

1. Data

The primary objective of the paper is to provide practical comparison about investable portfolios, particularly a list of sector ETFs versus a set of factor ETFs. The result from this approach would be more convenient than Briere and Szafarz (2021) which adopted sector and factor indexes constructed by all traded stocks in the US market. The latter case required investors to collect and adjust individual stocks manually to replicate the paper's results while this time consuming, tedious work can be implemented directly through vastly available ETFs in the market.

All selected ETFs are designed by Blackrock – the world's largest asset manager, with more than US 8 trillion assets under management (December 2020). The historical monthly returns are retrieved from Center for Research in Security Prices (CRSP)¹ for the period from August 2013 to December 2020, including:

a. 12 sector ETFs:

- iShares U.S. Utilities ETF (ticker IDU) with objective: “seeks to track the investment results of an index composed of U.S. equities in the utilities sector, including electricity, gas, and water”.
- iShares U.S. Consumer Discretionary ETF (ticker IYC) with objective: “seeks to track the investment results of an index composed of U.S. equities in the consumer discretionary sector, including food, drugs, general retail items, and media”.
- iShares U.S. Financials ETF (ticker IYF) with objective: “seeks to track the investment results of an index composed of U.S. equities in the financial sector, including banks, insurers, and credit card companies”.
- iShares U.S. Financial Services ETF (ticker IYG) with objective: “seeks to track the investment results of an index composed of U.S. equities in the financial services sector, including investment banks, commercial banks, asset managers, credit card companies, and securities exchanges”.
- iShares U.S. Healthcare ETF (ticker IYH) with objective: “seeks to track the investment results of an index composed of U.S. equities in the healthcare sector, including healthcare equipment and services, pharmaceuticals, and biotechnology companies”.

¹ I thank NEOMA Business School for granting me access to this database

- iShares U.S. Industrials ETF (ticker IYJ) with objective: “seeks to track the investment results of an index composed of U.S. equities in the industrials sector, including companies that produce goods used in construction and manufacturing”.
- iShares U.S. Consumer Staples ETF (ticker IYK) with objective: “seeks to track the investment results of an index composed of U.S. equities in the consumer staples sector, including companies that produce a wide range consumer goods, including food, automobiles, and household goods”.
- iShares U.S. Basic Materials ETF (ticker IYM) with objective: “seeks to track the investment results of an index composed of U.S. equities in the basic materials sector, including companies involved with the production of raw materials, including metals, chemicals and forestry products”.
- iShares U.S. Real Estate ETF (ticker IYR) with objective: “seeks to track the investment results of an index composed of U.S. equities in the real estate sector, including real estate companies and REITs, which invest in real estate directly and trade like stocks”.
- iShares U.S. Transportation ETF (ticker IYT) with objective: “seeks to track the investment results of an index composed of U.S. equities in the transportation sector, including airline, railroad, and trucking companies”.
- iShares U.S. Technology ETF (ticker IYW) with objective: “seeks to track the investment results of an index composed of U.S. equities in the technology sector, including electronics, computer software and hardware, and informational technology companies”.
- iShares U.S. Telecommunications ETF (ticker IYZ) with objective: “seeks to track the investment results of an index composed of U.S. equities in the telecommunications sector, including companies that provide telephone and internet products, services, and technologies”.

b. 7 factor-based ETFs:

- iShares MSCI Emerging Markets Min Vol Factor ETF (ticker EEMV) with objective: “seeks to track the investment results of an index composed

of emerging market equities that, in the aggregate, have lower volatility characteristics relative to the broader emerging equity markets

- iShares MSCI EAFE Min Vol Factor ETF (ticker EFAV) with objective: “seeks to track the investment results of an index composed of developed market equities that, in the aggregate, have lower volatility characteristics relative to the broader developed equity markets, excluding the U.S. and Canada, including stocks in Europe, Australia, Asia and the Far East with potentially less risk”.
- iShares MSCI USA Momentum Factor ETF (ticker MTUM) with objective: “seeks to track the investment results of an index composed of U.S. large- and mid-capitalization stocks exhibiting relatively higher price momentum”
- iShares MSCI USA Quality Factor ETF (ticker QUAL) with objective: “seeks to track the investment results of an index composed of U.S. large- and mid-capitalization stocks with quality characteristics as identified through certain fundamental metrics, including high return on equity, stable year-over-year earnings growth and low financial leverage”.
- iShares MSCI USA Size Factor ETF (ticker SIZE) with objective: “seeks to track the investment results of an index composed of U.S. large- and mid-capitalization stocks with relatively smaller average market capitalization”.
- iShares MSCI USA Min Vol Factor ETF (ticker USMV) with objective: “seeks to track the investment results of an index composed of U.S. equities that, in the aggregate, have lower volatility characteristics relative to the broader U.S. equity market”.
- iShares MSCI USA Value Factor ETF (ticker VLUE) with objective: “seeks to track the investment results of an index composed of U.S. large- and mid-capitalization stocks with value characteristics and relatively lower valuations based on fundamentals”.

c. Treasury Bill (T-bill) with 30 days to maturity is treated as the risk free rate.

d. And lastly, returns on the Standard & Poor's Composite Index (S&P500) is considered as the market portfolio.

2. Methodology

The study employs the geometric test for mean-variance efficiency which was first proposed by Basak, Jagannathan, and Sun (2002) (henceforth BJS). Specifically, given a benchmark portfolio with $E(r) = \beta$, $\text{Var}(r) = v$, the efficiency measurement λ is defined as the difference between the variance of the benchmark portfolio with its identically expected return counterpart lining on the efficient frontier which constructed from p primitive assets with $E(R) = \mu$ and $\text{Cov}(R) = \Omega$. The efficiency measure λ , accordingly, is the solution of the following optimization problem:

$$\begin{aligned}\lambda &= \min_w w' \Omega w - v \\ \text{s. t. } \sum w_i &= 1, w_i \geq 0\end{aligned}$$

Under the null hypothesis: $\lambda = 0$, the benchmark portfolio is mean-variance efficient, and BJS proved that λ asymptotically follows a normal distribution:

$$T^{\frac{1}{2}}(\lambda_t - \lambda) \rightarrow N(0, \sigma^2)$$

Where σ^2 is the variance of the efficiency measure with sample size T .

In case the null is rejected, if λ is negative, the benchmark portfolio has higher variance than its counterpart in the frontier while both of the portfolios have the same level of return, meaning the benchmark portfolio is not efficient. In contrast, a positive value of λ indicates that the benchmark portfolio is efficient.

BJS paper originally designed this test to compare a market portfolio as the benchmark, which was calculated by value weighted index of stocks traded on NYSE, Amex and NASDAQ, with 25 size and book-to-market portfolios as the primitive assets. Subsequently, Ehling and Ramos (2006) applied the BJS test to compare two different efficient frontiers with each other. They first anchored one of the efficient frontier, then picked two special points on the other frontier (the minimum variance portfolio and the tangency portfolio) and treated these two as benchmark portfolios. Finally, they adopted the BJS test with the reference frontier and the benchmarks. Ehling and Ramos (2006) concluded that the reference frontier is mean-variance efficient compared to the other if one of the benchmark portfolios is significantly inefficient based on the BJS test. This paper will follow the same technique to analyze the mean-variance efficiency of sector ETFs and of factor ETFs.