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ON THE PROFITABILITY OF VOLUME-AUGMENTED MOMENTUM TRADING STRATEGIES: EVIDENCE FROM THE UK

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Abstract

This paper investigates whether returns from momentum trading strategies could be enhanced by incorporating information on trading volume. Our results show that price momentum and trading volume individually and jointly predict future returns. We find that a volume-augmented momentum strategy appears more profitable than a pure price momentum strategy. However, the most profitable volume-augmented momentum strategy in this study involves buying high turnover winners and selling low turnover losers, contrary to the findings of earlier US studies. Moreover, accounting for transaction costs the optimal strategy is profitable and realisable only if there are no short selling constraints as the bulk of the profits are generated by short selling the low volume loser portfolio.

Key words: Momentum strategy, overreaction, trading volume, transaction cost.
JEL Classifications: G10, G11, G14.

1. Introduction

Recent studies on momentum strategies provide evidence that buying previously winning stocks and selling previously losing stocks are profitable strategies in many markets. For the US market, Jegadeesh and Titman (1993, 2001) and Chan, Jegadeesh and Lakonishok (1999), among others, report that a zero-cost arbitrage strategy of buying past winners and selling past losers generate significant positive returns over a period of 3 to 12 months. For the UK market, Liu, Strong and Xu (1999) and Hon and Tonks (2003) provide evidence on the profitability of momentum trading. Rouwenhorst (1998, 1999), in a study of European and emerging market stocks, also report strong momentum premium in the returns of international stocks. Similar momentum returns have also been reported in Asian markets (Chui, Titman and Wei, 2000) and the German market (Schiereck, DeBondt and Weber, 1999). Rachev et al. (2004) also examine a variant of the momentum strategy where stocks are ranked based on their risk-adjusted returns instead of total returns. They find that momentum portfolios formed on the basis of past total returns outperform momentum portfolios formed on the basis of risk-adjusted returns, but with higher risk.

Regardless of the evidence on momentum returns in different markets, there is no consensus on the sources of its existence and why the momentum strategy works. Up till now it has not been easy to explain the momentum premium within a rational asset pricing framework. For example, Conrad and Kaul (1998), suggest that the higher return may be due to cross-sectional variation in the average returns of individual securities. Hence, the momentum premium could be a compensation for higher risk levels. However, Grundy and Martin (2001) and Griffin, Ji and Martin (2003) find quite the opposite. They show that stocks in the momentum portfolio appear to have lower risk but not higher risk. Other studies investigating the effect of common market risk factors on momentum returns also fail to fully explain the higher returns generated by the momentum strategies. See for example, Jegadeesh and Titman (2001, 2002), Liu, Strong and Xu (1999) and Fama and French (1996). Indeed, in the absence of any risk-based or rational explanations, the persistence of significant momentum returns is inconsistent with market efficiency.

As an alternative to the risk-based explanations, others focus on seemingly market irrationality, or biases in the way new information is impounded into prices, to explain the momentum premium. Cognitive biases such as conservatism, overconfidence, representativeness and self-

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attribution have all been used to explain short-term momentum and the subsequent reversal in the long term. The literature on behavioural explanations includes the models of Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), Hong and Stein (1999), Barberis and Shleifer (2003). For example, Daniel, Hirshleifer, and Subrahmanyam (1998) argue that biased self-attribution, where investors attribute good performances to skill and blame others for bad performances (e.g. bad luck), causes a delayed market overreaction. These behavioural models suggest that the momentum phenomenon is the result of short-term underreaction to news and long-term overreaction as investors become overconfident in their beliefs of the future prospects of the stock following the initial news.

Other recent papers have also examined the interaction between momentum returns and other market variables. For example, Lee and Swaminathan (2000) demonstrate that information contained in trading volume can be useful in predicting the magnitude and persistence of price momentum returns. They argue that trading volume serves as a proxy for investor misperception of future earnings, as analyst forecasts for high volume stocks tend to be overly optimistic compared to low volume stocks. Consequently, momentum reversals would be more associated with high (low) volume winners (losers) than low (high) volume winners (losers). Using data from the US market, they find that momentum returns are more pronounced among high-volume stocks than among low-volume stocks and that conditional on past returns, low-volume stocks outperform high-volume stocks. An implication of this study is that investors can create a stronger momentum portfolio by using trading volume information to separate strong performers from eventual underperformers.

The volume-augmented momentum strategy has also been examined for the German market (Glaser and Weber, 2003) and six Asian markets (Hameed and Kusnadi, 2002). Hameed and Kusnadi (2002) show that momentum strategies (including the volume-augmented strategy) fail to generate significant returns in the majority of the markets they study. Indeed, they find profitable momentum returns among only the high-volume stocks but in only two out of the six markets. On the other hand, Glaser and Weber (2003) find significant momentum returns for the German market and that the momentum strategy is more profitable among high-volume stocks. However, contrary to the findings of Lee and Swaminathan (2000) regarding high-volume losers driving the momentum results, they find that the significant momentum returns for the German market are driven by high volume winners. These results suggest that the evidence, hitherto, on the profitability of the volume-augmented strategy is market-dependent. Consequently, further work on the profitability of this strategy in other markets would be of interest.

In this paper, we examine the profitability of the volume-augmented momentum strategy for the UK market over the period of 1988-2005. Among other things, we also examine the impact of portfolio turnover on the profitability of the strategy. The paper, therefore, contributes to the literature by providing out-of-sample evidence in terms of a different market and time period, which includes the recent general decline in stock markets. It is usually argued that the apparent evidence of stock market anomalies may simply be the result of data snooping; hence such findings may be sample or methodologically dependent. Indeed, Hon and Tonks (2003) show that, over the period from 1955 to 1996, momentum is only profitable in the period between 1976 and 1996 for the UK market, whilst Dawson and Steeley (2003), in their study on technical patterns in the UK market, report that UK stocks are less influenced by technical patterns compared to US stocks. Thus, empirical findings in one market may not necessarily hold across all markets or time periods.

As a first step, we investigate the profitability of the pure momentum strategies for the years 1988 to 2005. We then examine the volume-augmented momentum strategy over the same period. The results for the pure momentum strategy exhibit a significant outperformance of the winner portfolio over the loser portfolio in virtually all cases over all combinations of ranking periods and holding periods. Consistent with the literature, we find evidence of significant short- to medium-term momentum returns followed by return reversals in the longer run. The results for the volume-augmented strategy also confirm earlier US studies that momentum returns can be enhanced by incorporating volume information in the momentum strategy. However, we find that high volume stocks consistently outperform low volume stocks, contrary to the findings of Lee

and Swaminathan (2000). Furthermore, we find that the "late-stage" momentum strategy (buying high volume winners and selling low volume losers) yields higher returns than the early-stage momentum strategy (buying low volume winners and selling high volume losers) but the returns are driven largely by the loser portfolio. We also provide evidence of significant portfolio turnover associated with the strategies that can lead to substantial transaction costs.

The remainder of the paper is structured as follows. In Section 2 we present the data and the methodology used in this study. Section 3 presents the results of the basic momentum and the volume-augmented momentum analysis, whilst section 4 concludes.

2. Data and Methodology

Our sample consists of UK listed firms that traded on the London Stock exchange between January 1988 and December 2005 with available data on Datastream. Consequently, our period of study overlaps some earlier UK studies on momentum trading strategies. Our sample period starts in 1988 because trading volume data is not available in the earlier years. The sample includes both 'dead' and surviving companies but we exclude investment trusts, unit trusts, warrants, foreign stocks and ADRs from this analysis. The number of stocks in the sample in each year varies from 250 in 1988 to 1620 in 2005 with an average of 1050 stocks per month.

For each stock in the sample, we collect information on monthly returns and monthly turnover. Monthly turnover is calculated as number of shares traded in the month divided by the total number of shares outstanding at the end of the month. Where the strategy requires a multiple sort, for example sorting by returns and then by trading volume, only stocks that have available data for both variables are used. Our methodology follows the methods used by previous researchers such as Jegadeesh and Titman (1993) and Lee and Swaminathan (2000). Portfolios are formed basing on relevant past information and their performance measured over some holding period. The portfolio formation procedures are described in detail in the sections below.

2.1. Portfolio Formation

2.1.1. Pure Momentum Strategy

The methodology adopted for the pure momentum analysis follows Jegadeesh and Titman (1993). Each month, stocks in the sample were ranked based on their performance over the past J months (J = 3, 6, 9 and 12) and assigned to one of 10 decile portfolios. Stocks in the top decile were assigned to portfolio P1 (Winners) whilst stocks in the bottom decile were assigned to portfolio P10 (Losers) with intermediate deciles labelled P2-P9 accordingly. The performance of each portfolio and the zero-cost "winner minus loser" (W-L) portfolio is evaluated over various holding periods ranging from 3 months to 60 months[1]. Where a stock ceases to exist during the holding period, the month on month returns for the remaining months were deemed to be zero. In accordance with Jegadeesh and Titman (1993), the portfolio returns were calculated on an overlapping holding period basis[2]. Accordingly, the winner portfolio at time t based on the previous 3 months return consists of stocks from the best performing decile at month t_{-3}, the best performing stocks at t_{-2} as well as the winning stocks at t_{-1}. For example, a September winner portfolio return is calculated as a third of the returns of the winner stocks based on the rankings in August, a third of the returns of the winner stocks based on the rankings in July and a third of the returns of the winner stocks based on the rankings in June. Thus, a third of the stocks in that portfolio will change each month, with the rest being carried over from the previous month.

[1] The "winner minus loser" portfolio is the zero-net investment strategy of buying the winner (P1) portfolio and selling the loser (P10) portfolio.

[2] We use overlapping portfolio returns in order to increase the power of the statistical tests. Although, we do not analyse non-overlapping returns Hon and Tonks (2003) obtain similar conclusions using non-overlapping and overlapping returns.

2.1.2. Volume-Augmented Momentum Analysis

For the volume-augmented momentum analysis, the methodology is similar to Lee and Swaminathan (2000). Each month, stocks in the sample were ranked based on their average monthly returns over the past J months (J = 3, 6, 9 and 12) and assigned to one of ten portfolios. The same set of stocks were independently sorted into three portfolios, labelled V1, V2 and V3, based on the average monthly turnover over the previous J months. V1 is the high volume portfolio consisting of stocks in the top 30th percentile, whilst V3 is the low volume portfolio consisting of stocks in the bottom 30th percentile. V2 consists of stocks in the middle 40%. As in Lee and Swaminathan (2000), we use turnover instead of the value of stocks traded as the measure of trading volume. This ensures that the high volume portfolio does not necessarily contain stocks with high market capitalisation, which by their nature are likely to be more heavily traded. The two independent sorts thus yield 30 volume/momentum portfolios. The performance of each portfolio is assessed over the subsequent K month holding periods, where K equals 3, 6, 9, or 12 month duration.

3. Results

3.1. Returns on Pure Momentum Portfolios

Table 1 presents the average monthly returns to the pure momentum strategies for the various ranking and holding periods. For each ranking and holding period, we report the average monthly equally-weighted returns to the P1 (winners) portfolio, the P10 (losers) portfolio, an intermediate portfolio P5 and the winner minus loser (W-L) portfolio for the entire sample period, 1988-2005, and two sub-periods, 1988-1997 and 1998-2005. The table also shows the average monthly return and the average monthly trading volume (turnover) of the portfolios during the ranking periods. Over the entire sample period, the winner portfolio generates the highest returns whilst the loser portfolio yields the lowest returns. For example, for the case of J=6 and K=6, the returns from holding the winner portfolio averaged 0.65% per month but the loser portfolio generated an average monthly return of -2.43%. The corresponding W-L portfolio yields a significantly positive average return of 3.08% per month. The results of the sub-period analysis also show that in each of the sub-periods, the return generated by the W-L portfolio is positive and significant for all the ranking and holding periods with the exception of the 12 x 12 strategy in the 1998-2005 sub-period. Although the results from the pure momentum strategies are, qualitatively, consistent with those reported in the US studies, the magnitude of the returns on the W-L portfolios reported in this study appear larger than those reported in the US studies. Also, unlike the US studies, most of the return generated by the W-L portfolio is driven by the loser portfolio. This is the case for the entire sample period as well as for each of the two sub-periods.

Column 3 and Column 4 of Table 1 show, respectively, the average monthly returns and the average monthly turnover during the ranking period. We observe that, over the ranking period, stocks in the winner portfolio have, on average, the highest turnover. For example, for the 6-month ranking period, the return on the winner portfolio in the ranking period is 8.46% per month and an average monthly turnover of 10.84%. Over the same period, the loser portfolio lost 11.7% per month with an average monthly turnover of 7.42%. Across all ranking periods we observe a positive association between turnover and price momentum, consistent with Lee and Swaminathan (2000) and Glaser and Weber (2003). The results are also consistent with a number of studies that tend to suggest that trading volume information can be an important predictor of security returns. These include Campbell, Grossman and Wang (1993), Blume, Easley and O'hara (1994) and Datar, Naik and Ratcliffe (1998). In particular, Datar, Naik and Ratcliffe (1998) show that firms experiencing high turnover tend to earn significantly higher returns.

Table 1

Average Monthly Returns of Pure Momentum Portfolios

Ranking Period (J)	Portfolio	Ranking Period Return	Ranking Period Turnover	1988-2005 Holding Period (K) 3	6	9	12	1988-1997 Holding Period (K) 3	6	9	12	1998-2005 Holding Period (K) 3	6	9	12
3	P1 (W)	0.1174	0.1084	0.0027	0.0028	0.0014	0.0015	0.0039	0.0042	0.0041	0.0043	0.0010	0.0009	-0.0021	-0.0026
	P5	0.0090	0.0730	0.0009	0.0002	0.0000	-0.0002	0.0008	0.0011	0.0010	0.0010	0.0007	-0.0009	-0.0010	-0.0016
	P10 (L)	-0.1488	0.0742	-0.0238	-0.0231	-0.0214	-0.0198	-0.0206	-0.0202	-0.0188	-0.0172	-0.0294	-0.0280	-0.0261	-0.0252
	W-L (t-stat)			0.0265[a] (5.993)	0.0259[a] (7.668)	0.0228[a] (7.600)	0.0213[a] (7.746)	0.0245[a] (5.120)	0.0244[a] (6.960)	0.0229[a] (8.006)	0.0215[a] (8.246)	0.0304[a] (3.506)	0.0289[a] (4.110)	0.0240[a] (3.631)	0.0226[a] (3.581)
6	P1 (W)	0.0846	0.1075	0.0085	0.0065	0.0054	0.0041	0.0089	0.0082	0.0081	0.0075	0.0076	0.0040	0.0016	-0.0009
	P5	0.0081	0.0745	-0.0010	-0.0009	-0.0011	-0.0008	0.0001	0.0002	0.0002	0.0001	-0.0024	-0.0018	-0.0022	-0.0021
	P10 (L)	-0.1170	0.0742	-0.0261	-0.0243	-0.0227	-0.0202	-0.0237	-0.0227	-0.0211	-0.0185	-0.0303	-0.0274	-0.0258	-0.0239
	W-L (t-stat)			0.0346[a] (7.979)	0.0308[a] (9.156)	0.0281[a] (9.499)	0.0243[a] (8.851)	0.0326[a] (6.752)	0.0309[a] (8.632)	0.0292[a] (10.074)	0.0260[a] (10.055)	0.0379[a] (4.397)	0.0314[a] (4.428)	0.0274[a] (4.142)	0.0230[a] (3.594)
9	P1 (W)	0.0705	0.1073	0.0095	0.0081	0.0056	0.0035	0.0104	0.0103	0.0091	0.0072	0.0075	0.0046	0.0005	-0.0024
	P5	0.0074	0.0749	-0.0006	-0.0009	-0.0009	-0.0005	-0.0003	-0.0005	-0.0001	0.0002	-0.0014	-0.0017	-0.0017	-0.0015
	P10 (L)	-0.1016	0.0758	-0.0256	-0.0240	-0.0216	-0.0185	-0.0244	-0.0235	-0.0212	-0.0182	-0.0280	-0.0253	-0.0229	-0.0199
	W-L (t-stat)			0.0351[a] (8.098)	0.0321[a] (9.646)	0.0272[a] (9.094)	0.0220[a] (7.943)	0.0348[a] (7.196)	0.0338[a] (9.549)	0.0303[a] (10.406)	0.0254[a] (9.742)	0.0355[a] (4.115)	0.0299[a] (4.240)	0.0234[a] (3.502)	0.0175[b] (2.784)
12	P1 (W)	0.0622	0.1072	0.0107	0.0078	0.0046	0.0023	0.0120	0.0108	0.0086	0.0066	0.0081	0.0032	-0.0011	-0.0043
	P5	0.0069	0.0741	-0.0004	-0.0005	-0.0004	-0.0001	-0.0012	-0.0006	0.0002	0.0005	0.0006	-0.0003	-0.0006	-0.0005
	P10 (L)	-0.0906	0.0754	-0.0249	-0.0220	-0.0193	-0.0165	-0.0249	-0.0229	-0.0201	-0.0177	-0.0259	-0.0215	-0.0189	-0.0159
	W-L (t-stat)			0.0356[a] (8.322)	0.0298[a] (8.810)	0.0239[a] (7.983)	0.0188[a] (6.830)	0.0369[a] (7.669)	0.0337[a] (9.317)	0.0287[a] (9.875)	0.0243[a] (9.430)	0.0340[a] (3.991)	0.0247[a] (3.509)	0.0178[a] (2.712)	0.0116 (1.870)

Stocks are initially ranked based on the previous J-months returns. We assign stocks in the top decile to the winner portfolio (P1) and those in the lower decile to the loser portfolio (P10). The table reports the average monthly returns of the winner portfolio (P1), an intermediate portfolio (P5), the loser portfolio (P10) and the zero-cost investment strategy of winner minus loser (W-L) portfolio for various ranking and holding periods. The t-statistics testing the significance of the winner minus loser portfolio from zero are shown in brackets. [a] Significant at the 99% level [b] Significant at the 95% level.

Table 2

Momentum returns assessed using the previous 6-month performance for holding period of 1 to 5 years

Holding Period	Portfolio	Average Monthly Returns	Annualised	t-stat
12 months	P1 (W)	0.0041	0.0503	
	P10 (L)	-0.0202	-0.2712	
	W-L	0.0243[a]	0.3215	8.34
24 months	P1 (W)	0.0001	0.0012	
	P10 (L)	-0.0136	-0.1760	
	W-L	0.0137[a]	0.1772	4.67
36 months	P1 (W)	-0.0009	-0.0109	
	P10 (L)	-0.0108	-0.1376	
	W-L	0.0099[a]	0.1267	3.95
48 months	P1 (W)	-0.0009	-0.0109	
	P10 (L)	-0.0086	-0.1082	
	W-L	0.0077[b]	0.0973	1.83
60 months	P1 (W)	-0.0012	-0.0145	
	P10 (L)	-0.0065	-0.0808	
	W-L	0.0053	0.0663	1.01

Stocks are initially ranked based on the previous 6-months returns. We assign stocks in the top decile to the winner portfolio (P1) and those in the lower decile to the loser portfolio (P10). The table reports the average monthly and annualised returns of the winner portfolio (P1), the loser portfolio (P10) and the zero-cost investment strategy of winner minus loser (momentum) portfolio for holding periods of 12 to 60 months. The t-statistics testing the significance of the winner minus loser portfolio from zero are shown in brackets.

[a] Significant at the 99% level.

[b] Significant at the 95% level.

3.2. Momentum Reversals

Table 2 presents the returns from holding the momentum portfolios for periods of one to five years for the case of J=6. Columns 3 and 4 detail the average monthly and the annualised buy-and-hold returns respectively for various holding periods. The results reveal a monotonous decline in the average monthly returns of the winner minus loser (W-L) portfolio as the holding period increases beyond 12 months. The reversal in the momentum returns occurs as the return on the winner portfolio reduces whilst the return on the loser portfolio increases. For example, the average monthly return for the winner portfolio reduces from 0.41% for a 12-month holding period to -0.12% for the 60-month holding period. On the other hand, the return on the loser portfolio increases from -2.12% for a 12-month holding to -0.65% for the 60-month holding period. As a result, the winner minus loser portfolio falls from an average return of 2.43% per month for a 12-month holding to 0.53% for the 60-month holding period. Although we find evidence of reversal in the momentum returns after the 12-month holding period, the momentum return remains significant until after 36 months. Figure 1 illustrates the findings by plotting returns from the winner minus loser portfolio for the holding periods of three months to five years. Although not reported for the sake of brevity, we observe similar patterns of reversals, as the holding period increases, for the other portfolio formation periods. These results are consistent with previous studies such as Jegadeesh and Titman (2001) and Lee and Swaminathan (2000), and provide further evidence that price momentum is a short-term phenomenon.

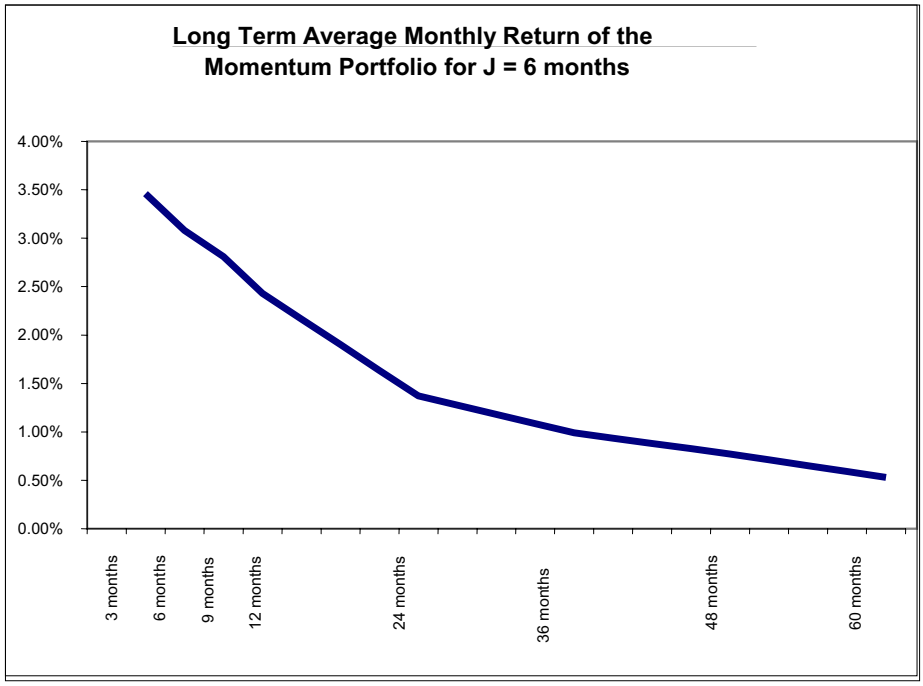

Fig. 1. Highlighting the dissipation of momentum returns over the longer term

3.3. Returns on Volume-Momentum Portfolios

Evidence from Table 1 suggests that past turnover is associated with past stock returns. Table 3 presents the average monthly returns of the volume-augmented trading strategy for holding periods up to 12 months. Each month, the stocks are ranked independently by the past J-months returns and then by their turnover over the same period as described in section 2.1.2. Table 3 shows that, both past returns and past turnover independently predict future returns. For example, in the case of J=6 and K=6, holding turnover constant the return on the winner minus loser portfolio ranged between 2.90% per month for the high volume stocks and 3.11% per month for the low turnover stocks with an average of 3.05%. On the other hand, holding past returns constant, high volume stocks outperform low volume stocks. The low volume winners earn an average monthly return of -0.32% compared to a return of 0.78% for the high volume winners, a difference of 1.10% per month. Similarly, the high volume losers outperform the low volume losers by 1.31%, whilst the intermediate portfolio P5 shows a return differential of 0.72% per month in favour of high volume stocks.

We also find that the W-L portfolio is significantly positive for all turnover groups, however this varies among the various turnover groups. The W-L returns are higher in high turnover stocks than in low turnover stocks for the three month ranking period and the case of J=6 and K=3. Although this suggests that momentum is more pronounced among high turnover stocks, it does not occur consistently across all ranking and holding periods. The situation reverses for the other ranking and holding periods, where the W-L portfolio in the low turnover group outperforms that of the high turnover group. Another interesting observation is that, the return on the W-L portfolio dissipates faster over time for the high volume stocks compared to the low volume stocks. This is also illustrated in Figure 2. Thus, reversal in momentum returns may be driven largely by high turnover stocks in the portfolio.

Table 3

Average Monthly Returns of the Volume-Momentum Portfolios

Ranking Period	Portfolio	K=3				K=6				K=9				K=12			
		V1	V2	V3	V1-V3	V1	V2	V3	V1-V3	V1	V2	V3	V1-V3	V1	V2	V3	V1-V3
3	P1 (W)	0.0058 (1.742)	0.0042 (1.399)	-0.0129 (-3.022)	0.0187 (3.881)	0.0056 (2.449)	0.0047 (2.277)	-0.0102 (-4.175)	0.0158 (4.802)	0.0033 (1.684)	0.0036 (1.896)	-0.0094 (-4.452)	0.0127 (4.476)	0.0031 (1.682)	0.0036 (2.084)	-0.0099 (-3.910)	0.0130 (4.849)
	P5	0.0050 (2.105)	0.0036 (1.754)	-0.0030 (-1.254)	0.0080 (2.389)	0.0046 (2.009)	0.0030 (1.870)	-0.0043 (-2.332)	0.0089 (3.525)	0.0039 (2.082)	0.0018 (1.373)	-0.0038 (-2.044)	0.0076 (3.655)	0.0028 (2.018)	0.0010 (0.868)	-0.0038 (-2.313)	0.0066 (3.511)
	P10 (L)	-0.0247[a] (-5.631)	-0.0229[a] (-5.993)	-0.0359[a] (-7.944)	0.0113 (1.902)	-0.0210 (-5.346)	-0.0219 (-6.114)	-0.0338 (-8.926)	0.0127 (2.692)	-0.0193 (-5.631)	-0.0210 (-6.622)	-0.0317 (-9.460)	0.0124 (3.000)	-0.0173 (-6.019)	-0.0189 (-6.653)	-0.0296 (-9.854)	0.0122 (3.245)
	W-L	0.0305 (5.673)	0.0271 (5.699)	0.0231 (4.365)	0.0074 (1.478)	0.0267 (8.835)	0.0266 (7.458)	0.0236 (5.778)	0.0031 (0.785)	0.0226 (6.756)	0.0246 (7.654)	0.0223 (6.210)	0.0003 (0.086)	0.0204 (6.510)	0.0225 (7.779)	0.0197 (5.941)	0.0008 (0.225)
6	P1 (W)	0.0107 (3.440)	0.0097 (3.384)	-0.0028 (-0.939)	0.0135 (3.150)	0.0078 (3.562)	0.0079 (3.867)	-0.0032 (-1.477)	0.0110 (3.598)	0.0063 (3.374)	0.0065 (3.599)	-0.0031 (-1.481)	0.0094 (3.396)	0.0049 (2.790)	0.0055 (3.344)	-0.0046 (-2.393)	0.0095 (3.689)
	P5	0.0020 (0.817)	0.0013 (0.590)	-0.0067 (-2.918)	0.0086 (2.606)	0.0022 (1.222)	0.0013 (0.842)	-0.0050 (-2.821)	0.0072 (2.885)	0.0011 (0.711)	0.0005 (0.401)	-0.0053 (-3.239)	0.0065 (2.852)	0.0009 (0.639)	0.0005 (0.414)	-0.0051 (-3.376)	0.0059 (2.938)
	P10 (L)	-0.0255 (-5.833)	-0.0241 (-6.328)	-0.0364 (-8.191)	0.0110 (1.867)	-0.0212 (-6.319)	-0.0235 (-7.636)	-0.0343 (-9.161)	0.0131 (2.765)	-0.0191 (-5.833)	-0.0219 (-7.214)	-0.0325 (-9.001)	0.0133 (3.280)	-0.0165 (-6.061)	-0.0176 (-6.356)	-0.0297 (-9.054)	0.0132 (3.482)
	W-L	0.0362 (6.985)	0.0338 (7.367)	0.0336 (6.984)	0.0026 (0.496)	0.0290 (7.528)	0.0314 (8.963)	0.0311 (7.528)	-0.0021 (-0.524)	0.0255 (7.802)	0.0284 (9.324)	0.0294 (8.566)	-0.0039 (-1.110)	0.0214 (6.818)	0.0231 (8.327)	0.0251 (7.937)	-0.0037 (-1..070)
9	P1 (W)	0.0109 (2.549)	0.0092 (2.148)	0.0020 (0.660)	0.0089 (2.063)	0.0088 (3.050)	0.0083 (3.067)	0.0004 (0.168)	0.0085 (2.757)	0.0059 (3.044)	0.0060 (3.428)	-0.0019 (-0.916)	0.0077 (2.776)	0.0040 (2.137)	0.0041 (2.460)	-0.0044 (-2.265)	0.0085 (3.138)
	P5	0.0030 (1.246)	0.0008 (0.380)	-0.0056 (-2.380)	0.0087 (2.567)	0.0027 (1.428)	0.0005 (0.324)	-0.0054 (-2.746)	0.0081 (2.987)	0.0018 (1.137)	0.0002 (0.123)	-0.0053 (-3.092)	0.0071 (3.065)	0.0017 (1.155)	0.0001 (0.127)	-0.0049 (-3.103)	0.0065 (3.096)
	P10 (L)	-0.0251 (-5.721)	-0.0236 (-6.334)	-0.0353 (-7.938)	0.0103 (1.748)	-0.0221 (-6.635)	-0.0212 (-6.330)	-0.0338 (-9.380)	0.0116 (2.512)	-0.0194 (-5.021)	-0.0184 (-6.454)	-0.0313 (-8.619)	0.0119 (2.864)	-0.0168 (-6.113)	-0.0143 (-6.500)	-0.0274 (-8.768)	0.0106 (2.851)
	W-L	0.0360 (6.957)	0.0328 (7.182)	0.0373 (7.803)	-0.0014 (-0.271)	0.0310 (8.125)	0.0295 (8.695)	0.0341 (9.202)	-0.0032 (-0.820)	0.0253 (7.447)	0.0244 (8.448)	0.0294 (8.638)	-0.0042 (-1.155)	0.0208 (6.431)	0.0183 (6.888)	0.0230 (7.438)	-0.0022 (-0.630)
12	P1 (W)	0.0113 (3.598)	0.0101 (3.528)	0.0036 (1.134)	0.0077 (1.723)	0.0082 (2.511)	0.0078 (2.725)	0.0014 (0.601)	0.0068 (2.049)	0.0047 (2.215)	0.0053 (2.858)	-0.0021 (-0.977)	0.0068 (2.266)	0.0028 (1.364)	0.0029 (1.657)	-0.0049 (-2.256)	0.0077 (2.591)
	P5	0.0014 (0.568)	0.0012 (0.542)	-0.0024 (-1.096)	0.0038 (1.156)	0.0017 (0.885)	0.0006 (0.367)	-0.0028 (-1.570)	0.0045 (1.725)	0.0017 (1.038)	0.0003 (0.184)	-0.0029 (-1.778)	0.0046 (1.993)	0.0021 (1.445)	0.0002 (0.162)	-0.0036 (-2.388)	0.0057 (2.742)
	P10 (L)	-0.0222 (-5.326)	-0.0214 (-5.876)	-0.0359 (-7.104)	0.0137 (2.393)	-0.0197 (-5.920)	-0.0187 (-6.556)	-0.0326 (-7.953)	0.0129 (2.780)	-0.0171 (-5.326)	-0.0155 (-5.719)	-0.0299 (-8.291)	0.0127 (3.096)	-0.0144 (-5.499)	-0.0125 (-5.138)	-0.0260 (-8.565)	0.0115 (3.138)
	W-L	0.0336 (6.624)	0.0315 (7.042)	0.0395 (8.150)	-0.0060 (-1.147)	0.0279 (7.110)	0.0265 (7.807)	0.0340 (8.873)	-0.0061 (-1.554)	0.0219 (8.048)	0.0208 (7.295)	0.0278 (6.171)	-0.0059 (-1.593)	0.0173 (5.274)	0.0154 (5.873)	0.0211 (6.612)	-0.0038 (-1.070)

Each month all stocks with the relevant data are ranked based on the previous J-months returns and assigned to decile portfolios as described in Table 1. The stocks are then independently ranked, in descending order, by turnover and assigned to one of three categories. The top 30% are classified as high volume (V1) stocks with the bottom 30% classified as low volume (V3) stocks. The table reports the average monthly returns of the winner portfolio (P1), the loser portfolio (P10) and the zero-cost investment strategy of winner minus loser (W-L) portfolio for various ranking and holding periods. The t-statistics are shown in brackets.

[a] Significant at the 99% level. [b] Significant at the 95% level.

In this regard, our results are contrary to the findings of Lee and Swaminathan (2000) that low volume stocks consistently outperformed their high volume counterparts when controlling for momentum. Glaser and Weber (2003) also report a different set of results. Their results show that high turnover winners outperform low turnover winners but high turnover losers underperform low turnover losers. Thus, low volume stocks outperform their high volume counterparts only in the stocks with low past returns. In contrast, our findings are partly consistent with the findings of Hameed and Kusnadi (2002) who report that, with the exception of Hong Kong, high volume winners outperform low volume winners in their study of six Asian stock markets and that high volume losers outperform low volume losers with the exception of Hong Kong and Singapore. As in Glaser and Weber (2003) our results also show that a strategy of buying high volume winners and selling low volume losers outperform the investment strategy of buying low volume winners and selling high volume losers.

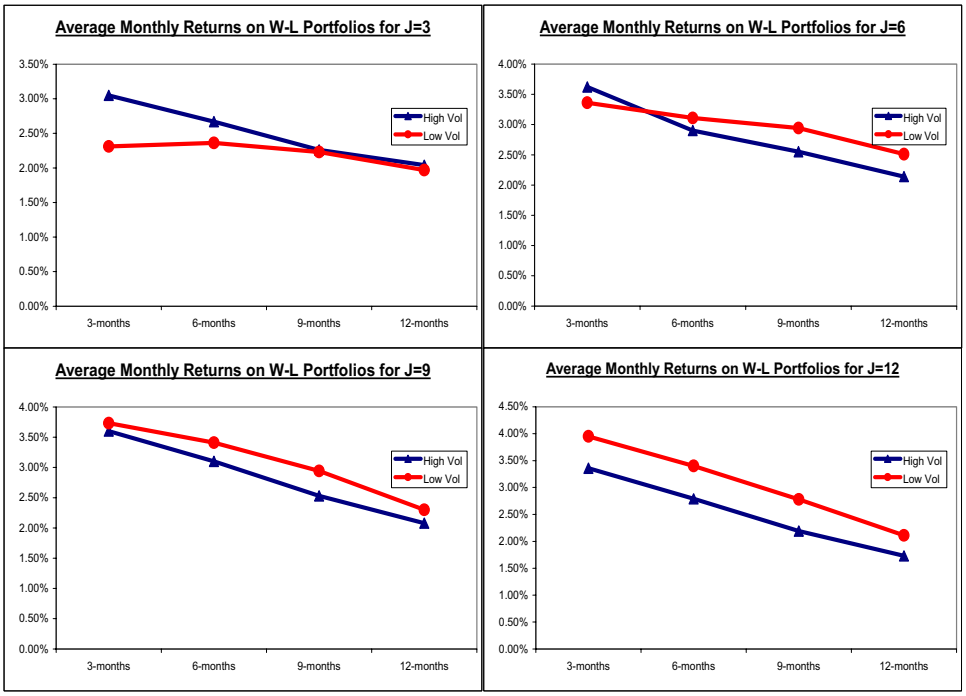

Fig. 2. Average monthly returns on the winner minus loser portfolio within high and low turnover stocks for various ranking and holding periods

3.4. Robustness of the Volume-Momentum Portfolios

In Section 3.3, stocks were ranked independently based on past returns and turnover. In this section, we examine the relationship between turnover and momentum in more detail by examining the returns of price-momentum portfolios conditioning on turnover and turnover-based portfolios conditioning on past returns. In the first case, stocks are first sorted by turnover into five quintile portfolios and within each turnover quintile stocks are further sorted into five momentum portfolios based on past returns. In the second case, the order of sorting is reversed; stocks are initially sorted into momentum portfolios and within each momentum portfolio the stocks are further sorted into turnover portfolios. We also examine the marginal contribution of the momentum effect and the turnover effect. By this, we examine whether the volume effect is linked to or independent of the pure momentum effect. For brevity we report results for the 6 x 6 strategy in Table 4, but we find similar results for the other ranking and holding periods.

Panel A of Table 4 reports the average monthly return of momentum portfolios conditioning on past turnover. The results show that conditioning on trading volume information the average returns of the momentum portfolios increase as turnover increases. Furthermore, the difference between the returns of the winner and loser portfolios (W-L) in each turnover quintile is positive and significant; however the spread does not increase monotonically with the turnover quintiles. For the highest turnover (V1) quintile, the spread between the winner and loser portfolio is 2.17% per month, in comparison with the spread of 1.88% for the V2 quintile and 2.99% for the lowest turnover quintile (V5) which shows a nonlinear U-shaped relationship. As in Table 3, the momentum spread appears more pronounced among stocks with the lowest turnover in the ranking period.

Panel B presents the results for the turnover portfolios conditioning on past returns. The results show that conditioning on past returns, the highest volume stocks significantly outperform stocks in the lowest volume quintile. The difference between the high turnover stocks and the low turnover stocks is positive and statistically significant among all the five price momentum quintiles. However, the marginal contribution of the volume effect ranged between 0.73% and 1.58% per month, which is about half the marginal contribution of the price momentum effect. Hence, controlling for trading volume does not eliminate the momentum effect, neither does controlling for price momentum eliminate the volume effect. Nonetheless, the price momentum effect outweighs the volume effect.

Comparing the W-L returns across the five volume quintiles reveal that the returns in the volume quintiles differ significantly from one another. For example, comparing the W-L returns in the two lowest volume quintiles against the rest (i.e. V4 and V5 vs V1, V2 and V3), momentum return is significantly higher among the lowest volume quintiles than the relatively higher volume quintiles (mean of 2.79% vrs 2.04%; the difference in means is 0.75%; t-statistic = 2.842) but we do not find any significant difference between the momentum returns for the V4 quintile and the V5 quintile (mean of 2.99% vrs 2.59%; the difference in means is 0.4%; t-statistic = 1.305). Given trading volume as a proxy for liquidity, these differences could be attributed to liquidity risk. However, among the high volume quintiles (V1 and V2) the momentum return in the highest volume quintile (V1) is greater than that of the V2 quintile but the difference is not statistically significant (mean of 2.17% vrs 1.88%; the difference in means is 0.29%; t-statistic = 1.058). If momentum were a compensation for liquidity risk we would expect momentum returns to decline monotonically across the volume quintiles as trading volume increases. Liquidity risk, therefore, does not fully explain the observed differences in momentum returns across the five volume quintiles.

Table 4

Average monthly returns of portfolios double sorted on past returns and turnover for the 6x6 strategy

Panel A: Average monthly returns of momentum portfolios conditioning on past turnover						
	Turnover					
Momentum	V1 (High)	V2	V3	V4	V5 (Low)	V1-V5
P1 (W)	0.0079 (2.998)	0.0054 (2.416)	0.0080 (4.181)	0.0057 (2.773)	-0.0038 (-1.459)	0.0117 (4.694)
P2	0.0071 (3.603)	0.0059 (3.549)	0.0058 (3.250)	0.0045 (2.527)	-0.0039 (-1.699)	0.0109 (4.991)
P3	0.0048 (2.081)	0.0042 (2.068)	0.0025 (1.082)	0.0014 (0.444)	-0.0111 (-5.165)	0.0159 (6.565)
P4	0.0007 (0.297)	-0.0003 (-0.155)	-0.0009 (-0.315)	-0.0058 (-2.121)	-0.0191 (-6.860)	0.0198 (6.687)
P5 (L)	-0.0138 (-3.954)	-0.0134 (-4.195)	-0.0128 (-4.431)	-0.0202 (-6.875)	-0.0337 (-9.035)	0.0199 (4.694)
W-L	0.0217 (6.251)	0.0188 (6.102)	0.0208 (7.481)	0.0259 (9.051)	0.0299 (8.722)	-0.0082 (-2.616)

Table 4 (continuous)

Panel B: Average monthly returns of volume quintile portfolios conditioning on past returns						
	Momentum					
Turnover	P1 (W)	P2	P3	P4	P5 (L)	W-L
V1 (High)	0.0086 (3.517)	0.0064 (3.536)	0.0036 (1.443)	-0.0027 (-0.460)	-0.0162 (-4.822)	0.0248 (7.350)
V2	0.0060 (2.733)	0.0060 (3.511)	0.0035 (1.461)	-0.0013 (0.138)	-0.0169 (-5.369)	0.0229 (7.379)
V3	0.0067 (3.128)	0.0061 (3.584)	0.0021 (0.559)	-0.0037 (-0.985)	-0.0177 (-5.679)	0.0243 (7.907)
V4	0.0064 (3.085)	0.0045 (2.508)	0.0022 (0.727)	-0.0067 (-2.275)	-0.0259 (-7.486)	0.0322 (9.718)
V5 (Low)	-0.0009 (-0.549)	-0.0010 (-0.666)	-0.0041 (-1.815)	-0.0145 (-6.521)	-0.0320 (-9.009)	0.0311 (9.502)
V1-V5	0.0095 (3.701)	0.0073 (3.614)	0.0077 (3.462)	0.0118 (4.101)	0.0158 (3.810)	-0.0063 (-2.348)

This table reports the equally-weighted average monthly returns of the various volume-momentum portfolios for the 6-month ranking and 6-month holding period (6x6) strategy. Each month all stocks with the relevant data are double sorted on past returns and turnover into portfolios. In Panel A, stocks are first sorted into 5 quintile portfolios based past returns. Subsequently, within each past return quintile the stocks are sorted into 5 quintile portfolios based on past turnover. In Panel B, we reverse the order of sorting, stocks are first sorted into 5 quintile portfolios based past turnover and then within each turnover quintile the stocks are further sorted into 5 portfolios based on past returns. The t-statistics are shown in brackets.

3.5. Returns on Volume-Augmented Momentum Portfolios

The results in Tables 3 and 4 suggest that in spite of their individual effects, trading volume and price momentum interact. Hence, a trading strategy that exploits the volume-price momentum interactions could be more profitable than either a pure price momentum strategy or a strategy based only on trading volume. Below, we examine the returns of two momentum strategies conditioning on turnover (volume-augmented momentum strategies) for different ranking and holding periods. The first involves buying low volume winners, and selling high volume losers, whilst the second involves buying high volume winners and selling low volume losers. Lee and Swaminathan (2000) characterise these strategies as the "early-stage" momentum strategy and the "late-stage" momentum strategy respectively.

Table 5 compares the average monthly returns of the W-L portfolio of the pure momentum strategy presented in Table 1 to those of the late-stage and early-stage volume-price momentum strategies. What is interesting about our results is that contrary to the predictions of the momentum life cycle model (Lee and Swaminathan, 2000), we find that the late-stage strategy outperform the early-stage strategy as well as the pure momentum strategy for holding periods up to 12 months. This pattern holds across all ranking and holding periods. For example, for the 6-month ranking and 6-month holding period, the late-stage strategy generates an average monthly return of 4.21% compared to 3.08% from the pure momentum strategy and 1.08% from the early-stage strategy. Ellis and Thomas (2004) find similar evidence using FTSE 350 stocks. Although the early-stage and late-stage momentum strategies are not directly reported in their study, Table 2 of Ellis and Thomas suggests that a late-stage strategy would earn an average monthly return of 2.34% compared to 0.9% for the early-stage, for the 6-month ranking period and 6-month holding period. The differences in the magnitude of the profits reported in this paper and those of Ellis and Thomas can be attributed to different samples and time periods as they examine a smaller sample of stocks and a different time period. To sum up, our results show that although a trading strategy that seeks to exploit the price-volume interactions could be more profitable than a pure momentum strategy, the optimal strategy for the UK market is different from that observed in the US.

3.6. Portfolio Turnover and Implementation Cost of the Volume-Augmented Momentum Strategies

Results from Table 5 suggest that in the absence of transaction costs, the late-stage strategy could earn average monthly returns as high as 4.21% per month. Recently a number of studies have examined the post-cost profitability of the momentum strategy but the evidence appears mixed. For example, Lesmond, Schill and Zhou (2004) find that momentum returns net of transaction costs are largely insignificant but Korajczyk and Sadka (2004) provide evidence to suggest that transaction costs do not necessarily eliminate the significance of momentum returns. In this section we examine the incidence of portfolio turnover associated with the strategy and its impact on the profitability of the strategy.

Table 5

Early and Late Stage Momentum Portfolio Returns

Ranking Period	Portfolio	Holding Period			
		3 Months	6 Months	9 Months	12 Months
3 Months	P1V1 – P10V3 (Late Stage)	0.0417 (8.387)	0.0394 (10.265)	0.0350 (10.375)	0.0327 (10.659)
	P1 – P10 (Pure Momentum)	0.0265 (5.993)	0.0259 (7.668)	0.0228 (7.600)	0.0213 (7.746)
	P1V3 – P10V1 (Early Stage)	0.0118 (2.101)	0.0109 (2.659)	0.0099 (2.819)	0.0074 (2.229)
6 Months	P1V1 – P10V3 (Late Stage)	0.0472 (9.976)	0.0421 (11.320)	0.0388 (12.090)	0.0346 (11.671)
	P1 – P10 (Pure Momentum)	0.0346 (7.979)	0.0308 (9.156)	0.0281 (9.499)	0.0243 (8.851)
	P1V3 – P10V1 (Early Stage)	0.0226 (4.328)	0.0180 (4.556)	0.0161 (4.655)	0.0119 (3.617)
9 Months	P1V1 – P10V3 (Late Stage)	0.0462 (9.835)	0.0426 (11.833)	0.0371 (11.420)	0.0314 (10.630)
	P1 – P10 (Pure Momentum)	0.0351 (8.098)	0.0321 (9.646)	0.0272 (9.094)	0.0220 (7.943)
	P1V3 – P10V1 (Early Stage)	0.0271 (5.175)	0.0225 (5.777)	0.0175 (4.989)	0.0124 (3.710)
12 Months	P1V1 – P10V3 (Late Stage)	0.0472 (9.983)	0.0408 (10.921)	0.0346 (10.257)	0.0288 (9.503)
	P1 – P10 (Pure Momentum)	0.0356 (8.322)	0.0298 (8.810)	0.0239 (7.983)	0.0188 (6.830)
	P1V3 – P10V1 (Early Stage)	0.0259 (5.012)	0.0211 (5.282)	0.0151 (4.188)	0.0095 (2.814)

This table reports the equally-weighted average monthly returns of the "pure" price momentum strategy and the "late stage" and "early stage" volume-price momentum strategies. The pure momentum strategy involves selling the losers (P10) to buy the winners (P1). The early stage strategy involves selling high volume losers (P10V1) to buy low volume winners (P1V3), whilst the late stage strategy involves selling low volume losers (P10V3) to buy high volume winners (P1V1). The t-statistics are shown in brackets.

To maintain the investment strategy, investors would have to rebalance the portfolios at the end of the holding period by selling stocks that no longer meet the eligibility criteria and replacing them with newly eligible ones. This can lead to high portfolio turnover. If there are trans-

action costs associated with buying and selling stocks the frequent trading affects the net portfolio returns (see for example Barber and Odean, 2000). The cost of implementing the investment strategy therefore depends on portfolio turnover, among other things. Table 6 presents the average portfolio turnover rates for the four extreme volume-momentum portfolios. Across all the ranking and holding periods, portfolio rebalancing is higher among the low volume winner (P1V3) portfolios. For example, for the 6-month ranking/6-month holding period, the average turnover rate for the low volume winner portfolio is 92.7% (annualised 185.4% = 92.7% x 2). This implies that only 7% of the portfolio is carried over to the next holding period. Thus, almost the entire portfolio would be changed every 6 months. For the 6-month ranking/3-month holding period the entire low volume winner portfolio would be changed almost three times in one year (annualised turnover of 292.4%). In comparison, the corresponding turnover for the 12-month holding period is 95% per year. We would thus expect the transaction cost associated with the longer holding periods to be lower than that for the shorter holding periods.

Table 6

Portfolio Turnover for the Momentum – Volume Portfolios

This table shows the average percentage turnover of the selected momentum-volume portfolios for different ranking and holding periods. For each cell the top number is the percentage turnover per holding period, whilst the number in squared brackets is the corresponding annualised turnover value.

Ranking Period	Portfolio	Holding Period			
		3 Months	6 Months	9 Months	12 Months
3	High Turnover Winners (P1V1)	87.8 [351.2]	90.0 [180.0]	91.9 [122.5]	91.0 [91.0]
	Low Turnover Winners (P1V3)	91.9 [367.6]	92.8 [185.6]	94.0 [125.3]	93.7 [93.7]
	High Turnover Losers (P10V1)	83.7 [334.8]	87.2 [174.4]	89.7 [119.6]	91.0 [91.0]
	Low Turnover Losers (P10V3)	80.4 [321.6]	83.4 [166.8]	85.5 [114.0]	86.2 [86.2]
6	High Turnover Winners (P1V1)	64.8 [259.2]	87.1 [174.2]	89.5 [119.3]	90.6 [90.6]
	Low Turnover Winners (P1V3)	73.1 [292.4]	92.7 [185.4]	93.5 [124.7]	95.0 [95.0]
	High Turnover Losers (P10V1)	61.0 [244.0]	84.3 [168.6]	88.2 [117.6]	91.2 [91.2]
	Low Turnover Losers (P10V3)	60.1 [240.4]	80.8 [161.6]	83.0 [110.7]	85.0 [85.0]
9	High Turnover Winners (P1V1)	52.7 [210.8]	73.4 [146.8]	86.9 [115.9]	89.9 [89.9]
	Low Turnover Winners (P1V3)	62.3 [249.2]	81.3 [162.6]	93.0 [124.0]	93.6 [93.6]
	High Turnover Losers (P10V1)	50.2 [200.8]	71.7 [143.4]	85.4 [113.9]	89.4 [89.4]
	Low Turnover Losers (P10V3)	50.5 [202.0]	68.6 [137.2]	80.9 [107.9]	84.4 [84.4]
12	High Turnover Winners (P1V1)	45.5 [182.0]	64.5 [129.0]	77.6 [103.5]	87.8 [87.8]
	Low Turnover Winners (P1V3)	57.8 [231.2]	75.6 [151.2]	86.5 [115.3]	93.0 [93.0]
	High Turnover Losers (P10V1)	43.8 [175.2]	63.9 [127.8]	80.0 [106.7]	87.8 [87.8]
	Low Turnover Losers (P10V3)	43.7 [174.8]	60.6 [121.2]	72.6 [96.8]	82.3 [82.3]

Given the portfolio turnover rates we can estimate the level of transaction costs needed to eliminate the profits generated by the various portfolios. Considering the optimal strategy of buying the high volume winners and selling the high volume losers, the break-even roundtrip cost for the high volume winner portfolio (P1V1) is 2.0% for the 3x3 strategy, 5.4% for the 6x6 strategy and 3.8% for the 12x12 strategy. On the other hand, the corresponding roundtrip costs necessary to break-even on short-selling the loser portfolio are 13.4%, 25.5% and 37.9% respectively. Based on estimates from Agyei-Ampomah (2006), roundtrip costs on the UK market could range between 2.1% for stocks in the largest size quintile based on market capitalisation, and 16.9% for stocks in the smallest size quintile. Therefore, our results show that a long only volume-augmented strategy is unlikely to be profitable net of transaction costs and that the zero-cost "late stage" strategy is only profitable and realisable if there are no short-selling constraints since the profits of the long-short position largely occur from short-selling the low volume losers.

4. Discussions and Conclusion

Our results show that a volume-augmented momentum strategy appears more profitable than a pure price momentum strategy. We also find that the price momentum effect is more pronounced among low turnover stocks. The most profitable volume-augmented momentum strategy involves buying high turnover winners and selling low turnover loser stocks, the late-stage momentum strategy, contrary to the findings of earlier US studies. However, the profits of the volume-augmented momentum strategy may not be realisable taking into consideration transaction costs associated with the strategy. The profits are only realisable in our sample if there are no short selling constraints as the bulk of these profits are generated by short selling the low volume loser portfolio.

The sources of momentum portfolio returns continue to be debated in the literature. There is a body of research that attempts to explain these returns in a rational asset pricing framework. In the absence of any rational explanation, a profitable momentum strategy is an anomaly because it is inconsistent with weak-form market efficiency. Arguments consistent with the rational asset pricing framework include data mining, risk and transaction costs. However, there is no conclusive evidence that these arguments, individually or jointly, fully explain the momentum anomaly. On data mining, the momentum returns cannot be attributed to chance as these findings have been reported in different markets. In this regard, our findings provide out of sample evidence in support of earlier studies.

The momentum phenomenon is also frequently attributed to the risk characteristics of the constituent stocks (see for example Conrad and Kaul, 1998). Whereas the observed return differential of low and high volume stocks may constitute a profitable trading strategy it could also be a compensation for liquidity risk as suggested by Datar, Naik and Radcliffe (1998). As the low volume momentum portfolio in our sample consistently outperforms the high volume momentum portfolio, it is plausible to suggest that the higher return may be a rational compensation for the higher liquidity risk inherent in low volume stocks. However, we find that the momentum strategy is profitable even among stocks in the highest volume quintile. We also find a nonlinear U-shaped relationship between momentum returns and the volume quintiles. In contrast, liquidity risk would suggest a primarily linear relationship where momentum profit declines monotonically as trading volume increases. Thus, liquidity risk does not fully explain the findings in this study.

We have also shown that although a long only volume-augmented strategy may not be profitable, a long-short volume-augmented momentum strategy could be profitable after accounting for transaction costs. Thus, transaction cost alone does not fully eliminate the profitability of the strategy. However, the profits of the long-short strategy can only be realised if there are no short selling constraints as the bulk of these profits are generated by short selling the low volume loser portfolio.

In contrast to the standard rational explanations, others attribute the persistence of the momentum anomaly to irrational market behaviour. A number of behavioural models including Barberis, Shleifer, and Vishny (1998), Daniel, Hirshleifer, and Subrahmanyam (1998), Hong and Stein (1999) and Barberis and Shleifer (2003) suggest that irrational investor behaviour could lead

to overreaction or underreaction of market prices. For example, stock prices may initially underreact to news, leading to further price continuation as the market reacts slowly to the news. Thus, subsequent price changes would move in the same direction. Following the initial momentum, investors might become overoptimistic about the future prospects of the stocks over time therefore moving prices further away from its fundamental value. In the long term, corrections to this overreaction would lead to price reversals. The findings of significant momentum returns for holding periods up to 12 months and the subsequent return reversal for longer holding periods are consistent with this explanation.

Finally, our results provide further evidence that the optimal volume-augmented momentum strategy differs across markets.

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