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The Profitability of Momentum Strategies on the FTSE 100

by

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1. Introduction

Momentum strategies have been the subject of various studies since Jegadeesh and Titman (1993) first documented them in the early nineties. They stand in conflict with the widely accepted teaching of the weak form market efficiency, stating that historic price paths should have no impact on future movements as stated by Fama (1970). However, many studies show a serial correlation in stock prices resulting in profitable trend following momentum strategies where previously best performing stocks, often labelled as winners, continue to outperform the previously worst performing stocks, labelled as losers, over the next 3 to 12 months. The outperformance is not a result of higher risk. The effect has been observed in many markets around the world, in the UK specifically by Hon and Tonks (2003) and later by Galariotis, Holmes and Ma (2007). This paper aims to add to these studies by examining the profitability of momentum strategies on the FTSE 100 index from 1996 to 2020 using the same method as introduced by Jegadeesh and Titman in 1993.

It is an important issue to analyze how these strategies perform over recent time horizons to deem whether the effect is still present. The main results are evidence of significant momentum effects when comparing returns of past winners and losers. However, the returns produced are not as prevalent as previous studies suggests, this could be the result of a high frequency of market crashes, reducing the average profit. Accounting for risk measures, such as systematic risk and the firm size, cannot compensate for the returns. When accounting for transaction costs, profits disappear, and it is only over certain crisis free subperiods that momentum strategies yield significant profits. The momentum strategies analyzed in the sample period are subject to momentum crashes as a reaction to market distress with a large part of losses stemming from the loser portfolio. When limiting the investments to winners only, momentum strategies realize significant risk adjusted profits even after transaction costs.

2. Literature review

2.1 General Studies

The concept of momentum strategies has been widely researched over the past 30 years. Many studies show there to be a clear relationship between previous stock returns and future performances. Most notable is the research by Jegadeesh and Titman (1993) who, as one of the first, find substantial proof of the existence of momentum effects on the New York Stock Exchange (NYSE) and American Stock Exchange (AMEX). By sorting stocks into deciles based on their returns over the past 3 to 12 months in descending order, they form the top decile to the winner portfolio and the bottom decile to the loser portfolio. Portfolios are created every month and are then held for 3 to 12 months, they are thus overlapping. They find that winners consistently realize significantly higher returns than losers over these time periods. Creating a zero-cost portfolio by taking a long position in winners, and a short in losers, returns the outperformance of winners over losers. The return of such a portfolio averages 1% per month over the sample period. Rouwenhorst (1998) finds virtually identical results when analyzing 12 European countries including the UK using the same method. Griffin, Ji, and Martin (2005) confirm the outperformance of winners on further 40 countries from different parts of the world. Longer evaluation periods have been found to increase returns as found by both Rouwenhorst and Jegadeesh and Titman who find that their most profitable strategies have a formation period of 12 months with a holding period of 3 months. While losers do tend to underperform the market, they typically still have a positive return, thus decreasing the zero-cost profit. Accounting for conventional risk factors such as the CAPM-beta cannot explain the excess returns. Jegadeesh and Titman find the average winner beta to be 1.28 and the average loser beta to be 1.36 thus resulting in a zero-cost beta of -0.08 on average. Fama and French (1996) attempt to justify these returns found by Jegadeesh and Titman using the Fama-French 3 factor (FF3F) regression model, however, fail to succeed. Grundy and Martin (2001) calculate the abnormal return to be 1.3% per month for momentum strategies on the NYSE and AMEX during the period of 1966 to 1995 when using the FF3F model.

Although these are considerable profits which seem to be attainable with no increase in risk, it must be said that momentum strategies come with occasional downfalls. During the 1930s, shortly after the Great Depression, momentum strategies had returned -90% over the course of 2 months as noted by Jegadeesh and Titman. Further research on momentum crashes by Barroso and Santa Clara (2015) find that momentum strategies perform poorly after periods of market distress when the market recovers from its low. The poor performances originate from loser stocks' large returns, thus creating losses as these have been shorted. Winners underperform the market during these periods. This pattern is found throughout multiple market recoveries.

2.2 Studies in the UK

Hon and Tonks (2003) use data of all listed UK companies from 1955 to 1996 to form non-overlapping momentum portfolios ranging from 3 to 24 months formation and holding periods. They find that 24 of their 64 zero-cost portfolios return significant positive profits on average. For strategies with 3 to 12 months formation and holding periods, the average outperformance of winners amounts to approximately 0.64% per month. The most profitable strategy of 12 months formation and 6 months holding period, where outperformance is 1.26% monthly. They find that for most strategies the loser stocks return a positive return, thus decreasing the zero-cost profit as found in previous literature. They state that most of the profitable strategies have a holding period of 6 to 9 months and that longer formation periods up to twelve months increase profits. However, when analyzing the truncated period from 1955 to 1976 many strategies yield only insignificant positive returns, they therefore assume the momentum effect not to be consistent over time. To test whether the outperformance of the winner stocks is due to higher risk, they calculate CAPM-Betas of the portfolios and find that whether loser nor winner portfolios are significantly different from the market beta, and therefore conclude that the returns are not a product of higher risk. However, they note that losers have a slightly higher beta than winners. When adjusting for size of stocks in the winner and loser portfolios, they observe that on average winner stocks are larger than losers, the higher return cannot be assigned to the size effect. They conclude that although there is a momentum effect on the UK market, it is not present over all periods.

Ellis and Thomas (2003) examine the FTSE 350 from 1990 to 2003. They include all stocks in their analysis which have available data for the entire holding period, meaning if a stock is delisted it is not included, making this strategy only feasible in hindsight. They find that on average over all strategies the winner portfolio significantly outperforms loser portfolio, the average outperformance being around 1.4% per month. This is considerably higher than previous studies on other markets. Also, they find the loser stocks on average have a negative return, meaning they increase the profit of the zero-cost portfolio. When analyzing the CAPM-Betas, they find losers on average to have higher betas than winners, similar to the findings by Hon and Tonks. After accounting for transaction costs, which they estimate to be on average 5.8% for any given stock p.a., they conclude that most of the profits for shorter holding periods vanish, but still find significant returns for longer holding periods. The most profitable being 1.04% per month.

Using data from 1964 to 2005 Galariotis et al. (2007) analyze the complete UK market for momentum effects. They create non-overlapping portfolios with formation and holding periods ranging from 2 to 60 months. Additionally, they include 1-month formation and holding periods. They find that for the 64 strategies analyzed, 15 of them show significant momentum profits, with the most profitable one returning 1.22% monthly average for a formation period of 8 and a holding period of 4 months. All significant positive returns were found to have formation and holding periods of 12 months at most. This is in line with the previously documented midterm profitability of momentum strategies. When adjusting for risk using the FF3F model, they find that the model fails to explain the profits made. Portfolios created on 1-month formation and holding periods on average have negative returns, indicating that price movements in fact revert instead of following the trend in the short-term. Other 1-month formation period strategies do not show significant signs of momentum before a holding period of 8 months. When dividing into subperiods, they find that the number of significant momentum strategies varies, with the period from 1975 to 2005 containing noticeably fewer profitable strategies. This is somewhat contradicting to the findings of Hon and Tonks who find the time horizon succeeding 1976 to contain more significant profitable momentum strategies.

Further research on the UK market has been made by Li, Brooks, and Miffre (2009). They criticize previous studies for underestimating trading costs when evaluating the profits of momentum strategies. They estimate the transaction cost for winners to be 3.77% and 6.71% for losers on average. This is partly due to different capitalizations, as well as short selling fees for losers. Alike Galariotis et al. they construct non-overlapping zero-cost portfolios to reduce trading frequency and therefore also trading costs. They find that after accounting for fees, none of the momentum strategies are profitable and shorter holding periods even yield significant losses. They conclude that momentum strategies, as suggested by Jegadeesh and Titman, not to be profitable as a real trading strategy.

To conclude, it is found that the momentum effect exists for a period of around 3 to 12 months and is most dominant for stocks chosen based on the returns of the past 12 months.

The returns cannot be explained by risk measures. However, after accounting for transaction costs, many profits disappear as momentum strategies are very trading intensive.

This paper provides an update to momentum strategies specifically for the FTSE 100. This will give valuable information to the performance of momentum strategies after previous papers as new studies are needed to confirm the consistency of the momentum effect over time.

3. Methodology

By analyzing the existence of momentum strategies for the period of 1996 to 2020, I test the null hypothesis that momentum strategies had not returned any significant returns on the FTSE 100 index. I conduct a separate examination to identify whether the strategies are still profitable after transaction costs. As the outperformance of winners could result from risk measures such as the CAPM-Beta or firm size, the difference between winners and losers of these measures is tested. Lastly, a FF3F regression model is utilized to determine whether zero-cost profits are abnormal or can be explained by the model. I use overlapping portfolios to avoid starting point bias and include delisted but still tradeable stocks to exclude survivorship bias. Trading costs are estimated along the line of Li et al. (2009). This study is limited to the 100 largest stocks in the UK therefore altering the costs. Furthermore, the profits over different subperiods are demonstrated to gain insight of the robustness of momentum strategies over the sample period. The time frame includes 5 major events that have not all been included in previous research. These are the Asian Crisis in 1997, the Dotcom Bubble in 2001, the Financial Crisis in 2008, the Brexit vote 2016, and the beginning of the Corona Pandemic in 2020.

By using historic constituent lists of every month's end from January 1996 to December 2020 provided by Datastream, the relevant stocks are identified. Comparing with the FTSE Russell historic additions and deletions record (2021), the exact constitution at every month's end is recreated. The total return index for each of these firms is provided by Datastream for the entire time horizon covered by this paper. Firms whose total return data was not available are excluded from the analysis, these are Securicor and Greenalls. From the total return index, the monthly percentual changes are calculated to determine the monthly returns. To construct momentum portfolios, I follow the same methodology as used in Jegadeesh and Titman (1993). All stocks included in the FTSE 100 in a specific month are ranked in descending order based on their returns in the formation period in the previous J months, with J taking values 1, 3, 6, and 12. The stocks are sorted into deciles, with the top decile labelled as winners, and the bottom decile labelled as losers. The loser stocks are formed to a loser portfolio in which a short position is taken. With the capital received from short selling, a long position is taken in the winner stocks which are formed to a winner portfolio. The result of the short and long position is labelled as the zero-cost portfolio. All stocks in every portfolio are equally weighted. These portfolios are then held throughout the holding period which lasts K months, K taking the same values as J. At the end of the holding period the positions are liquidated, and the return of each portfolio is transformed into monthly average return, to facilitate comparisons between strategies. To avoid starting point bias, this process is repeated monthly so that portfolios are overlapping. The notation of a combination of formation and holding months is denoted as the JK strategy, a 6-month formation and 3-month holding period is for example labelled as J6K3.

If a stock is delisted from the FTSE 100 but remains tradeable while being part of a portfolio, it will remain in the respective portfolio and be sold or bought at the end of the holding period to avoid survivorship bias. If a stock is delisted and no longer tradeable, the stock is sold at the last available price and the capital kept in cash.

Trading costs include bid-ask spread, commissions for placing buy and sell orders, and a lending fee for short selling stocks. I have chosen to limit this study to these costs as other costs such as stamp duties or taxes differ depending on the country the strategy is executed in. Following Li et al. (2009) the bid-ask spread is calculated as

$$(1) \qquad Spread = \frac{P_{Ait} - P_{Bit}}{\left(\frac{P_{Ait} + P_{Bit}}{2}\right)}$$

where P_{Ait} is the ask price, and P_{Bit} is the bid price for stock *i* in month *t*. The bid and ask prices for the sample period from January 1996 to December 2020 are provided by Datastream. After having calculated the spreads for every stock in every month, the average of the entire data set, which is 0.381%, is taken as a proxy for the bid-ask spread.

Due to the rise of digitalization and online brokerages commission fees have undergone some price reduction from 1996 to 2020. While many online brokers nowadays provide commission-free trading even to private investors, this is not representable for the earlier years of the period analyzed. Jones and Lipson (2001) state that institutional commission fees post 1997 on the NYSE are on average 0.15%. While no such study for the UK is provided, the size and competitiveness of the London Stock Exchange allows to assume similar fees. This paper assumes commission fees to be 0.05% per trade, which is also found on online broker DEGIRO’s price list (2021), and therefore assumed representable for the entire sample period. The lending fee paid when short selling stocks faced the same issue. While Li et al. (2009) assume short selling costs of 1.5% p.a. for the entire UK market, this paper focuses on the FTSE 100 containing the largest 100 companies in the UK. It is therefore assumed the lending fee to be 1% p.a. which corresponds to safety category A in DEGIRO’s price list and is therefore also seen as representable.

Net returns R_i^{net} are the returns of momentum strategies adjusted for transaction costs.

(2) $$R_i^{net} = (1 + R_i) \times (1 - C_C)^2 \times (1 - C_S) - 1$$

Where R_i is the return on stock *i* over the holding period, C_C is the commission fee paid twice, and C_S is the spread. For shorted stocks, the lending fee is subtracted monthly from the stocks return.

(3) $$R_i = \prod_0^K (1 + R_{i,t}) \times (1 - C_{short}) - 1$$

Where $R_{i,t}$ is the return of stock *i* in month *t* and C_{short} is the lending fee p.a. transformed to monthly fees. After having calculated the return for the entire holding period K, equation (2) is applied. If a stock is no longer tradeable it will be sold at the last available price, and the capital is reinvested into the risk-free return, proxied by the 1-month Libor rate for the rest of the holding period. The average annual yield of 1-month Libor rates from 1996 to 2020 is provided by Macrotrends LLC (2021) which is then transformed to average 1-month rates for the respective year.

The CAPM-Beta for *i* in month *t* is calculated as

(4) $$\beta_{i,t} = \frac{Cov_{i,m}}{Var_m}$$

with $Cov_{i,m}$ being the covariance between stock *i* and the benchmark *m*, and Var_m the variance of the benchmark over the last 12 months. In this paper, the benchmark is the FTSE 100 index. The total return index of the FTSE 100 is provided by Datastream and is transformed to monthly returns by calculating the percentual change between months. Betas are calculated monthly, based on covariance and variance of the past 12 months. The window of 12 months is chosen to allow enough months to pass to estimate a reliable value without losing too many observations.

The FF3F regression model is used to measure the risk adjusted return of an investment. It is an extension to the CAPM by two additional factors, SMB and HML.

(5) $$R_{i,t} - R_{f,t} = \alpha + \beta_1(R_{m,t} - R_{f,t}) + \beta_2 \times SMB_t + \beta_3 \times HML_t + \epsilon_{i,t}$$

Where $R_{i,t}$ is the return of investment *i* in month *t*, $R_{f,t}$ is the risk-free rate proxied by the Libor rate in *t*, $R_{m,t}$ is the FTSE 100 return for month *t*, SMB_t and HML_t are size and value premiums in *t*, $\epsilon_{i,t}$ is the error for *i* in *t*, α is the intercept with the y-axis measuring the abnormal return over the model, and $\beta_{1,2,3}$ are the coefficients estimated using the OLS method. The monthly SMB and HML factors for the UK are provided by the University of Exeter (2021) from January 1996 to December 2017. To regress momentum portfolios monthly returns on the market return, market portfolios are created in the same month as the momentum portfolio and held for the same period. $R_{m,t}$ is therefore the monthly return of the market in *t* of the previous K months.

The size of companies is given as market capitalization which results from the price of the stock multiplied by the number of issued stocks. The data is provided by Datastream.

To test whether there is a significant difference between the mean of a group and an assumed mean of the population, a two-sided t-test is used. Hypotheses will be rejected if the t-statistic exceeds the critical value of the t-distribution.

$$t = \frac{\bar{x} - \mu_0}{\frac{s}{\sqrt{n}}} \qquad (6)$$

Where $\bar{x}$ is the group mean, μ_0 is the assumed mean from the null hypothesis, s is the standard error, and n is the group size.

4. Empirical Results

4.1 Gross Returns of Momentum Strategies

Table 1 displays the results over the complete period from 1996 to 2020. I find that for all strategies except for J1K1 strategy, winner portfolios on average outperform the loser portfolios. For the J1K1 strategy losers on average outperform winners, however insignificantly. Of the 15 other strategies, I find 9 outperformances to be significant to at least the 10% level. The best performing strategy is the J12K3 strategy, which yields a monthly average return of 0.638% for the zero-cost portfolio. As can be seen in figure 1, moving from shorter to longer formation periods tends to increase the average monthly return, while the effect of holding periods differs depending on the strategy. The 1- and 3-month formation periods both benefit from an increase in holding periods. 6- and 12-month formation periods peak at 3 and 6 months respectively, whereafter the returns begin to decline. These findings are coinciding with the results of non-overlapping portfolios by Hon & Tonks as well as overlapping tests by Jegadeesh and Titman, also suggesting the most profitable strategy to have a formation period of 12 and holding period of 3 months. As for 1 month formation period strategies, only the 1 month holding period shows signs of return reversals while the other strategies show signs of a momentum effect. For a 12-month holding period the outperformance of winners is even significant to the 10% level. These results are almost identical to findings of Galariotis et al. who also find return reversals in the very short term, however for longer holding periods of 8 to 12 months momentum strategies to be significantly positive.

Figure 1 – Gross Returns of Momentum Portfolios

Average monthly returns for all strategies from January 1996 to December 2020.

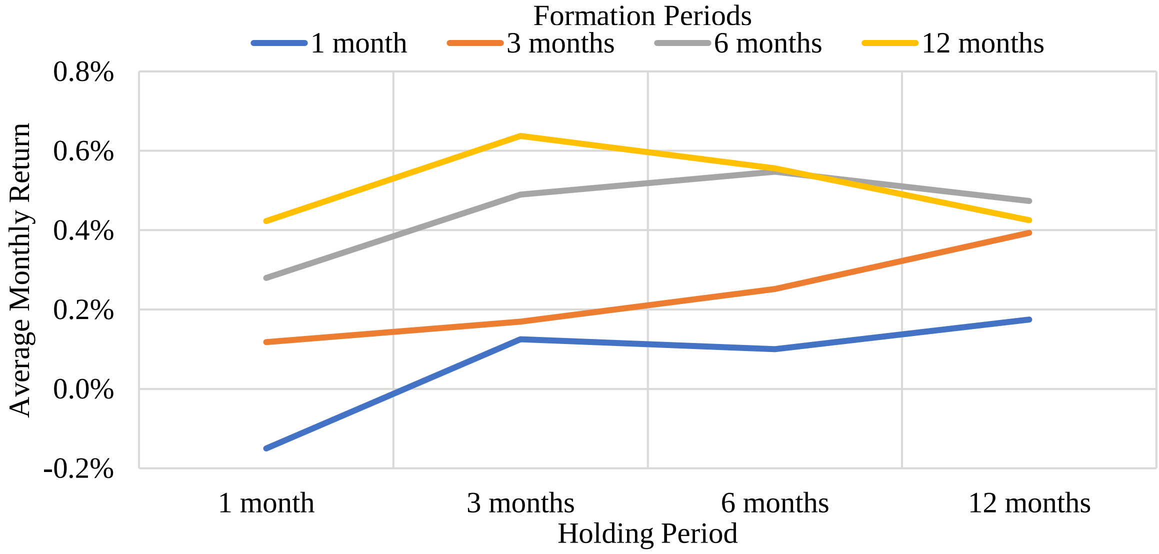

Table 1 - Gross Returns of Momentum Portfolios

At the end of each month the best performing decile from the past J months are formed to a winner portfolio and the worst performing decile to a loser portfolio. Both portfolios are held for K months before being liquidated. This process is repeated monthly meaning portfolios are overlapping. The returns over K months are converted to monthly returns using the geometric average, whereafter the average of all returns is calculated and displayed in this table with W standing for winners and L standing for losers. The excess return of buy portfolios over sell portfolios is shown in Zero-cost. The t-statistics are calculated for the zero-cost return being significantly different to zero and are reported in parentheses. The sample period is January 1996 to December 2020.

J	Portfolio	K			
		1	3	6	12
1	W	0.303%	0.342%	0.434%	0.507%
	L	0.453%	0.217%	0.334%	0.333%
	Zero-cost	-0.150%	0.125%	0.100%	0.175%*
	(t-stat)	(-0.42)	(0.58)	(0.69)	(1.71)
3	W	0.790%	0.627%	0.623%	0.669%
	L	0.673%	0.458%	0.372%	0.276%
	Zero-cost	0.118%	0.169%	0.251%*	0.393%***
	(t-stat)	(0.30)	(0.74)	(1.66)	(3.39)
6	W	0.939%	0.783%	0.708%	0.688%
	L	0.660%	0.294%	0.160%	0.215%
	Zero-cost	0.280%	0.489%*	0.547%**	0.473%***
	(t-stat)	(0.62)	(1.95)	(3.32)	(3.99)
12	W	0.959%	0.748%	0.642%	0.641%
	L	0.537%	0.110%	0.086%	0.216%
	W-L	0.423%	0.638%**	0.556%***	0.425%***
	(t-stat)	(0.85)	(2.21)	(2.82)	(3.29)

* indicates significance to the 10% level, ** to the 5% level, and *** to the 1% level.

As can be seen in table 1, all loser portfolios have a positive return, thus reducing the zero-cost profit. These results are coinciding with the general findings, however in contrast with those of Ellis and Thomas who find losers of the FTSE 350 to return negative returns. The average outperformance over all strategies, excluding all J1 strategies to be comparable with previous studies, is 0.397% which is noticeably lower than 1.4% found by Ellis and Thomas and 0.64% by Hon and Tonks. One explanation for the lower return might be due to the fading of the anomaly after it has been profoundly covered in previous studies. The large difference to Ellis and Thomas could be traced back to the fact that they do not include stocks that were delisted during the holding period and therefore do not have an accurate representation of the strategies' performances. A third reason could be the higher frequency of market crashes, reducing the average return over the entire sample period. The explanations do not exclude each other, such that the cause for lower returns might be a combination of all 3.

4.2 Accounting for Risk

Having established that winners outperform losers, I examine whether these outperformances are due to a higher risk of winner stocks. I analyze the average CAPM-Betas as a measure of systematic risk and the average market capitalizations to determine whether winners are smaller firms carrying a higher risk as findings by Banz (1981) would suggest. Table 2 displays the results. I find for formation periods of 6 months or above the average loser beta to be significantly larger than the average winner. For shorter formation periods up to 3 months loser betas are only insignificantly larger. The results match those of previous studies, suggesting that the outperformance of winner portfolios cannot be assigned to a higher volatility and losers to have slightly higher betas.

When analyzing the average size of firms in winner and loser portfolios, I find that for all strategies the average size of the winner portfolio is significantly larger than that of losers. The results are identical to previous studies which find winners on average to be larger firms than losers. I find that the outperformance of winner portfolios cannot be attributed to a higher risk stemming from either systematic risk or firm size.

To quantify the risk adjusted outperformance, table 3 presents the alphas of each strategy estimated by using a FF3F regression. The alphas represent the intercept and measure the abnormal return of portfolio that cannot be explained by the model. The 3 factors are available for the years 1996 to 2017 and therefore only returns made in this time frame are considered. I find that for half of the strategies, the FF3F model fails to explain the returns made as 8 strategies have a significant positive alpha coefficient. Strategies based off the past month's returns do not achieve any abnormal returns with the FF3F model explaining the before significant profit of the J1K12 strategy. Also, the model explains the returns of J3K6 strategy. These results suggest that although the gross returns are significant from 0, these strategies select riskier stocks thus lowering the risk adjusted return. However, for formation periods of 6 months or above the model fails to capture most of these returns. Noticeably, the J12K1 strategy also yields abnormal returns when adjusted for the 3 risk factors whereas the gross zero-cost returns are insignificant from 0. In fact, all 12-month formation period strategies achieve abnormal returns. These results are in line with the work done by Galariotis et al. who also find the FF3F model failing to explain momentum strategies' returns for momentum strategies in the UK.

Table 2 – Size and CAPM-Beta of Portfolios

At portfolio creation date the average market capitalization of the portfolio is calculated. The average over the entire sample period for each strategy given in million pounds is displayed in this table. The CAPM-Beta of a portfolio is the average of all companies included in that respective portfolio at creation date. The average betas over the entire sample period are displayed in this table. The difference between winner (W) and loser (L) portfolios in terms of size and beta are given in the row Zero-cost and are tested to be significantly different from 0. The t-statistics are reported in parentheses. The sample period is from January 1996 to December 2020.

J	Portfolio	K							
		1		3		6		12	
		Size	Beta	Size	Beta	Size	Beta	Size	Beta
1	W	13.9	1.11	13.9	1.11	13.9	1.10	13.9	1.11
	L	11.6	1.17	11.6	1.18	11.6	1.17	11.6	1.16
	Zero-cost	2.3***	-0.06	2.3***	-0.07	2.3	-0.07	2.3***	-0.05
	(t-stat)	(3.27)	(-0.88)	(3.25)	(-1.00)	(3.36)	(-1.00)	(3.36)	(-0.77)
3	W	14.3	1.10	14.3	1.10	14.3	1.10	14.2	1.11
	L	11.5	1.17	11.4	1.17	11.3	1.17	11.3	1.15
	Zero-cost	2.8***	-0.07	2.9***	-0.08	3.0	-0.07	2.9***	-0.04
	(t-stat)	(4.15)	(-1.03)	(4.27)	(-1.16)	(4.47)	(-1.07)	(4.35)	(-0.66)
6	W	14.7	1.05	14.7	1.04	14.6	1.05	14.5	1.06
	L	11.2	1.17	11.1	1.17	11.1	1.16	11.0	1.14
	Zero-cost	3.5***	-0.12*	3.6***	-0.12*	3.5***	-0.11***	3.5***	-0.08
	(t-stat)	(5.17)	(-1.80)	(5.40)	(-1.84)	(5.39)	(-1.67)	(5.25)	(-1.23)
12	W	15.3	0.99	15.3	1.00	15.3	1.00	15.2	1.00
	L	11.8	1.21	11.7	1.21	11.6	1.20	11.6	1.19
	Zero-cost	3.5***	-0.22***	3.6***	-0.21***	3.7***	-0.21***	3.6***	-0.19***
	(t-stat)	(4.99)	(-3.81)	(5.11)	(-3.69)	(5.22)	(-3.53)	(5.06)	(-3.17)

* indicates significance to the 10% level, ** to the 5% level, and *** to the 1% level.

Table 3 – Momentum Strategies after Adjusting for Risk

The monthly zero-cost profits returned by momentum strategies with J months formation and K months holding period are adjusted using the FF3F model. The intercepts with the y-axis, α, measure the abnormal return of the investment and are displayed in this table. The t-statistics are calculated for the α being significantly different to zero and are reported in parentheses. The sample period is January 1996 to December 2017.

J		K			
		1	3	6	12
1	α	-0.0036	0.0004	-0.0008	0.0003
	(t-stat)	(-0.94)	(0.16)	(-0.50)	(0.22)
3	α	0.0023	0.0018	0.0025	0.0034***
	(t-stat)	(0.55)	(0.76)	(1.51)	(2.59)
6	α	0.0049	0.0058**	0.0057***	0.0042***
	(t-stat)	(1.13)	(2.25)	(3.20)	(3.12)
12	α	0.0090**	0.0083***	0.0058***	0.0032**
	(t-stat)	(2.00)	(2.87)	(2.73)	(2.21)

* indicates significance to the 10% level, ** to the 5% level, and *** to the 1% level.

These results indicate that the momentum effect exists for stocks in the FTSE 100 during the sample period and is not consequence of a higher risk of winner portfolios. After adjusting for the 3 factors in the FF3F model, I find most of the longer formation periods of 6-months or above to achieve abnormal returns.

4.3 Net Returns of Momentum Strategies

When accounting for transaction costs all 16 strategies yield a negative return, 6 of which are significant. The results are displayed in table 4. This somewhat contradicts the results of Ellis and Thomas who still find significant profits for longer formation periods and is more in line with the suggestion of Li et al. who state that no profits are to be made after accounting for transaction costs. The average monthly return over all strategies decreased from 0.313% to -0.440%. I especially find the profits of the loser portfolios have declined; this is because they are more expensive to trade since investors incur lending fees when short selling.

Table 4 – Momentum Strategies after Accounting for Transaction Costs

At the end of each month the best performing decile from the past J months are formed to a winner portfolio and the worst performing decile to a loser portfolio. A long position in winners and short in losers is taken and held for K months before being liquidated. This process is repeated monthly meaning portfolios are overlapping. The returns over K months are adjusted for transaction costs and are afterwards converted to monthly returns using the geometric average, whereafter the average of all returns is calculated and displayed in this table with W standing for winners and L standing for losers. The zero-cost portfolio resulting from both winner and loser portfolios are shown in zero-cost. The t-statistics are calculated for the zero-cost return being significantly different to zero and are reported in parentheses. The sample period is January 1996 to December 2020.

J	Portfolio	K			
		1	3	6	12
1	W	-0.166%	0.196%	0.369%	0.488%
	L	-0.796%	-0.746%	-0.895%	-0.880%
	Zero-cost	-0.962%**	-0.550%***	-0.526%***	-0.393%
	(t-stat)	(-2.59)	(-2.23)	(-3.07)	(-3.11)
3	W	0.320%	0.493%	0.565%	0.651%
	L	-0.981%	-1.085%	-1.044%	-0.864%
	Zero-cost	-0.661%	-0.592%**	-0.478%**	-0.214%
	(t-stat)	(-1.57)	(-2.20)	(-2.53)	(-1.59)
6	W	0.476%	0.640%	0.644%	0.657%
	L	-1.002%	-0.983%	-0.938%	-0.902%
	Zero-cost	-0.526%	-0.343%	-0.294%*	-0.245%
	(t-stat)	(-1.12)	(-1.16)	(-1.49)	(-1.79)
12	W	0.487%	0.601%	0.578%	0.629%
	L	-0.871%	-0.868%	-0.895%	-0.921%
	Zero-cost	-0.384%	-0.267%	-0.317%	-0.292%
	(t-stat)	(-0.74)	(-0.77)	(-1.35)	(-1.93)

* indicates significance to the 10% level, ** to the 5% level, and *** to the 1% level.

When splitting the data into 5 subperiods with lengths of 5 years each, the number of profitable strategies varies noticeably as well as the returns produced, depending on the subperiod. From 2016 to 2020 no strategies are profitable compared to the best subperiod from 2011 to 2015 where 11 are profitable, 6 of which significant. This suggests that momentum strategies do not perform equally well over the selected time horizon as both Hon and Tonks as well as Galariotis et al. observe. Table 4 demonstrates net zero-cost returns over different subperiods. A reason to this variation could be due to certain market crisis falling into subperiods such as the Asian Crisis, the Dotcom Bubble, the Financial Crisis, the Brexit vote, as well as the beginning of the Corona Pandemic, thus causing momentum strategies to crash as previous research finds. Although the results are similar to previous studies in the UK regarding the consistency of momentum strategies, the cause might differ as the time horizons analyzed contain less frequent market crashes and stretch over longer time horizons relative to this paper. While Hon and Tonks and Galariotis et al. observe inconsistencies in the magnitude of the momentum effect itself, I constate that a negative market event has a large impact on the return of strategies over the specific subperiod which does not necessarily imply that the effect is not present.

Of all, only subperiod 4 is voided of any major events and stands out with an average return of 0.269% per month over all strategies, the only to be positive. The best performing strategies select stocks based on the past 12 months, the highest stemming from the J12K3 strategy with a monthly average of 1.108%. The dominance of J12 strategies is especially apparent for this subperiod, with the returns over all 4 strategies averaging 1% per month. In comparison, the average of all J6 strategies is 0.3% per month and 1- and 3- month formation period strategies have negative monthly returns on average. However, this dominance is not persistent over all subperiods, such that the J12 strategies perform worst in the succeeding fifth subperiod. When examining strategies over all subperiods, there seems to be no clear pattern as to which strategy consistently performs best or worst.

To visualize the effect of market crises on the return of momentum strategies, figure 2 graphs the monthly net profits of all J6K6 portfolios over the complete time horizon. The J6K6 is representative for other strategies. As can be seen, the monthly profit of the loser portfolio breaks down following times of market distress when the market begins to recover, resulting in a large negative return of the zero-cost portfolio. While there are some outliers on the positive side, these are not as frequent and not as large. The worst performing portfolio was that created in February 2009 and returned -62% over the course of 6 months. It becomes apparent, that the winner portfolio is less volatile and while it does react to market distress, the magnitude of reaction is not as large as loser's portfolios. The outcome is consistent with the results of Barroso and Santa-Clara who suggest the loser portfolio to be the driving force behind momentum crashes. The results of this study confirm previous findings that momentum strategies react negatively to market distress.

Figure 2 – Monthly Returns of the J6K6 Strategy

The monthly returns in percent for each of the 3 portfolios based on a J6K6 strategy for the entire sample period 1996 to 2020.

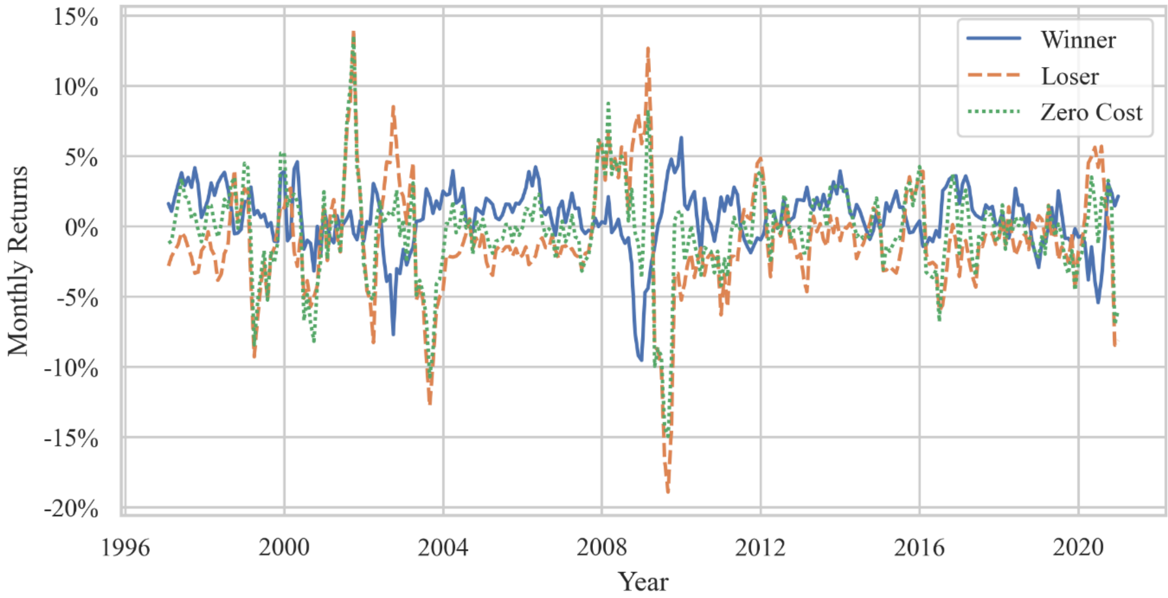

Table 5 – Zero-Cost Portfolios in Subperiods

At the end of each month the best performing decile from the past J months is formed to a winner portfolio with equal weights in which a long position is taken, whereas the worst performing decile is formed to a loser portfolio with equal weights in which a short position is taken. This results in a zero-cost portfolio. The portfolio is held for K months before being liquidated. This process happens on a rolling basis meaning portfolios are overlapping. The returns over K months are converted to monthly returns using the geometric average. The returns are divided into 5 subperiods each consisting of 5 years of the sample. For each subsample, the average of all returns for each strategy is calculated and presented in this table. The t-statistics are calculated for the zero-cost return being significantly different to zero and are reported in parentheses. The sample period is January 1996 to December 2020.

Subsample	J	K							
		1		3		6		12	
		Return	(t-stat)	Return	(t-stat)	Return	(t-stat)	Return	(t-stat)
1996-2001	1	-1.475%*	(-1.79)	-0.787%	(-1.31)	-0.458%	(-1.09)	-0.336%	(-1.30)
	3	-1.288%	(-1.38)	-0.920%	(-1.54)	-0.204%	(-0.47)	0.211%	(0.64)
	6	-0.937%	(-0.90)	-0.341%	(-0.57)	-0.286%	(-0.59)	0.207%	(0.71)
	12	-0.567%	(-0.47)	-0.124%	(-0.15)	0.089%	(0.16)	0.341%	(0.92)
2001-2005	1	-1.497%	(-1.49)	-1.110%	(-1.42)	-1.187%	(-2.24)	-0.624%	(-1.56)
	3	-0.826%	(-0.68)	-0.936%	(-1.20)	-1.009%*	(-1.90)	-0.581%	(-1.51)
	6	-0.618%	(-0.49)	-0.379%	(-0.45)	-0.431%	(-0.89)	-0.704%*	(-1.86)
	12	0.442%	(0.33)	-0.321%	(-0.36)	-0.625%	(-1.07)	-0.785%*	(-1.84)
2006-2010	1	0.035%	(0.05)	0.074%	(0.14)	-0.347%	(-0.96)	-0.581%**	(-2.04)
	3	0.199%	(0.20)	0.075%	(0.11)	-0.268%	(-0.50)	-0.530%	(-1.64)
	6	-0.211%	(-0.19)	-0.381%	(-0.46)	-0.597%	(-1.01)	-0.671%**	(-1.89)
	12	-0.751%	(-0.59)	-0.595%	(-0.62)	-1.041%	(-1.56)	-1.087%***	(-2.97)
2011-2015	1	-0.335%	(-0.60)	0.017%	(0.05)	-0.141%	(-0.57)	0.219%	(1.23)
	3	-0.242%	(-0.32)	-0.653%	(-1.66)	-0.285%	(-1.18)	0.490%**	(2.48)
	6	0.029%	(0.04)	0.056%	(0.15)	0.515%**	(2.20)	0.616%***	(3.53)
	12	0.845%	(1.00)	1.108%**	(2.21)	1.087%***	(3.38)	0.974%***	(5.35)
2016-2020	1	-1.556%	(-1.62)	-0.667%**	(-2.37)	-0.489%	(-1.64)	-0.629%***	(-2.92)
	3	-1.191%	(-1.58)	-0.558%	(-1.16)	-0.585%**	(-2.06)	-0.553%**	(-2.64)
	6	-0.942%	(-0.90)	-0.667%	(-1.23)	-0.669%**	(-2.16)	-0.539%**	(-2.27)
	12	-1.929%*	(-1.83)	-1.366%**	(-2.33)	-0.975%**	(-2.60)	-0.650%***	(-3.03)

* indicates significance to the 10% level, ** to the 5% level, and *** to the 1% level.

Noting that loser portfolios do not increase zero-cost returns and are responsible for a major part of losses during momentum crashes, I analyze the outcome of having invested in a winner-only J6K6 momentum strategy. An initial investment of GBP 1000 is evenly invested into each of the first 6 portfolios. After 6 months when the first portfolio is liquidated, the profits made are completely invested into portfolio number 7. Respectively, all profits made from the second portfolio are invested into portfolio number 8 and so on. Figure 3 visualizes both zero-cost and winner-only returns compared to a GBP 1000 investment into the market portfolio. As is shown, the winner-only portfolio outperforms both zero-cost as well as market portfolios over the entire sample period with a terminal wealth of GBP 5951 while the market portfolio appreciated to GBP 4100. The average monthly return of the J6K6 winner-only strategy is 0.644% which when tested to be significantly different to zero has a t-statistic of 5.13, thus being significant to the 1% level. As can be seen in the figure, it is in particular after 2012, during the 4th subperiod, that the strategy performs well. Similar results are found when analyzing other strategies with formation periods of at least 6 months. In comparison, the zero-cost portfolio noticeably underperforms the market and loses approximately half of the initial investment after 25 years.

Figure 3 – Cumulative Returns of the J6K6 Strategies

The cumulative wealth of the J6K6 winner-only strategy from January 1996 to December 2020 compared to the J6K6 zero-cost portfolio and FTSE 100 in GBP.

To assess whether this excess return is caused by higher risk, the FF3F monthly factors from 1996 to 2017 are used to regress the returns. The coefficients are displayed in table 6. I find that the beta coefficient is unit with the market beta, meaning the winner-only portfolio is equally volatile as the market. The SMB and HML coefficients are both insignificant, but still positive hinting that winners tend to be stocks slightly below average market capitalization with a slightly higher book to market ratio. The alpha factor measuring the abnormal return is calculated to be 0.19% per month which is significant to the 5% level. These results strongly suggest that the momentum effect exists and can be exploited over a longer time horizon even after transaction costs are considered.

Table 6 – J6K6 Winner-Only after Adjusting for Risk

The monthly winner-only profits returned by momentum strategies with a 6-month formation and 6-month holding period are adjusted using the FF3F model. CAPM-Beta measures the volatility compared to the benchmark, in this case the entire FTSE 100. The two factors SMB and HML measure the higher outperformance of small firms as well as the outperformance of value stocks. The intercept with the y-axis, α, measures the abnormal return of the investment. The t-statistics are calculated for the coefficients to be significantly different to zero and are reported in parentheses. The sample period is January 1996 to December 2017.

Factor	Coefficient	(t-stat)
CAPM-Beta	1.00***	(21.97)
SMB	0.011	(0.49)
HML	0.017	(0.80)
α	0.0019**	(2.35)

* indicates significance to the 10% level, ** to the 5% level, and *** to the 1% level.

5. Conclusion

Examining the profitability of momentum strategies on the FTSE 100 from 1996 to 2020, I find significant proof of the momentum effect, with winners consistently outperforming losers, thus rejecting the null hypothesis that momentum strategies had not yielded significant profits over the sample period. The outperformance is especially pronounced for strategies with formation periods of 6 to 12 months and holding periods of 3 to 6 months. I do not find evidence of winners bearing higher risk than losers, in fact the results suggest the opposite. When measuring CAPM-Beta and firm size I find winners to carry less risk than losers. After regressing the zero-cost returns with the FF3F model, I find strategies with longer formation periods to return abnormal returns, confirming the existence of the anomaly for the sample period. However, after accounting for transaction costs, all strategies either yield negative or significant negative returns. When the data is split into 5 even subperiods, momentum strategies with longer formation periods of 6 to 12 months earn significant profits, after transaction costs are subtracted, in subperiods where no major market events take place. When analyzing monthly returns over the entire sample period, I can confirm that momentum strategies are subject to momentum crashes, with the loser portfolio causing most of the losses. For the J6K6 strategy, applying a winner-only strategy can outperform the market and yield significant abnormal returns after adjusting with the FF3F model.

To truly determine the consistency of a winner-only strategy more research over a longer time horizon is needed. The strategy performs especially well over periods when there are no major events and the market itself performs rather well. While less severe than traditional zero-cost portfolios, in times of market crisis’, the flaws if the strategy are still apparent. Further analyses and a more sophisticated approach to risk management, could provide valuable information as to how to handle these crashes. This could be the subject of further research in the field.

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Declaration of Authorship

I hereby declare that the thesis, “The Profitability of Momentum Strategies on the FTSE 100” has been composed by myself without the assistance of any unpermitted aid. I confirm that the work submitted is my own. If external information was used it is also clearly indicated as such.