Pairs Trading in the UK Equity Market
Risk and Return

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In this paper we provide the first comprehensive UK evidence on the profitability of the pairs trading strategy. Evidence suggests that the strategy performs well in crisis periods, so we control for both risk and liquidity to assess performance. To evaluate the effect of market frictions on the strategy we use several estimates of transaction costs. We also present evidence on the performance of the strategy in different economic and market states. Our results show that pairs trading portfolios typically have little exposure to known equity risk factors such as market, size, value, momentum and reversal. However, a model controlling for risk and liquidity explains a far larger proportion of returns. Incorporating different assumptions about bid ask spreads leads to reductions in performance estimates. When we allow for time-varying risk exposures, conditioned on the contemporaneous equity market return, risk adjusted returns are generally not significantly different from zero.

Keywords: Pairs Trading; Statistical Arbitrage; Hedge Funds; Asset Allocation

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Given the majority of hedge fund activity and academic research focuses on the US, what are the returns from following such strategies in the UK? Is there a difference in performance and if so, can it be explained by the different characteristics of the two markets? In this paper we attempt to address these questions by examining the returns and risk of one type of hedge fund strategy known as pairs trading, using a large sample of UK stocks.

During 2007 and 2008, most hedge fund strategies generated considerable negative returns, with accompanying outflows of assets under management (AUM). According to the broad based Credit Suisse Tremont Hedge Fund Index, which is comprised of over 5000 hedge funds, the cumulative return from January 2007 to December 2008 was -10.1%. Specific arbitrage hedge fund sectors did far worse, with the Credit Suisse Tremont Hedge Equity Market Neutral (EMN) index returning -35.2%.

Pairs trading is typically classified as an EMN investment strategy that is based on short term price reversal. The strategy, characterised in industry as a form of statistical arbitrage, involves finding two stocks that follow a similar trading pattern. When the stock prices deviate from a specified trading rule, positions are taken long in the lower priced security and short in the higher priced security, with the expectation that prices will converge. The strategy derives returns from the well documented cross autocorrelation in stocks. Recent microstructure research has documented the relationship between liquidity and cross-autocorrelation [2] and Engelberg, Gao, and Jagannathan (2009) show that when information is common, market frictions such as illiquidity cause a lead lag relationship in pairs of stocks, leading to profitable pairs trading.

A growing body of research is focused on the performance of pairs trading in foreign markets. (see, for example, Nath (2003), Hong and Susmel (2004), Andrade, Pietro, and Seasholes (2005), Perlin (2007), Perlin (2009), Gatev, Goetzmann, and Rouwenhorst (2006) and Do and Faff (2010)). Gatev et al. (2006) examine pairs trading in the US equity market from

[2] For example Chordia, Sarkar, and Subrahmanyam (2011) model the effect of liquidity on the cross-autocorrelation of stocks.

1962 to 2002. Results demonstrate that the strategy generates an average annual return of 11% with low levels of risk and limited exposure to known equity risk factors. Do and Faff (2010) extend the study, examining the performance of the pairs trading strategy in the US equity market from 1962 to 2009, with similar conclusions. For US studies, the strategy reports the highest level of profitability during the 1970s and 1980s, with a notable decline after 1989.

Several studies have made modifications to the pairs trading methodology used in Gatev et al. (2006). Elliott, Van Der Hoek, and Malcolm (2005) use a Gaussian Markov chain model for the spread while Do, Faff, and Hamza (2006) make adaptations for spread measurement based on theoretical asset pricing methods and mean reversion. Vidyamurthy (2004) and Burgess (2005) utilize cointegration for pairs selection, while Papadakis and Wysocki (2007) expand on the methodology of Gatev et al. (2006) by examining the impact of accounting information events (i.e. earnings announcements and analyst forecasts) on the level of returns of the pairs trading strategy. More recently, Do and Faff (2012) present US evidence on the effect of transaction costs on strategy profitability.

We make five key incremental contributions to the literature on pairs trading. We are the first paper to provide extensive evidence on the profitability of the strategy in the UK. Second, we provide an analysis of the strategy during the 2008 financial crisis highlighting that unlike other EMN strategies, pairs trading performed well in the crisis. Third, we provide a comprehensive analysis of the risks in the strategy using a multi-factor model framework. Fourth, we are the first study to link the time series performance of the strategy with equity market liquidity, price impact and different estimates of bid ask spreads. Finally, we provide an analysis of the performance of the strategy across different market and economic states.

In this study we examine pairs trading performance in the UK equity market which is one of the largest and most developed in the world. To date only one paper has focused exclusively on the UK equity market, using only high frequency data and a limited sample period (Bowen, Hutchinson, and O'Sullivan (2010)). Here we examine pairs trading from 1980 to 2012. Over the full sample period, the average annual returns for the strategy range from 6.2% to 9.5% net of transaction costs compared to the FTSE All-Share Index average annual total return of 10.9%. The average annual standard deviation for the pairs trading portfolios (between 4.4% and 5.8%) is considerably lower than the market index (16.1%). When the sample is separated into two sub sample periods, based on the transition from a quote driven to order book trading system on the London Stock Exchange, the returns are consistent. These results contrast sharply with Gatev et al. (2006) and Do and Faff (2010) who report a drop in performance in the US through time.

When we focus our analysis on the financial crisis period, we find that the pairs trading portfolios deliver returns of 36% to 48% over a two year period, during which the FTSE All-Share Index return is -34%. This is a period characterised by both falling equity prices and a steep drop in liquidity. Similarly, in October 1987 the strategy delivered significantly positive returns.

To examine the risk exposure of the pairs trading portfolios, the returns are regressed against the common equity factors, market, size, value, momentum, and reversal. Overall, only the market factor is significantly related to the top five and twenty pairs trading portfolios and the factor model has low explanatory power. When the portfolio is separated into long and short portfolios the exposure to common risk factors greatly increases. Exposure to the market and size factor is positive and significant for the long portfolios and negative and significant for the short portfolios, whereas when the portfolios are combined the systematic risk exposure is hedged.

Explicitly modelling market frictions into portfolio returns has occurred in the literature for some time. Including estimates of direct transaction costs for size based strategies (Schultz (1983) and Stoll and Whaley (1983)), momentum (Grundy and Martin (2001) and Lesmond, Schill, and Zhou (2004)) and contrarian trading strategies (Ball, Kothari, and Shanken (1995) and Jegadeesh and Titman (1995)) eliminate much of the profitability in the strategies. Likewise, incorporating price impact has a further negative effect on the profitability of trading strategies (Knez and Ready (1996), Mitchell and Pulvino (2001) and Korajczyk and Sadka (2004)). Our results show that market frictions are particularly important for pairs trading, due to the frequent rebalancing inherent in the strategy. Controlling for market frictions in addition to market risk explains a much larger proportion of pairs trading returns than risk in isolation. When we incorporate different estimates of transaction costs, based on effective spreads (Roll (1984)) and quoted bid ask spreads, portfolio returns are up to 4% per annum lower, particularly for the top twenty portfolio, where trading is more frequent.

Cross-sectional momentum has been shown to be susceptible to periods of persistent negative returns, which occur following periods of persistent negative market returns (Cooper, Gutierrez, and Hameed (2004) and Daniel and Moskowitz (2011)) or economic states (Chordia and Shivakumar (2002)). Related literature has focused on the performance of strategies across differences in short term market returns (Mitchell and Pulvino (2001)). We show that the beta of the pairs trading portfolios vary when conditioned on contemporaneous equity market returns. The risk adjusted returns of the portfolios, controlling for time varying betas and transaction costs, are not significantly different to zero. In contrast to cross sectional momentum, we find that performance is invariant to changes in longer term market returns and economic conditions.

The remainder of the paper is structured as follows: Section 2 details the methodology utilized in the study. Section 3 describes the data. Section 4 outlines the summary statistics and trading statistics. Section 5 reports the performance characteristics of pairs trading. Section 6 provides a brief look at pairs trading at higher frequencies and finally Section 7 offers concluding remarks.

2.0 Methodology

Pairs trading involves finding two stocks that follow a similar trading pattern. When the stock prices diverge abnormally, long and short positions are entered to capture returns from the convergence of price. The first aim of this paper is to provide a comparison of the performance of this strategy using UK data. To ensure our results are directly comparable to the US, and to avoid potential data-mining bias, the methodology closely follows the work of Gatev et al. (2006). The pairs trading portfolio is formed over two periods, a formation and trading period. Pairs of stocks are matched during a twelve month formation period, based on a specified trading rule and traded during a six month period immediately following the formation period. Transaction costs are modelled using an estimate of the bid ask spread. Later in the paper, to test the robustness of transaction cost estimates from Gatev et al. (2006), we provide additional transaction cost estimates based upon both the quoted spread and effective spread (Roll (1984)).

2.1 Formation period

The index of total returns for each stock in the sample is normalized in the formation period by setting the first price to 1 as detailed in equation 1 below.

$$P^{*}_{i,t,t+1,t+2,......T} = \frac{P_{i,t,t+1,t+2,......T}}{P_{i,t}} \tag{1}$$

where $P^{*}_{i,t}$ is the normalized price of stock *i* at time *t*, and $P_{i,t}$ is the price series including reinvested dividends of stock *i* at time *t.*

Pairs are formed by matching each stock with a second stock that has the minimum sum of squared deviations between the normalized price series over the twelve month formation period. The top five and twenty pairs, ranked by minimum sum of squared deviation, are matched at the end of each formation period and are traded over the following six month trading period.

2.2 Trading period

The trading period begins on the first trading day following the end of the formation period. Pairs are traded over a six month period and follow a simple trading rule. Beginning on the first day of the trading period, pairs are opened when the normalized price series diverge by more than two historical standard deviations of the price difference (as estimated in the formation period). Pairs are closed when the normalized price series converge or on the last day in the trading period. Returns are calculated by going long one pound sterling in the lower priced equity and short one pound sterling in the higher priced equity.

Insert Figure 1 here

Figure 1 displays the normalized price series of both Legal & General and WPP during a six month trading period from June 2008 to December 2008. Legal and General is an insurance company in the financial sector and WPP is an advertising company in the service sector. Despite these two companies operating in different sectors, it is apparent from Figure 1 that the two stocks trade in a similar pattern. Over the six month trading period, the pairs open eight times, when the spread between the two normalized price series exceeds the two historical standard deviations trading metric.

The pairs first open on July 23rd 2008, and remain open until July 29th 2008. In this instance, the normalized price of WPP increases sharply on the 23rd, creating a spread of more than two historical deviations. The pairs are closed when the normalized prices converge. In the third opening, the pairs remain open for a total of twelve days. The pairs converge shortly after WPP announces an acquisition of a digital US advertising company on September 16th 2008. The pairs open several more times throughout the trading period and on the third to last day, the spread of the normalized price series once again increases to a margin greater than two historical standard deviations. However, the trading period ends before the pairs can converge and the pairs are closed on the last trading day of the period.

2.3 Returns calculation

Positive cash flows are generated as pairs open and close throughout the trading period. Pairs that open and diverge by the last trading day result in negative cash flow. Multiple positive cash flows occur as a result of pairs that open and close multiple times throughout the trading period. If pairs do not open during the trading period cash flows will be zero. The payoffs from trading pairs of long and short positions are then combined as portfolio excess returns, as displayed in equations 2 and 3.

$$r_{p,t} = \frac{\sum w_{i,t} r_{i,t}}{\sum w_{i,t}} \tag{2}$$

$$w_{i,t} = w_{i,t-1}(1 + r_{i,t-1}) = (1 + r_{i,t}).....(1 + r_{i,t-1}) \tag{3}$$

Where $r_{p,t}$ is the excess return on portfolio *p* at time *t*, $w_{i,t}$ is the weight of position *i* at time *t*, and $r_{i,t}$ is the return of position *i* at time *t*. The daily returns of each portfolio of pairs are then compounded to form a monthly time series of returns.

Two measures of excess returns for each portfolio are calculated. For the committed capital portfolio the returns are scaled by the number of pairs that are matched in the formation period. For example, in the top five pairs trading portfolio, the returns are scaled by five. However, in the fully invested portfolio, the returns are divided by the number of pairs that open a position during the formation period. If, in the top five pairs trading portfolio, only four pairs trade based on the standard deviation metric rule, then the fully invested portfolio returns are divided by four. Hence, committed capital portfolio returns are more conservative.

By staggering the start of each formation period by one month, there are six overlapping trading periods of excess returns, which we average to create our pairs trading portfolios.

2.4 Transaction costs

When considering the profitability of a trading strategy, it is important to model the transaction costs associated with the strategy. We initially follow Gatev et al. (2006), accounting for the bid ask spreads by delaying opening and closing of pairs by one trading day after a trade has been signalled.[3] The differences in 6 month excess returns for the committed capital and fully invested portfolios are 141 and 145 basis points, which results in transaction costs of 71 and 73 basis points per pair round trip and an effective estimated spread of 35 and 36 basis points. These effective spreads are about half the values set forth in Gatev et al. (2006) and slightly lower than the 57 bps effective spread found in the UK daily returns of FTSE All-Share constituents found in Foran, Hutchinson, and O'Sullivan (2010). Later in the paper we test the robustness of these transaction cost estimates using Roll (1984) effective spreads and the quoted spread. We also incorporate factors based upon each of these measures, and a measure of price impact (Amihud (2002)) to identify the effect of controlling for market frictions on pairs trading performance.[4]

3.0 Data

The data sample in this paper spans over thirty years, from January 1979 to December 2012, a time period that covers several market upturns and downturns, as well as relatively calm and volatile periods. All data come from Datastream. We include failed firms in the dataset up to the date they are delisted from the London Stock Exchange, which helps to alleviate survivor bias in the sample. Acquired firms' returns are included in the dataset up to the date they are delisted from the London Stock Exchange. We also omit all non-common equities from the sample. In addition, we manually scan the database for extreme returns which are then reversed in the following month as this indicates a data entry error. We remove these returns.

[3] Gatev et al. (2006) argue that where a trade is triggered when the price of the long position at the opening of a trade is the bid price and the short position is the ask price, and the next day prices are equally likely to be at bid or ask, then delaying trades by one day will reduce the excess returns on average by half the sum of the spread of the long and short positions. Likewise, at convergence if the short is trading at bid, and the long is trading at ask, then delaying the closing by one day should lower the excess returns on average by half the sum of the spread of winner and loser. By waiting one day in opening and closing pairs, it should effectively reduce the excess returns by one round trip transaction cost.

[4] In addition to bid ask spreads, investors will incur stamp duty, commission charges and charges for borrowing stock. Due to data unavailability we do not model these direct transaction costs but we caution the reader that incorporating these costs will lower returns.

The entire sample consists of a total of 6729 securities. However, at the beginning of every formation period, the sample is limited to the constituents of FTSE All-Share Index, in order to remove stocks that are illiquid. [5] The average sample for each formation period is 767 securities. For each of these securities we collect bid, ask and closing prices and turnover. Closing prices are available for the full sample period, whereas bid, ask and turnover data is only available from 1988.

4.0 Results

4.1 Trading statistics

The trading statistics for the top five and twenty pairs trading portfolios for the full sample and two sub sample time periods are displayed in Table 1. During each trading period, there is an average of 4.8 pairs that are open at least once for the top five pairs portfolio and 18.7 pairs out of the top twenty pairs portfolio. This is similar to the findings of Gatev et al. (2006), averaging 4.8 and 19.3 open pairs for the top five and twenty pairs trading portfolio in US equities. Each pair is open approximately 2.9 times in the top five pairs trading portfolio and 1.9 times in the top twenty pairs trading portfolio. The average price deviation triggers for opening pairs in the full sample are 1.9% and 3.4% for the top five and twenty pairs trading portfolios. These values are relatively small in percentage terms and they increase as the number of pairs traded increases.

Insert Table 1 here

[5] The concerns which have been raised by Ince and Porter (2006) amongst others about data errors in Datastream are mainly concentrated amongst small stocks and/or low price stocks. Focusing our sample on the FTSE All-Share Index provides a natural control for any remaining errors as constituents of this index are selected based upon size and liquidity constraints.

We split the sample, into the periods January 1980 to October 1997 and November 1997 to December 2012, based upon the transition from quote driven to order book driven trading on the London Stock Exchange, with the introduction of the SETS order book trading system on October 27th 1997. [6] [7] For the first sub sample, the average number of round trips for the top five and twenty pairs trading portfolio are 3.9 and 2.2. In the November 1997 to December 2012 period, the number of average round trips decreases to 1.5 and 2.1 for the top five and twenty pairs trading portfolios. The number of pairs that open at least once during the six month trading period does not change dramatically over the two sub sample time periods, approximately 4.7 for the top five pairs and 18.7 for the top twenty pairs. However, there is a difference in the average price deviation trigger for opening pairs between the two sub sample time periods. With the top five pairs trading portfolio, the price deviation trigger increases from 1.0% to 3.3%, while the top twenty average price deviation trigger for opening pairs in the first sub sample is 2.0%, compared to 4.9% in the second sub sample. Like the top five pairs trading portfolio, there is a sharp increase in the price deviation trigger between the first and second subsamples for the top twenty portfolio.

Figure 2 displays the average monthly returns for the top twenty committed capital pairs trading portfolios for the combined, long and short portfolios. Looking first in Panel A, at the combined portfolio, the returns generally range from -2% to 4%. The largest monthly return, 10.5%, occurs in October 1987, coinciding with a period of particularly poor equity market returns and liquidity. Overall, the combined portfolio offers consistent returns over the sample period, with positive excess returns in 81% of the months, compared to 77% reported by Gatev et al. (2006) in US equities.

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[6] Prior to the introduction of SETS the London Stock Exchange operated a market maker quote based system (SEAQ) for all stocks. SETS was introduced initially for FTSE100 stocks on October 27th 1997. Selected FTSE250 constituents began trading on SETS on January 11th 2000 and on October 9th 2003 a new order book system supported by market maker liquidity, SETSmm, was introduced for all other stocks. Our sub sample results are consistent using any of these dates to divide the sample.

[7] Hendershott, Jones, and Menkveld (2011) identify the move to an automated trading system on the NYSE in 2003 with a large effect on the liquidity.

When examining the long and short portfolios in Panels B and C, approximately 70% and 42% of the monthly returns are positive, respectively, but the short portfolio reduces systematic risk in negative market return months. For example, in October 1987, there is a negative return of -12.5% for the long portfolio; however it is accompanied by a short portfolio return of +23.1%. By investing in a hedged portfolio, investors are protected from large equity market shocks, which are unavoidable with either the long or short portfolio in isolation.

Insert Figure 2 here

4.2 Full sample results

The full sample descriptive statistics (January 1980 to December 2012) for the top five and top twenty pairs excess returns are detailed in Table 2 Panel A.[8] Returns both with and without transaction costs are reported. The FTSE All-Share Index descriptive statistics are also reported for comparison. Before transaction costs the top five and twenty pairs have mean annualised monthly returns of 7.4% and 11.5%, equivalent to the FTSE All-Share Index.

The top five and twenty pairs trading portfolios report mean returns of 6.2% and 8.9%, net of transaction costs. The standard deviation of each pairs trading portfolio is considerably lower than that of the FTSE All-Share Index. Over the thirty year sample period, the FTSE All-Share Index reports an annual standard deviation of 16.13%, compared to 5.0% and 4.4% for the top five and twenty pairs with transaction costs. The return series for pairs trading portfolios exhibits positive skewness and high kurtosis levels (greater than 14).

Table 2 Panel A also displays the correlation of each portfolio with the FTSE All-Share Index. There is a significant negative relationship between the market index and pairs trading

[8] For the sake of brevity we concentrate our discussion on the more conservative Committed Capital portfolios.

portfolios, with both the top five and twenty pairs being negatively correlated at the five and one percent level of significance, respectively.

Insert Table 2 here

Table 2 Panel B reports the pairs trading returns from January 1980 to October 1997 and Table 2 Panel C reports the results from November 1997 to December 2012. In the first sub sample, the top five and twenty pairs trading portfolios mean returns are 6.4% and 8.9% net of transaction costs, while the returns are 6.0% and 9.1%, respectively in the second sub sample. The consistency in returns is in contrast to the FTSE All-Share Index total returns which are considerably lower in the second sub sample. The average risk levels for all series are similar in both periods. It is notable that the performance of pairs trading in the second sub sample is considerably higher than the US results reported by Gatev et al. (2006) for the post 1989 period.

4.3 Returns during the 2007-2008 financial crisis

If pairs trading truly is a "market neutral" trading strategy, then the performance should not be significantly impacted by the recent financial crisis.[9] Figure 3 displays the cumulative performance of the top five and twenty pairs trading portfolios after transaction costs, compared to the FTSE All-Share Index from 2007 to 2008. During the first year, the pairs trading performance is similar to the FTSE All-Share Index. It is not until the second year that pairs trading generates higher cumulative returns than the market index. Over the two year sample, the FTSE All-Share Index reports a 34% loss, whereas the top five and twenty pairs trading portfolios report gains of 46% and 36%. The average monthly returns for the top five and twenty pairs trading portfolios are 1.64% and 1.32% respectively, compared to a -1.57% monthly return on the

[9] Khandani and Lo (2011) present evidence of the effect of the financial crisis on the returns of EMN funds in the US.

FTSE All-Share Index. Taken with the findings for October 1987, these results suggest that the pairs trading strategy could offer significant diversification benefits during equity market crises.

Insert Figure 3 here

5.0 Performance analysis

5.1 Risk characteristics of daily pairs trading

To examine the risk of pairs trading, the portfolio returns are risk adjusted using a five factor model following the methodology of Gatev et al. (2006). In addition to the Fama and French (1993) three factor model, two additional factors, momentum and reversal, are included to further evaluate the risk exposure of the pairs trading returns. The five factor model is detailed below in equation (4).

$$R_A = \alpha + \beta_{RMRF} RMRF + \beta_{SMB} SMB + \beta_{HML} HML + \beta_{MOM} MOM + \beta_{REV} REV + \varepsilon \qquad (4)$$

Where R_A is the excess return on portfolio *A*; α is the intercept, or measure of risk adjusted performance; β_{RMRF} is the measure of exposure of asset *A* to market risk; β_{SMB} is the measure of exposure to size risk; and β_{HML} is the exposure to value risk; β_{MOM} is exposure to momentum risk; β_{REV} is exposure to reversal risk; $RMRF$ is the excess return on the market portfolio minus the risk free rate at time *t*; SMB is the size factor; HML is the value factor; MOM is the momentum factor; REV is the reversal factor; and ε is the error term.

The market, size and value factors (Fama and French (1993)) and the momentum factor (Carhart (1997)) are created for UK data as discussed in Gregory, Tharyan, and Christidis

(2013).[10] The reversal factor is constructed using the constituents of the FTSE All-Share Index following Gatev et al. (2006). Following Fama and French (1993), Carhart (1997) and Gregory et al. (2013) we do not specify orthogonal factors. By not using orthogonal factors, there is the danger that high correlation amongst explanatory variables can lead to spurious significance levels for independent variables. However, our main focus is on interpreting the estimated intercepts as a measure of risk adjusted performance, rather than the factor coefficients, and intercept estimates are not affected by multicollinearity. Likewise, for the intercepts to be interpreted as a measure of risk adjusted performance, they need to be estimated using tradable risk factors (Jensen (1968)).[11]

Table 3 Panel A summarizes the descriptive statistics for the risk factors over the full sample period. The market and momentum factors have the highest mean returns of 6.1% and 9.0%, respectively. The market and momentum factors exhibit the highest standard deviations of 15.9% and 14.3% respectively. The market, value and momentum factors each exhibit negative skewness and the size and reversal factors exhibit positive skewness. Each factor exhibits excess kurtosis.

The correlations between each risk factor for the full sample are reported in Panel B of Table 3. The strong negative correlation between momentum and the value factors is particularly striking (Asness (1997) and Gregory et al. (2013) highlight similar effects in the US and UK respectively). Asness, Moskowitz, and Pedersen (2013) suggest that liquidity risk may be an important common component of value and momentum, and, help explain why value and momentum are negatively correlated. Their results show that value loads positively on liquidity

[10] We are grateful to Alan Gregory for providing the UK Fama and French factors.

[11] Related evidence by Petkova (2006) shows that having incorporated innovations in four macroeconomic predictive variables alongside the Fama and French (1993) factors computed from a vector autoregression (VAR) process the *SMB* and *HML* factors lose explanatory power. However, subsequent research has cast doubt over the ability of macroeconomic state variables to predict returns (Lewellen, Nagel, and Shanken (2010)) and highlights the limitations in the methodologies used to create orthogonal factors, which reduce the explanatory power of the Fama and French (1993) factors (Lioui and Poncet (2012)).

risk, whereas momentum loads either negatively or zero on liquidity risk, depending on the measure.

Insert Table 3 here

Table 4 Panel A reports the monthly risk exposures of the top five and twenty pairs trading portfolios for the full sample from 1980 to 2012 for the five factor model. Similar to the US results of Gatev et al. (2006), only a small portion of the excess returns in pairs trading can be explained by the common equity risk factors. The intercepts are significantly positive for each portfolio and risk adjusted returns are approximately equal to the excess returns. Only the market factor coefficient is significant across all portfolios to at least the five percent level. In addition, the momentum factor coefficient is significant at the ten percent level for the top twenty pairs trading portfolios.

Insert Table 4 here

To further understand the data generating process of the strategy, we examine the performance and risk factor analysis of the long and short portfolios. Table 4 Panel B reports the five factor risk exposure for the long and short portfolios in the top five and twenty pairs trading portfolio. For the top five pairs trading portfolio, the long portfolio risk exposure is positive and significant for the market and size factor to at the least the five percent level, whereas the top twenty long portfolio is also significantly related to both the momentum and reversal factors. With the top five short portfolio, the market and size factors are significant to at least the five percent level and the top twenty short portfolio is negatively related to the value factor. The adjusted R^2 values are 37% and 42% for the long and short components of the top five pairs trading portfolio and 60% and 56% for the top twenty pairs long and short portfolios. These values are far higher than those reported for the combined portfolio in Panel A.

To identify how robust these results are to changes in the trading regime of the London Stock Exchange, Table 5 reports results before and after the introduction of the SETS order book system. Tables 5 Panel A reports results for the first sub sample, January 1980 to October 1997, for the combined portfolio. The top five and twenty committed capital portfolios Sharpe Ratio of 1.58 and 2.60 are comparable to the full sample in Table 4. Again, the factor model does not explain a substantial portion of the returns. Similar to the full sample, the intercepts in the first sub sample are positive and significant for each portfolio and risk adjusted returns are approximately equal to the excess returns. Only the reversal factor is significant for the top five portfolios and the market factor is significantly negative for both the top twenty pairs trading portfolios.

Insert Table 5 here

In the second sub sample, reported in Panel B of Table 5, the Sharpe ratios drop to 1.01 and 1.82 for the top five and top twenty portfolios, respectively. The intercepts are positively significant for each portfolio and risk adjusted returns are approximately equal to the excess returns. For the second sub sample, the value and momentum factors are significant, to at least the five percent level for the top twenty pairs trading portfolio and none of the factor coefficients are significant for the top five pairs trading portfolio. While there is some drop off in performance across the two periods, both Sharpe ratios and abnormal returns are far more consistent for the UK than existing US evidence.

Gatev et al. (2006) argue that a common component is stronger in the first half of their sample that is not captured by the standard measures of risk. Do and Faff (2010) extend the work of Gatev et al. (2006) for the financial crisis period and find that the strategy performs particularly well during the crisis. The high returns in this period are driven by an increase in convergence rates. Do and Faff (2010) conclude that the rise in convergence is due to the increased mispricings that occur during turbulent times. Further, Engelberg et al. (2009) surmise that when information is common, market frictions like illiquidity cause a lead lag relationship in pairs of stocks that leads to profitable pairs trading.

Insert Table 6 here

To identify the cause of the consistent performance of UK pairs trading we examine the role of convergence rates and price deviation triggers in Table 6 through time. We classify pairs into four groups based upon the frequency with which they trade and converge in the trading period. A non-traded pair does not open during the trading period, while a non-convergent pair opens once, but does not converge before the end of the trading period. A single round trip opens and converges once and may have an additional non-convergent trade, whereas a multiple round trip opens and closes at least once, while also possibly having a non-convergent trade.

Non-convergent pairs have a greater incidence in the second sub sample with more negative monthly returns. Single round trips are also more frequent but while the price deviation trigger is larger, the average monthly return is smaller. Finally multiple round trips are about half as frequent in the second sub sample period but the average price deviation trigger is about twice as wide. Consequently, the average monthly returns are far larger. The net effect is the wider price deviation triggers in the second sub sample leads to less frequent trading, with a higher average return per trade. A wider price deviation trigger would suggest a decrease in liquidity or a rise in volatility in the second sub sample.

5.2 Controlling for liquidity and market frictions

Due to the frequency of trading and existing evidence of positive performance in periods of low liquidity, it is likely that the pairs trading strategy plays a role in providing liquidity to the equity market. As such, the performance of portfolios formed using the strategy should be sensitive to changes in aggregate market liquidity. To estimate aggregate market liquidity we use three measures: Amihud (2002) price impact, Roll (1984) effective spread and the quoted spread.

The first method used to capture aggregate market liquidity is the Amihud (2002) measure of price impact that seeks to capture the tendency for the price of illiquid assets to be more sensitive to trades, similar to Kyle's λ (Kyle (1985)). The Amihud (2002) measure does not produce an estimate of price impact for each stock that is interpretable as a transaction cost. Rather, it allows us to control for changes in price impact on the aggregate group of equities in the FTSE All-Share Index. For a given month *m*, the Amihud (2002) measure for stock *s* is given by:

$$A_{s,m} = \frac{1}{n_m} * \sum_{t=1}^{n_m} \ln\left[\frac{|r_{s,t}|}{turn_{s,t}}\right] \tag{5}$$

where $r_{s,t}$ and $turn_{s,t}$ are the return and turnover on stock *s* for day *t* and n_m is the number of observations in month *m*.

We use two measures of bid ask spreads to capture aggregate market liquidity. (Both these measures can also be interpreted as direct estimates of transaction costs.) The first is the Roll (1984) effective spread. Empirical evidence suggests that the price at which most trades take place is often inside the quoted spread (Blume and Goldstein (1992)). This inner spread is the effective spread. Roll (1984) develops a simple model to facilitate estimation of the effective spread. The market is assumed efficient in gross terms so covariance between returns can only be due to the "bid ask bounce" caused by the shifting of price from the bid to the ask prices. The estimate of $ES_{s,m}$, the effective spread for stock *s* for month *m* is given by:

$$ES_{s,m} = \frac{1}{n_m} * \sum_{t=1}^{n_m} C_{t,s} \tag{6}$$

where

$$C_{t,s} = -2 * \sqrt{Cov(r_{t,s}, r_{t-1,s})} \qquad (C_{t,s} \notin R) \rightarrow (C_{t,s} = 0)$$

where $r_{s,t}$ and $r_{s,t-1}$ are the returns on stock *s* for day *t* and *t-1*. As the measure relies on negative return covariance, all negative values of $C_{t,s}$ are replaced by zero.

Finally, we use closing bid ask quotes to estimate the proportional quoted spread, which is the difference between the closing bid and ask prices expressed as a percentage of the midpoint.

For month m and stock s, $QS_{s,m}$ is given by:

$$QS_{s,m} = \frac{1}{n_m} * \sum_{t=1}^{n_m} \frac{P_{s,t}^A - P_{s,t}^B}{m_{s,t}} \quad (7)$$

where $P_{s,t}^A$ is the ask price $P_{s,t}^B$ is the bid price and $m_{s,t}$ is the midpoint of the bid and ask prices on day d for stock s and n_m is the number of observations in month m.

For the two bid ask spread estimates, we then calculate the aggregate market liquidity as the average of each measure across all of the FTSE All-Share Index stocks for each month. Following Amihud (2002), we use the residuals from an autoregressive time series (AR(3)) model of the time series of cross sectional mean price impact as our Amihud (2002) liquidity measure.

To control for risk and liquidity, we augment the risk factor model (equation (4)) with the liquidity variables:[12]

$$R_A = \alpha + \beta_{RMRF} RMRF + \beta_{SMB} SMB + \beta_{HML} HML + \beta_{MOM} MOM + \beta_{REV} REV + \beta_{LIQ} LIQ + \varepsilon_t \quad (8)$$

where LIQ is the liquidity variable and the other variable are as in equation (4). We report the results for the top five and top twenty committed capital and fully invested portfolios in Table 7. Panel A shows results for the Amihud (2002) price impact measure, Panel B reports results for Roll (1984) effective spread and Panel C shows the quoted spread results.

It is notable that practically all of the factor loadings that were statistically significant (insignificant) prior to the introduction of the illiquidity factors remain statistically significant

[12] We thank the anonymous reviewers for encouraging us to include a liquidity variable in our regression model. In unreported results we also construct liquidity variables using only data on liquidity for the stocks in the pairs portfolios. As the portfolios are made up of relatively few stocks these measures are relatively noisy and have lower explanatory power than the market wide liquidity variables.

(insignificant). Furthermore, all of the coefficients on the liquidity variables are statistically significant and the explanatory power is greater than reported without a liquidity variable (Table 5).

We are cautious in interpreting the intercepts in Table 7 as the liquidity variable is not a tradable market factor. The intercept displays the 'liquidity-adjusted alphas" which are the excess portfolio returns after controlling for risk and aggregate market liquidity. These alphas can also be interpreted as estimates of risk adjusted returns of portfolios which have no aggregate market liquidity exposure (Aragon (2007)).

Insert Table 7 here

Interestingly, we find that after controlling for price impact (Panel A) the alphas are almost identical to those reported without a liquidity variable. However, when we include estimates of aggregate market bid ask spreads, either modelled as the effective spread (Roll (1984)) (Panel B) or quoted spread (Panel C), the alphas are no longer significant from zero.

5.3 Market states and pairs returns

Having controlled for aggregate market liquidity using non-tradable liquidity factors, we next investigate the effect on portfolio performance of including alternative estimates of transaction costs and evaluate the performance of the portfolios across different market states, using only tradable risk factors.

In order to model transaction costs we utilise the quoted spread and effective spread estimates for each stock from the preceding section. This allows for a direct comparison with the Gatev et al. (2006) transaction cost estimates.

Insert Table 8 here

Given that the top twenty portfolio trades on average 18.7 pairs in a six month period, versus 4.8 for the top five portfolio, we anticipate it will be more sensitive to transaction cost estimates. Table 8 reports the results of this analysis and factor model (equation (4)) results for the top five and top twenty portfolio for each of the three transaction cost estimates. Looking first at the top five portfolio results, it is notable that all three approaches lead to very similar conclusions on performance. While the quoted spread estimates have the lowest Sharpe ratio, the Gatev et al. (2006) estimates have the lowest risk adjusted returns, albeit the model has lower explanatory power.

On the contrary, the performance of the top twenty portfolios vary quite widely with the differing estimates of transaction costs. The Sharpe ratio of the portfolio using quoted spreads is half that of the Gatev et al. (2006) portfolio and both the Sharpe ratio and the alpha are at a similar level to the top five portfolios. The Sharpe ratio of the effective spread portfolio is approximately thirty percent less than the Gatev et al. (2006) portfolio with an alpha of 0.61. Nonetheless, having specified alternative estimates of bid ask spreads the portfolio alphas remain significantly positive.

The existing literature on trading strategies provides evidence of the sensitivity of performance to market states. In particular, cross-sectional momentum, which is a medium term strategy, has been shown to perform badly following periods of persistent negative market returns (Cooper et al. (2004) and Daniel and Moskowitz (2011)). Related literature has also focused on the sensitivity of strategies to short term market returns (Mitchell and Pulvino (2001)). Given the relatively short term holding period of pairs trading, we initially consider performance conditional on contemporaneous market returns, before also investigating the sensitivity of the strategy to longer term market and economic states.

Table 9 provides results of equation (4) estimated across two sub samples, where the total return on the FTSE All-Share Index is either greater than or equal to zero, or less than zero.

Insert Table 9 here

For the top five portfolios, the results are quite consistent. The explanatory power is higher across all market states. Though the Sharpe ratios of the portfolio in different market states are similar, the risk exposures and risk adjusted performance estimates differ. For portfolios formed using Gatev et al. (2006) transaction cost estimates or quoted spreads, risk adjusted performance is not significantly different from zero in either market state. The portfolio formed net of effective spreads has positive alpha, at the 10% level, only in up markets. All of the top five portfolios have negative market and value exposures and positive reversal exposures in down markets. In up markets all portfolios have negative reversal factor exposure and only the quoted spread portfolio has no positive market exposure.

For the top twenty portfolios explanatory power is again higher than the unconditional model and Sharpe ratios are quite similar across states. In positive equity market months, all portfolios have positive equity market exposure and a negative momentum coefficient. The quoted spread alphas are not significant in these periods. In negative market states, no portfolio has positive risk adjusted returns, all have negative value exposure, and the portfolio formed net of Gatev et al. (2006) bid ask spreads has negative market and positive reversal coefficients. Taken in aggregate, the results in Table 9 suggest that, while the raw returns of the strategy are consistent, the risk adjusted performance of the strategy can be explained by changing risk exposures across short term market states.

Henkel, Martin, and Nardari (2011) and Rapach, Strauss, and Zhou (2013) find that predictability is stronger in expansions than recessions and Cooper et al. (2004) finds that cross sectional momentum is sensitive to the prior thirty six month equity market returns. To test the robustness of the portfolios performance to changes in longer term states, we repeat the analysis based upon the prior thirty six month equity market returns and twelve month changes in Industrial Production. Our results, presented in Table 10, show that that the strategy is not sensitive to these longer term market and economic conditions.

Insert Table 10 here

This section has linked the performance of pairs trading to liquidity and market states in a number of ways. First, it is noteworthy that UK pairs trading returns have been more consistent through time than in the US. When we specify a range of factors which proxy for aggregate equity market liquidity, the coefficients on the factors are significantly positive and the explanatory power of the model increases. Next, we demonstrate how using alternative estimates of bid ask spreads leads to different conclusions on pairs trading performance, particularly for the top twenty portfolio, where mean returns drop by up to 4% per annum. Finally, we examine the performance of the strategy, using only tradable risk factors, across a range of short and long term market and economic states. Our results show that pairs trading performance is not sensitive to longer term states and while raw returns are consistent, risk adjusted performance is generally not statistically significant when conditioned upon short term equity market returns.

6.0 Pairs trading using high frequency data

While the results above clearly demonstrate the performance of pairs trading portfolios formed using daily data, we are also interested in how these results relate to trading at higher frequencies and whether there is a high correlation between an identical strategy being pursued at different frequencies. Using data from Bowen et al. (2010), we provide a comparison between pairs trading at different frequencies for a one year subset of the database.

Insert Table 11 here

Bowen et al. (2010) apply the pairs trading methodology to a sample of UK listed stocks for the period January 1st to December 31st 2007.[13] Data come from the London Stock Exchange Tick by Tick database and the authors limit the sample to the FTSE100 index constituents for liquidity reasons.

The high frequency pairs trading portfolio is divided into 30 overlapping subsample periods of 396 hours duration. Each subsample period begins 22 hours after the start of the previous period and is divided into a 264 hour formation period and a 132 hour trading period. As with the daily portfolios, the formation period is used to identify pairs of stocks which move

[13] We are restricted to investigating 2007 due to data constraints.

together with the actual transactions occurring in the trading period. We rank pairs based on the sum of squared deviations of the normalised price series. Trades are opened when the pair diverges to two times this metric during the trading period, closing on convergence or the end of the trading period.

Table 11 reports descriptive statistics for the daily portfolio and the high frequency portfolio (at different levels of transaction costs). Clearly in 2007 the high frequency portfolio outperforms the daily portfolio. Looking at the correlations, we can see that high frequency and daily portfolios have little correlation.

7.0 Conclusion

There is a growing body of literature examining the performance of hedge funds and the trading strategies they employ. In this paper, we add to the literature by providing an in depth examination of one such strategy, pairs trading, in the UK equity market. We first show that the returns of the strategy are high and relatively consistent through time.

We next show that unconditional returns of the strategy are not related to recognised systematic risk factors. After controlling for market, size, value, momentum and reversal factors, we find that the strategy generates statistically significant abnormal returns. However, only the market factor is weakly related to the returns of the strategy and the overall explanatory power is low. When we divide the portfolio into long and short components, both have large systematic risk exposure, which is hedged when the portfolios are combined.

Our next analysis focuses on the performance of the strategy during the financial crisis of 2007 and 2008. Unlike other EMN strategies, pairs trading performs particularly well during this period of weak equity market returns and falling liquidity.

We investigate the relationship between liquidity, market frictions and pairs trading performance. When we specify a range of non-tradable aggregate market liquidity measures, we find that the coefficients on the liquidity variables are significantly positive and the explanatory power of the model increases relative to the five factor model. For the two measures based upon bid ask spreads, the intercepts are no longer significantly different from zero. We also briefly explore the relationship between the returns of pairs trading at different frequencies. Comparing the returns of the portfolios, estimated using hourly and daily data, we present evidence that the two are not correlated and provide very different return characteristics.

To isolate the direct effect of transaction costs on the performance of the strategy, using solely tradable risk factors, we specify a range of bid ask spread estimates, across both long term and short term changes in market states. Transaction costs are particularly important for the top twenty portfolio, where trading is more frequent. However the top five portfolio performance is consistent across the different measures. Unlike cross-sectional momentum, we find no evidence of a link between performance and longer term market and economic states. When we condition performance on short term market returns, raw portfolio returns are equivalent but risk adjusted returns are, in most cases, not significantly different from zero, particularly for the more conservative estimates of bid ask spreads. Our results suggest that, in the UK, the abnormal returns documented for pairs trading can be accounted for by a combination of transaction costs and time varying risk exposures.

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Figure 1: Example Trading Period
Daily normalized price series for Legal & General and WPP from June 2008 to December 2008. Open/Close indicates when the pairs trade is opened (up) and closed (down).

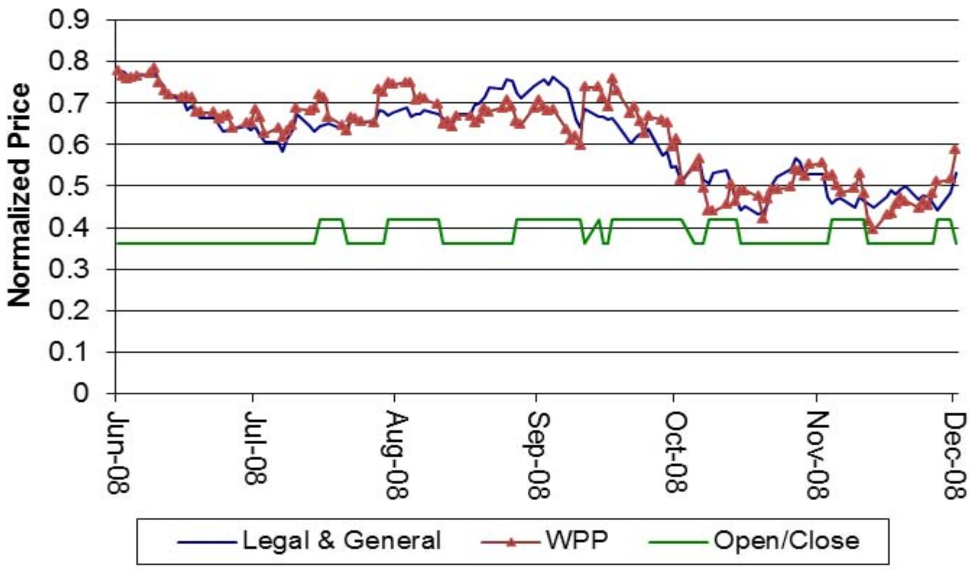
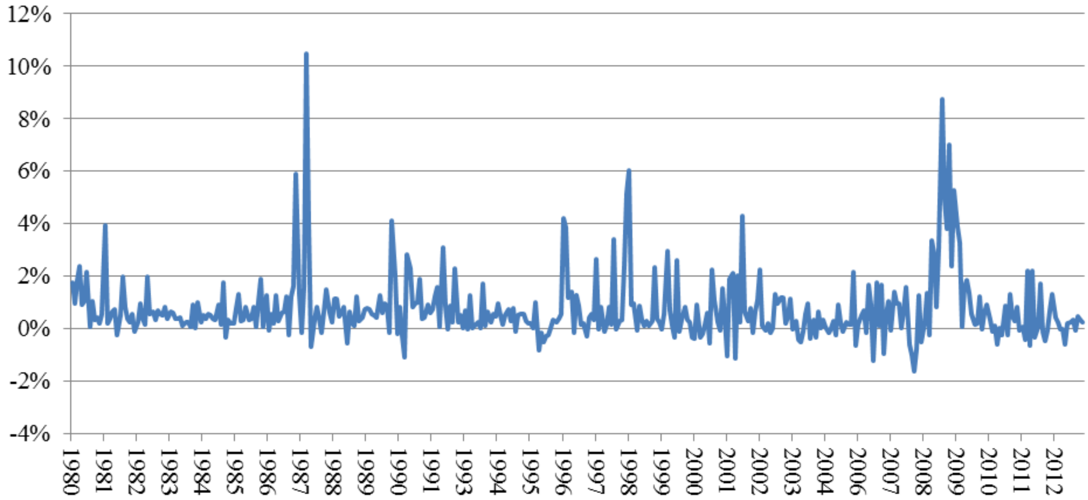


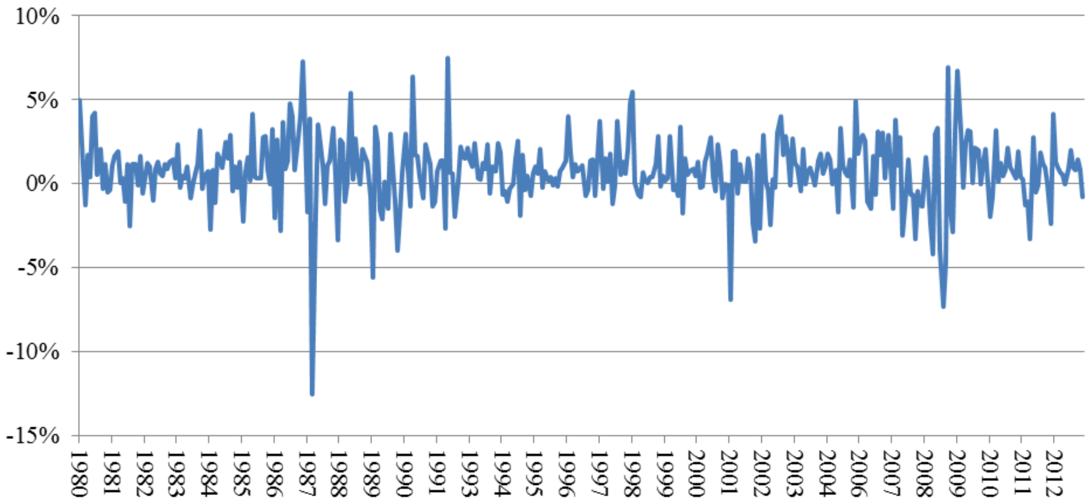
Figure 2: Time Series of Monthly Returns

This figure displays the time series of monthly returns for top twenty Committed Capital pairs trading portfolio net of transaction costs. Panel A displays the Combined portfolio while Panels B and C display the Long and Short portfolios respectively.

Panel A: Combined Portfolio



Panel B: Long Portfolio



Panel C: Short Portfolio

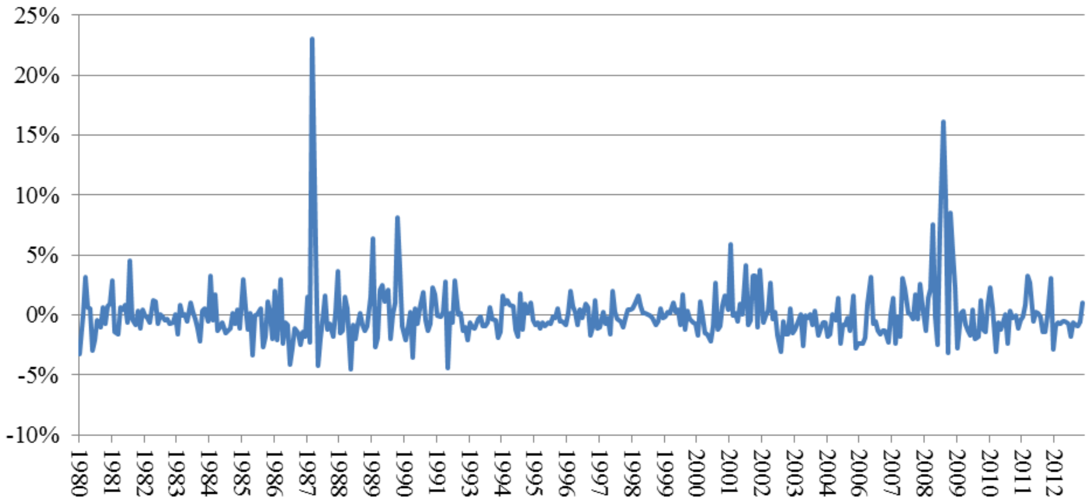


Figure 3: Cumulative Performance of Pairs Trading Portfolios during the 2007-2008 Financial Crisis

This figure displays monthly cumulative returns for the top five and twenty committed capital pairs trading portfolios and the FTSE All-Share index from January 2007 to December 2008 (24 observations).

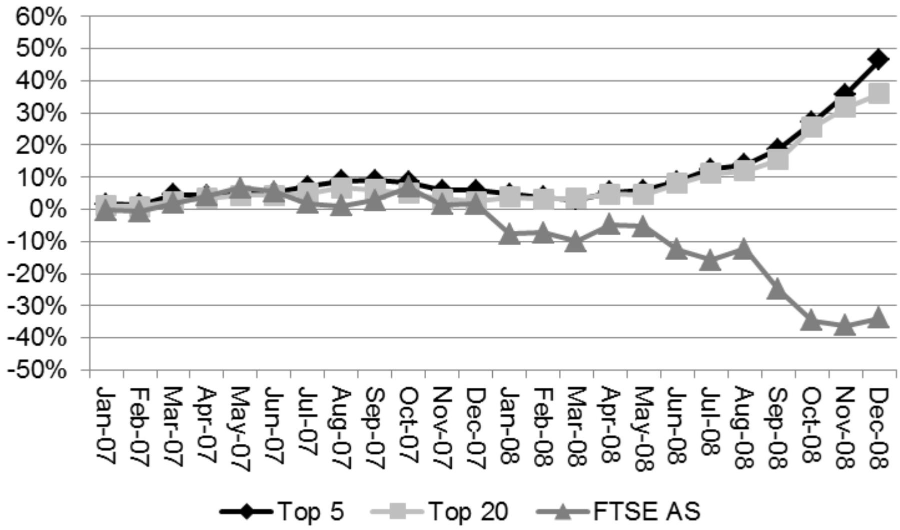


Table 1: Trading Statistics of Pairs Trading Portfolios
Trading statistics for the full sample and two sub sample time periods. Average price deviation trigger is the average deviation required for a pair to open. Average round trips per pair is the average number of times a pair opens and closes in each trading period. Average number of pairs traded per six month period is the average number of pairs which are opened at least once in the trading period.

	Top 5	Top 20
Panel A: Full Sample		
Average price deviation trigger for opening pairs	0.019	0.034
Average round trips per pair	2.85	1.90
Average number of pairs traded per six month period	4.76	18.74
Panel B: January 1980 - October 1997		
Average price deviation trigger for opening pairs	0.010	0.020
Average round trips per pair	3.94	2.21
Average number of pairs traded per six month period	4.83	18.42
Panel C: November 1997 – December 2012		
Average price deviation trigger for opening pairs	0.033	0.049
Average round trips per pair	1.49	1.51
Average number of pairs traded per six month period	4.68	19.10

Table 2: Descriptive Statistics of Daily Pairs Trading Returns

Descriptive statistics are reported for the monthly excess returns on top five and twenty pairs trading portfolios from January 1980 to December 2012 (Panel A), January 1980 to October 1997 (Panel B) and November 1997 to December 2012 (Panel C). For each portfolio the committed capital (CC) and fully invested (FI) portfolios are reported, with (TC) and without transaction costs. Statistics on the FTSE All-Share Index total returns are included for comparison. Mean is the annualised mean monthly return. Std Dev is the annualised standard deviation of monthly returns. Skewness and kurtosis are estimates of skewness and kurtosis calculated from monthly returns. Minimum (Maximum) is the minimum (maximum) monthly return. Range is the range of monthly returns. $\rho_{FTSE\ AS}$ is the correlation with the FTSE All-Share Index with associated P-Value in parenthesis.

	Top 5 pairs		Top 20		Top 5 TC		Top 20 TC		FTSE
	CC	FI	CC	FI	CC	FI	CC	FI	
Panel A: Pairs Trading Results Descriptive Statistics (01/80-12/12)									
Mean	7.41	7.69	11.50	12.18	6.24	6.47	8.99	9.54	10.93
Std Dev	5.57	5.80	5.14	5.38	5.02	5.22	4.42	4.65	16.13
Skewness	4.36	4.45	2.93	2.91	3.18	3.26	3.06	3.09	-1.31
Kurtosis	31.05	31.70	15.03	14.88	17.18	17.77	17.78	18.20	8.57
Minimum	-0.03	-0.03	-0.02	-0.02	-0.03	-0.03	-0.02	-0.02	-0.31
Maximum	0.15	0.15	0.10	0.11	0.10	0.10	0.10	0.11	0.13
Range	0.18	0.18	0.12	0.13	0.13	0.13	0.12	0.13	0.44
$\rho_{FTSE\ AS}$	-0.08*	-0.08	-0.14***	-0.14***	-0.09*	-0.09*	-0.16***	-0.16***	
P-Value	(0.10)	(0.13)	(0.01)	(0.01)	(0.07)	(0.07)	(0.00)	(0.00)	
Panel B: Pairs Trading Results Descriptive Statistics (01/80-10/97)									
Mean	7.15	7.39	11.56	12.44	6.44	6.62	8.86	9.57	15.78
Std Dev	3.74	3.87	4.46	4.73	4.10	4.23	3.87	4.17	16.89
Skewness	3.88	3.94	3.59	3.58	4.05	4.15	4.22	4.29	-1.67
Kurtosis	20.47	21.02	21.16	21.34	22.66	23.69	31.48	32.31	11.43
Minimum	-0.01	-0.01	-0.01	-0.01	-0.02	-0.02	-0.01	-0.01	-0.31
Maximum	0.07	0.08	0.10	0.11	0.08	0.08	0.10	0.11	0.13
Range	0.09	0.09	0.11	0.12	0.10	0.10	0.12	0.13	0.44
$\rho_{FTSE\ AS}$	-0.09	-0.09	-0.20***	-0.20***	-0.09	-0.10	-0.21***	-0.21***	
P-Value	(0.19)	(0.20)	(0.00)	(0.03)	(0.20)	(0.15)	(0.00)	(0.02)	
Panel C: Pairs Trading Results Descriptive Statistics (11/97-12/12)									
Mean	7.70	8.02	11.38	11.84	5.97	6.25	9.10	9.46	5.13
Std Dev	7.16	7.46	5.84	6.07	5.93	6.19	5.00	5.17	15.01
Skewness	3.82	3.89	2.48	2.46	2.66	2.73	2.32	2.27	-0.83
Kurtosis	22.99	23.34	11.21	10.92	13.29	13.62	10.47	10.00	3.84
Minimum	-0.03	-0.03	-0.02	-0.02	-0.03	-0.03	-0.02	-0.02	-0.14
Maximum	0.15	0.15	0.10	0.10	0.10	0.10	0.09	0.09	0.09
Range	0.18	0.18	0.12	0.12	0.13	0.13	0.10	0.10	0.24
$\rho_{FTSE\ AS}$	-0.08	-0.07	-0.08	-0.08	-0.11	-0.09	-0.12	-0.12	
P-Value	(0.26)	(0.32)	(0.27)	(0.29)	(0.15)	(0.21)	(0.11)	(0.12)	

Table 3: Risk Factor Descriptive Statistics and Cross Correlations

Panel A reports descriptive statistics for each of the monthly risk factors utilized to test for risk exposure for the entire sample period 1980 to 2012. Mean and Std Dev are annualised mean and standard deviation of monthly returns. Skewness and kurtosis are estimates of skewness and kurtosis calculated from monthly returns. Minimum (Maximum) is the minimum (maximum) monthly return. Range is the range of monthly returns. Panel B reports cross correlations.

Panel A: Descriptive Statistics

	Market	Size	Value	Momentum	Reversal
Mean	6.06	1.07	4.04	9.03	5.40
Std Dev	15.93	10.79	11.30	14.26	10.63
Skewness	-0.99	0.16	-0.55	-1.27	0.83
Kurtosis	6.55	5.43	9.24	10.87	5.73
Minimum	-0.27	-0.11	-0.19	-0.27	-0.08
Maximum	0.13	0.16	0.12	0.14	0.15

Panel B: Correlations

	Market	Size	Value	Momentum	Reversal
Market	1.00				
Size	0.01	1.00			
Value	0.05	-0.03	1.00		
Momentum	-0.16	-0.12	-0.52	1.00	
Reversal	-0.07	-0.09	-0.17	0.22	1.00

Table 4: Five Factor Model of Daily Pairs Trading Portfolios 1980-2012

This table reports results from estimating the five factor model on pairs trading portfolios from January 1980 to December 2012. Panel A displays results for the Top 5 and Top 20 Committed Capital and Fully Invested Portfolios. Panel B reports results for Top 5 and Top 20 Committed Capital Long and Short portfolios. In each panel rows 1 to 3 display annualised mean excess returns, standard deviation and Sharpe ratio. Rows 5 to 16 report estimated coefficients and associated P-Values (in parenthesis). Intercepts have been multiplied by 100 to aid interpretation. * ,** and *** indicate significance at 10%, 5% and 1% levels.

Panel A: Pairs Trading Portfolios 1980-2012

	Top 5 CC	Top 5 FI	Top 20 CC	Top 20 FI
Mean Excess Returns	0.06	0.06	0.09	0.09
Standard Deviations	0.05	0.05	0.04	0.05
Sharpe Ratio	1.24	1.24	2.03	2.04
Intercept	0.53***	0.55***	0.8***	0.84***
	(0.00)	(0.00)	(0.00)	(0.00)
Market	-0.04**	-0.04**	-0.05***	-0.05***
	(0.02)	(0.02)	(0.00)	(0.00)
SMB	0.02	0.03	0.00	0.00
	(0.33)	(0.30)	(0.96)	(0.94)
HML	-0.01	-0.01	-0.02	-0.01
	(0.72)	(0.72)	(0.47)	(0.55)
Momentum	-0.02	-0.02	-0.05***	-0.05***
	(0.30)	(0.26)	(0.01)	(0.01)
Reversal	0.00	-0.01	0.02	0.02
	(0.90)	(0.81)	(0.42)	(0.48)
Adjusted R^2	1%	1%	3%	3%

Panel B: Long and Short Portfolios 1980-2012

	Top 5		Top 20	
	Long	Short	Long	Short
Mean Excess Returns	0.07	-0.01	0.09	0.00
Standard Deviations	0.08	0.08	0.07	0.08
Sharpe Ratio	0.91	-0.14	1.28	0.00
Intercept	0.38***	0.00	0.55***	0.25***
	(0.00)	(0.12)	(0.00)	(0.00)
Market	0.3***	-0.34***	0.32***	-0.37***
	(0.00)	(0.00)	(0.00)	(0.00)
SMB	0.09***	-0.06**	0.12***	-0.12***
	(0.00)	(0.03)	(0.00)	(0.00)
HML	0.04	-0.05	0.03	-0.05*
	(0.25)	(0.15)	(0.20)	(0.10)
Momentum	0.00	-0.02	-0.04**	0.00
	(0.95)	(0.37)	(0.02)	(0.84)
Reversal	0.03	-0.03	0.04*	-0.02
	(0.39)	(0.34)	(0.08)	(0.43)
Adjusted R^2	37%	42%	60%	56%

Table 5: Five Factor Model of Daily Pairs Trading Portfolios 1980-2012

This table reports results from estimating the five factor model on pairs trading portfolios over two sub samples from January 1980 to October 1997 (Panel A) and November 1997 to December 2012 (Panel B). Top 5 (Top20) CC is the portfolio formed from the top five (20) pairs, identified in the formation period, assuming limited capital. Top 5 (Top 20) FI is the portfolio formed from the top five (20) pairs assuming unlimited capital. In each Panel row 1 to 3 displays annualised mean excess returns, standard deviation and Sharpe ratio. Rows 5 to 16 report estimated coefficients and associated P-Values (in parenthesis). Intercepts have been multiplied by 100 to aid interpretation. * ,** and *** indicate significance at 10%, 5% and 1% levels.

Panel A: Pairs Trading Portfolios: January 1980 - October 1997				
	Top 5 CC	Top 5 FI	Top 20 CC	Top 20 FI
Mean Excess Returns	0.06	0.07	0.10	0.12
Standard Deviations	0.04	0.04	0.04	0.04
Sharpe Ratio	1.58	1.57	2.30	2.60
Intercept	0.51***	0.53***	0.82***	0.99***
	(0.00)	(0.00)	(0.00)	(0.00)
Market	-0.02	-0.03	-0.04**	-0.05**
	(0.14)	(0.12)	(0.01)	(0.01)
SMB	0.05	0.05	0.01	0.02
	(0.10)	(0.12)	(0.87)	(0.64)
HML	0.04	0.04	0.06*	0.03
	(0.25)	(0.27)	(0.10)	(0.48)
Momentum	-0.02	-0.02	-0.05	-0.05
	(0.58)	(0.52)	(0.19)	(0.29)
Reversal	-0.06**	-0.06**	-0.03	-0.05
	(0.05)	(0.05)	(0.44)	(0.15)
Adjusted R^2	6%	6%	6%	5%
Panel B: Pairs Trading Portfolios: November 1997 to December 2012				
	Top 5 CC	Top 5 FI	Top 20 CC	Top 20 FI
Mean Excess Returns	0.06	0.06	0.09	0.11
Standard Deviations	0.06	0.06	0.05	0.06
Sharpe Ratio	1.01	1.02	1.82	1.93
Intercept	0.51***	0.53***	0.81***	0.97***
	(0.00)	(0.00)	(0.00)	(0.00)
Market	-0.04	-0.04	-0.04	-0.03
	(0.23)	(0.25)	(0.14)	(0.38)
SMB	0.00	0.00	-0.02	-0.03
	(0.97)	(0.96)	(0.60)	(0.34)
HML	-0.05	-0.05	-0.06*	-0.11***
	(0.24)	(0.25)	(0.07)	(0.01)
Momentum	-0.04	-0.04	-0.07***	-0.08***
	(0.20)	(0.19)	(0.01)	(0.00)
Reversal	0.04	0.04	0.06*	0.08**
	(0.31)	(0.35)	(0.09)	(0.03)
Adjusted R^2	0%	0%	3%	6%

Table 6: Trading Statistics by Pair Group for Top 20 Pairs

This table presents trading statistics by pair group, over different sample periods, for the portfolio of top twenty pairs. Group 1 pairs never trade. Group 2 pairs open but do not converge during the trading period. Group 3 pairs have one round-trip trade and possible also one non-convergent trade. Group 4 pairs have multiple round trip trades and possible one non-convergent trade. Proportion is the percentage of each Group that occur in each period. Price deviation trigger is the average deviation required for a pair to open. Average Monthly Return is the average monthly return per pair of each group in each period.

	Group 1 Nontraded Pairs			Group 2 Nonconvergent Pairs		
	01/80-10/97	11/97-12/12	01/80-12/12	01/80-10/97	11/97-12/12	01/80-12/12
Proportion	7.9%	4.7%	6.4%	41.0%	48.5%	44.5%
Price Deviation Trigger	0.022	0.041	0.028	0.022	0.049	0.036
Average Monthly Returns Per Pair	n.a.	n.a.	n.a.	0.0027	-0.0022	0.0002

	Group 3 Single Round Trips			Group 4 Multiple Round Trips		
	01/80-10/97	11/97-12/12	01/80-12/12	01/80-10/97	11/97-12/12	01/80-12/12
Proportion	15.1%	26.8%	20.6%	36.0%	20.0%	28.5%
Price Deviation Trigger	0.033	0.058	0.048	0.017	0.051	0.028
Average Monthly Returns Per Pair	0.0236	0.0147	0.0182	0.0235	0.0448	0.0305

Table 7: Model Controlling for Risk and Liquidity

This table reports results from estimating a model controlling for risk and liquidity for pairs trading portfolios from January 1988 to December 2012. In Panel A the Amihud (2002) Trade Impact measure for the FTSE All-Share Index sample is used to model aggregate equity market liquidity, whereas the Roll (1984) effective spread and the quoted spread are specified to proxy market lqiuidityin Panels B and C. All panels display results for the Top 5 and Top 20 Committed Capital and Fully Invested Portfolios. Rows 1 to 14 report estimated coefficients and associated P-Values (in parenthesis). Intercepts have been multiplied by 100 to aid interpretation. * ,** and *** indicate significance at 10%, 5% and 1% levels.

Panel A: Amihud (2002) Trade Impact

	Top 5 CC	Top 5 FI	Top 20 CC	Top 20 FI
Intercept	0.51***	0.54***	0.83***	0.88***
	(0.00)	(0.00)	(0.00)	(0.00)
Market	-0.03	-0.03	-0.04**	-0.04**
	(0.13)	(0.13)	(0.02)	(0.02)
SMB	0.05*	0.05*	0.02	0.02
	(0.09)	(0.07)	(0.36)	(0.33)
HML	-0.02	-0.02	-0.02	-0.02
	(0.60)	(0.61)	(0.43)	(0.51)
Momentum	-0.03	-0.03	-0.05**	-0.06**
	(0.26)	(0.23)	(0.01)	(0.01)
Reversal	-0.01	-0.01	0.01	0.01
	(0.83)	(0.73)	(0.74)	(0.81)
Liquidity	0.10**	0.11**	0.10***	0.11***
	(0.01)	(0.01)	(0.01)	(0.01)
Adjusted R^2	3%	3%	6%	6%

Panel B: Roll (1984) Effective Spread

	Top 5 CC	Top 5 FI	Top 20 CC	Top 20 FI
Intercept	-0.24	-0.24	-0.01	0.05
	(0.27)	(0.27)	(0.97)	(0.81)
Market	-0.04*	-0.04*	-0.04**	-0.05**
	(0.07)	(0.07)	(0.01)	(0.01)
SMB	0.04	0.04	0.02	0.02
	(0.12)	(0.10)	(0.42)	(0.43)
HML	-0.01	-0.01	-0.01	-0.01
	(0.81)	(0.82)	(0.66)	(0.74)
Momentum	-0.02	-0.02	-0.04**	-0.05**
	(0.46)	(0.41)	(0.04)	(0.04)
Reversal	-0.01	-0.01	0.00	0.00
	(0.70)	(0.60)	(0.89)	(0.96)
Liquidity	0.94***	0.97***	1.05***	1.04***
	(0.00)	(0.00)	(0.00)	(0.00)
Adjusted R^2	6%	6%	11%	10%

Panel C: Quoted Spread

	Top 5 CC	Top 5 FI	Top 20 CC	Top 20 FI
Intercept	0.30	0.34	0.17	0.20
	(0.24)	(0.19)	(0.40)	(0.35)
Market	-0.02	-0.02	-0.02	-0.01
	(0.24)	(0.29)	(0.38)	(0.45)
SMB	0.01	0.01	-0.02	-0.02
	(0.80)	(0.73)	(0.33)	(0.33)
HML	-0.04	-0.04	-0.06**	-0.06**
	(0.16)	(0.17)	(0.02)	(0.02)
Momentum	-0.04	-0.04	-0.06***	-0.06***
	(0.13)	(0.12)	(0.00)	(0.00)
Reversal	0.02	0.02	0.04*	0.04*
	(0.52)	(0.58)	(0.07)	(0.07)
Liquidity	0.17*	0.16**	0.23***	0.24***
	(0.08)	(0.04)	(0.00)	(0.00)
Adjusted R^2	2%	3%	5%	5%

Table 8: Five Factor Model of Daily Pairs Trading Portfolios 1988-2012

This table reports results from estimating a model controlling for risk for pairs trading portfolios formed net of different estimates of bid ask spread from January 1988 to December 2012. GGR is the Gatev et al. (2006) estimate of transaction costs. Quoted spreads are calculated from closing bid ask spreads and effective spreads are the Roll (1984) estimate of bid ask spreads. All panels display Committed Capital Portfolios. Rows 1 to 3 report annualised mean excess returns, standard deviations and Sharpe ratios. Rows 5 to 14 report estimated coefficients and associated P-Values (in parenthesis). Intercepts have been multiplied by 100 to aid interpretation.
* ,** and *** indicate significance at 10%, 5% and 1% levels.

Pairs Portfolios net of bid ask spread

	Top 5 GGR	Top 5 Quoted Spread	Top 5 Effective Spread	Top 20 GGR	Top 20 Quoted Spread	Top 20 Effective Spread
Mean Excess Returns	0.05	0.05	0.06	0.09	0.05	0.07
Standard Deviations	0.05	0.06	0.06	0.04	0.05	0.05
Sharpe Ratio	1.01	0.91	1.05	1.98	0.94	1.35
Intercept	0.46***	0.49***	0.56***	0.74***	0.47***	0.61***
	(0.00)	(0.00	(0.00)	(0.00)	(0.00)	(0.00)
Market	-0.03	-0.02	-0.02	-0.02	-0.01	0.00
	(0.24)	(0.49)	(0.48)	(0.35)	(0.66)	(0.96)
SMB	0.01	0.00	0.00	-0.01	-0.03	-0.01
	(0.73)	(0.96)	(0.96)	(0.53)	(0.29)	(0.67)
HML	-0.04	-0.08**	-0.08**	-0.05*	-0.11***	-0.08***
	(0.19)	(0.02)	(0.03)	(0.06)	(0.00)	(0.00)
Momentum	-0.04	-0.05*	-0.05*	-0.06***	-0.08***	-0.07***
	(0.13)	(0.06)	(0.06)	(0.00)	(0.00)	(0.00)
Reversal	0.02	0.04	0.04	0.05**	0.04	0.05*
	(0.48)	(0.25)	(0.23)	(0.04)	(0.11)	(0.07)
Adjusted R^2	0%	1%	1%	3%	4%	3%

Table 9: Pairs Trading Portfolios Performance in Short Term Market States 1988-2012

This table reports excess returns, risk adjusted returns and risk factor exposures in different market states. The sample is subdivided into different states based upon the current month market return. Panels A presents results for the Top 5 portfolio and Panel B reports results for the Top 20 portfolio. In each panel different estimates of transaction costs are included based upon waiting one day to execute (GGR); quoted spreads (QS) and effective spreads (ES). All panels display Committed Capital Portfolios. In each panel rows 1 to 3 report annualised mean excess returns, standard deviations and Sharpe ratios. Rows 5 to 14 report estimated coefficients and associated P-Values (in parenthesis). Intercepts have been multiplied by 100 to aid interpretation. * ,** and *** indicate significance at 10%, 5% and 1% levels.

Panel A: Top 5 Pairs Portfolios

	Top 5 Portfolio GGR		Top 5 Portfolio QS		Top 5 Portfolio ES	
	$R_{mkt} < 0$	$R_{mkt} \geq 0$	$R_{mkt} < 0$	$R_{mkt} \geq 0$	$R_{mkt} < 0$	$R_{mkt} \geq 0$
Mean Excess Returns	0.06	0.04	0.06	0.05	0.07	0.06
Standard Deviations	0.06	0.05	0.07	0.05	0.07	0.05
Sharpe Ratio	1.09	0.96	0.86	1.07	0.98	1.26
Intercept	-0.03	0.19	-0.08	0.25	-0.03	0.32*
	(0.90)	(0.23)	(0.80)	(0.15)	(0.92)	(0.08)
Market	-0.11**	0.07*	-0.11*	0.07	-0.12*	0.08*
	(0.03)	(0.08)	(0.07)	(0.11)	(0.06)	(0.09)
SMB	-0.03	0.04	-0.05	0.03	-0.05	0.03
	(0.51)	(0.19)	(0.40)	(0.35)	(0.39)	(0.33)
HML	-0.11**	0.01	-0.13**	-0.04	-0.12**	-0.05
	(0.03)	(0.75)	(0.03)	(0.31)	(0.04)	(0.29)
Momentum	0.00	-0.02	-0.02	-0.05	-0.01	-0.05
	(0.92)	(0.40)	(0.73)	(0.16)	(0.80)	(0.14)
Reversal	0.09**	-0.1***	0.11**	-0.08*	0.11**	-0.08**
	(0.03)	(0.01)	(0.03)	(0.05)	(0.03)	(0.05)
Adjusted R^2	12%	7%	10%	4%	10%	5%

Panel B: Top 20 Pairs Portfolios

	Top 20 Portfolio GGR		Top 20 Portfolio QS		Top 20 Portfolio ES	
	$R_{mkt} < 0$	$R_{mkt} \geq 0$	$R_{mkt} < 0$	$R_{mkt} \geq 0$	$R_{mkt} < 0$	$R_{mkt} \geq 0$
Mean Excess Returns	0.10	0.08	0.06	0.04	0.08	0.06
Standard Deviations	0.05	0.04	0.07	0.04	0.06	0.04
Sharpe Ratio	1.86	1.69	0.96	0.86	1.26	1.30
Intercept	0.18	0.36***	0.19	0.10	0.33	0.27**
	(0.39)	(0.00)	(0.48)	(0.46)	(0.21)	(0.04)
Market	-0.12***	0.11***	-0.06	0.10***	-0.05	0.1***
	(0.01)	(0.00)	(0.30)	(0.00)	(0.39)	(0.00)
SMB	-0.08**	0.04	-0.08	0.01	-0.06	0.02
	(0.04)	(0.12)	(0.13)	(0.68)	(0.24)	(0.43)
HML	-0.11***	-0.01	-0.19***	-0.04	-0.15***	-0.04
	(0.01)	(0.71)	(0.00)	(0.18)	(0.01)	(0.16)
Momentum	0.02	-0.07***	-0.03	-0.07***	0.00	-0.08***
	(0.54)	(0.00)	(0.50)	(0.01)	(0.93)	(0.00)
Reversal	0.07**	-0.02	0.08	-0.04	0.08*	-0.03
	(0.04)	(0.39)	(0.10)	(0.25)	(0.08)	(0.32)
Adjusted R^2	21%	18%	13%	10%	10%	14%

Table 10: Pairs Trading Portfolios Performance in Long Term Market and Economic States 1988-2012

This table reports excess returns, risk adjusted returns and risk factor exposures in different market and economics states. The sample is subdivided into different states based upon the prior 36 month market return and the 12 month growth in Industrial Production. Panels A (Panel C) presents results for the Top 5 portfolio and Panel B (Panel D) reports results for the Top 20 portfolio, based on the prior 36 month return (growth in Industrial Production). In each panel different estimates of transaction costs are included based upon waiting one day to execute (GGR); quoted spreads (QS) and effective spreads (ES). All panels display Committed Capital Portfolios. In each panel rows 1 to 3 reports annualised mean excess returns, standard deviations and Sharpe ratios. Rows 5 to 14 report estimated coefficients and associated P-Values (in parenthesis). Intercepts have been multiplied by 100 to aid interpretation.
* ,** and *** indicate significance at 10%, 5% and 1% levels.

Panel A: Top 5 Pairs Portfolios 36 Month Returns

	Top 5 Portfolio GGR		Top 5 Portfolio QS		Top 5 Portfolio ES	
	36 Month Down	36 Month Up	36 Month Down	36 Month Up	36 Month Down	36 Month Up
Mean Excess Returns	0.07	0.05	0.07	0.05	0.08	0.06
Standard Deviations	0.07	0.05	0.08	0.05	0.08	0.05
Sharpe Ratio	1.02	1.03	0.89	1.08	1.04	1.25
Intercept	0.7**	0.43***	0.76**	0.44***	0.86***	0.5***
	(0.01)	(0.00)	(0.02)	(0.00)	(0.01)	(0.00)
Market	-0.04	-0.01	-0.05	0.00	-0.05	0.00
	(0.49)	(0.51)	(0.51)	(0.86)	(0.49)	(0.89)
SMB	-0.13	0.06**	-0.19**	0.06*	-0.19**	0.06*
	(0.10)	(0.03)	(0.04)	(0.05)	(0.04)	(0.05)
HML	-0.05	-0.03	-0.07	-0.07**	-0.06	-0.07**
	(0.67)	(0.27)	(0.59)	(0.03)	(0.61)	(0.04)
Momentum	-0.04	-0.05**	-0.07	-0.07**	-0.07	-0.07**
	(0.51)	(0.04)	(0.34)	(0.02)	(0.35)	(0.02)
Reversal	-0.04	0.04	-0.05	0.06*	-0.04	0.06*
	(0.63)	(0.20)	(0.62)	(0.06)	(0.64)	(0.05)
Adjusted R^2	-2%	3%	1%	4%	1%	4%

Table 10 cont'd

Panel B: Top 20 Pairs Portfolios 36 Month Returns

	Top 20 Portfolio GGR		Top 20 Portfolio QS		Top 20 Portfolio ES	
	36 Month Down	36 Month Up	36 Month Down	36 Month Up	36 Month Down	36 Month Up
Mean Excess Returns	0.14	0.07	0.06	0.04	0.10	0.06
Standard Deviations	0.06	0.04	0.07	0.05	0.06	0.05
Sharpe Ratio	2.18	1.56	0.97	0.97	1.62	1.30
Intercept	1.34***	0.61***	0.76***	0.41***	0.99***	0.53***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market	-0.05	0.00	-0.02	0.00	-0.02	0.01
	(0.42)	(0.97)	(0.73)	(0.85)	(0.73)	(0.74)
SMB	-0.09	0.01	-0.12*	0.00	-0.09	0.01
	(0.20)	(0.63)	(0.08)	(0.93)	(0.16)	(0.60)
HML	-0.17	-0.03	-0.2*	-0.08***	-0.14	-0.07**
	(0.10)	(0.26)	(0.06)	(0.01)	(0.14)	(0.02)
Momentum	-0.13**	-0.05**	-0.14**	-0.07**	-0.12**	-0.07**
	(0.04)	(0.01)	(0.02)	(0.01)	(0.05)	(0.01)
Reversal	0.06	0.05**	0.01	0.06*	0.02	0.06**
	(0.40)	(0.02)	(0.86)	(0.06)	(0.74)	(0.04)
Adjusted R^2	3%	3%	5%	3%	1%	3%

Panel C: Top 5 Pairs Portfolios Economic States

	Top 5 Portfolio GGR		Top 5 Portfolio QS		Top 5 Portfolio ES	
	Recession	Expansion	Recession	Expansion	Recession	Expansion
Mean Excess Returns	0.04	0.07	0.04	0.08	0.05	0.09
Standard Deviations	0.05	0.06	0.05	0.07	0.05	0.07
Sharpe Ratio	0.81	1.28	0.70	1.39	0.83	1.59
Intercept	0.38***	0.58***	0.38***	0.66***	0.43***	0.75***
	(0.00)	(0.00)	(0.01)	(0.00)	(0.00)	(0.00)
Market	0.00	-0.01	0.01	0.01	0.01	0.00
	(0.89)	(0.82)	(0.87)	(0.89)	(0.81)	(0.90)
SMB	0.1***	-0.08*	0.08**	-0.09*	0.09**	-0.09*
	(0.00)	(0.07)	(0.03)	(0.09)	(0.03)	(0.08)
HML	-0.07	-0.06	-0.11**	-0.09	-0.11**	-0.08
	(0.11)	(0.28)	(0.03)	(0.15)	(0.03)	(0.17)
Momentum	-0.1***	-0.04	-0.11**	-0.05	-0.11**	-0.06
	(0.01)	(0.31)	(0.02)	(0.21)	(0.01)	(0.21)
Reversal	-0.01	0.06	0.01	0.07	0.01	0.08
	(0.82)	(0.14)	(0.79)	(0.13)	(0.76)	(0.12)
Adjusted R^2	6%	1%	4%	2%	4%	2%

Table 10 cont'd

Panel D: Top 20 Pairs Portfolios Economic States

	Top 20 Portfolio GGR		Top 20 Portfolio QS		Top 20 Portfolio ES	
	Recession	Expansion	Recession	Expansion	Recession	Expansion
Mean Excess Returns	0.07	0.11	0.05	0.05	0.06	0.07
Standard Deviations	0.03	0.05	0.05	0.05	0.05	0.05
Sharpe Ratio	2.01	1.98	0.94	0.92	1.29	1.31
Intercept	0.57***	0.95***	0.43***	0.51***	0.57***	0.67***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Market	0.00	-0.02	-0.01	0.00	0.00	0.01
	(0.84)	(0.56)	(0.73)	(0.91)	(0.93)	(0.78)
SMB	0.02	-0.05	0.01	-0.07	0.02	-0.04
	(0.33)	(0.20)	(0.82)	(0.11)	(0.64)	(0.28)
HML	-0.01	-0.09*	-0.08*	-0.12**	-0.08*	-0.08*
	(0.67)	(0.06)	(0.07)	(0.02)	(0.07)	(0.10)
Momentum	-0.04	-0.09**	-0.06	-0.09***	-0.07*	-0.08**
	(0.19)	(0.01)	(0.12)	(0.01)	(0.08)	(0.02)
Reversal	0.04	0.07*	0.06	0.04	0.06	0.05
	(0.15)	(0.07)	(0.13)	(0.32)	(0.13)	(0.23)
Adjusted R^2	0%	4%	1%	5%	1%	3%

Table 11: Summary Statistics Daily and High Frequency Portfolios 2007

This table reports key statistics for the Top 5 (Panel A) and Top 20 (Panel B) daily and high frequency portfolios using different levels of transaction costs (ranging from 0 to 15 basis points). Mean is the annualised mean monthly return. Std Dev is the annualised standard deviation of monthly returns. Skewness and kurtosis are estimates of skewness and kurtosis calculated from monthly returns. Minimum (Maximum) is the minimum (maximum) monthly return. Correlation is the correlation with the Daily Portfolio with associated P-Value in parenthesis.

	Daily Portfolio	High Frequency Portfolios			
		0bp	5 bp	10 bp	15 bp
Panel A: Top 5 Pairs					
Mean	3.806	19.801	15.014	10.229	5.444
Std Dev	5.248	5.040	5.007	4.983	4.971
Skewness	0.166	0.233	0.190	0.146	0.102
Kurtosis	4.115	4.054	4.007	3.959	3.910
Minimum	-0.011	-0.009	-0.009	-0.009	-0.009
Maximum	0.011	0.012	0.011	0.011	0.010
Correlation	1.000	0.100	0.103	0.106	0.109
P-Value	(0.000)	(0.141)	(0.127)	(0.115)	(0.105)
Panel B: Top 20 Pairs					
Annual Mean	1.588	15.029	10.696	6.364	2.032
Annual Std Dev	3.250	3.431	3.407	3.388	3.375
Skewness	-0.013	0.279	0.259	0.240	0.219
Kurtosis	4.010	4.039	4.062	4.082	4.098
Minimum	-0.006	-0.007	-0.007	-0.007	-0.007
Maximum	0.008	0.009	0.009	0.008	0.008
Correlation	1.000	0.092	0.093	0.093	0.093
P-Value	(0.000)	(0.174)	(0.171)	(0.170)	(0.170)