is rejected; the p-values are 0.02 both for the test of neighboring pairs and also for the test of all pairs. However, Figure 2 shows that the book-to-market characteristic plays a weaker role in explaining the difference in the performance of the equal- and price-weighted portfolios, and we see from Table 3 that for the relation between book-to-market and EW−PW, none of the p-values are significant.

Figure 3 shows the difference in returns of the equal- and value-weighted and also the equal- and price-weighted decile portfolios that are sorted on the basis of the 3-month momentum characteristic. From this figure, we see that the relation between 3-month momentum and the difference in returns of the equal-weighted and the price- and value-weighted portfolios decile portfolios is not monotonic. Table 3 confirms this: none of the p-values are significant for the test of a monotonic relation between 3-month momentum and EW−VW or 3-month momentum and EW−PW.

Figure 4 shows the difference in returns of the equal- and value-weighted and also the equal- and price-weighted decile portfolios that are sorted on the basis 12-month momentum. This figure shows that the relation between 12-month momentum and the difference in returns of the equal- and value-weighted is not monotonic; Table 3 supports this: the p-values for the relation between 12-month momentum and the difference in returns for the equal- and value-weighted portfolios, EW−VW, are not significant. However, the relation between 12-month momentum and the difference in returns of the equal- and price-weighted portfolios is monotonically increasing; Table 3 shows that the null of a monotonically increasing relation of EW−PW with 12-month momentum is rejected: the p-values for both the test of neighboring pairs and the test of all pairs are 0.01.

Figure 5 shows the difference in returns of the equal- and value-weighted and also the equal- and price-weighted decile portfolios that are sorted on the basis of the reversal characteristic. This figure shows that the relation between the “reversal” characteristic and the performance of the equal-weighted portfolio relative to the value- and price-weighted portfolios is also not monotonic, and Table 3 confirms this: none of the p-values for reversal are significant. However, the equal-weighted portfolio strongly outperforms the other two portfolio rules for the deciles with the lowest and the highest reversal characteristic; this observation will guide our investigation in Section 5.2 into the source of the excess alpha earned by the equal-weighted portfolio relative to the value- and price- weighted portfolios.

Figure 6 shows the difference in returns of the equal- and value-weighted and also the equal- and price-weighted decile portfolios that are sorted on the basis of price. From this figure, we see that the “price” characteristic has a strongly decreasing relation to the performance of equal-weighted portfolio relative to both the value- and price-weighted portfolios. Table 3 shows that we can reject the null of an increasing relation between the price characteristic and EW$-$VW and also EW$-$PW: the p-values are 0.0 for the test of neighboring pairs and also the test of all pairs.

Figure 7 shows the difference in returns of the equal- and value-weighted and also the equal- and price-weighted decile portfolios that are sorted on the basis of liquidity. We see from this figure that the relation between “liquidity” and the return of the equal-weighted portfolio relative to the value-weighted portfolio shows a strongly decreasing pattern; not surprisingly, in Table 3 the p-values for an increasing relation between the liquidity characteristic and EW$-$VW are 0.0. Similarly, the figure shows evidence of a monotonically decreasing relation between liquidity and the return on the price-weighted portfolio relative to the equal-weighted portfolio; the p-values in Table 3 for an increasing relation between liquidity and EW$-$PW are 0.0. However, in Section 6.3 when we correct returns for microstructure effects and liquidity differences across stocks as suggested in Asparouhova, Bessembinder, and Kalcheva (2010, 2012), we find that the monotonicity relation in Figure 9 disappears for the first three deciles and the monotonicity-relation tests, the p-values for which are reported in Table 10, are no longer significant.

Figure 8 shows the difference in returns of the equal- and value-weighted and also the equal- and price-weighted decile portfolios that are sorted on the basis of idiosyncratic volatility. This figure shows that idiosyncratic volatility has an increasing relation to the differences between the performance of the equal-weighted portfolio relative to the value- and price-weighted portfolios: the higher the idiosyncratic volatility of the assets in the portfolio, the higher is the return on the equal-weighted portfolio compared to that of the value- and price-weighted portfolios. Table 3 confirms this: the p-values for the hypothesis of a monotonically decreasing relation between idiosyncratic volatility and EW−VW and also EW−PW are 0.0 for the test of neighboring pairs and the test of all pairs.

In summary, Figures 1–8 and Table 3 show that the difference in returns of the equal- and value-weighted portfolios has a monotonically decreasing relation with size and price and a monotonically increasing relation with book-to-market and idiosyncratic volatility. These figures and table also indicate that the difference between the returns of the equal- and price-weighted portfolios has a monotonically decreasing relation with size, price, and 12-month momentum, and a monotonically increasing relation with idiosyncratic volatility.

5 Explaining Excess Return of Equal-Weighted Portfolio

In the section above, we have used a nonparametric approach to identify which characteristics of stocks could be driving differences in the *total return* of the equal-weighted portfolio relative to the value- and price-weighted portfolios. In Section 5.1, we use the standard four-factor model to decompose the total return into *systematic return*, which is compensation for bearing factor risk, and *alpha*. We then identify the difference in exposure to the four factors that are responsible for differences in the systematic returns of the equal-, value-, and price-weighted portfolios. Section 5.2 is devoted to understanding the source of the differences in alpha.

5.1 Explaining Excess Systematic Return of Equal-Weighted Portfolio

In this section, we measure the sensitivity of the returns for the equal-, value-, and price-weighted portfolios to the Fama and French (1993) and momentum (Carhart (1997)) factors. We estimate the beta parameters by regressing monthly excess portfolio returns on the excess market return, size, value, and momentum factors, and the results of this estimation are reported in Table 4. We see from this table that the R^2 for equal-, value-, and price-weighted portfolios exceed 0.93, which indicates that these four factors explain most of the variation in portfolio returns.

The systematic component of return for the equal-weighted portfolio, reported in Table 2, is 0.1144; it exceeds that of the value-weighted portfolio by 156 basis points per year, while it is similar to that of the price-weighted portfolio.[13] Annualized four-factor alpha (α_4) of the equal-weighted portfolio is 175 basis points and significant, while alphas of the value- and price-weighted portfolios are 60 and 67 basis points.[14]

To determine the source of differences in systematic returns for the equal-, value-, and price-weighted portfolios, we look at differences in exposure to the four risk factors. Exposure to the market ("mkt") factor for the equal-weighted portfolio is 1.0797; however, for the value-weighted portfolio it is 0.9890 and for the price-weighted portfolio it is 1.0311, with the difference relative to the value-weighted portfolio being statistically significant.

The exposure to the size factor ("smb") is positive for the equal-weighted portfolio (0.0955), but it is negative for the value- and price-weighted portfolios (-0.2024 and -0.0249, respectively), with the differences in exposure relative to the equal-weighted portfolio being significant; the reason for this difference is because the equal-weighted portfolio loads more on small stocks, compared to the value- and price-weighted portfolios. The beta for the value ("hml") factor for the equal-weighted portfolio is 0.3027, for the price-weighted portfolio it is only 0.1790, and for the value-weighted portfolio it is even smaller, only 0.0234. The exposures to hml of the value- and price-weighted portfolios differ significantly from the exposure of the equal-weighted portfolio, with these differences having p-values of 0.0. The higher exposure of the equal-weighted portfolio to the smb and hml factors supports the conjecture that the equal-weighted portfolio overweights small size and high value stocks.

Finally, all three portfolios have a negative exposure to the momentum factor: The exposure of the equal-weighted portfolio is -0.1379. The exposures for the value- and price-weighted portfolios are smaller in absolute magnitude: -0.0130 and -0.0063, respectively. Again, the differences in these exposures relative to the equal-weighted portfolio are significant.[15]

[13] Over our sample period, the annualized factor risk premiums are: mkt $-$ rf = 0.0494, where rf = 0.0553; smb = 0.0272; hml = 0.0496; and, umd = 0.0861.

[14] Note, that we discuss the significance of the estimated parameters, but in Table 4 we report p-values of the hypothesis that the exposure to the factors of the equal-weighted portfolio is different from the corresponding exposure of the value- and price-weighted portfolios.

[15] We also extend the four-factor model by including the reversal factor constructed by K. French and available on his web site. Over our sample period, the annualized risk premium for reversal is 0.064, and the standard deviation and the correlation of the reversal factor with the the other four factors is similar to the standard

In summary, relative to the value- and price-weighted portfolios, the equal-weighted portfolio has higher (more positive) exposure to the market, size, value and reversal factors, and a more negative exposure to the momentum factor. These differences in exposures explain the differences in the systematic component of returns of the value- and price-weighted portfolios relative to the equal-weighted portfolio.

5.2 Explaining Excess Alpha of Equal-Weighted Portfolio

In Table 4, the four-factor model shows that a substantial part of the differences in return of the equal-, value-, and price-weighted portfolios arise from differences in alpha. Of the total excess mean return earned by the equal-weighted portfolio over the value-weighted portfolio, 42% comes from the difference in alpha and 58% from the excess systematic component. On the other hand, of the total excess mean return earned by the equal-weighted portfolio relative to the price-weighted portfolio, 96% comes from the difference in alpha and only 4% from the difference in systematic return. In this section, we demonstrate that the source of this extra alpha of the equal-weighted portfolio is the "contrarian" rebalancing each month that is required to maintain equal weights, which exploits the "reversal" in stock prices that has been identified in the literature (see, for instance, Jegadeesh (1990) and Jegadeesh and Titman (1993, 2002)).

To demonstrate our claim, we consider two experiments, which are in opposite directions. In the first experiment, we reduce the frequency for rebalancing the equal-weighted portfolio from 1 month, to 6 months and then to 12 months. If our claim is correct, then as we reduce the rebalancing frequency, we should see the alpha of the equal-weighted portfolio decrease toward the level of the alpha of the value- and price-weighted portfolios, which do not entail any rebalancing.

In the second experiment, we reverse the process and artificially fix the weights of the value- and price-weighted portfolios to give them the contrarian flavor of the equal-weighted portfolio. For instance, consider the case where the rebalancing frequency is $t = 12$ months. Then each month we change the weights of the value- and price-weighted portfolios so that

deviation and correlation between market, size, value and momentum factors. We find that the exposure of the equal-weighted portfolio to the reversal factor equals 0.0292, and it is significant; the exposure of the value- and price-weighted portfolios to the reversal factor is not statistically significant. Moreover, the five-factor alpha of the equal-weighted portfolio is 0.0155, which is only 11% smaller than the four-factor alpha estimated earlier. Thus, the systematic reversal factor does not account for the entire alpha, and there is a significant unsystematic (idiosyncratic) component of total return that is earned by the equal-weighted portfolio and that is unexplained by the exposure to risk factors.

they are the same as the initial weights at $t = 0$. Only after 12 months have elapsed, do we set the weights to be the true value and price weights. Then, again for the next 12 months, we keep the weights of the value- and price-weighted portfolios constant so that they are equal to the weights for these portfolios at the 12-month date. Only after another 12 months have elapsed do we set the weights to be the true value and price-weighted weights at $t = 24$ months. We undertake this experiment for rebalancing frequencies of 6 and 12 months. If our claim is correct, then as we keep fixed the weights of the value- and price-weighted portfolios for 6 months and 12 months, the alphas of these two portfolios should *increase* toward the alpha of the equal-weighted portfolio.

The results of both experiments confirm our hypothesis that it is the monthly rebalancing of the equal-weighted portfolio that generates the alpha for this strategy. Table 5 shows that as we reduce the rebalancing frequency of the equal-weighted portfolio from the base case of 1 month to 6 months and then to 12 months, the per annum alpha of the equal-weighted portfolio drops from 175 basis points to 117 basis points and then to 80 basis points. Once the rebalancing frequency of the equal-weighted portfolio is 12 months, the difference in the alpha of the equal-weighted portfolio and that of the value- and price-weighted portfolios is no longer statistically significant (the p-value for the difference in alpha of the equal- and value-weighted portfolios is 0.96 and for the difference of the equal- and price-weighted portfolios is 0.98).

Similarly, for the second experiment we see from Table 6 that once we hold constant the weights of the value- and price-weighted portfolios for 12 months and rebalance the weights only after 12 months, the differences in alphas for the equal-weighted portfolio relative to the value- and price-weighted portfolios is statistically insignificant (with the p-values being 0.65 and 0.30).

An important insight from these experiments is that the higher alpha of the equal-weighted portfolio arises, *not* from the choice of equal weights, but from the monthly rebalancing to maintain equal weights, which is implicitly a contrarian strategy that exploits reversal that is present at the monthly frequency. Thus, alpha depends on only the rebalancing required to maintain constant weights and *not* on the choice of equal initial weights.

6 Robustness Tests

In this section, we briefly discuss some of the experiments we have undertaken to verify the robustness of our findings.

6.1 Different Number of Stocks

The results that we have reported are for portfolios with $N = 100$ stocks. In addition to considering portfolios with 100 stocks, we also consider portfolios with 30, 50, 200, and 300 stocks (again, with resampling over 1,000 portfolios). We find that our results are not sensitive to the number of assets in the portfolio. These results are available from the authors.

6.2 Different Stock Indexes

In addition to stocks sampled from the S&P500 for large-cap stocks, we consider also stocks from the S&P400 for mid-cap, and the S&P600 for small-cap stocks. The performance of portfolios constructed from the stocks constituents of S&P400 and S&P600 is reported in Tables 7 and 8, respectively. Comparing the performance metrics in these tables to those for the stocks constituents of S&P500, we see that the main insights for the weighting rules are similar across the three indexes. All experiments described in the paper for stocks in S&P500 are repeated using stocks in S&P400 and in S&P600; these results are available from the authors.

6.3 Bias in Computed Returns

In this section, we examine the effect on our findings of correcting returns for the potential biases that may arise from noisy prices and liquidity differences. To make this correction, we use the approaches suggested in Blume and Stambaugh (1983), Asparouhova, Bessembinder, and Kalcheva (2010, 2012), and Fisher, Weaver, and Webb (2010).

Asparouhova, Bessembinder, and Kalcheva (2012) show that for realistic assumptions about the noise parameter, the first-best method for reducing the bias in the estimated performance of the equal-weighted portfolio is to use *prior-gross-return weighting* (RW) instead of the pure equal weighting (EW):

$$w_{t,i}^{RW} = \frac{r_{t-1,i} + 1}{\sum_{i=1}^{N}(r_{t-1,i} + 1)}.$$

In this case, the value- and price-weighted portfolios are still computed using the end-of-month returns reported in CRSP.

Comparing the results in Table 9 to those in Table 2, we see that using prior-gross-return weighting instead of the standard equal-weighting reduces the total and non-systematic returns only slightly and does not change our main conclusions. For example, the total return of the equal-weighted portfolio after the correction is 0.1292 instead of the previously reported 0.1319; moreover, even with the correction, the equal-weighted portfolio outperforms the value- and price-weighted portfolios at less than 1% significance level. Similarly, the systematic return of the equal-weighted portfolio after the correction is 0.1146 instead of the previously reported 0.1144; and, even with the correction, the equal-weighted portfolio outperforms value-weighted at less than 1% significance level. Finally, the four-factor alpha of the equal-weighted portfolio using the prior-gross-return weighting to construct the equal-weighted portfolio is 1.46% instead of the previously reported 1.75% for the equal-weighted portfolio using uncorrected returns; the p-value of the difference with the alpha for the value-weighted portfolio is now 6%, instead of the earlier p-value of 2%, and for the difference with the alpha of the price-weighted portfolio the p-value is still smaller than 1%.

Thus, we conclude from Table 9 that using prior-gross-return weighting instead of pure equal weighting does not alter the main conclusions of our analysis: (i) the outperformance of the equal-weighted portfolio relative to value- and price-weighted portfolios is monotonically related to the average value of various characteristics of the stocks in each portfolio; (ii) part of the outperformance across the three weighting schemes arises from differences in systematic risk, which stems from a difference in exposure to common factors; and, (iii) the non-systematic outperformance measured by differences in alphas is a result of more frequent rebalancing of the equal-weighted portfolio as compared to value- and price-weighted portfolios; this result is consistent with also the monotonicity relation between equal-weighted portfolio outperformance and two characteristics related to rebalancing behavior—reversal and idiosyncratic volatility.[16]

[16] We also correct returns using the prior n-period gross return instead of the one-period gross return, as suggested in Asparouhova, Bessembinder, and Kalcheva (2012). In addition to the case of $n = 1$ considered above, we consider also the cases where $n = 2$ and $n = 3$. We find that our main results are robust to these corrections. Specifically, the total return, one-factor alpha, and the Sharpe ratio for the equal-weighted portfolio decrease with n, but the p-values for the differences of these metrics for the value-weighted portfolio are still equal to zero, even for the case of $n = 3$. The systematic return for the equal-weighted portfolio increases slightly with n. The only finding that changes as we adjust n is that the point estimate of the 4-factor alpha of the equal-weighted portfolio declines to 0.0104 for $n = 2$ and to 0.0086 for $n = 3$, which is still higher than the alpha of 0.0060 for the value-weighted portfolio, but the difference is no longer statistically significant. Note that using $n = 6$ and $n = 12$ would be similar to the experiments we conducted in Section 5.2 where we rebalance

Table 10 presents the results of the Patton and Timmermann (2010) monotonicity tests when the returns of the equal-weighted portfolio are constructed using prior-gross-return weighting. Comparing the statistics in Table 10 those reported in Table 3, we see that the results are almost unchanged, with one exception: for the liquidity characteristic, we now fail to reject both increasing and decreasing relations between liquidity of the stocks and the outperformance of equal-weighted portfolio compared to value- and price-weighted portfolios. This is consistent with the insight in Asparouhova, Bessembinder, and Kalcheva (2010). Figure 9 supports this finding and shows that it is because the outperformance of the equal-weighted portfolio in the first three deciles with low liquidity stocks becomes smaller and non-monotone after we correct for the (liquidity) bias.[17]

There are three additional methods that one can use to correct from the potential bias arising from microstructure effects. Each of these methods requires additional information – either about bid-ask prices, or about trading volume. The first additional method is to correct the end-of-month returns for the bid-ask bias by computing returns as follows:

$$r_{t,i} = \tilde{r}_{t,i} - \left(\frac{ask_{t-1,i} - bid_{t-1,i}}{ask_{t-1,i} + bid_{t-1,i}} \right)^2 ,$$

where $\tilde{r}_{t,i}$ is the "noisy" closing return reported in CRSP for time t and stock i, and $r_{t,i}$ is the return after correction. The second additional approach for correcting returns for microstructure effects is to use the midpoint of the closing bid and ask prices from CRSP. The third additional approach is to compute returns using the volume-weighted average prices (VWAP) for the last day of each month from the TAQ Database.

Note, however, that the bid- and ask-prices, and the high-frequency trading data are not available for our entire sample period, and so we implement these three additional correction measures only for the period 1995 to 2009 (180 points). In order to compare the results using the four methods for reducing the bias described above, with the results without correction for the bias, we report in Table 11 the "base-case" results which are based on the methodology adopted in our manuscript using end-of-month CRSP returns, but for the period 1995-2009. We report in Table 12 the results based on the prior-gross-return weighting for the period

the equal-weighted portfolio only every six months or twelve months, and similar also to the "buy-and-hold" strategy suggested in Blume and Stambaugh (1983) for correcting the bias arising from noisy prices.

[17]For the other stock characteristics, the figures look very similar and one can barely see the difference before and after correcting for the bias in returns, and so these figures are not included in the manuscript. They are available upon request.

1995-2009, and in Tables 13, 14, and 15 the results for the three additional correction methods described above.

We see from these tables that: (i) For all four bias-reduction methods, the equal-weighted portfolio outperforms the value- and price-weighted portfolios, and this outperformance is statistically significant for total return, systematic return, and the one- and four-factor alphas in most of the cases. (ii) The systematic return for the base case without bias correction is almost identical to the systematic return for the four cases with bias correction. (iii) We observe some variation in factor alphas among bias-correction methods, but the difference between alphas for equal-weighted and other portfolios is stable and it continues to be economically significant. (iv) The noise in prices and the shorter sample period reduce slightly the statistical significance in the difference between the four-factor alphas of the equal- and value-weighted portfolios, and the one-factor alphas of the equal- and price-weighted portfolios.

Based on the above analysis, we conclude that the bias in end-of-month returns is very small in the context of our analysis, and does not change the findings of our paper. The main reason why our results are not affected by these corrections for differences in bid-ask spreads and liquidity across stocks is because these differences are much smaller in the samples with which we are working. That is, because we are looking at only stocks in the S&P500, the heterogeneity across stocks is much smaller than it is across the entire population of stocks in the CRSP database. Moreover, the effect of the correction for differences in bid-ask spreads and liquidity across stocks is largest for small stocks.[18]

6.4 Different Economic Conditions

We also investigate whether the superior performance of the equal-weighted portfolio relative to the value- and price-weighted portfolios is sensitive to the date on which one invests in the portfolio. In particular, we examine whether the relative performance of these portfolios is different if one starts at the peak or trough of the business cycle.

[18]That the differences between the mean return of the equal-weighted portfolio and various portfolios after correction of returns are largest for the most illiquid stocks can be seen Table II of Asparouhova, Bessembinder, and Kalcheva (2012). For instance, Panel E of their table reports that the return for the least illiquid decile is 0.441 for the equal-weighted portfolio and 0.430 for the portfolio with prior-gross-return weighting; on the other hand, for the most illiquid decile, the return for the equal-weighted portfolio is 1.580, while for the portfolio with prior-gross-return weighting it is only 1.211. Note, in addition, that the sample studied in Asparouhova, Bessembinder, and Kalcheva (2012) consists of 3,762 stocks from NYSE, Amex, and Nasdaq; thus, the top decile ranked by size of their sample is very similar to the entire universe of S&P500 stocks in our sample, while the stocks in the bottom size decile of their sample are not part of our sample at all.

The NBER identifies peaks of the business cycle in March 2001 and December 2007, and a trough in November 2001. In Table 16, we report the performance of the equal-, value-, and price-weighted portfolios starting at these three dates and that are held to the end of our data period, December 2009. For all three starting dates, we find that the equal-weighted portfolio has a significantly higher total mean return. For all three starting dates, the one-factor and four-factor alphas are significantly higher for the equal-weighted portfolio relative to the value-weighted portfolios. In fact, the four-factor alpha for the equal-weighted portfolio is positive for all three starting dates, while it is negative for the value-weighted portfolio for the start dates of March 2001 and December 2007. The Sharpe ratio of the equal-weighted portfolio also exceeds that of the value- and price-weighted portfolios. For instance, if one had initiated the portfolios at the peak of March 2001, the Sharpe ratio of the equal-weighted portfolio would have been 0.2639 compared to only 0.0037 for the value-weighted portfolio; if one had started at the trough of November 2001, the Sharpe ratio of the equal-weighted portfolio would have been 0.3615 rather than the 0.1252 for the value-weighted portfolio; and, if one had started at the peak of December 2007, the Sharpe ratio of the equal-weighted portfolio would have been −0.0795 while that of the value-weighted portfolio was −0.3780, and that for the price-weighted portfolio was −0.2995. The certainty equivalent return for an investor with a risk aversion of $\gamma = 2$ is also higher for the equal-weighted portfolio relative to the value- and price-weighted portfolios. For a risk aversion of $\gamma = 5$, the equal-weighted portfolio outperforms the value-weighted portfolio but not the price-weighted portfolio; however, in both cases the difference is not statistically significant.

7 Conclusion

We compare the performance of the equal-weighted portfolio to that of the price- and value-weighted portfolios. We find that the equal-weighted portfolio outperforms the price- and value-weighted portfolios in terms average return, four-factor alpha, Sharpe ratio, and certainty-equivalent return, even though the return of the equal-weighted portfolio has higher volatility, kurtosis and turnover. Even after allowing for a transaction cost of 50 basis points, the equal-weighted portfolio has a significantly higher mean return and four-factor alpha than the value- and price-weighted portfolios.

To understand the reasons for this difference in performance, we select N stocks from a particular index and construct the equal-, value-, and price-weighted portfolios. For robustness, we consider several different values for the number of stocks in the portfolio: $N = \{30, 50, 100, 200, 300\}$. And, again for robustness, we choose stocks from three U.S. stock indices—the S&P500 for large-cap stocks, the S&P400 for mid-cap stocks, and the S&P600 for small-cap stocks. Finally, to ensure that our performance metrics are not based on just one sample of stocks, we form $1,000$ randomly chosen portfolios of a given size, and compute all performance metrics for each portfolio-weighting rule by averaging across these $1,000$ portfolios.

We first use the nonparametric test of Patton and Timmermann (2010) to investigate the presence of a monotonic relation between stock characteristics and the total return of the equal-weighted portfolio, relative to the total return of value- and price-weighted portfolios. We find that the return of the equal-weighted portfolio, in excess of the value- and price-weighted portfolios, is monotonically decreasing with size, price and liquidity, and monotonically increasing with idiosyncratic volatility. Book-to-market is monotonically related to the difference in returns of only the equal- and value-weighted portfolios, while 12-month momentum is related to the difference in returns of only the equal- and price-weighted portfolios.

Motivated by the findings from the non-parametric tests that indicate a monotonic relation between the excess returns earned by the equal-weighted portfolios relative to the value- and price-weighted portfolios and stock characteristics such as idiosyncratic volatility, we then use the standard four-factor model to decompose the total return into a systematic component and alpha. We find that the higher *systematic return* of the equal-weighted portfolio relative to the value- and price-weighted portfolios arises from its relatively higher exposure to the market, size and value factors. The higher *alpha* of the equal-weighted portfolio arises from the monthly rebalancing that is required to maintain equal weights, which is a contrarian strategy that exploits the time-series and cross-sectional properties of stock returns (see, for example, Campbell, Lo, and MacKinlay (1997, pp. 77–79)); thus, alpha depends only on the rebalancing strategy and *not* on the particular choice of initial weights.

Therefore, the answer to the question posed in the title of this manuscript is that the equal-weighted portfolio outperforms the value- and price-weighted portfolios partly because of its higher exposure to the market, size, and value risk factors, and partly because of the higher alpha of the equal-weighted portfolio, whose source is the portfolio's monthly rebalancing that takes advantage of reversal, idiosyncratic volatility, and the lead-lag characteristics of stock returns at the monthly frequency.

A Data

From February 1967 to the end of 2009 there were 1449 stocks that were part of the S&P500 index. Our time series consists of 515 months, which corresponds to 43 years. From the set of 1,449 stocks we randomly choose a sample of stocks that are constituents of the index at the time they are selected.

We work with these samples and construct portfolios of different stock numbers: $N = \{30, 50, 100, 200, 300\}$ stocks. In order to reduce the selection bias, for each portfolio with N stocks, we randomly resample to select N stocks 1,000 times and construct 1,000 portfolios. To compute the portfolio performance metrics, we compute the performance metrics for each of the 1,000 portfolios and report the performance metrics averaged across these 1,000 portfolios.

In Section 4, we study the characteristics of assets that could possibly drive the differences in the performance of the equal-, value- and price-based weighting rules. To perform the monotonicity test described in Section 4.1 for each resampled set of assets for each portfolio would be very demanding in terms of computer power and time. Therefore, for studying the portfolio of N stocks, we draw 1,000 times N assets from the population of stocks, and form 1,000 resampled portfolios of the size N. For each resampled portfolio every month, we sort the assets with respect to a particular characteristic (size, book-to-market, momentum, reversal, price, liquidity, idiosyncratic volatility) and construct a "synthetic" asset, which is the average asset over the 1,000 samples. We assign to each asset of rank $j = 1, \ldots, N$ the mean return and mean characteristic over the randomly chosen 1,000 assets with the same rank j.

We then analyze the performance of the portfolio deciles constructed from the synthetic assets. Each decile's characteristic is the time series mean of an average value of the characteristic of the assets in this decile. Annualized returns of each decile expressed in percentage are computed as the time series mean of the returns of the portfolios constructed from the assets of that decile, with three different weighting rules (equal-, value- and price-weighted), for each decile.

B Stock Characteristics

This section explains how we use CRSP and COMPUSTAT data to construct the various characteristics used in our analysis. Summary statistics for these characteristics are provided in Table 1.

B.1 Size, Book, Book-to-Market

To compute the size characteristic of the stock we multiply the stock's price (as given in CRSP) by the number of the shares outstanding (variable name in COMPUSTAT database: CSHOQ Common Shares Outstanding). To compute the book characteristic we take current assets (ACTQ Current Assets Total), subtract current liabilities (LCTQ Current Liabilities Total), subtract preferred/preference stock redeemable (PSTKRQ Preferred/Preference Stock Redeemable), and add deferred taxes and investment tax credit (TXDITCQ Deferred Taxes and Investment Tax Credit). The book-to-market characteristic is a ratio of the computed book characteristic and the market characteristic.

B.2 Momentum and Reversal

To compute three- and twelve-month momentum, we aggregate the returns over the past three months (months $t-4$ to $t-2$) and past twelve months (months $t-13$ to $t-2$). The stock's reversal characteristic is the return on the stock in the previous month.

B.3 Price and Liquidity

The price characteristic we consider is that given in CRSP. We compute the Amivest liquidity characteristic (Goyenko, Holden, and Trzcinka (2009)) as the previous month (22 working days) average of the ratio of the stock's dollar volume to the absolute value of the return.

B.4 Idiosyncratic Volatility

The typical ARCH model of Engle (1982) gives a volatility prediction at the sampling frequency of the input data. Hence, when the model is fitted to daily returns, it is not a very suitable for longer horizon forecasts that we need for a typical passive investor. Some recent papers (e.g., Fu (2009)) suggests using for this purpose the EGARCH model of Nelson (1991) fitted to monthly excess returns, but in our experiments the estimation did not lead to very stable results. To increase the stability of the estimation and the amount of data available for it, we utilize the MIDAS (Ghysels, Santa-Clara, and Valkanov (2005)) approach. It separates the volatilities into short-run and long-run components, and the latter can be used to predict the second moments at a slower frequency than the data.

For the predicted value of idiosyncratic volatility we use the long-term volatility component from the asymmetric GARCH-MIDAS model (for a detailed discussion of MIDAS models for volatility modeling see, for example, Ghysels, Santa-Clara, and Valkanov (2005); Engle, Ghysels, and Sohn (2008)) that we fit to the residual from regressing the daily stock return on the Fama and French (1993) factors.

Specifically, excess volatilities follow the ASYGARCH-MIDAS process as follows:

$$r_{k,t} = \alpha_{k,t} + \beta_{k,t}^{MKT} \times F_t^M + \beta_{k,t}^{SMB} \times F_t^{SMB} + \beta_{k,t}^{HML} \times F_t^{HML} + \varepsilon_{k,t} \tag{B1}$$

$$\varepsilon_{k,t} = \sqrt{m_{k,t} \times g_{k,t}} \xi_{k,t} \tag{B2}$$

$$g_{k,t} = (1 - \alpha_k - \kappa_k) + \alpha_k \frac{\varepsilon_{k,t}^2}{m_{k,t}} + \kappa_k \cdot g_{k,t-1} \tag{B3}$$

$$m_{k,t} = \overline{m}_k + \theta_k^+ \sum_{l=1}^{Lv} \varphi(\omega_{k,v}^+) \times RV_{k,t-l}^+ + \theta_k^- \sum_{l=1}^{Lv} \varphi(\omega_{k,v}^-) \times RV_{k,t-l}^- \tag{B4}$$

$$RV_{k,t}^+ = \frac{1}{N^+} \sum_{\tau=0}^{20} \left(r_{k,t-\tau} * 1_{r_{k,t-\tau}>0} \right)^2, \quad RV_{k,t}^- = \frac{1}{N^-} \sum_{\tau=0}^{20} \left(r_{k,t-\tau} * 1_{r_{k,t-\tau}<0} \right)^2, \tag{B5}$$

where $r_{k,t}$ is the (daily) return of asset $k = 1, 2, ..., N$, F_t^J is factor $J \in \{MKT, SMB, HML\}$, the short-run idiosyncratic volatility component $g_{k,t}$ follows a unit GARCH process, and the long-run idiosyncratic volatility component $m_{k,t}$ is the weighted sum of positive ($RV_{k,t}^+$) and negative ($RV_{k,t}^-$) mean-squared-return innovations (where N^+ and N^- are the number of positive and negative return innovations, respectively). To aggregate the past RV's, we use the Beta polynomial weighting functions $\varphi(\omega^+)$, and $\varphi(\omega^-)$ with $Lv = 126$ lags.

We fit the above model for each underlying stock at the end of each month, using three years of daily returns. We use maximum likelihood to find simultaneously factor sensitivities ($\beta_{k,t}^J$), the parameters of the short-run volatility α_k and κ_k, the parameters of the long-run volatility $\overline{m}_k$, θ_k^+, θ_k^-, and the optimal weights for the Beta weighting function ω^+ and ω^-. After estimating these parameters, we compute the predicted value of long-run idiosyncratic volatility $m_{k,t}$ and use that as the characteristic for idiosyncratic volatility.

Table 1: Summary of the Characteristics of the Data

In this table we summarize the characteristics of our data for S&P500 stocks, and also for stocks from the S&P400 and S&P600. The table reports the mean, median, and standard deviation of the following characteristics: size, book-to-market, 3-month momentum, 12-month momentum, reversal, price, liquidity, and idiosyncratic volatility.

Characteristic	S&P400			S&P500			S&P600		
	mean	median	std	mean	median	std	mean	median	std
Size	1.9668	1.6395	1.4659	8.1143	3.6323	14.9701	0.6501	0.5287	0.4917
Book-to-market	0.2745	0.1836	0.3773	0.4550	0.2646	1.4948	0.4049	0.2534	0.7032
Momentum: 3 mo	0.0318	0.0235	0.1774	0.0324	0.0253	0.1459	0.0342	0.0182	0.2290
Momentum: 12 mo	0.1095	0.0695	0.3765	0.1245	0.0953	0.3129	0.1154	0.0501	0.4855
Reversal	0.0107	0.0076	0.1036	0.0107	0.0076	0.0851	0.0109	0.0051	0.1317
Price	32.4643	28.4131	30.4060	39.2245	34.3366	27.5331	24.0431	21.2873	18.5587
Liquidity	2.9629	1.6640	6.5298	8.3305	3.6366	19.2228	1.0526	0.4885	2.6315
Idiosy. volatility	0.4232	0.3960	0.1762	0.3552	0.3276	0.1443	0.5199	0.4961	0.1965

Table 2: Performance of Equal-, Value-, and Price-Weighted Portfolios

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. All metrics are calculated using monthly returns from February 1967 to December 2009 (515 months). The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to equal weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.1319	0.1048	0.1207	0.1279	0.1041	0.1191
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Systematic Return	0.1144	0.0988	0.1140	0.1144	0.0988	0.1140
	(1.00)	(0.00)	(0.40)	(1.00)	(0.00)	(0.40)
Outperformance frequency	0.0000	0.6770	0.6418	0.0000	0.6674	0.6268
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0246	0.0028	0.0165	0.0205	0.0021	0.0150
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.02)
Four-factor alpha	0.0175	0.0060	0.0067	0.0135	0.0053	0.0052
	(1.00)	(0.02)	(0.00)	(1.00)	(0.08)	(0.00)
Turnover	0.8132	0.1431	0.3135	0.8132	0.1431	0.3135
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0041	0.0007	0.0016	0.0041	0.0007	0.0016
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to value weights	0.1867	0.0000	0.1733	0.1867	0.0000	0.1733
	(1.00)	(0.00)	(0.01)	(1.00)	(0.00)	(0.01)
Distance to price weights	0.0671	0.1733	0.0000	0.0671	0.1733	0.0000
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Volatility	0.1790	0.1583	0.1646	0.1790	0.1583	0.1646
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Skewness	-0.3266	-0.3860	-0.4996	-0.3266	-0.3860	-0.4996
	(1.00)	(0.21)	(0.00)	(1.00)	(0.21)	(0.00)
Kurtosis	5.5305	4.8372	5.3608	5.5305	4.8372	5.3608
	(1.00)	(0.00)	(0.19)	(1.00)	(0.00)	(0.19)
Max Drawdown	0.1152	0.1043	0.1075	0.1163	0.1045	0.1079
	(1.00)	(0.02)	(0.00)	(1.00)	(0.01)	(0.00)
Sharpe Ratio	0.4275	0.3126	0.3966	0.4048	0.3081	0.3871
	(1.00)	(0.00)	(0.03)	(1.00)	(0.00)	(0.13)
Sortino Ratio	0.6424	0.4534	0.5813	0.6054	0.4465	0.5663
	(1.00)	(0.00)	(0.01)	(1.00)	(0.00)	(0.06)
Treynor Ratio	0.0728	0.0526	0.0662	0.0690	0.0518	0.0646
	(1.00)	(0.00)	(0.01)	(1.00)	(0.00)	(0.05)
CEQ, $\gamma = 2$	0.0994	0.0793	0.0930	0.0953	0.0786	0.0914
	(1.00)	(0.00)	(0.01)	(1.00)	(0.00)	(0.07)
CEQ, $\gamma = 5$	0.0468	0.0389	0.0482	0.0427	0.0382	0.0466
	(1.00)	(0.13)	(0.33)	(1.00)	(0.23)	(0.10)

Table 3: Tests of Monotonicity Relations

In this table we report the p-values of the Patton and Timmermann (2010) test for a monotonic relation between a particular characteristic listed in the first column, and the difference in performance of the equal- and value-weighted portfolios (EW−VW), and the equal- and price-weighted portfolios (EW−PW). We report the p-values of the null hypothesis that difference in returns is increasing with respect to a given characteristics (first row) and also that the difference in returns is decreasing with respect to that characteristic (second row). We undertake two tests: in the first we consider only the differences of neighboring pairs of data points; in the second stronger test, we consider also the differences between all possible pairs. The analysis is based on monthly returns from February 1967 to December 2009.

Characteristic	EW−VW		EW−PW	
Null hypothesis	Neighboring pairs	All pairs	Neighboring pairs	All pairs
Size				
Monotonically increasing relation	0.00	0.00	0.00	0.00
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Book to market				
Monotonically increasing relation	1.00	1.00	1.00	1.00
Monotonically decreasing relation	0.02	0.02	0.34	0.32
Momentum: 3 month				
Monotonically increasing relation	0.94	0.98	0.74	0.69
Monotonically decreasing relation	0.99	1.00	1.00	1.00
Momentum: 12 month				
Monotonically increasing relation	0.96	0.92	0.01	0.01
Monotonically decreasing relation	0.99	1.00	1.00	1.00
Reversal				
Monotonically increasing relation	0.98	1.00	0.94	0.98
Monotonically decreasing relation	0.96	0.99	0.96	0.94
Price				
Monotonically increasing relation	0.00	0.00	0.00	0.00
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Liquidity				
Monotonically increasing relation	0.00	0.00	0.00	0.00
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Idiosyncratic volatility				
Monotonically increasing relation	1.00	1.00	1.00	1.00
Monotonically decreasing relation	0.00	0.00	0.00	0.00

Table 4: Estimation of the Four-Factor Model

In this table we report the results of estimating the 4-factor model with the three Fama and French (1993) factors and the Carhart (1997) momentum factor. We regress monthly returns of equal-, value-, and price-weighted portfolios on the constant, market excess return (*mkt*), small-minus-big (*smb*), high-minus-low(*hml*) and momentum (*umd*) factor returns. We report annualized four-factor alpha (α_4), betas corresponding to each factor along with p-value for the hypothesis that the coefficient is the same for the equal-weight portfolio and the value- and price-weight portfolios, R^2, and MSE (mean squared error) of the regressions. The analysis is based on monthly returns from February 1967 to December 2009. Over our sample period, the annualized factor means for the premia are: mkt−rf = 0.0494, with rf = 0.0553; smb = 0.0272; hml = 0.0496; and, umd = 0.0861.

Portfolio	α_4	β_{mkt}	β_{smb}	β_{hml}	β_{umd}	R^2	MSE
EW	0.0175	1.0797	0.0955	0.3027	-0.1379	0.9361	0.0002
	(1.00)	(1.00)	(1.00)	(1.00)	(1.00)	–	–
VW	0.0060	0.9890	-0.2024	0.0234	-0.0130	0.9330	0.0001
	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)	–	–
PW	0.0067	1.0311	-0.0249	0.1790	-0.0063	0.9351	0.0001
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	–	–

Table 5: Alpha As Rebalancing Frequency of Equal-Weighted Portfolio is Decreased

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. In the base case, the equal-weighted portfolio is rebalanced on a monthly frequency; in the other two cases considered, the equal-weighted portfolio is rebalanced every 6 and every 12 months. The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to value weights, distance to price weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance of the equal-weighted (EW) portfolio, the value-weighted (VW) portfolio, and the price-weighted (PW) portfolio.

Metrics (per year)	Rebalancing frequency				
	Base case: 1 month			6 month	12 month
	EW	VW	PW	EW	EW
Total Return	0.1319	0.1048	0.1206	0.1285	0.1306
	(1.00)	(0.00)	(0.00)	(0.00)	(0.21)
Systematic Return	0.1144	0.0988	0.1140	0.1168	0.1227
	(1.00)	(0.00)	(0.40)	(0.00)	(0.00)
Outperformance frequency	0.0000	0.6770	0.6419	0.6971	0.6143
	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)
One-factor alpha	0.0246	0.0028	0.0164	0.0219	0.0249
	(1.00)	(0.00)	(0.00)	(0.00)	(0.45)
Four-factor alpha	0.0175	0.0060	0.0066	0.0117	0.0080
	(1.00)	(0.02)	(0.00)	(0.00)	(0.00)
Turnover	0.8132	0.1431	0.3182	0.3810	0.2664
	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)
Transaction costs	0.0041	0.0007	0.0016	0.0019	0.0013
	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)
Distance to value weights	0.1867	0.0000	0.1737	0.1861	0.0664
	(1.00)	(0.00)	(0.01)	(0.00)	(0.23)
Distance to price weights	0.0675	0.1737	0.0000	0.0664	0.0663
	(1.00)	(0.00)	(0.00)	(0.00)	(0.01)
Volatility	0.1790	0.1583	0.1646	0.1761	0.1726
	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)
Skewness	-0.3266	-0.3860	-0.4990	-0.3636	-0.4868
	(1.00)	(0.21)	(0.00)	(0.02)	(0.00)
Kurtosis	5.5305	4.8372	5.3583	5.5370	5.7857
	(1.00)	(0.00)	(0.19)	(0.45)	(0.02)
Max Drawdown	0.1152	0.1043	0.1075	0.1136	0.1107
	(1.00)	(0.02)	(0.00)	(0.00)	(0.00)
Sharpe Ratio	0.4275	0.3126	0.3958	0.4148	0.4355
	(1.00)	(0.00)	(0.02)	(0.01)	(0.21)
Sortino Ratio	0.6424	0.4534	0.5801	0.6201	0.6457
	(1.00)	(0.00)	(0.01)	(0.00)	(0.43)
Treynor Ratio	0.0728	0.0526	0.0661	0.0706	0.0738
	(1.00)	(0.00)	(0.01)	(0.01)	(0.28)
CEQ, $\gamma = 2$	0.0994	0.0793	0.0929	0.0969	0.1001
	(1.00)	(0.00)	(0.01)	(0.00)	(0.35)
CEQ, $\gamma = 5$	0.0468	0.0389	0.0480	0.0458	0.0501
	(1.00)	(0.13)	(0.34)	(0.15)	(0.03)

Table 6: Alpha When Weights of Value- and Price-Weighted Portfolios Held Constant For Increasing Periods

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. In the base case, the weights of the value- and price-weighted portfolio are fixed for a month, and are revised at the end of the month. In the other two cases considered, the weights of the of the value- and price-weighted portfolios are reset each month so that they are the same as the initial weights at $t = 0$. Only after 6 months (12 months) have elapsed, do we set the weights to be the true value- and price-weighted weights. Then, again for the next 6 months (12 months), we reset the weights of the value- and price-weighted portfolios each months so that they are equal to the weights for these portfolios at the 6-month (12-month) date. Only after another 6 months (12 months) have elapsed do we set the weights to be the true value and price-weighted weights at $t = 6$ ($t = 12$) months. All metrics are calculated using monthly returns from February 1967 to December 2009. The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to value weights, distance to price weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance of the equal-weighted (EW) portfolio, the value-weighted (VW) portfolio, and the price-weighted (PW) portfolio.

Metrics (per year)	Weights fixed for						
	Base case: 1 month			6 month		12 month	
	EW	VW	PW	VW	PW	VW	PW
Total Return	0.1319	0.1048	0.1207	0.1079	0.1251	0.1082	0.1255
	(1.00)	(0.00)	(0.00)	(0.00)	(0.01)	(0.00)	(0.01)
Systematic Return	0.1144	0.0988	0.1140	0.0954	0.1112	0.0934	0.1088
	(1.00)	(0.00)	(0.80)	(0.00)	(0.02)	(0.00)	(0.00)
Outperformance frequency	0.0000	0.6770	0.6418	0.6692	0.6198	0.6682	0.6174
	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
One-factor alpha	0.0246	0.0028	0.0165	0.0056	0.0203	0.0057	0.0201
	(1.00)	(0.00)	(0.00)	(0.00)	(0.10)	(0.00)	(0.10)
Four-factor alpha	0.0175	0.0060	0.0067	0.0125	0.0139	0.0148	0.0166
	(1.00)	(0.04)	(0.00)	(0.39)	(0.26)	(0.65)	(0.75)
Turnover	0.8132	0.1431	0.3135	0.7707	0.9488	0.7624	0.9192
	(1.00)	(0.00)	(0.00)	(0.23)	(0.00)	(0.14)	(0.00)
Transaction costs	0.0041	0.0007	0.0016	0.0039	0.0047	0.0038	0.0046
	(1.00)	(0.00)	(0.00)	(0.23)	(0.00)	(0.14)	(0.00)
Distance to value weights	0.1867	0.0000	0.1733	0.0174	0.1738	0.0272	0.1732
	(1.00)	(0.00)	(0.02)	(0.00)	(0.03)	(0.00)	(0.02)
Distance to price weights	0.0671	0.1733	0.0000	0.1747	0.0167	0.1765	0.0265
	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Volatility	0.1790	0.1583	0.1646	0.1598	0.1669	0.1610	0.1688
	(1.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Skewness	-0.3266	-0.3860	-0.4996	-0.3687	-0.4763	-0.3397	-0.4413
	(1.00)	(0.43)	(0.00)	(0.58)	(0.00)	(0.83)	(0.00)
Kurtosis	5.5305	4.8372	5.3608	4.8464	5.3553	4.7626	5.2243
	(1.00)	(0.01)	(0.39)	(0.01)	(0.36)	(0.01)	(0.09)
Max Drawdown	0.1152	0.1043	0.1075	0.1042	0.1079	0.1046	0.1091
	(1.00)	(0.03)	(0.00)	(0.03)	(0.00)	(0.04)	(0.00)
Sharpe Ratio	0.4275	0.3126	0.3966	0.3292	0.4174	0.3286	0.4150
	(1.00)	(0.00)	(0.05)	(0.00)	(0.55)	(0.01)	(0.45)
Sortino Ratio	0.6424	0.4534	0.5813	0.4803	0.6155	0.4808	0.6138
	(1.00)	(0.00)	(0.02)	(0.00)	(0.33)	(0.01)	(0.28)
Treynor Ratio	0.0728	0.0526	0.0662	0.0555	0.0698	0.0556	0.0693
	(1.00)	(0.00)	(0.01)	(0.00)	(0.31)	(0.01)	(0.20)
CEQ, $\gamma = 2$	0.0994	0.0793	0.0930	0.0820	0.0966	0.0819	0.0964
	(1.00)	(0.00)	(0.01)	(0.00)	(0.35)	(0.00)	(0.27)
CEQ, $\gamma = 5$	0.0468	0.0389	0.0482	0.0408	0.0506	0.0403	0.0496
	(1.00)	(0.27)	(0.66)	(0.39)	(0.21)	(0.35)	(0.39)

Table 7: Portfolio Performance for S&P400 Constituent Stocks

In this table we report the performance metrics of the portfolios constructed from the constituents of the S&P400 index. All metrics are calculated using monthly returns from July 1991 to December 2009 (222 months). The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance value weights, distance to price weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.1334	0.1268	0.1142	0.1281	0.1246	0.1116
	(1.00)	(0.22)	(0.00)	(1.00)	(0.31)	(0.00)
Systematic Return	0.1098	0.1150	0.1126	0.1098	0.1150	0.1126
	(1.00)	(0.02)	(0.12)	(1.00)	(0.02)	(0.12)
Outperformance frequency	0.0000	0.6257	0.6731	0.0000	0.6094	0.6541
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0364	0.0298	0.0229	0.0310	0.0275	0.0203
	(1.00)	(0.20)	(0.00)	(1.00)	(0.30)	(0.01)
Four-factor alpha	0.0237	0.0118	0.0016	0.0183	0.0096	-0.0010
	(1.00)	(0.08)	(0.00)	(1.00)	(0.15)	(0.00)
Turnover	1.0764	0.4551	0.5184	1.0764	0.4551	0.5184
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0054	0.0023	0.0026	0.0054	0.0023	0.0026
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to value weights	0.0737	0.0000	0.0858	0.0737	0.0000	0.0858
	(1.00)	(0.00)	(0.43)	(1.00)	(0.00)	(0.43)
Distance to price weights	0.0752	0.0858	0.0000	0.0752	0.0858	0.0000
	(1.00)	(0.17)	(0.00)	(1.00)	(0.17)	(0.00)
Volatility	0.1807	0.1743	0.1618	0.1807	0.1743	0.1618
	(1.00)	(0.10)	(0.00)	(1.00)	(0.10)	(0.00)
Skewness	-0.4807	-0.6358	-0.7018	-0.4807	-0.6358	-0.7018
	(1.00)	(0.15)	(0.01)	(1.00)	(0.15)	(0.01)
Kurtosis	6.0077	5.5355	5.7554	6.0077	5.5355	5.7554
	(1.00)	(0.12)	(0.29)	(1.00)	(0.12)	(0.29)
Max Drawdown	0.1142	0.1118	0.1057	0.1155	0.1124	0.1063
	(1.00)	(0.23)	(0.00)	(1.00)	(0.17)	(0.00)
Sharpe Ratio	0.5444	0.5265	0.4891	0.5146	0.5134	0.4730
	(1.00)	(0.32)	(0.03)	(1.00)	(0.46)	(0.08)
Sortino Ratio	0.8195	0.7807	0.7151	0.7702	0.7594	0.6896
	(1.00)	(0.28)	(0.01)	(1.00)	(0.41)	(0.05)
Treynor Ratio	0.0961	0.0896	0.0851	0.0909	0.0874	0.0824
	(1.00)	(0.19)	(0.02)	(1.00)	(0.30)	(0.04)
CEQ, $\gamma = 2$	0.1000	0.0955	0.0872	0.0946	0.0933	0.0846
	(1.00)	(0.27)	(0.00)	(1.00)	(0.39)	(0.02)
CEQ, $\gamma = 5$	0.0452	0.0440	0.0429	0.0398	0.0417	0.0403
	(1.00)	(0.41)	(0.35)	(1.00)	(0.41)	(0.46)

Table 8: Portfolio Performance for S&P600 Constituent Stocks

In this table we report the performance metrics of the portfolios constructed from the constituents of the S&P600 index. All metrics are calculated using monthly returns from November 1994 to December 2009 (182 months). The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to value weights, distance to price weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.1391	0.1153	0.1256	0.1325	0.1128	0.1226
	(1.00)	(0.00)	(0.04)	(1.00)	(0.01)	(0.10)
Systematic Return	0.1206	0.1238	0.1221	0.1206	0.1238	0.1221
	(1.00)	(0.12)	(0.30)	(1.00)	(0.12)	(0.30)
Outperformance frequency	0.0000	0.6533	0.6039	0.0000	0.6368	0.5893
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0421	0.0224	0.0354	0.0355	0.0199	0.0324
	(1.00)	(0.01)	(0.19)	(1.00)	(0.03)	(0.35)
Four-factor alpha	0.0185	-0.0086	0.0035	0.0119	-0.0111	0.0005
	(1.00)	(0.00)	(0.03)	(1.00)	(0.00)	(0.07)
Turnover	1.3253	0.4942	0.5969	1.3253	0.4942	0.5969
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0066	0.0025	0.0030	0.0066	0.0025	0.0030
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to value weights	0.0747	0.0000	0.0631	0.0747	0.0000	0.0631
	(1.00)	(0.00)	(0.18)	(1.00)	(0.00)	(0.18)
Distance to price weights	0.0688	0.0631	0.0000	0.0688	0.0631	0.0000
	(1.00)	(0.06)	(0.00)	(1.00)	(0.06)	(0.00)
Volatility	0.2151	0.1991	0.1922	0.2151	0.1991	0.1922
	(1.00)	(0.01)	(0.00)	(1.00)	(0.01)	(0.00)
Skewness	-0.3895	-0.5945	-0.6271	-0.3895	-0.5945	-0.6271
	(1.00)	(0.08)	(0.06)	(1.00)	(0.08)	(0.06)
Kurtosis	5.2823	4.6113	4.7212	5.2823	4.6113	4.7212
	(1.00)	(0.07)	(0.10)	(1.00)	(0.07)	(0.10)
Max Drawdown	0.1462	0.1388	0.1330	0.1479	0.1395	0.1337
	(1.00)	(0.05)	(0.00)	(1.00)	(0.03)	(0.00)
Sharpe Ratio	0.4841	0.4036	0.4719	0.4533	0.3912	0.4563
	(1.00)	(0.02)	(0.37)	(1.00)	(0.06)	(0.47)
Sortino Ratio	0.7180	0.5785	0.6829	0.6683	0.5594	0.6585
	(1.00)	(0.01)	(0.30)	(1.00)	(0.04)	(0.43)
Treynor Ratio	0.0959	0.0792	0.0937	0.0898	0.0768	0.0906
	(1.00)	(0.02)	(0.39)	(1.00)	(0.05)	(0.46)
CEQ, $\gamma = 2$	0.0917	0.0743	0.0875	0.0851	0.0718	0.0845
	(1.00)	(0.02)	(0.30)	(1.00)	(0.05)	(0.47)
CEQ, $\gamma = 5$	0.0141	0.0071	0.0249	0.0074	0.0047	0.0219
	(1.00)	(0.22)	(0.09)	(1.00)	(0.37)	(0.04)

Table 9: Portfolio Performance With Prior-Gross Return Weighting for Equal-Weighted Portfolio

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. All metrics are calculated using monthly returns from February 1967 to December 2009 (515 months). The performance of equal-weighted portfolio is computed using the prior gross-return weighting. The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to equal weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.1292	0.1048	0.1207	0.1252	0.1041	0.1191
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.01)
Systematic Return	0.1146	0.0988	0.1140	0.1146	0.0988	0.1140
	(1.00)	(0.00)	(0.36)	(1.00)	(0.00)	(0.36)
Max Outperformance	0.0000	0.0623	0.0288	0.0000	0.0608	0.0278
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Outperformance frequency	0.0000	0.5512	0.5184	0.0000	0.5455	0.5099
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Cum. Outperformance frequency	0.0000	0.6695	0.6246	0.0000	0.6601	0.6092
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0222	0.0028	0.0165	0.0182	0.0021	0.0150
	(1.00)	(0.00)	(0.01)	(1.00)	(0.00)	(0.11)
Four-factor alpha	0.0146	0.0060	0.0067	0.0106	0.0053	0.0052
	(1.00)	(0.06)	(0.00)	(1.00)	(0.17)	(0.04)
Turnover	0.7957	0.1431	0.3135	0.7957	0.1431	0.3135
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0040	0.0007	0.0016	0.0040	0.0007	0.0016
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to VW weights	0.1862	0.0000	0.1733	0.1862	0.0000	0.1733
	(1.00)	(0.00)	(0.01)	(1.00)	(0.00)	(0.01)
Distance to PW weights	0.0669	0.1733	0.0000	0.0669	0.1733	0.0000
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Volatility	0.1774	0.1583	0.1646	0.1774	0.1583	0.1646
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Skewness	-0.3322	-0.3860	-0.4996	-0.3322	-0.3860	-0.4996
	(1.00)	(0.24)	(0.00)	(1.00)	(0.24)	(0.00)
Kurtosis	5.5484	4.8372	5.3608	5.5484	4.8372	5.3608
	(1.00)	(0.00)	(0.17)	(1.00)	(0.00)	(0.17)
Max Drawdown	0.1145	0.1043	0.1075	0.1156	0.1045	0.1079
	(1.00)	(0.02)	(0.00)	(1.00)	(0.01)	(0.00)
Sharpe Ratio	0.4156	0.3126	0.3966	0.3933	0.3081	0.3871
	(1.00)	(0.00)	(0.11)	(1.00)	(0.00)	(0.35)
Sortino Ratio	0.6229	0.4534	0.5813	0.5866	0.4465	0.5663
	(1.00)	(0.00)	(0.05)	(1.00)	(0.00)	(0.22)
Treynor Ratio	0.0707	0.0526	0.0662	0.0669	0.0518	0.0646
	(1.00)	(0.00)	(0.05)	(1.00)	(0.00)	(0.20)
CEQ, $\gamma = 2$	0.0972	0.0793	0.0930	0.0932	0.0786	0.0914
	(1.00)	(0.00)	(0.05)	(1.00)	(0.00)	(0.26)
CEQ, $\gamma = 5$	0.0455	0.0389	0.0482	0.0415	0.0382	0.0466
	(1.00)	(0.17)	(0.19)	(1.00)	(0.28)	(0.04)

Table 10: Tests of Monotonicity Relations With Prior Gross-Return Weighting for Equal-Weighted Portfolio

In this table we report the p-values of the Patton and Timmermann (2010) test for a monotonic relation between a particular characteristic listed in the first column, and the difference in performance of the equal- and value-weighted portfolios (EW−VW), and the equal- and price-weighted portfolios (EW−PW). The performance of equal-weighted portfolio is computed using the prior gross-return weighting. We report the p-values of the null hypothesis that difference in returns is increasing with respect to a given characteristics (first row) and also that the difference in returns is decreasing with respect to that characteristic (second row). We undertake two tests: in the first we consider only the differences of neighboring pairs of data points; in the second stronger test, we consider also the differences between all possible pairs. The analysis is based on monthly returns from February 1967 to December 2009.

Characteristic	EW−VW		EW−PW	
Null hypothesis	Neighboring pairs	All pairs	Neighboring pairs	All pairs
Size				
Monotonically increasing relation	0.00	0.00	0.00	0.00
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Book to market				
Monotonically increasing relation	1.00	1.00	1.00	1.00
Monotonically decreasing relation	0.02	0.02	0.34	0.33
Momentum: 3 month				
Monotonically increasing relation	0.95	0.99	0.80	0.80
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Momentum: 12 month				
Monotonically increasing relation	0.97	0.94	0.01	0.01
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Reversal				
Monotonically increasing relation	0.94	1.00	0.91	0.93
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Price				
Monotonically increasing relation	0.00	0.00	0.00	0.00
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Liquidity				
Monotonically increasing relation	1.00	1.00	0.75	0.75
Monotonically decreasing relation	1.00	1.00	1.00	1.00
Idiosyncratic volatility				
Monotonically increasing relation	1.00	1.00	1.00	1.00
Monotonically decreasing relation	0.00	0.00	0.00	0.00

Table 11: Portfolio Performance Using Returns From Closing Prices Without Correction (Base Case)

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. All metrics are calculated using monthly returns from *January 1995 to December 2009* (180 points). The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to equal weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.1206	0.0949	0.1067	0.1163	0.0941	0.1050
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.01)
Systematic Return	0.0994	0.0873	0.1011	0.0994	0.0873	0.1011
	(1.00)	(0.00)	(0.18)	(1.00)	(0.00)	(0.18)
Max Outperformance	0.0000	0.0738	0.0340	0.0000	0.0722	0.0333
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Outperformance frequency	0.0000	0.5622	0.5062	0.0000	0.5573	0.4984
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Cum. Outperformance frequency	0.0000	0.6448	0.5927	0.0000	0.6361	0.5754
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0266	0.0052	0.0179	0.0222	0.0044	0.0161
	(1.00)	(0.00)	(0.04)	(1.00)	(0.01)	(0.10)
Four-factor alpha	0.0213	0.0076	0.0056	0.0169	0.0067	0.0039
	(1.00)	(0.09)	(0.00)	(1.00)	(0.15)	(0.01)
Turnover	0.8780	0.1661	0.3449	0.8780	0.1661	0.3449
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0044	0.0008	0.0017	0.0044	0.0008	0.0017
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to VW weights	0.1723	0.0000	0.1657	0.1723	0.0000	0.1657
	(1.00)	(0.00)	(0.03)	(1.00)	(0.00)	(0.03)
Distance to PW weights	0.0594	0.1657	0.0000	0.0594	0.1657	0.0000
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Volatility	0.1801	0.1617	0.1599	0.1801	0.1617	0.1599
	(1.00)	(0.04)	(0.00)	(1.00)	(0.04)	(0.00)
Skewness	-0.5680	-0.7209	-0.8771	-0.5680	-0.7209	-0.8771
	(1.00)	(0.14)	(0.00)	(1.00)	(0.14)	(0.00)
Kurtosis	5.2128	4.1825	5.3609	5.2128	4.1825	5.3609
	(1.00)	(0.01)	(0.34)	(1.00)	(0.01)	(0.34)
Max Drawdown	0.1243	0.1174	0.1118	0.1255	0.1176	0.1122
	(1.00)	(0.21)	(0.00)	(1.00)	(0.19)	(0.00)
Sharpe Ratio	0.4773	0.3741	0.4507	0.4529	0.3690	0.4399
	(1.00)	(0.02)	(0.18)	(1.00)	(0.05)	(0.32)
Sortino Ratio	0.6985	0.5251	0.6375	0.6597	0.5174	0.6210
	(1.00)	(0.01)	(0.10)	(1.00)	(0.04)	(0.19)
Treynor Ratio	0.0869	0.0660	0.0798	0.0825	0.0651	0.0779
	(1.00)	(0.01)	(0.09)	(1.00)	(0.04)	(0.19)
CEQ, $\gamma = 2$	0.0873	0.0679	0.0802	0.0829	0.0671	0.0785
	(1.00)	(0.01)	(0.07)	(1.00)	(0.02)	(0.17)
CEQ, $\gamma = 5$	0.0330	0.0244	0.0364	0.0285	0.0236	0.0347
	(1.00)	(0.25)	(0.27)	(1.00)	(0.34)	(0.13)

Table 12: Portfolio Performance With Prior Gross-Return Weighting for Equal-Weighted Portfolio (Case 1)

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. All metrics are calculated using monthly returns from *January 1995 to December 2009* (180 points). The performance of equal-weighted portfolio is computed using the prior gross-return weighting. The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to equal weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.1170	0.0949	0.1067	0.1126	0.0941	0.1050
	(1.00)	(0.00)	(0.02)	(1.00)	(0.01)	(0.05)
Systematic Return	0.0990	0.0873	0.1011	0.0990	0.0873	0.1011
	(1.00)	(0.00)	(0.12)	(1.00)	(0.00)	(0.12)
Max Outperformance	0.0000	0.0721	0.0323	0.0000	0.0706	0.0316
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Outperformance frequency	0.0000	0.5571	0.4997	0.0000	0.5516	0.4909
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Cum. Outperformance frequency	0.0000	0.6411	0.5742	0.0000	0.6323	0.5564
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0235	0.0052	0.0179	0.0191	0.0044	0.0161
	(1.00)	(0.01)	(0.11)	(1.00)	(0.04)	(0.27)
Four-factor alpha	0.0180	0.0076	0.0056	0.0136	0.0067	0.0039
	(1.00)	(0.14)	(0.01)	(1.00)	(0.24)	(0.02)
Turnover	0.8734	0.1661	0.3449	0.8734	0.1661	0.3449
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0044	0.0008	0.0017	0.0044	0.0008	0.0017
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to VW weights	0.1715	0.0000	0.1657	0.1715	0.0000	0.1657
	(1.00)	(0.00)	(0.05)	(1.00)	(0.00)	(0.05)
Distance to PW weights	0.0591	0.1657	0.0000	0.0591	0.1657	0.0000
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Volatility	0.1784	0.1617	0.1599	0.1784	0.1617	0.1599
	(1.00)	(0.07)	(0.00)	(1.00)	(0.07)	(0.00)
Skewness	-0.5292	-0.7209	-0.8771	-0.5292	-0.7209	-0.8771
	(1.00)	(0.08)	(0.00)	(1.00)	(0.08)	(0.00)
Kurtosis	5.2851	4.1825	5.3609	5.2851	4.1825	5.3609
	(1.00)	(0.01)	(0.40)	(1.00)	(0.01)	(0.40)
Max Drawdown	0.1229	0.1174	0.1118	0.1240	0.1176	0.1122
	(1.00)	(0.27)	(0.00)	(1.00)	(0.24)	(0.00)
Sharpe Ratio	0.4615	0.3741	0.4507	0.4369	0.3690	0.4399
	(1.00)	(0.04)	(0.35)	(1.00)	(0.09)	(0.47)
Sortino Ratio	0.6760	0.5251	0.6375	0.6371	0.5174	0.6210
	(1.00)	(0.03)	(0.19)	(1.00)	(0.06)	(0.35)
Treynor Ratio	0.0840	0.0660	0.0798	0.0795	0.0651	0.0779
	(1.00)	(0.03)	(0.20)	(1.00)	(0.07)	(0.36)
CEQ, $\gamma = 2$	0.0844	0.0679	0.0802	0.0800	0.0671	0.0785
	(1.00)	(0.02)	(0.18)	(1.00)	(0.06)	(0.36)
CEQ, $\gamma = 5$	0.0314	0.0244	0.0364	0.0270	0.0236	0.0347
	(1.00)	(0.28)	(0.17)	(1.00)	(0.38)	(0.06)

Table 13: Portfolio Performance Using Returns From Bid-Ask Prices (Case 2)

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. All metrics are calculated using monthly returns from *January 1995 to December 2009* (180 points). The performance of equal-weighted portfolio is computed with returns corrected for potential biases using bid-ask prices. The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to equal weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.1123	0.0920	0.1015	0.1068	0.0902	0.0983
	(1.00)	(0.00)	(0.01)	(1.00)	(0.02)	(0.04)
Systematic Return	0.0980	0.0869	0.0991	0.0980	0.0869	0.0991
	(1.00)	(0.00)	(0.28)	(1.00)	(0.00)	(0.28)
Max Outperformance	0.0000	0.0670	0.0303	0.0000	0.0653	0.0296
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Outperformance frequency	0.0000	0.5546	0.4976	0.0000	0.5486	0.4896
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Cum. Outperformance frequency	0.0000	0.6397	0.5849	0.0000	0.6303	0.5682
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0197	0.0033	0.0140	0.0141	0.0015	0.0108
	(1.00)	(0.02)	(0.11)	(1.00)	(0.07)	(0.25)
Four-factor alpha	0.0144	0.0051	0.0024	0.0088	0.0033	-0.0008
	(1.00)	(0.18)	(0.01)	(1.00)	(0.29)	(0.03)
Turnover	1.1188	0.3584	0.6312	1.1188	0.3584	0.6312
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0056	0.0018	0.0032	0.0056	0.0018	0.0032
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to VW weights	0.1723	0.0000	0.1657	0.1723	0.0000	0.1657
	(1.00)	(0.00)	(0.03)	(1.00)	(0.00)	(0.03)
Distance to PW weights	0.0594	0.1657	0.0000	0.0594	0.1657	0.0000
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Volatility	0.1762	0.1590	0.1565	0.1762	0.1590	0.1565
	(1.00)	(0.06)	(0.00)	(1.00)	(0.06)	(0.00)
Skewness	-0.5848	-0.7471	-0.9167	-0.5848	-0.7471	-0.9167
	(1.00)	(0.13)	(0.00)	(1.00)	(0.13)	(0.00)
Kurtosis	5.4796	4.2424	5.6440	5.4796	4.2424	5.6440
	(1.00)	(0.01)	(0.32)	(1.00)	(0.01)	(0.32)
Max Drawdown	0.1233	0.1169	0.1116	0.1248	0.1174	0.1124
	(1.00)	(0.24)	(0.00)	(1.00)	(0.21)	(0.00)
Sharpe Ratio	0.4406	0.3620	0.4270	0.4088	0.3506	0.4068
	(1.00)	(0.07)	(0.33)	(1.00)	(0.13)	(0.46)
Sortino Ratio	0.6397	0.5061	0.6002	0.5900	0.4892	0.5698
	(1.00)	(0.05)	(0.19)	(1.00)	(0.10)	(0.33)
Treynor Ratio	0.0804	0.0639	0.0759	0.0746	0.0619	0.0723
	(1.00)	(0.05)	(0.19)	(1.00)	(0.10)	(0.32)
CEQ, $\gamma = 2$	0.0804	0.0659	0.0760	0.0748	0.0641	0.0729
	(1.00)	(0.04)	(0.18)	(1.00)	(0.10)	(0.34)
CEQ, $\gamma = 5$	0.0282	0.0237	0.0339	0.0226	0.0219	0.0308
	(1.00)	(0.36)	(0.14)	(1.00)	(0.47)	(0.06)

Table 14: Portfolio Performance Using Returns From Mid-Point of Bid and Ask Prices (Case 3)

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. All metrics are calculated using monthly returns from *January 1995 to December 2009* (180 points). The performance of the equal-weighted portfolio is computed using the returns computed from the mid-point of closing bid and ask prices instead of closing prices. The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to equal weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.0963	0.0750	0.0867	0.0904	0.0729	0.0831
	(1.00)	(0.00)	(0.02)	(1.00)	(0.02)	(0.07)
Systematic Return	0.0990	0.0868	0.0994	0.0990	0.0868	0.0994
	(1.00)	(0.00)	(0.42)	(1.00)	(0.00)	(0.42)
Max Outperformance	0.0000	0.0666	0.0296	0.0000	0.0648	0.0289
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Outperformance frequency	0.0000	0.5569	0.5003	0.0000	0.5507	0.4922
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Cum. Outperformance frequency	0.0000	0.6458	0.5774	0.0000	0.6360	0.5615
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0039	-0.0132	-0.0004	-0.0020	-0.0153	-0.0040
	(1.00)	(0.03)	(0.20)	(1.00)	(0.08)	(0.33)
Four-factor alpha	-0.0027	-0.0118	-0.0126	-0.0086	-0.0139	-0.0163
	(1.00)	(0.21)	(0.05)	(1.00)	(0.31)	(0.09)
Turnover	1.1832	0.4199	0.7228	1.1832	0.4199	0.7228
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0059	0.0021	0.0036	0.0059	0.0021	0.0036
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to VW weights	0.1723	0.0000	0.1657	0.1723	0.0000	0.1657
	(1.00)	(0.00)	(0.03)	(1.00)	(0.00)	(0.03)
Distance to PW weights	0.0594	0.1657	0.0000	0.0594	0.1657	0.0000
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Volatility	0.1756	0.1579	0.1559	0.1756	0.1579	0.1559
	(1.00)	(0.06)	(0.00)	(1.00)	(0.06)	(0.00)
Skewness	-0.5959	-0.7426	-0.8907	-0.5959	-0.7426	-0.8907
	(1.00)	(0.17)	(0.01)	(1.00)	(0.17)	(0.01)
Kurtosis	5.4887	4.2014	5.4793	5.4887	4.2014	5.4793
	(1.00)	(0.01)	(0.43)	(1.00)	(0.01)	(0.43)
Max Drawdown	0.1268	0.1203	0.1147	0.1284	0.1209	0.1157
	(1.00)	(0.24)	(0.00)	(1.00)	(0.21)	(0.00)
Sharpe Ratio	0.3508	0.2561	0.3337	0.3171	0.2426	0.3105
	(1.00)	(0.04)	(0.30)	(1.00)	(0.08)	(0.40)
Sortino Ratio	0.5006	0.3516	0.4625	0.4497	0.3324	0.4286
	(1.00)	(0.03)	(0.21)	(1.00)	(0.07)	(0.32)
Treynor Ratio	0.0640	0.0453	0.0595	0.0579	0.0429	0.0553
	(1.00)	(0.03)	(0.22)	(1.00)	(0.06)	(0.32)
CEQ, $\gamma = 2$	0.0646	0.0492	0.0615	0.0587	0.0471	0.0579
	(1.00)	(0.04)	(0.27)	(1.00)	(0.10)	(0.42)
CEQ, $\gamma = 5$	0.0127	0.0076	0.0199	0.0067	0.0055	0.0162
	(1.00)	(0.34)	(0.10)	(1.00)	(0.47)	(0.04)

Table 15: Portfolio Performance Using Returns From Volume-Weighted Average Prices (Case 4)

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. All metrics are calculated using returns computed from value-weighted average prices for the last day of each month from the TAQ Database from *January 1995 to December 2009* (180 points). The performance of equal-weighted portfolio is computed the volume-weighted average prices (VWAP) for the last day of each month. The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to equal weights, volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs, and net of transactions costs of 50 basis points, for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Performance before transaction costs			Performance net of transaction costs		
	EW	VW	PW	EW	VW	PW
Total Return	0.1246	0.0980	0.1133	0.1202	0.0969	0.1113
	(1.00)	(0.00)	(0.01)	(1.00)	(0.00)	(0.03)
Systematic Return	0.0980	0.0857	0.1006	0.0980	0.0857	0.1006
	(1.00)	(0.00)	(0.11)	(1.00)	(0.00)	(0.11)
Max Outperformance	0.0000	0.0752	0.0338	0.0000	0.0738	0.0332
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Outperformance frequency	0.0000	0.5557	0.4997	0.0000	0.5506	0.4920
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Cum. Outperformance frequency	0.0000	0.6487	0.5762	0.0000	0.6410	0.5613
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0314	0.0094	0.0253	0.0270	0.0083	0.0232
	(1.00)	(0.00)	(0.11)	(1.00)	(0.01)	(0.22)
Four-factor alpha	0.0266	0.0123	0.0127	0.0222	0.0112	0.0107
	(1.00)	(0.08)	(0.00)	(1.00)	(0.14)	(0.01)
Turnover	0.8804	0.2170	0.4029	0.8804	0.2170	0.4029
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0044	0.0011	0.0020	0.0044	0.0011	0.0020
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to VW weights	0.1723	0.0000	0.1657	0.1723	0.0000	0.1657
	(1.00)	(0.00)	(0.03)	(1.00)	(0.00)	(0.03)
Distance to PW weights	0.0594	0.1657	0.0000	0.0594	0.1657	0.0000
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Volatility	0.1799	0.1608	0.1602	0.1799	0.1608	0.1602
	(1.00)	(0.04)	(0.00)	(1.00)	(0.04)	(0.00)
Skewness	-0.5170	-0.6959	-0.8220	-0.5170	-0.6959	-0.8220
	(1.00)	(0.10)	(0.00)	(1.00)	(0.10)	(0.00)
Kurtosis	5.1827	3.9993	5.0624	5.1827	3.9993	5.0624
	(1.00)	(0.00)	(0.38)	(1.00)	(0.00)	(0.38)
Max Drawdown	0.1221	0.1150	0.1093	0.1233	0.1153	0.1098
	(1.00)	(0.21)	(0.00)	(1.00)	(0.19)	(0.00)
Sharpe Ratio	0.4999	0.3954	0.4908	0.4754	0.3887	0.4782
	(1.00)	(0.02)	(0.38)	(1.00)	(0.05)	(0.46)
Sortino Ratio	0.7371	0.5555	0.7013	0.6977	0.5453	0.6817
	(1.00)	(0.01)	(0.22)	(1.00)	(0.03)	(0.36)
Treynor Ratio	0.0923	0.0708	0.0885	0.0877	0.0696	0.0862
	(1.00)	(0.02)	(0.24)	(1.00)	(0.04)	(0.38)
CEQ, $\gamma = 2$	0.0915	0.0713	0.0867	0.0871	0.0703	0.0847
	(1.00)	(0.00)	(0.16)	(1.00)	(0.01)	(0.31)
CEQ, $\gamma = 5$	0.0377	0.0285	0.0433	0.0333	0.0275	0.0412
	(1.00)	(0.23)	(0.16)	(1.00)	(0.31)	(0.07)

Table 16: Portfolio Performance for Different Start Dates Over the Business Cycle

In this table we report the performance metrics for portfolios constructed from the constituents of the S&P500 index. All metrics are calculated using monthly returns with *different starting dates* but all ending at December 2009. The three starting dates considered are: the peak of the business cycle in March 2001; the trough of November 2001; and, the peak of the business cycle in December 2007. The first column gives the names of the various metrics we use to measure portfolio performance on a per annum basis, which are: total mean portfolio return, systematic return for bearing factor risk (estimated from the 4-factor asset pricing model of Fama and French (1993) and Carhart (1997) using market, size, value and momentum factors), outperformance frequency of equal-weighted portfolio, one-factor alpha from the market model, four-factor alpha, turnover, transaction costs, distance to value weights, distance to price weights volatility (standard deviation) of portfolio returns, skewness, kurtosis, average value of the maximum portfolio drawdown, Sharpe ratio, Sortino ratio, Treynor ratio, certainty equivalent for an investor who has a power utility function with the relative risk aversion and coefficient $\gamma = 2$ and $\gamma = 5$. The remaining columns report the performance, before transactions costs and net of transactions costs of 50 basis points for portfolios formed using different weighting rules: EW denotes the equal-weighted portfolio, VW the value-weighted portfolio, and PW the price-weighted portfolio.

Metrics (per year)	Start of the investment period								
	Peak of March 2001			Trough of November 2001			Peak of December 2007		
	EW	VW	PW	EW	VW	PW	EW	VW	PW
Total Return	0.0754	0.0236	0.0566	0.0931	0.0417	0.0746	-0.0143	-0.0788	-0.0674
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Systematic Return	0.0318	0.0288	0.0304	0.0419	0.0366	0.0354	-0.0747	0.0178	-0.0291
	(1.00)	(0.22)	(0.24)	(1.00)	(0.15)	(0.02)	(1.00)	(0.00)	(0.01)
Outperformance frequency	0.0000	0.7380	0.6069	0.0000	0.7246	0.5928	0.0000	0.5665	0.6312
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
One-factor alpha	0.0202	-0.0316	0.0015	0.0372	-0.0136	0.0195	-0.0422	-0.1074	-0.0968
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)	(1.00)	(0.01)	(0.00)
Four-factor alpha	0.0436	-0.0052	0.0262	0.0512	0.0052	0.0392	0.0604	-0.0965	-0.0382
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.05)	(1.00)	(0.00)	(0.00)
Turnover	0.8577	0.1507	0.2474	0.8356	0.1487	0.2429	1.0596	0.1624	0.2234
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Transaction costs	0.0043	0.0008	0.0012	0.0042	0.0007	0.0012	0.0053	0.0008	0.0011
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Distance to value weights	0.1726	0.0000	0.1730	0.1713	0.0000	0.1723	0.1688	0.0000	0.1718
	(1.00)	(0.00)	(0.48)	(1.00)	(0.00)	(0.44)	(1.00)	(0.00)	(0.48)
Distance to price weights	0.0629	0.1730	0.0000	0.0640	0.1723	0.0000	0.0869	0.1718	0.0000
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Volatility	0.1977	0.1619	0.1675	0.1967	0.1598	0.1661	0.2985	0.2322	0.2558
	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)	(1.00)	(0.00)	(0.00)
Skewness	-0.4788	-0.6941	-0.9326	-0.4943	-0.8028	-1.0137	-0.2545	-0.5324	-0.6001
	(1.00)	(0.07)	(0.00)	(1.00)	(0.03)	(0.00)	(1.00)	(0.03)	(0.00)
Kurtosis	4.9714	4.2763	5.4341	5.2173	4.6696	5.8636	3.1466	2.7510	3.2251
	(1.00)	(0.09)	(0.15)	(1.00)	(0.15)	(0.11)	(1.00)	(0.10)	(0.40)
Max Drawdown	0.1445	0.1301	0.1284	0.1391	0.1242	0.1243	0.2631	0.2365	0.2502
	(1.00)	(0.08)	(0.00)	(1.00)	(0.06)	(0.00)	(1.00)	(0.13)	(0.10)
Sharpe Ratio	0.2639	0.0037	0.1993	0.3615	0.1252	0.3163	-0.0795	-0.3780	-0.2995
	(1.00)	(0.00)	(0.03)	(1.00)	(0.00)	(0.09)	(1.00)	(0.00)	(0.00)
Sortino Ratio	0.3741	0.0062	0.2676	0.5223	0.1684	0.4311	-0.1070	-0.4658	-0.3752
	(1.00)	(0.00)	(0.02)	(1.00)	(0.00)	(0.04)	(1.00)	(0.00)	(0.00)
Treynor Ratio	0.0455	0.0006	0.0342	0.0610	0.0212	0.0531	-0.0200	-0.0953	-0.0748
	(1.00)	(0.00)	(0.03)	(1.00)	(0.00)	(0.08)	(1.00)	(0.00)	(0.00)
CEQ, $\gamma = 2$	0.0353	-0.0035	0.0274	0.0535	0.0153	0.0457	-0.1033	-0.1336	-0.1343
	(1.00)	(0.00)	(0.09)	(1.00)	(0.00)	(0.09)	(1.00)	(0.14)	(0.02)
CEQ, $\gamma = 5$	-0.0301	-0.0472	-0.0214	-0.0115	-0.0278	-0.0028	-0.2459	-0.2216	-0.2448
	(1.00)	(0.17)	(0.11)	(1.00)	(0.17)	(0.11)	(1.00)	(0.26)	(0.48)

Figure 1: Size and Differences in Portfolio Performance

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within size-sorted deciles.

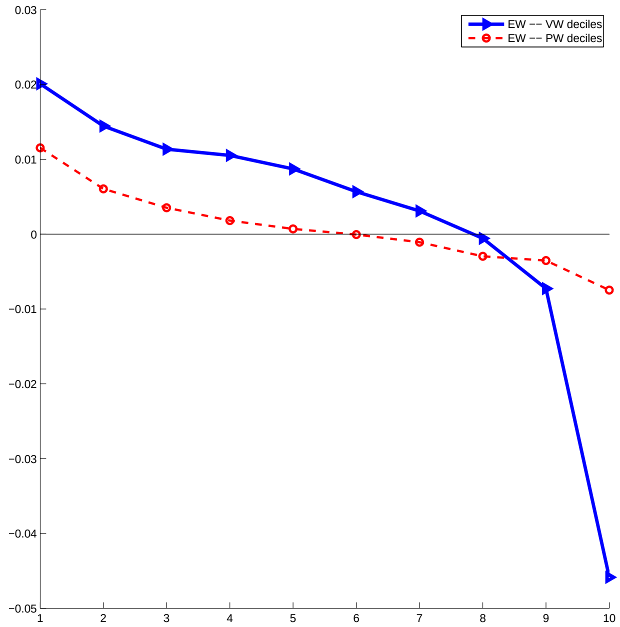


Figure 2: Book-to-Market and Differences in Portfolio Performance

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within book-to-market-sorted deciles.

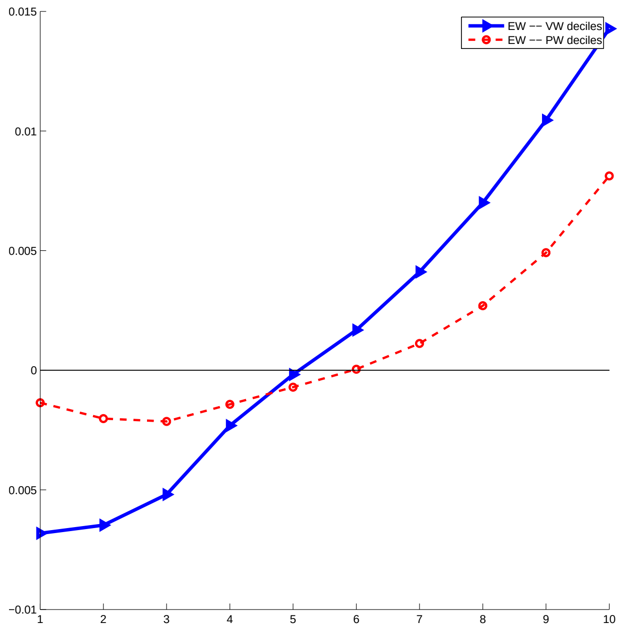


Figure 3: Three-Month Momentum and Differences in Portfolio Performance

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within deciles sorted on the basis of three-month momentum.

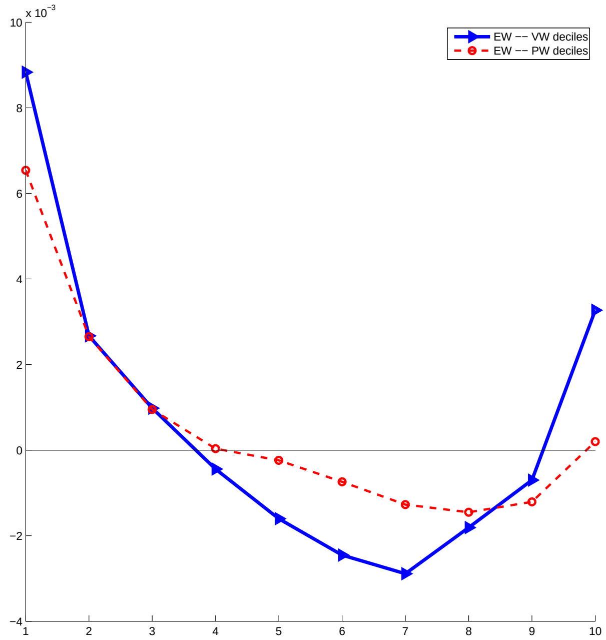


Figure 4: Twelve-Month Momentum and Differences in Portfolio Performance

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within deciles sorted on the basis of twelve-month momentum.

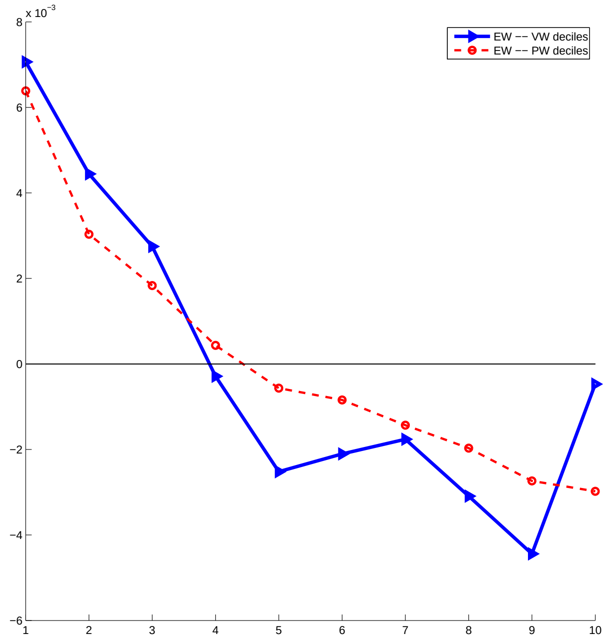


Figure 5: Reversal and Differences in Portfolio Performance

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within deciles sorted on the basis of reversal.

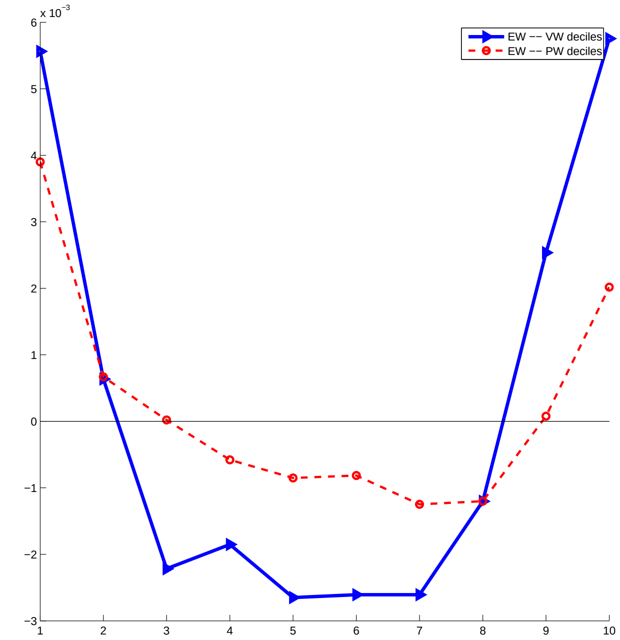


Figure 6: Price and Differences in Portfolio Performance

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within deciles sorted on the basis of price.

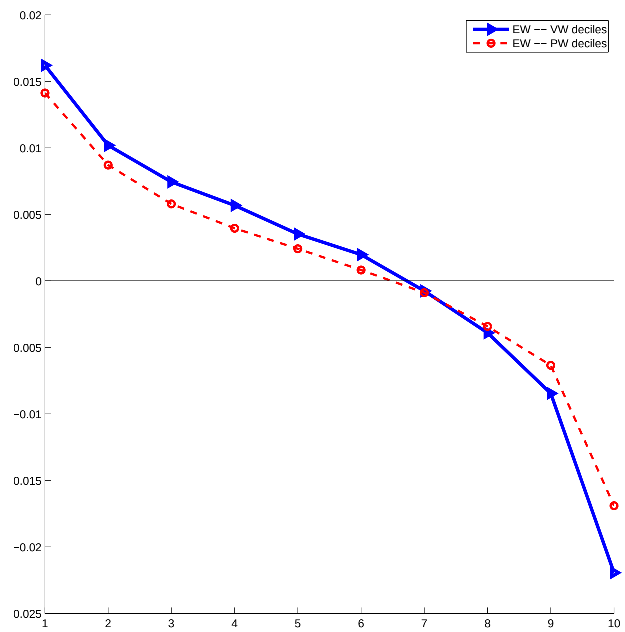


Figure 7: Liquidity and Differences in Portfolio Performance

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within deciles sorted on the basis of liquidity.

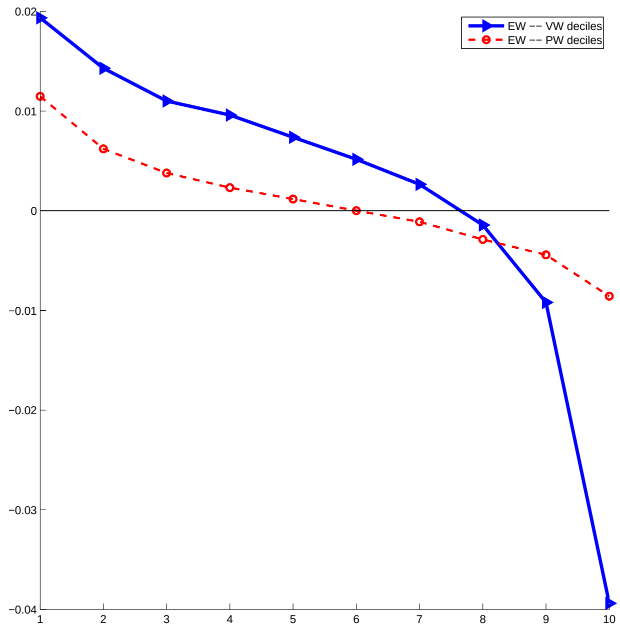


Figure 8: Idiosyncratic Volatility and Differences in Portfolio Performance

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within deciles sorted on the basis of idiosyncratic volatility.

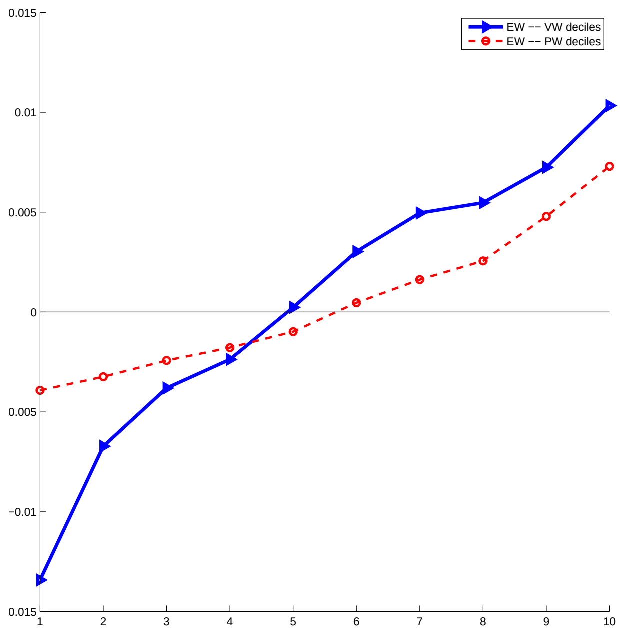
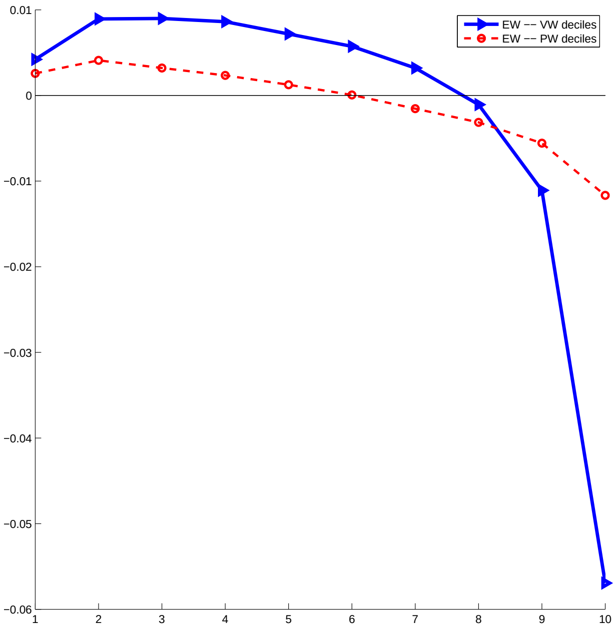


Figure 9: Liquidity and Differences in Portfolio Performance Using Prior-Gross-Return Weighting

In this figure, we plot the differences between the returns on the equal- and value-weighted portfolios (blue line with triangles) and the equal- and price-weighted portfolios (red dashed line with circles) within deciles sorted on the basis of liquidity. The returns on equal-weighted portfolios are computed using end-of-month returns with prior gross-return weighting.



References

Amenc, N., F. Goltz, L. Martellini, and P. Retkowsky, 2010, "Efficient Indexation: An Alternative to Cap-Weighted Indices," EDHEC-Risk Institute Publication.

Amihud, Y., 2002, "Illiquidity and Stock Returns: Cross-Section and Time-Series Effects," *Journal of Financial Markets*, 5, 31–56.

Asness, C. S., T. J. Moskowitz, and L. H. Pedersen, 2009, "Value and Momentum Everywhere," Working Paper.

Asparouhova, E., H. Bessembinder, and I. Kalcheva, 2010, "Liquidity biases in asset pricing tests," *Journal of Financial Economics*, 96, 215 – 237.

Asparouhova, E., H. Bessembinder, and I. Kalcheva, 2012, "Noisy Prices and Inference Regarding Returns," *Journal of Finance*.

Black, F., M. C. Jensen, and M. S. Scholes, 1972, "The Capital Asset Pricing Model: Some Empirical Tests," in Michael C. Jensen (ed.), *Studies in the Theory of Capital Markets*, Praeger Publishers Inc.

Blume, M. E., and R. F. Stambaugh, 1983, "Biases in computed returns : An application to the size effect," *Journal of Financial Economics*, 12, 387–404.

Breen, W. J., and R. A. Korajczyk, 1995, "On Selection Biases in Book-to-Market Based Test of Asset Pricing Models," Working Paper, Northwestern University.

Campbell, J. Y., A. W. Lo, and A. G. MacKinlay, 1997, *The Econometrics of Financial Markets*, Princeton University Press, Princeton, New Jersey.

Carhart, M. M., 1997, "On Persistence in Mutual Fund Performance," *Journal of Finance*, 52, 57–82.

Chevalier, J., and G. Ellison, 1997, "Risk Taking by Mutual Funds as a Response to Incentives," *Journal of Political Economy*, 105, 1167–1200.

Chow, T.-m., J. Hsu, V. Kalesnik, and B. Little, 2011, "A Survey of Alternative Equity Index Strategies," Working Paper, Texas A&M University and UCLA Anderson Business School.

Conrad, J., and G. Kaul, 1998, "An Anatomy of Trading Strategies," *Review of Financial Studies*, 11, 489–519.

Conrad, J. S., M. Cooper, and G. Kaul, 2003, "Value versus Glamour," *Journal of Finance*, 58, 1969 – 1996.

DeMiguel, V., F. J. Nogales, and R. Uppal, 2010, "Stock Return Serial Dependence and Out-of-Sample Portfolio Performance," Working Paper LBS.

Engle, R. F., 1982, "Autoregressive Conditional Heteroscadicity with Estimates of the Variance of U.K. Inflation," *Econometrica*, 50, 987–1008.

Engle, R. F., E. Ghysels, and B. Sohn, 2008, "On the Economic Sources of Stock Market Volatility," Working paper.

Fama, E. F., and K. R. French, 1993, "Common Risk Factors in the Returns on Stock and Bonds," *Journal of Financial Economics*, 33, 3–56.

Fama, E. F., and J. D. MacBeth, 1973, "Risk Return and Equilibrium: Empirical Tests," *Journal of Financial Political Economy*, 71, 607–636.

Fisher, L., D. Weaver, and G. Webb, 2010, "Removing Biases in Computed Returns," *Review of Quantitative Finance and Accounting*, 35, 137–161.

Fu, F., 2009, "Idiosyncratic Risk and the Cross-Section of Expected Stock Returns," *Journal of Financial Economics*, 91, 24–37.

Ghysels, E., P. Santa-Clara, and R. Valkanov, 2005, "There Is a Risk-Return Trade-Off After All," *Journal of Financial Economics*, 76, 509 – 548.

Gibbons, M. R., S. A. Ross, and J. Shanken, 1989, "A Test of the Efficiency of a Given Portfolio," *Econometrica*, 57, 1121–1152.

Goyenko, R. Y., C. W. Holden, and C. A. Trzcinka, 2009, "Do Liquidity Measures Measure Liquidity?," *Journal of Financial Economics*, 92, 153–181.

Greene, J. T., and D. Rakowski, 2011, "The Sources of Portfolio Returns: Underlying Stock Returns and the Excess Growth Rate," Working Paper, Southern Illinois University, Carbondale.

Haugen, R. A., and N. L. Baker, 1991, "The Efficient Market Inefficiency of Capitalization-Weighted Stock Portfolios," *Journal of Portfolio Management*, Spring, 35–40.

Jegadeesh, N., 1990, "Evidence of Predictable Behavior of Security Returns," *The Journal of Finance*, 45, pp. 881–898.

Jegadeesh, N., and S. Titman, 1993, "Returns to Buying Winners and Selling Losers: Implications for Stock Market Efficiency," *Journal of Finance*, 48, 65–91.

Jegadeesh, N., and S. Titman, 2002, "Cross-Sectional and Time-Series Determinants of Momentum Returns," *Review of Financial Studies*, 15, 143–157.

Kothari, S. P., and J. B. Warner, 2006, "Econometrics of Event Studies," in Espen B. Eckbo (ed.), *Handbook of Corporate Finance: Empirical Corporate Finance*, Elsevier/North-Holland.

Lo, A., and A. C. MacKinlay, 1990, "When Are Contrarian Profits Due to Stock Market Overreaction?," *The Review of Financial Studies*, 3, 175–205.

Miller, M. H., and M. S. Scholes, 1982, "Dividends and Taxes: Some Empirical Evidence," *Journal of Political Economy*, 90, 1118–1141.

Nelson, D. B., 1991, "Conditional Heteroskedasticity in Asset Returns: A New Approach," *Econometrica*, 59, 347–70.

Patton, A. J., and A. Timmermann, 2010, "Monotonicity in Asset Returns: New Tests with Applications to the Term Structure, the CAPM and Portfolio Sorts," *Journal of Financial Economics*, 98, 605 – 625.

Platen, E., and R. Rendek, 2010, "Simulation of Diversified Portfolios in a Continuous Financial Market," Working Paper Quantitative Finance Research Centre.

Romano, J. P., and M. Wolf, 2011, "Testing for Monotonicity in Expected Asset Returns," Working Paper.

Sharpe, W. F., 1964, "Capital Asset Prices: A Theory of Market Equilibrium under Conditions of Risk," *Journal of Finance*, 19, 425–442.