# The relevance of information and trading costs in explaining momentum profits: Evidence from optioned and non-optioned stocks

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Abstract

Considerable evidence from many countries suggests momentum strategies generate profits. These have been difficult to rationalise and evidence on the sources of such profitability is inconclusive. We utilise a sample of optioned stocks, characterised by high liquidity, high market capitalisation and fewer short sales constraints and compare results with control samples of non optioned stocks chosen on the basis of market value, turnover and bid-ask spread. The sample characteristics, and the fact that derivatives improve the impounding of information into prices, enable us to draw conclusions about the causes of momentum profits. While we find that short sales constraints are not the major driver of profitability and that most momentum profits disappear using two transactions costs measures of the bid-ask spread, one not previously used, the persistence of some momentum profits indicates that the market underreacts even to the most publicly available information.

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## 1. Introduction

Considerable empirical evidence exists which supports the view put forward in the seminal work of Jegadeesh and Titman (henceforth, JT, 1993) that above average risk adjusted returns can be obtained by following a momentum (or relative strength) strategy of buying recent winners and selling (or shorting) recent losers. Such evidence has been found in many different markets and irrespective of the approaches used for accounting for risk[1]. In recent work attention has been focused on the question of *why* momentum strategies appear to generate profits and trying to determine whether any such excess returns are genuine, or would not be exploitable in practice (see, for example, Cooper et al. (2004), Liu and Zhang (2008) and Agyei-Ampomah, (2007)). While profits from a relative strength strategy have traditionally been explained with reference to the underreaction of investors to new information (see, for example, JT (2001) and Chan et al. (1999)), others argue that rational factors explain the apparent profits (see, for example, Wang (2003)). Specifically, it has been argued that returns may not be exploitable in practice due to market imperfections such as short sales constraints, thin trading (and the associated stale prices) and transactions costs, including the bid-ask spread. Results of studies investigating these issues have been mixed. For example, while Lesmond et al. (2004), argue that abnormal returns generated by momentum strategies do not exceed the trading costs and Ali and Trombley (2006) show that momentum profits are largely driven by short sales constraints, Korajczyk and Sadka (2004) find that transactions costs do not fully explain past winner stocks' return persistence and

[1] See for example, Chordia and Shivakumar (2002), Jegadeesh and Titman (1993, 2001) and Avramov and Chordia (2006) for the USA; Liu et al (1999), Hon and Tonks (2003) and Galariotis et al. (2007) for the UK and Rouwenhorst (1998), for 12 European countries, Hart et al. (2003) for 32 emerging markets, Griffin et al. (2003) for 40 countries in Africa, the Americas, Asia and Europe, Gupta et al. (2010) for 51 countries including more than 51,000 stocks and Chui et al. (2010) who examine cross cultural differences in momentum profits in 41 countries around the world and find evidence of positive momentum profits in all but 4 of the countries examined.

Geczy et al. (2002) find that short sales costs do not eliminate the large documented return of the loser portfolios. Thus, the question of what drives returns from relative strength strategies remains unresolved. In order to answer this question it is helpful to consider whether momentum profits can be generated when using a sample for which short sales constraints are not a major issue and where thin trading is not of concern. With the construction of such a sample, it should be possible to concentrate on determining the roles of (possible underreaction to) information and transactions costs in explaining momentum returns.

Prior literature suggests that underreaction and momentum are most likely to occur where information is relatively scarce, where the costs of trading are high, particularly in relation to short selling, and where thin trading exists. For example, the role of information availability is central to the arguments of Hong and Stein (1999), who argue that momentum arises as a result of the slow diffusion of private information in the market. Their view is supported by Hong, Lim and Stein (2000) who find that the momentum effect is most marked for firms where diffusion will be slowest (those with low analyst coverage and small firms). Trading costs, including short selling, are likely to impact on underreaction, since such costs impede the arbitrage process which could move prices to their fundamental value (for consideration of the issues surrounding costs and arbitrage see, for example, Pontiff, 1996 and Shleifer and Vishny, 1997). Similarly, thin trading can increase the risks associated with arbitrage, since arbitrageurs cannot guarantee that they will easily find a counterparty when the time comes to close out a trade. Furthermore, thin trading can also lead to spurious association between consecutive returns (see, for example, Chordia and Shivakumar, 2006).

There are strong grounds for believing that equity derivatives will impact on both the availability of information and the scope for, and costs of, short selling. Cox (1976) argues that futures trading alters the amount of available information for two reasons: more traders are attracted to the market and; futures trading incurs lower transactions costs than the underlying markets. These arguments hold equally true for other forms of exchange traded derivatives and, hence, trading in equity derivatives such as stock futures or stock options is expected to improve the information available to market participants[2]. In addition, stock options provide a means by which investors can mitigate the impact of short sales constraints and this may lead to improvements in market efficiency. For example, Figlewski and Webb (1993) "*present empirical evidence that trading in options contributes to both the transactional and informational efficiency of the stock market by reducing the effect of constraints on short sales.*" (p. 761). Furthermore, options are typically written on stocks which are highly liquid. Therefore, a sample of stocks on which options exist is expected to be one in which underreaction is less prevalent compared to non-optioned stocks. Consequently, if momentum profits result from underreaction, then we would expect to find lower profits for the former sample than for a sample of stocks without options. In this paper we investigate the primary drivers of momentum profits by analysing returns to zero-cost relative strength portfolios for both a sample of optioned stocks and for four control samples of non-optioned stocks. Given the focus of explanations of returns to relative strength portfolios, we construct control samples based on non-optioned stocks which have the highest market capitalisation (to capture the impact of illiquidity and information), turnover (to capture the impact

[2] Several papers have found that derivatives' trading has a positive impact on available information in the underlying market. See, for example, Antoniou and Holmes (1995), Chatrath and Song (1998), Antoniou et al. (2005) and Chau et al. (2008) in relation to futures and Damodaran and Lim (1991) and Huang and Wang (1997) in relation to options.

of illiquidity, price impact and information) and bid-ask spread (to capture the impact of a key element of direct transactions costs). In addition, we have a control sample based on all three factors. These five samples provide the main means by which we can gain insights into the drivers of momentum profits. We also consider the role of risk by adjusting returns for the three Fama-French factors.

From the analysis of these five samples, it emerges that optioned stocks are capable of generating substantial momentum profits. We re-examine all five samples taking account of trading costs. In addition to using the standard quoted spread trading cost measure, we also directly take account of the prices at which stocks in the winner and loser portfolios are traded, to capture the effect of the changing bid-ask spread width over the momentum cycle. This is an important feature that trading cost measures used in previous research ignore. Our findings suggest that while trading costs play an important role in explaining some of the momentum anomaly, the robustness of some momentum strategies implies that market underreaction remains a determinant of momentum profits. The results from this part of the analysis are considerably different from those using the standard approach and demonstrate the need to take account of actual trading prices in determining whether momentum profits are robust. The results of the analysis provide important new insights into the main causes of momentum profits.

The rest of the paper is organised as follows. The next section briefly reviews the relevant literature and states the hypotheses to be investigated. Section 3 discusses the data and methodology, while empirical results are provided and discussed in section 4. Section 5 concludes the paper.

## 2. Literature review and statement of hypotheses

In this section we review literature relating to the trading of options and trading costs relevant to the momentum issues to be addressed[3].

### *2.1 Options trading and momentum profits*

As far as options are concerned, there are four ways in which the trading of such derivatives has the potential to impact on momentum profits: namely, in relation to information/price discovery; liquidity; transactions costs; and short sales constraints. We briefly consider each of these in turn.

It has long been argued that a key function of derivatives markets is to aid the price discovery process. Empirical evidence in relation to stock options supports this view showing that they enhance and speed the price discovery process. For example, Damodaran and Lim (1991) show that following option listing the price of the underlying stock tends to adjust more quickly to information. Using a model developed by Amihud and Mendelson (1986) to decompose the return variance into components, Damodaran and Lim (1991) provide evidence of a significant increase in the price adjustment coefficient and a significant decrease in the noise variance component following option listing. In a different context, Jennings and Starks (1986) find that stocks with listed options adjust faster to quarterly earnings announcements than stocks without listed options and argue that the existence of option markets improves the dissemination of earnings news. Similarly, Skinner (1990) shows that

[3] We do not provide a full review of all relevant literature on momentum, since this is too vast. For good selective reviews see, Grundy and Martin (2001) or more recently Li et al. (2008), Asem (2009), Verardo (2009) and Chui et al. (2010).

the market anticipates a larger proportion of the information contained in earnings releases after option listing.

Furthermore, there is evidence that options can help resolve information asymmetry among investors. For example, Kraus and Smith (1996) show that in the presence of heterogeneous beliefs, trading in a replicable option reveals investors' private beliefs, while Back (1993) argues that options and stocks convey different information, and as a result, the existence of options changes the information flow in the market. He argues that when investors execute their option trades, they reveal some of their private information which helps to resolve information asymmetry and correct mispricing. Option trading should, therefore, reveal more information, reducing arbitrage opportunities in the mispricing of the underlying stocks. Thus, there is considerable evidence to suggest that optioned stocks should be prone to less mispricing than other high market capitalisation stocks. Given that momentum profits have typically been witnessed over relatively long horizons (3-12 months), this allows us to consider our first hypothesis:

*H1: momentum profits on portfolios formed of optioned stocks will not be significantly different from those of high market capitalisation non-optioned stocks.*

If the availability and the speed at which information is impounded in prices is the main determinant of momentum profits, then this hypothesis should be rejected.

Option listing and option trading can impact on liquidity in two ways. First, options are normally only issued on relatively large liquid stocks (see, for example, Mayhew and Mihov, 2004). Second, evidence suggests that option trading increases liquidity for the underlying stocks (see, Kumar et al. (1998) who show this empirically and Cao and Ou-Yang (2009) who develop a model to examine how differences of opinion impact on the dynamics of trading volume and show that the trading volume increases after option introduction). The second point again has implications for momentum profits and leads to the following hypothesis:

*H2: momentum profits on portfolios formed of optioned stocks will not be significantly different from those of non-optioned stocks with a high turnover.*

As liquidity is found to improve following option listing, it is expected that optioned stocks should generate lower momentum profits than non-optioned stocks.

As far as transactions costs are concerned, evidence is mixed. For example, while Damodaran and Lim (1991) and Kumar et al. (1998) show that option trading decreases the bid-ask spread, Stein (1987) finds contrary effects of option trading on bid-ask spreads of the underlying stocks. However, Fedenia and Grammatikos (1992) suggest that highly liquid stocks tend to have spread increases after option introduction, while the opposite effect holds true for illiquid stocks. While there is some ambiguity as to the effect of option listing on the bid-ask spread, it appears that the introduction of options leads to a change in the spread. To test the implications of this view, together with the fact that options are normally written on highly liquid stocks which typically have a low bid-ask spread we have our third hypothesis:

*H3: momentum profits on portfolios formed of optioned stocks will not be significantly different from those of non-optioned stocks with low bid-ask spreads.*

To date there has not been a direct test of the possibility that option trading could reduce or eliminate momentum profits due to improved information flows, increased liquidity or changes in the bid-ask spread. In light of this it is important to conduct a cross-sectional analysis on how momentum returns differ among optioned and non-optioned stocks.

The other relevant factor about option trading relates to short sales constraints. In order to successfully implement a zero-cost momentum strategy it is clearly necessary to short sell loser stocks. In practice there are costs associated with short selling and in some cases it is simply not possible to short sell. A relevant question then becomes, are apparent momentum profits the result of short sales constraints? As noted in the introduction, Ali and Trombley (2006) provide a positive answer to this question, showing that momentum profits are largely driven by short sales constraints. Similarly, the findings of Nagel (2005) are consistent with the view that stocks with higher institutional ownership (a proxy for short sales constraints) underreact less to bad news than stocks with low institutional ownership. However, Geczy et al. (2002) find that short sales costs do not eliminate the large documented return of the loser portfolios and, in distinct but related work, Asquith et al. (2005) show that short-sales constraints are not widespread. If this is the case then short sales constraints cannot be the main reason behind momentum profits. Thus, the issue of the role of short sales constraints in explaining momentum profits has not been resolved.

Options mitigate many of the problems associated with shorting stocks. As Chang et al. (2007) state *"[s]ince traded put and call options arguably offer a low-cost way of establishing a short position, the listing of options can be viewed as the de facto alleviation of short-sales constraints.*" (p.2099). Furthermore, Figlewski and Webb (1993) show that optioned stocks exhibit a significantly higher level of short interest than stocks without options. This leads to our fourth hypothesis:

*H4: momentum profits on portfolios formed of optioned stocks will not be significantly different from those of non-optioned stocks with similar characteristics.*

Rejection of this hypothesis will suggest that short sales constraints are the cause of momentum profits, since we would expect to see differences between the returns to a momentum strategy using optioned stocks and those to a strategy using otherwise similar non-optioned stocks, if these constraints are important.

To address the first three hypotheses we, therefore, examine momentum profits for a sample of optioned stocks and compare these findings with those from three control samples of non-optioned stocks. The three control samples are selected on the basis of (i) market capitalisation, (ii) turnover and (iii) bid-ask spread respectively. To examine the fourth hypothesis we compare the momentum profits from a sample of optioned stocks with those from a sample of nearest neighbour non-optioned stocks. The nearest neighbour stocks are determined using logit analysis with three independent variables, namely market value, turnover and the bid-ask spread. Thus, in total there are four control samples of non-optioned stocks.

*2.2 Trading costs and momentum profits*

A growing body of literature exists on the robustness of momentum profits to trading costs. Korajczyk and Sadka (2004) show that quoted and effective spread costs do not eliminate momentum profits. In contrast, Lesmond et al. (2004) argue that abnormal returns generated by momentum strategies do not exceed the trading costs associated with stocks lying in the winner and loser portfolios. For the UK, Li et al. (2009) show that momentum strategies based on short listing low cost stocks, after deducting quoted spread, commission, stamp duty and short selling costs, produce significant profits. Examining the robustness of momentum profits to trading costs requires an estimation of several cost components. The various costs incurred in the implementation of a momentum strategy are: bid-ask spread; broker's commission; immediacy costs; short sales costs; and the price impact costs. Incorporating all these components into a single trading cost measure is extremely difficult due to factors including data availability and the difficulty of estimating the price impact on losers[4]. However, Chen et al. (2002) provide evidence that the largest decile portfolio in market value exhibits low sensitivity of price reaction to trading volume. Therefore, given that optioned stocks are mainly large capitalisation firms, price impact costs are likely to be trivial. Furthermore, as noted above, options mitigate many of the issues associated with shorting. Hence, the optioned stocks are likely to be affected by price impact and short sales constraints to a much lesser degree (if at all) than non-optioned stocks.

[4] An exception is Ellis and Thomas (2004) who adjust momentum returns of the FTSE ALL Share 350 to trading costs that were collected from Plexis Group and that represent the average cost across all stocks traded by a fund. They report that for a full round trip of momentum trading, the average price impact costs is 0.8%; stamp duty 1%; commission costs 0.5%; spread cost 2% and short-selling costs 0.75% semi-annually. Therefore, their total trading cost estimate for a 6x6 momentum strategy is roughly 5%, of which over 30% relates to price impact and short-selling costs.

We, therefore, examine adjustments for trading costs which are not associated with short sales constraints or price impact. A conventional trading cost measure is the quoted spread measure proposed by Stoll and Whaley (1983). Direct effective spread estimates of trading costs are substantially lower than the quoted spread estimate (see, for example, Korajczyk and Sadka, 2004; Lesmond et al., 2004), and, therefore, the quoted spread estimate provides one means by which to consider the robustness of momentum profits to trading costs. If momentum profits persist after using this higher figure, then trading costs do not appear to explain the anomaly.

However, the quoted spread suffers from a shortcoming, since it employs bid-ask quotes prior to the portfolio formation date for the momentum portfolio. In practice, the bid-ask spread varies over time, specifically for the past winner and loser stocks. Therefore, the bid-ask spread during the ranking period is expected to be different from that at the end of the holding period when the position is closed. With respect to momentum strategies, using pre-ranking or ranking period bid-ask spreads *might* consequently incorrectly estimate the cost of trade. It is, therefore, essential to examine the impact of variations in the spread on momentum profits using bid and ask prices at the time of execution of momentum strategies. Our final hypothesis is:

*H5: once transactions costs are taken into account using bid and ask prices the profit from momentum strategies will be insignificantly different from zero.*

We test this hypothesis using both the quoted spread estimate and actual bid and ask prices at the time of execution of trades.

By examining these five hypotheses we are able to draw clear inferences about the factors which generate apparent momentum profits.

## 3. Data and Methodology

The sample consists of the FTSE All Share constituents excluding Fledging shares and the FTSE AIM stocks, for the period from 1989 to 2010. The FTSE All Share Index accounts for more than 98% of the UK market by market capitalisation. The names of the constituents are obtained from DataStream from March 2001 and from the Financial Times prior to that date. All data are retrieved from DataStream after matching the names from the FT historical lists with the names from DataStream[5]. Table 1 provides descriptive statistics for the full sample of stocks from which the sub-samples used for the analysis are drawn. Panel A shows that the total number of firms per year increases in the first few years but then falls between 1995 and 2009. In Panel B, the statistical properties of returns are displayed for the full sample, as well as for 5 size-sorted monthly rebalanced portfolio sub-samples, based on the previous month-end stock market capitalisation. The table shows that the two largest quintiles by market value have the highest average return over the whole period. The panel also shows that the range of returns (maximum-minimum) increases as market value decreases, suggesting that the returns of smaller stocks have greater volatility.

INSERT TABLE 1 ABOUT HERE

[5] Company name changes were checked and matched from two sources. The first is the Journal of the Institute of Actuaries online Resource Centre and the second source is the Share Data Services online resource.

To test for serial correlations in sample stock returns, we provide the Durbin-Watson statistic for time-series of monthly returns for the full sample and the five size-sorted sub-samples in Panel C. DW statistics reported are lower than 2 for all samples. We also display the p-values for the Breusch-Godfrey test of autocorrelation. The null hypothesis states that the coefficients of an AR of $p^{th}$ order for the residual term are all zero. The reported p-values reject the null hypothesis for all samples, but the largest size sub-sample[6]. This indicates the existence of serial correlation in the portfolio returns of four size sub-samples. However, importantly, given the finding of no serial correlation for the largest sub-sample, it should be noted that the optioned sample and other sub-samples used in the analysis of momentum contain large stocks.

We now turn to consider the five samples used to test the hypotheses relating to momentum: the first sample consists of all stocks that belong to our FTSE All Share index sample which have options listed on the London International Financial Futures and Options Exchange (LIFFE). The number of optioned stocks at any formation month is denoted *n*[7,8]. Stocks in the control samples are selected from the FTSE All Share stocks that do not have options listed on LIFFE over the subsequent 6 months. The first three control samples are constructed with respect to size,

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[6] The results are for 1 lag, however, similar findings are obtained when changing increasing the number of lags

[7] The number of stocks, *n*, in any of the five portfolios varies with respect to the number of listed stock options on LIFFE over the sample period, which tends to increase over the sample period as more options get listed over time. The maximum, minimum and mean values of *n* are 92, 47 and 73.2, respectively.

[8] When the number of stocks within the sample is at the minimum (maximum) of 47 (92), winner and loser deciles consist of 4 (9) stocks. While such a strategy is riskier than one where a winner/ loser portfolio is diversified among a large number of stocks, the relatively small sample has the advantage that it provides a more feasible and practical investment and reduces the trading costs involved in holding and short selling stocks. Nonetheless, quintile formations are also applied to mitigate any effects arising from the examination of small samples.

turnover[9] and bid-ask spread as discussed in the previous section. The first control sample consists of the *n* largest market value (MV) stocks. The second control sample consists of the *n* highest turnover stocks, where the turnover, T, is the trading volume over the last month before the formation date, divided by the number of outstanding shares at the date of formation. The third control sample has the *n* lowest bid-ask percentage spread (BAPS) stocks where the BAPS is estimated from daily data over the last month before the formation date.

Using a logit model, we select the *n* nearest neighbour stocks to the optioned stocks to construct our final control sample. Nearest neighbours are those stocks from the FTSE All Share index with the highest propensity score, where the propensity score is estimated from the following[10]:

$$\ln\left(\frac{P_i}{1-P_i}\right) = \alpha_i + \beta_M(MV)_i + \beta_T(T)_i + \beta_B(BAPS)_i + \varepsilon_i \qquad (1)$$

where $P_i$ is the probability that a stock is optioned, $(1-P_i)$ is the probability that a stock is not optioned and $ln\left(\frac{P_i}{1-P_i}\right)$ is the log-odds ratio in favour of having listed options on LIFFE. The estimated parameters $\beta_M$, $\beta_T$ and $\beta_B$ are the coefficients of the three control factors MV, T and BAPS respectively. The propensity scores of all stocks that are within the FTSE All Share and which are not included in the option

[9] Turnover is used as a measure of liquidity rather than trading volume since the latter is unscaled and could be highly correlated with firm size. Similarly, the bid-ask spread is divided by price to represent a scaled measure.

[10] Since the control samples consist of the largest, most traded or cheapest to trade, micro-structure problems resulting from infrequent trading and low priced firms are not serious, as stocks within the control samples are neither illiquid nor suffer from the low price effect. Therefore, no limitations to the selection of stocks are required. It should be noted that some stocks are selected in more than one control sample simultaneously.

listed sample are ranked and compared cross-sectionally at each month *t*. The stocks with the *n* highest propensity scores form portfolio P[11].

The sample of stocks with listed options will be referred to as "sample L"; while "sample M", "sample T", "sample B" and "sample P" refer to control samples representing the largest MV, highest turnover, lowest BAPS and highest propensity score, respectively.

Table 2 shows the characteristics of the five samples used. The means (medians in brackets) of the MV, T and BAPS are displayed for each sample. The mean MV of the sample with listed options (£12409 million) is far larger than the mean MV of any control sample (£2808 million is the next largest MV of all control samples[12]). However, the sample with listed options has the lowest average turnover. As for the BAPS, table 1 shows that stocks that have listed options are not the cheapest to trade (second largest median spread), which is consistent with earlier evidence of option trading widening the bid-ask spreads of the underlying stocks (see Stein, 1987). Overall, it is noticed that stocks from the second sample (largest MV stocks) and fifth sample (nearest neighbours from the logit model) are more closely related to the sample with listed options than the other control samples.

[11] The logit model has been used by Mayhew and Mihov (2004) to address the exchanges' selection criteria for listing options; however, the explanatory variables in their model differ from those here as the objective and the purpose of finding the nearest neighbours are distinct between the two studies. Specifically, Mayhew and Mihov (2004) examine the likelihood of a stock being selected for option listing and examine whether stock exchanges select volatile stocks for option listing. Their paper focuses on volatility dynamics prior to option listing to identify which stocks will be selected. Our concern is very different. For our control samples we seek to select non-optioned stocks which have the nearest characteristics to those of optioned stocks in terms of the factors discussed earlier concerning possible impact on momentum profitability. By controlling for these factors, any discrepancy between momentum returns from a sample of optioned stocks and one of non-optioned stocks should not then be the consequence of these firm-specific characteristics.

[12] While the MV of sample M is much lower than that of L, nonetheless, sample M does contain relatively large capitalisation stocks when compared to the universe of stocks.

INSERT TABLE 2 ABOUT HERE

Overlapping momentum portfolios are constructed from each of the five samples at each month *t* of the sample period. Stocks within each sample are ranked based on their past *j* month returns[13] in descending order and are assigned into deciles with the highest (lowest) past performance assigned to the top (bottom) decile[14]. The momentum strategy entails that short positions in the bottom (loser) portfolios finance long positions in the top (winner) portfolios (i.e. zero-cost positions). Positions are held for *k* months, which results in *k* positions being opened at the same time. Since the first momentum portfolio in the sample period is formed on January 1990 and the last on October 2009 (although stock returns employed in this study span over the sample period 1989 to 2010), there are a total of 238 calendar formation months in the sample period.

In line with the literature[15], this study controls for short-run return reversals by skipping a month between the ranking period and the holding period in order to separate the momentum effect from other factors that might generate negative serial correlation[16]. The return of the momentum portfolio is estimated by subtracting the losers' return from the winners' return.

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[13] The monthly return for stock *i* at month *t* is obtained from the difference in natural logarithmic monthly prices.

[14] Note that this study also applies quintile sorting, where winners and losers are assigned to the top and bottom quintiles. Only the decile formation is used when testing the last hypothesis, to examine whether trading costs can capture the largest momentum profits observed.

[15] See Jegadeesh and Titman (1993) who skip a week between formation and holding periods.

[16] Jegadeesh and Titman (1995) show that there exist short run reversals even among large stocks which is due to overreaction to firm-specific components rather than lead-lag effects. This necessitates the need to control for short-run reversals even among large and liquid stocks.

To test the robustness of the momentum strategy to the quoted spread measure, the quoted spread is estimated based on observations over the last month. This is different from previous studies that estimate the quoted spread over the past 12 months. The rationale behind this is that since momentum returns are the consequence of the near past performance, the quoted spread estimate should also reflect the trading cost in the near past. The return to a momentum portfolio at any month is then:

$$\sum_{r=1}^{n}\left(R_{r,w}-Q_{r,w}\right)-\sum_{s=1}^{n}\left(R_{s,l}+Q_{s,l}\right) \qquad (2)$$

where $R_{r,w}$ is the return to the winner portfolio; $R_{s,l}$ is the return to the loser portfolio; $n$ is the number of stocks in either the winner or the loser portfolio; and $Q_{r,w}$ and $Q_{s,l}$ are the quoted spread estimates of the individual stocks r and s, respectively.

However, since the conventional quoted spread ignores the bid-ask spread during the holding period, this paper implements an alternative trading cost measure that embeds the transaction costs on the date of liquidation into the total trading costs. Specifically, the holding period returns are estimated from quoted prices at the time of executing a buy or sell transaction. The execution time trading cost measure entails that the ask price is paid for acquiring a stock and the bid price is received from selling a stock. The advantage of the execution time trading cost model over other spread based cost models is that the former uses the quoted bid and ask prices at the dates of opening and closing positions rather than using random quoted bid and ask prices over past periods. This reflects a more accurate estimate of the spread cost as it has a tendency to vary over time and hence past estimates may not necessarily reflect the current cost to trade the corresponding stock.

While it is possible to buy a stock at a price lower than the quoted ask price and sell at a price higher than the quoted bid price, the proposed measure involves the strictest case of incurring the highest trading costs. In comparison with the conventional way of obtaining stock returns from the difference in logarithmic closing prices, the execution time measure replaces the ask (bid) price for the closing price if the underlying transaction was buying (selling) the stock. The return to a winner stock that is held over a period of *k* months is then

$$R_i = \ln\left(Bid\ price_{i,t+k}\right) - \ln\left(Ask\ price_{i,t}\right) \qquad (3)$$

where $Ask\ price_{i,t+k}$ and $Bid\ price_{i,t}$ are the ask and bid prices of stock *i* at month *t* +k and *t,* respectively. Similarly, the return to a loser stock that is held over a period of *k* months is the difference between the buying price at the end of the holding period (Ask price) and the selling price at the beginning of the holding period (Bid price).

The return to the winner and loser portfolios is the weighted average of all winning and losing stocks.

## 4. Empirical Results

Analysis begins by calculating momentum profits for the five sub-samples for combinations of ranking, *j,* and holding, *k,* periods of 1, 2, 3 and 6 months and for both decile and quintile portfolios. Thus for each sample 16 sets of decile results and 16 quintile results are obtained, representing all possible combinations of *j* and *k*. Table 3 presents the results, with the returns to the winner portfolio, the loser portfolio and the momentum strategy (winner-loser) for sample L, M, T, B and P being shown in panels A-E. Within each panel the top half shows results for the decile portfolios and the lower half those for the quintile portfolios. The ranking period *j* is shown in the first column and the holding period *k* varies across the rows.

Thus for example, the results presented in the third row, fourth column, of panel A relate to returns to the winner decile portfolio when *j*=3 and *k*=2. Panel F shows the results for testing for the equality of momentum returns for pairs of samples in order to test our hypotheses[17].

INSERT TABLE 3 ABOUT HERE

Consideration of panel A shows that despite the fact that optioned stocks are less likely to be affected by short sales constraints, slow impounding of information and illiquidity, there is clear evidence of significant momentum profits. As far as the decile (quintile) portfolios are concerned, momentum profits are significantly different from zero in 15 (12) out of 16 cases. The exception for the decile portfolio is for the 2x3 strategy, while those for the quintile portfolios are the 3x1, 3x2, 2x3 and 3x3. In all 16 cases the returns to the decile portfolio are higher than those to the equivalent quintile portfolio. There is also a general pattern that momentum returns increase as *j* increases and that for decile portfolios shorter holding periods (*k*=1,2) generate higher returns for a given value of *j*[18]. Furthermore, not only is there evidence of statistically significant profits, but also the size of the profits is economically meaningful. For the decile portfolios the lowest (highest) monthly return from the 16 strategies is 0.70% (1.96%) and in 12 out of 16 cases the return to the zero-cost portfolio is over 1% per month. Indeed, in 8 cases it is greater than 1.35% per month. These are substantial profits for such highly liquid stocks and are in line with the pattern of profits in JT (1993) for their analysis of NYSE and AMEX stocks. Not

[17] Results are reported for strategies of 2x3, 3x3 and 6x3. Results for other strategies are similar. In unreported results, F-tests were also carried out for the equality of momentum returns in all samples. In all cases the test of equality was rejected at the 5% level.

[18] For the quintile portfolios the profits are greater when k=3 or 6 in 3 out of four cases.

surprisingly, the corresponding figures for the quintile portfolio are smaller. However, the lowest (highest) monthly return is 0.46% (1.30%), which represents an economically meaningful return to a zero-cost portfolio. While these zero-cost portfolios generate significant returns, the same is not generally true for the components of the strategy: in no case are the returns to winner or loser portfolios significantly different from zero at the 5% level[19]. Nonetheless, the overall pattern from panel A is clear: optioned stocks generate momentum profits. Given the characteristics of these stocks, this provides *prima facie* evidence that momentum profits are not due to short sales constraints or illiquidity. However, to examine our hypotheses more fully, we need to consider the momentum profits for the other samples.

INSERT FIGURE 1 ABOUT HERE

Figure 1 shows the momentum returns for each event month over a 1-year period for decile portfolios for sample L. The four lines represent four momentum return series with different formation periods (1, 2, 3 and 6 months). These returns are not cumulative, but rather reflect the performance of the four momentum strategies at each event month. It is interesting to note that in each event month up to month 11 returns from each of the strategies are positive, with the exception of the one month formation period, which shows a marginally negative return in month 4.While there are some fluctuations across months for the four samples, the figure shows clearly that momentum profits continue for almost a year after formation in each case.[20]

[19] In 6 out of 16 cases the loser portfolio returns are significantly different from zero at the 10% level.
[20] Figures for the other four samples are not included, in the interests of brevity, but reveal similar patterns. For sample M monthly returns are positive for all months up to month 10, with the exception of a formation period of one month. For sample T (P) monthly returns are significant for all formation

Examination of panel B of table 3 again shows evidence of momentum strategies generating significant profits, particularly for the decile portfolios. In all 32 cases returns are positive and for the decile (quintile) portfolio in 12 (9) out of 16 cases returns are significantly different from zero. Based on arguments that option listing improves the impounding of information, we would expect to reject hypothesis H1 that momentum strategies from optioned stocks will not be significantly different from those for high market-capitalisation non-optioned stocks. Indeed, if information arguments dominate then we expect that optioned stocks will generate lower returns. Comparing results in panels A and B does not support this view. The monthly returns in panel B range from 0.55-1.30% (compared to 0.70-1.96% for optioned stocks) and in only 4 cases is the return greater than 1% per month. Indeed, in 29 (out of 32) cases the returns to the momentum strategy are *higher* for the optioned stocks than for the non-optioned stocks, although the differences are not statistically significant. These results suggest that despite the view that information flows and the speed at which information is impounded in prices increases with equity derivatives, H1 is not rejected and mispricing remains, even for optioned stocks. One potential explanation for these findings may be related to the effect of informed trading. More specifically, Pan and Poteshman (2006) show that optioned stocks are more affected by informed trading compared to non optioned ones, while Hameed et al. (2008) show that the returns of stocks with high informed trading exhibit strong momentum patterns related to price discovery.

To test hypothesis H2 and consider the impact of liquidity on momentum profits, we examine returns to the zero-cost strategy for sample T and compare them to those

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periods and all months up to 12 (11), while for sample B they are positive up to 10 months, with a marginal exception (month 9) for the formation period of one month.

for sample L. Results for sample T are presented in panel C of table 3 and show that in all 32 cases momentum returns are significant and positive. Moreover, in all cases they are higher than (and in many cases more than two times) those for equivalent strategies for optioned stocks. Indeed, for the decile portfolios the lowest monthly return in panel C is higher than the largest in panel A. This difference is reflected in panel F, which shows that in two out of three cases the mean momentum returns are statistically different, suggesting that H2 is rejected in favour of the view that momentum profits on portfolios formed of optioned stocks are significantly lower than those of non-optioned stocks with a high turnover. This leads us to conclude that liquidity in optioned stocks has rather a different impact on momentum returns than liquidity on non-optioned stocks[21].

In order to consider the impact of bid-ask spread and hypothesis H3, we examine the momentum profits of sample B, as shown in panel D of table 3. The results in this panel are in marked contrast to those in panel A. For only 2 out of the 32 strategies considered are the momentum profits significantly different from zero at the 5% level[22] and in all 32 cases the returns to the strategy for optioned stocks are higher than the equivalent for the non-optioned stocks. In no case does the monthly return reach 1%. While we see in panel F that the differences between the two samples are not statistically significant for the three strategies reported, nonetheless, these results suggest that the bid-ask spread might be an important determinant of momentum profits and that once we consider the spread, momentum profits may disappear. The role of this aspect of transactions costs will be considered in more detail later in the paper.

[21] As was seen in table 2, turnover for sample T is more than three times that for sample L.
[22] In another 17 cases they are significant at the 10% level, mainly for longer holding periods.

Investigation of hypothesis H4 (momentum profits on portfolios formed of optioned stocks will not be significantly different from those of non-optioned stocks with similar characteristics) involves comparing the results from sample P with those from sample L. Returns to sample P are given in panel E of table 3 and show that in all cases momentum profits are positive and significant. Furthermore, comparison with results in panel A show a very similar pattern of momentum returns and the test of the equality of momentum returns between samples L and P (panel F) all show no significant difference. Thus, H4 is not rejected. Given that sample P is a nearest neighbour sample based on market value, turnover and bid-ask spread, the major difference between the two samples relates to short sales constraints. The similarity in results for the two samples, strongly points to the conclusion that short sales constraints are *not* the main determinant of momentum profits[23].

INSERT TABLE 4 ABOUT HERE

The analysis to date has been of raw momentum profits, i.e. momentum profits unadjusted for risk. While previous research has shown that adjusting for risk cannot explain away momentum profits, we want to determine whether our results are robust to such an adjustment. We, therefore, repeat the analysis for momentum portfolios adjusting for risk using the three Fama-French factors (the FF3F model).

[23] To ensure that the observed momentum returns of the constructed samples are not due to data snooping bias, we apply the White (2000) reality check. The best performing zero cost momentum portfolio is tested against the zero return benchmark. The null hypothesis is that the returns from the best momentum strategy are no better than the zero return benchmark. See White (2000) and Ericsson and González (2003) for further details on constructing the test statistic. We apply the White reality check to the 16 momentum strategies using the decile formation for the optioned stocks sample and for each control sample. We vary $\rho$ to control for possible autocorrelation in monthly returns. The obtained p-values reject the null hypothesis indicating that the best momentum strategy is superior to the zero return benchmark when $\rho$ is set to 0.1, 0.2 or 1. Thus taking account of data snooping does not eliminate the significance of the momentum effect.

Results for the momentum portfolios are shown in table 4[24]. Once again, panels A-E present the results for samples L, M, T, B and P respectively. The first four columns of results show the findings for the decile portfolios and the last four for the quintile portfolios. The results in table 4 are extremely similar to those presented in table 3, both qualitatively and quantitatively, demonstrating that the existence (or otherwise) of momentum profits is not due to failure to take account of risks measured by the FF3F model. Thus, as in previous research, the FF3F model is not able to rationalise momentum profits.

It is possible that apparent momentum profits are illusory and result from thin trading. The sample used in this work mitigates against this, given that all stocks are highly traded. To illustrate, of the 18463 return observations, only 599 observations (3.2%) are zero. To further verify that thin trading is not the major source of momentum profits, a cross-sectional regression is run of individual stock return on the lagged size and lagged return, a winner dummy variable capturing the past winner effect and another the past loser effect, in line with George and Hwang (2004) for the 6x6 decile strategy. The coefficient of the size variable accounts for the size effect, the latter controls for bid-ask bounces. Unsurprisingly, given that the sample consists of highly traded stocks with large market values, the results for both raw returns and FF3F returns show that in all cases the coefficients relating to both the size dummy and the lagged return variable are insignificant. Furthermore, after controlling for these effects, the returns to the winner-loser portfolio remain significant in nine out of ten cases.[25] In view of the very considerable similarity of results using raw and FF3F

[24] In the interest of brevity results are not presented separately for the winner and loser portfolios.
[25] The exception relates to raw returns for sample B. In the interests of brevity, the results from these estimations are not included. They are available from the authors on request.

adjusted returns, the rest of the paper will examine the remaining issue using raw returns.

INSERT TABLE 5 ABOUT HERE

In the light of the findings presented in tables 3 and 4, it is important to investigate further the role of transactions costs in momentum profitability. We, therefore, determine the level of momentum profits after adjusting for the bid-ask spread, in two ways. First, we examine momentum profits after adjusting for the quoted spread estimate. Results are presented in table 5. Panels A-E present the results for decile portfolios for the five samples, as in previous tables. Panel F shows the estimated quoted spread costs used when calculating momentum profits adjusted for the spread. The results in table 5 are in stark contrast to those in table 3. Momentum returns are reported for 80 different strategies (16 strategies each for five samples) and without exception the returns are negative. Indeed, in 63 cases the negative returns are statistically significant from zero at the 10% level or greater. The only sample for which a majority of strategies are not significant is, unsurprisingly sample B. For this sample only 7 strategies produce significantly negative returns at the 10% level and only 3 at the 5% level. The clear conclusion to be drawn from table 5 is that once we adjust for the quoted spread, momentum strategies generally deliver significant losses. We can compare these results to those in the existing literature on momentum profits and transaction costs. In contrast to the findings here, Korajczyk and Sadka (2004) show that momentum profits are robust to the quoted bid ask spread and Lesmond et al. (2004) find that momentum profits disappear for the quintile of largest stocks, but not for the quintile of highest turnover stocks[26]. This suggests that the impact of trading costs on the momentum strategies applied in the US market is less than that of the UK market[27].

INSERT TABLE 6 ABOUT HERE

However, as noted earlier, the bid-ask spread varies over time, with the spread in the ranking period expected to be different from that at the end of the holding period. Thus, using pre-ranking or ranking period bid-ask spreads could incorrectly estimate the cost of trade. We, therefore, examine momentum profits using bid and ask prices at the time of execution of momentum strategies. Results from this analysis are shown in table 6, which follows the same layout as table 5, except that there is no panel F in table 6. The picture which emerges once we take account of actual bid and ask prices at trade execution is quite different from those using the historical quoted spread. Most notably, rather than all 80 strategies generating negative returns, with 63 significantly negative when using the quoted spread, when we adjust for actual bid and ask prices there is a much more mixed picture. It can be seen from table 6 that 36 of the 80 strategies lead to negative returns (with half of these significantly different from zero at the 10% level), whereas 44 are positive (with 8 being significant at the 10% level or better). Furthermore, there is a clear difference in results between those strategies with shorter holding periods and those with longer holding periods. Specifically, for k=1 or 2 momentum returns are negative in 34 out of 40 cases (18 significant), compared to only 2 out of 40 (none significant)

[26] Lesmond et al. (2004) use the direct effective spread estimate + commission estimate. The sum of the direct effective spread estimate + commission estimate is shown to be close to the quoted spread estimate when both models were applied to the whole sample of stocks.

[27] To some extent, the different method followed in estimating the quoted spread in this paper could explain some of the variation between our results and previous studies.

when k= 3 or 6. All 8 of the significantly positive returns arise when k equals 3 or 6. Thus, it appears that the quoted spread estimate used in previous studies overestimates the impact of transactions costs on momentum returns. Once we accurately measure the bid-ask spread we find that rather than over three quarters of strategies producing significantly negative returns, less than a quarter do so. Furthermore, ten percent of the strategies still produce significantly positive returns. Thus, while, it is clear from tables 5 and 6 that a large part of momentum profits in the UK market can be explained by transactions costs, the persistence of momentum profits for optioned stocks and non-optioned high turnover stocks for longer holding periods suggests that transactions costs are not the only cause of apparent profits[28]. Hence, using bid and ask prices at the execution time of liquidating the winner and loser portfolios suggests that the impact of transaction costs in explaining momentum profits in previous research has been overstated. Combining these results with those from earlier tables, it appears that illiquidity and short sales constraints are much less important (if at all) than transactions costs for these samples of stocks and that market underreaction is a determinant of momentum profits.

## 5. Conclusion

In this paper we investigate the profitability of momentum strategies for a sample of optioned stocks and for four other control samples using overlapping portfolios. This analysis is undertaken to add to the understanding of the sources of apparent

[28] It was earlier pointed out that Ellis and Thomas (2004) estimated that in addition to the spread cost and price impact and short selling costs, all of which have been taken into account here, stamp duty and commission amount to 1.5% for a 6x6 strategy. However, the strategies in table 6 which are significantly positive generate a monthly return of at least 0.9%. Therefore, even allowing for an additional 1.5% of cost, these strategies remain profitable.

momentum profits and to try to determine whether documented profits are genuine or not. Optioned stocks have the advantage that they are typically high market capitalisation stocks, highly liquid and are much less susceptible to short sales constraints. In addition, there is evidence that derivative trading increases the information available to the market and the speed at which information is impounded, which suggests that mispricing should be less prevalent in such securities. By comparing the results from this sample with four control samples, chosen on the basis of market value, turnover, bid-ask spread and nearest neighbour stocks we are able to draw inferences about the role of information, liquidity, short sales constraints and transactions costs in momentum profitability. This provides greater insights into the causes of momentum profits in a major international equity market.

Hong and Stein (1999) argue theoretically that momentum arises because of the slow diffusion of private information and Hong, Lim and Stein (2000) provide empirical evidence to support this. Given the greater visibility and following of optioned stocks and the fact that derivative trading has been shown to improve the information flow, it would be expected that optioned stocks would be less prone to momentum profitability if Hong and Stein (1999) are correct. However, the results presented here suggest that despite the informational and short sales advantages of options, significant momentum profits exist for the optioned stock sample. Indeed, the profits to be earned from the zero-cost momentum portfolios of optioned stocks are in line with those found by JT (1993) for NYSE and AMEX stocks. Furthermore, the returns to the momentum strategy are higher for the optioned stocks than for the high market value non-optioned stocks and the low bid-ask spread non-optioned stocks and significantly lower than those of high turnover non-optioned stocks.

Interestingly, a very similar pattern of momentum returns is evident between the optioned stocks sample and the nearest neighbours' sample, which clearly suggests that short sales constraints are not a major driver of momentum profitability. In further analysis it is also shown that adjustments for risk cannot rationalise the profitability of momentum strategies. Thus, taking account of three of the arguments which have been put forward to try to rationalise momentum profits (information scarcity, short sales constraints and risk) does not lead to the elimination of such profits.

Consideration is finally given to the issue of transaction costs using two approaches: the (historical) quoted spread estimate and actual bid and ask prices at execution of trades. Overall, the evidence suggests that once these costs are taken into account, momentum profitability largely disappears for the sample in this study. However, using execution time bid and ask prices, we show that significant momentum profits persist only over 6 month holding periods for optioned sample stocks and highest turnover stocks. This suggests that these costs could be offset if the holding period is extended to allow for profits to accumulate over a period of time. It is also apparent that the quoted spread used in previous literature overestimates the true costs imposed by the bid-ask spread.

The evidence in this paper makes an important contribution to our understanding of the sources of apparent momentum profitability. Through the choice of a carefully selected sample we have been able to distinguish between different possible causes of momentum returns. It is seen that for the highly liquid, high market value stocks in the sample, short sales constraints are not a primary cause of momentum strategy profitability. While transactions costs are important, they cannot fully explain momentum profits. The robustness of some momentum profits after controlling for the various known market frictions indicates that the market underreacts even to the most publicly available information. Given the earlier evidence in previous literature that momentum profits are not robust to trading costs, the findings in this paper are of considerable interest to both the academic world and to the industry.

References:

Agyei-Ampomah, S., 2007. The post-cost profitability of momentum trading strategies: Further evidence from the UK. European Financial Management 13, 776–802.

Ali, A., Trombley, M.A., 2006. Short sales constraints and momentum in stock returns. Journal of Business Finance and Accounting 33, 587–615.

Amihud, Y., Mendelson, H., 1986. Asset pricing and the bid–ask spread. Journal of Financial Economics 17, 223–249.

Antoniou, A., Holmes, P., 1995. Futures trading, information and spot price volatility: Evidence for the FTSE-100 stock index futures contract using GARCH. Journal of Banking and Finance 19, 117–129.

Antoniou, A., Koutmos, G., Pericli, A., 2005. Index futures and positive feedback trading: Evidence from major stock exchanges. Journal of Empirical Finance 12, 219–238.

Asem, E., 2009. Dividends and price momentum. Journal of Banking and Finance 33, 486–494.

Asquith, P., Pathak, P.A., Ritter, J.R., 2005. Short interest, institutional ownership, and stock returns. Journal of Financial Economics 78, 243–276.

Doron, A., Chordia, T., 2006. Asset pricing models and financial market anomalies. The Review of Financial Studies 19, 1001–1040.

Back, K., 1993. Asymmetric information and options. Review of Financial Studies 6, 435–472.

Cao, H.H., Ou-Yang, H., 2009. Differences of opinion of public information and speculative trading in stocks and options. Review of Financial Studies 22, 299–335.

Chan, L.K.C., Jegadeesh, N., Lakonishok, J., 1999. The profitability of momentum strategies. Financial Analyst Journal 55, 80–90.

Chang, E.C., Cheng, J.W., Yu, Y., 2007. Short-sales constraints and price discovery: Evidence from the Hong Kong market. Journal of Finance 62, 2097–2121.

Chatrath, A., Song, F., 1998. Information and volatility in futures and spot markets: The case of the Japanese yen. Journal of Futures Markets 18, 201–223.

Chau, F., Holmes, P., Paudyal, K., 2008. The impact of universal stock futures on feedback trading and volatility dynamics. Journal of Business Finance and Accounting 35, 227–249.

Chen, Z., Stanzl, W., Watanabe, M., 2002. Price impact costs and the limits of arbitrage. working paper, Yale School of Management.

Chordia, T., Shivakumar, L., 2002. Momentum, business cycle and time-varying expected returns. Journal of Finance 57, 985–1019.

Chordia, T. and Shivakumar, L., 2006, “Earnings and price momentum”, Journal of Financial Economics, 80, 627-656.

Chui, A.C.W., Titman, S., Wei, K.C.J., 2010. Individualism and momentum around the World. Journal of Finance 65, 361–392.

Cooper, M.J., Gutierrez Jr., R.C., Hameed, A., 2004. Market states and momentum. Journal of Finance 59, 1345–1365.

Cox, C.C., 1976. Futures trading and market information. Journal of Political Economy 84, 1215–1237.

Damodaran, A., Lim, J., 1991. The effects of option listing on the underlying stocks' return processes. Journal of Banking and Finance 15, 647–664.

Ericsson, J., González, A., 2003, “Is momentum due to data-snooping?”, Working paper, Stockholm School of Economics.

Fedenia, M., Grammatikos, T., 1992. Options trading and the bid–ask spread of the underlying stocks. Journal of Business 65, 335–351.

Figlewski, S., Webb, G.P., 1993. Options, short sales, and market completeness”, Journal of Finance 48, 761–777.

Galariotis, E., Holmes, P., Ma, X.S., 2007. Contrarian and momentum profitability revisited: Evidence from the London Stock Exchange 1964–2005. Journal of Multinational Financial Management 17, 432–447.

Geczy, C.C., Musto, D.K., Reed, A.V., 2002. Stocks are special too: An analysis of the equity lending market. Journal of Financial Economics 66, 241–269.

Griffin, J.M., Ji, X., Martin, J.S., 2003. Momentum investing and business cycle risk: Evidence from pole to pole. Journal of Finance 53, 2515–2547.

Grundy, B.D., Martin, J.S., 2001. Understanding the nature of the risks and the source of the rewards to momentum investing. Review of Financial Studies 14, 29–78.

Gupta, K., Locke, S., Scrimgeour, F., 2010. International comparison of returns from conventional, industrial and 52-week high momentum strategies. International Financial Markets, Institutions and Money 20, 423 – 435.

Hameed, A., Hong, D., Warachka, M., 2008. Momentum and informed trading. Working Paper.

Hart, J.V.D., Slagter, E., Dijk, D.V., 2003. Stock selection strategies in emerging markets. Journal of Empirical Finance 10, 105–132.

Hon, M., Tonks, I., 2003. Momentum in the UK stock market. Journal of Multinational Financial Management 13, 43–70.

Hong, H., Lim, T. and Stein, J., 2000, "Bad news travels slowly: size, analyst coverage, and the profitability of momentum strategies", Journal of Finance 55, 265–295.

Hong, H., and Stein, J., 1999, "A unified theory of underreaction, momentum trading, and overreaction in asset markets", Journal of Finance 54, 2143–2184.

Huang, J., Wang, J., 1997. Market structure, security prices and informational efficiency. Macroeconomic Dynamics 1, 169–205.

George T.J., Hwang C.Y., 2004, "The 52-week high and momentum investing", Journal of Finance, 59, 2145-2176

Jegadeesh, N., Titman, S., 1993. Returns to buying winners and selling losers: Implications for stock market efficiency. Journal of Finance 48, 65–91.

Jegadeesh, N., Titman, S., 1995. Overreaction, delayed reaction, and contrarian profits. Review of Financial Studies 8, 973–993.

Jegadeesh, N., Titman, S., 2001. Profitability of momentum strategies: An evaluation of alternative explanations. Journal of Finance 56, 699–720.

Jennings, R., Starks, L., 1986. Earnings announcements, stock price adjustment, and the existence of option markets. Journal of Finance 41, 107–125.

Korajczyk, R.A., Sadka, R., 2004. Are momentum profits robust to trading costs? Journal of Finance 59, 1039–1082.

Kraus, A., Smith, M., 1996. Heterogeneous beliefs and the effects of replicatable options on asset prices. Review of Financial Studies 8, 723–756.

Kumar, R., Sarin, A., Shastri, K., 1998. The impact of options trading on the market quality of the underlying security: An empirical analysis. Journal of Finance 53, 717–732.

Lesmond, D.A., Schill, M.J., Zhou, C., 2004. The illusory nature of momentum profits. Journal of Financial Economics 71, 349–380.

Li, X., Brooks, C., Miffre, J., 2009. Low-cost momentum strategies. Journal of Asset Management 9, 366–379.

Li, X., Miffre, J., Brooks, C., O'Sullivan, N., 2008. Momentum profits and time-varying unsystematic risk. Journal of Banking and Finance 32, 541–558.

Liu, L.X., Zhang, L., 2008. Momentum profits, factor pricing, and macroeconomic risk. Review of Financial Studies 21, 2417–2448.

Liu, W., Strong, N., Xu, X., 1999. The profitability of momentum investing. Journal of Business Finance and Accounting 26, 1043–1091.

Mayhew, S., Mihov, V., 2004. How do exchanges select stocks for option listing? Journal of Finance 59, 447–471.

Nagel, S., 2005. Short sales, institutional investors and the cross-section of stock returns. Journal of Financial Economics 78, 277–309.

Newey, Whitney K., and Kenneth D. West, 1987, "A simple, positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix", Econometrica 55, 703–708.

Pan, J., Poteshman, A.M., 2006. The information in option volume for future stock prices. Review of Financial Studies 19, 871–908.

Politis, D., Romano, J., 1994, "The stationary bootstrap", Journal of the American Statistical Association, 89, 1303–1313.

Pontiff, Jeffrey, 1996, "Costly arbitrage: Evidence from closed-end funds", Quarterly Journal of Economics 111, 1135-1152.

Rouwenhorst, K.G., 1998. International momentum strategies. Journal of Finance 53, 267–284.

Shleifer, A., and R. Vishny, 1997, "The limits of arbitrage", Journal of Finance 52, 35–55.

Skinner, D.J., 1990. Options markets and the information content of accounting earnings releases. Journal of Accounting and Economics 13, 191–211.

Stein, J., 1987. Informational externalities and welfare-reducing speculation. Journal of Political Economy 95, 1123–1145.

Stoll, H.R., Whaley, R.E., 1983. Transaction costs and the small firm effect. Journal of Financial Economics 12, 57–79.

Verardo, M., 2009. Heterogeneous beliefs and momentum profits. Journal of Financial and Quantitative Analysis 44, 795–822.

Wang, K.Q., 2003. Asset pricing with conditioning information: A new test. Journal of Finance 58, 161–196.

White, H., 2000, "A reality check for data snooping", Econometrica, 68, 1097–1127.

**Table 1**

Descriptive statistics of the Full sample from which sub-samples are drawn

This table reports the statistical properties for the full sample from which sub-samples are drawn for analysis. Panel A displays the number of constituents within the FTSEALL Share incorporated into our full sample during the period 1990–2009. Panel B presents descriptive return statistics for the full sample and size-sorted sub-samples. Returns are continuously compounded, defined as the first difference of the logarithmic price levels. Stocks are assigned to five size-sorted monthly rebalanced sub-samples that contain 20% of firms, based on the previous month-end stock market capitalisation. The 'full sample' category consists of all sample stocks. Panel C reports the Durbin-Watson statistic and the Breusch–Godfrey statistic using one lag.

**Panel A**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **1990** | 685 | **1995** | 904 | **2000** | 815 | **2005** | 707 |
| **1991** | 668 | **1996** | 903 | **2001** | 773 | **2006** | 686 |
| **1992** | 660 | **1997** | 897 | **2002** | 727 | **2007** | 695 |
| **1993** | 807 | **1998** | 897 | **2003** | 703 | **2008** | 675 |
| **1994** | 863 | **1999** | 841 | **2004** | 703 | **2009** | 617 |
| **Mean** | 761 | **Median** | 717 | **Maximum** | 904 | **Minimum** | 617 |

**Panel B**

| | Full sample | Largest | Large | Medium | Small | Smallest |
|---|---|---|---|---|---|---|
| **Mean** | -0.00276 | 0.0062 | 0.0063 | 0.0047 | 0.0013 | -0.0118 |
| **Median** | 0.006586 | 0.0120 | 0.0116 | 0.0088 | 0.0065 | -0.0055 |
| **Maximum** | 0.176908 | 0.1300 | 0.1604 | 0.1659 | 0.2102 | 0.2477 |
| **Minimum** | -0.22844 | -0.1483 | -0.1996 | -0.2055 | -0.2439 | -0.3389 |
| **Std dev** | 0.05463 | 0.0476 | 0.0537 | 0.0544 | 0.0568 | 0.0681 |
| **Skewness** | -0.89308 | -0.5213 | -0.6193 | -0.7519 | -0.7031 | -1.1568 |
| **Kurtosis** | 5.634184 | 3.9348 | 4.6683 | 4.9148 | 5.6855 | 7.1912 |
| **Jarque-Bera** | 101.2933 | 19.611 | 43.177 | 59.280 | 91.894 | 229.193 |

**Panel C**

| | | | | | | |
|---|---|---|---|---|---|---|
| **Durbin Watson** | 1.4690 | 1.8322 | 1.6255 | 1.5323 | 1.4189 | 1.2841 |
| **Breusch–Godfrey Test** | 0.0000 | 0.208 | 0.0039 | 0.0003 | 0.0000 | 0.0000 |

**Table 2**
**Characteristics of the sample of stocks with listed options and the control samples**

This table reports characteristics of the sample of stocks with listed options and the control samples. The sample from which the stocks are drawn to construct the various portfolios is the FTSE All Share. At each month *t*, the universe of stocks is divided into 2 groups: the first group consists of all stocks with options listed on LIFFE for that month; the second group contains all the remaining stocks. Four control samples are also constructed at each month *t* from the second group. Three control samples consist, respectively, of the *n* largest market value (MV) stocks, *n* highest turnover stocks and *n* smallest bid-ask percentage spread (BAPS) stocks, where *n* is the number of stocks within the sample of relevance at month *t*. The fourth control sa7mple consists of the *n* highest propensity scores stocks where propensity score is estimated from a logit model that predicts the nearest *n* neighbour stocks to the stocks with listed options on LIFFE. In the logit model, the stocks belonging to the L portfolio are assigned a value of 1 to their dependent variables, whereas the rest of the stocks are assigned a value of zero to their dependent variables. The logit model employed regresses the dependent variable over a constant and 3 explanatory variables: MV, turnover and BAPS

$$L_i(List) = \alpha_i + \beta_M (MV)_i + \beta_T (T)_i + \beta_B (BAPS)_i + \varepsilon_i$$

The means and (medians) of the market value, turnover and bid-ask percentage spread (BAPS) are estimated for all samples. The sample period starts in January 1990 and ends in October 2009.

| | MV | | Turnover | | Bid-ask percentage spread | |
|---|---|---|---|---|---|---|
| Sample L (stocks with listed options) | 12409.91 | (11996.07) | 0.12417 | (0.10938) | 0.00874 | (0.00937) |
| Control Sample M (largest MV stocks) | 2808.11 | (2511.84) | 0.18954 | (0.09316) | 0.00882 | (0.00894) |
| Control Sample T (highest turnover stocks) | 869.409 | (859.44) | 0.40243 | (0.22936) | 0.01805 | (0.01858) |
| Control Sample B (lowest BAPS) | 1872.59 | (1857.93) | 0.18299 | (0.08534) | 0.00586 | (0.00603) |
| Control Sample P (highest propensity score stocks) | 2402.13 | (2293.86) | 0.15601 | (0.15168) | 0.01057 | (0.00877) |

**Table 3**

**Momentum returns of optioned stocks sample and control samples**

The table reports monthly momentum profits in percentages for strategies with ranking periods *j* of 1,2,3 and 6 months and holding periods *k* of 1,2,3 and 6 months skipping one month between ranking and holding periods. Stocks in the top (bottom) decile/quintile are assigned to the Winner (Loser) portfolio. Within all portfolios, firms are equally weighted. Zero-cost overlapping momentum portfolio is formed by buying Winners and short-selling Losers. The zero-cost momentum portfolio is held for *k* months which allows for *k* positions to be opened at the same month. The sample from which the stocks are drawn to construct the various portfolios is the FTSE All Share. At each month *t*, the universe of stocks is divided into 2 groups: the first group consists of all stocks with options listed on LIFFE for that month; the second group contains all the remaining stocks. L representing the portfolio constructed only from the *n* stocks with options listed on LIFFE at month *t*. M, T, B and P represent portfolios formed of *n* stocks with largest market value (M), highest turnover (T), lowest bid-ask percentage spread (B) and highest propensity score (P), respectively, that don't have options listed on LIFFE at month *t*. M is the market value of the stock at the formation date. T is the total volume of traded shares in the month preceding the formation date divided by the number of outstanding stocks at the formation date. The bid-ask percentage spread (B) is the average of the daily B over the last month prior to the formation date, where the daily B is the spread divided by the midpoint of the bid price and ask price. P, the propensity score, is estimated from a logit model that predicts the nearest *n* neighbour stocks to the stocks with listed options on LIFFE. In the logit model, the stocks belonging to the L portfolio are assigned a value of 1 for the dependent variables, whereas the rest of the stocks are assigned a value of zero. The logit model employed regresses the dependent variable over a constant and 3 explanatory variables: M, T and B

$$L_i(List) = \alpha_i + \beta_M (MV)_i + \beta_T (T)_i + \beta_B (BAPS)_i + \varepsilon_i$$

Finally Panel F presents the F-Test on testing the null hypothesis that the momentum profits of pairs of samples are equal for 4 strategies: 6x1, 6x2, 6x3 and 6x6. The sample period starts on January 1990 and ends on December 2009. Newey-West (HAC) adjusted *t*-statistics are used with overlapping portfolios. †, * and ^ indicates statistical significance at 1%, 5% and 10%, respectively.

**Panel A: Portfolio of stocks with listed options**

| | K | 1 | | | 2 | | | 3 | | | 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| Deciles | 1 | 0.26 | -1.35^ | **1.61†** | $5x10^{-5}$ | -1.23^ | **1.24†** | -0.13 | -1.01 | **0.88*** | -0.18 | -0.93 | **0.75*** |
| | 2 | 0.11 | -1.36^ | **1.47*** | -0.09 | -1.11 | **1.02^** | -0.17 | -0.87 | **0.70** | -0.01 | -0.97 | **0.96*** |
| | 3 | 0.30 | -1.20 | **1.50*** | 0.12 | -1.04 | **1.16^** | 0.18 | -1.04 | **1.22^** | 0.23 | -1.15 | **1.38†** |
| | 6 | 0.47 | -1.41 | **1.88*** | 0.44 | -1.52^ | **1.96*** | 0.33 | -1.53^ | **1.86*** | 0.21 | -1.42^ | **1.63*** |
| Quintiles | 1 | 0.04 | -0.65 | **0.69^** | 0.03 | -0.67 | **0.70*** | -0.03 | -0.52 | **0.49^** | 0.03 | -0.43 | **0.46*** |
| | 2 | 0.25 | -0.51 | **0.76^** | 0.10 | -0.60 | **0.70^** | 0.03 | -0.48 | **0.51** | 0.16 | -0.61 | **0.77*** |
| | 3 | 0.15 | -0.55 | **0.70** | 0.01 | -0.56 | **0.57** | 0.05 | -0.58 | **0.63** | 0.20 | -0.66 | **0.86*** |
| | 6 | 0.37 | -0.90 | **1.26*** | 0.41 | -0.89 | **1.30*** | 0.35 | -0.85 | **1.20*** | 0.27 | -0.85 | **1.12*** |

**Panel B: Portfolio of stocks with largest market value**

| | K | 1 | | | 2 | | | 3 | | | 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| Deciles | 1 | 0.36 | -0.75 | **1.11*** | 0.12 | -0.79 | **0.91*** | 0.09 | -0.65 | **0.74^** | -0.01 | -0.56 | **0.55^** |
| | 2 | 0.18 | -0.83 | **1.01^** | 0.14 | -0.79 | **0.93^** | 0.12 | -0.61 | **0.73** | 8x10$^{-5}$ | -0.67 | **0.68^** |
| | 3 | 0.17 | -0.72 | **0.89** | 0.18 | -0.66 | **0.84** | 0.23 | -0.61 | **0.84^** | -0.08 | -0.68 | **0.60** |
| | 6 | 0.51 | -0.79 | **1.30*** | 0.39 | -0.72 | **1.11*** | 0.16 | -0.70 | **0.86^** | 0.08 | -0.82 | **0.90^** |
| Quintiles | 1 | 0.32 | -0.37 | **0.69*** | 0.20 | -0.33 | **0.53^** | 0.17 | -0.30 | **0.47^** | 0.10 | -030 | **0.40^** |
| | 2 | 0.31 | -0.34 | **0.65** | 0.26 | -0.37 | **0.63** | 0.16 | -0.24 | **0.40** | 0.12 | -0.33 | **0.45** |
| | 3 | 0.41 | -0.50 | **0.91*** | 0.23 | -0.32 | **0.55** | 0.26 | -0.30 | **0.56** | 0.10 | -0.40 | **0.50^** |
| | 6 | 0.29 | -0.53 | **0.82^** | 0.24 | -0.53 | **0.77^** | 0.19 | -0.45 | **0.64** | 0.20 | -0.51 | **0.71^** |

**Panel C: Portfolio of stocks with highest turnover**

| | K | 1 | | | 2 | | | 3 | | | 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| Deciles | 1 | 0.56 | -2.46† | **3.02†** | 0.05 | -2.24* | **2.29†** | -0.15 | -2.36† | **2.21†** | -0.05 | -2.05* | **2.00†** |
| | 2 | 0.93 | -1.98* | **2.91†** | 0.32 | -2.28* | **2.60†** | 0.16 | -2.41† | **2.57†** | 0.16 | -1.91* | **2.07†** |
| | 3 | 1.15^ | -2.59* | **3.74†** | 0.78 | -2.66† | **3.44†** | 0.62 | -2.79† | **3.41†** | 0.41 | -2.27† | **2.68†** |
| | 6 | 1.32* | -2.31* | **3.63†** | 1.11* | -2.54* | **3.65†** | 0.82 | -2.66† | **3.48†** | 0.70 | -2.39* | **3.09†** |
| Quintiles | 1 | 0.42 | -1.10 | **1.52†** | 0.14 | -1.16 | **1.30†** | 0.04 | -1.25^ | **1.29†** | 0.14 | -1.23^ | **1.37†** |
| | 2 | 0.84 | -1.20 | **2.04†** | 0.52 | -1.39^ | **1.91†** | 0.32 | -1.55* | **1.87†** | 0.30 | -1.35^ | **1.65†** |
| | 3 | 0.96^ | -1.66* | **2.62†** | 0.67 | -1.74* | **2.41†** | 0.51 | -1.91* | **2.42†** | 0.45 | -1.64* | **2.09†** |
| | 6 | 1.03* | -1.72* | **2.75†** | 0.85^ | -1.85* | **2.70†** | 0.73 | -2.06* | **2.79†** | 0.69 | -1.85* | **2.54†** |

**Panel D: Portfolio of stocks with minimal percentage spread**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| Deciles | 1 | 0.67 | 0.20 | **0.47** | 0.46 | 0.03 | **0.43** | 0.54 | 0.03 | **0.51^** | 0.38 | -0.08 | **0.46^** |
| | 2 | 0.57 | -0.15 | **0.72^** | 0.48 | -0.18 | **0.66^** | 0.48 | -0.09 | **0.57^** | 0.34 | -0.21 | **0.55^** |
| | 3 | 0.47 | 0.01 | **0.46** | 0.53 | -0.07 | **0.60** | 0.60 | -0.08 | **0.68^** | 0.36 | -0.21 | **0.57** |
| | 6 | 0.61* | -0.12 | **0.73*** | 0.53 | -0.35 | **0.88^** | 0.50 | -0.29 | **0.79^** | 0.40 | -0.38 | **0.78^** |
| Quintiles | 1 | 0.37 | 0.21 | **0.16** | 0.31 | 0.14 | **0.17** | 0.39 | 0.14 | **0.25** | 0.33 | $-4\times10^{-6}$ | **0.33^** |
| | 2 | 0.62^ | 0.09 | **0.53^** | 0.49 | 0.08 | **0.41** | 0.50 | 0.14 | **0.36** | 0.39 | -0.02 | **0.41^** |
| | 3 | 0.45 | $5\times10^{-5}$ | **0.44** | 0.44 | -0.04 | **0.48** | 0.51 | -0.02 | **0.53^** | 0.37 | -0.12 | **0.49^** |
| | 6 | 0.52 | -0.02 | **0.54** | 0.49 | -0.20 | **0.69*** | 0.49 | -0.12 | **0.61^** | 0.43 | -0.19 | **0.62^** |

**Panel E: Portfolio of stocks with highest propensity score from the Logit model**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| Deciles | 1 | 0.77 | -0.70 | **1.47*** | 0.50 | -0.79 | **1.29*** | 0.50 | -0.72 | **1.22†** | 0.28 | -0.59 | **0.87*** |
| | 2 | 0.70 | -0.72 | **1.42*** | 0.58 | -0.96 | **1.54*** | 0.61 | -1.01 | **1.62†** | 0.42 | -0.80 | **1.22*** |
| | 3 | 0.76 | -1.01 | **1.77*** | 0.73 | -1.04 | **1.77†** | 0.69 | -1.07 | **1.76†** | 0.33 | -0.80 | **1.13*** |
| | 6 | 1.06* | -1.31 | **2.37†** | 0.97* | -1.39 | **2.36†** | 0.71 | -1.34 | **2.05†** | 0.51 | -1.06 | **1.57*** |
| Quintiles | 1 | 0.60 | -0.55 | **1.15†** | 0.38 | -0.48 | **0.86*** | 0.45 | -0.43 | **0.88†** | 0.33 | -0.34 | **0.67*** |
| | 2 | 0.62 | -0.48 | **1.10*** | 0.60 | -0.52 | **1.12*** | 0.55 | -0.48 | **1.03*** | 0.41 | -0.41 | **0.82*** |
| | 3 | 0.75 | -0.82 | **1.57†** | 0.63 | -0.73 | **1.36†** | 0.63 | -0.64 | **1.27†** | 0.37 | -0.53 | **0.90*** |
| | 6 | 0.91* | -1.05 | **1.96†** | 0.75^ | -1.08 | **1.83†** | 0.62 | -0.92 | **1.54†** | 0.51 | -0.82 | **1.33†** |

**Panel F: F-Test testing the equality of momentum returns in pairs of samples**

| | Sample L and Sample M | | Sample L and Sample T | | Sample L and Sample B | | Sample L and Sample P | |
|---|---|---|---|---|---|---|---|---|
| *JxK* | 2x3 | **0.00** | 2x3 | **4.68*** | 2x3 | **0.06** | 2x3 | **1.47** |
| | 3x3 | **0.29** | 3x3 | **4.94*** | 3x3 | **0.62** | 3x3 | **0.38** |
| | 6x3 | **1.60** | 6x3 | **2.21** | 6x3 | **1.90** | 6x3 | **0.02** |

**Table 4**

**Fama-French alphas for momentum returns for the five samples**

This table reports the alphas (intercepts) in percentages after adjusting momentum profits for the Fama-French three factor model for strategies with ranking periods *j* of 1,2,3 and 6 months and holding periods *k* of 1,2,3 and 6 months skipping one month between ranking and holding periods. Stocks in the top (bottom) decile/quintile are assigned to the Winner (Loser) portfolio. Within all portfolios, firms are equally weighted. A zero-cost momentum portfolio is formed by buying Winners and short-selling Losers. The zero-cost momentum portfolio is held for *k* months. The sample from which the stocks are drawn to construct the various portfolios is the FTSE All Share. At each month *t*, the universe of stocks is divided into 2 groups: the first group consists of all stocks with options listed on LIFFE for that month; the second group contains all the remaining stocks. L representing the portfolio constructed only from the *n* stocks with options listed on LIFFE at month *t*. M, T, B and P represent portfolios formed of *n* stocks with largest market value (M), highest turnover (T), lowest bid-ask percentage spread (B) and highest propensity score (P), respectively, that don't have options listed on LIFFE at month *t*. M is the market value of the stock at the formation date. T is the total volume of traded shares in the month preceding the formation date divided by the number of outstanding stocks at the formation date. The bid-ask percentage spread (B) is the average of the daily B over the last month prior to the formation date, where the daily B is the spread divided by the midpoint of the bid price and ask price. P, the propensity score, is estimated from a logit model that predicts the nearest *n* neighbour stocks to the stocks with listed options on LIFFE. In the logit model, the stocks belonging to the L portfolio are assigned a value of 1 for the dependent variables, whereas the rest of the stocks are assigned a value of zero. The logit model employed regresses the dependent variable over a constant and 3 explanatory variables: M, T and B

$$L_i\left(List\right)_i = \alpha_i + \beta_M (MV)_i + \beta_T (T)_i + \beta_B (BAPS)_i + \varepsilon_i$$

The sample period starts on January 1990 and ends on December 2009. Newey-West (HAC) adjusted *t*-statistics are used with overlapping portfolios. †, * and ^ indicates statistical significance at 1%, 5% and 10%, respectively.

| | | **Decile** | | **Panel A: Sample L** | | | **Quintile** | |
|---|---|---|---|---|---|---|---|---|
| ***j*** | ***k* = 1** | ***k* = 2** | ***k* = 3** | ***k* = 6** | ***k* = 1** | ***k* = 2** | ***k* = 3** | ***k* = 6** |
| **1** | 1.56† | 1.19† | 0.84* | 0.72* | 0.66^ | 0.65* | 0.47^ | 0.46* |
| **2** | 1.42* | 0.99^ | 0.68 | 0.95* | 0.72^ | 0.66^ | 0.49 | 0.75* |
| **3** | 1.41* | 1.1^ | 1.17^ | 1.35† | 0.66 | 0.53 | 0.59 | 0.85* |
| **6** | 1.79* | 1.88* | 1.81* | 1.60* | 1.23* | 1.28* | 1.19* | 1.12* |
| | | | | **Panel B: Sample M** | | | | |
| **1** | 1.10* | 0.90* | 0.74^ | 0.55^ | 0.69* | 0.52^ | 0.47^ | 0.42* |
| **2** | 1.00^ | 0.92^ | 0.72 | 0.69^ | 0.64 | 0.62 | 0.4 | 0.46^ |
| **3** | 0.89 | 0.83 | 0.84^ | 0.61 | 0.89* | 0.54 | 0.57 | 0.51^ |
| **6** | 1.32* | 1.12* | 0.88^ | 0.94^ | 0.82^ | 0.776 | 0.65^ | 0.74^ |
| | | | | **Panel C: Sample T** | | | | |
| **1** | 3.07† | 2.29† | 2.19† | 2.02† | 1.55† | 1.28† | 1.27† | 1.37† |
| **2** | 2.94† | 2.56† | 2.53† | 2.08† | 2.01† | 1.87† | 1.83† | 1.63† |
| **3** | 3.65† | 3.35† | 3.34† | 2.69† | 2.58† | 2.35† | 2.38† | 2.10† |
| **6** | 3.63† | 3.6† | 3.46† | 3.12† | 2.71† | 2.66† | 2.76† | 2.54† |
| | | | | **Panel D: Sample B** | | | | |
| **1** | 0.52 | 0.42 | 0.50^ | 0.47* | 0.18 | 0.17 | 0.26 | 0.35* |
| **2** | 0.74^ | 0.66^ | 0.56^ | 0.58^ | 0.54^ | 0.41 | 0.36 | 0.44^ |
| **3** | 0.44 | 0.59 | 0.67^ | 0.60^ | 0.43 | 0.47 | 0.53^ | 0.52^ |
| **6** | 0.78^ | 0.93* | 0.82^ | 0.84* | 0.56 | 0.73* | 0.65^ | 0.67* |
| | | | | **Panel E: Sample P** | | | | |
| **1** | 1.50* | 1.28* | 1.21† | 0.88† | 1.17† | 0.85* | 0.88† | 0.68* |
| **2** | 1.40* | 1.51* | 1.59† | 1.23† | 1.10* | 1.11† | 1.03† | 0.84* |
| **3** | 1.75* | 1.76† | 1.74† | 1.16* | 1.56† | 1.35† | 1.27† | 0.92* |
| **6** | 2.38† | 2.36† | 2.05† | 1.62† | 1.98† | 1.84† | 1.55† | 1.37† |

**Table 5**

**Momentum Profits after adjusting for the quoted spread estimate**

The table reports momentum profits in percentages for strategies with ranking periods *j* of 1,2,3 and 6 months and holding periods *k* of 1,2,3 and 6 months skipping one month between ranking and holding periods after adjusting for trading costs using the quoted bid-ask spread measure. Stocks in the top decile are assigned to the Winners portfolio, and those in the lowest decile to the Losers portfolio. Within all portfolios, firms are equally weighted. A zero-cost momentum portfolio is formed by buying Winners and short-selling Losers. The quoted bid ask spread is estimated for each individual stock and then subtracted from the stock's return if the stock belongs to the winner portfolio, or added to the stock's return if the stock belongs to the loser portfolio. The sample from which the stocks are drawn to construct the various portfolios is the FTSE All Share. Samples L, M, T, B and P are as defined previously. The sample period starts in January 1990 and ends in October 2009. Newey-West (HAC) adjusted *t*-statistics are used with overlapping portfolios. Panel F reports the quoted spread of the winner and loser portfolios (x $10^4$). The subscripts †, *, and ^ denote statistical significance at 1%, 5%, and 10% respectively.

**Panel A: Portfolio of stocks with listed options**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -0.75 | 0.39 | **-1.14*** | -1.00* | 0.50 | **-1.50†** | -1.14* | 0.72 | **-1.86†** | -1.19† | 0.81 | **-2.00†** |
| | 2 | -0.86^ | 0.54 | **-1.40*** | -1.07* | 0.78 | **-1.85†** | -1.14* | 1.02 | **-2.16†** | -0.99* | 0.92 | **-1.91†** |
| Deciles | 3 | -0.80 | 0.82 | **-1.62*** | -0.98* | 0.98 | **-1.96†** | -0.92* | 0.99 | **-1.91†** | -0.87* | 0.87 | **-1.74†** |
| | 6 | -0.37 | 0.90 | **-1.27** | -0.40 | 0.79 | **-1.19** | -0.50 | 0.78 | **-1.28** | -0.63 | 0.89 | **-1.52*** |

**Panel B: Portfolio of stocks with largest MV**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -0.58 | 0.31 | **-0.89^** | -0.82^ | 0.26 | **-1.08*** | -0.84 | 0.41 | **-1.25†** | -0.95 | 0.50 | **-1.45†** |
| | 2 | -0.78 | 0.22 | **-1.00^** | -0.83 | 0.25 | **-1.08^** | -0.84^ | 0.44 | **-1.28*** | -0.96* | 0.38 | **-1.34†** |
| Deciles | 3 | -0.78 | 0.33 | **-1.11** | -0.77 | 0.39 | **-1.16^** | -0.72 | 0.44 | **-1.16*** | -1.03* | 0.38 | **-1.41†** |
| | 6 | -0.46 | 0.28 | **-0.74** | -0.58 | 0.35 | **-0.93^** | -0.82^ | 0.37 | **-1.19*** | -0.90^ | 0.25 | **-1.15*** |

**Panel C: Portfolio of stocks with highest turnover**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -1.39^ | 1.05 | **-2.44†** | -1.90† | 1.27 | **-3.17†** | -2.10† | 1.15 | **-3.25†** | -2.00 | 1.46^ | **-3.46†** |
| | 2 | -0.92 | 1.58 | **-2.50†** | -1.53† | 1.29 | **-2.82†** | -1.69† | 1.15 | **-2.84†** | -1.69† | 1.65^ | **-3.34†** |
| Deciles | 3 | -0.55 | 1.22 | **-1.77^** | -0.92 | 1.15 | **-2.07*** | -1.09* | 1.01 | **2.10*** | -1.29† | 1.53^ | **-2.82†** |
| | 6 | -0.24 | 1.81^ | **-2.05*** | -0.45 | 1.58 | **-2.03*** | -0.74 | 1.46 | **-2.20*** | -0.86^ | 1.73^ | **-2.59†** |

**Panel D: Portfolio of stocks with lowest BAPS**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | 0.08 | 0.80^ | **-0.72^** | -0.13 | 0.63 | **-0.76*** | -0.05 | 0.63 | **-0.68*** | -0.20 | 0.52 | **-0.72†** |
| | 2 | -0.02 | 0.44 | **-0.46** | -0.10 | 0.42 | **-0.52** | -0.10 | 0.50 | **-0.60^** | -0.24 | 0.37 | **-0.61^** |
| Deciles | 3 | -0.11 | 0.61 | **-0.72^** | -0.05 | 0.52 | **-0.57** | 0.02 | -0.51 | **-0.49** | -0.22 | 0.38 | **-0.60** |
| | 6 | 0.03 | 0.48 | **-0.45** | -0.05 | 0.24 | **-0.29** | -0.08 | 0.30 | **-0.38** | -0.18 | 0.21 | **-0.39** |

**Panel E: Portfolio of stocks with the highest propensity score**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -0.47 | 1.05 | **-1.52*** | -0.74 | 0.96 | **-1.70†** | -0.73 | 1.04^ | **-1.77†** | -0.91^ | 1.08^ | **-1.99†** |
| | 2 | -0.40 | 1.14^ | **-1.54*** | -0.52 | 0.90 | **-1.42*** | -0.48 | 0.86 | **-1.34*** | -0.63 | 0.97 | **-1.60†** |
| Deciles | 3 | -0.28 | 0.89 | **-1.17^** | -0.31 | 0.87 | **-1.18^** | -0.35 | 0.84 | **-1.19*** | -0.68 | 1.01 | **-1.69†** |
| | 6 | 0.11 | 0.70 | **-0.59** | 0.02 | 0.61 | **-0.59** | -0.24 | 0.67 | **-0.91** | -0.44 | 0.85 | **-1.29*** |

**Panel F: quoted spread costs of winner and loser portfolios**

| | **Sample L** | | **Sample M** | | **Sample T** | | **Sample B** | | **Sample P** | |
|---|---|---|---|---|---|---|---|---|---|---|
| J | **W** | **L** | **W** | **L** | **W** | **L** | **W** | **L** | **W** | **L** |
| 1 | 1.0086 | 1.7372 | 0.9385 | 1.0558 | 1.9483 | 3.5126 | 0.5927 | 0.5983 | 1.2386 | 1.7557 |
| 2 | 0.9754 | 1.8966 | 0.9665 | 1.0506 | 1.8531 | 3.5625 | 0.5874 | 0.5930 | 1.0954 | 1.8639 |
| 3 | 1.1015 | 2.0228 | 0.9529 | 1.0537 | 1.7047 | 3.8029 | 0.5852 | 0.5948 | 1.0468 | 1.9081 |
| 6 | 0.8380 | 2.3093 | 0.9728 | 1.0755 | 1.5613 | 4.1200 | 0.5815 | 0.5953 | 0.9481 | 2.0088 |

**Table 6**

**Momentum Profits after adjusting for Bid-Ask quotes at execution time**

The table reports momentum profits in percentages for strategies with ranking periods *j* of 1,2,3 and 6 months and holding periods *k* of 1,2,3 and 6 months skipping one month between ranking and holding periods using the Bid and Ask prices at the date of executing the order. Stocks in the top (bottom) decile are assigned to the Winner (loser) portfolio. Within all portfolios, firms are equally weighted. A zero-cost momentum portfolio is formed by buying Winners and short-selling Losers. The price to buy (short sell) Winners (Losers) at the beginning of the holding period is the Daily Closing Ask (Bid) price, whereas the price to sell (buy) Winners (Losers) at the end of the holding period is the Daily Closing Bid (Ask) price at that day of liquidation. If there was no trading in the market on the first day of the month then the nearest trading day is used to replace the non-trading day starting with the next trading day. The sample from which the stocks are drawn to construct the various portfolios is the FTSE All Share. Samples L, M, T, B and P are as defined previously. The sample period starts in January 1990 and ends in October 2009. Newey-West (HAC) adjusted *t*-statistics are used with overlapping portfolios. The subscripts †, *, and ^ denote statistical significance at 1%, 5%, and 10% respectively.

**Panel A: Sample L**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -1.13* | 0.35 | **-1.48*** | -0.74 | -0.49 | **-0.25** | -0.63 | -0.61 | **-0.02** | -0.47 | -0.80 | **0.33** |
| | 2 | -1.01* | 0.73 | **-1.74†** | -0.66 | -0.19 | **-0.47** | -0.45 | -0.37 | **-0.08** | -0.13 | -0.83 | **0.70** |
| Deciles | 3 | -0.78 | 0.68 | **-1.46*** | -0.39 | -0.16 | **-0.23** | -0.10 | -0.49 | **0.39** | 0.13 | -1.00 | **1.13*** |
| | 6 | -0.47 | 0.88 | **-1.35^** | 0.08 | -0.45 | **0.53** | 0.18 | -0.91 | **1.09** | 0.15 | -1.27 | **1.42^** |

**Panel B: Sample M**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -0.65 | 0.34 | **-0.99** | -0.38 | -0.23 | **-0.15** | -0.20 | -0.21 | **0.01** | -0.17 | -0.40 | **0.23** |
| | 2 | -0.83 | 0.21 | **-1.04^** | -0.38 | -0.21 | **-0.17** | -0.18 | -0.23 | **0.05** | -0.15 | -0.54 | **0.39** |
| Deciles | 3 | -0.75 | 0.39 | **-1.14^** | -0.26 | -0.11 | **-0.15** | -0.02 | -0.22 | **0.20** | -0.23 | -0.54 | **0.31** |
| | 6 | -0.52 | 0.40 | **-0.92** | -0.05 | -0.13 | **0.08** | -0.13 | -0.35 | **0.22** | -0.07 | -0.67 | **0.60** |

**Panel C: Sample T**

| | K | | 1 | | | 2 | | | 3 | | | 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -1.61* | 1.16 | **-2.77†** | -1.05 | -0.50 | **-0.55** | -0.94 | -1.08 | **0.14** | -0.55 | -1.45^ | **0.90^** |
| | 2 | -1.14^ | 1.73^ | **-2.87†** | -0.58 | -0.38 | **-0.20** | -0.45 | -1.14 | **0.69** | -0.22 | -1.35 | **1.13^** |
| Deciles | 3 | -0.62 | 1.64^ | **-2.26*** | $-9\times10^{-3}$ | -0.63 | **0.62** | 0.11 | -1.38 | **1.49^** | 0.19 | -1.62^ | **1.81†** |
| | 6 | -0.28 | 2.02* | **-2.30*** | 0.30 | -0.37 | **0.67** | 0.31 | -1.35 | **1.66^** | 0.46 | -1.85^ | **2.31†** |

**Panel D: Sample B**

| | K | 1 | | | 2 | | | 3 | | | 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -0.21 | 0.92 | **-1.13†** | -0.03 | 0.39 | **-0.42** | 0.23 | 0.22 | **$2x10^{-3}$** | 0.16 | 0.01 | **0.15** |
| | 2 | -0.30 | 0.55 | **-0.85*** | $3x10^{-4}$ | 0.17 | **-0.17** | 0.17 | 0.12 | **0.05** | 0.14 | -0.13 | **0.27** |
| Deciles | 3 | -0.33 | 0.70 | **-1.03*** | 0.14 | 0.29 | **-0.15** | 0.32 | 0.11 | **0.21** | 0.17 | -0.15 | **0.32** |
| | 6 | -0.28 | 0.57 | **-0.85^** | 0.06 | -0.01 | **0.07** | 0.18 | -0.12 | **0.30** | 0.24 | -0.36 | **0.60** |

**Panel E: Sample P**

| | K | 1 | | | 2 | | | 3 | | | 6 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | J | W | L | **M** | W | L | **M** | W | L | **M** | W | L | **M** |
| | 1 | -0.78 | 1.28^ | **-2.06*** | -0.28 | 0.22 | **-0.50** | 0.05 | -0.08 | **0.13** | $2x10^{-3}$ | -0.21 | **0.21** |
| | 2 | -0.66 | 1.53* | **-2.19*** | -0.17 | 0.13 | **-0.30** | 0.17 | -0.28 | **0.45** | 0.15 | -0.45 | **0.60** |
| Deciles | 3 | -0.46 | 1.46^ | **-1.92*** | 0.12 | 0.17 | **-0.05** | 0.32 | -0.32 | **0.64** | 0.13 | -0.51 | **0.64** |
| | 6 | -0.08 | 1.37^ | **-1.45^** | 0.38 | -0.11 | **0.49** | 0.33 | -0.51 | **0.84** | 0.27 | -0.59 | **0.87** |

**Figure 1**
**Momentum Returns by event month**

The figure shows the momentum returns for each event month over a 1-year period for decile portfolios for sample L. The four graph lines displayed represent four momentum return series with different formation periods (1, 2, 3 and 6 months formation periods). These returns are not cumulative, but rather reflect the performance of four momentum strategies at each event month.