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# Essays on Alternative Weighting Schemes for Active Equity Indexes

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# ESSAYS ON ALTERNATIVE WEIGHTING SCHEMES FOR ACTIVE EQUITY INDEXES

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This dissertation is dedicated to my parents.

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**Abstract**

By definition, cap-weighted indexes place the largest (smallest) weights on the most overvalued (undervalued) securities. Fundamental indexation has recently been proposed as a passive, low-cost strategy that outperforms classical cap-weighted indexes. This dissertation focuses on new alternative weighting schemes based on fundamental indexation and analyzes underlying forces that drive their outperformance.

The first essay proposes an alternative weighting strategy based on enterprise-value multiple (EM). Over the period 1972–2013, the EM-weighted index (Details of the weighting scheme can be referred to appendix) has the lowest tracking error and the highest information ratio when compared with six fundamental-weighted indexes based on book-equity (BE), earnings (E), sales (S), dividends (D), cash-flow (CF) and EBITDA. The EM-weighted index generates an information ratio of 0.73, 35% larger than that of the composite of the fundamental indexes. Further results show that it is the combination of the market information and firm's fundamentals, especially the debt information, that drives the outperformance of the EM-weighted index.

The second essay is the first to demonstrate that outperformance of smart beta strategies can come from capturing diversification returns embedded in portfolio rebalancing of the strategies. This is different from the traditional argument that outperformance of smart beta strategies is due to their implicit tiling into different risk factors such as value and size. A 3X3 matrix of different weighting schemes is constructed to investigate this phenomenon, which combines market capitalization, equal, and fundamental weighting schemes into two levels - first it is weighted on an industry level and then weighted on a stock level within its specific industry. Results show that the diversification returns can consistently explain outperformance of alternative weighting schemes in the matrix, and it is not subsumed by factors in different asset pricing models. This suggests that when measuring the performance of smart beta strategies, not only should investors pay attention to the factor tiling of these strategies but also be cautious about diversification returns captured by rebalancing embedded in these strategie.

## Chapter 1: Combining Firms' Economic Footprint and Market Information -- A Blended Approach to Enhance Fundamental Indexation

### 1.1 Introduction

Motivated by its capacity to compare firms with different degrees of leverage, I believe this essay is the first to introduce enterprise multiple (EM) as a metric in constructing an enhanced index based on fundamental indexation (details of construction of Em-weighted index can be referred to the appendix). The premise of fundamental indexation is that it is a semi-passive strategy that presumably outperforms traditional cap-weighted indexes. Arnott et al. (2005) propose alternative weighting schemes based on firms' fundamental data including book value, cash flows, dividends, and sales. However, the proposed measures do not integrate debt information with equity values when measuring firms' fundamentals. Subsequent research also omits information on firms' debt or leverage (Walkshaul and Lobe 2009, Arya and Kaplan 2008, Basu Forbes 2013). Loughran & Wellman (2011) provide an excellent example of the merits of integrating debt into a measure of firm value. In 2005, General Motors had $287 billion in outstanding debt, compared with $17 billion in equity. This example vividly illustrates that omitting debt from measures of fundamental firm value may dramatically misestimate a firm's economic footprint. On the other hand, fundamental indexation is a look-back measurement of a firm's valuation, it does not integrate market information of future value for a firm. EM-based index proposed in this essay can integrate both debt and market information.

This essay compares the performance of the enterprise-multiple (EM) weighted scheme with traditional fundamental-index (FI) weighted schemes, with weights based on book-equity (BE), earnings (E), sales (S), dividends (D), cash-flow (CF) and EBITDA, and a composite based on fundamental weighting scheme. Over the period 1972 – 2013 the EM-weighted scheme has an information ratio of 0.73, which is 35% larger than the average of the six traditional FI's and 19% larger than that of the sales-weighted scheme (the highest of the above six traditional FI's).

Further tests show that the EM-weighted index earns positive and significant alpha using the Fama-French (1992, 1993) 3- factor model. By contrast, none of above 6 traditional FI's and a composite based on BE, S, D and CF generate significant alpha using the 3-factor model. This second result is consistent with other research (Jun and Malkiel 2008, Amenc, Goultz and Le Sourd 2009). It also shows that alphas for Fama-French (1992, 1993) 3-factor model and Carhart (1997) 4-facotr model are quite stable during 1972-2013 when using different historical average data in constructing the EM-weighted index. Alphas are around 10 basis points and 15 basis points per month, respectively, for the 3-factor model and the 4-factor model. Further research shows that a combination of debt information and market information drives the alphas of the EM-weighted scheme.

The essay is structured as follows. Section 1.2 presents a literature review and provides motivation for using the EM-weighted scheme. Section 1.3 describes the data and methodology for constructing indexes weighted by various fundamental value measures. Empirical analyzes of the performance of fundamental indexes in the US market and a breakdown of the EM-weighted scheme are presented in section 1.4. Robustness checks and conclusions follow in sections 1.5 and 1.6, respectively.

## 1.2 Literature Review and Motivation

Capitalization-weighted indexing has long been the standard for passive investing in the finance industry due to the theoretical foundation of capital asset pricing model (CAPM) (Sharpe (1964), Lintner (1965)). It is the only index that can be passively held by all investors. Another implication of the CAPM is that prices are in equilibrium, and thus efficiently priced. However, a large body of empirical evidence seems to contradict market efficiency. For example, Shiller (1981) demonstrates that stock prices are too volatile compared with their dividends, which implies that stock prices can temporarily deviate from their intrinsic values. If stock prices do not reflect intrinsic values, then a capitalization-weighted index will not be the optimal passive strategy. On the contrary, Siegel (2006) argues that a cap-weighted index will systematically overweight overvalued stocks and underweight undervalued stocks. And Treynor (2005) and Hsu (2006, 2008) demonstrate that with mispricing or noise in prices, a cap-weighted index underperforms any diversified non-price-weighted portfolio.

Arnott et al. (2005) propose alternative weighting schemes based on firms' fundamental data such as book value, cash flows, dividends, sales or employees. The basic premise is that such fundamental data represents the economic footprint of a firm, and is thus closely tied to intrinsic value. Fundamental indexes arguably are less subject to noise in market prices. Arnott et al. (2005) show that fundamental indexation outperforms the corresponding market-cap-weighted scheme by about 2% per year over 1962-2004. Further analysis shows that fundamental indexation generates significant positive Jensen's (1968) alpha and volatilities similar to or lower than that of corresponding market-cap-weighted indexes. Similar results are found in European stock markets (Hemminki and Puttonen (2008), Stotz, Wanzenried and Döhnert (2010)) and Tamura and Shimizu (2005) produce similar results for global indexes (MSCI World and FTSE Developed). Walkshaul and Lobe (2009) focus on a net payout-weighted scheme and Estrada (2008) applies a dividend-weighted scheme. Both weighting schemes above outperform their corresponding cap-weighted index on a risk-adjusted basis.

Since none of above research integrates information on debt or leverage, a critical dimension of a firm's economic footprint, EM is proposed in this essay as a metric for the weighting scheme that can capture information on both equity and debt. EM is calculated as enterprise value (EV) (equity value + debt + preferred stock - cash) divided by income before interest, taxes, depreciation and amortization (EBITDA). The introduction of this metric is motivated by its capacity to compare firms with different leverage.The choice of the EM measure is also motivated by Loughran & Wellman (2011). They demonstrate that enterprise multiple is a strong determinant of stock returns. They create an EM factor that generates a return premium of 5.28% per year in their sample, and interpret EM as a proxy for the firm's discount rate. Low EM values imply higher discount rates and higher subsequent returns than high EM values.

The EM-weighted index can be considered a blended approach that integrates both fundamental information and equity market capitalization. Two other blended approaches have been suggested in the literature. Arya and Kaplan (2006) argues that a combination of fundamentals and market capitalization has the potential to produce better results than using either method separately. This approach differs from the collared approach in Arya and

Kaplan (2006), which uses fundamental weights to set boundaries for market capitalization weights. The collared approach is intended to avoid concentrations in overvalued growth stocks when there is a bubble. This approach also differs from Chen et al. (2007) who use a smoothed average of market cap weights to proxy for underlying fundamental weights.

Not surprisingly, the claim that fundamental indexes outperform a comparable market cap index has generated controversy and conflicting results. The main critique of fundamental indexation is that it is value investing in disguise. Jun and Malkiel (2008), Amenc, Goultz, Le Sourd (2009) and Blitz and Swinkels (2009) all find insignificant alpha for various fundamental indexation using the Fama-French (1992, 1993) 3-factor model. Mar, Bird, Casavecchia and Yeung (2009) find that fundamental indexing outperforms a cap-weighted index by an average of 193 basis points per year, but also tilts toward the value factor when using Fama-French-Carhart 4-factor model. On a theoretical basis, Perold (2007) argues that fundamental indexing will underperform in environments of persistent mispricing or under-reaction in stock prices. Moreover, he argues that fundamental indexing rests on the questionable premise that such simple measures provide superior information about intrinsic value than market prices. Graham (2012) notes that outperformance by fundamental indexes relies on the critical assumption that stock prices consistently revert to fair values. Further research (Chen, Dempsey, and Lajbcygier 2014, De Moor, Liu, Sercuand Vinaimont 2013) indicates that value added by fundamental indexes disappears when considering time-varying exposure to various risk factors.

By contrast, based on Berk (1995), Arnott (2005) argues that noise in prices may be a key driver of the value and size premiums (also supported by Siegel (2006)). Arnott, Hsu, Liu, and Markowitz (2014) demonstrate that a modest amount of noise in prices can create size and value effects. This is also consistent with mispricing proposed by Lakonishok, Shleifer, and Vishny (1994). Finally, Arnott, Hsu, Kalesnik and Tindall (2013) show that value and size effects can arise naturally in random or simply constructed non-price-weighted strategies. This essay does not focus on resolving the controversy surrounding fundamental indexing but contributes to the growing evidence on its efficacy.

## 1.3 Methodology and Data

### 1.3.1 Data and Index construction

Indexes in this essay are constructed via using the 1000 largest US stocks by market cap each year during January 1972 and December 2010 (before 1972 year there are less than 1000 stocks based on the standard of stock-screening used in this essay). Monthly stock prices are obtained from Center for Research on Security Prices (CRSP) database at the University of Chicago. Stock splits and stock dividends have been adjusted so that all returns and earnings are aligned on a comparable basis. The company's shares are traded on the New York Stock Exchange, American Stock Exchange, or NASDAQ. This essay also uses different fundamental metrics, including book value (BE), sales (S), dividends (D), earnings (E), cash flow (CF), earnings before the deduction of interest expenses, taxes, depreciation, and amortization (EBITDA), and enterprise-multiple-based metric (EM) to construct the fundamental indexation (please refer to the appendix for more information about the construction of EM-weighted index). All accounting information is from Compustat database in Wharton Research Data Services (WRDS).

### 1.3.2 Fundamental metrics

Cash flow, sales revenue, net earnings and book value are used for constructing fundamental indexation composite. Cash flow is used to measure the short-term sustainability of a company without considering other factors such as the cost of depreciation of plant and equipment. Sales revenue is to measure the expansion of products to the markets. Compared with earnings, it is hard to manipulate and also ties to the companies' growth. Net earnings are one of the most important metrics for the companies and shareholder. Although it drives the long-term performance of a stock, it is sensitive to the business cycle and managers can easily manipulate this metric in the short term. Dividends are hard to be manipulated by managers based on Siegel's view (2006), but the dividend policy depends on the growth phase of a company. In this essay, book value is calculated as the book value of stockholders' equity, plus balance sheet deferred taxes and investment tax credit, and minus the book value of preferred stock.

This essay also introduces enterprise-multiple (EM) weighted scheme, which is based on the multiplication of market equity value and the reverse of the enterprise multiple (EM) ratio. The enterprise multiple (EM) is a valuation metric, which is calculated as enterprise value (EV) (equity value + debt + preferred stock - cash) divided by operating income before depreciation (EBITDA). Value firms usually have low EM ratios while growth firms have high EM ratios. EBITDA is a metric to measure a firm's operating cash flow. It is usually considered as a better metric to measure firm's profitability compared with net income because it is less easily manipulated. It is also very useful to use this metric to compare firm within or across different industries.

The portfolio weights at the beginning of each year were calculated by using information available at the end of each year. The company's most recent fiscal annual financial statement was used to calculate the following year's fundamental weightings. Rebalance takes place at the end of the last trading day of each year. For capitalization weighting index, market capitalization of a stock at the end of last December is used as the weighting factor, which is equal to the multiplication of closing stock prices and the number of its shares outstanding. For fundamental indexes, weights are based on fundamental metrics. Each stock in the portfolio is given a weight according to its relative size against the whole portfolio. Enterprise-multiple (EM)–weighted scheme is defined as a weighting scheme based on the multiplication of equity market value and the reverse of the enterprise multiple ratio. When the value of a fundamental metric is negative, such as negative earnings and negative cash flows, it is forced to be equal to zero for calculating weights. This implies that there are no short positions in the construction of fundamental indexes. This method is in line with Arnett (2005). Different from Arnott (2005) using the last 5-year-average annual fundamental information, the latest available fundamentals are used as the primary weighting scheme to capture a firm's updated information. Historical average metrics are also applied to check the robustness of the findings.

1.3.3 Performance evaluation

The annualized Sharpe ratio is calculated by multiplying square root of twelve to a monthly Sharpe ratio. And the monthly Sharpe ratio is equal to the average monthly excess return of a portfolio divided by the monthly standard deviation of excess returns. The information ratio is calculated as dividing excess return by tracking error, where tracking error is equal to the standard deviation of the excess returns and the excess return is calculated by subtracting the return of cap-weighted scheme from returns of fundamental-weighted scheme or EM-weighted scheme. Sortino ratio is calculated as the difference of average period return and required rate of return (three-month T-bill risk free rate) divided by the target downside deviation.

1.3.4 Measurement of risk with different asset pricing models

The one-factor CAPM model is estimated by the following time-series regressions

$$R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{mt} - R_{ft})_i + \varepsilon_{it} \qquad (1)$$

Where Rit is the return for common stock of firm i in month t. Three-month T-bill is used as a proxy for risk-free rate of return, Rft on day t. Rmt is the return on day t for the market. In the regressions, monthly excess returns of a portfolio weighted by different schemes, Rit - Rft, are regressed on monthly excess market returns, Rmt - Rft. The β1t and αi both can be derived based on the above regressions, where β1t measures the sensitivity of the average monthly excess returns to the variation of market premium and αi measures the abnormal return on this CAPM model.

Fama-French's three-factor model (1992) is also employed, with the form of:

$$R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i} SMB_t + \beta_{3i} HML_i + \varepsilon_{it} \qquad (2)$$

Where SMBt is the difference between the average monthly return on three small market-capitalization portfolios, including S/L, S/M, and S/H, and the average monthly return on three large market-capitalization portfolios, including B/L, B/M, and B/H; HMLt is the difference between the average monthly return on two high book-to-market equity portfolios, including S/H and B/H, and the average monthly return on low book-to-market equity portfolios, including S/L and B/L. The coefficients of the three risk factors, β1i, β2i, β3i, are the loadings of the monthly excess returns on these factors.

The 4-factor model (Carhart 1997) is also employed, which includes fama-french's three factors (1992) and Jegadeesh and Titman's (1993) momentum factor. The model has the form of

$$R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i} SMB_t + \beta_{3i} HML_i + \beta_{4i} UMD_i + \varepsilon_{it} \qquad (3)$$

UMDt is momentum factor based on 12-month momentum in returns, which is equal to the difference of average return on high prior 12-month return portfolios and that of the average return on low prior 12-month return portfolios (exclude month t-1). β4i is the coefficient to measure the loading of monthly excess return on momentum factor.

The data source for the above factor models is provided by the Center for Research on Security Prices (CRSP) at the University of Chicago, and also from Kenneth French's website.

**1.4 Results and Discussion**

1.4.1 Cumulative returns and weightings on different industries

Figure 1.1 shows cumulative returns for fundamental-weighted, EM-weighted and the capitalization-weighted portfolios from January of 1972 to December of 2013. Without considering the trading cost, it is obvious that the capitalization-weighted benchmark underperforms compared with all other alternative weighting schemes in the long run. If one dollar was invested at the beginning of 1972, it grows into $68.63 when using capitalization-weighted scheme, but it grows into $122.83 and $104.32, respectively, when applying sales-weighted scheme and EM-weighted scheme. FI, a composite equally weighted on sales, book equity value, cash flow and dividends, has a terminal value of $108.07. When using the capitalization-weighted scheme as a benchmark, it is intuitive to know that fundamental indexes underperform the capitalization-weighted indexes during late 90's technology /telecommunications bubble and the recent mortgage bubble around 2005-2007, where the market price can

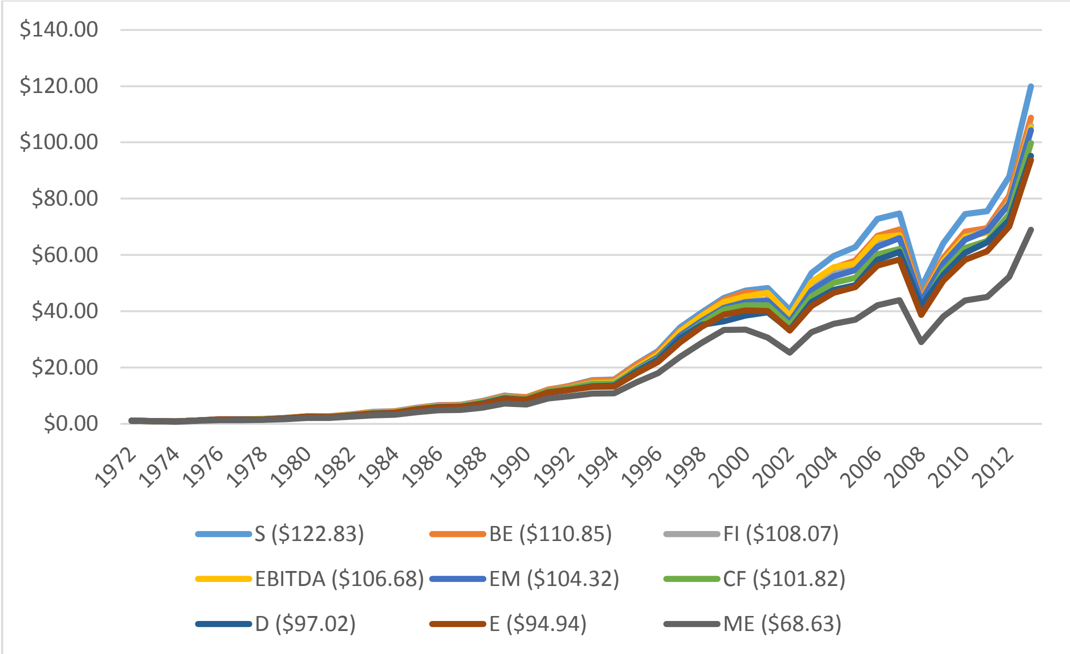
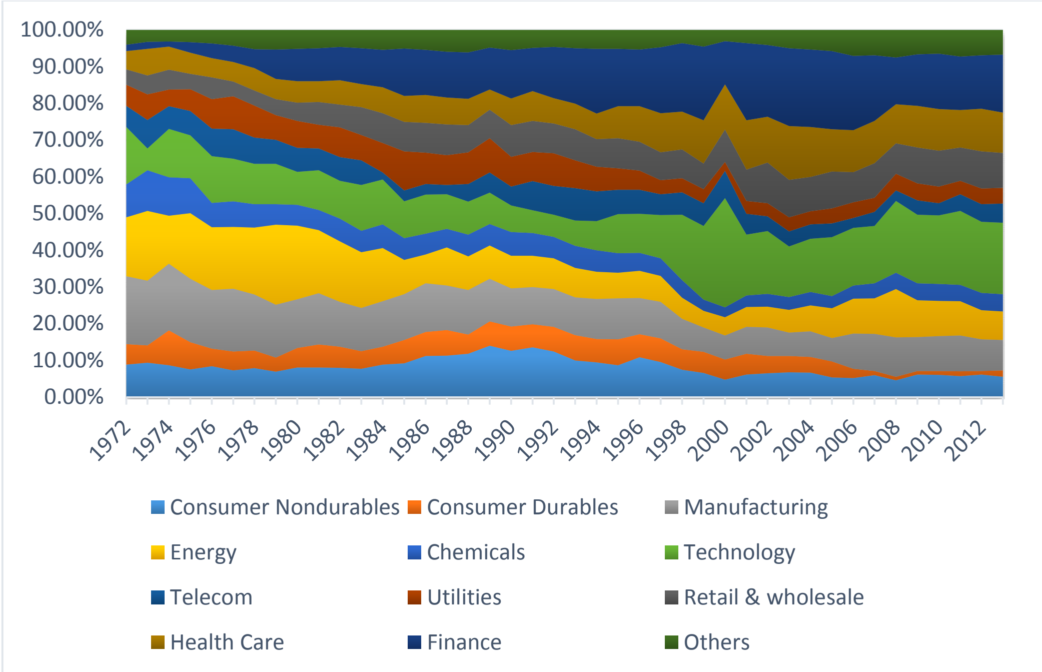



Figure 1.1 Cumulative returns of fundamental Weighting schemes compared with capitalization-weighted index during 1972–2013.

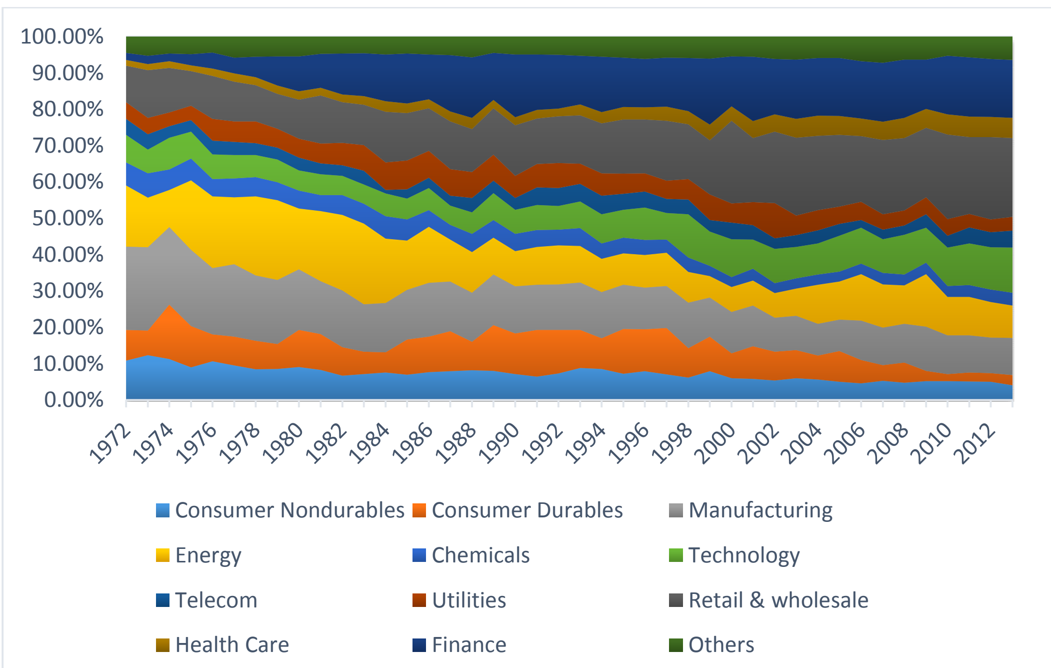
The capitalization-weighted benchmark is based on the 1000 largest US stocks. All weighting schemes are rebalanced on the last trading day of the year. ME is for the weighting scheme based on market value; BE is for the weighting scheme based on book value; E is for the weighting scheme based on earnings; S is for the weighting scheme based on sales; D is for the weighting scheme based on dividends; CF is for the weighting scheme based on cash flows; EBITDA is the weighting scheme based on EBITDA; EM is the weighting scheme based on enterprise multiple; FI is a composite fundamental weighting scheme equally based on four different financial metrics, including S, BE, CF, and D.

deviate far away from its fundamentals. The pattern of the cumulative returns is consistent with those from Arnott et al. (2005), although it does not use exactly the same time period.

Figure 1.2 provides information of industry weightings based on capitalization-weighted, sales-weighted and EM-weighted schemes. Compared with B in Figure 1.2, which applies sales weighing scheme, A in Figure 1.2 shows that there is a sharp increase of weightings on Technology in the late 90s when using the capitalization weighting scheme. C in Figure 1.2 shows that capitalization-weighted scheme put more weightings on technology industry, such as computers, software, and electronic equipment, and more on healthcare industries, such as medical equipment and drugs, when comparing with sales-weighted strategy. On the contrary, sales-weighted scheme weights more on industries of retail & wholesale, manufacturing (not shown in the Figure 1.2) and energy. During tech bubble in 2000, capitalization-weighted index concentrates 19.42% more on Tech industry including



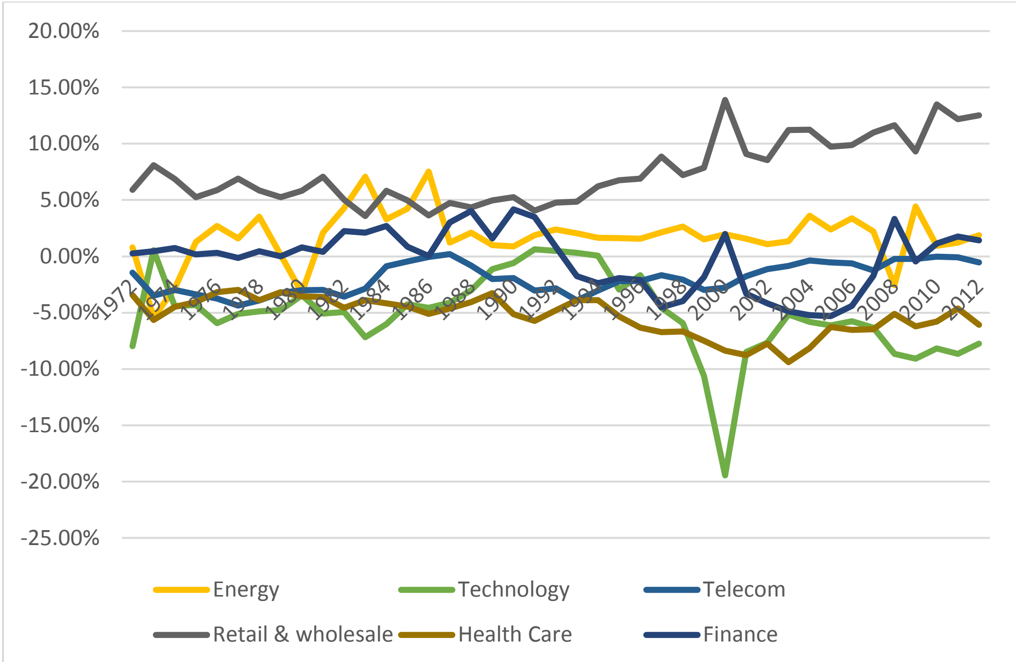

A. Industry weightings based on capitalization-weighted scheme



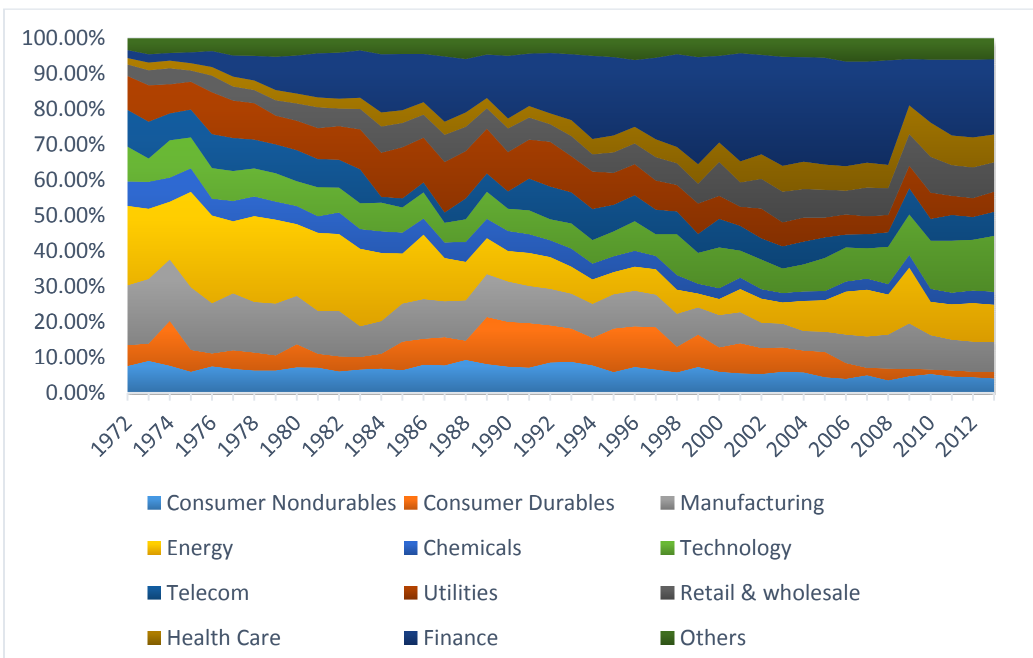

B. Industry weightings based on sales-weighted scheme

Figure 1.2 Industry weightings based on capitalization-weighted scheme, sales-weighted scheme, and EM-weighted scheme. The portfolio is divided into twelve industries based on Kenneth French's Website.

(Figure 1.2 continued)

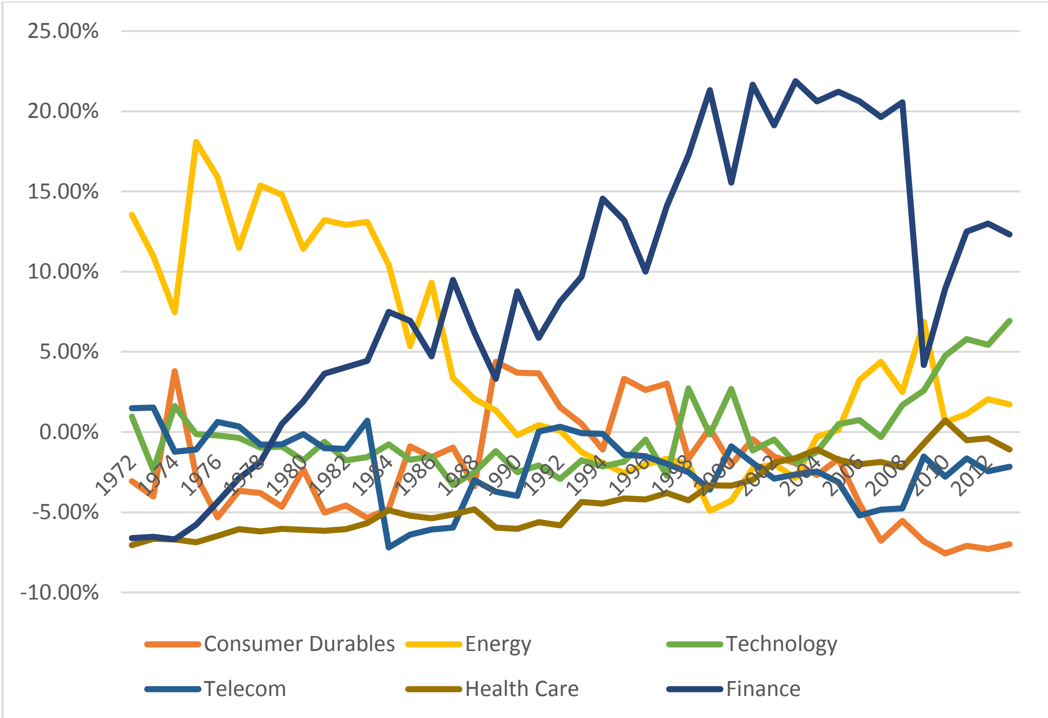



C. The difference of selected industry weightings between sales-weighted scheme and capitalization-weighted scheme, i.e. industry weights of sales-weighted index minus industry weights of capitalization-weighted index

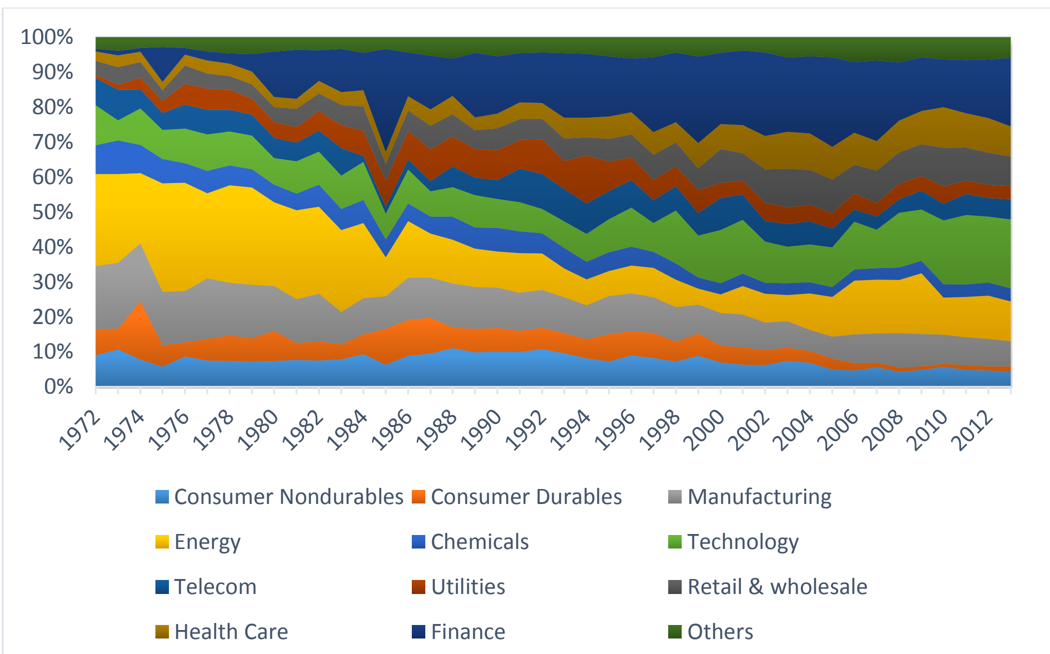



D. Industry weightings based on EBITDA-weighted scheme

(Figure 1.2 continued)

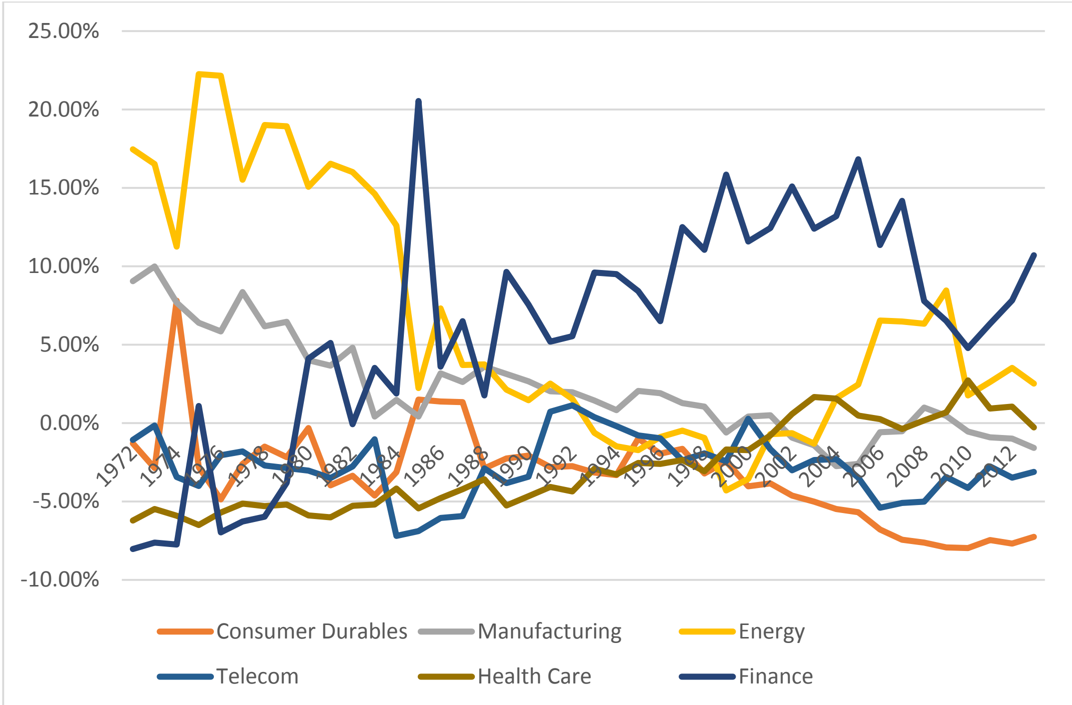



E. The difference of selected industry weightings between EBITDA-weighted scheme and capitalization-weighted scheme, i.e. industry weights of EBITDA-weighted index minus industry weights of capitalization-weighted index

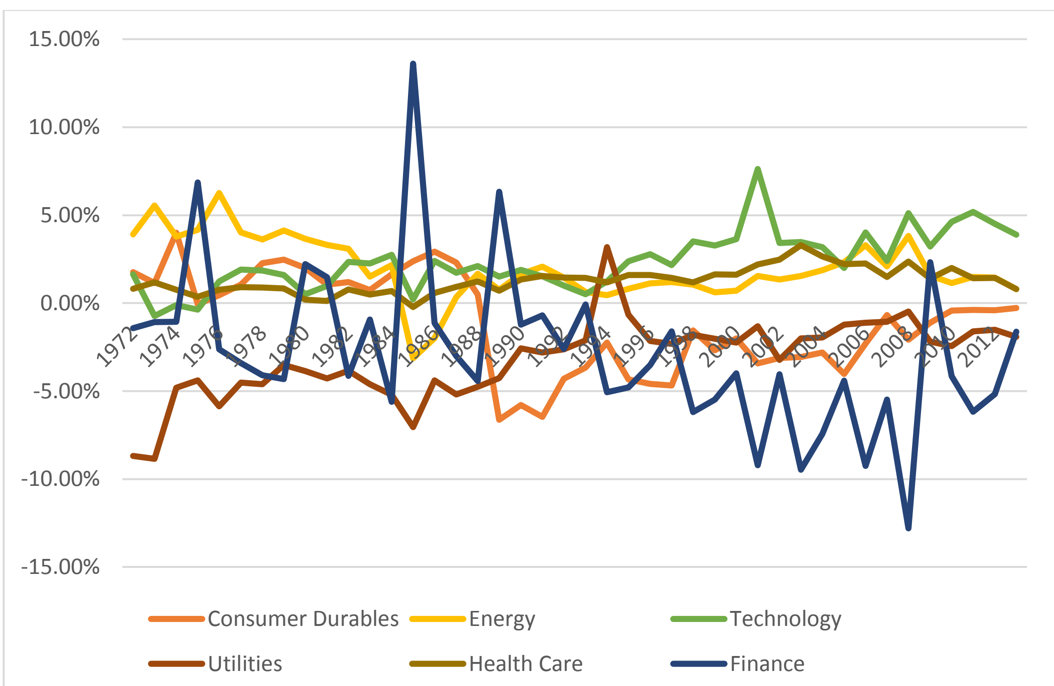



F. Industry weightings based on EM-weighted scheme

(Figure 1.2 continued)




G. The difference of selected industry weightings between EM-weighted scheme and capitalization-weighted scheme, i.e. industry weights of EM-weighted index minus industry weights of capitalization-weighted index




H. The difference of selected industry weightings between EM-weighted scheme and EBITDA-weighted scheme, i.e. industry weights of EM-weighted index minus industry weights of capitalization-weighted index computer, software and electronic equipment, while sales-weighted scheme weighs 14.82% more on the industry of Retail & Wholesale. This is consistent with results from Hsu (2014), which suggests that fundamental-weighted schemes are well diversified from an industry-concentration perspective. During 2009, the sales-weighted scheme weights 12.12% more, compared with capitalization-weighted index, on Wholesale, Retail, and Services such as Laundries & Repair Shops. On the other hand, the capitalization-weighted index has an additional 5.15% weighting in the healthcare industry and extra 8.23% weighting in the industry of technology during the same period, compared with the sales-weighted scheme. D and E in Figure 1.2 indicate that EBITDA-weighted scheme overweighs Energy and Finance industries when comparing with the capitalization-weighted scheme.

F and G in Figure 1.2 show that EM-weighted scheme also overweighs Energy and Finance industries when comparing with the capitalization-weighted scheme. H in Figure 1.2 shows that compared with the EBITDA-weighted scheme, EM-weighted scheme weighs less on industries of Finance and Consumer Durables, and more on Technology. For example, it holds 5.07% more on Technology and 13.72% less on Finance in 2009, compared with the corresponding EBITDA-weighted scheme.

Table 1.1 provides information on top 20 holdings for different weighting schemes. Although sales-weighted scheme holds 3.29% on Walmart in October 2007 (Panel A in Table 1.1), which is 1.78% larger than the corresponding weighting from the capitalization-weighted scheme, EBITDA-weighted scheme only holds 1.15% on Walmart. If using EM-weighted scheme, which integrates information of debt, EBITDA and market capitalization, the weighting on Walmart based on this scheme is equal to 1.30% in October 2007. Another example is Microsoft. In March 2009 (Panel B in Table 1.1),, the cap-weighted scheme holds 2.08% on Microsoft while sales-weighted scheme holds only 0.80% (which is not in Top 20 holdings of Table 1.1) on this stock. In contrast, ME-weighted scheme holds 2.13% on Microsoft at that time.

Panel A in Table 1.2 shows that correlation coefficients between all weighting schemes, including different fundamental weighting schemes and market weighing scheme, are really high. It also shows that EM weighting

Table 1.1 Top 20 holdings for different weighting schemes.

ME is for the weighting scheme based on market value; S is for the weighting scheme based on sales; EBITDA is for the weighting scheme based on EBITDA; EM is for the weighting scheme based on enterprise multiple.

Panel A. At peak, Oct 2007.

| Weight | ME | Weight | S |
|---|---|---|---|
| 3.56% | EXXON MOBIL CORP | 4.40% | EXXON MOBIL CORP |
| 3.03% | GENERAL ELECTRIC CO | 3.29% | WAL MART STORES INC |
| 1.84% | MICROSOFT CORP | 2.61% | CHEVRON CORP NEW |
| 1.64% | BANK OF AMERICA CORP | 2.52% | GENERAL MOTORS CORP |
| 1.60% | CITIGROUP INC | 2.22% | FORD MOTOR CO DEL |
| 1.59% | PROCTER & GAMBLE CO | 2.20% | CONOCOPHILLIPS |
| 1.51% | WAL MART STORES INC | 1.84% | GENERAL ELECTRIC CO |
| 1.40% | JOHNSON & JOHNSON | 1.23% | INTERNATIONAL BUSINESS MACHS COR |
| 1.39% | CHEVRON CORP NEW | 1.19% | VALERO ENERGY CORP NEW |
| 1.30% | ALTRIA GROUP INC | 1.16% | HEWLETT PACKARD CO |
| 1.29% | PFIZER INC | 1.14% | AMERICAN INTERNATIONAL GROUP INC |
| 1.15% | AMERICAN INTERNATIONAL GROUP INC | 1.13% | MCKESSON H B O C INC |
| 1.15% | CISCO SYSTEMS INC | 1.11% | CITIGROUP INC |
| 1.15% | INTERNATIONAL BUSINESS MACHS COR | 0.99% | VERIZON COMMUNICATIONS INC |
| 1.11% | INTEL CORP | 0.98% | BERKSHIRE HATHAWAY INC DEL |
| 1.10% | JPMORGAN CHASE & CO | 0.89% | BANK OF AMERICA CORP |
| 1.05% | CONOCOPHILLIPS | 0.88% | CARDINAL HEALTH INC |
| 1.02% | A T & T INC | 0.84% | JPMORGAN CHASE & CO |
| 0.99% | BERKSHIRE HATHAWAY INC DEL | 0.83% | KROGER COMPANY |
| 0.96% | COCA COLA CO | 0.83% | PROCTER & GAMBLE CO |

(Table 1.1 continued)

| Weight | EBITDA | Weight | EM |
|---|---|---|---|
| 4.15% | EXXON MOBIL CORP | 5.86% | EXXON MOBIL CORP |
| 3.04% | GENERAL ELECTRIC CO | 2.60% | CHEVRON CORP NEW |
| 2.72% | FEDERAL NATIONAL MORTGAGE ASSN | 2.08% | CONOCOPHILLIPS |
| 2.70% | CITIGROUP INC | 1.95% | GENERAL ELECTRIC CO |
| 2.00% | CHEVRON CORP NEW | 1.90% | VERIZON COMMUNICATIONS INC |
| 1.97% | VERIZON COMMUNICATIONS INC | 1.80% | INTEL CORP |
| 1.88% | BANK OF AMERICA CORP | 1.70% | BERKSHIRE HATHAWAY INC DEL |
| 1.77% | MORGAN STANLEY DEAN WITTER & CO | 1.64% | MICROSOFT CORP |
| 1.73% | CONOCOPHILLIPS | 1.54% | PFIZER INC |
| 1.71% | GOLDMAN SACHS GROUP INC | 1.48% | CITIGROUP INC |
| 1.68% | JPMORGAN CHASE & CO | 1.46% | INTERNATIONAL BUSINESS MACHS COR |
| 1.67% | FEDERAL HOME LOAN MORTGAGE CORP | 1.44% | JPMORGAN CHASE & CO |
| 1.37% | FORD MOTOR CO DEL | 1.37% | ALTRIA GROUP INC |
| 1.32% | AMERICAN INTERNATIONAL GROUP INC | 1.30% | WAL MART STORES INC |
| 1.31% | MERRILL LYNCH & CO INC | 1.26% | JOHNSON & JOHNSON |
| 1.24% | INTEL CORP | 1.15% | PROCTER & GAMBLE CO |
| 1.19% | INTERNATIONAL BUSINESS MACHS COR | 1.13% | BANK OF AMERICA CORP |
| 1.16% | ALTRIA GROUP INC | 1.09% | AMERICAN INTERNATIONAL GROUP INC |
| 1.15% | WAL MART STORES INC | 1.00% | A T & T INC |
| 1.14% | PFIZER INC | 0.86% | CISCO SYSTEMS INC |

(Table 1.1 continued)

Panel B. At through, Mar 2009.

| Weight | ME | Weight | S |
|---|---|---|---|
| 4.13% | EXXON MOBIL CORP | 4.19% | WAL MART STORES INC |
| 2.18% | MICROSOFT CORP | 3.88% | EXXON MOBIL CORP |
| 2.03% | WAL MART STORES INC | 2.13% | CHEVRON CORP NEW |
| 1.86% | INTERNATIONAL BUSINESS MACHS COR | 1.92% | FORD MOTOR CO DEL |
| 1.75% | CHEVRON CORP NEW | 1.62% | GENERAL MOTORS CORP |
| 1.74% | A T & T INC | 1.57% | CONOCOPHILLIPS |
| 1.62% | APPLE INC | 1.37% | INTERNATIONAL BUSINESS MACHS COR |
| 1.58% | JOHNSON & JOHNSON | 1.37% | MCKESSON H B O C INC |
| 1.51% | PROCTER & GAMBLE CO | 1.32% | MORGAN STANLEY DEAN WITTER & CO |
| 1.46% | GENERAL ELECTRIC CO | 1.26% | A T & T INC |
| 1.28% | CISCO SYSTEMS INC | 1.22% | BERKSHIRE HATHAWAY INC DEL |
| 1.14% | COCA COLA CO | 1.21% | GOLDMAN SACHS GROUP INC |
| 1.11% | BERKSHIRE HATHAWAY INC DEL | 1.13% | GENERAL ELECTRIC CO |
| 1.10% | INTEL CORP | 1.09% | CARDINAL HEALTH INC |
| 1.09% | CONOCOPHILLIPS | 1.08% | VALERO ENERGY CORP NEW |
| 0.99% | ORACLE CORP | 1.07% | JPMORGAN CHASE & CO |
| 0.92% | PEPSICO INC | 1.06% | HEWLETT PACKARD CO |
| 0.91% | HEWLETT PACKARD CO | 0.92% | SPRINT NEXTEL CORP |
| 0.89% | JPMORGAN CHASE & CO | 0.89% | HOME DEPOT INC |
| 0.86% | GENENTECH INC | 0.87% | C V S CAREMARK CORP |

(Table 1.1 continued)

| Weight | EBITDA | Weight | EM |
|---|---|---|---|
| 4.95% | MORGAN STANLEY DEAN WITTER & CO | 5.65% | EXXON MOBIL CORP |
| 4.36% | GOLDMAN SACHS GROUP INC | 2.54% | CHEVRON CORP NEW |
| 3.97% | EXXON MOBIL CORP | 2.40% | A T & T INC |
| 2.34% | A T & T INC | 2.13% | MICROSOFT CORP |
| 2.20% | GENERAL ELECTRIC CO | 2.06% | BERKSHIRE HATHAWAY INC DEL |
| 1.90% | JPMORGAN CHASE & CO | 1.72% | INTERNATIONAL BUSINESS MACHS COR |
| 1.88% | CHEVRON CORP NEW | 1.69% | CONOCOPHILLIPS |
| 1.49% | CONOCOPHILLIPS | 1.66% | WAL MART STORES INC |
| 1.45% | WAL MART STORES INC | 1.38% | PFIZER INC |
| 1.45% | FEDERAL NATIONAL MORTGAGE ASSN | 1.34% | JOHNSON & JOHNSON |
| 1.44% | MICROSOFT CORP | 1.20% | INTEL CORP |
| 1.43% | INTERNATIONAL BUSINESS MACHS COR | 1.20% | PROCTER & GAMBLE CO |
| 1.32% | BERKSHIRE HATHAWAY INC DEL | 1.09% | BANK OF NEW YORK MELLON CORP |
| 1.30% | SPRINT NEXTEL CORP | 1.05% | CISCO SYSTEMS INC |
| 1.27% | FEDERAL HOME LOAN MORTGAGE CORP | 1.03% | GENERAL ELECTRIC CO |
| 1.24% | FORD MOTOR CO DEL | 1.00% | SPRINT NEXTEL CORP |
| 1.05% | PROCTER & GAMBLE CO | 0.92% | JPMORGAN CHASE & CO |
| 1.00% | JOHNSON & JOHNSON | 0.85% | HEWLETT PACKARD CO |
| 0.92% | PFIZER INC | 0.78% | OCCIDENTAL PETROLEUM CORP |
| 0.80% | CITIGROUP INC | 0.76% | MORGAN STANLEY DEAN WITTER & CO |

Table 1.2 Spearman Correlation matrix of monthly index returns based on different weighting schemes.

ME is for the weighting scheme based on market value; BE is for the weighting scheme based on book value; E is for the weighting scheme based on earnings; S is for the weighting scheme based on sales; D is for the weighting scheme based on dividends; CF is for the weighting scheme based on cash flows; EBITDA is for the weighting scheme based on EBITDA; EM is for the weighting scheme based on enterprise multiple. FI is a composite fundamental weighting scheme equally based on four different financial metrics, including S, BE, CF, and D.

Panel A. During 1972-2013

| | ME | BE | E | S | D | CF | EBITDA | EM | FI |
|---|---|---|---|---|---|---|---|---|---|
| ME | 1 | | | | | | | | |
| BE | 0.9897 | 1 | | | | | | | |
| | <.0001 | | | | | | | | |
| E | 0.9934 | 0.9959 | 1 | | | | | | |
| | <.0001 | <.0001 | | | | | | | |
| S | 0.9858 | 0.9975 | 0.9946 | 1 | | | | | |
| | <.0001 | <.0001 | <.0001 | | | | | | |
| D | 0.9819 | 0.9899 | 0.9849 | 0.9876 | 1 | | | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | | | | | |
| CF | 0.9910 | 0.9964 | 0.9994 | 0.9955 | 0.9852 | 1 | | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | | | |
| EBITDA | 0.9919 | 0.9977 | 0.9968 | 0.9978 | 0.9905 | 0.9970 | 1 | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | | |
| EM | 0.9953 | 0.9954 | 0.9979 | 0.9939 | 0.9865 | 0.9970 | 0.9971 | 1 | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | |
| FI | 0.9900 | 0.9990 | 0.9968 | 0.9982 | 0.9935 | 0.9973 | 0.9988 | 0.9962 | 1 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | |

Panel B. During expansion in 1972-2013, based on NBER definition

| | ME | BE | E | S | D | CF | EBITDA | EM | FI |
|---|---|---|---|---|---|---|---|---|---|
| ME | 1 | | | | | | | | |
| BE | 0.9908 | 1 | | | | | | | |
| | <.0001 | | | | | | | | |
| E | 0.9924 | 0.9919 | 1 | | | | | | |
| | <.0001 | <.0001 | | | | | | | |
| S | 0.9874 | 0.9947 | 0.9880 | 1 | | | | | |
| | <.0001 | <.0001 | <.0001 | | | | | | |
| D | 0.9794 | 0.9818 | 0.9824 | 0.9800 | 1 | | | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | | | | | |
| CF | 0.9913 | 0.9936 | 0.9971 | 0.9908 | 0.9825 | 1 | | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | | | |
| EBITDA | 0.9926 | 0.9943 | 0.9926 | 0.9951 | 0.9861 | 0.9943 | 1 | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | | |
| EM | 0.9950 | 0.9930 | 0.9927 | 0.9916 | 0.9858 | 0.9935 | 0.9957 | 1 | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | |

(Table 1.2 continued)

| | ME | BE | E | S | D | CF | EBITDA | EM | FI |
|---|---|---|---|---|---|---|---|---|---|
| FI | 0.9921 | 0.9974 | 0.9946 | 0.9960 | 0.9901 | 0.9965 | 0.9972 | 0.9957 | 1 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | |

Panel C. During contraction in 1972-2013, based on NBER definition

| | ME | BE | E | S | D | CF | EBITDA | EM | FI |
|---|---|---|---|---|---|---|---|---|---|
| ME | 1 | | | | | | | | |
| | | | | | | | | | |
| BE | 0.9942 | 1 | | | | | | | |
| | <.0001 | | | | | | | | |
| E | 0.9938 | 0.9942 | 1 | | | | | | |
| | <.0001 | <.0001 | | | | | | | |
| S | 0.9910 | 0.9965 | 0.9938 | 1 | | | | | |
| | <.0001 | <.0001 | <.0001 | | | | | | |
| D | 0.9879 | 0.9907 | 0.9852 | 0.9898 | 1 | | | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | | | | | |
| CF | 0.9920 | 0.9946 | 0.9987 | 0.9943 | 0.9855 | 1 | | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | | | |
| EBITDA | 0.9934 | 0.9964 | 0.9957 | 0.9977 | 0.9912 | 0.9966 | 1 | | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | | |
| EM | 0.9963 | 0.9952 | 0.9951 | 0.9948 | 0.9907 | 0.9947 | 0.9965 | 1 | |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | | |
| FI | 0.9937 | 0.9982 | 0.9952 | 0.9982 | 0.9933 | 0.9959 | 0.9985 | 0.9961 | 1 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | |

Panel D. During different periods in 1972-2013.

| | ME | | | | | | |
|---|---|---|---|---|---|---|---|
| | All | Contraction | Expansion | 00s | 90s | 80s | 70s |
| BE | 0.9911 | 0.9942 | 0.9908 | 0.9886 | 0.9957 | 0.9874 | 0.9907 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| E | 0.9930 | 0.9938 | 0.9924 | 0.9892 | 0.9948 | 0.9935 | 0.9904 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| S | 0.9874 | 0.9910 | 0.9874 | 0.9824 | 0.9946 | 0.9859 | 0.9862 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| D | 0.9806 | 0.9879 | 0.9794 | 0.9935 | 0.9912 | 0.9676 | 0.9572 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| CF | 0.9916 | 0.9920 | 0.9913 | 0.9893 | 0.9926 | 0.9912 | 0.9908 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| EBITDA | 0.9928 | 0.9934 | 0.9926 | 0.9929 | 0.9955 | 0.9919 | 0.9891 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| EM | 0.9951 | 0.9963 | 0.9950 | 0.9946 | 0.9959 | 0.9924 | 0.9927 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |
| FI | 0.9920 | 0.9937 | 0.9921 | 0.9895 | 0.9957 | 0.9906 | 0.9896 |
| | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 | <.0001 |

scheme has a higher correlation, 0.9953, compared with the composite of fundamental indexation, FI, which only has 0.9900.

Breaking down the whole sample into expansion and contraction based on NBER definition, Panle B and Panel C in Table 1.2 indicate that correlation coefficients based on different weighting schemes are on average higher during contraction compared with those in the expansion. As time moves from the 1970's to the 2000's, the correlation decreases in Panel D of Table 1.2. For example, the correlation of returns between sales-weighted scheme and capitalization-weighted index decreases from 0.96 to 0.90 during decades from 1970 to 2000. Compared with other fundamental indexes, dividends-weighted and sales-weighted schemes have relatively low correlations with the capitalization-weighted index in all separate sub-periods. On the other hand, earning related weighting schemes, such as earnings (E) or earnings before interests, taxes, depreciation and amortization (EBITDA), have relatively high correlations with the capitalization-weighted weighting scheme, implying the traditional wisdom saying that it is the earnings that drive the stock prices. Since earnings could be manipulated, adding or using other financial metrics to measure the fundamentals of firms may alleviate this problem and add value to the long-term performance of the fundamental indexation. For example, EBITDA, which is hard to manipulate and may provide better information in measuring the intrinsic value compared with earnings, has a better performance in cumulative return.

### 1.4.2 Returns and Sharpe ratio analysis

Table 1.3 shows the return characteristics for different fundamental-weighted, EM-weighted and the capitalization-weighted schemes for of the top 1000 domestic stocks in the USA with the largest equity market value during 1972-2013.

It shows that all fundamental-weighted schemes and EM-weighted scheme outperform the capitalization-weighted index during this period. The sales-weighted scheme has a mean annual geometric return of 11.84%, which is the highest among all fundamental weighting schemes, while capitalization-weighted index only has an

Table 1.3 Measurement of return characteristics (1972-2013).

All statistics are annualized and monthly total returns from January of 1972 to December of 2010 are used for the analysis. ME is for the weighting scheme based on market value; BE is for the weighting scheme based on book value; E is for the weighting scheme based on earnings; S is for the weighting scheme based on sales; D is for the weighting scheme based on dividends; CF is for the weighting scheme based on cash flows; EBITDA is for the weighting scheme based on EBITDA; EM is for the weighting scheme based on enterprise multiples. FI is a composite fundamental weighting scheme equally based on four different financial metrics, including S, BE, CF and D.The cap-weighted benchmark is based on the 1000 largest market cap US stocks.

| Weighting Scheme | Annual Geometric Return | Annual Volatility | Sharpe Ratio (vs. rf) | Excess Return (vs. Ref) | t-Value of Excess Return | Tracking Error ( vs. Ref) | Information Ratio | Sortino Ratio |
|---|---|---|---|---|---|---|---|---|
| ME | 10.33% | 15.61% | 0.45 | \ | \ | \ | \ | 0.64 |
| BE | 11.57% | 15.80% | 0.52 | 1.16 | 3.40 | 2.20% | 0.53 | 0.74 |
| E | 11.17% | 15.54% | 0.55 | 0.81 | 2.79 | 1.87% | 0.43 | 0.80 |
| S | 11.84% | 16.07% | 0.53 | 1.63 | 3.89 | 2.69% | 0.61 | 0.68 |
| D | 11.23% | 14.89% | 0.51 | 0.78 | 1.62 | 3.09% | 0.25 | 0.74 |
| CF | 11.35% | 15.71% | 0.52 | 1.04 | 3.17 | 2.12% | 0.49 | 0.73 |
| EBITDA | 11.47% | 15.77% | 0.53 | 1.18 | 3.81 | 2.00% | 0.59 | 0.74 |
| EM | 11.41% | 15.46% | 0.54 | 1.15 | 4.73 | 1.57% | 0.73 | 0.75 |
| FI | 11.51% | 15.56% | 0.53 | 1.15 | 3.48 | 2.13% | 0.54 | 0.75 |

| Weighting Scheme | Skewness | Excess Kurtosis | Minimum Monthly Return | Minimum 3-Month Return | Minimum 12-Month Return | Maxmum Monthly Return | Maxmum 3-Month Return | Maxmum 12-Month Return |
|---|---|---|---|---|---|---|---|---|
| ME | -0.42 | 2.14 | -22.09% | -29.68% | -42.23% | 17.33% | 30.22% | 64.72% |
| BE | -0.42 | 2.39 | -22.59% | -30.34% | -45.05% | 18.07% | 32.23% | 66.60% |
| E | -0.40 | 2.25 | -21.74% | -29.96% | -42.86% | 16.54% | 29.26% | 67.50% |
| S | -0.44 | 2.57 | -23.17% | -30.65% | -44.96% | 19.16% | 32.98% | 69.12% |
| D | -0.44 | 2.43 | -21.73% | -29.39% | -43.80% | 16.35% | 30.57% | 64.08% |
| CF | -0.41 | 2.40 | -22.48% | -30.11% | -43.62% | 16.97% | 30.67% | 68.31% |
| EBITDA | -0.42 | 2.34 | -22.73% | -30.33% | -44.63% | 17.99% | 32.41% | 68.43% |
| EM | -0.47 | 2.41 | -22.05% | -30.66% | -42.73% | 16.53% | 29.53% | 66.10% |
| FI | -0.43 | 2.45 | -22.50% | -29.91% | -44.34% | 17.64% | 31.61% | 67.02% |

annual geometric return of 10.33%. The composite of fundamental weighting scheme, FI, also has an annual geometric return of 11.51%, which is higher than that of the capitalization-weighted index by 118 basis points per year. This is consistent with findings from Arnott et. al. (2005), and Basu and Forbes (2013). Even integrating a conservative transaction cost of 30 basis points per year (the transaction cost for block traders is usually less than 10 basis points in the current market), all fundamental-weighted schemes in Table 1.3 still outperform the capitalization-weighted index. On the other hand, EM-weighted scheme has a mean annual geometric return of 11.41%, outperforming the capitalization-weighted scheme by 108 basis points per year. Among all fundamental weighting schemes, which have similar annual volatilities with that of a capitalization-weighted index, the dividends-weighted scheme has the lowest volatility of 14.92%. EM-weighted scheme has a volatility of 15.46%, which is lower than that, 15.61%, of a capitalization-weighting scheme. Compared with capitalization-weighted indexes, all fundamental weighting schemes have positive excess returns, ranging from 0.78 for the dividends-weighted scheme to 1.63 for the sales-weighted scheme, and most of them are statistically significant. When using the "blended" EM-weighted scheme, it provides an excess return of 1.15 with a t-value of 4.73. The annualized Sharpe ratio, which measures the excess return to risk-free rate per unit of risk, is larger for all fundamental weighting schemes compared with that of the capitalization-weighted index. The Sharpe ratios vary from 0.45 to 0.55 for different fundamental indexation, and the EM-weighted scheme has a Sharpe ratio of 0.54, 20% higher than that of a capitalization-weighted scheme. This implies that compared with investing in a capitalization-weighted index, betting on these fundamental weighting schemes does have extra rewards without taking additional risks. Since investors concern about more downside deviation than the standard deviation, using Sortino ratio to measure risk provides more information compared with using standard deviation. Table 1.3 also shows that capitalization-weighted index has a Sortino ratio of 0.64, which is lower than that, 0.75, of the composite FI weighting scheme. This implies that betting on fundamental weighting schemes and EM weighting scheme does also have a lower probability of large losses, compared with the capitalization-weighted strategy.

Another important metric in portfolio performance measurement is tracking error, which measures the closeness of a portfolio following a benchmark. The tracking errors for fundamental weighting schemes range from 1.87%

(earning-weighted) to 3.09% (dividends-weighted). When investors look at the combination of the tracking error and excess return together, sales-weighted scheme has an information ratio of 0.63, which is higher than any other fundamental weighting scheme in the Table 1.3, including weighted schemes of book-equity (BE), earnings (E), sales (S), dividends (D), and cash flow (CF), EBITDA and also the composite (FI). On the other hand, the "blended" EM-weighted scheme introduce in this essay is even more competitive. It has an information ratio of 0.73, which is 19.67% larger than that of the sales-weighted scheme and 55% larger than the composite (FI) with a ratio of 35.19%.

All fundamental weighting schemes have similar skewnesses to that, -0.42, of a capitalization-weighted index. In addition, EM-weighted scheme has a skewness of -0.46, which implies that EM-weighted scheme has a similar asymmetric tail in returns tilting into negative values. This indicates that EM-weighted scheme has a little higher frequencies of outcomes at the extreme negative end of the distribution curve compared with that of the capitalization-weighted scheme. On the other hand, all fundamental weighting schemes and EM-weighted scheme have a litter higher kurtoses, ranging from 2.25 for the earnings-weighted scheme to 2.57 for the sales-weighted scheme, compared to 2.14 for the capitalization-weighted index. This indicates that fundamental weighting schemes have relatively concentrated distributions for returns compared with that of the capitalization-weighted index. Since weighting schemes with high kurtoses are more likely to overestimate the probability of getting the mean return, this implies that the lower volatility of fundamental weighting schemes and EM-weighted scheme may not be able to capture the true riskiness to a full extent.

Table 1.3 shows that twelve-month maximum loss of the capitalization-weighted index is equal to -42.23%, which is less than those of fundamental weighting schemes and EM weighting scheme with a range from -42.73% ( EM-weighted) to -45.05% (BE-weighted). One explanation is that capitalization-weighted index can automatically allocate less weighting to stocks in the portfolio when their prices drop (Arnott et al., 2005). On the other hand, the capitalization-weighted index has a relative small twelve-month maximum profit, 64.72%, compared with most of the fundamental weighting schemes with a range from 66.60% (BE-weighted scheme) to

69.12% (sales-weighted scheme) -- except for dividend-weighted scheme with a value of 64.08%. This may be due to the ineffectiveness of capitalization-weighted index to capture the value premium. For example, when a stock's price drops sharply from a growth stock to a value stock compared with other stocks in the portfolio, the capitalization-weighted index puts less weight on the stock; when a stock's price increase from a value stock to a growth stock compared with other stocks in the portfolio, the capitalization-weighted index puts more weights on the growth stocks which usually have lower returns. Comparing with fundamental weighting schemes, the capitalization-weighted index automatically tilts into growth stocks. The effectiveness of capturing the value premium is illuminated by Hsu (2014), who suggests that a non-price weighting scheme can effectively profit from the mean reversion of both stock prices and value premium via rebalancing embedded a mechanism of dollar cost averaging.

1.4.3 Risk analyses based on different asset pricing models

Table 1.4 shows alphas and loadings of risk factors on three asset pricing models for using different weighting schemes. Autocorrelation and heteroscedasticity in the returns are adjusted by Newey-West (1987) standard errors when estimating parameters in the table. CAPM model in Panel A of Table 1.4 shows that monthly alphas from fundamental weighting schemes are significantly larger than zero, ranging from 14 basis points for the earnings-weighted scheme to 19 points for the sales-weighted scheme. The EM-weighted scheme has a monthly alpha of 17 basis points. These results demonstrate that fundamental weighting schemes and EM-weighted scheme have positive Jensen's alphas compared with the cap-weighted index.

Alphas for all fundamental weighting schemes in Panle B of Table 1.4 all disappear when using Fama-French 3-factor model to evaluate their performance, indicating that Jensen alphas in CAPM model for fundamental weighting schemes may come from high loadings of value stocks, i.e., stocks with high book-to-mark values. The alphas disappear when using 3-factor, and this is consistent with most of other research (Jun and Malkiel 2008, Amenc, Goultz and Le Sourd 2009). In contrast, there is still an alpha of 10 basis points with a t-value of 2.53 for EM-weighting scheme. This indicates the potential of using EM weighting scheme to enhance

Table 1.4 Alphas and loadings of factors on asset pricing models, based on different weighting schemes during 1972-2013.

BE is for the weighting scheme based on book value; E is for the weighting scheme based on earnings; S is for the weighting scheme based on sales; D is for the weighting scheme based on dividends; CF is for the weighting scheme based on cash flows; EBITDA is for the weighting scheme based on EBITDA; EM is for the weighting scheme based on enterprise multiples. FI is a composite fundamental weighting scheme equally based on four different financial metrics, including S, BE, CF and D. The cap-weighted benchmark is based on the 1000 largest market cap US stocks. Market factor, Small size (SMB), Value (HML), Momentum (MOM) factors, risk-free rate are obtained from WRDS Data Library. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| BE | 0.0016*** | 0.9648*** | 0.9497 |
| | (2.97) | (59.51) | |
| E | 0.0014*** | 0.9491*** | 0.9507 |
| | (2.61) | (62.94) | |
| S | 0.0019*** | 0.9779*** | 0.9424 |
| | (3.22) | (56.88) | |
| D | 0.0017** | 0.8940*** | 0.9183 |
| | (2.54) | (42.81) | |
| CF | 0.0015*** | 0.9589*** | 0.9487 |
| | (2.82) | (61.17) | |
| EBITDA | 0.0017*** | 0.9640*** | 0.9504 |
| | (2.95) | (63.11) | |
| EM | 0.0017*** | 0.9481*** | 0.9567 |
| | (3.38) | (71.14) | |
| FI | 0.0017*** | 0.9490*** | 0.9471 |
| | (3.01) | (57.13) | |

Panel B. Use FF-3 factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| BE | 0.0005 | 1.0221*** | -0.0480 | 0.2277*** | 0.9718 |
| | (1.43) | (100.02) | (-1.61) | (8.56) | |
| E | 0.0008* | 1.0026*** | -0.1160*** | 0.1492*** | 0.9676 |
| | (1.84) | (80.47) | (-3.35) | (5.08) | |
| S | 0.0006 | 1.0367*** | -0.0166 | 0.2621*** | 0.9683 |
| | (1.43) | (80.96) | (-0.47) | (8.61) | |
| D | 0.0005 | 0.9755*** | -0.1319*** | 0.2671*** | 0.9623 |
| | (1.04) | (78.45) | (-6.04) | (10.81) | |
| CF | 0.0008* | 1.0131*** | -0.0890*** | 0.1764*** | 0.9660 |
| | (1.72) | (80.03) | (-2.62) | (6.13) | |

(Table 1.4 continued)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EBITDA | 0.0006 | 1.0236*** | -0.0735** | 0.2158*** | 0.9725 |
| | (1.58) | (91.20) | (-2.54) | (8.47) | |
| EM | 0.0010** | 1.0012*** | -0.0986*** | 0.1627*** | 0.9736 |
| | (2.53) | (99.83) | (-3.14) | (6.44) | |
| FI | 0.0006 | 1.0119*** | -0.0714** | 0.2331*** | 0.9728 |
| | (1.52) | (94.93) | (-2.43) | (9.07) | |

Panel C. Use Carhart 4-factor as the benchmark

| | | | 4-factor | | | |
|---|---|---|---|---|---|---|
| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
| BE | 0.0014*** | 1.0041*** | -0.0486** | 0.1990*** | -0.0907*** | 0.9780 |
| | (3.03) | (89.80) | (-2.32) | (10.41) | (-4.95) | |
| E | 0.0015*** | 0.9869*** | -0.1165*** | 0.1242*** | -0.0791*** | 0.9733 |
| | (3.23) | (75.89) | (-4.36) | (5.35) | (-4.43) | |
| S | 0.0015*** | 1.0181*** | -0.0172 | 0.2326*** | -0.0933*** | 0.9758 |
| | (2.98) | (74.60) | (-0.65) | (9.95) | (-4.84) | |
| D | 0.0011** | 0.9621*** | -0.1324*** | 0.2458*** | -0.0675*** | 0.9668 |
| | (2.46) | (70.75) | (-8.06) | (10.87) | (-4.23) | |
| CF | 0.0015*** | 0.9976*** | -0.0895*** | 0.1518*** | -0.0780*** | 0.9715 |
| | (3.09) | (73.00) | (-3.40) | (6.69) | (-4.26) | |
| EBITDA | 0.0015*** | 1.0060*** | -0.0741*** | 0.1878*** | -0.0886*** | 0.9795 |
| | (3.17) | (82.72) | (-3.64) | (9.92) | (-5.25) | |
| EM | 0.0018*** | 0.9848*** | -0.0991*** | 0.1367*** | -0.0822*** | 0.9799 |
| | (3.83) | (93.01) | (-4.31) | (7.46) | (-4.59) | |
| FI | 0.0014*** | 0.9955*** | -0.0719*** | 0.2072*** | -0.0821*** | 0.9790 |
| | (3.14) | (84.66) | (-3.38) | (10.86) | (-5.00) | |

fundamental-weighted schemes.  Loadings on the value factor (HML) in the 3-factor model in Panel B of Table 1.4 are comparatively larger for all fundamental weighting capitalization-weighted scheme, implying that EM weighting scheme can capture value premium more effectively than capitalization-weighted scheme but is less effective when comparing traditional fundamental weighting scheme. The effectiveness of capturing value premium for the EM-weighting scheme is also reflected in Carhart 4-factor model in Panel C of Table 1.4. This explains the fact in Figure 1.1 that cumulative return of EM-weighting scheme is not the highest compared with all other fundamental indexation since it has a lower loading on the value factor.

### 1.4.4 Disentangle the EM-weighted scheme

In order to know the underlying which drives the outperformance of the EM-weighting scheme, this section focuses on disentangling the effects of different information integrated into the EM-weighted scheme. The EM-weighting scheme is based on the multiplication of market equity value and the reverse of enterprise multiple schemes compared with that from the capitalization-weighted index. The loadings vary from 0.1492 (earnings-weighted) to 0.2671 (dividend-weighted) in the fundamental weighting schemes. The EM-weighted scheme has a loading of 0.1627 on value factor, which is lower than that of the composite (FI) but is larger than that of the ratios. Appendix formula (1) shows that EM-weighting scheme is essentially based on EBITDA multiplied by a coefficient, which is the combination of debt, preferred stocks, cash and short-term investments and also the market information. Formula (4) shows the calculation of EM2 weighting scheme. It just focuses on fundamental information of debt but does not consider information of preferred stocks and cash flow, while EM4 in formula (7) just ignores information of cash flow, and integrates both fundamental information of preferred stocks and debt. If market equity value in the EM multiple is replaced by book equity value, then EM, EM2, and EM4 weighting schemes will be adjusted into EM1, EM3 and EM5 weighting schemes, respectively. If EM multiple is multiplied by the book equity value instead of market equity value, then EM, EM2, and EM4 weighting schemes will be adjusted into EM1', EM3' and EM5' weighting schemes, respectively. In this case, there is no equity market value, i.e., market information, integrated into the weighting scheme.

Table 1.5 shows that there are no significant alphas for EM1 and EM1' weighting schemes when using CAPM and FF-3 models to measure their performance. It shows that alphas for EM, EM2, and EM4 weighting schemes are larger than those in EM1', EM3' and EM5' weighting schemes, respectively, when using CAPM model. Above observations imply that a combination of market information and fundamental information may add value to the performance of EM-weighted scheme. There are 17 basis points of alpha for EM weighting scheme, which is the largest with the highest t-value compared with EM2 and EM4 weighting schemes. The pattern also works for the FF-3 factor model, where the EM-weighting scheme has 10 basis points for the alpha with a t-value of

Table 1.5 Alphas and loadings of factors on asset pricing models, based on different weighting schemes during 1972-2013.

The cap-weighted benchmark is based on the 1000 largest market cap US stocks. Market factor, Small size (SMB), Value (HML), Momentum (MOM) factors, risk-free rate are obtained from WRDS Data Library. More information about EM, EM1, EM’, EM2, EM3, EM3’, EM4, EM5 and EM5’ can be referred in Appendix. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| EM | 0.0017*** | 0.9481*** | 0.9567 |
| | (3.38) | (71.14) | |
| EM1 | 0.0003 | 0.9824*** | 0.8936 |
| | (0.47) | (43.93) | |
| EM' | 0.0003 | 0.9824*** | 0.8936 |
| | (0.47) | (43.93) | |
| EM2 | 0.0015*** | 0.9405*** | 0.9573 |
| | (3.00) | (71.88) | |
| EM3 | 0.0007* | 0.9469*** | 0.9629 |
| | (1.75) | (71.61) | |
| EM3' | 0.0007* | 0.9469*** | 0.9629 |
| | (1.75) | (71.61) | |
| EM4 | 0.0015*** | 0.9400*** | 0.9573 |
| | (2.99) | (71.99) | |
| EM5 | 0.0007* | 0.9469*** | 0.9628 |
| | (1.73) | (71.33) | |
| EM5' | 0.0007* | 0.9469*** | 0.9628 |
| | (1.73) | (71.33) | |

Panel B. Use FF-3 factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EM | 0.0010** | 1.0012*** | -0.0986*** | 0.1627*** | 0.9736 |
| | (2.53) | (99.83) | (-3.14) | (6.44) | |
| EM1 | 0.0006 | 0.9984*** | -0.1163*** | -0.0275 | 0.8983 |
| | (0.96) | (58.02) | (-3.15) | (-0.64) | |
| EM' | 0.0007 | 0.9907*** | -0.0716** | 0.1268*** | 0.9288 |
| | (1.40) | (64.22) | (-2.36) | (4.32) | |
| EM2 | 0.0008** | 0.9946*** | -0.1045*** | 0.1623*** | 0.9751 |
| | (2.06) | (96.29) | (-3.45) | (6.56) | |
| EM3 | 0.0007** | 0.9840*** | -0.1543*** | 0.0380 | 0.9749 |
| | (2.21) | (92.83) | (-6.62) | (1.65) | |
| EM3' | 0.0008** | 0.9920*** | -0.0834*** | 0.1692*** | 0.9704 |
| | (2.10) | (92.84) | (-2.90) | (6.57) | |

(Table 1.5 continued)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EM4 | 0.0008** | 0.9940*** | -0.1064*** | 0.1604*** | 0.9751 |
| | (2.08) | (96.90) | (-3.53) | (6.52) | |
| EM5 | 0.0007** | 0.9842*** | -0.1553*** | 0.0380* | 0.9749 |
| | (2.19) | (93.14) | (-6.71) | (1.65) | |
| EM5' | 0.0009** | 0.9887*** | -0.0862*** | 0.1699*** | 0.9707 |
| | (2.22) | (97.43) | (-3.03) | (6.72) | |

Panel C. Use Carhart 4-factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| EM | 0.0018*** | 0.9848*** | -0.0991*** | 0.1367*** | -0.0822*** | 0.9799 |
| | (3.83) | (93.01) | (-4.31) | (7.46) | (-4.59) | |
| EM1 | 0.0015* | 0.9795*** | -0.1169*** | -0.0577 | -0.0955** | 0.9056 |
| | (1.86) | (59.21) | (-3.99) | (-1.46) | (-2.45) | |
| EM' | 0.0012* | 0.9808*** | -0.0719*** | 0.1111*** | -0.0495* | 0.9309 |
| | (1.78) | (58.89) | (-2.80) | (4.62) | (-1.70) | |
| EM2 | 0.0016*** | 0.9785*** | -0.1050*** | 0.1366*** | -0.0813*** | 0.9813 |
| | (3.47) | (87.48) | (-4.76) | (7.59) | (-4.70) | |
| EM3 | 0.0013*** | 0.9716*** | -0.1547*** | 0.0183 | -0.0625*** | 0.9785 |
| | (3.63) | (96.59) | (-8.67) | (1.01) | (-5.94) | |
| EM3' | 0.0015*** | 0.9775*** | -0.0839*** | 0.1462*** | -0.0728*** | 0.9754 |
| | (3.21) | (82.45) | (-3.87) | (7.38) | (-4.13) | |
| EM4 | 0.0016*** | 0.9779*** | -0.1069*** | 0.1349*** | -0.0809*** | 0.9813 |
| | (3.47) | (87.85) | (-4.88) | (7.54) | (-4.69) | |
| EM5 | 0.0013*** | 0.9719*** | -0.1557*** | 0.0185 | -0.0620*** | 0.9785 |
| | (3.60) | (97.54) | (-8.77) | (1.01) | (-5.91) | |
| EM5' | 0.0016*** | 0.9741*** | -0.0866*** | 0.1467*** | -0.0735*** | 0.9758 |
| | (3.37) | (87.38) | (-4.07) | (7.59) | (-4.19) | |

2.53. Then 1972-2013 is broken down into two sub-periods to further test this implication in Table 1.6 and Table 1.7. Table 1.6 shows that there are no alphas for EM1, EM3, and EM5 weighting schemes during 1972-1992 when using CAPM model. In this sub-period, alpha for EM weighting scheme is still the largest with the highest t-value compared with all other adjusted versions of the EM-weighting scheme, for both CAPM and FF-3 models. Further investigation in Table 1.6 shows that there are no alphas for EM1, EM3, EM5, EM1’, EM3’ and EM5’ weighting schemes. This implies that it is the combination of fundamental information and market information that adds value to the performance of EM-weighing scheme.

Table 1.6 Alphas and loadings of factors on asset pricing models, based on different weighting schemes during 1972-1992.

The cap-weighted benchmark is based on the 1000 largest market cap US stocks. Market factor, Small size (SMB), Value (HML), Momentum (MOM) factors, risk-free rate are obtained from WRDS Data Library. More information about EM, EM1, EM', EM2, EM3, EM3', EM4, EM5 and EM5' can be referred in Appendix. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| EM | 0.0017*** | 0.9660*** | 0.9854 |
| | (3.80) | (99.84) | |
| EM1 | 0.0007 | 0.9734*** | 0.9785 |
| | (1.45) | (62.21) | |
| EM1' | 0.0019*** | 0.9608*** | 0.9820 |
| | (4.16) | (86.78) | |
| EM2 | 0.0014*** | 0.9658*** | 0.9863 |
| | (3.38) | (96.85) | |
| EM3 | 0.0006 | 0.9718*** | 0.9845 |
| | (1.46) | (74.88) | |
| EM3' | 0.0018*** | 0.9653*** | 0.9817 |
| | (3.78) | (74.71) | |
| EM4 | 0.0014*** | 0.9651*** | 0.9864 |
| | (3.37) | (98.25) | |
| EM5 | 0.0005 | 0.9707*** | 0.9838 |
| | (1.38) | (72.18) | |
| EM5' | 0.0018*** | 0.9606*** | 0.9822 |
| | (3.96) | (80.15) | |

Panel B. Use FF-3 factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EM | 0.0010*** | 1.0064*** | -0.0536*** | 0.1225*** | 0.9899 |
| | (2.72) | (103.66) | (-4.23) | (7.56) | |
| EM1 | 0.0008** | 1.0033*** | -0.1501*** | 0.0066 | 0.9854 |
| | (2.46) | (69.88) | (-8.56) | (0.31) | |
| EM' | 0.0012*** | 1.0066*** | -0.0620*** | 0.1378*** | 0.9878 |
| | (3.12) | (89.55) | (-3.88) | (7.07) | |
| EM2 | 0.0007** | 1.0090*** | -0.0619*** | 0.1276*** | 0.9914 |
| | (2.20) | (104.25) | (-4.74) | (7.59) | |
| EM3 | 0.0007*** | 0.9995*** | -0.1373*** | 0.0074 | 0.9904 |
| | (2.65) | (81.19) | (-9.06) | (0.38) | |
| EM3' | 0.0009** | 1.0122*** | -0.0550*** | 0.1478*** | 0.9880 |
| | (2.57) | (82.53) | (-3.23) | (7.06) | |
| EM4 | 0.0007** | 1.0083*** | -0.0659*** | 0.1245*** | 0.9914 |
| | (2.23) | (105.00) | (-5.07) | (7.44) | |

(Table 1.6 continued)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EM5 | 0.0007** | 0.9986*** | -0.1399*** | 0.0061 | 0.9900 |
| | (2.59) | (78.80) | (-8.99) | (0.31) | |
| EM5' | 0.0010*** | 1.0080*** | -0.0571*** | 0.1481*** | 0.9886 |
| | (2.82) | (89.98) | (-3.44) | (7.22) | |

Panel C. Use Carhart 4-factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| EM | 0.0014*** | 1.0070*** | -0.0632*** | 0.1138*** | -0.0378*** | 0.9906 |
| | (3.69) | (111.69) | (-6.35) | (8.01) | (-3.44) | |
| EM1 | 0.0013*** | 1.0040*** | -0.1606*** | -0.0030 | -0.0416*** | 0.9863 |
| | (3.08) | (78.54) | (-10.08) | (-0.15) | (-2.72) | |
| EM' | 0.0016*** | 1.0072*** | -0.0720*** | 0.1287*** | -0.0395*** | 0.9886 |
| | (4.12) | (96.52) | (-5.69) | (7.38) | (-3.00) | |
| EM2 | 0.0011*** | 1.0097*** | -0.0723*** | 0.1181*** | -0.0410*** | 0.9923 |
| | (3.43) | (112.02) | (-7.14) | (7.96) | (-3.72) | |
| EM3 | 0.0011*** | 1.0001*** | -0.1459*** | -0.0005 | -0.0342** | 0.9910 |
| | (3.19) | (89.33) | (-11.76) | (-0.03) | (-2.40) | |
| EM3' | 0.0013*** | 1.0128*** | -0.0641*** | 0.1395*** | -0.0360*** | 0.9886 |
| | (3.37) | (84.13) | (-4.45) | (7.33) | (-2.70) | |
| EM4 | 0.0011*** | 1.0090*** | -0.0760*** | 0.1152*** | -0.0401*** | 0.9923 |
| | (3.41) | (112.81) | (-7.51) | (7.76) | (-3.65) | |
| EM5 | 0.0011*** | 0.9991*** | -0.1486*** | -0.0019 | -0.0345** | 0.9906 |
| | (3.12) | (86.81) | (-11.64) | (-0.11) | (-2.34) | |
| EM5' | 0.0013*** | 1.0086*** | -0.0660*** | 0.1401*** | -0.0350*** | 0.9892 |
| | (3.70) | (94.07) | (-4.77) | (7.54) | (-2.64) | |

Table 1.7 Alphas and loadings of factors on asset pricing models, based on different weighting schemes during 1993-2013. More information about variables can be referred in Table 1.6. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| EM | 0.0018** | 0.9274*** | 0.9236 |
| | (1.99) | (34.71) | |
| EM1 | -0.0001 | 0.9931*** | 0.8147 |
| | (-0.08) | (22.19) | |
| EM1' | 0.0007 | 0.9388*** | 0.8540 |
| | (0.60) | (27.52) | |
| EM2 | 0.0017* | 0.9112*** | 0.9233 |
| | (1.87) | (35.95) | |

(Table 1.7 continued)

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| EM3 | 0.0009 | 0.9179*** | 0.9378 |
| | (1.33) | (40.00) | |
| EM3' | 0.0015* | 0.9118*** | 0.9215 |
| | (1.66) | (33.92) | |
| EM4 | 0.0017* | 0.9108*** | 0.9233 |
| | (1.88) | (35.94) | |
| EM5 | 0.0009 | 0.9192*** | 0.9383 |
| | (1.33) | (40.30) | |
| EM5' | 0.0016* | 0.9087*** | 0.9205 |
| | (1.70) | (33.80) | |

Panel B. Use FF-3 factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EM | 0.0012* | 0.9807*** | -0.1198*** | 0.1804*** | 0.9574 |
| | (1.85) | (71.20) | (-2.90) | (5.79) | |
| EM1 | 0.0002 | 1.0049*** | -0.1012 | -0.0425 | 0.8174 |
| | (0.17) | (28.08) | (-1.63) | (-0.62) | |
| EM' | 0.0003 | 0.9743*** | -0.0813* | 0.1181*** | 0.8665 |
| | (0.34) | (34.14) | (-1.74) | (2.78) | |
| EM2 | 0.0011* | 0.9652*** | -0.1249*** | 0.1786*** | 0.9590 |
| | (1.73) | (72.02) | (-3.13) | (5.99) | |
| EM3 | 0.0009 | 0.9575*** | -0.1573*** | 0.0584* | 0.9579 |
| | (1.52) | (59.64) | (-4.83) | (1.84) | |
| EM3' | 0.0009 | 0.9608*** | -0.0972** | 0.1804*** | 0.9519 |
| | (1.36) | (69.89) | (-2.50) | (5.69) | |
| EM4 | 0.0011* | 0.9647*** | -0.1249*** | 0.1782*** | 0.9589 |
| | (1.73) | (72.01) | (-3.13) | (5.97) | |
| EM5 | 0.0009 | 0.9589*** | -0.1567*** | 0.0596* | 0.9584 |
| | (1.50) | (60.56) | (-4.84) | (1.89) | |
| EM5' | 0.0009 | 0.9584*** | -0.1002*** | 0.1810*** | 0.9517 |
| | (1.42) | (69.98) | (-2.61) | (5.82) | |

Panel C. Use Carhart 4-factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| EM | 0.0021*** | 0.9369*** | -0.1018*** | 0.1500*** | -0.1118*** | 0.9738 |
| | (3.07) | (57.55) | (-3.44) | (7.06) | (-4.54) | |
| EM1 | 0.0012 | 0.9539*** | -0.0803 | -0.0779 | -0.1303** | 0.8340 |
| | (0.95) | (26.94) | (-1.57) | (-1.35) | (-2.31) | |
| EM' | 0.0008 | 0.9498*** | -0.0713* | 0.1012*** | -0.0623 | 0.8706 |
| | (0.70) | (26.06) | (-1.65) | (2.88) | (-1.39) | |

(Table 1.7 continued)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| EM2 | 0.0020*** | 0.9216*** | -0.1070*** | 0.1483*** | -0.1113*** | 0.9759 |
| | (3.03) | (60.24) | (-3.79) | (7.69) | (-4.79) | |
| EM3 | 0.0016*** | 0.9234*** | -0.1433*** | 0.0347 | -0.0870*** | 0.9682 |
| | (2.79) | (63.49) | (-6.09) | (1.54) | (-6.52) | |
| EM3' | 0.0017** | 0.9207*** | -0.0807*** | 0.1525*** | -0.1025*** | 0.9661 |
| | (2.43) | (58.38) | (-2.86) | (6.83) | (-4.29) | |
| EM4 | 0.0020*** | 0.9210*** | -0.1070*** | 0.1479*** | -0.1114*** | 0.9758 |
| | (3.04) | (60.35) | (-3.79) | (7.67) | (-4.80) | |
| EM5 | 0.0016*** | 0.9253*** | -0.1429*** | 0.0362 | -0.0858*** | 0.9683 |
| | (2.76) | (63.72) | (-6.11) | (1.60) | (-6.40) | |
| EM5' | 0.0018** | 0.9178*** | -0.0836*** | 0.1528*** | -0.1037*** | 0.9663 |
| | (2.51) | (59.02) | (-3.02) | (7.04) | (-4.36) | |

## 1.5 Robustness Checks

### 1.5.1 Performance in sub-periods

In order to double-check the competitive performance of the EM-weighting scheme, it is also tested during sub-periods of 1972-1992 (Table 1.8) and 1993-2013 (Table 1.9). Table 1.8 confirms that EM weighting scheme has the lowest tracking error compared with all other weighting schemes. It has 1.42% during 1972-1992 while has 1.69% during 1993-2013. Also, it shows that EM weighting scheme has higher information ratio compared with all fundamental weighting schemes during each period. During 1993-2013, it has an information ratio of 0.61, which is 69.44% larger than that of the composite FI weighting scheme, while it has an information ratio of 0.90, which is 20% larger than that of the composite FI weighing scheme during 1972-1992.

On the other hand, Table 1.10 shows that there is consistent and statistically significant alpha for EM weighting scheme when using different factor models. This is different from other fundamental weighing schemes, including the FI composite. For example, during 1972-1992 in Panels B of Table 1.10 only EM-weighting scheme has an alpha of 10 basis points with significance at the 1% level, which is the highest among all weighing scheme; during 1993-2013 in Panel E of Table 1.10, only EM-weighting scheme has an alpha of 12 basis points with significance at the 10% level, which is also the highest among all weighing scheme.

Table 1.8 Measurement of return characteristics duirng 1972-1992.

All statistics are annualized and monthly total returns from January of 1972 to December of 1992 are used for the analysis. ME is for the weighting scheme based on market value; BE is for the weighting scheme based on book value; E is for the weighting scheme based on earnings; S is for the weighting scheme based on sales; D is for the weighting scheme based on dividends; CF is for the weighting scheme based on cash flows; EBITDA is for the weighting scheme based on EBITDA; EM is for the weighting scheme based on enterprise multiples. FI is a composite fundamental weighting scheme equally based on four different financial metrics, including S, BE, CF and D. The cap-weighted benchmark is based on the 1000 largest market cap US stocks.

| Weighting Scheme | Annual Geometric Return | Annual Volatility | Sharpe Ratio (vs. rf) | Excess Return (vs. Ref) | t-Value of Excess Return | Tracking Error ( vs. Ref) | Information Ratio | Sortino Ratio |
|---|---|---|---|---|---|---|---|---|
| ME | 4.34% | 16.59% | 0.33 | \ | \ | \ | \ | 0.49 |
| BE | 7.26% | 16.68% | 0.44 | 1.68 | 3.28 | 2.27% | 0.74 | 0.65 |
| E | 5.93% | 16.74% | 0.44 | 1.16 | 2.76 | 1.87% | 0.62 | 0.68 |
| S | 7.19% | 17.09% | 0.41 | 1.95 | 3.09 | 2.80% | 0.7 | 0.57 |
| D | 6.81% | 15.97% | 0.4 | 1.04 | 2.33 | 1.99% | 0.52 | 0.62 |
| CF | 6.30% | 16.92% | 0.42 | 1.52 | 2.97 | 2.26% | 0.67 | 0.62 |
| EBITDA | 6.68% | 16.75% | 0.42 | 1.49 | 3.41 | 1.94% | 0.77 | 0.63 |
| EM | 6.30% | 16.40% | 0.42 | 1.28 | 4 | 1.42% | 0.9 | 0.61 |
| FI | 6.90% | 16.63% | 0.43 | 1.55 | 3.34 | 2.05% | 0.75 | 0.63 |

| Weighting Scheme | Skewness | Excess Kurtosis | Minimum Monthly Return | Minimum 3-Month Return | Minimum 12-Month Return | Maxmum Monthly Return | Maxmum 3-Month Return | Maxmum 12-Month Return |
|---|---|---|---|---|---|---|---|---|
| ME | -0.24 | 2.54 | -22.09% | -29.68% | -38.98% | 17.33% | 28.24% | 64.72% |
| BE | -0.25 | 2.86 | -22.59% | -29.68% | -32.39% | 18.07% | 29.51% | 66.60% |
| E | -0.21 | 2.42 | -21.74% | -29.96% | -34.59% | 16.54% | 28.89% | 67.50% |
| S | -0.27 | 2.9 | -23.17% | -30.46% | -32.85% | 19.16% | 31.16% | 69.12% |
| D | -0.27 | 2.75 | -21.73% | -29.39% | -32.72% | 16.35% | 27.61% | 64.08% |
| CF | -0.24 | 2.64 | -22.48% | -30.11% | -33.61% | 16.97% | 29.39% | 68.31% |
| EBITDA | -0.25 | 2.78 | -22.73% | -30.33% | -33.70% | 17.99% | 29.73% | 68.43% |
| EM | -0.27 | 2.69 | -22.05% | -29.63% | -34.66% | 16.53% | 28.67% | 66.10% |
| FI | -0.26 | 2.8 | -22.50% | -29.91% | -32.88% | 17.64% | 29.05% | 67.02% |

Table 1.9 Measurement of return characteristics duirng 1993-2013.

All statistics are annualized and monthly total returns from January of 1993 to December of 2013 are used for the analysis. ME is for the weighting scheme based on market value; BE is for the weighting scheme based on book value; E is for the weighting scheme based on earnings; S is for the weighting scheme based on sales; D is for the weighting scheme based on dividends; CF is for the weighting scheme based on cash flows; EBITDA is for the weighting scheme based on EBITDA; EM is for the weighting scheme based on enterprise multiples. FI is a composite fundamental weighting scheme equally based on four different financial metrics, including S, BE, CF and D. The cap-weighted benchmark is based on the 1000 largest market cap US stocks.

| Weighting Scheme | Annual Geometric Return | Annual Volatility | Sharpe Ratio (vs. rf) | Excess Return (vs. Ref) | t-Value of Excess Return | Tracking Error ( vs. Ref) | Information Ratio | Sortino Ratio |
|---|---|---|---|---|---|---|---|---|
| ME | 9.80% | 14.70% | 0.58 | \ | \ | \ | \ | 0.78 |
| BE | 10.35% | 14.96% | 0.62 | 0.69 | 1.51 | 2.13% | 0.32 | 0.83 |
| E | 10.45% | 14.39% | 0.66 | 0.49 | 1.23 | 1.87% | 0.26 | 0.91 |
| S | 10.86% | 15.09% | 0.65 | 1.33 | 2.4 | 2.58% | 0.52 | 0.8 |
| D | 10.36% | 13.86% | 0.63 | 0.54 | 0.66 | 3.83% | 0.14 | 0.86 |
| CF | 10.42% | 14.55% | 0.63 | 0.61 | 1.44 | 1.97% | 0.31 | 0.84 |
| EBITDA | 10.54% | 14.85% | 0.64 | 0.91 | 2.06 | 2.06% | 0.44 | 0.86 |
| EM | 10.75% | 14.58% | 0.66 | 1.03 | 2.85 | 1.69% | 0.61 | 0.87 |
| FI | 10.51% | 14.53% | 0.64 | 0.79 | 1.68 | 2.19% | 0.36 | 0.86 |

| Weighting Scheme | Skewness | Excess Kurtosis | Minimum Monthly Return | Minimum 3-Month Return | Minimum 12-Month Return | Maxmum Monthly Return | Maxmum 3-Month Return | Maxmum 12-Month Return |
|---|---|---|---|---|---|---|---|---|
| ME | -0.65 | 1.44 | -16.50% | -29.14% | -42.23% | 11.72% | 30.22% | 61.47% |
| BE | -0.65 | 1.64 | -17.50% | -30.34% | -45.05% | 13.44% | 32.23% | 66.44% |
| E | -0.68 | 1.71 | -17.25% | -29.64% | -42.86% | 12.21% | 29.26% | 61.84% |
| S | -0.69 | 1.93 | -18.00% | -30.65% | -44.96% | 14.17% | 32.98% | 67.32% |
| D | -0.71 | 1.71 | -15.49% | -26.19% | -43.80% | 11.46% | 30.57% | 61.95% |
| CF | -0.67 | 1.77 | -17.50% | -30.09% | -43.62% | 12.98% | 30.67% | 64.56% |
| EBITDA | -0.65 | 1.58 | -17.01% | -29.88% | -44.63% | 12.65% | 32.41% | 65.51% |
| EM | -0.73 | 1.89 | -17.96% | -30.66% | -42.73% | 11.55% | 29.53% | 60.57% |
| FI | -0.68 | 1.74 | -17.11% | -29.32% | -44.34% | 13.02% | 31.61% | 65.08% |

Table 1.10 Alphas and loadings of factors on asset pricing models, based on different weighting schemes during 1972-1992 .

BE is for the weighting scheme based on book value; E is for the weighting scheme based on earnings; S is for the weighting scheme based on sales; D is for the weighting scheme based on dividends; CF is for the weighting scheme based on cash flows; EBITDA is for the weighting scheme based on EBITDA; EM is for the weighting scheme based on enterprise multiples. FI is a composite fundamental weighting scheme equally based on four different financial metrics, including S, BE, CF and D. The cap-weighted benchmark is based on the 1000 largest market cap US stocks. Market factor, Small size (SMB), Value (HML), Momentum (MOM) factors, risk-free rate are obtained from WRDS Data Library. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark (During 1972-1992)

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| BE | 0.0019*** | 0.9784*** | 0.9769 |
| | (3.67) | (61.91) | |
| E | 0.0015*** | 0.9848*** | 0.9834 |
| | (3.22) | (85.76) | |
| S | 0.0021*** | 0.9999*** | 0.9715 |
| | (3.36) | (54.78) | |
| D | 0.0016*** | 0.9355*** | 0.9751 |
| | (2.81) | (72.51) | |
| CF | 0.0017*** | 0.9923*** | 0.9773 |
| | (3.27) | (72.33) | |
| EBITDA | 0.0018*** | 0.9842*** | 0.9804 |
| | (3.49) | (67.39) | |
| EM | 0.0017*** | 0.9660*** | 0.9854 |
| | (3.80) | (99.84) | |
| FI | 0.0018*** | 0.9766*** | 0.9790 |
| | (3.55) | (68.31) | |

Panel B. Use FF-3 factor as the benchmark (During 1972-1992)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| BE | 0.0008* | 1.0268*** | -0.0075 | 0.1901*** | 0.9861 |
| | (1.95) | (79.57) | (-0.40) | (8.45) | |
| E | 0.0009** | 1.0197*** | -0.0440** | 0.1074*** | 0.9866 |
| | (2.16) | (91.44) | (-2.32) | (5.05) | |
| S | 0.0006 | 1.0455*** | 0.0507** | 0.2234*** | 0.9851 |
| | (1.36) | (74.99) | (2.42) | (9.76) | |
| D | 0.0006 | 0.9974*** | -0.0815*** | 0.1882*** | 0.9864 |
| | (1.32) | (83.17) | (-4.82) | (10.06) | |
| CF | 0.0010* | 1.0317*** | -0.0330 | 0.1343*** | 0.9818 |
| | (1.96) | (80.40) | (-1.55) | (5.60) | |
| EBITDA | 0.0007* | 1.0329*** | -0.0214 | 0.1803*** | 0.9886 |
| | (1.84) | (78.81) | (-1.32) | (8.76) | |

(Table 1.10 continued)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EM | 0.0010*** | 1.0064*** | -0.0536*** | 0.1225*** | 0.9899 |
| | (2.72) | (103.66) | (-4.23) | (7.56) | |
| FI | 0.0007* | 1.0254*** | -0.0177 | 0.1841*** | 0.9877 |
| | (1.84) | (85.53) | (-1.00) | (9.15) | |

Panel C. Use Carhart 4-factor as the benchmark (During 1972-1992)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| BE | 0.0012*** | 1.0275*** | -0.0171 | 0.1813*** | -0.0382** | 0.9868 |
| | (3.06) | (81.29) | (-1.08) | (8.57) | (-2.36) | |
| E | 0.0012*** | 1.0201*** | -0.0513*** | 0.1008*** | -0.0287* | 0.9870 |
| | (3.12) | (92.66) | (-3.23) | (5.03) | (-1.69) | |
| S | 0.0011** | 1.0462*** | 0.0401** | 0.2137*** | -0.0419** | 0.9859 |
| | (2.32) | (77.52) | (2.30) | (10.22) | (-2.35) | |
| D | 0.0010** | 0.9982*** | -0.0931*** | 0.1777*** | -0.0457*** | 0.9875 |
| | (2.44) | (84.81) | (-5.97) | (10.31) | (-3.67) | |
| CF | 0.0012** | 1.0321*** | -0.0381** | 0.1297*** | -0.0201 | 0.9819 |
| | (2.59) | (80.29) | (-2.00) | (5.88) | (-0.96) | |
| EBITDA | 0.0011*** | 1.0336*** | -0.0326** | 0.1701*** | -0.0439*** | 0.9896 |
| | (2.96) | (82.50) | (-2.33) | (9.07) | (-3.18) | |
| EM | 0.0014*** | 1.0070*** | -0.0632*** | 0.1138*** | -0.0378*** | 0.9906 |
| | (3.69) | (111.69) | (-6.35) | (8.01) | (-3.44) | |
| FI | 0.0011*** | 1.0260*** | -0.0269* | 0.1758*** | -0.0360** | 0.9883 |
| | (2.91) | (87.18) | (-1.79) | (9.47) | (-2.31) | |

Panel D. Use CAPM as the benchmark (During 1972-1992)

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| BE | 0.0014 | 0.9494*** | 0.9187 |
| | (1.42) | (31.47) | |
| E | 0.0015 | 0.9080*** | 0.9125 |
| | (1.50) | (30.94) | |
| S | 0.0019* | 0.9528*** | 0.9087 |
| | (1.81) | (30.86) | |
| D | 0.0019 | 0.8460*** | 0.8526 |
| | (1.61) | (20.41) | |
| CF | 0.0015 | 0.9206*** | 0.9154 |
| | (1.53) | (31.14) | |
| EBITDA | 0.0016 | 0.9407*** | 0.9156 |
| | (1.62) | (33.09) | |
| EM | 0.0018** | 0.9274*** | 0.9236 |
| | (1.99) | (34.71) | |

(Table 1.10 continued)

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| FI | 0.0017* | 0.9172*** | 0.9099 |
| | (1.65) | (28.90) | |

Panel E. Use FF-3 factor as the benchmark (During 1993-2013)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| BE | 0.0005 | 1.0036*** | -0.0670* | 0.2440*** | 0.9575 |
| | (0.81) | (79.37) | (-1.78) | (7.23) | |
| E | 0.0010 | 0.9651*** | -0.1560*** | 0.1625*** | 0.9514 |
| | (1.44) | (56.41) | (-3.80) | (4.81) | |
| S | 0.0009 | 1.0095*** | -0.0544 | 0.2731*** | 0.9531 |
| | (1.26) | (67.02) | (-1.27) | (7.69) | |
| D | 0.0008 | 0.9269*** | -0.1453*** | 0.3142*** | 0.9445 |
| | (1.17) | (46.33) | (-5.38) | (10.86) | |
| CF | 0.0008 | 0.9758*** | -0.1173*** | 0.1945*** | 0.9523 |
| | (1.24) | (58.99) | (-2.80) | (5.96) | |
| EBITDA | 0.0008 | 0.9987*** | -0.1010*** | 0.2287*** | 0.9568 |
| | (1.21) | (69.38) | (-2.79) | (7.55) | |
| EM | 0.0012* | 0.9807*** | -0.1198*** | 0.1804*** | 0.9574 |
| | (1.85) | (71.20) | (-2.90) | (5.79) | |
| FI | 0.0007 | 0.9789*** | -0.0961*** | 0.2561*** | 0.9603 |
| | (1.22) | (73.87) | (-2.73) | (8.65) | |

Panel F. Use Carhart 4-factor as the benchmark (During 1993-2013)

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| BE | 0.0015** | 0.9546*** | -0.0469* | 0.2100*** | -0.1250*** | 0.9770 |
| | (2.25) | (68.53) | (-1.94) | (10.29) | (-5.29) | |
| E | 0.0019*** | 0.9206*** | -0.1377*** | 0.1316*** | -0.1136*** | 0.9688 |
| | (2.73) | (53.08) | (-4.79) | (5.72) | (-5.57) | |
| S | 0.0019*** | 0.9599*** | -0.0341 | 0.2387*** | -0.1268*** | 0.9728 |
| | (2.66) | (54.00) | (-1.14) | (9.62) | (-5.47) | |
| D | 0.0016** | 0.8906*** | -0.1304*** | 0.2890*** | -0.0926*** | 0.9569 |
| | (2.50) | (44.08) | (-5.91) | (10.89) | (-5.23) | |
| CF | 0.0018*** | 0.9298*** | -0.0984*** | 0.1625*** | -0.1176*** | 0.9706 |
| | (2.66) | (56.33) | (-3.39) | (7.63) | (-6.11) | |
| EBITDA | 0.0018*** | 0.9520*** | -0.0819*** | 0.1963*** | -0.1193*** | 0.9748 |
| | (2.61) | (57.32) | (-3.14) | (9.37) | (-5.41) | |
| EM | 0.0021*** | 0.9369*** | -0.1018*** | 0.1500*** | -0.1118*** | 0.9738 |
| | (3.07) | (57.55) | (-3.44) | (7.06) | (-4.54) | |
| FI | 0.0017*** | 0.9338*** | -0.0776*** | 0.2247*** | -0.1153*** | 0.9778 |
| | (2.75) | (66.10) | (-3.36) | (12.18) | (-6.08) | |

Table 1.10 also shows that EM-weighted scheme has relatively low loadings on the value factor compared with other fundamental indexation. Its loading is consistently lower than that of the composite. Panel B in Table 1.10 show that during 1972-1992 it has a loading of 0.1225 on value factor, while FI composite has a loading of 0.1841. And the sales weighting scheme has a loading of 0.2234 in the same Panel B, the highest among all fundamental weighting schemes. During 1993-2013, the loading on value factor on average is larger for different weighing schemes compared with those during 1972-1992. Panel E in Table 1.10 shows that it has a loading of 0.1804 on value factor while FI composite has a loading of 0.2561 during 1993-2013. In this period, the dividend weighting scheme has a loading of 0.2234, the highest among all fundamental weighting scheme.

### 1.5.2 Using historical average of fundamental weightings

Table 1.11 shows that EM-weighted scheme has an alpha of 10 basis points with a t-value of 2.22, for using financial accounting information in the most recent fiscal year, while both EBITDA-weighted scheme (Table 1.12) and sales-weighted scheme (Table 1.13) do not have statistically significant alphas in 3 factors model. Table 1.11 shows that when using historical fundamental data within last five years, which is the traditional way in fundamental indexation, there is also an alpha for the EM-weighting scheme with statistical significance in the 10% level when using the 3-factor model. The alpha is higher when using the CAPM model, which is 20 basis points when using the most recent fundamental accounting information and 23 basis points when using the last five years' average fundamental information.

## 1.6 Conclusion

Although there is still a debate on whether market noise can result in value and size premium, fundamental indexation gets more attention and application in both industry and academia. One dimension missed by previous research on fundamental indexation is to integrate debt information in measuring firms' economic footprint. Without information pertaining to debt, it is hard to compare values of firms with different leverage.

Table 1.11 Alphas, and loadings of different factors for EM-weighted portfolio in different asset pricing models.

Market factor (MKTRF), Small size (SMB), Value (HML), Momentum (MOM) factors, risk-free rate are obtained from Wrds Data Library. Monthly total returns from January of 1972 to December of 2013 are used for the analysis. EM_AVE_1 is the EM-weighted scheme based on last fiscal year EM ratio; EM_AVE_12 is based on average of EM ratios in last 2 fiscal years; EM_AVE_321 is based on average of EM ratios in last 3 fiscal years; EM_AVE_5 is based on average of EM ratios in last 5 fiscal years; EM_AVE_432 is based on three-year average of EM ratios beginning at the last 4th fiscal year; EM_AVE_543 is based on three-year average of EM ratios beginning at the last 5th fiscal year. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| EM_AVE_1 | 0.0020*** | 0.9324*** | 0.9356 |
| | (3.32) | (53.95) | |
| EM_AVE_12 | 0.0022*** | 0.9300*** | 0.9223 |
| | (3.30) | (45.80) | |
| EM_AVE_321 | 0.0022*** | 0.9300*** | 0.9201 |
| | (3.32) | (44.33) | |
| EM_AVE_432 | 0.0024*** | 0.9286*** | 0.9116 |
| | (3.46) | (41.79) | |
| EM_AVE_5 | 0.0023*** | 0.9244*** | 0.9152 |
| | (3.46) | (42.32) | |
| EM_AVE_543 | 0.0025*** | 0.9249*** | 0.9050 |
| | (3.45) | (38.79) | |

Panel B. Use FF-3 factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EM_AVE_1 | 0.0010** | 1.0043*** | -0.1254*** | 0.2278*** | 0.9673 |
| | (2.22) | (84.66) | (-3.84) | (7.59) | |
| EM_AVE_12 | 0.0008* | 1.0104*** | -0.0892*** | 0.3001*** | 0.9652 |
| | (1.69) | (79.80) | (-2.93) | (10.49) | |
| EM_AVE_321 | 0.0007 | 1.0118*** | -0.0810*** | 0.3139*** | 0.9655 |
| | (1.59) | (77.63) | (-2.72) | (11.10) | |
| EM_AVE_432 | 0.0008* | 1.0134*** | -0.0711** | 0.3365*** | 0.9616 |
| | (1.69) | (73.95) | (-2.44) | (11.77) | |
| EM_AVE_5 | 0.0008* | 1.0083*** | -0.0793*** | 0.3252*** | 0.9638 |
| | (1.74) | (77.71) | (-2.80) | (11.46) | |
| EM_AVE_543 | 0.0008 | 1.0121*** | -0.0673** | 0.3517*** | 0.9589 |
| | (1.63) | (72.14) | (-2.44) | (12.09) | |

(Table 1.11 continued)

Panel C. Use Carhart 4-factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| EM_AVE_1 | 0.0015*** | 0.9927*** | -0.1258*** | 0.2093*** | -0.0583*** | 0.9705 |
| | (3.32) | (84.65) | (-4.65) | (7.92) | (-3.59) | |
| EM_AVE_12 | 0.0014*** | 0.9964*** | -0.0897*** | 0.2778*** | -0.0706*** | 0.9699 |
| | (3.23) | (83.54) | (-3.78) | (10.56) | (-4.59) | |
| EM_AVE_321 | 0.0014*** | 0.9975*** | -0.0815*** | 0.2912*** | -0.0720*** | 0.9703 |
| | (3.18) | (80.84) | (-3.53) | (11.27) | (-4.65) | |
| EM_AVE_432 | 0.0015*** | 0.9993*** | -0.0716*** | 0.3142*** | -0.0709*** | 0.9663 |
| | (3.16) | (72.75) | (-3.13) | (12.10) | (-4.34) | |
| EM_AVE_5 | 0.0014*** | 0.9945*** | -0.0797*** | 0.3033*** | -0.0693*** | 0.9682 |
| | (3.23) | (76.26) | (-3.58) | (11.72) | (-4.26) | |
| EM_AVE_543 | 0.0014*** | 0.9981*** | -0.0677*** | 0.3294*** | -0.0704*** | 0.9635 |
| | (3.07) | (68.79) | (-3.11) | (12.67) | (-4.08) | |

Table 1.12 Alphas, and loadings of different factors for EBITDA-weighted portfolio in different asset pricing models.

Market factor (MKTRF), Small size (SMB), Value (HML), Momentum (MOM) factors, risk-free rate are obtained from Wrds Data Library. Monthly total returns from January of 1972 to December of 2013 are used for the analysis. EBITDA_AVE_1 is the EBITDA-weighted scheme based on last fiscal year EBITDA; EBITDA_AVE_12 is based on the average of EBITDA in last 2 fiscal years; EBITDA_AVE_321 is based on the average of EBITDA in last 3 fiscal years; EBITDA_AVE_5 is based on the average of EBITDA in last 5 fiscal years; EBITDA_AVE_432 is based on three-year average of EBITDA beginning at the last 4th fiscal year; EBITDA_AVE_543 is based on three-year average of EBITDA beginning at the last 5th fiscal year. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| EBITDA_AVE_1 | 0.0019*** | 0.9445*** | 0.9069 |
| | (2.71) | (41.60) | |
| EBITDA_AVE_12 | 0.0022*** | 0.9486*** | 0.8892 |
| | (2.79) | (36.73) | |
| EBITDA_AVE_321 | 0.0022*** | 0.9491*** | 0.8860 |
| | (2.77) | (35.79) | |
| EBITDA_AVE_432 | 0.0022*** | 0.9501*** | 0.8756 |
| | (2.69) | (33.64) | |
| EBITDA_AVE_5 | 0.0022*** | 0.9477*** | 0.8769 |
| | (2.69) | (34.31) | |
| EBITDA_AVE_543 | 0.0022** | 0.9485*** | 0.8634 |
| | (2.56) | (32.04) | |

(Table 1.12 continued)

Panel B. Use FF-3 factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| EBITDA_AVE_1 | 0.0003 | 1.0388*** | -0.1034*** | 0.3529*** | 0.9634 |
| | (0.65) | (79.64) | (-3.87) | (11.76) | |
| EBITDA_AVE_12 | 0.0002 | 1.0499*** | -0.0754*** | 0.4107*** | 0.9576 |
| | (0.37) | (72.79) | (-2.92) | (12.58) | |
| EBITDA_AVE_321 | 0.0001 | 1.0513*** | -0.0696*** | 0.4200*** | 0.9564 |
| | (0.26) | (69.15) | (-2.68) | (12.38) | |
| EBITDA_AVE_432 | 0.0000 | 1.0551*** | -0.0607** | 0.4410*** | 0.9508 |
| | (0.05) | (61.98) | (-2.29) | (11.76) | |
| EBITDA_AVE_5 | 0.0000 | 1.0527*** | -0.0686*** | 0.4342*** | 0.9512 |
| | (0.09) | (64.58) | (-2.66) | (11.85) | |
| EBITDA_AVE_543 | -0.0001 | 1.0566*** | -0.0583** | 0.4582*** | 0.9432 |
| | (-0.19) | (57.77) | (-2.18) | (11.16) | |

Panel C. Use Carhart 4-factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| EBITDA_AVE_1 | 0.0010** | 1.0239*** | -0.1039*** | 0.3292*** | -0.0749*** | 0.9684 |
| | (2.34) | (89.01) | (-5.13) | (12.09) | (-5.03) | |
| EBITDA_AVE_12 | 0.0009** | 1.0347*** | -0.0759*** | 0.3865*** | -0.0765*** | 0.9626 |
| | (2.05) | (83.50) | (-3.84) | (13.06) | (-4.74) | |
| EBITDA_AVE_321 | 0.0008** | 1.0356*** | -0.0701*** | 0.3951*** | -0.0788*** | 0.9617 |
| | (1.98) | (80.23) | (-3.53) | (12.90) | (-4.65) | |
| EBITDA_AVE_432 | 0.0008* | 1.0388*** | -0.0613*** | 0.4151*** | -0.0820*** | 0.9564 |
| | (1.73) | (71.87) | (-2.95) | (12.37) | (-4.32) | |
| EBITDA_AVE_5 | 0.0008* | 1.0368*** | -0.0691*** | 0.4089*** | -0.0799*** | 0.9567 |
| | (1.77) | (74.19) | (-3.42) | (12.48) | (-4.46) | |
| EBITDA_AVE_543 | 0.0007 | 1.0401*** | -0.0588*** | 0.4319*** | -0.0832*** | 0.9490 |
| | (1.43) | (66.43) | (-2.73) | (11.82) | (-4.17) | |

Table 1.13 Alphas, and loadings of different factors for Sales-weighted in different asset pricing models.

Market factor (MKTRF), Small size (SMB), Value (HML), Momentum (MOM) factors, risk-free rate are obtained from Wrds Data Library. Monthly total returns from January of 1972 to December of 2013 are used for the analysis. S_AVE_1 is the Sales-weighted scheme based on last fiscal year sales; S_AVE_12 is based on average of sales in last 2 fiscal years; EM_AVE_321 is based on average of sales in last 3 fiscal years; EM_AVE_5 is based on average of sales in last 5 fiscal years; EM_AVE_432 is based on three-year average of sales beginning at the last 4th fiscal year; EM_AVE_543 is based on three-year average of sales beginning at the last 5th fiscal year. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| S_AVE_1 | 0.0023*** | 0.9775*** | 0.9049 |
| | (3.03) | (40.18) | |

(Table 1.13 continued)

| DEPVAR | INTERCEPTS | MKTRF | ADJRSQ |
|---|---|---|---|
| S_AVE_12 | 0.0026*** | 0.9817*** | 0.8956 |
| | (3.20) | (37.57) | |
| S_AVE_321 | 0.0026*** | 0.9822*** | 0.8933 |
| | (3.16) | (36.97) | |
| S_AVE_432 | 0.0026*** | 0.9814*** | 0.8876 |
| | (3.11) | (35.71) | |
| S_AVE_5 | 0.0026*** | 0.9796*** | 0.8882 |
| | (3.09) | (35.83) | |
| S_AVE_543 | 0.0026*** | 0.9777*** | 0.8817 |
| | (3.02) | (34.56) | |

Panel B. Use FF-3 factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | ADJRSQ |
|---|---|---|---|---|---|
| S_AVE_1 | 0.0003 | 1.0560*** | 0.0157 | 0.3842*** | 0.9565 |
| | (0.63) | (60.91) | (0.35) | (9.78) | |
| S_AVE_12 | 0.0004 | 1.0629*** | 0.0397 | 0.4182*** | 0.9550 |
| | (0.74) | (61.79) | (0.88) | (10.69) | |
| S_AVE_321 | 0.0003 | 1.0640*** | 0.0445 | 0.4252*** | 0.9543 |
| | (0.64) | (61.23) | (0.98) | (10.80) | |
| S_AVE_432 | 0.0003 | 1.0656*** | 0.0478 | 0.4395*** | 0.9525 |
| | (0.52) | (60.42) | (1.06) | (11.05) | |
| S_AVE_5 | 0.0003 | 1.0646*** | 0.0408 | 0.4369*** | 0.9528 |
| | (0.53) | (60.81) | (0.90) | (11.04) | |
| S_AVE_543 | 0.0002 | 1.0649*** | 0.0458 | 0.4515*** | 0.9503 |
| | (0.40) | (59.81) | (1.01) | (11.26) | |

Panel B. Use Carhart 4-factor as the benchmark

| DEPVAR | INTERCEPTS | MKTRF | SMB | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| S_AVE_1 | 0.0012** | 1.0383*** | 0.0151 | 0.3560*** | -0.0891*** | 0.9630 |
| | (2.23) | (63.10) | (0.42) | (10.27) | (-4.69) | |
| S_AVE_12 | 0.0013** | 1.0442*** | 0.0391 | 0.3884*** | -0.0940*** | 0.9622 |
| | (2.41) | (64.83) | (1.10) | (11.30) | (-4.78) | |
| S_AVE_321 | 0.0013** | 1.0446*** | 0.0439 | 0.3943*** | -0.0976*** | 0.9620 |
| | (2.38) | (64.79) | (1.24) | (11.49) | (-4.88) | |
| S_AVE_432 | 0.0012** | 1.0456*** | 0.0472 | 0.4077*** | -0.1008*** | 0.9607 |
| | (2.29) | (63.93) | (1.34) | (11.85) | (-4.83) | |
| S_AVE_5 | 0.0012** | 1.0446*** | 0.0401 | 0.4052*** | -0.1004*** | 0.9609 |
| | (2.29) | (64.03) | (1.15) | (11.84) | (-4.88) | |
| S_AVE_543 | 0.0012** | 1.0442*** | 0.0451 | 0.4186*** | -0.1040*** | 0.9590 |
| | (2.18) | (63.21) | (1.29) | (12.19) | (-4.90) | |

This essay is the first to use enterprise-multiple-based weighting scheme, which is the multiplication of market equity value and reverse of the enterprise multiple, in constructing the long only active index. This weighting scheme not only incorporates debt information when measuring fundamentals of the firms but also implicitly integrates market information. Both dimensions are missed in the traditional fundamental indexation. The new weighing scheme has the highest information ratio of 0.73 during 1972–2013, compared with other six individual fundamental indexes weighted by different schemes, including book-equity weighted, earnings-weighted, sales-weighted, dividends-weighted, cash-flow-weighted and EBITDA-weighted schemes. The information ratio is also 35.19% larger than that of the composite of of fundamental indexes, which is equally based on four fundamental metrics of S, BE, CF and D. It is also 19.67% larger than that of the sales-weighted indexation, the highest in the above six fundamental indexes. Further research shows that there is alpha for EM-weighting scheme when using 3- factor model, which distinguishes the EM-weighting scheme from all other traditional fundamental indexation, and the alpha is due to the combination of debt and market information integrated in the weighting scheme.

## Chapter 2: Is Smart Beta Still Smart Under the Lens of Diversification Return?

### 2.1 Introduction

Recently there is a surge of interests in alternative weighting strategies (so-called smart beta strategies) with the development and evolution of the indexing industry. Traditional indices are weighted by market capitalization because it is the only weighting scheme that all investors can passively hold the markek,t at the same time based on the capital asset pricing model (CAPM), which is a buy and hold strategy without future rebalancing. On the other hand, the cap-weighted index can suffer from concentration of risks in a specific firm, sector or country. Cap-weighted index may not be mean-variance efficient in reality because it is a poor approximation for the real market proxy (Roll and Ross 1994). Based on ex-post results, the cap-weighted index is sub-optimal to other indices using alternative weighting schemes (Amène, Goltz, and Martellini 2011). Chow, Hsu, Kalesnik and Little (2011) points out that outperformance of alternative weighting schemes are due to high loadings on value factor. This is consistent with conclusions from Arnott and Hsu (2008), who shows that non-price weighting schemes using regular rebalancing naturally result in a positive value factor. Arnott, Hsu, Kalesnik and Tindall (2013) shows that incremental returns for different investment theses come from tilting to value and size factors. The authors argue that because cap-weighted strategies implicitly have a large weighting on the stocks with high prices, the strategy will automatically result in lower returns compared with all other weighting schemes which employ non-price valuation metrics.

A key finding in this essay is that outperformance of different weighting schemes can be explained by a diversification return. While traditional insights (Asness 2006, Arnott, Hsu, Kalesnik and Tindall 2013) propose that it is due to tilting to value and size factors for the outperformance of alternative weighting schemes, this essay is the first to demonstrate that diversification return is a key driver for the returns of these alternative weighting schemes. It reveals that the outperformance of smart beta can come from capturing the diversification return via portfolio rebalancing, and suggests that in order for the smart beta to be smart, it should not only harvest different risk premium effectively but also capture diversification return smartly. This is consistent with the spirit of dynamic index proposed by Lo (2015). Further tests show that results are also robust under alternative benchmark used by Cremers, Petajisto, and Zitzewitz (2013). They shows that passive benchmarks can have statistically significant and economically meaningful alphas when using Fama-French 3-factor or Carhart's 4-factor models.

One innovation in this essay is about constructing new alterative weighting schemes. Alternative weighting schemes usually can be categorized into two classes, including "heuristic" techniques and "optimization techniques" (Hsu, Kalesnik, and Little, 2011). Although "optimization techniques" seem to have a sound theoretical foundation, these techniques frequently end up with sub-optimal returns due to huge estimation errors, such as for estimation of the correlation matrix (Arnott & Hsu 2013). Compared with cap-weighted, equally-weighted and fundamental-weighted schemes are other two popular heuristic weighting schemes. This essay spans the weighting schemes of cap-weighted (Vw), equal-weighted (Ew), and fundamental-weighted (Fw) into a 3X3 matrix based on an industry level first and then on a stock level within an industry, and systematically compares risks and returns of these alternative weighting schemes. Spanning weighting schemes into a 3X3 matrix is partially motivated to capture value premium more efficiently. Although fundamental weighting scheme bases on a noise-hypothesis, other research (Asness 2006) points out that the strategy implicitly tilts into the value factor. Also, Chou, Ho and Ko (2012) show that the value factor is more related to the intra-industry phenomenon. One of the essay's focuses is to exam the fundamental-weighted scheme within each industry. More details about the construction of the weighting schemes are provided in the experimental design in section 2.3.2.

A fundamental question implied in this essay for asset pricing is whether portfolio returns exactly reflect underlying stock returns that a portfolio method tries to reflect. Booth and Fama (1992) demonstrate that portfolio returns come from two components: the first one is from returns of underlying stocks and the other one is from diversification return, which is related to the difference of the weighted variance of stock returns and the variance of the portfolio. This essay applies the diversification return to evaluate smart beta strategies and finds that the diversification return can explain outperformance of these strategies. The findings are also consistent with results from Ferholz and Shay (1982), and Greene and Rakowski (2015). Greene and Rakowski (2015) compare the real premium of size and value factors when considering diversification returns with those in Fama-French 3-factor model, while this essay focuses on performance measurement and tries to explain the source of returns for alternative weighing schemes.

The following essay is organized in this way: Section 2.2 is for literature review; section 2.3 describes diversification returns, data, and methodology to constructing indexes weighted by different methods; empirical risk and return analyses of different weighing schemes is integrated in section 2.4; robustness checks and the conclusion are followed in section 2.5 and 2.6, respectively.

## 2.2 Literature Review

### 2.2.1 Alternative weighting schemes

DeMiguel, Garlappi, and Uppal (2009) demonstrates that gains of optimization methods could be less than the estimation errors of parameters in these methods and that the optimization methods usually can't outperform 1/N weighting strategy. The competitive properties of 1/N weighting strategy are also indicated by Chan et. al. (1999) and Jagannathan and Ma (2003). Pflug, Pichler and Wozabal (2012) show that 1/N strategy is actually a rational strategy in stochastic portfolio decision problems. On the other hand, there is a psychological bias for an investor to use 1/N strategy based on experimental findings of Benartzi and Thaler (2001), where investor's choice of 1/N strategy is independent of the risk appetite of funds with different risks. This is due to cognitive bias which has been documented by Tversky and Kahneman (1981) and Kahneman (2003). In reality, even Markowitz also applied 1/N strategy when managing his own funds (Zweig, 1998). Implicitly, the equal weighting scheme tilts into the size and value stocks. Arnott, Hsu, Kalesnik and Tindall (2013) consider equal-weighted scheme as an effective approach for capturing the mean-reversion of stock prices. Under this weighting scheme, the portfolio buys stocks that have relative fallen prices and sell stocks that have relative rising prices, compared with other stocks.

Arnott et al. (2005) first introduce the innovative fundamental indexation. They show that fundamental indexation can outperform the traditional cap-weighted index. This is further confirmed by Tamura and Shimizu (2005) who demonstrate that global fundamental index can also outperform the cap-weighted benchmark of MSCI World and FTSE between 1988 and 2005. Walkshaul and Lobe (2009) use net payout as a metrics to measure a firm's fundamentals. The dividends-weighted scheme is applied by Estrada (2008), which shows that during 1974-2005 the weighting strategy outperforms the corresponding cap-weighted index. Hemminki and Puttonen (2008) find that in European stock markets fundamental indexation also has higher risk-adjusted returns than the capitalization-weighted index.

### 2.2.2 Weighting schemes and the role of industry

As for fundamental indexation, Asness (2006) points out that these fundamental indexes just implicitly tilt into the value factor. In order to design fundamental indexation that could capture value premium deeply,this essay also use two-level weighting schemes: the first level is based on inter-industry weighting and the second one is based on intra-industry weighting.

Intuitively, there is no role for industries to play in traditional asset pricing modes, because the supply and demand for a financial asset is infinitely elastic when there is no market friction (Chou, Ho, and Ko, 2012). On the other hand, firms in the same industry are related. They are in competitive positions when producing similar products, and in a cooperative position when producing complementary products. The properties of competition and cooperation within-industry will strengthen comovements of stock returns in the same industry. This may imply more non-diversifiable risk within the same industry, so additional factor is needed to address this concern. Moskowitz and Grinblatt (1999) document that correlations of stock returns within an industry are on average higher than those across industries. Hou and Robinson (2006) demonstrates that stocks in concentrated industries have lower returns because there are less risky due to higher barriers to entry and less competition within the industries. They use Herfindahl index for each industry to detect the across-industry premium. Hou (2007) explains that the industry momentum is primarily driven by the intra-industry lead-lag effect. Chan et al. (2007)

also show that large stocks have higher return comovement compared with small stocks within an industry. Hong (2007) indicates that information in lead industries can be used to forecast economic and the whole market returns. Although prior empirical evidence shows that industry plays a role in stock returns, it is not clear whether this is due to unidentified rational asset factors or due to investor's behavioral activities, i.e., mispricing. Barberis and Shleifer (2003, 2005) theoretically prove that the higher return comovement within a style investment can be due to investor sentiment. Kumar and Lee (2006) further show that investors may treat different industries as styles, resulting in a high return comovement within an industry.

As for the value factor, Fama and French (1997) show that HML factor loadings vary considerably across industries and with time horizon, and point out that there is a difficulty for three-factor model to explain returns of portfolio grouped by industry. This was further confirmed by Lewellen et al. (2010). Cohen and Polk (1996) and Nelson (2006) also show that value effect exits across industries but it is much less significant than that in a firm level. It is intuitive to imagine that different industries have different average BE/ME characteristics due to different capital structures. This may explain why Houge and Loughran (2006) observe that it is hard for money managers to harvest value premium as indicated in the academic literature. Because they allocate assets to stocks with relative high BE/ME, and these stocks may just concentrate in a few industries.

Banko and Conover (2006) shows that industry affiliation plays a role in the value effect. They demonstrate that the value premium is related to the variation of BE/ME both within industries and across industries. Their results also show that intra-industry variation in BE/ME is much more important than that across industries. This is confirmed by Chou, Ho, and Ko (2012), who demonstrates that value effect is essentially an intra-industry phenomenon when using BM ratios as a proxy for value/growth stocks. BM premium comes from stocks within the industry and not from across industries. Based on the above researches on intra-industry value premium, the essay breaks down the whole weighting schemes into inter-industry and intra-industry to capture value premium more deeply.

### 2.2.3 Diversification Return

Detailed information about diversification returns can be referred to Booth & Fama (1992). A stochastic version of the diversification return is proposed in Fernholz and Shay (1982), where it is referred as "excess growth rate". The following section focuses on the calculation of the diversification return. For a stock i, $\overline{G}_i(h)$ is defined as the geometric return during a period with time horizon of h; $\overline{R}_i(h)$ is defined as the arithmetic return for stock i during the same time period. Based on Taylor expansion, the average compound return ( $\overline{G}_i(h)$ ) can be approximated by the difference of average holding period return ( $\overline{R}_i(h)$ ) and the one half of the stock i's variance during period h:

$$\overline{G}_i(h) \approx \overline{R}_i(h) - \sigma_i^{\,2}(h)/2 \qquad (1)$$

For a portfolio P, similarly, the average compound return ( $\overline{G}_P(h)$ ) can be approximated by similar relationship:

$$\overline{G}_P(h) \approx \overline{R}_P(h) - \sigma_P^{\,2}(h)/2 \qquad (2)$$

Where $\overline{G}_P(h)$ can be approximated by the difference between the average return during the holding period for the portfolio $\overline{R}_P(h)$ and it's the corresponding variance during the period h.

On the other hand,

$$\overline{R}_p(h) = \sum_i w_i \overline{R}_i(h) \qquad (3)$$

, where $\overline{R}_p(h)$ is the average return of a portfolio, P, and $\overline{R}_i(h)$ is the average return for an individual stock i. The weighting of individual stock i is expressed as $w_i$, which has the properties of $1 = \sum_i w_i$ . This relationship exist only if $w_i$ is held constant in period h (Willenbrock and Scott 2011). Although all alternative weighting schemes in this essay do not have a constant weighting for each stock, they do have portfolio rebalances in each period, which implicitly pushes wi to be nearly constant to captures properties of above formula.

The above equation implies that arithmetic average return of the portfolio, $\bar{R}_P$, is equal to the sum of the arithmetic average returns of individual stocks, $\bar{R}_i$. Extract $\bar{R}_P$ and $\bar{R}_i$, respectively from formula (1) and (2) and plug them into formula (4) to get:

$$\overline{G}_P(h) + \sigma_P{}^2(h)/2 \approx \sum_i w_i(\overline{G}_i(h) + \sigma_i{}^2(h)/2) \qquad (4)$$

Arrange (4) to get:

$$\overline{G}_P(h) \approx \sum_i w_i \overline{G}_i(h) + \tfrac{1}{2}(\sum_i w_i \sigma_i{}^2(h) - \sigma_P{}^2(h)) \qquad (5)$$

Let

$$\overline{G}_P^{DR}(h) \approx \tfrac{1}{2}(\sum_i w_i \sigma_i{}^2(h) - \sigma_P{}^2(h)) \qquad (6)$$

where $\overline{G}_P^{DR}(h)$ is defined as the portfolio's diversification return (or portfolio's excess growth rate), which is equal to the half of difference of the sum of weighted individual stock i's variance and portfolio's variance during the period h. The essential part of the diversification return, i.e., the difference of the sum of weighted individual stock i's variance and portfolio's variance, is also used as an independent variable in regressions later in portfolio performance measurement.

Formula (5) implies that the average compound return ($\overline{G}_P(h)$) of a portfolio is composed of two components: the first one is equal to the sum of the average geometric return ($\overline{G}_i(h)$) of individual stock i; the second one is from the portfolio's diversification return, which is equal to one-half of the difference between the weighted average of individual asset's variance and the portfolio variance in formula (6). Formula (6) implies that in order to improve diversification return not only should the portfolio variance be minimized but also individual asset variance in the portfolio should be considered at the same time.

This essay proposes that for all these alternative weighting schemes, which implicitly use rebalancing, their geometric returns are boosted by a weighted average of volatilities of stocks in these portfolios, resulting in the outperformance of these alternative investing strategies.

Based on above analysis, the source of returns for a portfolio can be due to individual stock's returns, or the covariance of stock returns in the portfolio. Inspired by Greene and Rakowski (2015), I provide an example in Table 2.1 to show the difference. Table 2.1 shows that there are four stocks A1, A1', B1, B1' with returns in two periods T1 and T2.

First, Panel B in Table 2.1 shows that average of log returns of the portfolio (A+B) is quite different from the sum of the average of log returns of individual returns during multiple periods. For example, during periods of T1 and T2, the portfolio's average log return is 0.95555 in panel B, which puts equal weights on stock A and stock B at the beginning of each period, but the average log return for each stock is quite different. Either Stock A or stock B has an average log return of zero during these two periods, and the sum of the log returns for A and B is also equal to zero. In this case, the portfolio average return comes from covariance of returns for the stocks during the time horizon. This is different from the source of returns for portfolio (A'+B') in Panel D of

Table 2.1 Illustration of the sources of returns for constituent assets and their portfolios

| Panel A | Returns: r | | | |
|---|---|---|---|---|
| Equal Weight | T1 | T2 | Average | Variance |
| A | 400% | -80% | 160% | 5.7600 |
| B | -80% | 400% | 160% | 5.7600 |
| Portfolio(A+B) | 160% | 160% | 160% | 0.0000 |

| Panel B | Log Returns : ln(1+r) | | | |
|---|---|---|---|---|
| Equal Weight | T1 | T2 | Average | Variance |
| A | 1.6094 | -1.6094 | 0.0000 | 2.5902 |
| B | -1.6094 | 1.6094 | 0.0000 | 2.5902 |
| Portfolio(A+B) | 0.9555 | 0.955 | 0.955 | 0.0000 |

| Panel C | Returns: r | | | |
|---|---|---|---|---|
| Equal Weight | T1 | T2 | Average | Variance |
| A' | 160% | 160% | 160% | 0.0000 |
| B' | 160% | 160% | 160% | 0.0000 |

(Table 2.1 continued)

| Equal Weight | T1 | T2 | Average | Variance |
|---|---|---|---|---|
| Portfolio(A'+B') | 160% | 160% | 160% | 0.0000 |

| Panel D | | Log Returns: ln(1+r) | | |
|---|---|---|---|---|
| Equal Weight | T1 | T2 | Average | Variance |
| A' | 0.9555 | 0.955 | 0.955 | 0.0000 |
| B' | 0.9555 | 0.955 | 0.955 | 0.0000 |
| Portfolio(A'+B') | 0.9555 | 0.955 | 0.955 | 0.0000 |

Table 2.1,where the portfolio average return comes directly from individual stock's return. This essay focuses on the source of portfolio average return in multiple periods when doing portfolio rebalancing, which can be different from source of underlying stock's returns. This is also different from traditional concept that the average geometric return (log return) for a stock is different from the log of the average return for the stock in the multiple periods. The traditional concept just focuses on a single stock but not a portfolio.

The expected return, which is an arithmetic return, of a portfolio may not tell the whole story for the long-term performance of a portfolio. Two portfolios with equal expected returns could have totally different performance in the long term, if they have a different probability distribution of the expected returns. Fama-Macbeth regressions employed in asset pricing model implicitly use the average of the arithmetic returns but not the log returns. This might cause a bias in the performance measurement, especially when the distribution of returns is not normal. Log returns are used for performance measurement later when using different asset pricing models in this essay.

## 2.3 Methodology and Data

### 2.3.1 Data and Index construction

Indexes in this essay are constructed by using the 1000 largest US stocks by market cap each year during January 1972 and December 2010. Monthly stock prices are obtained from Center for Research on Security Prices (CRSP) database at the University of Chicago. All accounting information is from Compustat database in Wharton Research Data Services (WRDS). Different fundamental metrics, including book value (BE), sales (S), dividends (D) and cash flow (CF) are used to construct the composite of fundamental indexation, which is equally based on above four financial metrics. More information about the data and index construction can be referred in section 1.3.1.

### 2.3.2 Experimental design (weighting schemes)

The weighting scheme is first based on weighting in an industry level, and then weighting based on a stock level within an industry. For example, an Ew-Fw weighting scheme means that a stock in the portfolio is first equally weighted in different industries and then fundamentally weighted within its industry. A Fw-Ew weighting scheme first assigns weights for different industries based on fundamental metrics in an industry level and then equally weighs each stock within its industry. Traditional cap-weighted scheme, Vw-Vw, can be found on the first item of diagonal of Table 2.2. Fw-Fw weighting is on the third idem of the diagonal.  This essay extends analytics to off-diagonal weighting schemes and focuses more on weighting schemes of combining equal-weighted and fundamental-weighted schemes based on above analysis.

Table 2.2 Illustration of a 3X3 weighting matrix based on a combination of weightings in a inter-industry level first and then in a within-industry level

| | Cap-weighted (Inter-industry) | Equal-weighted (Inter-industry) | Fundamental-weighted (Inter-industry) |
|---|---|---|---|
| Cap-weighted (Within industry) | Vw-Vw | Ew-Vw | Fw-Vw |
| Equal-weighted (Within industry) | Vw-Ew | Ew-Ew | Fw-Ew |
| Fundamental-weighted (Within industry) | Vw-Fw | Ew-Fw | Fw-Fw |

2.3.3 Performance evaluation

Sharpe ratio, information ratio, and Sortino ratio are mainly used to measure the index's performance. More details about calculation of these parameters can be referred in section 1.3.3.

2.3.4 Measurement of risk with different asset pricing models

Except for CAPM, Fama-French's 3-factor, and Cahart's 4-factor models (details of the models can be referred in section 1.3.4), Fama-French's 5-factor model (Fama and French, 2014) is also applied to measure the performance of different weighting schemes in this essay:

$$R_{it} - R_{ft} = \alpha_i + \beta_{1i}(R_{mt} - R_{ft}) + \beta_{2i}SMB_t + \beta_{3i}HML_i + \beta_{4i}RMW_t + \beta_{5i}CMA_i + \varepsilon_{it} \qquad (4)$$

Where RMWt and CMAt are constructed in the same way as HMLt. RMWt is interpreted as the average of operating profitability (robust minus weak) for small and big stocks, and CMAt is interpreted as the average of investment (conservative minus aggressive) for small and big stocks. Data source for this 5-factor model is provided from Kenneth French's web page.

Cremers, Petajisto, and Zitzewitz (2013) show that passive benchmarks such as S&P 500 and Russell 2000 can have statistically significant and economically meaningful alphas when using fama-french 3-factor model or Carhart 4-factor model. They demonstrate that this is due to overweight on small value stocks for the construction of Fama-French factors, and also due to underperformance of other types of securities, such as closed-end funds and REITs, which have been included in the CRSP value-weighted market index for measuring U.S. stocks performance. In order to alleviate bias from downward-biased CRSP value-weighted market index for US stock when using fama-french factors, this essay also uses 4-factor adjusted model proposed by Cremers, Petajisto and Zitzewitz (2013). In the adjusted model, market factor is constructed by the return difference of S&P 500 and the risk-free rate; size factor (SML) is constructed by the return difference of Russell 2000 and S&P 500; value factor (HML) is constructed by the return difference of Russell 3000 Value and Russell 3000 Growth; momentum factor is the same as that in Carhart's 4-factor model.

**2.4 Results and Discussion**

2.4.1 Cumulative returns and weightings in different sectors

Figure 2.1 shows cumulative returns for different weighting strategies, including capitalization-weighting scheme, during January of 1972 and December of 2013. One dollar invested at the beginning of 1972 can grow into $68.63

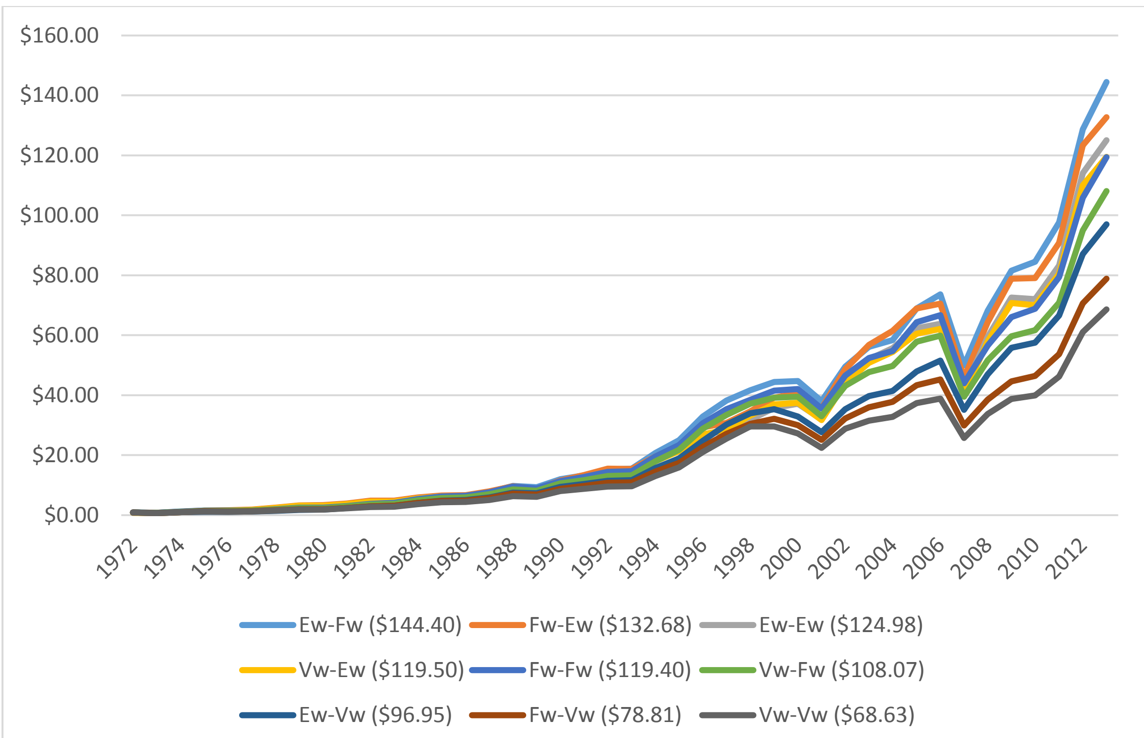



Figure 2.1 Cumulative returns of indexes during 1972–2013.

All different weighting schemes use industry weighting scheme first and then use individual stock weighting scheme within its specific industry. There are nine different weighting schemes. Vw means cap-weighted; Ew means equal-weighted and Fw means fundamental-weighted. Industries are based on Fama-French 12 industry divisions. For example, Vw-Vw weighting scheme is first weighted by market capitalization for Fama-French 12 industries then weighted by stock market capitalization within its specific industries; in the same way, Ew-Fw weighting scheme is first equally weighted by industries and then fundamentally weighted for each stock within its industry.

when using Vw-Vw weighting scheme, and it grows into $124.98 and $119.40, respectively, when using the Ew-Ew and Fw-Fw schemes. All above weighting schemes are first weighted in an industry level and then in a firm level within its industry. The above weighting schemes are in the diagonal of the weighting matrix in Table 2.2. For example, Fw-Fw weighting scheme is first fundamental-weighted by Fama-French 12 industries then fundamental-weighted by stocks within their industries.

Weighting schemes in the first row or first column (except for Vw-Vw weighted scheme), such as Ew-Vw, Fw-Vw, Vw-Ew, and Vw-Fw, have higher cumulative terminal returns compared with that of the Vw-Vw weighted scheme. For example, Ew-Vw weighting scheme, which is first equal-weighted by Fama-French 12 industries and then cap-weighted by stocks within their industries, has a cumulative return of $96.95 at the end of 2013. On the other hand, Ew-Vw weighting scheme ($96.95) has a lower cumulative return than Vw-Ew weighting scheme ($119.50), and Fw-Ew weighting scheme ($132.68) has a higher cumulative return than Vw-Ew weighting scheme ($119.50). Here Fw-Vw weighting scheme is essentially similar to that used by Obunn et al. (2014), who propose that industries with lower CAPE ratio have higher 10-year long run cross-sectional returns. Ew-Fw weighting scheme is based on the rationalness that value premium is an intra-industry phenomenon.

Fw-Ew and Ew-Fw weighting schemes have higher cumulative returns, $132.68 and $144.40 respectively, compared with Ew-Ew weighting ($124.98) and Fw-Fw weighting ($78.81). The Ew-Fw weighting scheme is based on the reason that 1/N weighting scheme is a competitive weighting scheme, and that value premium is an intra-industry phenomenon. This essay is the first to propose these two new weighting schemes.

Figure 2.1 shows that cap-weighted indexes underperform all other alternative weighting schemes, which is consistent with that from Arnott et al. (2005). Table 2.3 shows that cumulative returns for different weighting schemes in periods ending in different times, including the time before and after stock crash in 1987, the time before and after stock bubble around 2000, and the time before and after 2008 crisis. Results show that Vw-Vw weighting scheme has the lowest cumulative return. Results also show that Ew-Fw weighting scheme has higher

Table 2.3 Cumulative returns of indexes weighted by different schemes during different periods.

All different weighting schemes use industry weighting scheme first and then use individual stock weighting scheme within its specific industry. There are nine different weighting schemes. Vw means cap-weighted; Ew means equal-weighted and Vw means fundamental-weighted. Industries are based on Fama-French 12 industry divisions. For each matrix, columns represent different weighting schemes based on an industry level, and rows represent weighting schemes based on a stock level within each industry.

| | Inter industry | | | | Inter industry | | |
|---|---|---|---|---|---|---|---|
| | 1972-1987 | | | | 1972-1989 | | |
| | Vw | Ew | Fw | | Vw | Ew | Fw |
| Vw | 5.06 | 5.89 | 5.65 | Vw | 6.08 | 7.21 | 6.81 |
| Ew | 7.3 | 7.28 | 7.86 | Ew | 7.98 | 7.75 | 8.61 |
| Fw | 6.9 | 7.7 | 7.59 | Fw | 8.12 | 9.26 | 8.87 |
| Within industry | 1972-2000 | | | | 1972-2002 | | |
| | Vw | Ew | Fw | | Vw | Ew | Fw |
| Vw | 27.15 | 32.91 | 30.01 | Vw | 28.82 | 35.29 | 32.21 |
| Ew | 37.46 | 37.14 | 40.61 | Ew | 44.07 | 44.55 | 48.65 |
| Fw | 39.51 | 44.72 | 42.03 | Fw | 43.11 | 49.5 | 46.56 |
| | 1972-2007 | | | | 1972-2009 | | |
| | Vw | Ew | Fw | | Vw | Ew | Fw |
| Vw | 25.69 | 35.12 | 29.86 | Vw | 38.75 | 55.75 | 44.61 |
| Ew | 40.42 | 41.78 | 45.8 | Ew | 70.75 | 59.44 | 78.83 |
| Fw | 39.51 | 49.9 | 43.91 | Fw | 59.61 | 81.55 | 65.99 |

cumulative return compared with Fw-Fw weighting scheme, indicating that 1/N strategy is competitive when it is applied in an industry level weighting scheme.

2.4.2 Returns and Sharpe ratio analysis

Table 2.4 shows that Vw-Vw weighting scheme has the lowest geometric return within all nine different weighting schemes during 1972-2013. The Ew-Fw weighting scheme has a mean annual geometric return of 12.57% and Fw-Ew has a mean annual geometric return of 12.34%, which is higher than that of the Vw-Vw weighting scheme by 198 points and 175 basis points per year, respectively. These weighting schemes still outperform a Vw-Vw weighting scheme if transaction cost is assumed to be 30 basis points per year, which is usually less than 10 basis points for block traders in the current market. Compared with Fw-Fw weighting, Ew-Fw weighing scheme still outperforms when similar transaction cost is considered. Within all the nine different weighing schemes, Ew-Fw weighing scheme has the highest geometric return. On the other hand, the Fw-Ew weighing scheme has higher volatility (16.76%) compared with that of theVw-Vw weighting scheme, while the Ew-Fw weighting scheme has lower annual volatility (14.89%) compared with that (15.22%) of the Vw-Vw weighing scheme.

All these alternative weighing schemes have positive excess returns when compared with the Vw-Vw weighting scheme, which vary from 0.42 for the Fw-Vw weighing scheme to 2.18 for the Fw-Ew weighing scheme. The annualized Sharpe ratio is used to measure the excess return to risk-free rate per unit of risk. It shows that the Ew-Fw weighing scheme has a Sharpe ratio of 0.44, which is 13% higher than that of the Vw-Vw weighting scheme. All other weighting schemes have higher Sharpe ratios compared with the Vw-Vw weighing scheme. This shows that a combination of different weighting schemes between inter-industry and intra-industry can provide extra rewards without taking additional risks. Results also show that the Ew-Fw weighing scheme could be a competitive weighing scheme candidate. In Table 2.4, the Vw-Vw weighing scheme has a Sortino ratio of 0.54, which is lower than those of all other alternative weighing schemes with a range from 0.60 (the Fw-Vw weighting scheme) to 0.69 (the Ew-Fw weighting scheme). This illustrates that using alternative weighing scheme also has a lower risk of large losses, compared with that of the Vw-Vw weighting scheme.

Table 2.4 Measurement of return characteristics (1972-2013).

All statistics are annualized based on monthly total returns from January of 1972 to December of 2013 are used for the analysis. All different weighting schemes use industry weighting scheme first and then use individual stock weighting scheme within its specific industry. There are nine different weighting schemes. Vw means cap-weighted; Ew means equal-weighted and Fw means fundamental-weighted. Industries are based on Fama-French 12 industry divisions. For example, Vw-Vw weighting scheme is first weighted by market capitalization for Fama-French 12 industries then weighted by stock market capitalization within its specific industries; in the same way, an Ew-Fw weighting scheme is first equally weighted by industries and then fundamentally weighted for each stock within its industry.

| Weighting Scheme | Annual Geometric Return | Annual Volatility | Sharpe Ratio (vs. rf) | Excess Return (vs. Ref) | t-Value of Excess Return | Tracking Error ( vs. Ref) | Information Ratio | Sortino Ratio |
|---|---|---|---|---|---|---|---|---|
| Vw-Vw | 10.59% | 15.22% | 0.4 | \ | \ | \ | \ | 0.54 |
| Ew-Ew | 12.18% | 16.96% | 0.48 | 1.88 | 2.01 | 5.78% | 0.33 | 0.62 |
| Vw-Ew | 12.06% | 17.23% | 0.47 | 1.93 | 2.15 | 5.52% | 0.35 | 0.62 |
| Ew-Vw | 11.51% | 14.79% | 0.46 | 0.65 | 1.76 | 2.31% | 0.28 | 0.62 |
| Fw-Vw | 10.96% | 14.74% | 0.44 | 0.42 | 1.39 | 1.86% | 0.22 | 0.6 |
| Vw-Fw | 11.79% | 15.05% | 0.47 | 0.92 | 2.8 | 2.04% | 0.45 | 0.62 |
| Ew-Fw | 12.57% | 14.89% | 0.52 | 1.5 | 2.71 | 3.42% | 0.44 | 0.69 |
| Fw-Ew | 12.34% | 16.76% | 0.51 | 2.18 | 2.39 | 5.63% | 0.39 | 0.66 |
| Fw-Fw | 12.06% | 14.77% | 0.5 | 1.18 | 2.26 | 3.23% | 0.37 | 0.65 |

| Weighting Scheme | Skewness | Excess Kurtosis | Minimum Monthly Return | Minimum 3-Month Return | Minimum 12-Month Return | Maxmum Monthly Return | Maxmum 3-Month Return | Maxmum 12-Month Return |
|---|---|---|---|---|---|---|---|---|
| Vw-Vw | -0.57 | 2.56 | -21.99% | -29.59% | -40.92% | 17.70% | 31.98% | 78.24% |
| Ew-Ew | -0.78 | 3.04 | -25.24% | -34.68% | -42.21% | 18.98% | 38.27% | 98.13% |
| Vw-Ew | -0.74 | 2.83 | -25.28% | -35.23% | -42.62% | 18.67% | 39.18% | 97.10% |
| Ew-Vw | -0.56 | 2.72 | -21.71% | -29.30% | -38.39% | 17.04% | 31.27% | 79.58% |
| Fw-Vw | -0.57 | 2.63 | -21.12% | -28.86% | -41.74% | 16.77% | 34.18% | 80.12% |
| Vw-Fw | -0.65 | 2.83 | -22.39% | -29.82% | -42.56% | 15.29% | 33.84% | 83.51% |
| Ew-Fw | -0.57 | 2.99 | -22.03% | -29.58% | -40.13% | 17.68% | 34.35% | 87.79% |
| Fw-Ew | -0.74 | 3 | -24.67% | -35.14% | -43.42% | 18.71% | 39.55% | 96.97% |
| Fw-Fw | -0.63 | 2.91 | -21.52% | -29.04% | -43.57% | 15.41% | 36.98% | 86.86% |

Tracking errors for other alternative weighting schemes range from 1.86% (the Fw-Vw weighting scheme) to 5.78% (the Ew-Ew weighting scheme). As for the Ew-Fw weighing scheme, it has a tracking error of 3.42%, which is very close to that of the Fw-Fw weighting scheme (3.23%) and much lower than that of the Fw-Ew weighting scheme (5.63%). When considered on both tracking error and excess return together, the Vw-Fw weighting scheme has the highest information ratio of 0.45 among all eight alternative weighting schemes. As for the Ew-Fw weighting scheme, it has an information ratio of 0.44, which is very close to that of the Vw-Fw weighting scheme. Compared with information ratios of Ew-Ew weighting scheme and Fw-Fw weighing scheme, Ew-Fw weighing scheme has a higher information ratio, indicating the added value of the combination of equal-weighting in an industry level first and then fundamental-weighting within an industry.

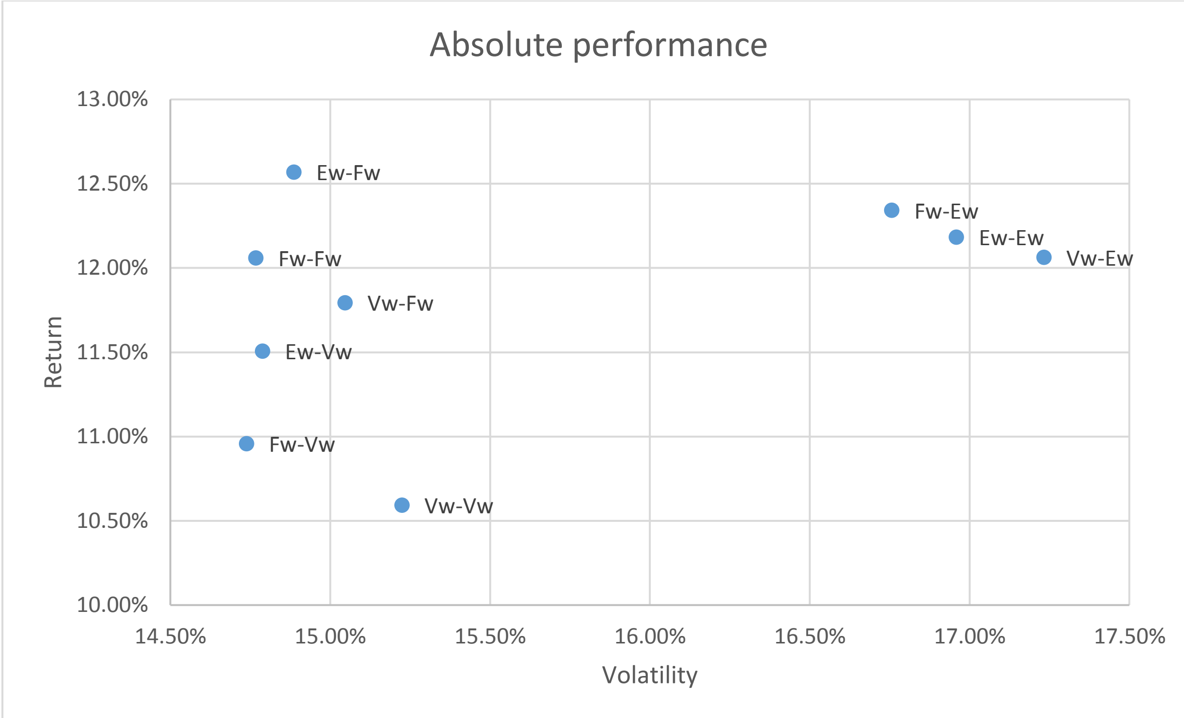
Compared with skewness of the Vw-Vw weighting scheme, all alternative weighting schemes in Table 2.4 (except for the Ew-Vw weighting scheme) have equal or less skewness. This implies that these alternative weighing schemes have negative tail risks compared with that of the Vw-Vw weighting scheme. This can also be confirmed from results in the minimum 3-month return and minimum 12-month return, which shows that alternative weighting schemes have similar or lower minimum returns, compared with the cap-weighted scheme. On the other hand, these alternative weighing schemes also have higher excess kurtoses, ranging from 2.63 for the Fw-Vw weighting scheme to 3.04 for the Ew-Ew weighting scheme, compared to 2.56 for the Vw-Vw weighting scheme. Since high kurtosis indicates high possibility to overestimate the probability of getting the mean return, lower volatility of some alternative weighting schemes may not capture the true underlying riskiness.

Table 2.4 shows that twelve-month minimum return of the Vw-Vw weighting scheme is equal to -40.92%. Its magnitude is less than other alternative weighing schemes. This may be because Vw-Vw weighting scheme automatically allocates less weight to stocks with dropping prices in the portfolio. Compared with those alternative weighing schemes, Vw-Vw weighting scheme has a relative small twelve-month maximum profit, 78.24%. This can be due to the effectiveness of alternative weighting schemes in capturing risk premium. A combination of equal-weighing scheme or fundamental-weighting scheme in levels, including an inter-industry level and an intra-industry level, can enhance a portfolio to capture value premium. Comparing with all other weighting schemes, the Vw-Vw weighting scheme does automatically tilt into growth stocks. Hsu (2014) suggests that non-price weighting schemes can effectively capture value premium via rebalancing because it integrates a mechanism of dollar cost averaging. It is intuitive to imagine that the Vw-Vw weighting scheme tilts into growth stocks, which has a lower return compared to value stocks based on the historical empirical evidence. When a stock's price drops, where the stock can change from a growth stock to a value stock, the Vw-Vw weighting scheme will automatically weigh less on the stock. In contrast, it weighs more on a stock when the stock's price increases.

Figure 2.2 illustrates that the Fw-Fw weighting scheme dominates the Vw-Ew or the Ew-Ew weighting scheme when using mean-variance analysis. The Ew-Fw and Fw-Fw weighting schemes are closer to the market frontier compared with other weighing schemes with similar returns. Based on relative performance, the eight alternative weighting schemes can be divided into three categories: the Ew-Fw and Fw-Fw weighting schemes with medium tracking errors around 3.50%; and the Fw-Vw, Ew-Vw and Vw-Fw weighting schemes with low tracking errors around 2.00%; the Fw-Ew, Vw-Ew and Ew-Ew weighing schemes with high tracking errors around 5.80%. Relative performance in Figure 2.2 shows that the Fw-Ew, Ew-Fw and Vw-Fw weighting schemes have the relative higher information ratios compared with other weighting schemes in the same category.

2.4.3 Risk analyses based on different asset pricing models

Intercepts and loadings of risk factors on different asset pricing models are shown in Table 2.5. Standard errors are adjusted by Newey-West (1987) method which accounts for autocorrelation when estimating parameters in Table 2.5. Panel A in Table 2.5 shows that Jensen alphas for fundamental indexes are significantly larger than zero for all the alternative weighting schemes, varying from monthly 17 basis points for the Fw-Vw weighting scheme to monthly 28 basis points for the Fw-Ew weighing scheme. The Ew-Fw weighting scheme has a monthly alpha of 25 basis points, which is economic significant and is also the most statistically significant within all weighing schemes.



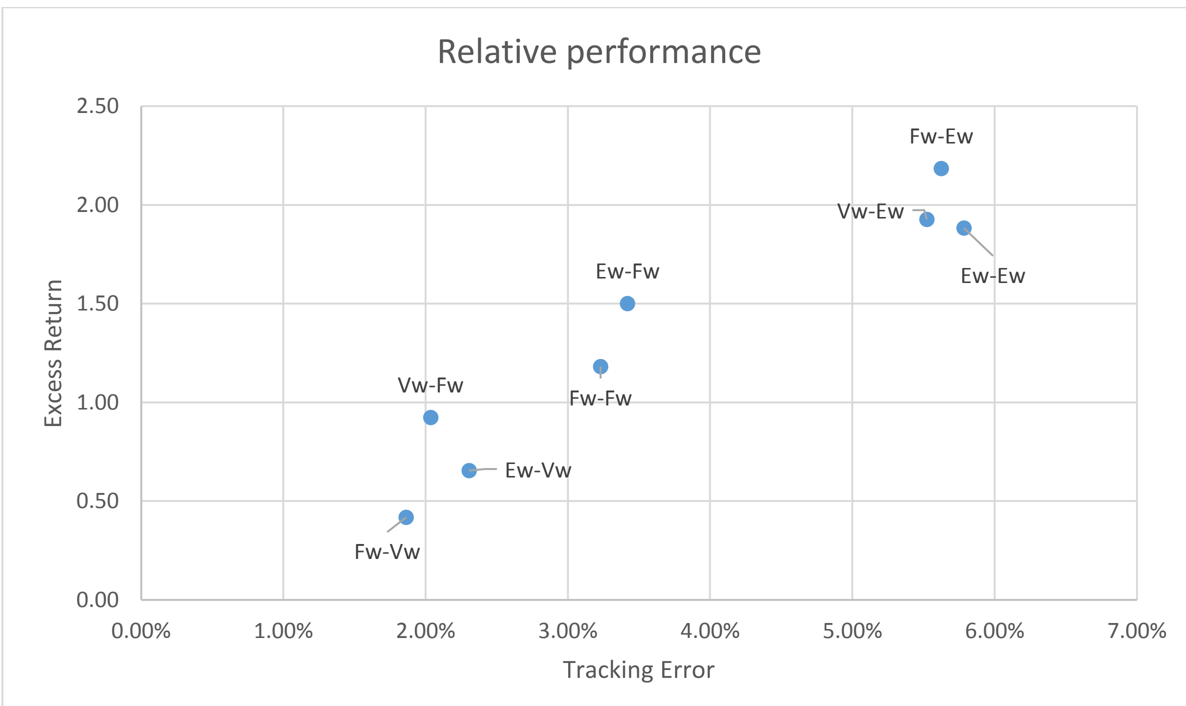




Figure 2.2 Sketches of absolute and relative performance during 1972-2013 (more details about the data can be refereed in the Table 2.4).

Table 2.5 Intercepts and loadings of factors on different asset pricing models

Different weighting schemes which use industry weighting scheme first and then use individual stock weighting scheme within its specific industry. There are nine different weighting schemes. Vw means cap-weighted; Ew means equal-weighted and Fw means fundamental-weighted. Industries are based on Fama-French 12 industry divisions. For example, Vw-Vw weighting scheme is first weighted by market capitalization for Fama-French 12 industries then weighted by stock market capitalization within its specific industries; in the same way, an Ew-Fw weighting scheme is first equally weighted by industries and then fundamentally weighted for each stock within its industry. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| Vw-Vw | 0.0011 | 0.8618*** | | | | 0.8308 |
| | (1.41) | (27.38) | | | | |
| Ew-Ew | 0.0024* | 0.9296*** | | | | 0.7678 |
| | (1.96) | (21.71) | | | | |
| Fw-Fw | 0.0023*** | 0.8105*** | | | | 0.7885 |
| | (2.61) | (23.50) | | | | |
| Fw-Ew | 0.0028** | 0.9153*** | | | | 0.7662 |
| | (2.35) | (21.55) | | | | |
| Ew-Fw | 0.0025*** | 0.8163*** | | | | 0.7864 |
| | (2.73) | (22.74) | | | | |
| Fw-Vw | 0.0017** | 0.8224*** | | | | 0.8136 |
| | (2.12) | (25.62) | | | | |
| Vw-Fw | 0.0019** | 0.8440*** | | | | 0.8176 |
| | (2.34) | (25.66) | | | | |
| Ew-Vw | 0.0019** | 0.8237*** | | | | 0.8093 |
| | (2.25) | (24.48) | | | | |
| Vw-Ew | 0.0023** | 0.9565*** | | | | 0.7864 |
| | (2.06) | (23.03) | | | | |

Panel B. Use FF 3-factor model as the benchmark

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| Vw-Vw | 0.0011 | 0.8930*** | -0.1303** | 0.0310 | | 0.8386 |
| | (1.50) | (25.10) | (-2.36) | (0.46) | | |
| Ew-Ew | 0.0013 | 0.9140*** | 0.2692*** | 0.1720* | | 0.7974 |
| | (1.38) | (18.77) | (3.29) | (1.79) | | |
| Fw-Fw | 0.0013* | 0.8786*** | -0.0948* | 0.2423*** | | 0.8212 |
| | (1.75) | (23.35) | (-1.66) | (3.33) | | |
| Fw-Ew | 0.0017* | 0.9129*** | 0.2189*** | 0.1899** | | 0.7903 |
| | (1.77) | (18.96) | (2.70) | (1.98) | | |

(Table 2.5 continued)

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| Ew-Fw | 0.0017** | 0.8730*** | -0.0743 | 0.2063*** | | 0.8088 |
| | (2.06) | (22.40) | (-1.27) | (2.75) | | |
| Fw-Vw | 0.0012* | 0.8745*** | -0.1343** | 0.1282* | | 0.8313 |
| | (1.74) | (24.40) | (-2.41) | (1.84) | | |
| Vw-Fw | 0.0013* | 0.8901*** | -0.0832 | 0.1465** | | 0.8308 |
| | (1.76) | (23.83) | (-1.51) | (2.10) | | |
| Ew-Vw | 0.0016** | 0.8648*** | -0.1149** | 0.0935 | | 0.8202 |
| | (2.06) | (23.29) | (-2.05) | (1.32) | | |
| Vw-Ew | 0.0016* | 0.9282*** | 0.2553*** | 0.0979 | | 0.8085 |
| | (1.76) | (19.69) | (3.39) | (1.07) | | |

Panel C. Use Carhart 4-factor model as the benchmark

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| Vw-Vw | 0.0015* | 0.8813*** | -0.1322** | 0.0117 | -0.0598** | 0.8421 |
| | (1.95) | (24.24) | (-2.49) | (0.18) | (-2.17) | |
| Ew-Ew | 0.0019* | 0.9010*** | 0.2671*** | 0.1506 | -0.0663 | 0.8006 |
| | (1.68) | (18.57) | (3.39) | (1.63) | (-1.64) | |
| Fw-Fw | 0.0019** | 0.8657*** | -0.0969* | 0.2210*** | -0.0660** | 0.8258 |
| | (2.25) | (22.52) | (-1.78) | (3.10) | (-2.26) | |
| Fw-Ew | 0.0022* | 0.9025*** | 0.2172*** | 0.1727* | -0.0533 | 0.7923 |
| | (1.94) | (18.77) | (2.75) | (1.87) | (-1.26) | |
| Ew-Fw | 0.0022** | 0.8598*** | -0.0765 | 0.1844** | -0.0678** | 0.8135 |
| | (2.53) | (21.53) | (-1.38) | (2.49) | (-2.13) | |
| Fw-Vw | 0.0017** | 0.8632*** | -0.1361** | 0.1096 | -0.0575** | 0.8347 |
| | (2.18) | (23.68) | (-2.54) | (1.60) | (-2.13) | |
| Vw-Fw | 0.0018** | 0.8776*** | -0.0852 | 0.1259* | -0.0638** | 0.8348 |
| | (2.24) | (22.82) | (-1.61) | (1.83) | (-2.25) | |
| Ew-Vw | 0.0020** | 0.8537*** | -0.1167** | 0.0751 | -0.0571** | 0.8235 |
| | (2.45) | (22.42) | (-2.18) | (1.07) | (-1.98) | |
| Vw-Ew | 0.0021** | 0.9160*** | 0.2533*** | 0.0778 | -0.0623 | 0.8112 |
| | (2.02) | (19.49) | (3.47) | (0.88) | (-1.57) | |

There is no statistically significant alpha for the Ew-Ew weighing scheme when using FF-3 factor model in Panel B of Table 2.5, while there are still alphas for all other alternative weighing schemes, including the Fw-Fw scheme. While the t-value of alpha for the Fw-Fw weighing scheme is only 1.75, it is 2.06 for the Ew-Fw weighing scheme, which is the highest among all the weighting schemes. Furthermore, the Ew-Fw weighing scheme has the largest alpha, 17 basis points, among all weighting schemes. Further evaluation of Carhart 4-factor model in

Panel C of Table 2.5 shows that there are alphas for all different weighing schemes. This could be due to both overweighting on small value stocks and the underperformance of other types of securities in the CRSP value-weighted market index when constructing risk factors for measuring U.S. stocks performance (Cremers el at 2013). Table 2.5 also shows that adjusted R-square for the Ew-Vw weighting scheme consistently increases when switching asset pricing models from CAPM, FF-3, to Carhart 4-factor models.

In order to see effects of diversification return on performance of different weighing schemes, a diversification return (DRET) is also integrated into different asset pricing models in Table 2.6, which shows that the diversification return does help explain the total return for different weighting schemes, and there are no positive intercepts for different weighting schemes when considering effects of the diversification return on the performance. For example, the Ew-Fw weighing scheme has a significant coefficient of 0.6319 for the DRET, and the significant intercept is gone when integrating the diversification return again.

Panel A of Table 2.6 shows that coefficients of the DRET are significant for all weighing schemes in the matrix except for the Vw-Vw weighing scheme. The coefficient of DRET varies from 0.4030 for the Ew-Vw weighing scheme to 1.0702 for the Fw-Ew weighing scheme. The Ew-Ew, Vw-Ew and Fw-Ew weighting schemes actually have negative intercepts when integrating the diversification return into the CAPM model.

Using the FF 3-factor model integrated with diversification return in Panel B of Table 2.6 also provide similar results. There are no positive intercepts with statistical significance for all the alterative weighing schemes and the coefficients of DRET is close to 0.5 for different weighing schemes. Similar results in Panel C of Table 2.6 can also be observed by using Carhart 4-factor model integrated with the diversification return.

On the other hand, the coefficient of the diversification return is not statistically significant for the Vw-Vw weighting scheme when using different factor models. This may be due to non rebalancing for the Vw-Vw weighting scheme, while the alternative weighing schemes implicitly integrate rebalancing. In order to address the concern about traditional benchmark from Cremers el at (2013), this essay also uses Cremers' adjusted 4-factor benchmark in Table 2.7 to measure the performance of different weighing schemes. Table 2.7 shows that

Table 2.6 Intercepts and loadings of factors on asset pricing models

Different weighting schemes which use industry weighting scheme first and then use individual stock weighting scheme within its specific industry. Here a new parameter, diversification return (DRET) is introduced as a dependent variable (please refer to formula 6 for more information). It is equal to the difference of the sum of weighted individual volatilities and the portfolio's volatility during the former 36 months. There are nine different weighting schemes. Vw means cap-weighted; Ew means equal-weighted and Fw means fundamental-weighted. Industries are based on Fama-French 12 industry divisions. For example, a Vw-Vw weighting scheme is first weighted by market capitalization for Fama-French 12 industries then weighted by stock market capitalization within its specific industries; in the same way, an Ew-Fw weighting scheme is first equally weighted by industries and then fundamentally weighted for each stock within its industry. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Use CAPM as the benchmark

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | DRET | ADJRSQ |
|---|---|---|---|---|---|---|---|
| Vw-Vw | -0.0007 | 0.8588*** | | | | 0.2528 | 0.8221 |
| | (-0.45) | (25.78) | | | | (1.05) | |
| Ew-Ew | -0.0069** | 0.9151*** | | | | 1.0568*** | 0.7671 |
| | (-2.55) | (20.64) | | | | (3.30) | |
| Fw-Fw | -0.0021 | 0.8041*** | | | | 0.6643*** | 0.7817 |
| | (-1.33) | (22.22) | | | | (2.68) | |
| Fw-Ew | -0.0066** | 0.9025*** | | | | 1.0702*** | 0.7651 |
| | (-2.38) | (20.41) | | | | (3.21) | |
| Ew-Fw | -0.0016 | 0.8061*** | | | | 0.6319** | 0.7775 |
| | (-0.83) | (21.50) | | | | (2.06) | |
| Fw-Vw | -0.0016 | 0.8178*** | | | | 0.4965** | 0.8056 |
| | (-1.00) | (24.20) | | | | (1.98) | |
| Vw-Fw | -0.0016 | 0.8372*** | | | | 0.5058** | 0.8094 |
| | (-1.02) | (24.16) | | | | (2.21) | |
| Ew-Vw | -0.0007 | 0.8161*** | | | | 0.4030 | 0.7999 |
| | (-0.39) | (23.13) | | | | (1.36) | |
| Vw-Ew | -0.0059** | 0.9444*** | | | | 0.8959*** | 0.7847 |
| | (-2.50) | (21.79) | | | | (3.41) | |

Panel B. Use FF-3 factor as the benchmark

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | DRET | ADJRSQ |
|---|---|---|---|---|---|---|---|
| Vw-Vw | -0.0012 | 0.8885*** | -0.1390** | 0.0278 | | 0.3337 | 0.8308 |
| | (-0.73) | (24.14) | (-2.41) | (0.41) | | (1.46) | |
| Ew-Ew | -0.0057** | 0.9072*** | 0.2276*** | 0.1629* | | 0.8130** | 0.7900 |
| | (-2.21) | (18.41) | (2.73) | (1.75) | | (2.54) | |
| Fw-Fw | -0.0030* | 0.8707*** | -0.1157** | 0.2364*** | | 0.6780*** | 0.8165 |
| | (-1.82) | (22.73) | (-1.98) | (3.33) | | (2.67) | |
| Fw-Ew | -0.0058** | 0.9063*** | 0.1805** | 0.1803* | | 0.8656*** | 0.7841 |
| | (-2.12) | (18.63) | (2.19) | (1.94) | | (2.60) | |

(Table 2.6 continued)

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | DRET | ADJRSQ |
|---|---|---|---|---|---|---|---|
| Ew-Fw | -0.0023 | 0.8636*** | -0.1005* | 0.2035*** | | 0.6409** | 0.8029 |
| | (-1.20) | (21.71) | (-1.71) | (2.78) | | (2.14) | |
| Fw-Vw | -0.0023 | 0.8680*** | -0.1479** | 0.1243* | | 0.5595** | 0.8249 |
| | (-1.40) | (23.64) | (-2.55) | (1.81) | | (2.26) | |
| Vw-Fw | -0.0022 | 0.8827*** | -0.1024* | 0.1410** | | 0.5294** | 0.8241 |
| | (-1.38) | (23.02) | (-1.81) | (2.05) | | (2.28) | |
| Ew-Vw | -0.0013 | 0.8571*** | -0.1317** | 0.0921 | | 0.4652* | 0.8129 |
| | (-0.70) | (22.50) | (-2.30) | (1.32) | | (1.66) | |
| Vw-Ew | -0.0048** | 0.9226*** | 0.2195*** | 0.0861 | | 0.7048*** | 0.8011 |
| | (-2.11) | (19.27) | (2.84) | (0.96) | | (2.67) | |

Panel C. Use Carhart 4-factor as the benchmark

| SCHEME | INTER-CEPTS | MKT | SML | HML | UMD | DRET | ADJRSQ |
|---|---|---|---|---|---|---|---|
| Vw-Vw | 0.0001 | 0.8773*** | -0.1355** | 0.0090 | -0.0571** | 0.2152 | 0.8338 |
| | (0.05) | (23.31) | (-2.39) | (0.14) | (-1.97) | (1.03) | |
| Ew-Ew | -0.0047* | 0.8981*** | 0.2307*** | 0.1478* | -0.0462 | 0.7359** | 0.7913 |
| | (-1.79) | (18.33) | (2.81) | (1.65) | (-1.12) | (2.38) | |
| Fw-Fw | -0.0017 | 0.8603*** | -0.1122* | 0.2189*** | -0.0530* | 0.5393** | 0.8192 |
| | (-0.97) | (21.89) | (-1.96) | (3.15) | (-1.75) | (2.17) | |
| Fw-Ew | -0.0049* | 0.8993*** | 0.1829** | 0.1687* | -0.0352 | 0.8012** | 0.7847 |
| | (-1.78) | (18.57) | (2.24) | (1.89) | (-0.83) | (2.46) | |
| Ew-Fw | -0.0011 | 0.8536*** | -0.0971* | 0.1864** | -0.0518 | 0.5078* | 0.8053 |
| | (-0.53) | (20.83) | (-1.69) | (2.58) | (-1.58) | (1.74) | |
| Fw-Vw | -0.0011 | 0.8584*** | -0.1448** | 0.1080 | -0.0493* | 0.4365* | 0.8271 |
| | (-0.69) | (22.93) | (-2.55) | (1.60) | (-1.78) | (1.87) | |
| Vw-Fw | -0.0009 | 0.8722*** | -0.0988* | 0.1235* | -0.0536* | 0.4010* | 0.8267 |
| | (-0.55) | (22.02) | (-1.77) | (1.82) | (-1.81) | (1.80) | |
| Ew-Vw | -0.0002 | 0.8482*** | -0.1288** | 0.0768 | -0.0466 | 0.3539 | 0.8149 |
| | (-0.12) | (21.64) | (-2.29) | (1.11) | (-1.58) | (1.34) | |
| Vw-Ew | -0.0038 | 0.9131*** | 0.2225*** | 0.0703 | -0.0482 | 0.6371** | 0.8025 |
| | (-1.59) | (19.22) | (2.90) | (0.82) | (-1.17) | (2.44) | |

Table 2.7 Intercepts and loadings of factors for different weighting schemes on the adjusted 4-factor model from Cremers et. al. (2013).

The weighting schemes use industry weighting scheme first and then individual stock weighting within its specific industry. Adjusted 4-factor model is constructed as follows: Market factor is constructed by the return difference of S&P 500 and the risk-free rate; Size factor (SML) is constructed by the return difference of Russell 2000 and S&P 500, and value factor (HML) is constructed by the return difference of Russell 3000 Value and Russell 3000 Growth. Momentum factor is the same as Carhart's momentum factor. Adjusted 4-factor model enhanced by a new parameter, diversification return (DRET, please refer to formula 6 for more information) is also used in table 5 (2). DRET is equal to the difference of the sum of weighted individual volatilities and the portfolio's volatility during the former 36 months. There are nine different weighting schemes. Vw means cap-weighted; Ew means equal-weighted and Fw means fundamental-weighted. Industries are based on Fama-French 12 industry divisions. For example, Vw-Vw weighting scheme is first weighted by market capitalization for Fama-French 12 industries then weighted by stock market capitalization within its specific industries; in the same way, Ew-Fw weighting scheme is first equally weighted by industries and then fundamentally weighted for each stock within its industry. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Without diversification return

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | ADJRSQ |
|---|---|---|---|---|---|---|
| Vw-Vw | 0.0014* | 0.9091*** | 0.0837** | 0.0572 | -0.0564** | 0.8730 |
| | (1.67) | (27.06) | (2.23) | (1.15) | (-2.38) | |
| Ew-Ew | 0.0033*** | 0.9241*** | 0.4657*** | 0.1487** | -0.0847*** | 0.8666 |
| | (3.09) | (23.03) | (10.40) | (2.28) | (-3.21) | |
| Fw-Fw | 0.0021** | 0.9025*** | 0.1119*** | 0.3023*** | -0.0570** | 0.8733 |
| | (2.55) | (27.32) | (3.35) | (6.20) | (-2.59) | |
| Fw-Ew | 0.0032*** | 0.9278*** | 0.4309*** | 0.1949*** | -0.0698** | 0.8593 |
| | (2.94) | (23.38) | (9.35) | (3.00) | (-2.27) | |
| Ew-Fw | 0.0028*** | 0.8907*** | 0.1295*** | 0.2692*** | -0.0564** | 0.8610 |
| | (3.11) | (25.20) | (3.77) | (5.14) | (-2.26) | |
| Fw-Vw | 0.0019** | 0.8912*** | 0.0869** | 0.1911*** | -0.0491** | 0.8734 |
| | (2.25) | (27.56) | (2.45) | (3.96) | (-2.46) | |
| Vw-Fw | 0.0019** | 0.9135*** | 0.1169*** | 0.1829*** | -0.0569*** | 0.8756 |
| | (2.23) | (26.46) | (3.47) | (3.79) | (-2.69) | |
| Ew-Vw | 0.0025*** | 0.8750*** | 0.1011*** | 0.1551*** | -0.0459** | 0.8616 |
| | (2.80) | (25.34) | (2.80) | (3.06) | (-2.13) | |
| Vw-Ew | 0.0030*** | 0.9395*** | 0.4588*** | 0.0616 | -0.0840*** | 0.8706 |
| | (2.86) | (24.41) | (11.37) | (1.00) | (-3.16) | |

Panel B. With diversification return

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | DRET | ADJRSQ |
|---|---|---|---|---|---|---|---|
| Vw-Vw | -0.0008 | 0.9103*** | 0.0794** | 0.0553 | -0.0516** | 0.3082 | 0.8714 |
| | (-0.49) | (27.39) | (2.06) | (1.14) | (-2.25) | (1.35) | |
| Ew-Ew | -0.0048** | 0.9313*** | 0.4499*** | 0.1432** | -0.0705*** | 0.8729*** | 0.8712 |
| | (-1.98) | (24.83) | (9.99) | (2.40) | (-3.08) | (2.96) | |

(Table 2.7 continued)

| SCHEME | INTERCEPTS | MKT | SML | HML | UMD | DRET | ADJRSQ |
|---|---|---|---|---|---|---|---|
| Fw-Fw | -0.0019 | 0.9056*** | 0.1042*** | 0.3015*** | -0.0458** | 0.5792** | 0.8740 |
| | (-1.10) | (28.25) | (3.06) | (6.69) | (-2.32) | (2.39) | |
| Fw-Ew | -0.0051* | 0.9341*** | 0.4136*** | 0.1930*** | -0.0539** | 0.9133*** | 0.8644 |
| | (-1.91) | (25.11) | (9.03) | (3.28) | (-2.00) | (2.85) | |
| Ew-Fw | -0.0012 | 0.8934*** | 0.1226*** | 0.2675*** | -0.0478** | 0.5794** | 0.8612 |
| | (-0.61) | (25.82) | (3.49) | (5.46) | (-2.08) | (2.07) | |
| Fw-Vw | -0.0017 | 0.8934*** | 0.0801** | 0.1903*** | -0.0399** | 0.5257** | 0.8733 |
| | (-1.03) | (28.35) | (2.21) | (4.21) | (-2.18) | (2.17) | |
| Vw-Fw | -0.0014 | 0.9158*** | 0.1104*** | 0.1808*** | -0.0488** | 0.4528** | 0.8750 |
| | (-0.85) | (27.03) | (3.18) | (3.96) | (-2.44) | (2.01) | |
| Ew-Vw | -0.0008 | 0.8772*** | 0.0960*** | 0.1533*** | -0.0395* | 0.4857* | 0.8610 |
| | (-0.46) | (25.74) | (2.60) | (3.19) | (-1.94) | (1.86) | |
| Vw-Ew | -0.0040* | 0.9455*** | 0.4432*** | 0.0553 | -0.0723*** | 0.7328*** | 0.8737 |
| | (-1.81) | (25.90) | (10.98) | (0.96) | (-2.95) | (2.86) | |

there is still a positive intercept for the Vw-Vw weighing scheme, with a t-value of 1.67, which is lower than that of 1.95 when using traditional 4-factor model. The Fw-Ew weighing scheme still has an intercept of 32 basis points with a t-value of 2.94 when this adjusted 4-factor model is used. There are also positive intercepts for all other weighing schemes, including the Ew-Fw weighing scheme with an intercept of 28 basis points and also with the highest t-value within all weighing schemes. On the other hand, adjusted R-squares for all alternative weighting scheme are larger when using this adjusted 4–factor model, compared with using the traditional Carhart 4-factor model. When using this adjusted 4-factor integrated with the diversification return, all intercepts with statistical significance disappear and coefficients of the diversification return (DRET) for all these alternative weighing schemes are statistically significant. The coefficients range from 0.4528 for the Vw-Fw weighing scheme to 0.8729 for the Ew-Ew weighing scheme, which is also very close to 0.5. Furthermore, the adjusted R-squares for using adjusted Cremers model with the diversification return are larger than those in the corresponding adjusted Cremers model without the diversification return. This illustrates that the diversification return has explaining power for portfolio return when using this adjusted model.

Last, in order to test the effectiveness of the diversification return, portfolio returns are also regressed on the FF-5-factor model. Results in Table 2.8 show that the diversification return is not subsumed by FF-5 factors, where

Table 2.8 Intercepts and loadings of factors on Fama-French 5-factor model.

Different weighting schemes use industry weighting scheme first and then use individual stock weighting scheme within its specific industry. Fama-french 5-factor model enhanced by a new parameter, diversification return (DRET, please refer to formula 6 for more information) is also used for comparison in the table (2). DRET is equal to the difference of the sum of weighted individual volatilities and the portfolio's volatility during the former 36 months. There are nine different weighting schemes. Vw means cap-weighted; Ew means equal-weighted and Fw means fundamental-weighted. Industries are based on Fama-French 12 industry divisions. For example, Vw-Vw weighting scheme is first weighted by market capitalization for Fama-French 12 industries then weighted by stock market capitalization within its specific industries; in the same way, an Ew-Fw weighting scheme is first equally weighted by industries and then fundamentally weighted for each stock within its industry. *, **, and *** indicate two-tailed significance at the 10%, 5%, and 1% levels, respectively.

Panel A. Without diversification return

| SCHEME | INTERCEPTS | MKT | SML | HML | RMW | CMA | ADJRSQ |
|---|---|---|---|---|---|---|---|
| Vw-Vw | 0.0006 | 0.9055*** | -0.1241** | 0.0025 | 0.0547 | 0.1001 | 0.8396 |
| | (0.86) | (26.82) | (-2.25) | (0.03) | (1.16) | (1.18) | |
| Ew-Ew | 0.0007 | 0.9301*** | 0.3041*** | 0.0763 | 0.1363** | 0.1244 | 0.8013 |
| | (0.65) | (21.28) | (4.06) | (0.62) | (2.23) | (1.13) | |
| Fw-Fw | 0.0004 | 0.9020*** | -0.0610 | 0.1608* | 0.1303*** | 0.2055** | 0.8258 |
| | (0.53) | (25.90) | (-1.13) | (1.82) | (2.62) | (2.50) | |
| Fw-Ew | 0.0009 | 0.9313*** | 0.2588*** | 0.0898 | 0.1463** | 0.1494 | 0.7953 |
| | (0.93) | (21.60) | (3.45) | (0.74) | (2.35) | (1.35) | |
| Ew-Fw | 0.0005 | 0.9023*** | -0.0275 | 0.1044 | 0.1887*** | 0.2384*** | 0.8178 |
| | (0.61) | (25.12) | (-0.50) | (1.17) | (3.89) | (2.83) | |
| Fw-Vw | 0.0005 | 0.8932*** | -0.1097** | 0.0748 | 0.1077** | 0.1530* | 0.8340 |
| | (0.71) | (26.71) | (-2.04) | (0.88) | (2.31) | (1.88) | |
| Vw-Fw | 0.0005 | 0.9116*** | -0.0619 | 0.0714 | 0.0999** | 0.1914** | 0.8341 |
| | (0.68) | (25.98) | (-1.16) | (0.83) | (2.14) | (2.31) | |
| Ew-Vw | 0.0007 | 0.8878*** | -0.0811 | 0.0256 | 0.1517*** | 0.1746** | 0.8256 |
| | (0.85) | (25.56) | (-1.51) | (0.30) | (3.20) | (2.12) | |
| Vw-Ew | 0.0012 | 0.9412*** | 0.2713*** | 0.0109 | 0.0727 | 0.1190 | 0.8098 |
| | (1.20) | (22.07) | (3.71) | (0.09) | (1.22) | (1.07) | |

(Table 2.8 continued)

Panel B. With diversification return

| SCHEME | INTERCEPTS | MKT | SML | HML | RMW | CMA | DRET | ADJRSQ |
|---|---|---|---|---|---|---|---|---|
| Vw-Vw | -0.0013 | 0.8991*** | -0.1349** | 0.0105 | 0.0382 | 0.0776 | 0.3027 | 0.8313 |
| | (-0.81) | (25.26) | (-2.31) | (0.13) | (0.78) | (0.88) | (1.29) | |
| Ew-Ew | -0.0055** | 0.9176*** | 0.2576*** | 0.0965 | 0.0925 | 0.0699 | 0.7353** | 0.7915 |
| | (-2.20) | (20.39) | (3.26) | (0.80) | (1.60) | (0.65) | (2.36) | |
| Fw-Fw | -0.0034** | 0.8928*** | -0.0804 | 0.1702* | 0.1137** | 0.1727** | 0.5982** | 0.8192 |
| | (-2.01) | (24.54) | (-1.42) | (1.96) | (2.29) | (2.11) | (2.39) | |
| Fw-Ew | -0.0057** | 0.9206*** | 0.2184*** | 0.1050 | 0.1134* | 0.1013 | 0.7804** | 0.7868 |
| | (-2.17) | (20.85) | (2.77) | (0.88) | (1.88) | (0.93) | (2.43) | |
| Ew-Fw | -0.0027 | 0.8918*** | -0.0509 | 0.1179 | 0.1659*** | 0.2035** | 0.5200* | 0.8089 |
| | (-1.39) | (23.72) | (-0.89) | (1.34) | (3.44) | (2.39) | (1.78) | |
| Fw-Vw | -0.0026 | 0.8853*** | -0.1229** | 0.0837 | 0.0917* | 0.1252 | 0.4957** | 0.8263 |
| | (-1.54) | (25.30) | (-2.16) | (0.99) | (1.94) | (1.51) | (1.98) | |
| Vw-Fw | -0.0024 | 0.9024*** | -0.0816 | 0.0817 | 0.0797* | 0.1600* | 0.4525* | 0.8259 |
| | (-1.47) | (24.46) | (-1.44) | (0.96) | (1.69) | (1.91) | (1.93) | |
| Ew-Vw | -0.0015 | 0.8790*** | -0.0963* | 0.0369 | 0.1318*** | 0.1468* | 0.3680 | 0.8164 |
| | (-0.83) | (24.15) | (-1.71) | (0.44) | (2.72) | (1.72) | (1.32) | |
| Vw-Ew | -0.0046** | 0.9298*** | 0.2277*** | 0.0272 | 0.0307 | 0.0685 | 0.6566** | 0.8010 |
| | (-2.05) | (21.23) | (2.93) | (0.23) | (0.53) | (0.63) | (2.55) | |

the coefficient of diversification return varies from 0.4957 for the Fw-Vw weighting scheme to 0.7353 for the Ew-Ew weighting scheme, which is still very close to 0.5, consistent with the coefficient of the difference of sum of weighted individual stock i's variance and portfolio's variance on the right side of formula (6).

## 2.5 Robustness Checks

In order to confirm that diversification return can explain returns for alternative weighing schemes, A couple of robustness checks is also done, including using different constituents for a portfolio, such as breaking down the whole top 1000 stocks into two groups, which includes top 500 stocks and the bottom 500 stocks based on their market values. All these robustness checks indicate that diversification return has a consistent power in explaining returns for all these alternative weighting schemes. It is also robust for using different subset with different time periods, such as during 1980-2005, which was used for Cremers el at (2013). It also survives when using different industries, such as Fama-French 38 industries, to construct the weighting schemes in the Table 2.1.

## 2.6 Conclusion

In summary, this essay demonstrates that outperformance of alternative weighting schemes, i.e., smart beta strategies, can come from the diversification return embedded in portfolio rebalancing. And it is complementary to traditional views that outperformance of these smart beta strategies is because of factor tilting. When measuring performance for these investing strategies, not only should investors pay attention to factor tiling of these strategies but also be very cautious about the diversification returns captured by these strategies. These diversification returns essentially contribute to the outperformance of smart beta strategies, and are naturally embedded in the continuous portfolio rebalancing within these strategies. Results here are consistent with former research from Ferholz and Shay (1982), Booth and Fama (1992), Erb and Harvey (2006), and Greene and Rakowski (2015). All these authors point to a fact that portfolio returns can come from two parts: the first one is directly from returns of underlying stocks and the second is from variance and covariance of the underlying stock returns while this essay focuses more on the performance measurement, especially for the smart beta strategies.

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## Appendix: Calculation of EM-related Weighting Schemes

Definition of variables:

EM: enterprise multiple

EV: enterprise value

ME: market value of equity

BE: book value of equity

EBITDA: earnings before interest, taxes, depreciation and amortization

Compustat data items:

DLC: debt in current liabilities-total

DLTT: long-term debt-total

PSTKRV: preferred stock value

CHE: cash and short-term investments

OIBDP: operating income before depreciation

Following Loughran and Wellman (2011), this paper calculates Enterprise value (EV) as the sum of market value of equity (ME), prior year's total debt (Sum of DLC and DLTT) preferred stock value (PSTKRV), minus cash and short-term investments (CHE). Using the prior year's operating income before depreciation (OIBDP) as EBITDA, Enterprise Multiple (EM) is calculated as EV/EBITDA, where EV is calculated as:

$$EV = ME + DLC + DLTT + PSTKRV$$

And EM-weighting scheme is based on the multiplication of market equity value to the reverse of enterprise multiple. EM-weighted scheme and its adjusted weighting schemes are shown in the following formulas. Formula

(1) is constructed for the original EM-weighted scheme, and Formulas (2)-(9) are adjusted EM-weighting schemes used to disentangle factors that drive the performance of EM-weighted scheme.

$$EM\ WIGHITNG\ SCHEME = ME * [EBITDA/EV]$$

$$(1)\ EM = ME * \left[\frac{EBITDA}{ME + DLC + DLTT + PSTKRV - CHE}\right]$$

$$= EBITDA\left[\frac{1}{1 + \frac{DLC + DLTT + PSTKRV - CHE}{ME}}\right]$$

$$(2) EM1 = ME * \left[\frac{EBITDA}{BE + DLC + DLTT + PSTKRV - CHE}\right]$$

$$= EBITDA\left[\frac{1}{\frac{BE}{ME} + \frac{DLC + DLTT + PSTKRV - CHE}{ME}}\right]$$

$$(3) EM1' = BE * \left[\frac{EBITDA}{BE + DLC + DLTT + PSTKRV - CHE}\right]$$

$$= EBITDA\left[\frac{1}{1 + \frac{DLC + DLTT + PSTKRV - CHE}{BE}}\right]$$

$$(4) EM2 = ME * \left[\frac{EBITDA}{ME + DLC + DLTT}\right] = EBITDA\left[\frac{1}{1 + \frac{DLC + DLTT}{ME}}\right]$$

$$(5) EM3 = ME * \left[\frac{EBITDA}{BE + DLC + DLTT}\right] = EBITDA\left[\frac{1}{\frac{BE}{ME} + \frac{DLC + DLTT}{ME}}\right]$$

$$(6) EM3' = BE * \left[\frac{EBITDA}{BE + DLC + DLTT}\right] = EBITDA\left[\frac{1}{1 + \frac{DLC + DLTT}{BE}}\right]$$

$$(7) EM4 = ME * \left[\frac{EBITDA}{ME + DLC + DLTT + PSTKRV}\right] = EBITDA \left[\frac{1}{1 + \frac{DLC + DLTT + PSTKRV}{ME}}\right]$$

$$(8) EM5 = ME * \left[\frac{EBITDA}{BE + DLC + DLTT + PSTKRV}\right] = EBITDA \left[\frac{1}{\frac{BE}{ME} + \frac{DLC + DLTT + PSTKRV}{ME}}\right]$$

$$(9) EM5' = BE * \left[\frac{EBITDA}{BE + DLC + DLTT + PSTKRV}\right] = EBITDA \left[\frac{1}{1 + \frac{DLC + DLTT + PSTKRV}{BE}}\right]$$

## Vita

Wenguang Lin earned an MBA degree from University of Notre Dame with a concentration in investments, where he was trained in value investing via Applied Investment Management (AIM) program. During his study at LSU, he taught Business Finance at undergraduate level, and was selected to participate in the 2015 Financial Management Association's Doctoral Student Consortium.