# Time Series Momentum in Exchange Traded Funds

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## Abstract

In this paper an attempt is made to capture time-series momentum in a momentum portfolio consisting of real estate, hedge fund, private equity, commodity, currency, treasury bond, government bond and equity ETFs with a 4-, 13-, 26- and 52- week holding periods. I find that there are no significant alphas when testing the momentum strategies on MSCI-world, and MSCI-momentum. Explanations for this could be not using factors that capture the effect of the financial crisis, too small amount of observations in the early sample due to which top and bottom 60% of Winner and Losers are taken instead of a lower top and bottom percentile and time-series momentum used instead of cross-sectional momentum.

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## 1. Introduction

Momentum is a phenomenon that has been studied quite extensively since the momentum factor returns high profits throughout the world (Chui, Titman and Wei (2010)). Considering the shift to passive management over the recent years, the active momentum strategy is thus an interesting investment factor worth further investigation to determine whether it is interesting in addition to passive management. In a momentum strategy, one usually buys Winners and sells Losers, and then in turn holds this portfolio for 1 to 12 months. For the Winner-Loser strategy, the holding period and lookback period (signal period) have always been a focal point of momentum research since it affects the returns and statistical characteristics of the momentum portfolios. In Jegadeesh and Titman (1993), conclusions regarding the holding period and the lookback period were drawn, and it can be found that 1 to 12 months of lookback and holding period usually generate significant momentum profits. Possible explanations for the holding period of 1 to 12 months and not longer than that, is a delayed overreaction (Jegadeesh and Titman (2001)). Initially an underreaction to the new information is present, after that the price of the Winners (Losers) will be pushed above (below) the price of the long-term equilibrium value as the information gets fully incorporated in the price.

What needs to be considered when studying momentum is whether a cross-sectional signal or time-series signal should be used. The difference between time-series and cross-sectional momentum is found in the signal, where cross-sectional momentum ranks the assets based on past k-month return (Jegadeesh and Titman (1993)), while time-series momentum takes long and short positions based on whether the average of past returns is above or below zero (Moskowitz, Ooi and Pedersen (2012)), or average prices of the asset are above or below the current prices of the asset (He and Li (2015)) or whether the returns are above a benchmark (Antonacci (2012)). Since there is no wide range of literature available for time-series momentum, I decide to study time-series momentum.

Normally in momentum strategies long and short positions, the well-known Winner-Loser portfolios, are taken such that the total investment in a strategy is zero. Taking a short position in an aggregate of an asset class is difficult due to the number of assets involved which lead to significant transaction costs. A potential remedy for these transaction costs lead me to a recent phenomenon, the exchange traded fund (ETF). ETFs are products that track indices, which means an ETF tracks an aggregate of assets, so the amount of effort to obtain an amount of assets similar to an asset class is greatly reduced. In addition, ETFs allow investors to take short position in the ETF of their choosing which makes it possible to construct the standard

Winner-Loser portfolios. Since momentum portfolios can be constructed from ETFs I deem it worthwhile to investigate whether momentum exists in ETFs.

Inspired by He and Li (2015), Moskowitz, Ooi and Pedersen (2012) and Antonacci (2012), this study investigates a time-series momentum effect in ETFs covering multiple asset classes in order to determine whether a time-series momentum effect can be determined, and what holding-period would be most profitable. This hypothesis is analyzed by using a linear regression model in which I determine whether there are significant alphas based on benchmark returns from the MSCI-momentum, and the MSCI-World index. In addition, the summarizing statistics of the Winner-Loser are determined in order to investigate the characteristics of these portfolios.

There is currently a limited range of literature available on momentum in ETFs. In order to add to established literature, this research aims to fill a gap in time-series momentum portfolios for ETFs literature by using a wide variety of ETFs which cover multiple asset classes, including commodities, currencies, equities, government bonds, private equity, hedge funds, real estate and treasury bonds, as a basis for the momentum portfolio and then in turn determining what an appropriate holding period would be for these asset classes based on a time-series momentum signal. There is an overlap in asset classes with established literature in this study, which is chosen to determine whether momentum profits exist within the ETFs covering those asset classes that were previously found to have momentum profits, while the additional asset classes are used in order to broaden the sample and to test whether the Winner-Loser portfolio of the entire group of asset classes is a worthwhile investment.

The structure of this paper is to consider relevant literature in section 2, which motivates the decisions made for the model used in this research. Then in section 3, data is described in a data description in order to gain insight into the statistical properties of the different ETFs from different asset classes and to gain an understanding of the data underlying the momentum portfolios. In section 4, the methodology for the construction of the momentum portfolios is discussed. Then in section 5, the results of the momentum portfolios are shown with a section with robustness checks afterwards, after which there is a concluding section with a discussion and conclusion of the results and suggestions for future research.

## 2. Literature review

Most studies cover cross-sectional momentum in which assets are ranked based on the lookback period price or return. Jegadeesh and Titman (1993) introduce a cross-sectional signal where a long and short position are taken in the respective top (Winner) and bottom (Loser) decile based on previous j-month return. The asset classes and holding-periods in cross-sectional and time-series momentum have been subject to extensive research. De Jong and Rhee (2008) find that using broad-based domestic equity, factor, sector, international and bond indices for cross-sectional momentum strategies results in a significant positive performance based on a 4-, 8-, 12-, 16-, 20-, 26- and 39-week holding period and identical signal periods. Miffre and Rallis (2007) find that a cross-sectional momentum strategy with a holding period of 1-, 3-, 6-, and 12- months have significant returns in the commodity-futures asset class depending on the ranking period and vice versa. In their research, when considering a 1- and 3-month holding (ranking) period all ranking (holding) periods of 1-, 3-, 6- and 12-months have significant returns. When considering a 6- and 12-month ranking period, the 1-, 3- and 6-month holding periods are significant and the 1- and 3-month holding periods are significant respectively. For the 6- and 12-month holding periods, the 1-, 3- and 6-month ranking periods and the 1- and 3-month ranking periods have significant returns.

Less traditional asset classes have also been subject to cross-sectional momentum research. Multi-asset class investing with cross-sectional momentum signals has been shown to improve risk-return relationships when considering a 12-month lookback period and a monthly holding period (Clare et al. (2016)), which means that using a wide selection of asset classes would improve the performance in terms of risk-return of the momentum portfolios. Antonacci (2011) mentions a choice between a 6- and 12-month lookback period due to both performing considerably well in cross-sectional momentum research, and he ends up using a 6-month look-back period due to it reportedly having less volatility. The research by Antonacci also uses a 1-month holding period which, accompanied by the 6-month lookback period, results in the conclusion that adding fixed income securities and commodities and other non-correlated assets enhance the performance of a momentum strategy to a greater extent than it would enhance a regular buy and hold investment strategy. Beracha and Skiba (2011) find that in residential real estate, there is cross-sectional momentum when using Winner-Loser portfolios. Based on portfolios with the top 30% and bottom 30% returns they also find that momentum is present. Specifically, they find that when holding the holding period constant, increasing the selection period (lookback period) up to 3 quarters increases the return, and when holding the base period (lookback period) constant they find that increasing the holding period up to 3 quarters increases the momentum returns. A further increase to 4 quarters of the holding or ranking period when holding the ranking or holding period constant respectively decreases the returns to slightly below the 3 quarter levels.

Time-series momentum is a phenomenon that has limited literature availability as opposed to cross-sectional momentum. Moskowitz, Ooi and Pedersen (2012) propose time-series momentum where a long position is taken when the return of a particular asset i is positive over the last k months, while a short position is taken if the return of asset i is negative over the last k months. The time-series signals with 3-, 6-, 9-, and 12-month ranking (lookback) periods from Moskowitz, Ooi and Pedersen (2012) with equity indices and commodity, currency and bonds futures result in positive profits on average on the 58 assets they tested. Furthermore, the portfolios made by Moskowitz, Ooi and Pedersen (2012) also had significant alphas when tested on a market, bond, and commodity index and the small minus big, high minus low and momentum factors. He and Li (2015) use a time-series signal where a long position is taken when the price at time t is above the price of the decaying weighted moving average of the price of t-1 to t-m and vice versa for the short position. The time-series signal in He and Li (2015) results in significant returns for the stocks in the S&P-500 when using a 1 to 12 month holding period and a 6 month to 3 year selection (lookback) period. Antonacci (2012) considers a time-series momentum portfolio where he takes Winner positions in assets which have a higher return than treasury-bills, which he uses as a benchmark. Antonacci (2012) finds that equities and real estate have significant time-series momentum when testing these portfolios on the Fama-French three factor model. In a more recent study, Antonacci (2013) investigates time-series momentum where he takes a long position when the return over the lookback period is greater than zero, and takes a position in a treasury-bill when the return is below zero. In his research Antonacci (2013) finds positive significant alphas when regressing his time-series momentum portfolio on the US-market, CAPM, and the three factor Fama-French model.

The recent occurrence of the global financial crisis means that in order to have a representative time-series the financial crisis is included in the sample in this study. Cooper, Gutierrez, and Hameed (2004) find that momentum significantly depends on the market state, as they found that there are significant returns when conditioning the momentum portfolios on the market state. They also find that when accounting for macroeconomic variables, the momentum profits in the UP-state remain significant. In addition to previous studies, Kim, Mahajan and Petkevich (2012) find that in periods of high default shocks, momentum in corporate bonds exists, which means that in the period from 2007-2008, there might be corporate bond momentum which could enhance the performance of the momentum portfolio created. Chordia and Shivakumar (2002) find that when testing the momentum portfolios on macro-economic variables, specifically when conditioning on market state, it is found that momentum strategies are only interesting in market states of positive growth, whereas in negative market states momentum strategies are found to have negative insignificant returns. The fact that momentum portfolios perform better or worse depending on the market state might imply the momentum portfolio used in this study will perform significantly worse from 2007-2008 and during the aftermath of the global financial crisis.

Established literature (as previously mentioned in this study) is consistent in finding insignificant profits when holding periods exceed 12 months. A potential reason for this could be a delayed overreaction. Moskowitz, Ooi and Pedersen (2012) and Jegadeesh and Titman (1993) find that after a year, the trend reverses which leads to negative returns after a holding period of 12-months as the Winners start having lower returns and the Losers start having higher returns. As a result of the trend reversal, holding periods should not be longer than 12 months. Jegadeesh and Titman (2001) and Hong and Stein (1999) both propose the behavioral model of delayed overreaction to be a source of momentum profits. The delayed overreaction explains why it is only worthwhile holding a momentum portfolio for 12 months or less, since a reversal to equilibrium prices occurs after 12 months due to the delayed overreaction. Hong and Stein (1999) further argue that the early momentum traders cause a negative externality for the later momentum traders from them not knowing in what part of the momentum cycle they enter the trade. This means that the delayed overreaction causes negative returns for momentum traders in the long-run which is shown by the positive profits 1 to 12 months after the portfolio formation with negative profits 13-60 months after the portfolio formation. In addition, He and Li (2015) find that active momentum traders in the market lead to market-price underreaction in the short-run and market-price overreaction in the long-run which leads to gains in the short-run and losses in the long-run. Kent, Hirshleifer, and Subrahmanyam (1998) find that investors are overconfident in their own abilities. The overconfidence combined with a self-attribution bias leads to overreaction which causes short-run momentum and long run reversals. According to Chui and Titman (2010), overconfidence is caused by individualism and an attribution bias. Since individualism is very prevalent in the United States (Hofstede, 1980) the ETFs used in my study are mostly US traded ETFs which would lead to the ETFs being traded by individualistic traders, and as such, a significant overreaction could be present. These studies (e.g. (Jegadeesh and Titman (1993)), (Miffre and Rallis (2007))) confirm the success of the 1-, 3-, 6- and 12-month holding period, the delayed overreaction and the return reversals which leads to the use of holding periods of 4, 13, 26, and 52 weeks in order to capture the success of the respective holding periods and avoid the long-run reversal.

## 3. Data description

In this section the different statistical properties of the multiple asset classes that I use to analyze momentum in ETFs are described. I consider weekly data between 2004 and 2019 on the return index of commodities, corporate bonds, currencies, hedge funds, private equity, real estate, stocks, and treasury bond ETFs retrieved from Thomson Reuters Datastream. The return index considers the price, while also reinvesting dividends such that no artificial returns are created by price changes as a result of dividends. This data lends me to determine the 4-, 13-, 26- and 52-weekly return in percentages for each individual data point for each ETF in accordance with formula 1. In formula 1, k then varies based on what period return is needed which means the k is either 4, 13, 26 or 52.

$$R_{i,t} = ((P_{i,t} - P_{i,t-k})/P_{i,t-k}) * 100 \qquad (1)$$

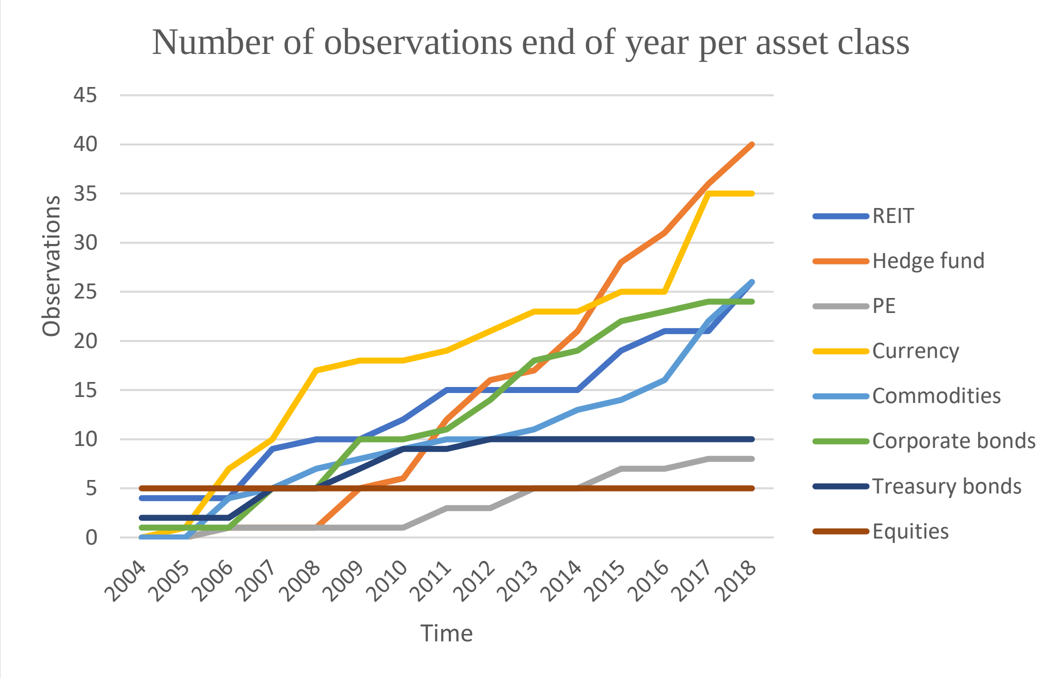
For all asset classes besides stocks I use a wide range of available data on multiple exchange traded funds (ETFs) per asset class since all ETFs within the non-traditional asset classes have different properties and different investing strategies. The most important ETFs to consider for number of ETF observations are ETFs in which a lot of variation occurs in terms of investments between different ETFs in order to obtain a representative sample. What this means is that for hedge funds, commodities and private equity ETFs more observations are needed while for equity not as many ETFs are needed due to the variety of investments of the ETFs.

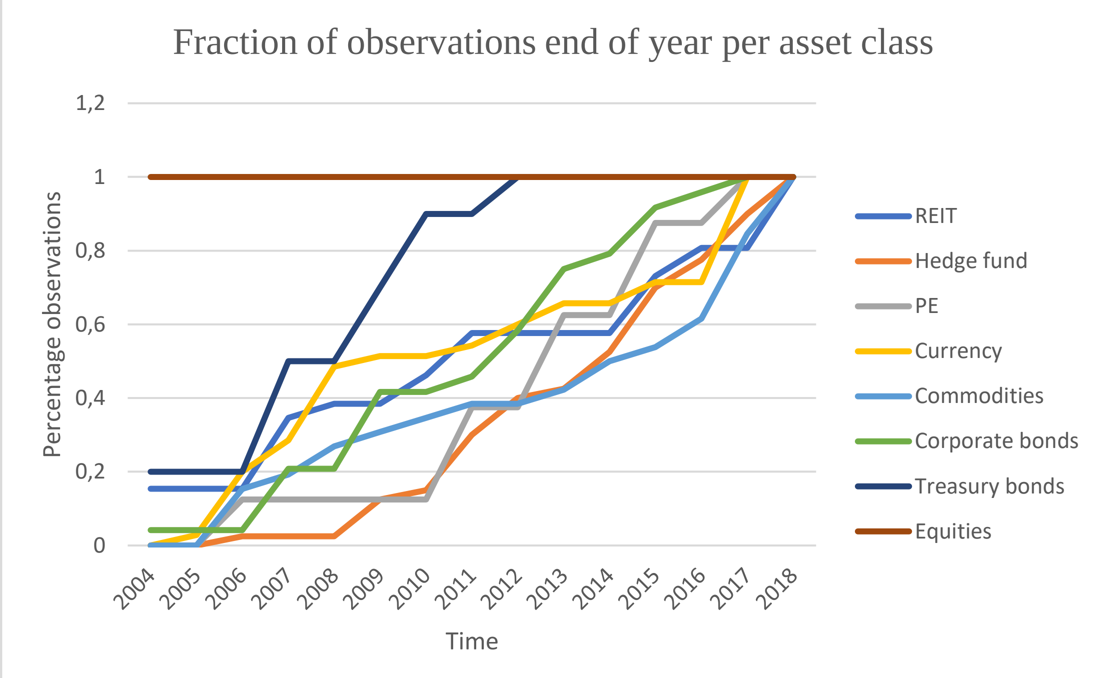
Since I chose only ETFs that still existed at the end of the sample in 2019 the argument of survivorship bias affecting the results could be made. However, since ETFs simply track indices and do not attempt to outperform the market, the return of ETFs is not affected by survivorship bias due to no own investing being done. Since outperformance is not a factor taken into consideration when considering ETFs, the effect of an ETF tracking an index that does not exist anymore on returns is irrelevant.

In graph 1a the cumulative number of observations for all asset classes are shown. Graph 1a shows that for most asset classes the amount of ETFs which have observations at the end of a particular year is considerably low in the first years of observations. Graph 1b shows that from 2012 and on in all asset classes at least 40% of all ETF observations are available. In 2014 graph 1b shows that hedge funds and commodities have at least half of the total observations of that particular ETF type available. Private equity has observations available at a slightly earlier point, namely 2013. Since both hedge funds and commodities have a high amount of absolute observations from an earlier point as shown in graph 1a, the low percentile of ETF availability is not a problem since there are enough observations available to have a wide variety of ETFs included in the Winner-Loser portfolios.

In table 1a to 1d the statistical behavior of the ETFs for each different individual asset class is further investigated for different holding periods. These average values displayed are an equally weighted average of each statistic for each individual asset class. Furthermore, mean return and standard deviation are annualized in order to facilitate comparison throughout the paper. When first considering the mean return, table 1a to 1d show that commodities have a negative average yearly return as an asset class while the rest of the assets have a positive average yearly return across all holding periods. What's more is that the standard deviations for REITs, commodities, PE, currencies and stocks are relatively high compared to the remaining asset classes across all holding periods. From the highly volatile classes, the currency asset class has a positive skew across the holding periods of 13, 26 and 52 weeks. The treasury bonds provide a stark contrast with the other asset classes, since treasury bonds have a low volatility across all holding periods in addition to a positive skew, which makes treasury ETFs relatively attractive within the dataset. The entirety of the 4-week holding period asset classes in table 1a lacks a positive skew besides the treasury bond asset class.

In addition to mean return, standard deviation, and skewness I also determined the kurtosis for the ETFs to get a more broad understanding of the distribution of returns. Across all holding periods REITs and equities have a relatively high kurtosis within their respective holding period. Treasury bonds have a relatively high kurtosis for the 13-, 26- and 52-week holding period. Corporate bonds have a relatively high kurtosis for the 4- and 13-week holding period.  Corporate bonds, REIT, and stocks have a very high kurtosis in the 4-week holding period, as can be seen in table 1a. It can be seen that in the 26- and 52-week holding period the kurtosis is closer to 0 which means the returns of those asset classes are slightly more normally distributed.




Graph 1a and 1b, the cumulative number of observations per asset class per year, and the cumulative percentage of number of observations per asset class per year.

| Statistic\|Asset class | REIT | Hedge fund | Commodity | PE | Currency | Corporate bond | Treasury bond | Equity |
|---|---|---|---|---|---|---|---|---|
| Mean (annualized) | 9.52 | 1.43 | -6.09 | 5.29 | 0.44 | 3.53 | 2.11 | 10.13 |
| Standard deviation (annualized) | 18.11 | 7.21 | 15.93 | 19.01 | 15.99 | 3.83 | 2.92 | 14.80 |
| Skewness | -0.02 | -0.36 | -0.28 | -0.28 | -0.05 | -0.05 | 0.67 | -0.80 |
| Kurtosis | 3.34 | 1.73 | 0.89 | 1.22 | 1.44 | 3.61 | 1.73 | 3.50 |

Table 1a, summary statistics of asset classes for the 4-week holding period.

| Statistic\|Asset class | REIT | Hedge fund | Commodity | PE | Currency | Corporate bond | Treasury bond | Equity |
|---|---|---|---|---|---|---|---|---|
| Mean (annualized) | 7.60 | 0.99 | -4.81 | 4.64 | 0.47 | 3.48 | 2.12 | 9.51 |
| Standard deviation (annualized) | 16.27 | 6.95 | 15.89 | 18.15 | 14.50 | 4.03 | 3.14 | 15.03 |
| Skewness | -0.16 | -0.33 | -0.45 | -0.25 | 0.01 | -0.01 | 0.75 | -1.06 |
| Kurtosis | 1.84 | 0.55 | 0.76 | 0.81 | 0.50 | 1.57 | 1.61 | 4.42 |

Table 1b, summary statistics of asset classes for the 13-week holding period.

| Statistic\|Asset class | REIT | Hedge fund | Commodity | PE | Currency | Corporate bond | Treasury bond | Equity |
|---|---|---|---|---|---|---|---|---|
| Mean (annualized) | 6.71 | 0.75 | -4.35 | 5.16 | 0.59 | 3.32 | 2.07 | 9.73 |
| Standard deviation(annualized) | 15.00 | 5.97 | 15.21 | 17.40 | 12.11 | 3.84 | 3.24 | 15.90 |
| Skewness | -0.16 | -0.16 | -0.25 | 0.19 | 0.02 | 0.26 | 0.96 | -1.11 |
| Kurtosis | 1.76 | 0.20 | 0.04 | -0.10 | 0.02 | 0.73 | 1.69 | 4.18 |

Table 1c, summary statistics of asset classes for the 26-week holding period.

| Statistic\|Asset class | REIT | Hedge fund | Commodity | PE | Currency | Corporate bond | Treasury bond | Equity |
|---|---|---|---|---|---|---|---|---|
| Mean (annualized) | 7.83 | 1.59 | -0.27 | 5.70 | 0.67 | 3.23 | 1.95 | 10.17 |
| Standard deviation (annualized) | 15.88 | 5.17 | 14.17 | 17.14 | 10.18 | 3.60 | 2.98 | 16.03 |
| Skewness | 0.30 | -0.21 | -0.03 | 0.30 | 0.31 | 0.47 | 0.99 | -1.01 |
| Kurtosis | 1.31 | -0.13 | -0.39 | 0.04 | -0.23 | 0.31 | 1.16 | 2.37 |

Table 1d, summary statistics of asset classes for the 52-week holding period.

To further identify statistical properties of each asset class I take a closer look at each asset class' scatterplots individually in order to look for outliers and to get a general idea of the assets that will be included in the momentum portfolios. In graphs 4a to 4g (see appendix B) the scatterplots for standard deviation, the mean monthly return, skewness and kurtosis for each distinct asset class and the 4-week holding period can be found. In addition, the graphs for the 13-, 26- and 52-week holding period are discussed in this section and can be requested per email to the author. High kurtosis and high (low) skewness will show whether a certain ETF might occur more often in the winner-loser portfolios due to the kurtosis and skewness being a direct measure of distribution of returns of these ETFs.

The graphs of the scatterplots of mean return and standard deviation show that across all asset classes there are not a high number of outliers which means that the mean returns are relatively similar within asset classes, which also holds true for the standard deviation. Relative to the mean and standard deviation there is a slightly higher number of outliers in the kurtosis and skewness statistics within asset classes. When first considering kurtosis, in the 4-week holding period for currencies in graph 4b there are 5 outliers with a high kurtosis, while in the rest of the holding period there is only one outlier each. The Graphs shows that the hedge fund ETFs have 3 outliers in the 13-week holding period in terms of kurtosis which have high values, while the hedge fund ETFs have 5 outliers with high values in the 26-week holding period. Furthermore, the graphs shows that corporate bonds have 4 outliers in the 52-week holding period with high values.

When next considering skewness, graph 3f shows for the real estate ETF with a 4-week holding period that there are 5 outliers. Furthermore, graphs show that commodities have 3 outliers in the 13-week holding period and hedge funds with a 26-week holding period have 5 outliers. For hedge funds, in the 52-week holding period it can also be seen that there are 6 outliers, in terms of skewness. Moreover, in the 52-week holding period real estate also has 3 outliers.

What can be concluded from looking at the scatterplots and looking at the outliers is that all ETFs with a 4- and 13-week holding period are mostly leptokurtic since they have an excess kurtosis greater than 0. For the 26-week holding period it can be seen that these ETFs are about equally divided in a considerable amount of kurtosis greater than 0, a considerable amount of kurtosis equal to 0 and a considerable amount of kurtosis of ETFs smaller than 0. The 52-week holding period has kurtosis for all ETFs besides REIT divided equally between leptokurtic and platykurtic.

## 4. Methodology

I construct momentum portfolios based on the ETFs for the 4-, 13-, 26- and 52-week holding periods, and enter a new momentum position every month. An ETF has positive or negative momentum, which is determined with a signal based on a 52-week linearly increasing weighted moving average (WMA) (He and Li (2015)). The linearly increasing WMA of the 52-week lookback period is used where the more recent observations are attached a higher weight (He and Li (2015)). This WMA is a linearly increasing function of 4-week returns, where each return closer to the signal date is given a higher weight which ranges from 1/52 to 52/52 as shown in formula 3 below. In turn, the WMA is divided by the sum of 1/52 to 52/52 in order to give the signal a weight of one which is shown in formula 3 below. Winner and Loser positions are taken based on whether the 4-week return is above or below the WMA, which is in accordance with the following formulas, formula 2 and 3, where $R_{t+1-k}$ is the average 4-week holding period return of all ETFs until a particular time t+1-k, and $R_{i,t}$ is the 4-week return of an ETF i until time t. The entire cross-section of ETF returns is considered instead of own returns in the WMA, since the cross-section of ETFs would be greatly reduced in the early periods if solely using the own returns due to the lookback period being 52 weeks. Formula 2 shows signal 1, where if the result of the subtraction is positive, ETF i is a Winner, while if the subtraction is negative ETF i is a Loser.

$$Signal_1 = R_{i,t} - WMA_t \tag{2}$$

$$WMA_t = 1/(\sum_{j=1}^{52} 1/j) * \sum_{\mathrm{k}=1}^{52} (R_{t+1-k} * (53-k)/52) \tag{3}$$

The top and bottom 60th percentile Winner and Loser portfolios are constructed based on whether the return on asset i is greater than the 40th percentile return of previous determined Winners, and whether the return on asset i is smaller than the 60th percentile return of previous determined Losers, which makes these top and bottom portfolios subsets of the original Winner and Loser portfolios. Specifically, if asset i has a return above the 40th percentile of Winner returns, it will be included in the top subset of the Winners, and if asset i has a return below the 60th percentile of Loser returns, it will be included in the bottom subset of the Loser portfolio. The resulting 60th percentile momentum portfolio of Winners-Losers will be referred to as the extreme momentum portfolios in the remainder of this paper. The top 60% and bottom 60% of returns of the Winners and the Losers respectively are used in this portfolio since literature on momentum in general tests the top and bottom 30% returns. In this study, I wanted to keep the number of observations in the early periods at a reasonable level, so I decided to take the top and bottom 60% of Winners and Losers respectively in order to still take into account the higher and lower returns of the respective Winner and Loser portfolios while still retaining a reasonable amount of observations.

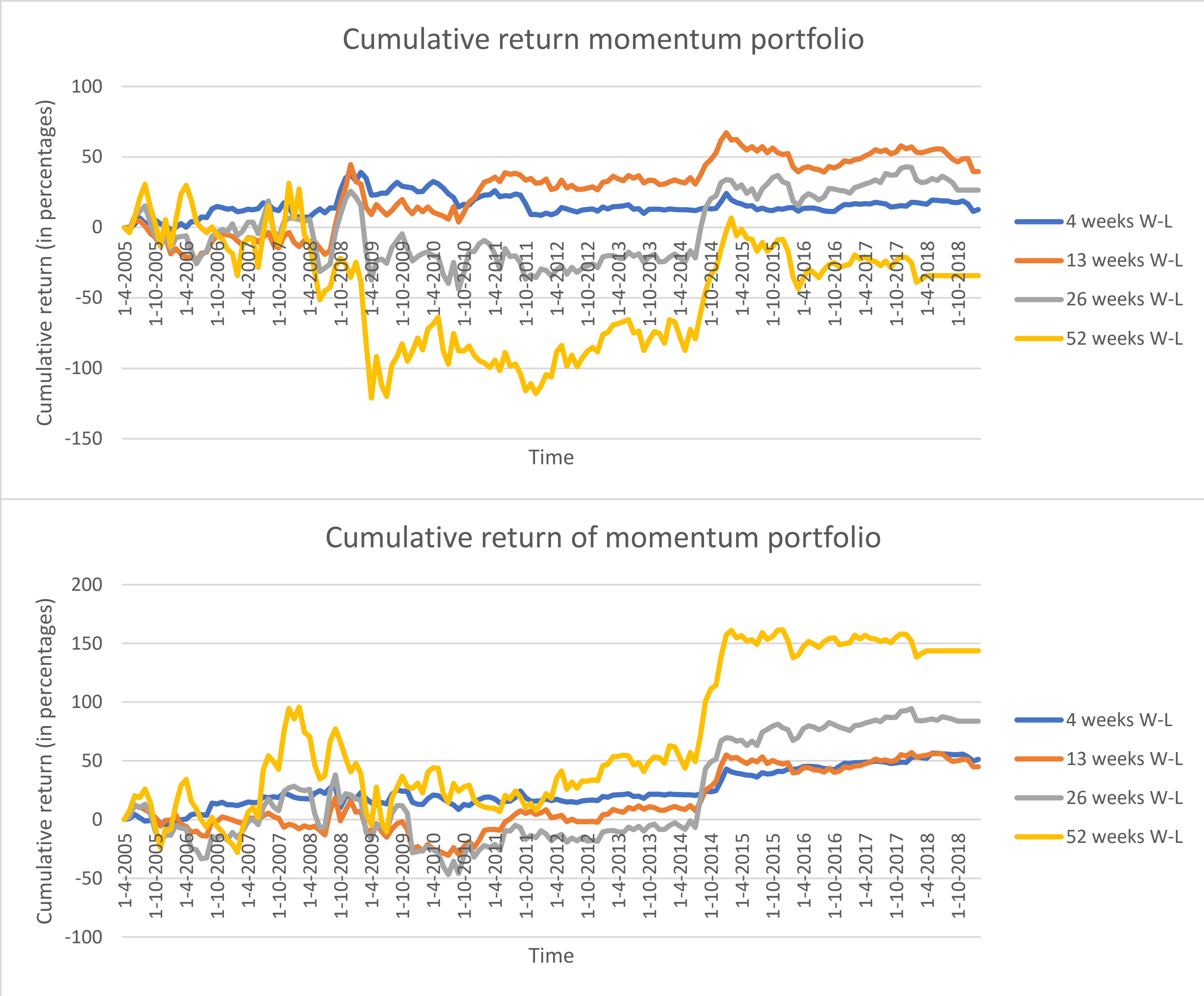
Due to the nature of the signal in some periods (8 maximum in the case of the extreme momentum portfolio without a waiting period), there are no observations available for either a long (short) position due to the WMA being higher (lower) than all returns. To keep exposure to the market in these particular periods, a long (short) position is taken, depending on whether a long or short observation is missing, in a treasury bill with a maturity that matches the holding period of the particular strategy. Due to these treasury positions, k and l in formula 4 will never be 0, so formula 4 is never undefined. Each portfolio is assigned an equal weight to each of the available ETFs within the short and long portfolios in accordance to the following formula where k and l are the number of ETFs in the Winner and Loser parts of the portfolios respectively. The momentum portfolios are formed in accordance with formula 4.

$$Winner - Loser\ portfolio\ return = 1 * 1/k \sum_{i=1}^{k} R_{i,winner} - 1 * 1/l \sum_{j=1}^{l} R_{j,loser} \qquad (4)$$

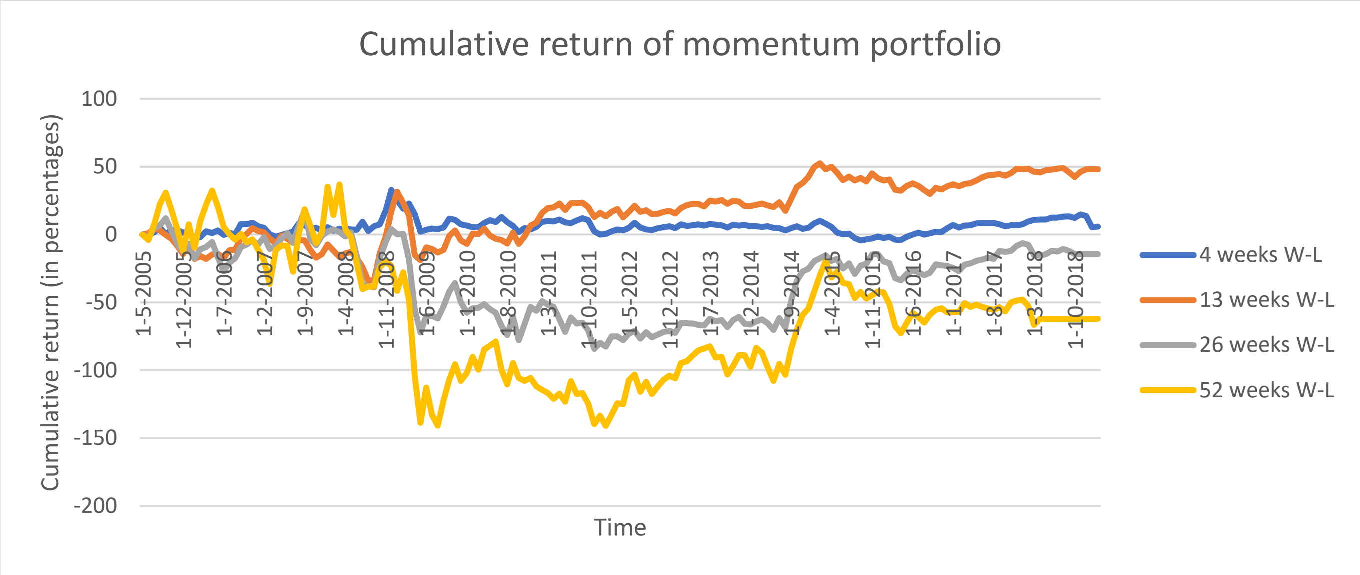
In addition, in all these cases, a distinction is made between waiting one week and not waiting one week after the signal before investing in the portfolios to conform to the literature of Jegadeesh and Titman (1995). The waiting period is included in order to reduce the effect of liquidity on the bid-ask spread consistent with Jegadeesh and Titman (1995). Taking the waiting period into account should lead to smoother returns (decreased volatility) as opposed to not taking the waiting period into account. The following equation, equation 5, is then used to test whether the Winner-Loser momentum portfolios add any value.

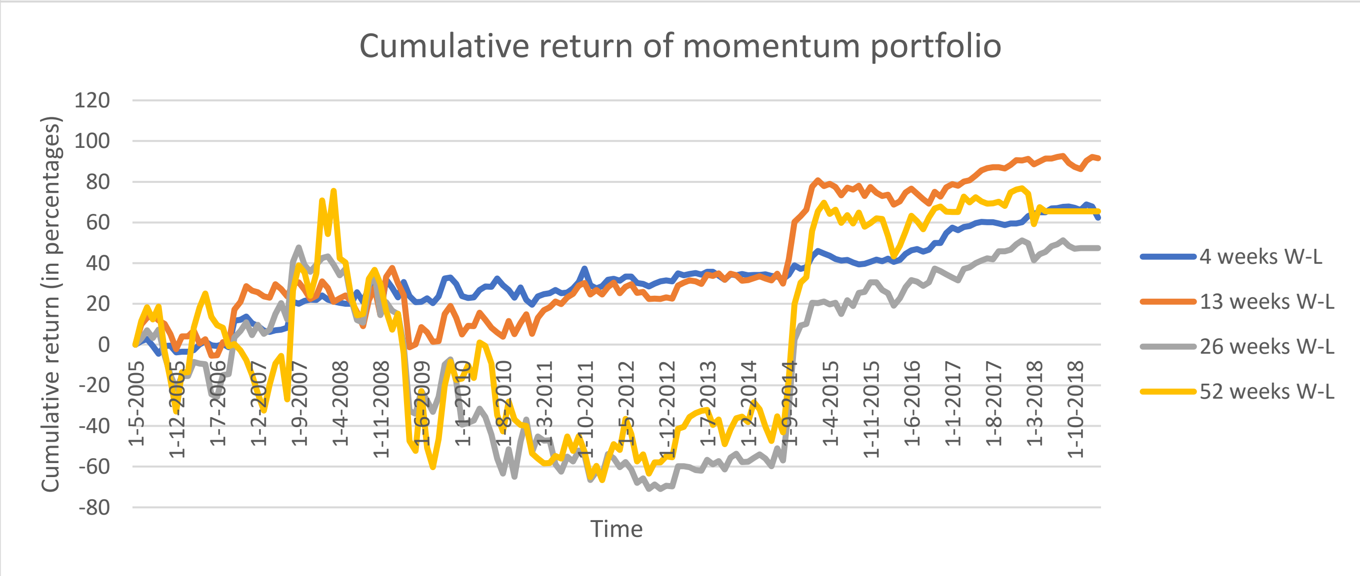
$$R_i^{mom} = \alpha_1 + \beta_1 * R_i^{MSCIworld} + \beta_2 * R_i^{MSCImom} + \epsilon \qquad (5)$$

In formula 5, $R_i^{mom}$, $R_i^{MSCIworld}$, and $R_i^{MSCImom}$ are the Winner-Loser momentum portfolio, and the MSCI World and the MSCI momentum (is used as a tool to study characteristics of momentum strategies (MSCI (2014))) index respectively with the index i indicating the 4-, 13-, 26- and 52-week holding period. All returns of the independent variables in this regression are excess returns besides the momentum returns since momentum consists of Winner-Loser portfolios. If alpha is significant, it can be concluded that the strategy is worth investing in, in addition to the benchmarks provided in equation 5. When one or more of the betas is found to be significant, the ETF momentum strategy has an overlap in return variance with the significant factors.




Graph 2a and 2b. Graph 2a (top) shows the cumulative return of the time-series momentum portfolio including all Winner and Loser returns without a waiting period. Graph 2b (bottom) shows the cumulative return of the extreme time-series momentum portfolio without a waiting period.



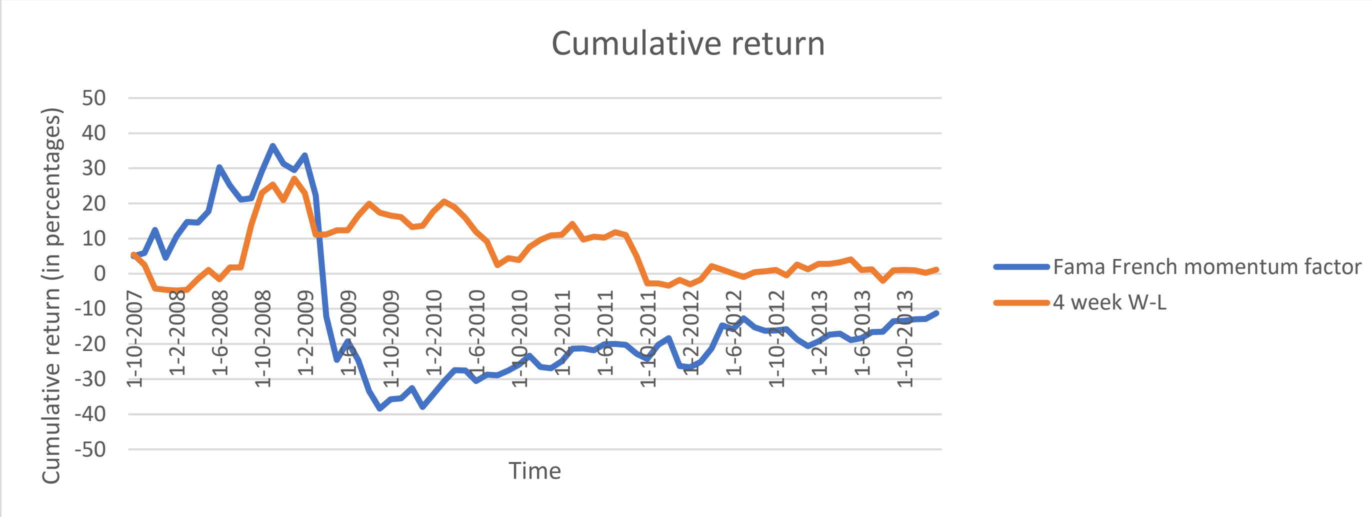



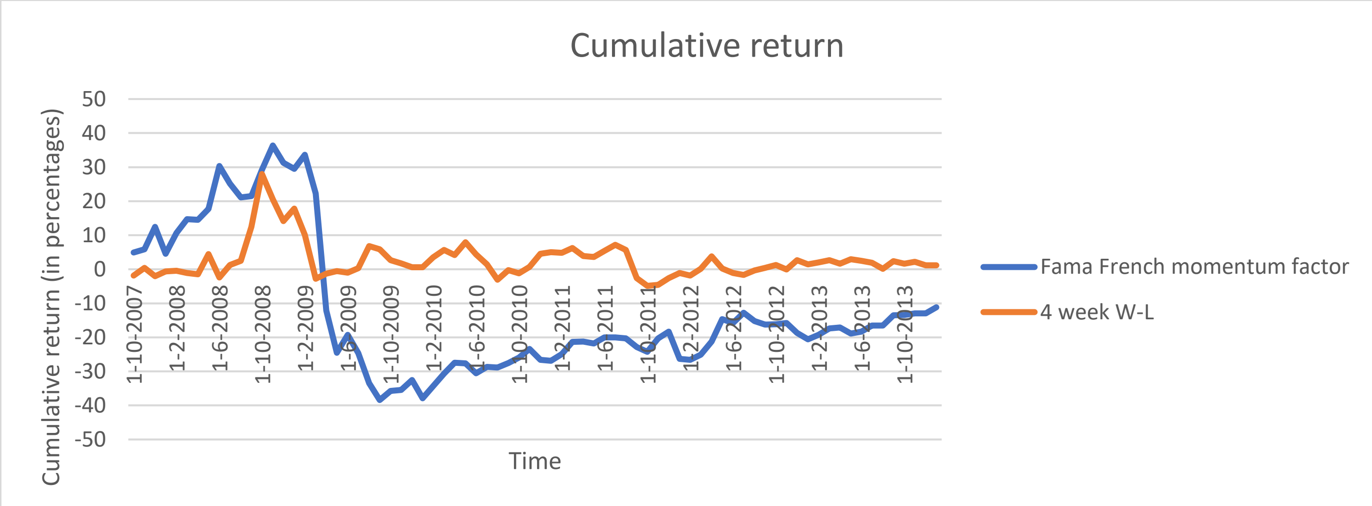

Graph 2c and 2d. Graph 2c (top) shows the cumulative return of the time-series momentum portfolio with all Winner and Loser returns with a waiting period. Graph 2d (bottom) shows the cumulative return of the extreme time-series momentum portfolio with a waiting period.

## 5. Results

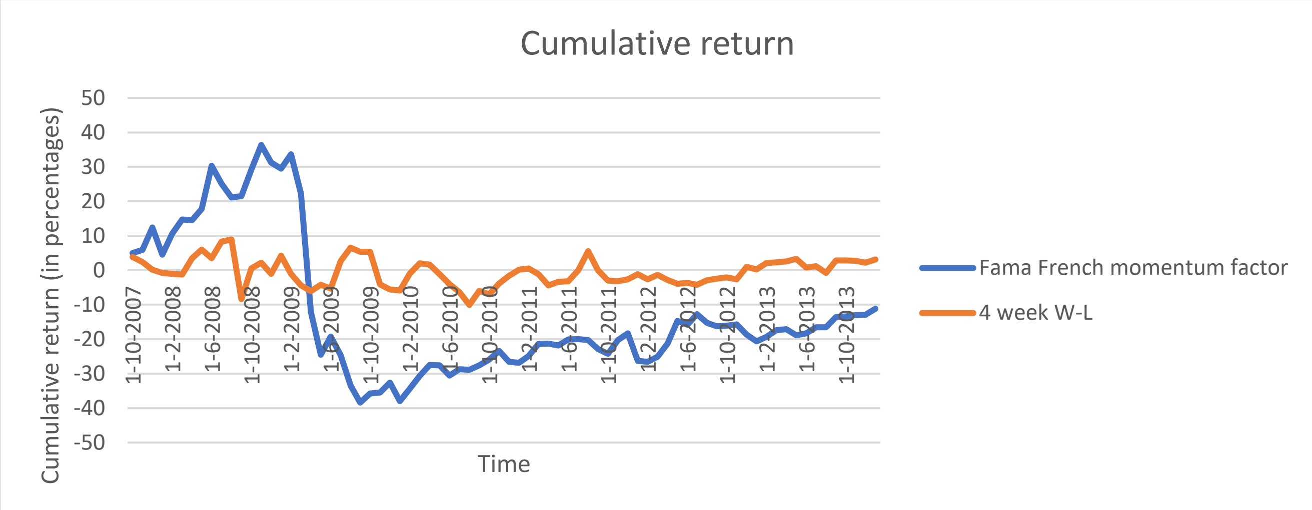
Graphs 2a to 2d show the cumulative returns of each strategy. When considering the extreme momentum portfolios with and without a waiting period, increasing the holding period does not necessarily lead to an increased return. Only when considering the extreme momentum portfolio in graph 2b, it can be seen that the 52-week holding period has the highest cumulative return, which is the only momentum portfolio that is in accordance with the result of Beracha and Skiba (2011) who state that returns increase when increasing the holding period with a constant lookback period. Crash risk is seen as a source of momentum profits and researchers in favor of this theory (e.g. Daniel and Moskowitz (2016)) might find graphs 2a to 2d interesting due to the large decline in returns at the end of 2008 and beginning of 2009. The cumulative returns in that period occurred during the financial crisis, which is a state of financial panic. Daniel and Moskowitz (2016) propose financial panic to be a reason for momentum crashes. This considerably large decline in profits seems to be a significant reason for the weak performance of these portfolios in terms of cumulative return.

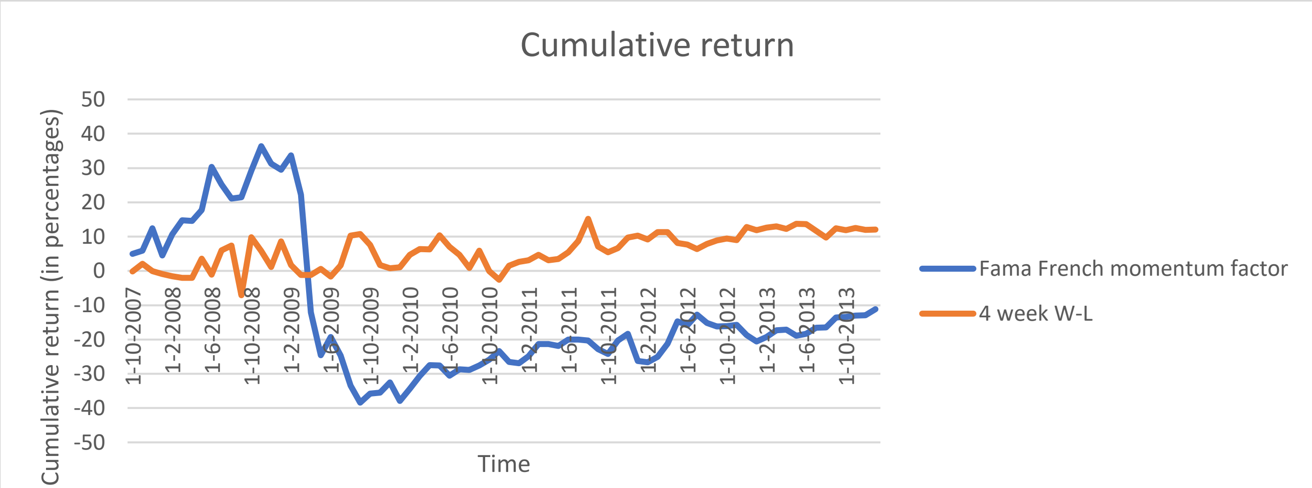
Graphs 3a to 3d show the cumulative return of the 4-week holding period of all time-series momentum strategies in this study and the Fama-French cross-sectional momentum factor during the 2007 to 2014 period. Graphs 3a to 3d show that the momentum crash is significantly larger for the cross-sectional Fama-French momentum factor than for the 4-week time-series momentum factor. Furthermore, graphs 3a to 3d show that when comparing the cross-sectional momentum with the time-series momentum portfolios that the time-series momentum outperforms the cross-sectional momentum in the 2007 to 2014 time period in terms of cumulative return, since there is a higher cumulative return at the end of 2014 for all time-series momentum portfolios.




Graph 3a and 3b, 3a (top) shows the cumulative return of Fama-French momentum factor and the 4 week W-L portfolio with all Winner and Loser returns without a waiting period, while 3b (bottom) shows the cumulative return of Fama-French momentum factor and the 4 week W-L portfolio with all Winner and Loser returns with a waiting period.




Graph 3c and 3d, graph 3c (top) shows the cumulative return of the Fama-French momentum strategy and the extreme momentum portfolio without a waiting period, while graph 3d (bottom) shows the cumulative return of the extreme momentum portfolio with a waiting period and the Fama-French momentum factor.

To delve deeper into the characteristics of the momentum portfolios, table 2a shows the summary statistics for the momentum strategy for all holding periods using the entire set of returns from the Winner and Loser portfolios without a waiting period. The annualized mean and standard deviation are shown in the table. The mean return of the momentum strategy is considerably low, and even negative in case of the 52-week holding period. Moreover, The standard deviations of the momentum portfolios are all lower than the equity indices. For the 4- and 13-week holding periods, the skewness is positive, while for the 26- and 52-week holding periods, the skewness is negative. Furthermore, the kurtosis for all these momentum portfolios in table 2a is higher than 0, which indicates a leptokurtic return character.

Table 2b shows the momentum strategy for momentum portfolios with all Winner and Loser returns with a waiting period. The mean returns are positive but considerably low for the 4- and 13-week holding period while the mean returns are negative for both the 26-and 52-week holding period. Table 2b shows lower Sharpe ratios which is attributed to the higher standard deviations in table 2b than in table 2a. The standard deviations in table 2b are all of a similar magnitude to (though slightly higher than) the standard deviations in table 2a. The skewness in table 2b is only positive for the 4-week holding period, while the skewness is negative for the other holding periods. Moreover, the kurtosis of the momentum portfolios in table 2b are all higher than those in table 2a. Surprisingly, the waiting period of Jegadeesh and Titman (1995) does not achieve its purpose of a lower volatility.

Overall, when comparing table 2c to 2d, which are the extreme momentum portfolios with and without a waiting period respectively, the portfolio with the waiting period does not necessarily display less extreme behavior. The mean return of both the portfolios in table 2c and 2d are extremely low in comparison to the equity returns, while the standard deviations are rather high for the mean returns occurring in these portfolios. When comparing across these portfolios, the mean return of the portfolios in table 2d is higher for the 26- and 52-week holding period, while it is lower for the 4- and 13-week holding period. For the skewness and kurtosis, the portfolio with the waiting period performs worse in terms of the kurtosis, while the skewness is higher for the portfolio with the waiting period. The Sharpe-ratios of the 26- and 52-week holding period in table 2d are higher than the Sharpe-ratios in table 2c. For the 4- and 13-week holding period the Sharpe-ratios in table 2c are higher than the Sharpe-ratios in table 2d. In terms of absolute performance compared to the equity asset class, the mean of these momentum portfolios is significantly smaller than the mean of the equity indices, while the standard deviation is only slightly lower. The kurtosis and skewness are also similar to the equity indices, which means that the momentum portfolios overall have less attractive statistical characteristics.

| *Statistic\|Table 2a. All Winner and Loser returns without waiting* | *4 week W-L* | *13 week W-L* | *26 week W-L* | *52 week W-L* |
|---|---|---|---|---|
| Mean (Yearly) | 1.01 | 0.96 | 0.33 | -0.22 |
| Standard deviation (Yearly) | 10.23 | 9.72 | 10.88 | 12.21 |
| Skewness | 0.05 | 0.24 | -0.57 | -0.36 |
| Kurtosis | 3.71 | 2.13 | 2.57 | 1.03 |
| Sharpe-Ratio (Yearly) | 0.10 | 0.10 | 0.03 | -0.02 |
| *Statistic\|Table 2b. All Winner and Loser returns with waiting* | *4 week W-L* | *13 week W-L* | *26 week W-L* | *52 week W-L* |
| Mean (Yearly) | 0.47 | 1.18 | -0.18 | -0.40 |
| Standard deviation (Yearly) | 11.10 | 10.67 | 10.85 | 12.46 |
| Skewness | 0.17 | -0.37 | -0.86 | -0.51 |
| Kurtosis | 5.88 | 6.42 | 3.34 | 2.19 |
| Sharpe-Ratio (Yearly) | 0.04 | 0.11 | -0.02 | -0.03 |
| *Statistic\|Table 2c. Extreme momentum portfolios without waiting* | *4 week W-L* | *13 week W-L* | *26 week W-L* | *52 week W-L* |
| Mean (Yearly) | 4.02 | 1.09 | 1.03 | 0.92 |
| Standard deviation (Yearly) | 10.84 | 9.93 | 11.59 | 11.69 |
| Skewness | -0.62 | -0.12 | -0.17 | 0.43 |
| Kurtosis | 8.39 | 3.58 | 3.84 | 1.24 |
| Sharpe-Ratio (Yearly) | 0.37 | 0.11 | 0.09 | 0.08 |
| *Statistic\|Table 2d. Extreme momentum portfolios with waiting* | *4 week W-L* | *13 week W-L* | *26 week W-L* | *52 week W-L* |
| Mean (Yearly) | 4.91 | 2.22 | 0.59 | 0.42 |
| Standard deviation (Yearly) | 12.12 | 10.62 | 11.53 | 12.35 |
| Skewness | 0.79 | -0.03 | 0.24 | 0.48 |
| Kurtosis | 7.02 | 4.63 | 3.82 | 3.13 |
| Sharpe-Ratio (Yearly) | 0.41 | 0.21 | 0.05 | 0.03 |

Table 2, statistical characteristics of time-series momentum portfolios where row 1 column 2, 3, 4 and 5 indicate the holding period for the respective momentum portfolio.

To investigate whether the time-series momentum portfolios have less attractive statistical characteristics than equity ETFs and cross-sectional Fama-French momentum portfolios, table 3 is used. Table 3 shows the summary statistics for the S&P 500 SPY ETF, the Fama-French cross-sectional momentum portfolio and the 4-week holding period extreme time-series momentum portfolio without a waiting period. Table 3 shows that the Fama-French momentum portfolio does perform worse than the time-series momentum portfolio in terms of risk-return tradeoff over the 2005 to 2019 period. Moreover, table 3 shows that the S&P 500 ETF SPY outperforms the time-series momentum portfolio in terms of the risk-return tradeoff. The skewness of the time-series momentum portfolio is only slightly higher, while the kurtosis for the time-series momentum portfolio is considerably higher. The passive investment strategy in the S&P 500 ETF SPY seems more interesting due to these statistical characteristics.

| ***Statistic / Portfolio*** | **S&P 500 ETF SPY** | **Fama-French momentum factor** | **Time-series momentum portfolio** |
|---|---|---|---|
| Mean (annualized) | 7.61 | 0.52 | 4.02 |
| Standard deviation (annualized) | 13.60 | 15.50 | 10.84 |
| Skewness | -0.79 | -2.87 | -0.62 |
| Kurtosis | 2.19 | 20.83 | 8.39 |
| Sharpe-Ratio (Yearly) | 0.56 | 0.03 | 0.37 |

Table 3, summary statistics for S&P 500 ETF SPY, the Fama-French momentum portfolio, and the time-series extreme momentum portfolio without a waiting period with the 4-week holding period.

Comparing the portfolios from tables 2a and 2b, as well as 2c and 2d, it shows that the waiting period does not necessarily smoothen the standard deviation of these portfolios as the literature of Jegadeesh and Titman (1995) suggests. Neither does it lead to a higher mean return in all cases. The statistical characteristics show that these portfolios do not support the literature by Jegadeesh and Titman (1995) regarding the effect of bid-ask spread on momentum portfolios (increased volatility) for which a reason could be that an ETF is an aggregate of assets due to which the bid-ask spread has a smaller effect. Furthermore, the time-series momentum portfolio seems to outperform the Fama-French momentum portfolio but underperform the equity ETFs in terms of statistical characteristics.

To delve deeper into each strategy, tables 4a to 4d provide the alpha and beta coefficients and significance levels of the alphas and betas of each strategy when testing these strategies on the chosen benchmarks MSCI-world and MSCI-momentum as shown in formula 5. It can be concluded from the test whether the momentum strategy adds value to the relevant indices based on whether the alpha is significantly different from zero. The stars display the significance level, where *, ** and *** imply a 10%, 5%, and 1% significance level.

Table 4a shows the factor analysis for the time-series momentum portfolios with all Winner and Loser returns without a waiting period. In each of the 4-, 13-, 26- and 52-week holding period, there are no significant alphas. The portfolio shows significant beta coefficients with other factors. In the 4-week holding period the MSCI-world factor is significant at the 10% level. In the 13-week holding period MSCI-world is significant at the 5% level. In the 26-week holding period both MSCI-world and MSCI-momentum are significant at the 1% level. The significance of these factors means the returns from the momentum portfolio constructed from the ETFs have an overlap in variance with the returns from the MSCI momentum factor and MSCI-world factor, suggesting a cross-sectional momentum and MSCI-world component to the 26-week holding period portfolio. The significant betas of -0.31 and 0.27 of the MSCI-world and MSCI-momentum factors respectively shows that when investing in this portfolio with the 26-week holding period, an exposure of -0.31 to MSCI-world and 0.27 to MSCI-momentum would be gained. Moreover, the negative betas of the MSCI-world index coefficients of -0.22 and -0.15 significant at the 5% and 10% level that investing in the momentum portfolio with the 13- and 4-week holding period would offer negative exposure to the return of the MSCI-all index.

Table 4b shows the time-series momentum portfolio with all returns of Winners and Losers with a one week waiting period, as suggested in Jegadeesh and Titman (1995). The alpha coefficients are not significant implying that these portfolios do not add significant value to the existing indices used as explanatory variables in this regression. The MSCI-momentum factor is significant in the 26- and 52-week holding period at the 5% and 10% level respectively. In addition to those factors, MSCI-world is significant for the 4 week-holding period at the 1% level, significant at the 5% level for the 13- and 26-week holding period and significant at the 10% level for the 52-week holding period. These significant factors mean that the momentum portfolios created from ETFs have a significant overlap in return variation in the 26-week and 52-week holding period with the MSCI-momentum factor, while there is also significant overlap in return variation in all holding periods with the MSCI-world factor.

| Statistic\|Factor 4 week holding period | Constant | MSCI world | MSCI momentum | $R^2$ |
|---|---|---|---|---|
| Coefficient | 0.15 | -0.15 | -0.01 | 0.05 |
| T-statistic | 0.64 | -1.73* | -0.29 | |
| **Statistic\|Factor 13 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 0.45 | -0.22 | 0.10 | 0.06 |
| T-statistic | 0.96 | -2.39** | 1.48 | |
| **Statistic\|Factor 26 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 0.12 | -0.31 | 0.27 | 0.08 |
| T-statistic | 0.19 | -2.77*** | 3.22*** | |
| **Statistic\|Factor 52 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | -0.01 | -0.15 | 0.09 | 0.00 |
| T-statistic | -0.01 | -1.58 | 1.17 | |

Table 4a, factor analysis of time-series momentum portfolio with all Winner and Loser returns without a waiting period.

| Statistic\|Factor 4 week holding period | Constant | MSCI world | MSCI momentum | $R^2$ |
|---|---|---|---|---|
| Coefficient | 0.14 | -0.25 | 0.00 | 0.11 |
| T-statistic | 0.59 | -2.73*** | 0.06 | |
| **Statistic\|Factor 13 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 0.54 | -0.28 | 0.12 | 0.10 |
| T-statistic | 1.03 | -2.35** | 1.03 | |
| **Statistic\|Factor 26 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | -0.10 | -0.28 | 0.24 | 0.06 |
| T-statistic | -0.17 | -2.05** | 2.57** | |
| **Statistic\|Factor 52 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | -0.31 | -0.32 | 0.24 | 0.04 |
| T-statistic | -0.26 | -1.8* | 1.78* | |

Table 4b, factor analysis of time-series momentum portfolios with all Winner and Loser returns taken with  a waiting period.

| Statistic\|Factor 4 week holding period | Constant | MSCI world | MSCI momentum | $R^2$ |
|---|---|---|---|---|
| Coefficient | 0.27 | 0.06 | 0.03 | 0.00 |
| T-statistic | 1.00 | 0.45 | 0.65 | |
| **Statistic\|Factor 13 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 0.40 | -0.06 | 0.01 | 0.00 |
| T-statistic | 1.01 | -0.66 | 0.07 | |
| **Statistic\|Factor 26 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 0.58 | -0.16 | 0.12 | 0.01 |
| T-statistic | 0.89 | -1.56 | 1.08 | |
| **Statistic\|Factor 52 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 1.58 | -0.11 | 0.01 | 0.01 |
| T-statistic | 1.33 | -1.38 | 0.14 | |

Table 4c, factor analysis of extreme time-series momentum portfolio without a waiting period.

| Statistic\|Factor 4 week holding period | Constant | MSCI world | MSCI momentum | $R^2$ |
|---|---|---|---|---|
| Coefficient | 0.40 | -0.12 | 0.05 | 0.01 |
| T-statistic | 1.51 | -0.97 | 0.63 | |
| **Statistic\|Factor 13 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 0.64 | -0.15 | 0.08 | 0.02 |
| T-statistic | 1.8* | -1.46 | 0.93 | |
| **Statistic\|Factor 26 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 0.34 | -0.12 | 0.09 | 0.00 |
| T-statistic | 0.52 | -1.13 | 1.03 | |
| **Statistic\|Factor 52 week holding period** | **Constant** | **MSCI world** | **MSCI momentum** | **$R^2$** |
| Coefficient | 0.79 | -0.25 | 0.15 | 0.03 |
| T-statistic | 0.72 | -2.38** | 1.87* | |

Table 4d, factor analysis of extreme time-series momentum portfolio with a waiting period.

Table 4c shows the results of the extreme time-series momentum portfolio without the waiting period, which shows that there is no significant alpha, suggesting that these portfolios do not add value to the existing portfolios used as a benchmark. These extreme momentum portfolios do not load significantly on any of the MSCI-world and MSCI-momentum factors which means the extreme momentum portfolio does not have a significant overlap in returns variations with the MSCI-momentum and MSCI-world factors.

Table 4d shows the factor analysis for the extreme time-series momentum portfolio with a waiting period of one week (Jegadeesh and Titman (1995); (1993)). Table 4d shows that there is a significant alpha coefficient at the 10% level for the 13-week holding period, meaning that this portfolio does add limited value to the available investor strategies. Moreover, in the 52 week holding period MSCI-world and MSCI momentum are significant at the 5% and 10% level respectively. What this means is that the extreme momentum portfolio with a waiting period has a significant overlap in variation with the MSCI-world and MSCI-momentum factor of -0.25 and 0.15 respectively. These significant coefficients imply a negative and positive MSCI-world and MSCI-momentum component respectively, which means that buying the extreme momentum portfolio with a 52-week holding period offers exposure to the MSCI-world and MSCI-momentum factor.

| Factor\|Momentum portfolios | 4 week W-L | 4 week W-L | 4 week W-L | 4 week W-L |
|---|---|---|---|---|
| Constant | 0.08 | 0.04 | 0.31 | 0.38 |
| T-statistic | 0.35 | 0.15 | 1.38 | 1.85* |
| Coefficient of Fama-French factor | 0.03 | -0.03 | 0.01 | -0.07 |
| T-statistic | 0.71 | -0.48 | 0.12 | -1.11 |
| $R^2$ | 0.00 | 0.00 | 0.01 | 0.00 |

Table 5, portfolio in column 2, 3, 4 and 5 show the time-series momentum portfolio with all Winner and Loser returns without the waiting period, the time-series momentum portfolio with all Winner and Loser returns with a waiting period, the extreme time-series momentum portfolio without a waiting period and the extreme time-series momentum portfolio with a waiting period respectively.

To test whether the 4-week holding period time-series momentum has overlapping return variation with the cross-sectional Fama-French momentum factor, formula 6 is used. This additional test is done to check whether there are similarities between the traditional cross-sectional Fama-French momentum factor and the time-series momentum factor created in my study. In formula 6, $R_{4,t}$ and $R_t^{FamaFrench}$ are the returns of the time-series momentum portfolios with a 4 week holding period and the return on the monthly Fama-French cross-sectional momentum factor respectively.

$$R_{4,t} = \alpha_i + \beta_1 * R_t^{FamaFrench} + \epsilon \qquad (6)$$

Table 5 shows that none of the betas for all the time-series momentum portfolios are significant. Furthermore, in the 4-week W-L portfolio of column 5, which is the extreme momentum portfolio with a waiting period, it can be seen that there is a significant alpha. The significant alpha means that the time-series momentum adds significant value in addition to the cross-sectional momentum factor. Moreover, table 5 shows an $R^2$ close to zero indicating that the cross-sectional momentum factor hardly explains any variation of the time-series momentum factor return. To conclude, table 5 show that the time-series momentum portfolios do not load significantly on the Fama-French factors which means that the returns on these factors are distinct from each other.

Another test is shown in formula 7. Formula 7 has the factors S&P-value and S&P-growth in addition the MSCI-world and MSCI-momentum, in order to investigate whether the specified model in formula 5 is the right model or whether the model in formula 7 performs better in capturing return variation of the time-series momentum model. The returns of S&P-value, S&P-growth and MSCI-world are excess returns.

$$R_i^{mom} = \alpha_i + \beta_1 * R_i^{S\&P-value} + \beta_2 * R_i^{S\&P-growth} + \beta_3 * R_i^{MSCIworld} + \beta_4 * R_i^{MSCImom} + \epsilon \qquad (7)$$

Table 6 shows the results of the factor analysis based on formula 7. Table 6 shows that there are no significant alphas which means that the time-series momentum portfolio does not add significant value to the indices on which it is tested. Furthermore, table 6 shows that the time-series momentum loads significantly on the S&P-growth index at the 5% and 1% level for the 4- and 13-week holding period as opposed to no significant factor loadings for the factors in table 5c. Since the alpha and the original factors MSCI-world and MSCI-momentum remain insignificant and the $R^2$ remains considerably low the difference between the test of formula 5 and the test of formula 7 is deemed irrelevant, which means the results from formula 5 are used as the main results of this study.

| *Statistic/Factor 4 week holding period* | S&P Value | S&P growth | MSCI World | MSCI momentum | Constant | $R^2$ |
|---|---|---|---|---|---|---|
| Coefficient | -0.14 | 0.40 | -0.16 | 0.03 | 0.18 | 0.02 |
| T-statistic | -0.69 | 2.12** | -0.75 | 0.69 | 0.66 | |
| ***Statistic/Factor 13 week holding period*** | **S&P Value** | **S&P growth** | **MSCI World** | **MSCI momentum** | **Constant** | $R^2$ |
| Coefficient | -0.06 | 0.41 | -0.33 | -0.02 | 0.09 | 0.02 |
| T-statistic | -0.40 | 2.96*** | -1.58 | -0.23 | 0.23 | |
| ***Statistic/Factor 26 week holding period*** | **S&P Value** | **S&P growth** | **MSCI World** | **MSCI momentum** | **Constant** | $R^2$ |
| Coefficient | -0.16 | 0.22 | -0.15 | 0.08 | 0.27 | 0.00 |
| T-statistic | -0.91 | 1.24 | -0.70 | 0.70 | 0.42 | |
| ***Statistic/Factor 52 week holding period*** | **S&P Value** | **S&P growth** | **MSCI World** | **MSCI momentum** | **Constant** | $R^2$ |
| Coefficient | -0.08 | 0.06 | -0.06 | 0.00 | 1.41 | -0.00 |
| T-statistic | -0.49 | 0.32 | -0.36 | 0.02 | 1.14 | |

Table 6, factor analysis for regression formula 7, extreme time-series momentum portfolio without a waiting period.

The results of the momentum portfolios tested show that the 13-week holding period has a positive significant alpha at the 10% level, which implies that the 13-week holding period extreme momentum portfolio does add value to the investable asset universe. Moreover, these momentum portfolios created from ETFs have some overlapping aspect with the MSCI-world, and MSCI-momentum indices. The $R^2$ in tables 4c and 4d are extremely low in the case of the extreme momentum portfolios, while the $R^2$ is slightly higher in the momentum portfolios where all returns are considered. This low $R^2$ means that MSCI-world and MSCI-momentum explain little of the return variation in the time-series momentum portfolio for the extreme momentum portfolios. For the momentum portfolios where all returns are considered in table 4a and 4b, the $R^2$ ranges from 0.00 to 0.11. This $R^2$ range means that the MSCI-momentum and MSCI-world explain 0.00 to 0.11 of the return variation in the time-series momentum portfolios. A potential explanation for the low $R^2$ could be that MSCI-momentum and MSCI-world are indices of equities, while the time-series momentum portfolios constructed in this study are based on ETFs from a wide variety of asset classes, resulting in considerably small $R^2$ factors due to the equity returns being different from the ETF returns.

Besides the 13-week holding period extreme momentum portfolio with a waiting period, the exposure the time-series momentum portfolio offers can be attained in the market by simply buying the desired indices. In addition, the mean return and volatility of these portfolios are unattractive compared to more traditional investment indices. From these characteristics the portfolios could be seen as an unattractive addition to the investable asset universe.

**6. Robustness**

To check whether the returns are robust on staying in or exiting the market when no signal for a long or short position is given, I investigate the statistical characteristics and the factor loadings for the extreme momentum portfolio without a waiting period when no long and short position is taken. In the main body of the study, a treasury-bill (T-bill) position is taken in the missing long or short position, while in this robustness check, instead of the long or short position in the treasury-bill, no position is taken. This means that the resulting Winner-Loser return is zero in that specific time-period, since a Winner (Loser) is absent, the position in the respective Loser (Winner) that is present is also not taken. The factor analysis from formula 5 is performed again without the T-bill positions for the extreme momentum portfolio without a waiting period, since the waiting period does not affect the performance to a significant extent, and since the extreme portfolio is most in accordance with the literature (Beracha and Skiba (2011)). The statistical characteristics, the alpha and beta coefficients, as well as the accompanying t-statistics and $R^2$ are reported in table 7 and 8 (see appendix A, page 35). The comparison between tables 2c and table 7, which are both the extreme momentum portfolios without waiting, shows that the portfolios of table 7 perform better in terms of the risk-return tradeoff than the portfolios of table 2c. Looking at the differences in kurtosis and skewness, table 2c shows smaller skewness and greater kurtosis than table 7. The kurtosis in the 26-week holding period in table 2c is smaller than the kurtosis in table 7. Overall, these tables show that including the T-bill positions does not lead to more attractive statistical characteristics in the extreme momentum portfolio.

In order to check whether the large differences persist for the respective portfolios with and without the T-bill positions, the same factor analysis, based on formula 5, is performed for the extreme momentum portfolio without positions in T-bills. The result of this factor analysis is shown in table 8 (see appendix A, page 35). Table 8 shows a significant alpha at the 5% level for the 4-week holding period, whereas there is no significant alpha in table 4c for the 4-week holding period. Moreover, table 8 shows that the 13-week holding period has a negative significant MSCI-world coefficient at the 10% level, and the 26-week holding period has a negative significant coefficient at the 5% level for MSCI-world. This means that there is significant overlap in return variation between MSCI-world and the extreme momentum portfolio without a waiting period without T-bills in the 13- and 26-week holding period. From the difference between table 4c and 8 it can be concluded that the returns are not robust based on exiting the market entirely for one period when no signal is given or taking a position in a T-bill when no signal is given. Nonetheless, the choice to stick with the momentum portfolios without exiting the market is made since opportunities to exit the market only present itself due to a relatively small cross-section of ETFs in the beginning of the sample. Since this problem of exiting and staying in the market can be circumvented by looking for more ETFs, I choose to consider the results for staying in the market as the main results of my study.

## 7. Conclusion

The strategy of buying past Winners and selling past Losers in ETFs based on a time-series signal fails to generate significant abnormal profits over the period of 2004-2019. This research shows that based on a 52-week time-series signal there is no momentum in ETFs in the chosen holding periods of 4-, 13-, 26- and 52-weeks. In this study, the signal is based on a comparison between the 52-week weighted moving average of the past 4-week returns and the past 4-week returns from time 0. In turn, for this signal, this study used a one week waiting period after the signal or no waiting period, and took the $60^{th}$ percentile top subset returns of Winners and $60^{th}$ percentile bottom subset returns of the Losers, or took the entirety of the Winners and Losers returns. For each of these variations the holding period is varied to 4-, 13-, 26- or 52-weeks. The strategy that is most consistent with established literature is the $60^{th}$ percentile momentum portfolios (Beracha and Skiba (2011), Jegadeesh and Titman (1993)) and the inclusion of a waiting period (Jegadeesh and Titman (1995)) after the signal in that portfolio. For this particular portfolio, it is found that there is a significant alpha at the 10% level for the 13-week holding period implying a weak added value to the MSCI-momentum and MSCI-world factors, and that the 52-week holding period has a significant factor loading for the MSCI-world and MSCI-momentum factors at the 5% and 10% level. Besides this portfolio, the other variations of the ETF momentum portfolios fail to have a significant alpha which means those portfolios fail to add significant value to the investable asset universe.

A possible explanation for this failure to capture momentum profits could lie in the fact that the global financial crisis is included in the sample. Cooper, Gutierrez and Hameed (2004) find that momentum profits mostly follow good states of the market. In the state where a market made losses, the momentum profits turn out to be insignificant and negative. In the cumulative returns in graph 2a to 2d, it can clearly be seen that there is a depression of profits at the end of 2008. The exclusion of the global financial crisis would benefit the portfolio. However, it would produce a result with little extrapolation purposes. The other option then is to have a longer time-series since in this study the data runs from 2004 to 2019 which means that in a significant period of time the financial crisis is present due to which momentum profits will be negative and insignificant according to Cooper, Gutierrez and Hameed (2004). Another possible reason for the failure of these portfolios could be found in the signal. Time-series momentum has been used to produce a signal where perhaps cross-sectional momentum would have performed better. However, it is found that during the financial crisis, time-series momentum performs better than the Fama-French momentum factor when comparing cumulative return across similar holding periods.

The failure of the ETF-momentum portfolios and the possible reasons for the failure offer indications for future research. The portfolio tests could include market state by including factors that signal the state of the market such as the dividend yield, default spread, term-spread and the short-term interest rates which should account for the financial crisis included in the sample. Furthermore, these portfolios could be based on cross-sectional momentum or a different time-series signal, with a higher amount of observations in the early stage, which might also improve the performance of the portfolios since numerous momentum research is based on cross-sectional momentum when it concerns individual assets and not ETFs. By increasing the sample of ETFs, there is also a greater cross-section of ETFs present in the beginning. This would allow the researcher in question to take the top and bottom $30^{th}$ or lower percentile of returns which would be more in accordance to conventional momentum literature, which would presumably lead to a better performance of the Winner and Loser components of the momentum portfolios and as such to a better performance of the momentum portfolios. Moreover, if the cross-section is increased in the early periods, it is possible to base the signal on own returns (He and Li (2015)), rather than all returns which might also lead to a stronger time-series momentum effect.

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## 9. Appendix A

| *Statistic\|Portfolio holding period* | 4 week W-L | 13 week W-L | 26 week W-L | 52 week W-L |
|---|---|---|---|---|
| Mean (Yearly) | 6.19 | 1.92 | 1.72 | 1.32 |
| Standard deviation (Yearly) | 9.39 | 9.31 | 11.02 | 11.35 |
| Skewness | 0.83 | 0.23 | -0.07 | 0.46 |
| Kurtosis | 3.70 | 3.35 | 4.63 | 1.55 |
| Sharpe-Ratio (Yearly) | 0.66 | 0.21 | 0.16 | 0.12 |

Table 7, Summary statistics extreme momentum portfolio without a waiting period and without T-bills.

| *Statistic\|Portfolio 4-week holding period* | Constant | MSCI-world | MSCI-momentum | $R^2$ |
|---|---|---|---|---|
| Coefficient | 0.50 | -0.06 | 0.01 | 0.02 |
| T-statistic | 2.39** | -1.29 | 0.24 | |
| ***Statistic\|Portfolio 13-week holding period*** | **Constant** | **MSCI-world** | **MSCI-momentum** | $R^2$ |
| Coefficient | 0.66 | -0.13 | 0.04 | 0.02 |
| T-statistic | 1.50 | -1.79* | 0.54 | |
| ***Statistic\|Portfolio 26-week holding period*** | **Constant** | **MSCI-world** | **MSCI-momentum** | $R^2$ |
| Coefficient | 0.96 | -0.19 | 0.14 | 0.02 |
| T-statistic | 1.38 | -2.31** | 1.55 | |
| ***Statistic\|Portfolio 52-week holding period*** | **Constant** | **MSCI-world** | **MSCI-momentum** | $R^2$ |
| Coefficient | 2.04 | -0.06 | -0.04 | 0.01 |
| T-statistic | 1.69 | -0.64 | -0.40 | |

Table 8, factor analysis of extreme momentum portfolio without the waiting period and without T-bills.

| Statistic\|ETF | SPY | IVV | IWF | IWM | IWV |
|---|---|---|---|---|---|
| Mean (annualized) | 9.65 | 9.86 | 9.66 | 10.65 | 10.83 |
| Standard deviation(annualized) | 13.63 | 14.14 | 13.69 | 13.84 | 18.72 |
| Skewness | -0.80 | -0.85 | -0.84 | -0.84 | -0.64 |
| Kurtosis | 3.68 | 4.10 | 3.85 | 3.07 | 2.78 |

Table 9a, summary statistics for equity ETF with 4 week holding period.

| Statistic\|ETF | SPY | IVV | IWF | IWM | IWV |
|---|---|---|---|---|---|
| Mean (annualized) | 9.11 | 9.32 | 9.14 | 10.12 | 9.86 |
| Standard deviation (annualized) | 13.94 | 14.50 | 13.99 | 14.55 | 18.16 |
| Skewness | -1.09 | -1.11 | -1.10 | -1.29 | -0.70 |
| Kurtosis | 4.50 | 4.72 | 4.51 | 5.18 | 3.19 |

Table 9b, summary statistics for equity ETF with 13 week holding period.

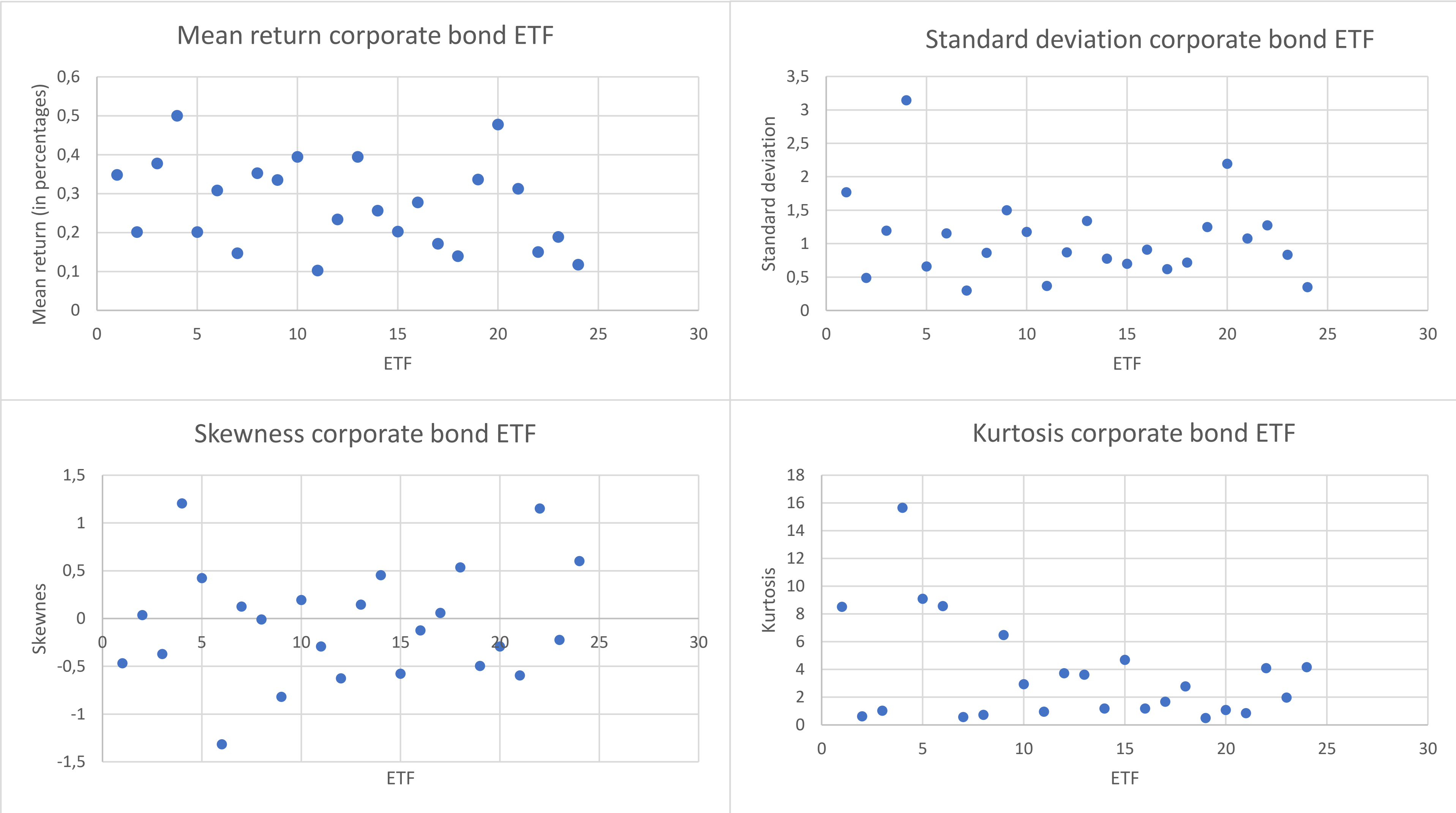
| Statistic\|ETF | SPY | IVV | IWF | IWM | IWV |
|---|---|---|---|---|---|
| Mean (annualized) | 9.34 | 9.55 | 9.38 | 10.39 | 9.99 |
| Standard deviation (annualized) | 14.98 | 15.52 | 15.01 | 15.36 | 18.62 |
| Skewness | -1.24 | -1.18 | -1.24 | -1.25 | -0.66 |
| Kurtosis | 4.71 | 4.54 | 4.70 | 4.33 | 2.63 |

Table 9c, summary statistics for equity ETF with 26 week holding period.

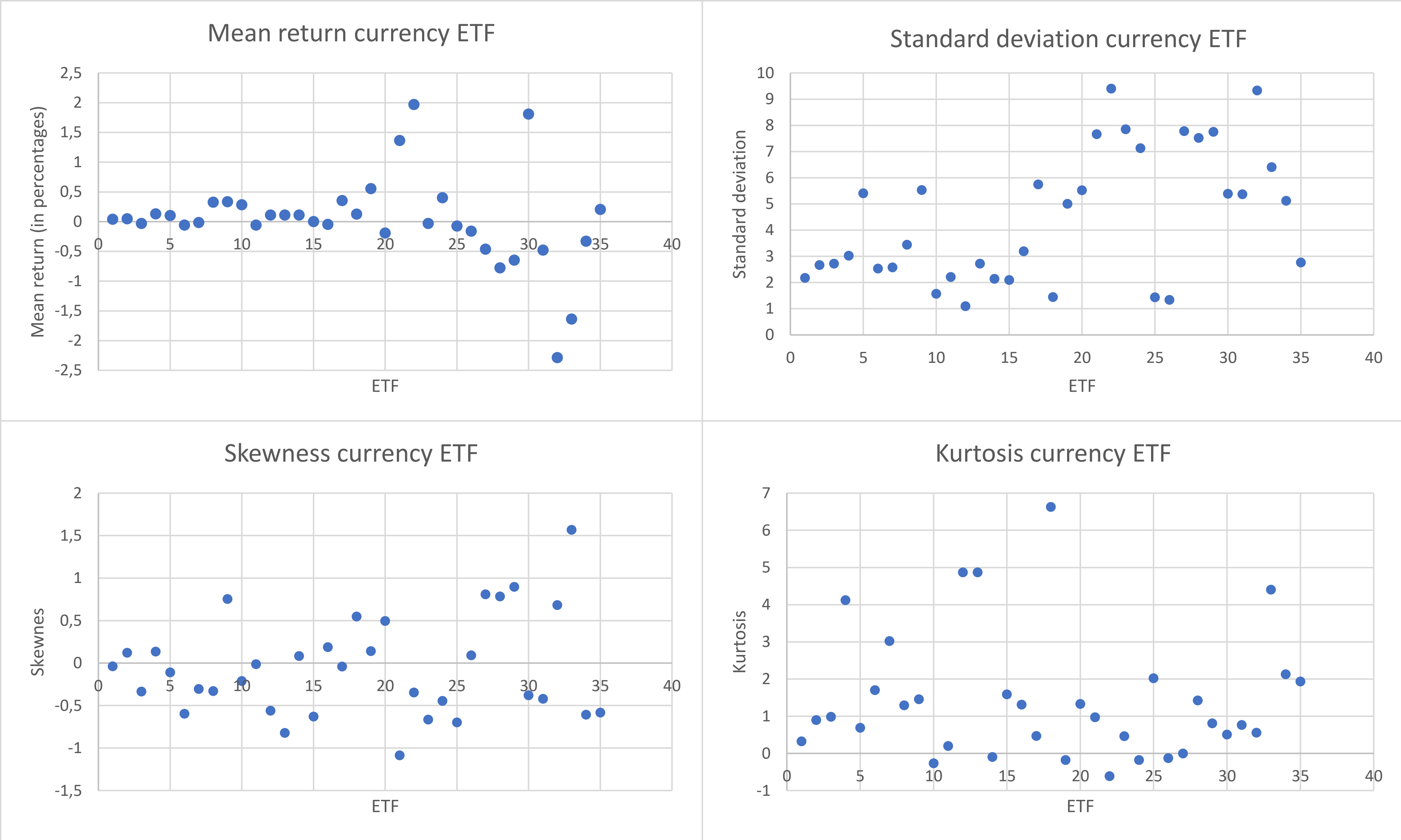
| Statistic\|ETF | SPY | IVV | IWF | IWM | IWV |
|---|---|---|---|---|---|
| Mean | 9.78 | 9.96 | 9.82 | 10.99 | 10.28 |
| Standard deviation | 15.32 | 15.78 | 15.37 | 15.56 | 18.11 |
| Skewness | -1.23 | -1.12 | -1.23 | -1.08 | -0.38 |
| Kurtosis | 2.82 | 2.61 | 2.81 | 2.50 | 1.13 |

Table 9d, summary statistics for equity ETF with 52 week holding period.

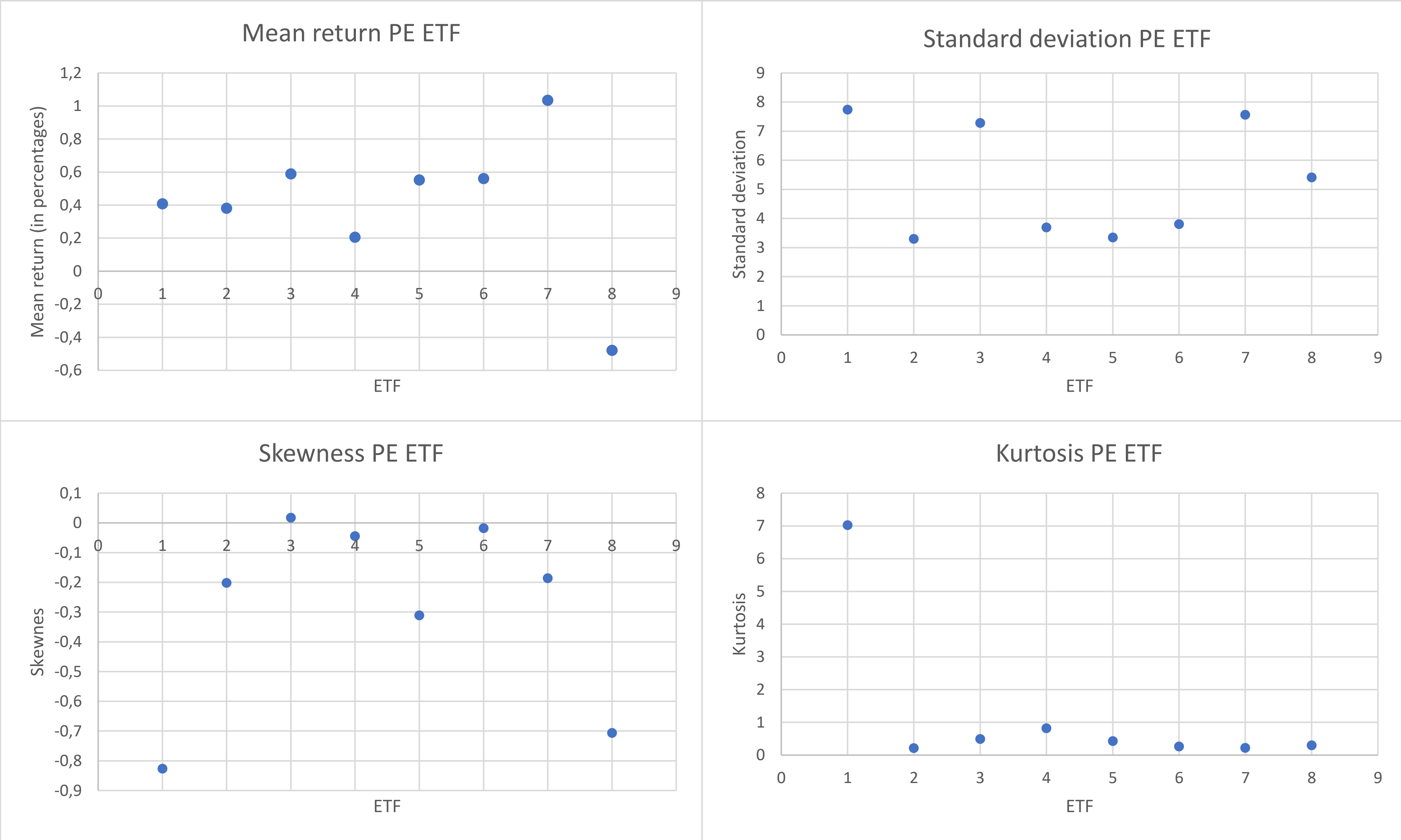
## 10. Appendix B



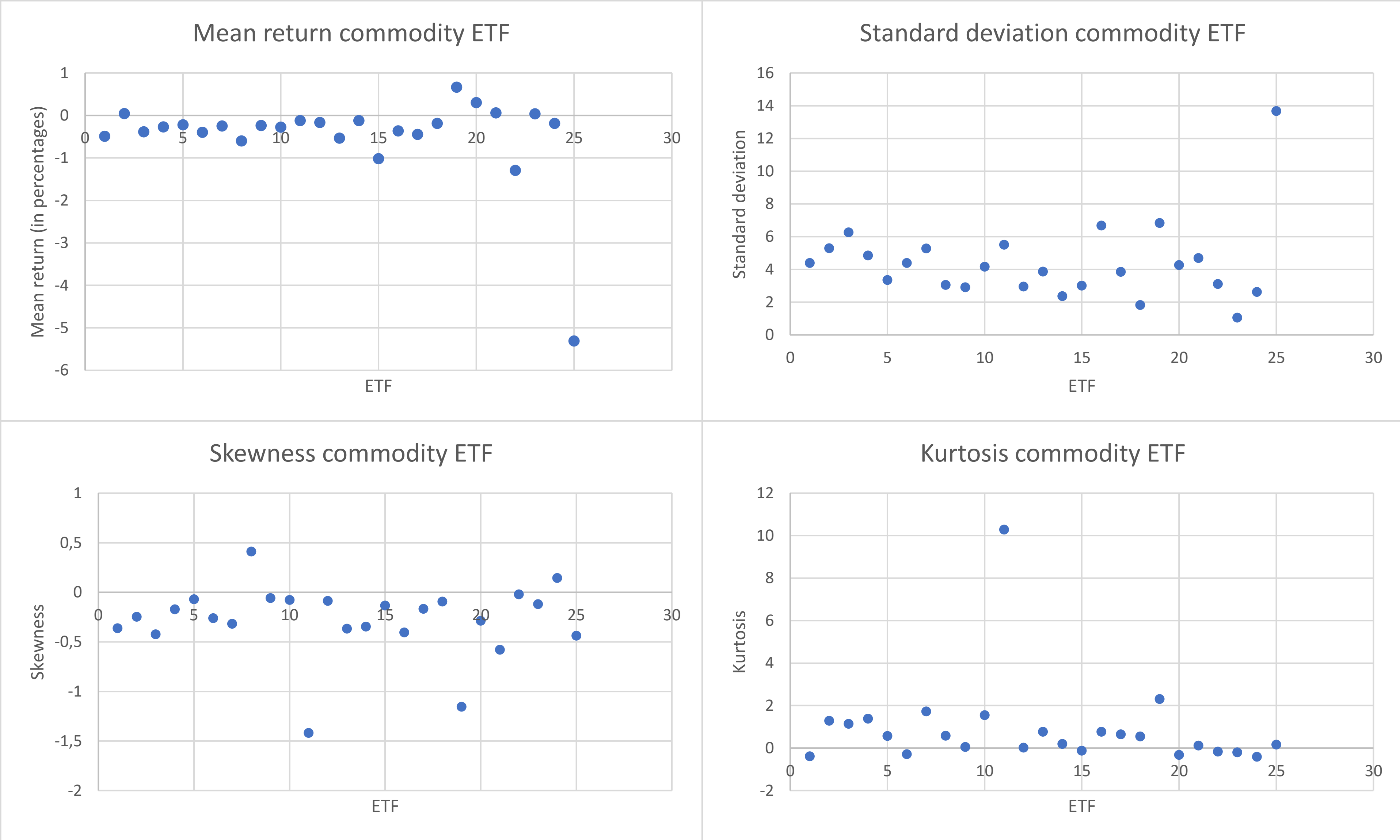

Graph 4a, statistical properties of corporate bond ETFs 4-week holding period.



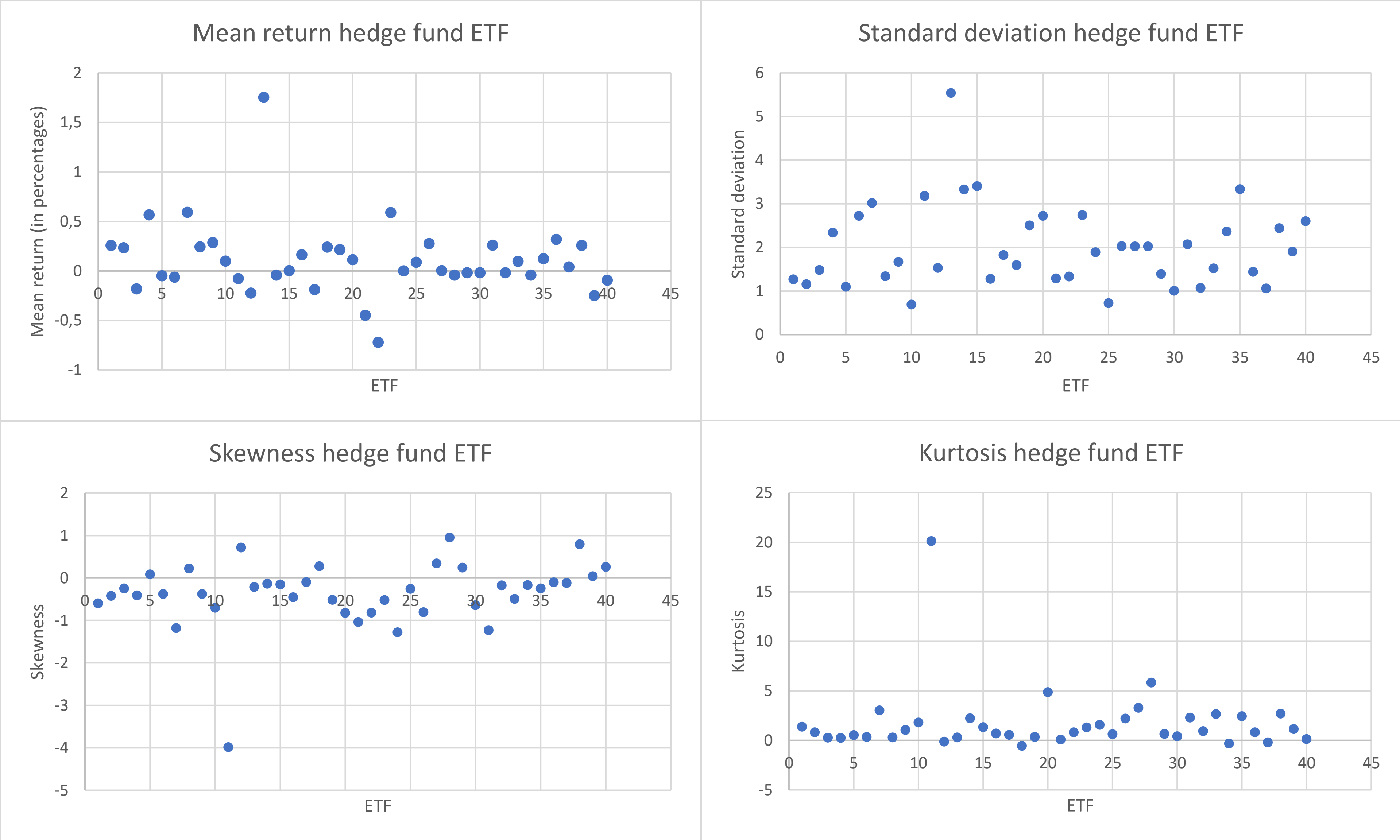

Graph 4b, statistical properties of currency ETFs 4 weekly returns 4-week holding period.



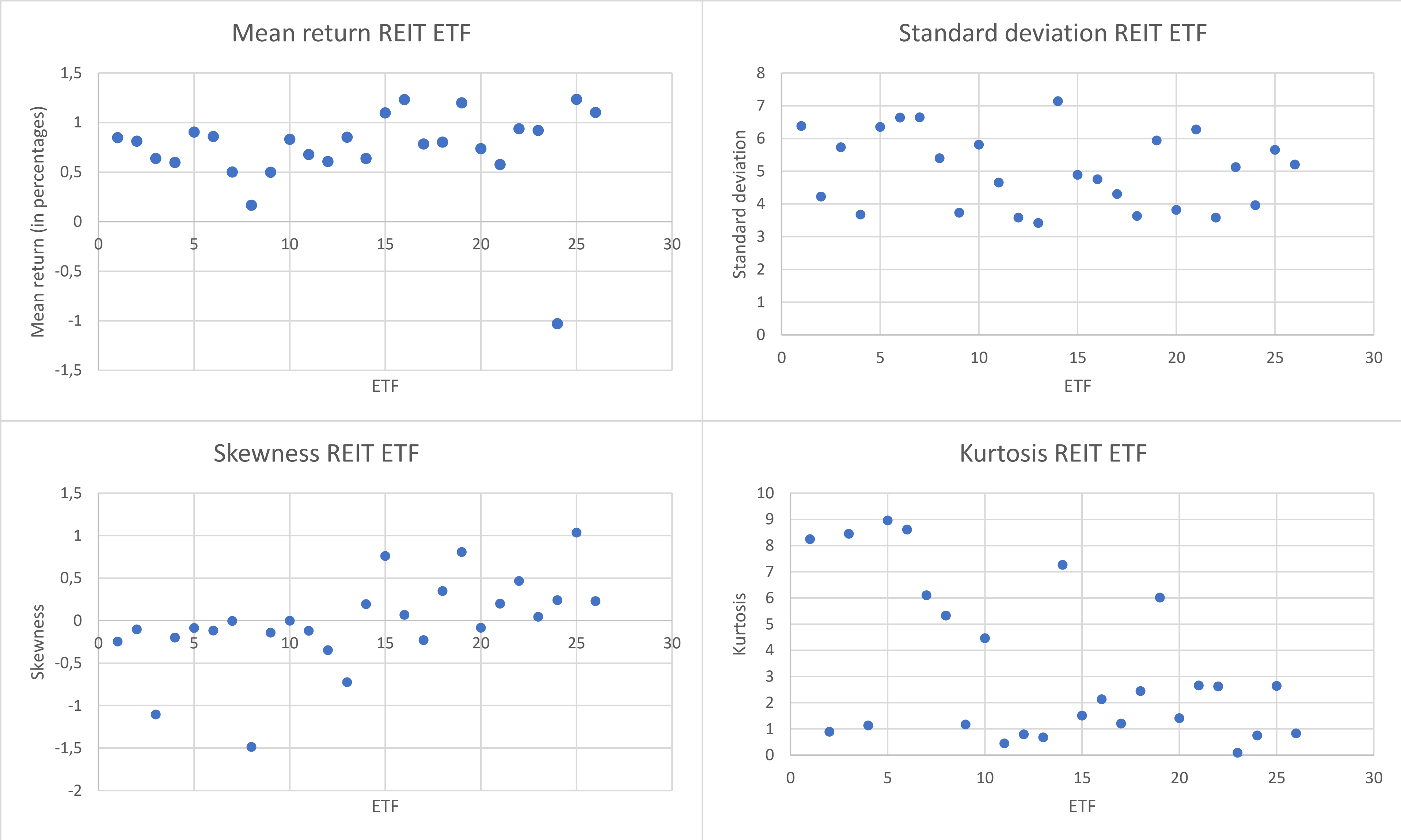

Graph 4c, statistical properties of PE ETFs 4-week holding period.



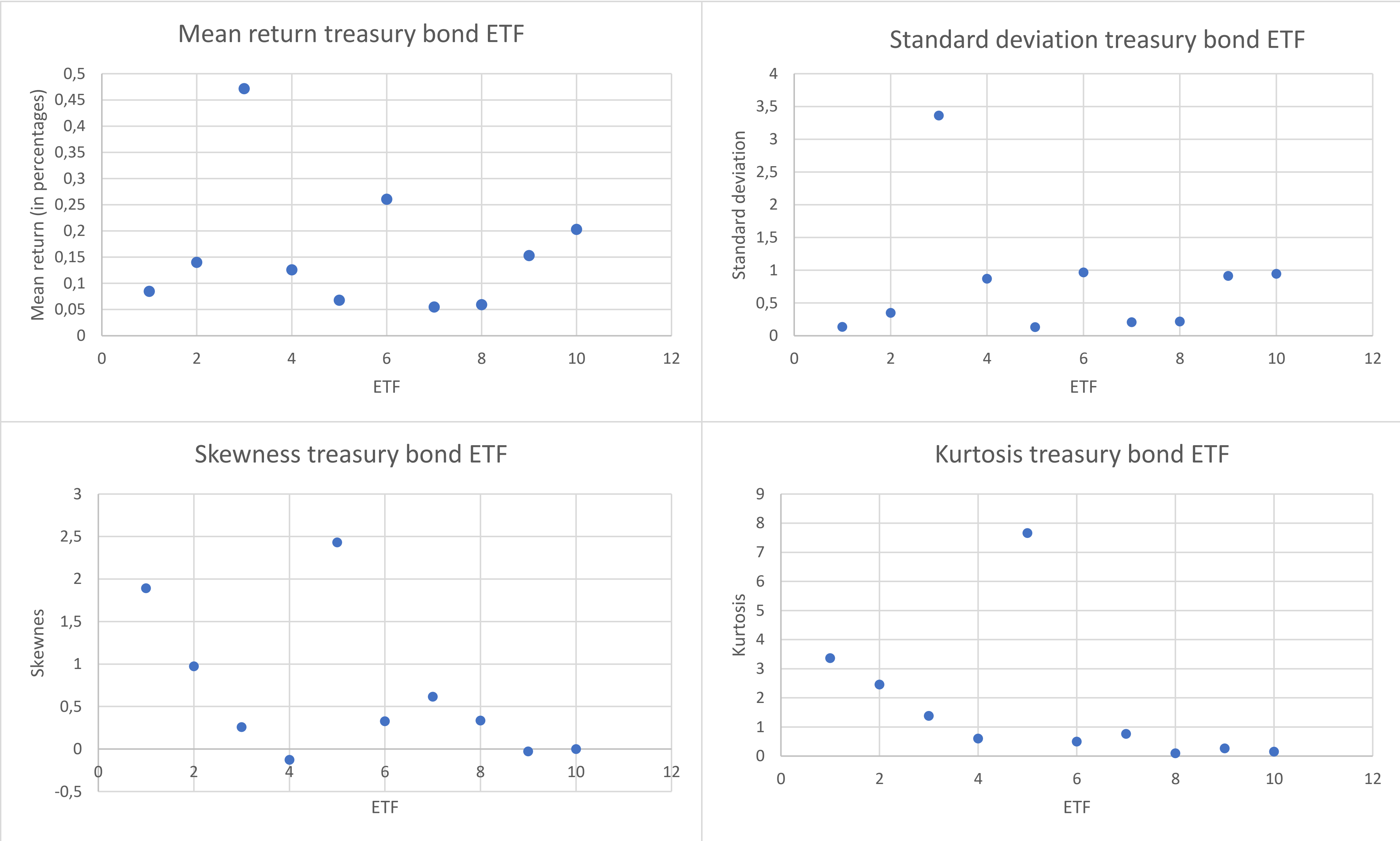
Graph 4d, statistical properties of commodity ETFs 4-week holding period.




Graph 4e, statistical properties of hedge funds ETFs 4-week holding period.




Graph 4f, statistical properties of real estate ETFs 4-week holding period.




Graph 4g, statistical properties of treasury bonds 4-week holding period.