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Published in:
European Journal of Finance

DOI:
10.1080/1351847X.2024.2377363

Publication date:
2024

The European Journal of Finance

ISSN: (Print) (Online) Journal homepage: www.tandfonline.com/journals/rejf20

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To cite this article: Y. Alburaythin, S. G. M. Fifield & S. Paramati (27 Jul 2024): Interaction between investor sentiment, limits to arbitrage and the returns of stock market anomalies: evidence from the UK stock market, The European Journal of Finance, DOI: 10.1080/1351847X.2024.2377363

To link to this article: https://doi.org/10.1080/1351847X.2024.2377363

THE EUROPEAN JOURNAL OF FINANCE
https://doi.org/10.1080/1351847X.2024.2377363

Routledge
Taylor & Francis Group

Interaction between investor sentiment, limits to arbitrage and the returns of stock market anomalies: evidence from the UK stock market

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ABSTRACT

This study investigates the role of two prominent concepts in finance: limits to arbitrage and investor sentiment in stock prices. The study examines how changes in market-wide investor sentiment and limits to arbitrage can affect the performance of nine UK stock market anomalies. The extant literature relating to investor sentiment focuses mainly on the US stock market, whilst research on the UK market typically examines aggregated index-level data. In addition, previous studies have focused on examining investor sentiment and limits to arbitrage separately. Using data from UK-listed companies over the period January 1997 to December 2019, the study finds that five stock market anomalies were related to changes in UK investor sentiment and produced significantly higher returns following periods of high investor sentiment, while the effect of limits to arbitrage was mostly limited. However, the interaction analysis provided support to the limits to arbitrage theory and demonstrated that the effect of high investor sentiment on stock market anomalies was more pronounced when combined with high limits to arbitrage and had less effect during periods characterised by low limits to arbitrage.

ARTICLE HISTORY
Received 18 August 2023
Accepted 26 June 2024

KEYWORDS
Investor sentiment; limits to arbitrage; stock market anomalies

JEL CODES
G10; G14; G41

1. Introduction

The Efficient Market Hypothesis (EMH) asserts that, at every point in time, stock prices reflect all available information and the effect of irrational behaviour on stock prices will be eliminated by sophisticated arbitrageurs (Fama 1970). However, given the theoretical and empirical challenges to the EMH, academic interest in the area has broadened to question the setting in which only economic and firm-specific factors influence asset prices (Barberis and Thaler 2003). Behavioural economists have suggested that real world arbitrage is both risky and expensive and, therefore, that it is ineffective in eliminating sentiment-driven mispricing. As Shleifer and Summers (1990, p. 19) theoretically argued:

> "Our approach rests on two assumptions. First, some investors are not fully rational and their demand for risky assets is affected by their beliefs or sentiments that are not fully justified by fundamental news. Second, arbitrage—defined as trading by fully rational investors not subject to such sentiment—is risky and therefore limited. The two assumptions together imply that changes in investor sentiment are not fully countered by arbitrageurs and so affect security returns. We argue that this approach to financial markets is in many ways superior to the efficient markets paradigm."

This paper builds on the theoretical work and examines three hypotheses, which aim to examine the abnormal returns associated with nine well-documented investment strategies and how the returns of these investment strategies would react to changes in investor sentiment and arbitrage limitations. These anomalies include net

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Supplemental data for this article can be accessed online at https://doi.org/10.1080/1351847X.2024.2377363.

operating assets, asset growth, investment to assets, momentum, return on assets (ROA), turnover, net stock issuance, composite stock issuance and gross profit. For each strategy sorting variable, a long-short portfolio using the extreme deciles is constructed, with the long leg containing stocks expected to outperform and the short leg containing stocks expected to underperform.

The first hypothesis is that the performance of stock market anomalies should be stronger following high sentiment and more driven by the short leg of the anomaly. Theoretically, Miller (1977) hypthesised that a market with short sale restrictions only impounds the view of optimistic investors, leading to inflated stock prices. With constraints on short sales and during a period of high sentiment, irrational investors could bid up the price of stocks beyond their fair value, leading to inflated stock prices and these stocks subsequently experience lower returns. Therefore, to the extent that the anomaly reflects mispricing, stocks in the short legs should be more overpriced as compared to stocks in the long legs and, thus, have lower returns (more profitable) following high sentiment. The findings confirm that the returns of eight of the nine examined anomalies behaved the same way predicated by the hypothesis and produced higher returns following periods of high investor sentiment and is mainly driven by the short leg of the anomaly.

The second hypothesis is that anomalies should produce higher returns when arbitrage limitations are high. Theoretically, anomalies appear when irrational investors drive stock prices away from fundamental values, and arbitrageurs, because of some limitations, are unable to correct sentiment-driven price diversions (Shleifer and Summers 1990; Barberis and Thaler 2003). Therefore, mispricing should be stronger when arbitrage limitations are high (more restrictive). However, the empirical findings show that limits to arbitrage measures played either a partial or no role in explaining the abnormal risk-adjusted returns from the nine anomalies.

The first and second hypotheses lead to the third hypothesis that if the abnormal returns generated from stock market anomalies are due to mispricing, then each anomaly strategy should yield the highest returns when both investor sentiment and limits to arbitrage are high. Combining the presence of market-wide investor sentiment with arbitrage limitations in one model will empirically test the theoretical prediction that investor sentiment should have the strongest impact when arbitrage conditions are tight. The findings of the paper provide evidence for the theoretical prediction, where nine anomalies generated their highest returns following months when both investor sentiment and limits to arbitrage are high. In addition, the findings demonstrated that the impact of high investor sentiment on stock market anomalies was more (less) pronounced when combined with high (low) limits to arbitrage.

The findings make new contributions and provide support for the limits to arbitrage theory, which suggests that arbitrageurs in stock markets are confronted with arbitrage constraints, which can undermine their ability and willingness to engage in arbitrage activity; thus leading to sentiment-driven mispricing in stock markets (Shleifer and Summers 1990; Shleifer 2000; Barberis and Thaler 2003). Furthermore, the results provide a richer understanding of the impact of investor sentiment on stock market anomalies by examining its interaction with arbitrage limitation. Previous empirical literature examining the impact of investor sentiment and limits to arbitrage on stock market anomalies have investigated these two measures separately (for example, Baker and Wurgler 2007; Stambaugh, Yu, and Yuan 2012; Jacobs 2015; DeLisle, Yüksel, and Zaynutdinova 2020).

The remainder of this paper is structured as follows. Section 2 sets out a brief review of the literature and discusses motivations to examine the UK stock market, while Section 3 presents the data employed in the study and some descriptive statistics. The analysis contained within this paper is presented in Section 4. Finally, Section 5 provides a number of concluding observations.

2. Literature Review and Motivation

As a result of market irregularities and abnormal patterns in stock returns, an extensive literature has shifted from the classical finance paradigm and attempted to model empirically the effect of investor sentiment on stock returns (De Long et al. 1990; Baker and Wurgler 2006; Brown and Cliff 2004). Over the past decade and with improvements in data availability that capture investor sentiment, a body of research has provided evidence that investor sentiment contributes significantly to explaining stock returns in general and stock market anomalies in particular. Some studies have investigated the effect of investor sentiment on the cross-section of US stock returns (Baker and Wurgler 2006; Ding, Mazouz, and Wang 2019) and international stock returns (Baker,

Wurgler, and Yuan 2012; Corredor, Ferrer, and Santamaria 2013). However, a more limited literature, which has typically concentrated on the US stock market, has explored the role of investor sentiment in explaining the abnormal returns generated from stock market anomalies. For example, Stambaugh, Yu, and Yuan (2012) examined the role of investor sentiment in explaining abnormal returns for11 prominent anomalies in the US. Their study showed that each anomaly was stronger following high sentiment periods and, thus, had higher long-short returns in subsequent periods of high investor sentiment. The short legs from the 11 anomalies were lower (more profitable) following high sentiment, while returns from the long legs did not generate higher returns following low sentiment. This asymmetrical effect of investor sentiment on stock market anomalies supports Miller (1977) who asserted that, because of limits to arbitrage and short-selling constraints, high sentiment creates overpricing more than than low sentiment creates underpricing. Chung, Hung, and Yeh (2012) argued that the signficant positive relationship between return of stock market anomalies and investor sentiment was dependent on the states of the economy, where the relationship was strongly signficant during economic expansion and insigificant when the economy was in contraction. By analysing a larger set of anomalies, Jacobs (2015) supported the influence of investor sentiment on US stock market anomalies. Overall, the study demonstrated that, for more than 80 anomalies, the investor sentiment effect was consistent with the theoretical prediction that long-short returns from these anomalies were generally higher following high levels of the Baker-Wurgler investor sentiment index as compared to low level.[1]

Another strand of the literature has focused on the ability of arbitrageurs to correct non-fundamental demand shocks. Ali, Hwang, and Trombley (2003) presented one of the earliest attempts to investigate the association between arbitrage constraints and the abnormal returns of stock market anomalies. The study found that stocks with higher idiosyncratic volatility exhibited a stronger book-to-market effect, which is in keeping with the argument advanced by Shleifer and Vishny (1997). Subsequent studies by Israel and Moskowitz (2013), Jacob (2015) and DeLisle, Yüksel, and Zaynutdinova (2020) have extended this early analysis and included more measures of limits to arbitrage and a larger set of anomalies. For example, Israel and Moskowitz (2013) found evidence that supported the limits to arbitrage view, but only for the value strategy where the returns from the anomaly were concentrated mainly amongst smaller firms. However, for the momentum strategy, the study documented no relationship between the returns of the strategy and firm size. Recently, DeLisle, Yüksel, and Zaynutdinova (2020) studied how barriers to arbitrage may affect three forms of the profitability anomaly (gross, operating and cash-based profitability). The study provided evidence that limits to arbitrage associated with arbitrage risk and arbitrage cost significantly explained the risk-adjusted returns of portfolios based on gross and cash-based profitability.[2] Chu, Hirshleifer, and Ma (2020) criticised previous studies for using limits to arbitrage proxies and argued that these proxies are likely to be correlated with risk factors over time. They stressed that their experiment of examining the return of stock market anomalies during the temporary relaxation of short sales regulation provided a direct casual test between limits to arbitrage and the performance of stock market anomalies. Using the list of anomalies employed by Stambaugh, Yu, and Yuan (2012), the authors found that 11 stock market anomalies became weaker and less profitable during the temporary relaxation.

Overall, the existing literature relating to investor sentiment focuses mainly on the US stock market, whilst research on the UK market typically examines aggregated index-level data. However, because of market and regulatory differences, US evidence may not be indicative of behaviour outside of a US market setting. Stambaugh, Yu, and Yuan (2012) suggested that short selling constraints are the main barrier to eliminating sentiment-driven mispricing.[3] Short selling in the UK is regulated by the Financial Services Authority (FSA) whose short selling provisions are more relaxed as compared to those in the US (Au, Doukas, and Onayev 2009). Specifically, the most notable difference between the US and the UK market is the absence of the 'up-tick'[4] rule in the UK. In a discussion paper in 2002, the FSA argued that the implementation of a US-style up-tick rule would hamper market efficiency and prevent the acceleration of price corrections of overvalued securities (FSA 2002). The findings of Chu, Hirshleifer, and Ma (2020) highlighted the effect of short sale regulations on the behaviour of stock market anomalies; these results showed that a temporary removal of the price test restrictions on short sales had a significant impact on the performance of stock market anomalies in the US. Therefore, since the UK stock market imposes less stringent regulations on short selling, it is predicted that stock market anomalies should be weaker in the UK stock market and investor sentiment has a limited impact on these anomalies compared to the US stock market.

In addition to the regulatory differences on short selling, there are some differences between the UK and the US stock markets. For instance, Petrovic, Manson, and Coakley (2016) highlighted that stocks in the UK are generally smaller and less liquid than those in the US market.[5] Besides, the adoption of International Financial Reporting Standards (IFRS) by UK firms in 2005 represents an influential difference between the UK and US stock markets.[6]

3. Data and Summary Statistics

3.1. Anomalies

This study explores the effect of market-wide changes in investor sentiment and limits to arbitrage on nine equity market anomalies using data for a broad cross section of UK stocks. These anomalies include net operating assets, asset growth, investment to assets, momentum, return on assets, turnover, net stock issuance, composite stock issuance and gross profit. Monthly prices and accounting data for a cross section of UK stocks were obtained from Thomson Reuters Datastream and WorldScope. The total sample consisted of 2,381 UK-listed companies from January 1997 to December 2019. To ensure that the sample did not suffer from survivorship bias, both active and dead[7] stocks were included. This study applied a number of filters in order to improve the quality of the dataset. First, it required each stock to be a major security (Security = Y), listed on the London Stock Exchange (EXNAME = London) and identified by Datastream as a common stock (Type = EQ). However, many stocks may escape the Datastream filtering of common stocks, and, therefore, following Griffin, Kelly, and Nardari (2010) and Schmidt et al. (2015), an additional manual company name filter was applied to exclude securities that may not have been captured by the Datastream filtering. This additional filter included non-common stocks such as preferred stock, American Depositary Receipts, investment trusts, real estate investment trusts, mutual funds and index funds. Second, a number of screening procedures of the monthly returns were applied, as suggested by Ince and Porter (2006) and Lu, Stambaugh, and Yuan (2017). These included the removal of returns over 300 per cent that is reversed within one month and any returns that fell in the 0.10 and 99.90 per cent percentiles. A similar screening was also applied to the anomaly variables; for the net operating assets, momentum, return on assets, turnover, net stock issuance and composite stock issuance, the top and bottom one per cent of the anomaly values were removed every month in order to avoid the effect of outliers.[8] The accounting information that was required to construct the anomalies in this study was downloaded from WorldScope; each stock had to have available data for the anomaly sorting variable and positive total assets for it to be included in the sample. Finally, to ensure that accounting data were publicly available in the anomaly formation month, this study followed the steps of Lu, Stambaugh, and Yuan (2017) and required a four-month gap between the anomaly formation month and the end of the financial year.[9] This means that, at the anomaly formation month $t-1$, accounting data with the fiscal year end between $t-5$ and $t-16$ were considered to be the most recent accounting information.[10] The number of firms varied across months and anomaly variables. However, the average number of firms from all nine anomalies across all months is 1,122 after applying all filtering procedures and removing missing data.

3.2. UK Investor Sentiment

The investor sentiment index for the UK was constructed following Baker, Wurgler, and Yuan (2012) using the Principal Components Analysis (PCA), which takes the first principal component of four sentiment proxies. These proxies included volatility premium (PVOL), the number of initial public offerings (IPO), the first day returns of an IPO, and market turnover. PVOL essentially identifies periods when the valuation of high volatility stocks is higher than the valuation of low volatility stocks. Baker, Wurgler, and Yuan (2012) suggested this proxy as an alternative to the dividend premium for non-US countries, where dividends, in most cases, are uncommon or are not viewed by local investors as a sign of stability, as historically shown by US investors. PVOL was measured as the monthly log ratio of the equally-weighted average market-to-book ratios of stocks with high volatility (top three deciles) and stocks with low volatility (bottom three deciles). The second and third proxies of the Baker, Wurgler, and Yuan (2012) investor sentiment index are the monthly number of public initial offerings (IPOs) and their average first-day returns. The number of IPOs (NIPO) was computed as the log of the

The figure shows the historical behaviour of the composite UK investor sentiment index from January 1997 to December 2019. The index is the first principal component of four sentiment proxies. These proxies are volatility premium (PVOL), the number of initial public offerings (IPO), the first day returns of an IPO, and market turnover.

Figure 1. The Composite UK Investor Sentiment Index

number of IPOs in any given month from January 1997 to December 2019. However, following Baker and Wurgler (2006), the index used the sum of NIPO over the prior six months to smooth noise, and then used the *t-6* value of the result.[11] Over the examined period, there were 3,365 new IPOs in the UK stock market. The initial returns on IPOs (RIPO) are the equally-weighted average of the first-day returns of IPOs in that month. Similar to NIPO, the index used the NIPO average over the prior six months to smooth noise, and then used the *t-6* value of the result. The last sentiment proxy is market turnover (TURN), TURN was measured as the monthly log of the total dollar volume of the FTSE all-share index over the month divided by the total capitalisation of the FTSE All-Share index over the previous month.

The PCA procedure leads to a composite index with the following weights:

$$Sentiment_t = 0.44RIBO_t + 0.60NIBO_t + 0.52VOL_t + 0.42TUR_t \quad (1)$$

The results show that the proportion of variance explained by the first principal component is 0.52 per cent, therefore, one factor captures much of the common variation in the four sentiment proxies. The proportion of variance explained for this four-factor index is comparable to the 0.49 per cent reported in Baker and Wurgler (2006) for a six-proxy index of US investor sentiment. Figure 1 shows the historical behaviour of the composite UK investor sentiment index. It is apparent from the figure that there were distinct periods of high and low investor sentiment over the period considered; the lowest investor sentiment occurred during the 2008/09 Global Financial Crisis, while it peaked in 2005.

3.3. Measures of Limits to Arbitrage

This study considers three categories of limits to arbitrage; each category consists of two measures of limits to arbitrage except the arbitrage risk category, which includes only one measure. The five measures were selected based on a literature survey (Wurgler and Zhuravskaya 2002; Jacobs 2015; Zaremba, 2015).[12] The first category represents the risk that arbitrageurs face when they decide to put arbitrage capital at risk; the second category deals with constraints relating to transaction costs; and the third is the interest rate spread, which measures the

aggregate cost of short-term borrowing for large financial institutions. Each of the five proxies were examined separately and then a composite index[13] of the five measures was constructed to investigate the combined effect of the six measures on the profitability of the nine anomalies.

Studies have suggested that arbitrageurs in stock markets are confronted with arbitrage risk, which can undermine their ability and willingness to engage in arbitrage activity. Arbitrage risk refers to the risk that, in the short-term, the prices of two hedged securities may not converge in a smooth and systematic way. Even worse, in extreme circumstance, the actions of irrational traders in the stock market may lead to the widening of mispricing between the two securities. If this happened in real-world arbitrage, and assuming an arbitrageur has limited access to capital, the arbitrageur will experience a loss on the arbitrage. Therefore, arbitrage risk can be defined as the idiosyncratic portion of a security's total volatility that arbitrageurs are not able to eliminate by holding an offsetting position in other similar securities or indexes (Wurgler and Zhuravskaya 2002; Mendenhall 2004). In this analysis, idiosyncratic volatility was used as a proxy for arbitrage risk. To estimate the market-wide idiosyncratic volatility of the UK stock market, this study considered the equally-weighted average idiosyncratic volatility of all stocks listed in the FTSE All Share[14] index as the first measure of limits to arbitrage. To calculate idiosyncratic volatility this study follows Ang et al. (2006), for a given month, the stock's idiosyncratic volatility was computed as the standard deviation of the residual, which was obtained from regressing the daily excess return of the stock on the daily Fama and French (1993) three factor model. To minimise the effect of outliers, each stock was required to have at least 15 observations in a single month to be included in the sample of that month.[15]

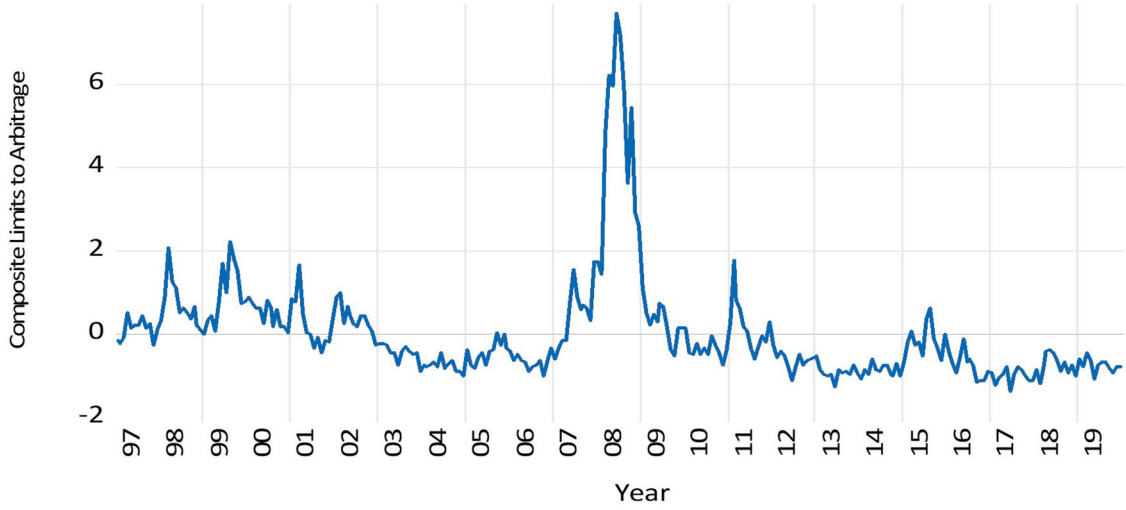
The second category of limits to arbitrage that is examined in this study relates to the stock's transaction cost. When a stock is mispriced and arbitrageurs are aware of the mispricing in the market, transaction costs may still hinder arbitrageurs from taking advantage of it and eliminating it. Transaction costs and trading expenses reduce the profitability of arbitrage strategies, making them less attractive to investors. Therefore, stocks with higher transaction costs are, in general, more likely to exhibit larger mispricing (Ali, Hwang, and Trombley 2003). Prior literature has identified two types of transactions costs: direct transaction costs and indirect transaction costs. Direct transaction costs are the expenses incurred directly by the traders when buying or selling a security in the financial markets; these expenses include bid-ask spreads, brokerage commissions and any direct taxes (Ali, Hwang, and Trombley 2003). By contrast, indirect transaction costs include factors that can adversely affect the price of a security or delay the processing of a transaction.

This study considers the UK market-wide bid-ask spread as a measure of the direct transaction costs that may deter investors from engaging in arbitrage activities. The market-wide measure of the ask-bid spread was estimated using the proposed algorithm in Corwin and Schultz (2012). Corwin and Schultz (2012) developed a bid-ask spread estimator from daily high and low prices that has a 0.9 correlation with the actual bid-ask spread. To estimate the monthly market-wide ask-bid spread of the UK stock market, this study considered the equally-weighted average ask-bid spread of all stocks listed in the FTSE All Share index. Daily bid-ask spreads for individual stocks were computed using data of daily high and low prices. The second measure of transaction costs considered in this study was the Amihud (2002) illiquidity ratio. This ratio is one of most popular measures used by investors to determine stock liquidity. To estimate the monthly market-wide illiquidity of the UK stock market, this study considered the equally-weighted average illiquidity of all stocks listed in the FTSE All Share index.

The final category of arbitrage limitations is interest rate spreads, which aim to measure the availability of funds in the financial system. It consists of two main measures: the UK LIBOR rate and the Ted spread. The LIBOR and Ted spreads are good macroeconomic proxies for the aggregate cost of short-term borrowing for large financial institutions (Ang, Gorovyy, and Van Inwegen 2011).[16] Using the five measures outlined above, the PCA leads to a limits to arbitrage composite index with the following weights:

$$Limits\ to\ Arbitrage_t = 0.55IVOL_t + 0.42BidAsk_t + 0.54\text{Illiquidity}_t + 0.40Ted_t + 0.28LIBOR_t \quad (2)$$

The results show that the proportion of variance explained by the first principal component is 0.53 per cent, while idiosyncratic volatility and the Amihud illiquidity proxies provide the largest weight in the construction of the composite limits to arbitrage index. Figure 2 shows a plot of the composite limits to arbitrage index over the time period considered.



The figure shows the historical behaviour of the composite limits to arbitrage index from January 1997 to December 2019. The index is the first principal component of five limits to arbitrage proxies. These proxies are idiosyncratic volatility, ask-bid spread, the Amihud (2002) illiquidity ratio, the LIBOR rate and the Ted spread.

Figure 2. The Composite Limits to arbitrage Index

Table 1. Summary Statistics of the Anomaly Variables.

Anomaly	Mean	Median	Std. Dev.	Min	Max	Skew.	Kurt.
Net operating assets (NOA)	0.60	0.65	0.61	−2.89	2.97	−1.33	8.02
Asset growth (AG)	0.09	0.06	0.69	−0.98	9.90	5.82	49.72
Investment-to-assets	0.04	0.02	0.22	−0.99	6.10	3.92	83.85
Momentum	0.06	0.05	0.61	−1.45	2.04	1.61	14.07
Return on assets (ROA)	−0.02	0.05	0.21	−0.87	0.44	−2.19	5.63
Turnover	0.06	0.03	0.09	0.00	1.82	6.91	81.76
Net stock issuance (NCI)	0.02	0.00	0.06	−0.11	0.38	1.44	3.13
Composite stock issuance (CSI)	0.08	0.01	0.83	−0.97	1.34	1.39	7.18
Gross profit	0.37	0.32	0.28	−0.12	0.99	1.18	1.69

The table provides mean, median, standard deviation, minimum, maximum, skewness, and kurtosis statistics for each of the nine anomaly sorting variables over the sample period January 1997 to December 2019. The Mean is the equally – weighted average of all monthly observations. Median is the middle value of the series. Std. Dev indicates the standard deviation of the series. Min is the minimum value and Max represents the maximum value. Skewness is the Kendall-Stuart measure of Skewness and Kurtosis is the Kendall-Stuart measure of Kurtosis.

3.4. Summary Statistics

Table 1 presents the mean, median, standard deviation, skewness and kurtosis of each of the anomaly sorting variables. The table shows that the annual median of asset growth of all firms in the sample is 0.06 per cent with a relatively large standard deviation of 0.69 per cent. As expected, the momentum variable shows a positive annual median of about 0.05 per cent. The median of gross profit shows that, on average, most of the UK firms reported positive gross profit with respect to total revenue, with an annual median of 0.32 per cent. For some anomaly variables, the standard deviation, skewness, and kurtosis are substantial. The values of skewness and kurtosis for the most anomaly variables show some evidence of non-normal distribution, this especially true for anomalies such as the asset growth, investment to assets, momentum and turnover strategies which associated with high skewness and kurtosis. Table 2.1A and 2.2A in Appendix 2 reports summary statistics of investor sentiment and limits to arbitrage proxies and time series correlation among anomaly variables.

Table 2. Anomaly Returns

Anomaly	Long Leg	Short Leg	Long-Short
Net operating assets	0.70***	−0.84***	1.54***
	(5.06)	(−2.91)	(5.73)
Asset growth	0.34**	−0.58***	0.92***
	(2.36)	(−2.93)	(5.82)
Investment to assets	0.25	−0.58**	0.83***
	(1.57)	(−2.75)	(4.78)
Momentum	0.48**	−1.05***	1.53***
	(2.25)	(−3.05)	(4.20)
Return on assets	0.50***	−1.11***	1.61***
	(3.83)	(−3.33)	(5.13)
Turnover	0.70***	−1.36***	2.06***
	(3.71)	(−6.92)	(10.01)
Net stock issuance	0.03	−0.26	0.29
	(0.13)	(−1.25)	(1.54)
Composite stock issuance	0.03	−0.47***	0.51***
	(0.23)	(−3.15)	(4.60)
Gross profit	0.44***	−0.34	0.78***
	(3.70)	(−1.07)	(2.67)

Table 2 shows the equally-weighted risk adjusted average monthly returns of hedged portfolios, which are long and short extreme deciles of stocks sorted by a given anomaly variable. The returns represent the risk-adjusted returns, which were computed using the Fama and French (1993) three factor model in Equation [3]. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). The table reports the results for the full sample from January 1997 to December 2019. Note: ∗ indicates significance at the ten per cent level, ∗∗ indicates significance at the five per cent level, and ∗∗∗ indicates significance at the one per cent level.

4. Empirical Analysis

4.1. Anomalies and the Cross-Section of Expected Stock Returns

The analysis in this study starts by estimating the returns of the nine portfolios constructed by sorting stocks into deciles based on anomaly variables. Each month, stocks in the sample were sorted into ten equal deciles, with the long leg being the higher-performing and the short leg the lower-performing decile. Table 2 reports the alphas (in percentage terms) of the monthly average return spread between the portfolios containing stocks in the highest and lowest deciles of the ranking variable. The alphas represent the benchmark-adjusted returns, which were computed using the Fama and French (1993) three factor time series model:

$$R_{i,t} = a_i + b_i(MKT_t) + c_i(SML_t) + d_i(HML_t) + \varepsilon_{i,t} \tag{3}$$

where $R_{i,t}$ is the excess return (returns in excess of the monthly Treasury bill rate) from the strategy i in month t, MKT_t is the market excess return, SMB_t is the size risk premium, HML_t is the value risk premium and the regression estimate of a_i is the portfolio monthly average risk-adjusted return. The table shows that, with the exception of net stock issuance, the long-short of all stock market anomalies have positive and statistically significant alphas as compared to the Fama and French (1993) three factor model. The results from Table 2 suggest that a hedged strategy based on turnover generated the strongest returns when compared with the eight remaining anomalies, with a monthly average return of 2.06 per cent that is statistically different from zero at the one per cent significance level. Other anomalies also yielded significant positive average returns. For example, hedged portfolios constructed based on net operating assets, momentum and return on assets all generated significant monthly average excess returns of 1.54, 1.53 and 1.61 per cent, respectively.

The results reported in Table 2 reveals that short positions are the primary driver of returns for these anomalies; with the exception of gross profit, all of the nine anomalies generated higher returns from the short leg than the returns from the long leg. There are six anomalies where the long leg of the strategy yielded significant returns (net operating assets, asset growth, momentum, return on assets, turnover and gross profit) while the long leg for the remaining three anomalies were not statistically significant. However, even for anomalies with a significant long-leg, the short-leg of the strategy remains the major contributor of the total returns of the hedged portfolio. One example is the return on assets anomaly, where the long leg generated a significant 0.50 per cent return, with a t-statistic of 3.83, while the short leg earned 1.11 per cent, with a t-statistic of – 3.33.

Results from this section show that the returns associated with some of these anomalies can be large in an economic sense and have the potential to offer a profitable trading return. For instance, the return on assets anomaly in Table 2 has a monthly average return of 1.61 per cent per month, which corresponds to 19.32 per cent per annum. Other strategies such as net operating assets, momentum and turnover are of a similar magnitude with average returns of 18.48, 18.36 and 24.72 per cent per annum, respectively. In addition, the findings from Table 2, which indicate that eight of the nine anomalies produce significantly higher returns relative to the Fama and French (1993) three factor model, could be taken as strong evidence of stock market inefficiency and aligns with the US and international evidence linking these nine anomalies with abnormally high returns. For example, the findings support Stambaugh, Yu, and Yuan (2012) who found that these anomalies generate positive risk-adjusted returns in the US stock market. In the UK stock market, the risk-adjusted returns generated from the momentum, assets growth and turnover strategies support Cotter and McGeever (2018) who demonstrated that these anomalies produced high unexplained abnormal returns in the UK stock market over the period from 1990 to 2013.

The results from the analysis, which indicate that the returns from these anomalies are mainly driven by the short leg, are consistent with the idea that the returns from the long leg are easier to exploit by investors and are, therefore, eliminated. By contrast, short sales, as a form of limits to arbitrage, may prevent investors from exploiting the excess returns generated by the short leg. The finance literature has identified several constraints that explain why arbitrageurs fail to bring prices back to their fundamental values. For example, Barberis, Shleifer, and Vishny (1998) considered non-fundamental risk generated by noise traders, Shleifer and Vishny (1997) referred to constraints on equity capital, whilst other studies have suggested short selling constraints (Miller 1977; Harrison and Kreps 1978).

4.2. Anomalies Returns: High versus Low UK Investor Sentiment

This section considers the first hypothesis that the performance of stock market anomalies should be stronger following high sentiment and more driven by the short leg of each anomaly. Table 3 reports the average risk-adjusted returns following high and low levels of investor sentiment. A high-sentiment month is one in which the value of the sentiment index in the previous month is above the median value for the sample period, and the low sentiment months are those with below-median value.

$$R_{i,t} = a_{H,i}(d_{H,t}) + a_{L,i}(d_{L,t}) + b_i(MKT_t) + c_i(SML_t) + d_i(HML_t) + \varepsilon_{i,t} \tag{4}$$

where $d_{H,t}$and $d_{L,t}$are dummy variables indicating high and low sentiment periods, and the average returns in high – and low-sentiment periods are estimates of $a_{H,i}$and $a_{L,i}$ in Equation [4]. However, to capture the return difference between high sentiment and low sentiment periods, Equation [4] is restructured as follow:

$$R_{i,t} = a_i + a_{S,i}(d_{S,t}) + b_i(MKT_t) + c_i(SML_t) + d_i(HML_t) + \varepsilon_{i,t} \tag{5}$$

where $d_{S,t}$ is a dummy variable that takes the value of one when sentiment is high and zero when sentiment is low, and the estimate of $a_{S,i}$ in the equation represents the anomaly return difference between high and low sentiment periods.

The results in Table 3 reveal that five of the nine anomalies, namely, net operating assets, momentum, return on assets, turnover, and composite stock issuance had stronger long-short returns following periods of high sentiment, and that the differences between the returns following high and low sentiment periods are statistically significant at the five per cent level.

In Table 3, the t-statistics from the five anomalies reject, at the five per cent significance level, the null hypothesis of no difference in returns between high and low sentiment months. For example, the net operating assets, return on assets and momentum earn 1.41, 1.54 and 1.76 per cent more per month following high sentiment with t-statistics indicating significance at the five per cent significance level. The other two remaining anomalies (turnover and composite stock issuance) were less affected by waves of investor sentiment when compared to the net operating assets, return on assets and momentum strategies. The turnover and composite stock issuance

Table 3. Anomaly Returns Following High and Low UK Sentiment Periods

	Long Leg			Short Leg			Long-Short		
Anomaly	High Sentiment	Low Sentiment	Difference	High Sentiment	Low Sentiment	Difference	High Sentiment	Low Sentiment	Difference
Net operating assets	0.44**	0.96***	−0.52*	−1.81***	0.12	−1.93***	2.25***	0.84**	1.41***
	(2.22)	(4.96)	(−1.91)	(−4.51)	(0.29)	(−3.42)	(5.96)	(2.25)	(2.85)
Asset growth	0.13	0.55***	−0.42	−1.03***	−0.13	−0.90**	1.17***	0.69***	0.48
	(0.64)	(2.70)	(−1.45)	(−3.71)	(−0.48)	(−2.30)	(5.19)	(3.08)	(1.52)
Investment to assets	0.04	0.45**	−0.41	−0.81***	−0.36	−0.45	0.84***	0.81***	0.03
	(0.17)	(2.06)	(−1.32)	(−2.70)	(−1.20)	(−1.06)	(3.43)	(3.31)	(0.10)
Momentum	0.60**	0.36	0.24	−1.81***	−0.29	−1.52**	2.41***	0.65	1.76**
	(1.99)	(1.19)	(0.58)	(−3.73)	(−0.63)	(−2.20)	(4.71)	(1.29)	(2.43)
Return on assets	0.20	0.80***	−0.61**	−2.19***	−0.04	−2.15***	2.39***	0.84*	1.54**
	(1.02)	(4.24)	(−2.25)	(−4.72)	(−0.09)	(−3.29)	(5.41)	(1.93)	(2.48)
Turnover	0.68**	0.72**	−0.04	−2.02***	−0.70***	−1.32***	2.70***	1.42***	1.28***
	(2.01)	(2.16)	(−0.09)	(−7.38)	(−2.61)	(−3.40)	(9.38)	(5.01)	(3.23)
Net stock issuance	0.06	0.01	0.05	−0.52*	0.00	−0.52	0.58**	0.01	0.57
	(0.17)	(0.02)	(0.10)	(−1.76)	(−0.01)	(−1.24)	(2.15)	(0.03)	(1.50)
Composite stock issuance	0.08	−0.01	0.09	−0.71***	−0.24	−0.47	0.79***	0.23	0.56***
	(0.40)	(−0.06)	(0.33)	(−3.34)	(−1.14)	(−1.57)	(5.11)	(1.49)	(2.58)
Gross profit	0.23	0.64***	−0.41	−0.47	−0.21	−0.27	0.71*	0.85**	−0.14
	(1.02)	(2.84)	(−1.27)	(−1.06)	(−0.46)	(−0.42)	(1.70)	(2.07)	(−0.24)

This table reports the alphas (in percentage terms) of the monthly average risk-adjusted returns (with respect to the Fama and French (1993) model) following high and low levels of investor sentiment, as classified according to the median level of the UK investor sentiment index. The average returns in high – and low-sentiment periods are estimates of $a_{H,i}$and $a_{L,i}$ in Equation [4], while the estimate of $a_{S,i}$ in Equation [5] represents the anomaly return difference between high and low sentiment periods. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). The table reports the results for the full sample from January 1997 to December 2019. Note: ∗ indicates significance at the ten per cent level, ∗∗ indicates significance at the five per cent level, and ∗∗∗ indicates significance at the one per cent level.

produced excess returns of 1.28 and 0.56 per cent more per month following high sentiment (all significant at the five per cent significance level).

The results present evidence that investor sentiment in the UK may have a different impact on different strategies. For the asset growth, investment to assets and net stock issuance strategies, the returns following high sentiment periods were stronger than following low sentiment periods. However, the difference in returns between the two periods is not statistically significant. The only exception to these results is the gross profit strategy, where the long-short spread of the strategy is less following high sentiment by – 0.14 per cent, however, the difference between the two periods is not statistically significant. While it is challenging to provide a precise explanation of why investor sentiment does not exert an equal impact on every individual anomaly, the varying effect of sentiment can be attributed to several factors. One factor is related to the characteristic of each anomaly, as different anomalies may have distinct characteristics that make them more or less susceptible to sentiment. For example, Baker and Wurgler (2006) suggested that the impact of sentiment is more noticeable on firms that are hard to arbitrage, such as small stocks, young stocks, high volatility stocks, unprofitable stocks, non-dividend-paying stocks, extreme growth stocks, and distressed stocks. Prior studies have linked stock market anomalies to some of these characteristics, for instance, Lam and Wei (2011) found that the asset growth anomaly is more concentrated in stocks that are difficult to arbitrage. Similarly, Chou, Huang, and Yang (2013) supplied evidence that turnover effect is more pronounced among stocks with high idiosyncratic volatility. Another factor is related to the suggested behavioural explanations provided by previous literature for certain stock market anomalies. For instance, previous studies associated the net stock issuance and composite equity issues with managers optimism (Daniel and Titman 2006), momentum with investors underreaction (Jegadeesh and Titman 1993), and net operating assets with investors limited attention (Hirshleifer et al. 2004).

Additional findings from Table 3 indicate that investor sentiment has a strong impact on the profitability of the short legs and marginally affect the long legs of the nine strategies. In Table 3, the short legs of all nine anomalies have a lower average return (more profitable) following high sentiment, and five of them have t-statistics that reject the null hypothesis of no difference in returns between high and low sentiment months. The only four strategies with short legs that are not affected by investor sentiment are the investment to assets, net stock issuance, composite stock issuance and gross profitability anomalies. The long legs from the nine anomalies are less affected by investor sentiment. Even though the long legs of seven of the nine anomalies have higher returns following low sentiment than high sentiment months, only one strategy (return on assets) have t-statistics that reject the null hypothesis of no-returns difference between high and low sentiment months at the five per cent significance level. The long legs of the other remaining anomalies appear to be unaffected by swings in UK investor sentiment.

The evidence from Tables 2 and 3 support the theoretical argument that, with constraints on short sale and limits on arbitrage, overpricing should be more common in stock markets than underpricing. In Tables 2 and 3, the empirical results show that stock market anomalies are stronger following high sentiment and mainly driven by the short legs, which supports the overpricing argument. A market with short sale constraints will only impound the view of optimistic investors, leading to inflated stock prices. When informed investors are restricted from taking short positions, a small group of optimistic investors could bid up the price of stocks beyond their fair value leading to inflated stock prices and these stocks subsequently experience lower returns (Miller 1977; Harrison and Kreps 1978). To some extent, the findings from the UK stock market support those from the US regarding the impact of investor sentiment on stock market anomalies. Stambaugh, Yu, and Yuan (2012), Jacobs (2015) and Doukas and Han (2021) found that investor sentiment plays a significant role in the profitability of stock market anomalies in the US.[17] The similar impact of investor sentiment in the US and the UK also does not support our initial prediction that less strict short sale regulations in the UK may limit the impact of investor sentiment on the stock market in the UK.

4.3. Anomalies Returns and Limits to arbitrage Proxies

This part sheds light on the second hypothesis that anomalies should produce higher returns when arbitrage limitations are high. Table 4 reports the average risk-adjusted returns following high and low levels of limits to arbitrage proxies, as classified according to the median value of each proxy. The average returns in high – and

Table 4. Anomaly Returns Following High and Low Levels of Limits to Arbitrage Measures

	Idiosyncratic Volatility			Bid-Ask Spread			Amihud Illiquidity		
Anomaly	High	Low	High-Low	High	Low	High-Low	High	Low	High-Low
Net operating assets	1.66***	1.42***	0.24	1.82***	1.26***	0.55	1.49***	1.60***	−0.11
	(4.34)	(3.72)	(0.43)	(4.80)	(3.30)	(1.02)	(3.91)	(4.20)	(−0.20)
Asset growth	0.84***	1.01***	−0.17	0.94***	0.90***	0.04	1.15***	0.70	0.45
	(3.71)	(4.48)	(−0.55)	(4.22)	(3.98)	(0.13)	(5.14)	(3.14)	(1.42)
Investment to assets	0.66***	0.99***	−0.33	0.91***	0.75***	0.16	0.72***	0.94***	−0.23
	(2.69)	(4.04)	(−0.95)	(3.72)	(3.02)	(0.46)	(2.90)	(3.86)	(−0.66)
Momentum	1.63***	1.44***	0.19	1.36***	1.70***	−0.34	1.48***	1.59**	−0.11
	(3.13)	(2.77)	(0.25)	(2.65)	(3.27)	(−0.46)	(2.86)	(3.09)	(−0.16)
Return on assets	1.81***	1.41***	0.40	1.72***	1.49***	0.23	1.86***	1.36***	0.50
	(4.06)	(3.17)	(0.63)	(3.90)	(3.34)	(0.37)	(4.20)	(3.10)	(0.80)
Turnover	2.48***	1.65***	0.83**	1.90***	2.23***	−0.33	2.41***	1.72***	0.69*
	(8.52)	(5.65)	(2.01)	(6.54)	(7.58)	(−0.79)	(8.31)	(5.93)	(1.70)
Net stock issuance	0.85***	−0.27	1.13***	0.28	0.30	−0.02	0.77***	−0.18	0.94**
	(3.22)	(−1.02)	(2.99)	(1.04)	(1.13)	(−0.07)	(2.88)	(−0.67)	(2.52)
Composite stock issuance	0.80***	0.20	0.60***	0.62***	0.39**	0.23	0.42***	0.59***	−0.17
	(5.26)	(1.30)	(2.77)	(3.97)	(2.48)	(1.04)	(2.72)	(3.81)	(−0.77)
Gross profit	0.38	1.17***	−0.79	0.49	1.07**	−0.58	0.77*	0.78*	−0.01
	(0.93)	(2.84)	(−1.35)	(1.20)	(2.59)	(−0.99)	(1.87)	(1.91)	(−0.02)

Anomaly Returns Following High and Low Levels of Limits to Arbitrage Measures (Continued)

Anomaly	Ted Spread			LIBOR Rate			Composite Limits to arbitrage		
	High	*Low*	*High − Low*	*High*	*Low*	*High − Low*	*High*	*Low*	*High − Low*
Net operating assets	1.62***	1.46***	0.16	1.48***	1.60***	−0.12	1.61***	1.47***	0.14
	(4.26)	(3.85)	(0.30)	(2.92)	(4.20)	(−0.21)	(4.25)	(3.86)	(0.26)
Asset growth	0.77***	1.08***	−0.31	0.91***	0.94***	−0.03	0.92***	0.93***	−0.01
	(3.42)	(4.84)	(−0.99)	(4.07)	(4.19)	(−0.11)	(4.09)	(4.14)	(−0.05)
Investment to assets	0.83***	0.83***	0.00	0.56**	1.10***	−0.53	0.82***	0.84***	−0.02
	(3.37)	(3.40)	(−0.01)	(2.32)	(4.49)	(−1.56)	(3.35)	(3.40)	(−0.06)
Momentum	1.45***	1.62***	−0.17	1.58***	1.48***	0.10	1.32**	1.75***	−0.43
	(2.80)	(3.15)	(−0.24)	(3.08)	(2.85)	(0.14)	(2.56)	(3.38)	(−0.59)
Return on assets	1.41***	1.81***	−0.40	1.75***	1.47***	0.28	1.71***	1.51***	0.20
	(3.18)	(4.10)	(−0.64)	(3.96)	(3.31)	(0.45)	(3.86)	(3.39)	(0.32)
Turnover	2.35***	1.78***	0.57	2.19***	1.93***	0.26	2.56***	1.56***	1.00**
	(8.07)	(6.15)	(1.38)	(7.54)	(6.63)	(0.63)	(8.88)	(5.39)	(2.44)
Net stock issuance	0.65**	−0.06	0.71*	0.25	0.33	−0.08	0.69**	−0.11	0.80**
	(2.43)	(−0.23)	(1.89)	(0.94)	(1.24)	(−0.21)	(2.58)	(−0.41)	(2.12)
Composite stock issuance	0.52***	0.49***	0.03	0.52***	0.50***	0.02	0.58***	0.43***	0.15
	(3.35)	(3.18)	(0.13)	(3.33)	(3.19)	(0.07)	(3.75)	(2.76)	(0.69)
Gross profit	0.55	1.01**	−0.46	0.92**	0.63	0.29	0.42	1.14**	−0.72
	(1.34)	(2.44)	(−0.76)	(2.25)	(1.53)	(0.49)	(1.03)	(2.77)	(−1.24)

This table reports the long-short alphas (in percentage terms) of the monthly average risk-adjusted returns (with respect to the Fama and French (1993) model) following high and low levels of idiosyncratic volatility, the bid-ask Spread and Amihud Illiquidity, as classified according to the median level of their indexes. The average returns in high – and low-arbitrage limitation periods are estimates of $a_{H,i}$and $a_{L,i}$ in Equation [4], while the estimate of $a_{S,i}$ in Equation [5] represents the anomaly return difference between high and low levels of limits to arbitrage. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). The table reports the results for the full sample from January 1997 to December 2019. Note: ∗ indicates significance at the ten per cent level, ∗∗ indicates significance at the five per cent level, and ∗∗∗ indicates significance at the one per cent level.

This table reports the long-short alphas (in percentage terms) of the monthly average risk-adjusted returns (with respect to the Fama and French (1993) model) following high and low levels of the Ted Spread, the LIBOR Rate and the Composite limits to arbitrage as classified according to the median level of their indexes. The average returns in high – and low-arbitrage limitation periods are estimates of $a_{H,i}$and $a_{L,i}$ in Equation [4], while the estimate of $a_{S,i}$ in Equation [5] represents the anomaly return difference between high and low levels of limits to arbitrage. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). The table reports the results for the full sample from January 1997 to December 2019. Note: ∗ indicates significance at the ten per cent level, ∗∗ indicates significance at the five per cent level, and ∗∗∗ indicates significance at the one per cent level.

low-arbitrage limitation periods are estimates of $a_{H,i}$and $a_{L,i}$ in Equation [4], where $d_{H,t}$is a dummy variable indicating high arbitrage limitations and $d_{L,t}$is a dummy variable indicating low arbitrage limitations.

Table 4 shows the returns of each of the nine anomalies following high and low levels of the limits to arbitrage proxies. The table demonstrates that arbitrage constraint proxies have a secondary role compared to investor

sentiment in explaining stock market anomalies in the UK. The table also shows that, out of the six limits to arbitrage measures, idiosyncratic volatility had the strongest effect on the returns of stock market anomalies. With the exception of asset growth, investment to assets and gross profitability, all of the nine anomalies have higher average returns following high periods of idiosyncratic volatility than periods of low idiosyncratic volatility. However, only three anomalies (turnover, net stock issuance and composite stock issuance) have an average return following high periods of idiosyncratic volatility that is significantly different from the returns following low periods of idiosyncratic volatility. The turnover, net stock issuance and composite stock issuance produce statistically significant excess returns of 0.83, 1.13 and 0.60 per cent more per month following high idiosyncratic volatility. The positive effect of idiosyncratic volatility on these stock market anomalies aligns with the theoretical prediction that, during periods of difficult arbitrage conditions, when arbitrageurs have limited ability to correct mispricing in the market, stock market anomalies may produce higher abnormal returns.

The other four limits to arbitrage measures have a very limited effect on the returns of the nine anomalies. The findings also show that none of the nine anomalies is significantly affected by changes in the bid-ask spread, the Ted spread and the LIBOR rate. However, the composite limits to arbitrage and Amihud illiquidity measures positively influence the returns of two anomalies: turnover and net stock issuance. In particular, the turnover and net stock issuance anomalies are about 1.00 and 0.80 per cent more pronounced in months following high composite limits to arbitrage than following periods of low composite limits to arbitrage. This finding is statistically significant at the five per cent level, and also substantial in relative terms. For example, difference in returns for the turnover anomaly of 1.00 per cent following high composite limits to arbitrage corresponds to about two-thirds of the average anomaly returns following times of lower than median composite limits to arbitrage. The Amihud illiquidity proxy has a weaker effect on the returns of the turnover and stock issuance anomalies; these two anomalies yielded abnormal returns of 0.69 and 0.94 per cent more following periods of high Amihud illiquidity as compared to periods of low Amihud illiquidity. However, the effect of Amihud illiquidity on the turnover anomaly is only significant at the ten per cent level.[18]

The partial effect of limits to arbitrage on stock market anomalies in the UK align with Jacobs' (2015) and Zaremba's (2016) findings for the US stock market. However, by contrast, a recent study by DeLisle, Yüksel, and Zaynutdinova (2020), where arbitrage risk and arbitrage cost played an important role in explaining the returns of profitability strategies based on gross and cash-based, they found that none of the limits to arbitrage proxies affected the risk-adjusted returns from a strategy constructed based on operating profitability.

4.4. Interaction between Investor Sentiment and Arbitrage Limitations

The third part of the analysis in this study examines the interaction between UK investor sentiment and arbitrage constraints, which provides a test of the third hypothesis that each anomaly strategy should yield the highest returns when sentiment is high and arbitrage conditions are tight. This study tests the returns of the nine anomalies following different periods of investor sentiment and limits to arbitrage. Table 5 reports the monthly average abnormal returns of each of the nine anomalies following interactions between the UK investor sentiment and limits to arbitrage. In order to examine the combined effect of investor sentiment and limits to arbitrage, the study created four separate binary measures that use the UK investor sentiment composite index and the composite index of limits to arbitrage, and the following time series equation was estimated:

$$R_{it} = a_{HH,i}(d_{HH,t}) + a_{LL,i}(d_{LL,t}) + a_{HL,i}(d_{HL,t}) + a_{LH,i}(d_{LH,t}) + b_i(MKT_t) + c_i(SML_t) + d_i(HML_t) + \varepsilon_{i,t} \quad (6)$$

where $d_{HH,t}$ is a dummy variable that combines high sentiment and high limits to arbitrage, and takes on a value of one when both investor sentiment and limits to arbitrage are above their median value in the previous month and zero otherwise. Similarly, $d_{LL,t}$ is a dummy variable that combines low sentiment and low limits to arbitrage periods. The last two dummy variables are $d_{HL,t}$ which combines high sentiment and low limits to arbitrage, while $d_{LH,t}$ combines low sentiment and high limits to arbitrage. The$a_{HH,i}$, $a_{LL,i}$, $a_{HL,i}$ and $a_{LH,i}$ in the equation are the average monthly abnormal returns associated with each of the four measures for strategy*i*. This method of examining the interaction between investor sentiment and limits to arbitrage represents an extension

Table 5. Long-Short Portfolio Returns Following Interactions between Investor Sentiment and Arbitrage Limitations

Anomaly	High sentiment and High limits to arbitrage ($a_{HH,i}$)	Low sentiment and Low limits to arbitrage($a_{LL,i}$)	High sentiment and Low limits to arbitrage ($a_{HL,i}$)	Low sentiment and High limits to arbitrage ($a_{LH,i}$)
Net operating assets	2.57***	1.14**	1.87***	0.47
	(5.05)	(2.26)	(3.34)	(0.85)
Asset growth	1.38***	0.94**	0.91***	0.36
	(4.56)	(3.16)	(2.74)	(1.10)
Investment to assets	1.04***	1.02***	0.60*	0.54
	(3.16)	(3.10)	(1.65)	(1.50)
Momentum	2.77***	1.53**	2.01***	−0.41
	(4.02)	(2.25)	(2.64)	(−0.55)
Return on assets	2.48***	0.88	2.28***	0.79
	(4.15)	(1.49)	(3.48)	(1.22)
Turnover	3.22***	1.13***	2.09***	1.79***
	(8.31)	(2.96)	(4.91)	(4.22)
Net stock issuance	0.77**	−0.47	0.34	0.59
	(2.13)	(−1.32)	(0.86)	(1.51)
Composite stock issuance	0.80***	0.16	0.77***	0.31
	(3.86)	(0.77)	(3.33)	(1.36)
Gross profit	0.27	1.07*	1.23**	0.59
	(0.49)	(1.93)	(2.01)	(0.98)

The table displays the nine anomalies long-short alphas (in percentage terms) of the monthly average risk-adjusted returns (with respect to the Fama and French (1993) model) following interactions between UK investor sentiment and the Composite limits to arbitrage measure, as classified according to the median level of their indexes. The average anomaly returns are the estimates of $a_{HH,i}$, $a_{LL,i}$, $a_{HL,i}$ and $a_{LH,i}$ in Equation [6]. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). UK investor sentiment is the first principal component of four sentiment proxies (volatility premium (PVOL), the number of initial public offerings (IPO), the first day returns of an IPO and market turnover). The composite limits to arbitrage measure is the first principal component of five limits to arbitrage measures (idiosyncratic volatility, the bid-ask spread, Amihud illiquidity, the Ted spread and the LIBOR rate). * indicates significance at the ten per cent level, ** denotes significance at the five per cent level and *** indicates significance at the one per cent level.

to the approach adopted by Stambaugh, Yu, and Yuan (2012) and Jacobs (2015) to examine the effect of investor sentiment on stock market anomalies.

The results in Table 5 show that, with the exception of gross profit, all of the nine anomalies generate their highest returns in months followed by high investor sentiment and high limits to arbitrage. For example, the monthly average return of the net operating asset anomaly following high sentiment and high limits to arbitrage is 2.57 per cent as compared to 1.14 per cent following low sentiment and low limits to arbitrage or 1.87 per cent following high sentiment and low limits to arbitrage. Another example is the turnover strategy, which yielded an average return of 3.22 per cent in months when sentiment and arbitrage limitations were both high in the previous month. This return is considerably higher than what the strategy generated following low sentiment and low limits to arbitrage months (1.13 per cent), high sentiment and low limits to arbitrage (2.09 per cent) or low sentiment and high limits to arbitrage (1.79 per cent). However, the results for the gross profit anomaly pose a challenge to the limits to arbitrage theory as it generated its highest returns following months of low arbitrage limitations.

Table 5 also demonstrates that the impact of high investor sentiment on stock market anomalies is more (less) pronounced when combined with high (low) limits to arbitrage.[19] The third column in Table 5 shows the average abnormal returns of the nine anomalies following both high sentiment and low limits to arbitrage. The results indicate that eight of the nine anomalies produce smaller alphas during months when high sentiment is combined with low limits to arbitrage as compared to months when high sentiment is combined with high limits to arbitrage. These anomalies are net operating assets, asset growth, investment to assets, momentum, return on assets, turnover, net stock issuance and composite stock issuance. For instance, the net operating assets, asset growth and momentum earned average monthly returns of 2.57, 1.38 and 2.77 per cent, respectively, following months combining high sentiment and high limits to arbitrage. However, even though the returns of these anomalies are statistically significant, they are substantially smaller when high sentiment is combined with low arbitrage limitations; they are 1.87, 0.91 and 2.01 per cent, respectively.

Table 6. Anomaly Returns Across Sub-Periods

	Long Leg			Short Leg			Long-Short		
Anomaly	Jan 1997 – Aug 2004	Sep 2004 – Apr 2012	May 2012 – Dec 2019	Jan 1997 – Aug 2004	Sep 2004 – Apr 2012	May 2012 – Dec 2019	Jan 1997 – Aug 2004	Sep 2004 – Apr 2012	May 2012 – Dec 2019
Net operating assets	0.28	0.82***	0.99***	−1.72***	−0.26	−0.57	2.00***	1.08**	1.56***
	(1.17)	(3.45)	(4.20)	(−3.43)	(−0.52)	(−1.14)	(4.27)	(2.32)	(3.37)
Asset growth	0.15	0.48*	0.40	−0.53	−0.57*	−0.58*	0.68**	1.06***	1.03***
	(0.59)	(1.92)	(1.58)	(−1.53)	(−1.68)	(−1.85)	(2.46)	(3.87)	(3.77)
Investment-to-assets	0.26	0.21	0.27	0.01	−0.74*	−1.09***	0.25	0.85***	1.36***
	(0.96)	(0.76)	(1.01)	(0.02)	(−1.77)	(−3.03)	(0.85)	(2.86)	(4.36)
Momentum	1.01***	0.34	0.11	−0.88	−0.95	−1.33**	1.88***	1.29**	1.43**
	(2.73)	(0.93)	(0.29)	(−1.45)	(−1.59)	(−2.23)	(2.95)	(2.04)	(2.28)
Return on assets	0.21	0.52**	0.77***	−1.82***	−0.95*	−0.56	2.04***	1.47***	1.33**
	(0.91)	(2.22)	(3.30)	(−3.16)	(−1.66)	(−0.99)	(3.73)	(2.71)	(2.47)
Turnover	0.82**	0.96**	0.32	−2.46***	−1.22***	−0.45	3.28***	2.19***	0.77**
	(1.99)	(2.37)	(0.80)	(−7.38)	(−3.70)	(−1.36)	(9.54)	(6.42)	(2.27)
Net stock issuance	0.34	−0.27	−0.50	−0.76**	−0.07	0.04	1.10***	0.34	−0.53*
	(0.82)	(−0.66)	(−1.21)	(−2.12)	(−0.19)	(0.11)	(3.40)	(1.05)	(−1.67)
Composite stock issuance	0.48**	−0.16	−0.21	−0.25	−0.47*	−0.70***	0.73***	0.31	0.49***
	(2.02)	(−0.68)	(−0.91)	(−0.94)	(−1.81)	(−2.70)	(3.80)	(1.63)	(2.58)
Gross profit	0.47*	0.20	0.64**	0.19	−0.21	−0.97*	0.29	0.41	1.61***
	(1.69)	(0.73)	(2.31)	(0.35)	(−0.39)	(−1.81)	(0.57)	(0.83)	(3.25)

This table reports the alphas (in percentage terms) of the monthly equally-weighted average return spread between the portfolios containing stocks in the highest and lowest deciles of the ranking variable. The table reports the results after splitting the full sample of 276 months to three equal sub-samples, one sample covering a period of 92 months from January 1997 to Aug 2004, a second sample covering a period of 92 months from Sep 2004 to Apr 2012, and a third sample covering a period of 92 months from May 2012 to Dec 2019. The returns represent the risk-adjusted returns, which were computed using the Fama and French (1993) three factor model in Equation [3]. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). Note: ∗ indicates significance at the 10 per cent level, ∗∗ indicates significance at the 5 per cent level, and ∗∗∗ indicates significance at the 1 per cent level.

Table 7. Anomaly Returns Following High and Low UK Sentiment Periods (Robustness Check under an Alternative Asset Pricing Model)

	Long Leg			Short Leg			Long-Short		
Anomaly	High Sentiment	Low Sentiment	Difference	High Sentiment	Low Sentiment	Difference	High Sentiment	Low Sentiment	Difference
Net operating assets	0.51**	1.00***	−0.49*	−1.29***	0.38	−1.66***	1.79***	0.62*	1.17**
	(2.48)	(5.09)	(−1.77)	(−3.18)	(0.97)	(−3.03)	(4.70)	(1.69)	(2.26)
Asset growth	0.30	0.64***	−0.34	−0.66***	0.05	−0.71*	0.96***	0.59***	0.38
	(1.41)	(3.11)	(−1.16)	(−2.38)	(0.18)	(−1.88)	(4.19)	(2.65)	(1.20)
Investment-to-assets	0.24	0.55**	−0.31	−0.55*	−0.23	−0.32	0.79***	0.78***	0.01
	(1.05)	(2.51)	(−1.00)	(−1.80)	(−0.80)	(−0.76)	(3.08)	(3.17)	(0.01)
Momentum	0.02	0.07	−0.05	−0.64	0.27	−0.91	0.65*	−0.20	0.85*
	(0.05)	(0.25)	(−0.14)	(−1.46)	(0.64)	(−1.52)	(1.76)	(−0.56)	(1.69)
Return on assets	0.17	0.79***	−0.62**	−1.74***	0.18	−1.92***	1.91***	0.61*	1.30**
	(0.86)	(4.13)	(−2.28)	(−3.68)	(0.39)	(−2.98)	(4.27)	(1.42)	(2.14)
Turnover	0.64*	0.70**	−0.06	−2.02***	−0.71***	−1.31***	2.66***	1.41***	1.25***
	(1.82)	(2.08)	(−0.13)	(−7.05)	(−2.57)	(−3.37)	(8.84)	(4.88)	(3.06)
Net stock issuance	0.00	−0.02	0.02	−0.41	0.05	−0.46	0.42	−0.07	0.48
	(0.01)	(−0.06)	(0.05)	(−1.35)	(0.17)	(−1.11)	(1.49)	(−0.26)	(1.28)
Composite stock issuance	0.21	0.05	0.16	−0.48**	−0.13	−0.35	0.69***	0.18	0.51**
	(1.03)	(0.26)	(0.57)	(−2.24)	(−0.62)	(−1.21)	(4.33)	(1.18)	(2.36)
Gross profit	0.28	0.69***	−0.42	−0.44	−0.16	−0.28	0.72*	0.85**	−0.14
	(1.20)	(3.14)	(−1.34)	(−0.96)	(−0.36)	(−0.45)	(1.67)	(2.07)	(−0.23)

This table reports the alphas (in percentage terms) of the monthly average risk-adjusted returns (with respect to the Carhart (1997) four factor model) following high and low levels of investor sentiment, as classified according to the median level of the UK investor sentiment index.

$$R_{i,t} = a_{H,i}(d_{H,t}) + a_{L,i}(d_{L,t}) + b_i(MKT_t) + c_i(SML_t) + d_i(HML_t) + e_i(MOM_t) + \varepsilon_{i,t}$$

Where MOM_t refers to the momentum premium, $a_{H,i}$ is the average risk-adjusted returns following high sentiment and $a_{L,i}$ is the average risk-adjusted returns following low sentiment. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). The table reports the results for the full sample from January 1997 to December 2019. Note: ∗ indicates significance at the ten per cent level, ∗∗ indicates significance at the five per cent level, and ∗∗∗ indicates significance at the one per cent level.

Table 8. Anomaly Returns Following High and Low Levels of Limits to Arbitrage Measures (Robustness Check under an Alternative Asset Pricing Model)

	Idiosyncratic Volatility			Bid-Ask Spread			Amihud Illiquidity		
Anomaly	High	Low	High-Low	High	Low	High-Low	High	Low	High-Low
Net operating assets	1.28***	1.08***	0.29	1.48***	0.87**	0.62	1.11***	1.25***	−0.14
	(3.38)	(2.88)	(0.37)	(3.99)	(2.29)	(1.19)	(2.95)	(3.35)	(−0.28)
Asset growth	0.67***	0.86***	−0.19	0.80***	0.73***	0.07	0.98***	0.55**	0.43
	(2.96)	(3.82)	(−0.61)	(3.59)	(3.21)	(0.23)	(4.38)	(2.48)	(1.40)
Investment-to-assets	0.62**	0.95***	−0.33	0.87***	0.70***	0.17	0.67***	0.90***	−0.23
	(2.45)	(3.80)	(−0.96)	(3.50)	(2.76)	(0.49)	(2.68)	(3.60)	(−0.66)
Momentum	0.23	0.19	0.04	0.16	0.26	−0.10	0.08	0.34	−0.26
	(0.62)	(0.52)	(0.07)	(0.44)	(0.71)	(−0.20)	(0.22)	(0.93)	(−0.51)
Return on assets	1.41***	1.06**	0.35	1.38***	1.08**	0.30	1.47***	1.01**	0.46
	(3.18)	(2.40)	(0.58)	(3.16)	(2.43)	(0.49)	(3.32)	(2.30)	(0.75)
Turnover	2.48***	1.55***	0.93**	1.85***	2.17***	−0.32	2.36***	1.67***	0.69*
	(8.29)	(5.23)	(2.26)	(6.25)	(7.19)	(−0.77)	(7.92)	(5.64)	(1.68)
Net stock issuance	0.72***	−0.39	1.11***	0.16	0.16	0.00	0.64**	−0.31	0.95**
	(2.67)	(−1.45)	(2.97)	(0.60)	(0.60)	(0.00)	(2.37)	(−1.15)	(2.56)
Composite stock issuance	0.73***	0.11	0.61***	0.53***	0.32**	0.21	0.34**	0.51***	−0.18
	(4.69)	(0.72)	(2.83)	(3.33)	(2.04)	(0.96)	(2.14)	(3.28)	(−0.82)
Gross profit	0.39	1.18**	−0.79	0.50	1.09**	−0.58	0.77*	0.78*	−0.01
	(0.93)	(2.81)	(−1.35)	(1.21)	(2.56)	(−1.00)	(1.87)	(1.91)	(−0.02)

This table reports the long-short alphas (in percentage terms) of the monthly average risk-adjusted returns (with respect to the Carhart (1997) four factor model) following high and low levels of idiosyncratic volatility, the bid-ask Spread and Amihud Illiquidity, as classified according to the median level of their indexes.

$$R_{i,t} = a_{H,i}(d_{H,t}) + a_{L,i}(d_{L,t}) + b_i(MKT_t) + c_i(SML_t) + d_i(HML_t) + e_i(MOM_t) + \varepsilon_{i,t}$$

Where $a_{H,i}$ is the average risk-adjusted returns following high limits to arbitrage and $a_{L,i}$ is the average risk-adjusted returns following low limits to arbitrage. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). The table reports the results for the full sample from January 1997 to December 2019. Note: ∗ indicates significance at the ten per cent level, ∗∗ indicates significance at the five per cent level, and ∗∗∗ indicates significance at the one per cent level.

The findings reported in Table 5 suggest that limits to arbitrage have a limited effect on stock market anomalies in the UK when tested separately, but the importance of arbitrage constraints becomes more significant when combined with investor sentiment. The results provide support for the limits to arbitrage theory, which suggests that arbitrageurs in stock markets are confronted with arbitrage constraints which can undermine their ability and willingness to engage in arbitrage activity – thus, leading to sentiment-driven mispricing in stock markets (Shleifer 2000; Shleifer and Summers 1990; Barberis and Thaler 2003). Aligning with this theoretical prediction, the results from the interactions between investor sentiment and arbitrage limitations reveal that anomalies in the UK are strongest when sentiment is high and arbitrage conditions are tight. Furthermore, the results indicate that when arbitrage limitations are low, investor sentiment has less effect on stock market anomalies. This result implies that arbitrageurs can partially eliminate sentiment-driven mispricing linked with these anomalies when arbitrage constraints are low. The findings provide a deeper understanding of the impact of investor sentiment on stock market anomalies that is documented in Table 3 and advance the ongoing academic debate on the effect of investor sentiment and limits to arbitrage in financial markets.

4.5. Robustness Check

This section considers further analysis of the main results presented in this article, including (i) a subsamples analysis; and (ii) an examination of the effect of investor sentiment and limits to arbitrage under an alternative risk model. To check the robustness of the abnormal returns from the nine anomalies studied in this paper, Table 6 examines their performance in three equal sub-samples. The table reports the results after splitting the full sample of 276 months into three equal sub-samples, one sample covering a period of 92 months from January 1997 to August 2004, a second sample covering a period of 92 months from September 2004 to April 2012, and

Table 8. Anomaly Returns Following High and Low Levels of Limits to Arbitrage Measures (Robustness Check under an Alternative Asset Pricing Model) (Continued)

	Ted Spread			LIBOR Rate			Composite Limit to Arbitrage		
Anomaly	High	Low	High-Low	High	Low	High-Low	High	Low	High-Low
Net operating assets	1.31***	1.05***	0.26	1.11***	1.25***	−0.14	1.30***	1.05***	0.25
	(3.51)	(2.79)	(0.50)	(2.96)	(3.34)	(−0.28)	(3.50)	(2.78)	(0.48)
Asset growth	0.63***	0.90***	−0.27	0.71***	0.82***	−0.12	0.78***	0.75***	0.03
	(2.83)	(4.01)	(−0.87)	(3.12)	(3.69)	(−0.37)	(3.50)	(3.31)	(0.09)
Investment-to-assets	0.79***	0.78***	0.01	0.52**	1.06***	−0.54	0.78***	0.79***	−0.01
	(3.17)	(3.12)	(0.02)	(2.09)	(4.23)	(−1.57)	(3.15)	(3.13)	(−0.03)
Momentum	0.30	0.12	0.18	0.21	0.20	0.01	0.19	0.23	−0.04
	(0.82)	(0.32)	(0.36)	(0.59)	(0.56)	(0.02)	(0.52)	(0.62)	(−0.08)
Return on assets	1.09**	1.38***	−0.30	1.36***	1.11**	0.25	1.39***	1.08**	0.31
	(2.48)	(3.14)	(−0.49)	(3.09)	(2.53)	(0.41)	(3.17)	(2.42)	(0.51)
Turnover	2.30***	1.72***	0.58	2.14***	1.88***	0.26	2.51***	1.49***	1.02**
	(7.76)	(5.75)	(1.42)	(7.17)	(6.32)	(0.62)	(8.56)	(5.00)	(2.48)
Net stock issuance	0.53**	−0.21	0.74**	0.12	0.21	−0.08	0.57**	−0.26	0.83**
	(1.98)	(−0.78)	(2.00)	(0.43)	(0.77)	(−0.25)	(2.14)	(−0.96)	(2.24)
Composite stock issuance	0.45***	0.40***	0.05	0.42***	0.43***	−0.01	0.50***	0.35**	0.15
	(2.87)	(2.53)	(0.23)	(2.70)	(2.71)	(−0.04)	(3.17)	(2.23)	(0.68)
Gross profit	0.56	1.01**	−0.45	0.93**	0.64	0.29	0.44	1.16**	−0.72
	(1.32)	(2.42)	(−0.77)	(2.23)	(1.53)	(0.50)	(1.05)	(2.73)	(−1.25)

This table reports the long-short alphas (in percentage terms) of the monthly average risk-adjusted returns (with respect to the Carhart (1997) four factor model) following high and low levels of the Ted Spread, the LIBOR Rate and the Composite limits to arbitrage as classified according to the median level of their indexes.

$$R_{i,t} = a_{H,i}(d_{H,t}) + a_{L,i}(d_{L,t}) + b_i(MKT_t) + c_i(SML_t) + d_i(HML_t) + e_i(MOM_t) + \varepsilon_{i,t}$$

Where $a_{H,i}$ is the average risk-adjusted returns following high limits to arbitrage and $a_{L,i}$ is the average risk-adjusted returns following low limits to arbitrage. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). The table reports the results for the full sample from January 1997 to December 2019. Note: ∗ indicates significance at the ten per cent level, ∗∗ indicates significance at the five per cent level, and ∗∗∗ indicates significance at the one per cent level.

a third sample covering a period of 92 months from May 2012 to December 2019. The results across the sub-samples provide confirmation of the abnormal returns associated with most of these nine anomalies. Out of the nine anomalies, seven strategies produced significant abnormal returns in at least two of the three sub-samples; net operating assets, asset growth, momentum, return on assets and turnover produced statistically positive abnormal returns in all three sub-samples, and two anomalies, including investment to assets and composite stock issuance, generated significant abnormal returns in two sub-samples. The net stock issuance and gross profitability anomalies were the only two anomalies that produced significant abnormal returns in just one sub-sample. However, it worth mentioning that net stock issuance was not significant for the full sample, as shown in Table 2.

Table 7 provides a robustness check by examining the impact of high versus low UK investor sentiment on the performance of the nine stock market anomalies under an alternative asset pricing model, which is the Carhart (1997) four factor model. The analysis in this section relied on the Fama and French (1993) three factor model to examine the impact of high versus low UK investor sentiment on the nine anomalies. The robustness check confirms the findings reported in Table 3 that, with the exception of the gross profit strategy, all nine stock market anomalies produced stronger returns following high periods of investor sentiment. The robustness check also showed that the same five strategies (net operating assets, momentum, return on assets, turnover, and composite stock issuance)[20] had significantly stronger long-short returns following periods of high UK sentiment than periods of low sentiment.

Table 8 provides robustness checks by examining the impact of the six measures of limits to arbitrage on the performance of the nine stock market anomalies under an alternative asset pricing model, which is the Carhart (1997) four factor model. The robustness checks confirm the limited impact of the individual limits to arbitrage proxies on the nine stock market anomalies and provide similar conclusions to the findings reported in Table 4.

Table 8. Long-Short Portfolio Returns Following Interactions between Investor Sentiment and Arbitrage Limitations (Robustness Check under an Alternative Assets Pricing Model)

Anomaly	High sentiment and High limits to arbitrage($a_{HH,i}$)	Low sentiment and Low limits to arbitrage($a_{LL,i}$)	High sentiment and Low limits to arbitrage($a_{HL,i}$)	Low sentiment and High limits to arbitrage($a_{LH,i}$)
Net operating assets	2.05***	0.74	1.50***	0.47
	(4.02)	(1.50)	(2.73)	(0.87)
Asset growth	1.16***	0.78**	0.76**	0.36
	(3.76)	(2.59)	(2.28)	(1.11)
Investment-to-assets	0.99***	0.98***	0.57	0.54
	(2.90)	(2.93)	(1.54)	(1.49)
Momentum	0.74	−0.01	0.57	−0.43
	(1.49)	(−0.02)	(1.06)	(−0.81)
Return on assets	1.92***	0.46	1.89***	0.79
	(3.20)	(0.79)	(2.91)	(1.24)
Turnover	3.16***	1.09***	2.05***	1.78***
	(7.90)	(2.79)	(4.75)	(4.22)
Net stock issuance	0.59	−0.63	0.19	0.56
	(1.58)	(−1.76)	(0.48)	(1.52)
Composite stock issuance	0.68***	0.09	0.70***	0.30
	(3.18)	(0.41)	(3.02)	(1.30)
Gross profit	0.29	1.08*	1.24**	0.60
	(0.51)	(1.92)	(2.00)	(0.98)

The table displays the nine anomalies long-short alphas (in percentage terms) of the monthly average risk-adjusted returns (with respect to the Carhart (1997) four factor model) following interactions between UK investor sentiment and the composite limits to arbitrage measure, as classified according to the median level of their indexes.

$$R_{i,t} = a_{HH,i}(d_{HH,t}) + a_{LL,i}(d_{LL,t}) + a_{HL,i}(d_{HL,t}) + a_{LH,i}(d_{LH,t}) + b_i(MKT_t) + c_i(SML_t) + d_i(HML_t) + e_i(MOM_t) + \varepsilon_{i,t}$$

Where the average anomaly returns are the estimates of $a_{HH,i}$, $a_{LL,i}$, $a_{HL,i}$ and $a_{LH,i}$. T-statistics (in parentheses) are based on the heteroskedasticity-consistent standard errors of White (1980). UK investor sentiment is the first principal component of four sentiment proxies (volatility premium (PVOL), the number of initial public offerings (IPO), the first day returns of an IPO and market turnover). The composite limits to arbitrage measure is the first principal component of five limits to arbitrage measures (idiosyncratic volatility, the bid-ask spread, Amihud illiquidity, the Ted spread and the LIBOR rate). * indicates significance at the ten per cent level, ** denotes significance at the five per cent level and *** indicates significance at the one per cent level.

Finally, Table 8 reproduces the results in Table 5 using an alternative asset pricing model, which is the Carhart (1997) four factor model. The outcome of the robustness check confirms that eight of the nine anomalies generated their highest returns in months followed by high investor sentiment and high limits to arbitrage. Similarly, the impact of high investor sentiment was more pronounced when combined with high limits to arbitrage.

5. Conclusion

This study has investigated the effect of UK investor sentiment and three categories of limits to arbitrage on the performance of nine UK stock market anomalies, including net operating assets, asset growth, investment to assets, momentum, return on assets, turnover, net stock issuance, composite stock issuance and gross profitability, over the 23-year period from January 1997 to December 2019. Furthermore, this study examined the interaction between investor sentiment and limits to arbitrage and its impact on the profitability of the nine anomalies. This latter part of the analysis aimed to test the theoretical prediction that arbitrageurs in stock markets are confronted with arbitrage constraints that can undermine their ability and willingness to engage in arbitrage activity, therefore, leading to sentiment-driven mispricing in stock markets (Shleifer and Summers 1990; Shleifer 2000; Barberis and Thaler 2003).

The results demonstrated that five strategies (net operating assets, momentum, return on assets, turnover and composite stock issuance) were related to changes in UK investor sentiment and produced significantly higher returns following periods of high investor sentiment. However, the results showed that limits to arbitrage measures played either a partial or no role in explaining the abnormal risk-adjusted returns from the nine

anomalies. Out of the five limits to arbitrage measures, idiosyncratic volatility had the strongest effect on stock market anomalies, where higher levels of the measure were associated with generally higher profitability from the turnover, net stock issuance and composite stock issuance anomalies.

Findings from the interaction of investor sentiment and limits to arbitrage demonstrated that long-short portfolios from the nine anomalies generated their highest returns following months when both investor sentiment and limits to arbitrage were high, except gross profit. In addition, the findings revealed that the effect of high investor sentiment on stock market anomalies was more pronounced when combined with high limits to arbitrage and they had less effect during periods characterised by low limits to arbitrage. The results indicated that eight of the nine anomalies produced smaller alphas during months when high sentiment was accompanied with low limits to arbitrage as compared to months when high sentiment was combined with high limits to arbitrage.

Finally, this research has some limitations that future studies may address. First, the investor sentiment and limits to arbitrage indexes were constructed using Principal Components Analysis. This approach estimates index coefficients based on data from the entire sample period, which might introduce look-ahead bias. Future research could explore alternative methods that mitigate this bias. Second, the classification of high and low sentiment periods relies on the median value of the sentiment index for the entire sample. This approach can be sensitive to small changes in the median value of the index.

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Notes

1. Instead of examining investor sentiment as an explanatory variable in the traditional unconditional versions of asset pricing models, Ho and Hung (2009) and Doukas and Han (2021) explored conditional versions that incorporated investor sentiment as a conditioning variable in the model. In particular, in the Doukas and Han (2021) study, the performance of the sentiment-scaled Capital Asset Pricing Model (CAPM) in explaining the size and value effects was comparable to the Fama and French (1993) three factor model, which included specific factors for the size and value premiums, thus demonstrating evidence for the ability of investor sentiment to capture the size and value anomalies.
2. The authors argued that the effect of limits to arbitrage on gross and cash-based profitability, which indicated mispricing, was potentially attributable to their correlations with the SG&A expenses and accruals anomalies.
3. The short-sale constraints assumption is critical when investigating sentiment-driven mispricing and implies that sentiment-driven investors will only be active when they are optimistic and when the market is overvalued. When the sentiment of irrational investors is negative, the short-sale constraints will keep these irrational investors out of the market (Baker and Stein 2004). In addition, Miller (1977) stressed that, with constraints on short sales, a small group of optimistic investors could bid up the price of a security beyond its fair value. The author argued that when informed investors are restricted from taking short positions, stock prices will only impound the view of optimistic investors, leading to inflated stock prices.
4. The up-tick rule essentially requires that, before a stock can be sold short, the most recent movement of the stock price has to be upwards (Howell 2016).
5. Often small and illiquid stocks are associated with higher transaction costs and limits to arbitrage that prevent informed investors from constructing arbitrage strategies to exploit potential mispricing (Soares and Stark 2009).
6. It is worth mentioning that the mandatory adoption of IFRS in 2005 may have an impact on the performance of some stock market anomalies. For example, according to Papanastasopoulos (2020), the empirical evidence of more timely loss recognition following the adoption of IFRS may exert an impact on the mispricing of the accruals anomaly in the UK. Specifically, he found that the per cent accruals anomaly was stronger after the mandatory adoption of IFRS in 2005 across losing firms.
7. A stock is identified as dead by Datastream when it is delisted from the London Stock Exchange.
8. For the asset growth, gross profitability, and investment to assets anomalies, a specific screening procedure was applied, which is discussed in the calculation of these anomaly measures in Appendix 1.
9. This is true if the anomaly requires accounting information that is available on an annual basis.
10. More details on the construction of stock market anomalies are provided in Appendix 1.
11. The monthly number of IPOs in the UK was obtained from the London Stock Exchange website, which provides monthly reports since 1995 detailing new IPOs in the UK main market.
12. Other studies have also attempted to determine measures of limits to arbitrage. For example, the reader is referred to Ali, Hwang, and Trombley (2003); Mendenhall (2004); Ang, Gorovyy, and Van Inwegen (2011) and DeLisle, Yüksel, and Zaynutdinova (2020).
13. The composite index was created as the first principal component of the five measures.
14. Excluding Exchange Traded Funds and Investment Trusts
15. This procedure is also followed in the calculation of Corwin and Schultz (2012)'s bid-ask spread and Amihud (2002)'s illiquidity ratio.

16. Monthly data for the UK LIBOR rate and the Ted spread were downloaded from Datastream and the Federal Reserve Bank of St. Louis, respectively.
17. Table 2.3A in Appendix 2 reports predictive regressions with continuous measures of sentiment, which provide an alternative analysis to investigate whether the UK investor sentiment index can predict the returns from the nine investment strategies. The predictive regressions deliver the same conclusions as the comparison of high- and low-sentiment periods in Table 3, where the excess returns from net operating assets, momentum, return on assets, turnover and composite stock issuance had a positive and significant relationship with the lagged investor sentiment index; that is, where higher sentiment led to higher profitability of the strategies.
18. Table 2.4A in Appendix 2 provides results from predictive regressions with continuous limit to arbitrage measures, which represents a robustness check of the results in Tables 4. The outcomes of the predictive regressions almost mirror the binary analysis in Tables 4. Specifically, the results show that the idiosyncratic volatility measure has a significant positive relationship with the turnover, net stock issuance and composite stock issuance anomalies. The lagged composite limits to arbitrage measure has a significant positive relationship with the same two anomalies identified in Table 4 - that is, turnover and net stock issuance.
19. Out of the full sample of 276 months, there are 138 months of high sentiment, of which 76 months are combined with high limits to arbitrage and 62 months are combined with low limits to arbitrage.
20. Under this alternative analysis, the impact of UK investor sentiment on the momentum strategy was significant but only at the 10 per cent level. The reason for this may be that Carhart (1997) incorporates a specific risk factor, which targets the momentum strategy and reduces its profitability.

Data availability statement

The data that support the findings of this study are available from the corresponding author, [SGMF], upon reasonable request.This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors .

Disclosure statement

No potential conflict of interest was reported by the author(s).

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