# Optimal ETF Portfolios for Different Objectives and Horizons

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*This study identifies optimal portfolios for investors with different objectives and horizons, using investable exchange-traded funds of major asset classes. The optimal portfolios offer much higher Sharpe ratios than the market portfolio. Only three funds representing corporate bonds, NASDAQ 100 index, and gold contribute to the optimal portfolios. Since short investment horizons are examined, most of the optimal portfolios invest mainly in corporate bonds. However, the optimal portfolios with market volatility invest mostly in the NASDAQ 100 index. As the only asset with normally distributed returns, gold participates in optimal portfolios for investors concerned about negative skewness and excess kurtosis.*

## INTRODUCTION

Modern portfolio theory developed by Markowitz (1952) assumes normal distribution of asset returns and indicates that risk-averse investors make investment decisions based on the mean and variance of returns. The mean-variance tradeoff is optimized by maximizing the Sharpe (1966) ratio, which shows the risk premium relative to total risk. This objective can be achieved by investing in diversified portfolios which enhance the risk-return tradeoff by reducing nonsystematic risk. Studies of portfolio optimization for U.S. equity investors have generally used returns on non-investable market indices, focused on the diversification potential of international equities, and paid scant attention to the skewness and kurtosis of return distributions.

Buetow and Henderson (2012) observe that exchange-traded funds (ETFs) are investable securities which provide investors with actual diversification opportunities, unlike benchmark indices that do not represent realizable investment performance. An ETF is an investment fund which commonly tracks the performance of a benchmark index and can be traded like a stock. ETFs have experienced phenomenal growth since the SPDR S&P 500 ETF was first introduced in the U.S. in 1993. BlackRock (2018) reports that there are 7,196 ETFs with 4.95 trillion dollars in global assets at the end of June 2018.

Roll (2013) argues that, since ETFs are generally diversified portfolios, they should have low idiosyncratic volatility, implying little diversification benefit of combining them in portfolios. However, he points out that even large diversified portfolios are generally quite volatile, with about half of the average volatility of its components. In addition, well-diversified portfolios have much lower correlations with other assets, countries, or sectors, than with the same assets. This suggests that ETFs representing different asset classes may provide the best diversification potential for U.S. equity investors.

Since ETF data are available for a limited historical period, studies of ETFs have used daily, weekly, or monthly returns. Levy (1972) shows that the Sharpe ratio depends on the return interval and recommends using a return interval matching the investment horizon. Levy (1973) demonstrates that the efficient set varies with the investment horizon. It is reasonable to assume that the investment horizon of investors is at least a year since financial advisors recommend annual rebalancing of portfolios and analysts forecast annual target prices of stocks.

Peiró (1999) and Chunhachinda et al. (1997) show that daily, weekly, and monthly U.S. and international equity returns are not normally distributed, implying that skewness and kurtosis cannot be ignored in investment decisions. Researchers have suggested that investors generally prefer positive skewness and low kurtosis, which indicate more upside potential compared to downside risk and low probability of extreme returns, respectively. Xiong and Idzorek (2011) observe that investors are especially concerned about the risk of large losses, represented by negative skewness and high kurtosis. Guidolin and Timmermann (2008) show that there are significant risk premiums for skewness and kurtosis, indicating investors' aversion to negative skewness and extreme returns. Mitton and Vorkink (2007) report a negative relationship between Sharpe ratios and skewness, suggesting that investors trade off volatility risk reduction for upside potential.

This study uses eleven large ETFs representing the market portfolio, U.S. equities, international equities, bonds, commodities, and alternatives to investigate the components and risk-return profiles of optimal portfolios for investors with different objectives, based on 132 monthly returns and a random sample of 100 annual returns constructed with block bootstraps.

## LITERATURE REVIEW

Lettau and Madhavan (2018) discuss several advantages of ETFs compared to mutual funds: greater liquidity, tax efficiency, transparency, and lower expenses. They indicate that ETFs present individual investors with more investment options but require them to be financially knowledgeable. Buetow and Henderson (2012) suggest that, since ETF returns are reduced by the direct and indirect costs of managing portfolios, ETFs represent more suitable performance benchmarks than indices. Their results show that ETFs of U.S. stocks and bonds closely track the daily returns of their benchmark indices, but ETFs which invest in less-liquid securities, such as high-yield bonds, commodities, derivatives, and international securities, have significant tracking error. These tracking errors are correlated with U.S. equity returns, implying lower diversification benefits than indicated by the index returns. Svetina (2010) shows that U.S. and international equity ETFs underperform their benchmarks by 0.26% and 0.19% per year, respectively, and they have average tracking error of 0.47% and 1.13%, respectively. However, U.S. equity ETFs match the performance of institutional equity funds and they outperform retail index funds by 0.31% per year, net of costs.

There is evidence that ETFs generally provide similar risk-adjusted returns, but a better risk-return tradeoff, compared to the market. A study of monthly returns of 150 U.S. equity ETFs during 1996-2005 by Adjei (2009) finds that the Jensen's alphas of ETFs and the market are not significantly different, but the ETFs provide a higher mean annualized Sharpe ratio of 0.625 compared to 0.565 for the market. DiLellio and Stanley (2011) investigate the performance of 18 investment strategies using cumulative ETF returns during 2004-08 and report that more than 70% of them offer higher returns and a higher Sharpe ratio than a representative buy-and-hold benchmark, but only a small fraction of the strategies significantly outperforms the benchmark.

Several studies have examined the diversification benefits and risk-return tradeoffs provided by ETFs. Based on a study of weekly returns of ETFs representing European, Asian, African, and U.S. stock markets, Huang and Lin (2011) find that diversified portfolios of U.S. and foreign market ETFs deliver better performance than the U.S. market alone, and the ETFs have higher Sharpe ratios than their target market indices, particularly for emerging markets. Kanuri and McLeod (2015) study monthly returns of equity ETFs and report that U.S. ETFs offer better risk-adjusted performance, with higher returns and lower volatility, than international ETFs. U.S. and international ETF returns are strongly positively correlated, indicating that diversification with global equity ETFs may not be beneficial. Miralles-Marcelo et al. (2015) demonstrate that a dynamic optimal international diversification strategy using timevarying daily returns and volatility forecasts from a multivariate model, using ETFs tracking stock market indices in the U.S., U.K. and Japan, provides higher out-of-sample Sharpe ratios than the benchmark for U.S. investors. Fapetu and Aluko (2017) show that monthly returns of emerging and developed market equity ETFs are not cointegrated, indicating that investors can reduce risk through international diversification in both markets.

## DATA AND METHODOLOGY

This study uses closing prices, adjusted for dividends and stock splits, from finance.yahoo.com/quote/, which obtains the data from the New York Stock Exchange's Intercontinental Exchange (ICE). The prices are obtained for 11 years, from June 30, 2007, to June 30, 2018, because all of the sample ETFs have data available for this period. The study period encompasses the severe recession from January 2008 to June 2009 and the subsequent ongoing expansion that started in July 2009. Daily adjusted closing prices are downloaded for the following twelve ETFs:

- Invesco D.B. commodity tracking (DBC): diversified commodity index,
- iShares MSCI EAFE (EFA): large- and mid-capitalization developed market equities index,
- SPDR gold shares (GLD): gold bullion,
- iShares iBoxx $ high yield corporate bond (HYG): liquid high-yield corporate bond index,
- iShares Russell 2000 (IWM): small-capitalization equity index,
- iShares iBoxx investment grade $ corporate bond (LQD): liquid investment-grade bond index,
- Invesco QQQ trust (QQQ): 100 largest non-financial companies in NASDAQ equity index,
- Invesco global listed private equity (PSP): global listed private equity index,
- iShares short Treasury bond (SHV): ICE U.S. Treasury short bond index,
- SPDR S&P 500 (SPY): large-capitalization equity index,
- Vanguard real estate (VNQ): publicly traded equity REITS index,
- Vanguard FTSE emerging markets (VWO): emerging markets equity index.

The benchmark market portfolio used in this study is SPY, which tracks the S&P 500 index and is by far the largest ETF, with net assets of 259 billion dollars in June 2018. The risk-free security used to calculate the risk premiums is SHV, which contains U.S. Treasury securities with maturities of one month to a year. The other ten ETFs comprise two different large funds representing five categories of assets: U.S. stocks (IWM and QQQ), international stocks (EFA and VWO), bonds (HYG and LQD), commodities (DBC and GLD), and other alternative assets (PSP and VNQ). These ETFs are all passive investments designed to track indices or, in the case of GLD, gold prices. Although IWM and QQQ are primarily U.S. stock market indices, they include 3% to 4% of foreign stocks.

Adjusted closing prices at the end of each month are used to compute the continuously compounded monthly return of each ETF:

Monthly Return = Natural Log (Price at end of month / Price at end of previous month) (1)

The study period contains 132 monthly returns but only 11 independent annual returns. A random sample of 100 annual returns is constructed with a block bootstrap method, drawing a random beginning month from the first 121 months of the study period and summing twelve months of continuously compounded monthly returns, starting with the beginning month, for each of the 12 ETFs. This procedure preserves the serial and cross-sectional correlations of the monthly returns in computing the annual returns. Efron and Tibshirani (1986) note that a bootstrap replicates the empirical data distribution and Kunsch (1989) recommends the use of overlapping blocks.

To examine the impact of using different return intervals, all of the analyses are conducted with both monthly and annual returns. The comparison of ETF returns is based on all four moments of their distributions. The moments of sample return distributions based on N observations, and excess kurtosis compared to the normal distribution, are formally defined below.

$$\text{Mean} = {}_{i=1}{}^{N}\text{Sum}\ (\text{Return}_i) / N \tag{2}$$

$$\text{Standard Deviation} = ({}_{i=1}{}^{N}\text{Sum}\ (\text{Return}_i - \text{Mean})^2 / N)^{1/2} \tag{3}$$

$$\text{Skewness} = N / ((N-1)(N-2))\ {}_{i=1}{}^{N}\text{Sum}\ (\text{Return}_i - \text{Mean})^3 / \text{Standard Deviation}^3 \tag{4}$$

$$\text{Kurtosis} = N(N+1) / ((N-1)(N-2)(N-3))\ {}_{i=1}{}^{N}\text{Sum}\ (\text{Return}_i - \text{Mean})^4 / \text{Standard Deviation}^4 \tag{5}$$

$$\text{Excess Kurtosis} = \text{Kurtosis} - 3(N-1)^2 / ((N-2)(N-3)) \tag{6}$$

The return distributions are tested for normality with the Jarque-Bera (JB) statistic formulated by Jarque and Bera (1980), which tests the joint null hypothesis that the skewness and kurtosis are not significantly different from the normal distribution:

$$\text{JB Statistic} = N/6\ (\text{Skewness}^2 + \text{Kurtosis}^2/4) \tag{7}$$

The risk-return tradeoffs of the ETFs are evaluated with the Sharpe ratio, which indicates the risk premium relative to total risk:

$$\text{Sharpe Ratio} = (\text{Mean ETF return} - \text{Mean SHV return}) / \text{Standard deviation of ETF returns} \tag{8}$$

The correlations between the ETF returns are examined to assess their diversification potential. The return distributions of the benchmark market portfolio and its risk-return tradeoff are compared to those of optimal portfolios formed from the eleven risky ETFs, including the market portfolio. Optimal portfolios allocations are identified for six different objectives: maximize the Sharpe ratio without any constraint and maximize the Sharpe ratio with five different constraints (no negative skewness, no excess kurtosis, no negative skewness or excess kurtosis, same returns as the market portfolio, and same standard deviation as the market portfolio). To exclude short positions and examine portfolios that are fully invested, the weight of each ETF is constrained to be non-negative and the total weights of the ETFs are required to equal 1 in each optimal model.

## RESULTS

The descriptive statistics of monthly returns in Panel A of Table 1 show that the market portfolio (SPY) has the third-highest mean of 0.62% and the third-lowest standard deviation of 4.29%, offering the third-highest Sharpe ratio of 0.13. U.S. stock ETFs have the highest mean returns of 1.05% (QQQ) and 0.63% (IWM), whereas bond ETFs have the lowest standard deviations of 2.22% (LQD) and 3.32% (HYG). Only two ETFs offer higher Sharpe ratios than SPY: QQQ (0.19), which provides the highest monthly return with the fourth-lowest standard deviation, and LQD (0.16), which has the seventh-highest monthly return and lowest volatility. International stocks, commodities, and alternatives provide lower monthly returns and higher standard deviations, resulting in lower Sharpe ratios, than SPY. Two ETFs (DBC and PSP) have negative monthly returns.

Returns of almost all the ETFs exhibit negative skewness and excess kurtosis, with highly significant JB statistics indicating severe departures from normality. Bonds and alternatives have particularly large JB statistics. Bonds are the only ETFs without negative skewness, but they have high kurtosis; LQD displays the highest kurtosis and HYG has the fourth-highest kurtosis. GLD is the only ETF without a significant JB statistic; it has the lowest negative skewness of -0.22 and the lowest excess kurtosis of 0.33.

There are severable notable differences between the annual return distributions in Panel B compared to the monthly return distributions in panel A. For all the ETFs with positive Sharpe ratios in panel A, the mean increases more than the standard deviation, making the Sharpe ratios of annual returns higher than those of monthly returns. The means and volatilities do not increase by similar percentages for different ETFs, resulting in changes in their rankings. SPY still has the third-highest mean, after QQQ and IWM, but its volatility ranking slips from third- to fourth-lowest, after LQD, HYG, and GLD, and its Sharpe ratio drops to the fifth-highest. LQD offers the highest Sharpe ratio, followed by QQQ, HYG, and IWM. The bond and U.S. stock ETFs provide higher Sharpe ratios than SPY primarily due to the lower risk of bonds and higher returns of U.S. stocks. International stocks, commodities, and alternatives underperform the market portfolio, U.S. stocks, and bonds, with lower means and higher volatility for all the ETFs, except GLD, which has the third-lowest standard deviation.

Annual returns are negatively skewed for all the ETFs except LQD, which has a skewness of 0.22. Excess kurtosis is much lower for annual returns compared to monthly returns for all the ETFs except QQQ, for which it increases from 1.57 to 1.97. The JB statistics based on annual returns are lower than those based on monthly returns for all the ETFs except QQQ and SPY, although these statistics remain significant at 1% level for most of the ETFs. GLD and LQD are the only ETFs without a significant JB statistic and the significance level of the JB statistic for DBC drops to the 5% level. Owing to large reductions in kurtosis, the JB statistics of bonds and alternatives, which are several multiples of the JB statistics of SPY for monthly returns, are lower than the JB statistics of SPY for annual returns.

Overall, these results indicate that the return interval has a significant influence on the distributions of returns as well as the relative risk-return tradeoffs of different ETFs. QQQ provides the highest Sharpe ratio for monthly returns, but LQD offers the best risk-return tradeoff for annual returns. Further, kurtosis is reduced as the return interval increases, reducing the deviations from normality for the return distributions of most of the ETFs. The return distributions are not significantly different from normal at both monthly and annual horizons for GLD and at annual horizons for LQD.

**TABLE 1**
**SUMMARY STATISTICS OF SAMPLE ETF RETURNS: 07/2007-06/2018**

| **Panel A. 132 Monthly Returns** | | | | | | |
|---|---|---|---|---|---|---|
| **ETF** | **Mean** | **Standard Deviation** | **Skewness** | **Excess Kurtosis** | **JB Statistic** | **Sharpe Ratio** |
| *Market Portfolio* | | | | | | |
| SPY | 0.62% | 4.29% | -0.95 | 2.46 | 53.05** | 0.13 |
| *Bonds* | | | | | | |
| HYG | 0.43% | 3.32% | 0.15 | 6.73 | 249.94** | 0.11 |
| LQD | 0.42% | 2.22% | 0.11 | 12.56 | 868.57** | 0.16 |
| *U.S. Stocks* | | | | | | |
| IWM | 0.63% | 5.61% | -0.81 | 2.10 | 38.75** | 0.10 |
| QQQ | 1.05% | 5.15% | -0.81 | 1.57 | 27.99** | 0.19 |
| *International Stocks* | | | | | | |
| EFA | 0.10% | 5.42% | -0.83 | 2.39 | 46.31** | 0.01 |
| VWO | 0.16% | 6.78% | -0.80 | 3.59 | 84.90** | 0.01 |
| *Commodities* | | | | | | |
| DBC | -0.25% | 5.86% | -1.05 | 3.83 | 105.06** | -0.05 |
| GLD | 0.46% | 5.38% | -0.22 | 0.33 | 1.70 | 0.08 |
| *Alternatives* | | | | | | |
| PSP | -0.09% | 8.17% | -2.05 | 8.40 | 480.71** | -0.02 |
| VNQ | 0.44% | 7.34% | -1.40 | 7.63 | 362.97** | 0.05 |
| **Panel B. 100 Random Annual Returns Constructed with Block Bootstraps** | | | | | | |
| **ETF** | **Mean** | **Standard Deviation** | **Skewness** | **Excess Kurtosis** | **JB Statistic** | **Sharpe Ratio** |
| *Market Portfolio* | | | | | | |
| SPY | 7.41% | 21.07% | -1.59 | 1.76 | 54.99** | 0.33 |
| *Bonds* | | | | | | |
| HYG | 5.68% | 12.23% | -1.03 | 2.01 | 34.44** | 0.42 |
| LQD | 5.18% | 6.94% | 0.22 | 0.96 | 4.64 | 0.67 |
| *U.S. Stocks* | | | | | | |
| IWM | 8.74% | 22.22% | -1.14 | 0.76 | 24.01** | 0.37 |
| QQQ | 12.71% | 21.38% | -1.54 | 1.97 | 55.65** | 0.57 |
| *International Stocks* | | | | | | |
| EFA | 2.21% | 24.50% | -1.41 | 1.55 | 43.30** | 0.07 |
| VWO | 1.21% | 29.11% | -0.95 | 1.47 | 24.08** | 0.02 |
| *Commodities* | | | | | | |
| DBC | -5.25% | 24.89% | -0.63 | -0.21 | 6.86* | -0.23 |
| GLD | 4.55% | 16.25% | -0.24 | -0.29 | 1.34 | 0.25 |
| *Alternatives* | | | | | | |
| PSP | -1.52% | 42.69% | -1.59 | 1.74 | 54.61** | -0.05 |
| VNQ | 2.78% | 30.59% | -1.23 | 1.90 | 40.14** | 0.07 |

*Significant at 5% level.
**Significant at 1% level.

**TABLE 2**
**CORRLEATIONS OF SAMPLE ETF RETURNS: 07/2007-06/2018**

| Panel A. 132 Monthly Returns | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **ETF** | **SPY** | **HYG** | **LQD** | **IWM** | **QQQ** | **EFA** | **VWO** | **DBC** | **GLD** | **PSP** |
| *Bonds* | | | | | | | | | | |
| HYG | 0.73** | | | | | | | | | |
| LQD | 0.30** | 0.66** | | | | | | | | |
| *U.S. Stocks* | | | | | | | | | | |
| IWM | 0.91** | 0.72** | 0.22* | | | | | | | |
| QQQ | 0.91** | 0.69** | 0.27** | 0.81** | | | | | | |
| *International Stocks* | | | | | | | | | | |
| EFA | 0.90** | 0.76** | 0.40** | 0.80** | 0.82** | | | | | |
| VWO | 0.80** | 0.71** | 0.37** | 0.72** | 0.77** | 0.88** | | | | |
| *Commodities* | | | | | | | | | | |
| DBC | 0.54** | 0.47** | 0.11 | 0.50** | 0.46** | 0.59** | 0.66** | | | |
| GLD | 0.06 | 0.14 | 0.25** | 0.03 | 0.02 | 0.15 | 0.32** | 0.44** | | |
| *Alternatives* | | | | | | | | | | |
| PSP | 0.88** | 0.75** | 0.26** | 0.87** | 0.79** | 0.84** | 0.76** | 0.53** | 0.06 | |
| VNQ | 0.74** | 0.75** | 0.42** | 0.75** | 0.63** | 0.70** | 0.62** | 0.35** | 0.11 | 0.80** |
| **Panel B. 100 Random Annual Returns Constructed with Block Bootstraps** | | | | | | | | | | |
| **ETF** | **SPY** | **HYG** | **LQD** | **IWM** | **QQQ** | **EFA** | **VWO** | **DBC** | **GLD** | **PSP** |
| *Bonds* | | | | | | | | | | |
| HYG | 0.85** | | | | | | | | | |
| LQD | 0.43** | 0.77** | | | | | | | | |
| *U.S. Stocks* | | | | | | | | | | |
| IWM | 0.97** | 0.84** | 0.36** | | | | | | | |
| QQQ | 0.97** | 0.86*g* | 0.49** | 0.93** | | | | | | |
| *International Stocks* | | | | | | | | | | |
| EFA | 0.97** | 0.87** | 0.46** | 0.94** | 0.95** | | | | | |
| VWO | 0.86** | 0.93** | 0.65** | 0.84** | 0.88** | 0.90** | | | | |
| *Commodities* | | | | | | | | | | |
| DBC | 0.65** | 0.59** | 0.19 | 0.70** | 0.59** | 0.64** | 0.61** | | | |
| GLD | -0.05 | 0.27** | 0.51** | -0.05 | 0.01 | -0.02 | 0.29** | 0.36** | | |
| *Alternatives* | | | | | | | | | | |
| PSP | 0.98** | 0.79** | 0.31** | 0.97** | 0.92** | 0.95** | 0.83** | 0.70** | -0.07 | |
| VNQ | 0.90** | 0.83** | 0.50** | 0.88** | 0.85** | 0.83** | 0.81** | 0.68** | 0.21* | 0.90** |

*Significant at 5% level.
**Significant at 1% level.

Table 2 displays the correlations of the ETF returns. Panel A shows that SPY has strong positive correlations with U.S. stocks, international stocks, alternatives, and HYG; it is moderately positively correlated with DBC and LQD, and not significantly correlated with GLD. Most of the ETF monthly returns are strongly positively correlated with each other at 1% significance level. However, GLD is not significantly correlated with most of the other ETFs; it has significant moderate correlations only with DBC, VWO and LQD. The only other ETF that is not strongly correlated with most of the other ETFs is LQD, which has strong correlations only with HYG and VWO.

Panel B indicates that the positive correlations between the ETFs increases between the monthly and annual horizons for all the ETFs except GLD whose correlations increase with five ETFs and decrease with five ETFs. All of the correlations are significant at 1% level except for the correlations of GLD with SPY, IWM, QQQ, EFA and PSP, and the correlation of LQD with DBC. GLD is significantly positively correlated with five ETFs for annual returns compared to three ETFs for monthly returns.

These findings suggest that most of the ETFs do not present much diversification potential, since they are significantly correlated with each other, and their diversification potential is reduced over a longer horizon as their correlations increase. GLD is the only ETF that can offer good diversification benefits at both monthly and annual horizons, although its benefit is reduced at the longer horizon. LQD may also provide some diversification benefit for the monthly horizon since it is not strongly correlated with most of the other ETFs.

Table 3 presents the weights, distributions and risk-return tradeoffs of optimal portfolios for different objectives in comparison with the market portfolio. The results based on monthly returns in Panel A show that the maximum Sharpe ratio is provided by optimal portfolio 1, comprising 54.38% LQD, 35.81% QQQ, and 9.80% GLD. This portfolio produces a Sharpe ratio of 0.23, compared to 0.13 for SPY, with a slightly higher return and much lower volatility than SPY. It has similar negative skewness but far greater excess kurtosis compared to SPY, and its JB statistic is more than twice that of SPY. Portfolio 2 maximizes the Sharpe ratio without negative skewness by increasing the weights of LQD to 76.52% and GLD to 15.64% while reducing QQQ to 7.84%. The skewness constraint, however, lowers the Sharpe ratio to 0.19 and increases excess kurtosis to 6.47, raising the JB statistic to 230.24. Since Panel A of Table 1 showed that all the ETFs have excess kurtosis, the Sharpe ratio cannot be maximized with constraints of non-positive excess kurtosis, so those results cannot be presented for monthly returns. Portfolio 3 maximizes the Sharpe ratio with the same return as SPY by slightly increasing the allocation to LQD and reducing the allocations to QQQ and GLD, compared to portfolio 1. This portfolio delivers a similar Sharpe ratio of 0.23 as portfolio 1, but it has a slightly lower return and volatility, and a higher excess kurtosis and JB statistic. Portfolio 4 maximizes the Sharpe ratio with the same standard deviation as SPY by investing 81.14% in QQQ, 14.03% in GLD, and 4.83% in LQD. This portfolio offers a Sharpe ratio of 0.20 with the highest return, lowest kurtosis, and lowest JB statistic among all the portfolios in Panel A.

The findings for annual returns in Panel B indicate that optimal portfolio 1, comprising 83.53% LQD and 16.47% QQQ, maximizes the Sharpe ratio, delivering a risk-return tradeoff more than double that of SPY, with a 13% lower return and 61% lower volatility. It also has less negative skewness and excess kurtosis, with a JB statistic which is less than half the JB statistic for SPY, although it is also significant at 1% level. Portfolio 2 provides a maximum Sharpe ratio of 0.69 without negative skewness by increasing LQD to 96.89% and reducing QQQ to 3.31%. This portfolio has a slightly lower Sharpe ratio, with lower return and volatility, than portfolio 1, and its JB statistic is not significant. Portfolio 3 offers a maximum Sharpe ratio of 0.66 without excess kurtosis by investing 66.45% in LQD, 21.12% in GLD, and 12.43% in QQQ. This portfolio has a slightly lower mean and higher volatility than portfolio 1, and its JB statistic is not significant. Portfolio 4 produces a maximum Sharpe ratio of 0.65 without negative skewness or excess kurtosis with a higher allocation to LQD and lower allocations to GLD and QQQ, compared to portfolio 3. This portfolio has a slightly lower return and volatility, and a similar risk-return tradeoff, as portfolio 3. Portfolio 5 lowers the LQD weight and raises the QQQ weight, compared to portfolio 1, and allocates a small proportion to GLD. This portfolio offers a maximum Sharpe ratio of 0.71 with the same return and a much lower volatility compared to SPY. It provides a similar Sharpe ratio as portfolio 1, with a higher return and volatility, but its JB statistic is more than twice a high. Portfolio 6 allocates 98.54% to QQQ and 1.46% to GLD, sharply increasing the mean return and risk-return tradeoff with the same volatility and similar JB statistic as SPY.

**TABLE 3**
**OPTIMAL ETF PORTFOLIOS FOR DIFFERENT OBJECTIVES AND HORIZONS**

| **Panel A. 132 Monthly Returns** | | | | | |
|---|---|---|---|---|---|
| **Mean** | **Standard Deviation** | **Skewness** | **Excess Kurtosis** | **JB Statistic** | **Sharpe Ratio** |
| *Market Portfolio Weight: 100% SPY* | | | | | |
| 0.62% | 4.29% | -0.95 | 2.46 | 53.05** | 0.13 |
| *Portfolio 1: Maximum Sharpe Ratio Weights: 54.38% LQD, 35.81% QQQ, 9.80% GLD* | | | | | |
| 0.65% | 2.58% | -0.94 | 4.70 | 140.95** | 0.23 |
| *Portfolio 2: Maximum Sharpe Ratio Without Negative Skewness Weights: 76.52% LQD, 15.64% GLD, 7.84% QQQ* | | | | | |
| 0.47% | 2.20% | 0.00 | 6.47 | 230.24** | 0.19 |
| *Portfolio 3: Maximum Sharpe Ratio with Same Return as Market Portfolio Weights: 59.70% LQD, 30.95% QQQ, 9.35% GLD* | | | | | |
| 0.62% | 2.45% | -0.91 | 5.46 | 182.46** | 0.23 |
| *Portfolio 4: Maximum Sharpe Ratio with Same Standard Deviation as Market Portfolio Weights: 81.14% QQQ, 14.03% GLD, 4.83% LQD* | | | | | |
| 0.94% | 4.29% | -0.78 | 1.95 | 34.28** | 0.20 |
| **Panel B. 100 Random Annual Returns Constructed with Block Bootstraps** | | | | | |
| **Mean** | **Standard Deviation** | **Skewness** | **Excess Kurtosis** | **JB Statistic** | **Sharpe Ratio** |
| *Market Portfolio Weight: 100% SPY* | | | | | |
| 7.41% | 21.07% | -1.59 | 1.76 | 54.99** | 0.33 |
| *Portfolio 1: Maximum Sharpe Ratio Weights: 83.53% LQD, 16.47% QQQ* | | | | | |
| 6.42% | 8.14% | -0.87 | 1.60 | 23.13** | 0.73 |
| *Portfolio 2: Maximum Sharpe Ratio Without Negative Skewness Weights: 96.89% LQD, 3.11% QQQ* | | | | | |
| 5.41% | 7.08% | 0.00 | 0.99 | 4.05 | 0.69 |
| *Portfolio 3: Maximum Sharpe Ratio without Excess Kurtosis Weights: 66.45% LQD, 21.12% GLD, 12.43% QQQ* | | | | | |
| 5.98% | 8.29% | -0.22 | 0.00 | 0.78 | 0.66 |
| *Portfolio 4: Maximum Sharpe Ratio without Negative Skewness or Excess Kurtosis Weights: 77.43% LQD, 16.87% GLD, 5.70% QQQ* | | | | | |
| 5.50% | 7.72% | 0.00 | 0.00 | 0.00 | 0.65 |
| *Portfolio 5: Maximum Sharpe Ratio with Same Return as Market Portfolio Weights: 68.88% LQD, 29.67% QQQ, 1.45% GLD* | | | | | |
| 7.41% | 9.71% | -1.33 | 2.16 | 49.05** | 0.71 |
| *Portfolio 6: Maximum Sharpe Ratio with Same Standard Deviation as Market Portfolio Weights: 98.54% QQQ, 1.46% GLD* | | | | | |
| 12.60% | 21.07% | -1.54 | 1.99 | 56.09** | 0.57 |

*Significant at 5% level.
**Significant at 1% level.

These results demonstrate that investors can design optimal ETF portfolios for different objectives and investment horizons to obtain much better risk-return tradeoffs than the benchmark market portfolio.

The optimal portfolios deliver maximum Sharpe ratios of 0.23 for monthly returns and 0.73 for annual returns, which are higher than the maximum Sharpe ratios of 0.19 and 0.57 for corresponding periods, provided by an individual ETF (QQQ). Investors who are averse to negative skewness or excess kurtosis can modify their portfolio allocations to eliminate these higher-moment risks for annual horizons, although excess kurtosis cannot be avoided for monthly horizons.

Of the eleven ETFs considered, only three contribute to the optimal portfolios: LQD, which has the lowest volatility; QQQ, which offers the highest return; and GLD, which is the only ETF whose returns are normally distributed at both monthly and annual horizons. All the optimal portfolios primarily invest in bonds (LQD), except the optimal portfolios for investors who are willing to accept the same volatility as the market portfolio; these portfolios mainly invest in U.S. stocks (QQQ) for both monthly and annual horizons. These results are not surprising since bonds are generally considered to be a more appropriate investment than stocks for the short horizons studied. The findings also indicate that the normal distribution of the returns on gold make it an attractive portfolio component for investors concerned about higher-moment risks. Notably, the market portfolio does not participate in any of the optimal portfolios although the optimization procedures consider it for inclusion.

## CONCLUSION

This study uses ETFs representing the market portfolio, U.S. equities, international equities, bonds, commodities, and alternatives to identify optimal portfolios for investors with different objectives and horizons. The results show that the return interval significantly affects the distributions and risk-return tradeoffs of the ETFs, changing their rankings. The ETFs generally do not offer much diversification potential as they tend to be significantly correlated, and their correlations increase with the investment horizon, reducing their diversification potential. Only gold has a normal return distribution at monthly and annual horizons, and it can offer diversification benefits at both horizons.

Optimal ETF portfolios provide much better risk-return tradeoffs than the market portfolio, which is not included in any optimal portfolio. Only three ETFs among eleven considered participate in the optimal portfolios: liquid investment-grade corporate bonds, with the lowest volatility; the NASDAQ 100 index, with the highest return; and gold, with normally distributed returns. Since the investment horizons studied are monthly and annual, owing to data limitations, the optimal portfolios generally contain large proportions of corporate bonds; only optimal portfolios with market volatility invest mostly in the NASDAQ 100 index. Since gold has returns that are normally distributed and not strongly correlated with the other assets, it is included in portfolios that seek to avoid negative skewness and excess kurtosis.

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