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The Determinants of the Merger Arbitrage Spread: Panel Data Approach Evidence from the UK

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Abstract

This thesis investigates merger arbitrage, an important hedge fund strategy. It addresses a significant gap in the literature by taking a panel data approach to ascertain the statistically significant determinants of the merger arbitrage spread (“spread”) for mergers and acquisitions (“M&A”) transactions involving UK listed companies. It also contributes to the extant literature concerning the risk return trade-off and level of efficiency of the UK equity market.

A spread is created when one listed company, the bidder, announces its intention to acquire another listed company, the target, and the consideration offered to the shareholders of the target contains an equity element. It is calculated as the percentage difference between the value of the bidder’s offer on a per share basis and the share price of the target and varies throughout the offer period which ends when the deal either completes or fails.

The collected data, a sample of 36 recent M&A transactions involving UK listed companies, demonstrate that spread for completed deals converges to parity over time as deal completion uncertainty is resolved. Conversely, there is no convergence of the spread for deals which fail to complete. These results are as expected in an efficient equity market with the presence of active arbitrageurs. The data also shows that the transactions take different lengths of time to complete or fail. Accordingly, and to create a balanced panel data-

set so that a range of panel data estimators could be employed, the offer period of each deal was innovatively converted from natural time into percentiles. This standardisation of time was possible because of the high frequency (minute-by-minute) nature of the collected data and it was found, via a number of robustness checks, not to significantly affect the conclusions drawn from the panel data regressions.

The first stage of the analysis was to econometrically estimate the determinants of the spread for a typical completed and failed deal using the static fixed and random effects models with ordinary least squares and generalised least squares estimators, respectively. Whilst the former produced plausible results when the autocorrelation and heteroscedasticity in the residuals were corrected for, it was found that a number of the variables were non-stationary and the results were, therefore, potentially spurious.

Evidence of an underlying cointegrating relationship between the spread and its hypothesised determinants was found for the completed deals and, accordingly, the next stage of the analysis was to estimate the determinants of the spread using a dynamic autoregressive distributed lag model with the pooled mean group estimator of Pesaran et al. (1999). The panel regression found that the statistically significant determinants of the spread were, as hypothesised, the premium payable by the bidder for the target, the recommendation of the deal by the target's board of directors to its shareholders, the presence of an alternate bidder for the target, the receipt of regulatory clearance and the approval by the target's shareholders. Conversely, the proportion of the consideration offered by the bidder which is in cash was found to be significant but positively related to the spread rather than negatively as hypothesised. This suggests that the proportion of cash consideration contributes to deal completion risk rather than supporting the notion that shareholders prefer the certainty of cash over other forms of consideration. For the failed deals, there was no evidence of cointegration and thus estimation of the panel was not possible.

These findings lend support to the conjecture that the UK equity market is informationally efficient and also strongly suggest that merger arbitrageurs in UK deals are rewarded for bearing unsystematic risk, primarily deal completion risk. They should also be of use to merger arbitrageurs for enhancing their trading profitability, in particular by exploiting the underlying relationship and short-run error correction mechanism identified between the spread and the tested determinants. Furthermore, the innovative methodological approach taken may stimulate further research into the determinants of the spread in other jurisdictions or may be applied to the investigation of other financial datasets.

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Chapter 1 – Introduction and Overview of the Research

1.1 Research Background

The initial motivations for conducting this research were twofold. The first was that merger arbitrage, alternatively known as risk arbitrage, is an important hedge fund strategy which currently has assets under management in excess of $100 billion (Barclayhedge 2022). The second derived from the author's professional work experience as an equity arbitrageur at an investment bank based in the City of London.

Before proceeding further, the definition of arbitrage, the merger arbitrage spread ("spread") and some clarification of the nature and objective of the strategy are deemed apposite.

Arbitrage is defined by The Oxford Dictionary of Economics as buying a good or asset in one market where price is low, and simultaneously selling in another market where price is higher (Hashimzade et al. 2017). A spread is created when one listed company, a bidder, announces its offer to acquire another listed company, a target, and all or part of its consideration offered to the shareholders of the target is in its equity. In such stock-only or hybrid (stock and cash) offers, a link is established between the share prices of the bidder and the target because, if the offer is successful, shares in the target company will convert into shares in the bidder company at an exchange ratio stipulated by the bidder in its offer document. This link means that a spread, the percentage difference between the share price of the target and the price per share offered for it as imputed by the share price of the bidder, is observable and can be calculated by using the share prices of the two companies and the exchange ratio. Further, the spread remains in existence throughout the offer period which commences when the bid is announced and ends when the transaction either completes, the bidder acquires the target, or is withdrawn, the bidder fails to acquire the target.

Merger arbitrage hedge fund managers establish positions which seek to profit from a positive merger arbitrage spread (i.e., when the market price of the target is trading at a discount to the imputed offer price) by simultaneously buying (going long) shares in the target and selling (going short) shares in the bidder at the exchange ratio. They will profit, capture the spread, if the deal is successful and completes with the original bidder. Conversely, they are likely to suffer significant losses if the transaction fails, is withdrawn or if the target is acquired by a different company, a counterbidder. As a result of this asymmetry in the potential returns to the strategy, the spread varies over the offer period due to fluctuating expectations about whether the deal will complete or fail, deal completion risk.

It is important to state at this juncture that merger arbitrageurs also set up positions in cash-only offers where the bidder does not offer any of its shares to the target's shareholders. Since this only involves buying shares in the target company it does not meet the definition of arbitrage, which involves taking positions in at least two different assets. Consequently, there is no merger arbitrage spread for cash-only offers. It is also worthy of mention that, although mergers and acquisitions ("M&A) are commonly referred to as interchangeable terms, there is a distinct legal difference between a merger and an acquisition in the UK. A merger involves the creation of a new parent company which owns the shares of the merging companies. Since the new parent company does not list (become tradeable) until the merger completes, no arbitrage is possible. Conversely, an acquisition involves the bidder seeking to own all of the shares in the target which are tradeable throughout the offer period. Accordingly, merger arbitrageurs in the UK only actually take positions in acquisitions and not in mergers.

1.2 Extant Literature

The extant academic literature on merger arbitrage can be categorised into three main strands, namely: i) the estimation of the nature of the returns to and the sources of risks of the strategy (i.e. Larcker and Lys 1987; Mitchell and Pulvino 2001); ii) the development of static probabilistic models to predict the outcome of a transaction (i.e. Walkling 1985; Wang and Branch 2009) and, latterly, iii) cross-sectional empirical research into the determinants of the spread (i.e. Jetley and Ji 2010; Redor 2019) at a single point in time.

The paper published by Jetley and Ji (2010) is worthy of further mention as its title, "The Shrinking Merger Arbitrage Spread: Reasons and Implications", suggests that it is the most similar to the research performed in this thesis. However, and whilst it; i) considers why the average spread has declined over time and; ii) seeks to ascertain the determinants of the spread at a single point in time, it does so separately. To clarify, it does not use panel data which combines the longitudinal and cross-sectional dimensions of the data. Rather, it studies the times series of average spreads on a longitudinal basis and, separately, estimates the determinants of the spread at a single point in time on a cross-sectional basis.

Indeed, no research has been published to date which takes a panel data approach with both cross-sectional and longitudinal dimensions to estimate the common determinants of the spread on a dynamic basis over the entire duration of the offer period. It is also noteworthy that the research performed to date has mostly been based upon US transactions and has included cash-only offers which do not, strictly speaking, involve arbitrage as there is no link between the share prices of the bidder and target companies. This literature has, however, been reviewed despite it not being directly relevant to the empirical work conducted for this thesis.

The most commonly found factors which affect the probability of deal completion and/or the determinants of the spread in the extant literature are as follows:

1. Hostility, defined as the whether the target's board of directors recommend that its shareholders either accept or reject the bidder's offer;

2. The run-up, percentage increase, in the target's share price prior to the bidder's announcement of its offer;

3. The size, market capitalisation, of the target company either in absolute terms or relative to the size of the bidder;

4. The existence of a break fee, payable by the target to the bidder in the event of the deal failing to complete;

5. The abnormal trading volume in the shares of the bidder and/or the target companies, as a proxy for merger arbitrage activity;

6. The percentage of the bidder's consideration for the target which is in cash;

7. The bid premium, defined as the percentage difference between the value of the consideration offered by the bidder for the target and the market capitalisation of the target; and

8. Toehold, defined as the percentage of the target's shares which are either owned by or pledged to the bidder.

Accordingly, and as well as testing the above determinants using a more recent sample of non-US (UK) transactions, this doctoral study also seeks to fill a number of the gaps in the literature by:

i) Taking a panel data approach to ascertain the common determinants of spread over the entire offer period rather than at a fixed point in time (i.e., on a dynamic rather than a static basis); and

ii) Incorporating potential determinants which, due to their time varying nature, have not been previously tested (e.g., the announcement that regulatory hurdles necessary for UK deal completion have been achieved).

1.3 Sample and Methodology

The sample used for this research is 36 UK stock-only and hybrid M&A transactions announced in the 18 years since the start of this century until the end of 2017. For each of these 36 deals, data was collected over the entire offer period on a minute-by-minute basis to enable the calculation of the: i) merger arbitrage spread; ii) abnormal volume of shares traded in the bidder and the target; iii) bid premium; iv) percentage of the bidder's consideration which is in cash; and v) percentage of the shares in the target which are either owned by or pledged to the bidder. Data was also collected on the timing of announcements relating to the: i) hostility of the directors of the target to the bid; ii) presence of a potential or actual counterbidder for the target; iii) receipt of regulatory clearance for the deal, if required and; iv) approval of the deal by the shareholders of the target. In addition to this longitudinal data, data to enable calculation of the relative size of the bidder and the target immediately prior to deal announcement and the run-up in the target's share were collected.

The collected data for each of the deals enabled the construction of a panel dataset. However, and because the offer period for each deal is different, the panel was unbalanced which would preclude regression using more recently developed dynamic panel data estimators. To overcome this issue, the data for each deal was converted from natural time (i.e., for each minute of the offer period) into percentiles of the offer period. This standardisation of time to create a balanced panel was only possible due to the purchase and collection of minute-by-minute data which has only relatively recently become available at reasonable cost.

To ascertain the statistically significant determinants of the spread, the balanced panel was regressed using the random effects, fixed effects and pooled mean group panel data estimators. Further, and because no extant literature exists regarding the standardisation of time into percentiles to create balanced panels, robustness checks were performed to test that the conclusions drawn were unaffected by this innovative approach.

1.4 Research Questions

The primary research question being addressed by this thesis is “what are the statistically significant determinants of the merger arbitrage spread in the UK equity market?” However, and as a result of the panel data approach that has been taken and the nature of the potential determinants tested, two further questions may be answered. Firstly, “is the UK equity market informationally efficient?” Light can be shed upon this because of the inclusion of previously untested potential determinants which relate to the hurdles which must be passed for a UK deal to complete. Secondly, “is the return to merger arbitrage in the UK compensation for bearing unsystematic risk?” Evidence can be provided to answer this question because the bulk of the determinants tested are aspects of undiversifiable deal completion risk.

1.5 Potential Impact

The methodological approach taken and the findings of this thesis, particularly the dynamic panel data regression results using the powerful pooled mean group estimator of Pesaran et al. (1999), are hoped to be useful to merger arbitrageurs as an aid to their trading decisions, particularly those who focus upon the UK equity market.

It is also hoped that it may stimulate further empirical research into the determinants of the spread employing the same methodological approaches in jurisdictions other than the UK. Similarly, this may shed light on the sources of risk of the strategy and the level of informational efficiency in these other equity markets.

Finally, the innovative standardisation of natural time into percentiles for the purposes of creating balanced panel datasets (which can be regressed with a wider range of more powerful estimators) may encourage other researchers to replicate the approach with financial data sets other than merger arbitrage.

1.6 Thesis Structure

The remainder of this thesis is structured as follows: chapter 2 provides a theoretical framework for the research by reviewing the extant literature which concerns the risk return trade-off in financial markets, the efficiency of equity markets and the risk of and returns to merger arbitrage; chapter 3 progresses the review to consider the empirical research performed on the factors which contribute towards the probability of M&A deal completion and the determinants of the spread itself. It also covers the relevant legal and regulatory aspects and develops testable hypotheses; chapter 4 sets out the research methodologies and describes the collected data; chapter 5 reports and discusses the regression results using the traditional panel data estimators; chapter 6 reports and discusses the dynamic regression results using the pooled mean group panel data estimator. It also includes the results of the robustness checks regarding the innovative standardisation of time into percentiles; and chapter 7 both summarises and concludes the thesis.

Chapter 2 – Theoretical Framework

2.1 Introduction

The two fundamental finance theories which underpin this research are the risk-return trade-off, specifically the nature of the risk that investors are rewarded for bearing, and market efficiency, specifically the informational efficiency of capital markets. These theories are deemed to be crucial for this research because, if investors are rewarded for bearing risk in an informationally efficient capital market, it logically follows that any new publicly available information which increases risk should be reflected in a higher expected return. Similarly, any new publicly available information which decreases risk should lead to a lower return. These two theories are also considered in the context of a third, more recently developed, theory known as the limits of arbitrage.

Accordingly, this chapter initially reviews the key extant literature on the risk return trade-off and how the understanding of the nature of the risk that affects the returns of risky assets has developed since the middle of the 20th century. It then proceeds to review the development of what has become known as the Efficient Markets Hypothesis and the challenges to it, particularly from proponents of what is commonly known as behavioural finance. Next, it reviews the emergent limits of arbitrage literature and considers the impact of this on the risk return trade-off and market efficiency. Finally, it reviews the literature concerning the risk of and returns to merger arbitrage.

2.2 Review of the Risk Return Trade-Off Literature

The risk return trade-off, the notion that the expected return from investing in a risky asset is compensation for the degree of uncertainty over its future outcomes, is arguably the most fundamental tenet of finance.

Markowitz, in his seminal 1952 paper, is commonly cited as the first to elucidate the risk return trade-off. He did so in terms of an expected returns – variance of returns ("E-V") rule which states that *"the investor would (or should) want to select one of those portfolios … with minimum V (variance) for given E (expected return) or more and maximum E for given V or less"* (1952, p. 82). Hence, he stated that the expected return of a risky asset is the compensation for bearing total risk which he defined as the variance of the expected returns. In deducing his E-V rule, Markowitz made the following assumptions:

1. Investors are rational and therefore risk averse, they prefer less risk to more risk for the same level of expected return;

2. The expected returns, variances and covariances of all asset returns are known and all investors have access to all information at no cost;

3. The expected returns of all assets are normally distributed so risk can be described by the variance (or standard deviation, the square root of the variance) of expected returns; and

4. Capital markets in which securities such as equities or bonds trade are frictionless, there are no transaction costs or taxes.

Whilst the first and third assumptions appear to be plausible approximations to reality, it is clear that the second and fourth are not. Assumption two implies that every investor has access to all the information required to form an opinion on expected returns, variances and covariances which is implausible. Similarly, assumption four does not hold in the real world with broker commissions and taxes levied upon both capital gains and investment income.

Sharpe (1964) developed Markowitz's work to posit that investors are not rewarded for bearing total risk (the variance of expected returns) but rather for that element of it which cannot be eliminated by portfolio diversification. This undiversifiable element of the variance, which he termed as systematic risk (alternatively known as market risk), arises from factors which are common to all securities trading in a particular capital market (i.e., equities or bonds) such as economic cycles, interest rates, inflation rates and political stability. The term given by Sharpe to the diversifiable element of total risk was unsystematic risk (also commonly known as idiosyncratic risk or specific risk) which relates to factors which are specific to a particular security rather than common factors. It is diversifiable because the formation of a portfolio of dissimilar securities will cause the positive sensitivity to the specific risk factor of some portfolio constituents to offset the negative sensitivity of others. Using a crude example, the sensitivity of an equity portfolio which only contains shares in airline companies to changes in the oil price may be reduced by the addition to the portfolio of shares in oil exploration companies. The profits, and thus the share prices, of airlines are negatively correlated with the oil price because aviation fuel is a significant element of their cost bases, whereas the profits generated by oil explorers are positively correlated with the oil price.

Accordingly, Sharpe asserted that, because diversification of security portfolios is relatively simple and inexpensive to achieve, investors would not be rewarded for bearing unsystematic risk. Furthermore, he asserted that the systematic risk of a particular security was quantifiable which he termed as its beta (β). These assertions, together a number of other restrictive assumptions which are explained below, enabled Sharpe to propose his now famous Capital Asset Pricing Model ("CAPM"), the formula for which is shown at equation 2.1 below.

$$E(R_i) = r_f + \lambda_M \beta_{i,M} \qquad (2.1)$$

where $E(R_i)$ is the expected return of security i, r_f is the risk-free rate, λ_M is the risk premium (expected return in excess of the risk-free rate) of the market portfolio and $\beta_{i,M}$ is the beta of security i, its systematic risk relative to the systematic risk of the market portfolio.

In arriving at the CAPM formula, and in addition to those made by Markowitz, Sharpe made the following assumptions:

1. There exists an investable portfolio termed the market portfolio which includes the entire universe of risky assets and is thus perfectly diversified (contains systematic risk only);

2. There exists an investable risk-free asset which has a guaranteed rate of return and which can be bought (lending at the risk-free rate) or sold short (borrowing at the risk-free rate) by investors without limit and without affecting the risk-free rate;

3. Investors have homogenous expectations, they all have the identical opinion about each risky asset's mean return, variances of return and covariances of returns with other risky assets; and

4. Investors are price takers; they can buy or sell risky assets in any quantity without affecting their market prices.

In the real world, none of the above assumptions hold absolutely. Indeed, Sharpe himself stated that "Needless to say, these are highly restrictive and undoubtedly unrealistic assumptions" (p. 434). First, the investable market portfolio and risk-free assets are theoretical constructs, neither actually exist although proxies (e.g., the expected return of a broad equity index for the expected return of the market portfolio and the yield to maturity on short-term government bills or bonds for the risk-free rate) are used in practice. Secondly, investors have heterogenous rather than homogenous expectations, particularly equity investors due to the uncertainty over future corporate profitability and cash flow generation. Thirdly, price-taking unrealistically implies that there is infinite liquidity in every market for every risky asset.

Despite the questionable realism of its underpinning assumptions, the CAPM makes an important contribution to the understanding of the risk return trade-off. The implications are that expected return derives solely from bearing systematic risk and that unsystematic risk can be ignored. Indeed, Sharpe states that "…the proper test of a theory is not the realism of its assumptions but the acceptability of its implications…" (p. 434). Moreover, and of particular importance for this research, the CAPM is also a model which describes a market in equilibrium and Sharpe, without actually using the term, introduces the notion of arbitrage and the actions of arbitrageurs. He does so by explaining that if the expected returns of an asset are above that predicted by the CAPM formula, investors will rush to buy the asset, pushing up its price and decreasing its expected return until it is the same as that predicted by the CAPM. Conversely, if the expected returns of an asset are below that predicted by the CAPM, investors will rush to sell the asset, pushing down its price and increasing its expected return until it is the same as that predicted by the CAPM.

Arbitrage is defined in Bodie et al. (2008) is the act of exploiting the mispricing of two or more securities to achieve risk-free profits. In addition to being risk-free, insofar that the profit is guaranteed, pure arbitrage is also investment free with the proceeds of shorting the relatively expensive security used to purchase the relatively inexpensive security. It also implies that the securities are perfect substitutes for one another. Accordingly, in a well-functioning capital market, there should be no arbitrage opportunities as the arbitrageurs will have already acted to exploit and thus eliminate them.

This concept of no arbitrage was applied by Ross (1976) to develop his Arbitrage Pricing Theory (APT). The derivation of the APT is based upon less restrictive assumptions than the CAPM and it is a multi-factor rather than a one-factor model. However, and alike the CAPM, it is an equilibrium model which relies upon arbitrage and it also proposes a linear relationship between the expected return of a risky asset and common, systematic, risk factors.

The APT formula for an individual risky asset (security) is shown at equation 2.2 below.

$$E(R_i) = r_f + \sum_{j=1}^{j=K} \lambda_j \beta_{i,j} \tag{2.2}$$

where $E(R_i)$ is the expected return of security i, r_f is the risk-free rate, λ_j is the risk premium (expected return in excess of the risk-free rate) for the common systematic risk factor j, $\beta_{i,j}$ is the sensitivity of security i to the systematic risk factor j and K is the number of systematic risk factors.

It can be seen from equation 2.2 that the APT effectively disaggregates the systematic risk of the market portfolio per Sharpe (1964) into a set of component common risk factors. However, the model does not specify nor quantify these components. Rather, Ross asserts that the components are an empirical matter to be identified via multivariate linear regression using those factors which are hypothesised to be the components of total systematic risk.

The CAPM and the APT have both been subject to extensive empirical investigation since they were developed and published. Whilst a detailed consideration of these investigations is beyond the scope of this research, the most consistent finding that they share in common is that neither model is particularly effective at forecasting actual returns. As a result of this, a number of other factor models have subsequently been developed (e.g., Fama and French's (1992) three factor model, Jagannathan and Wang's (1996) Conditional CAPM, Carhart's (1997) four factor model and Fama and French's (2015) five factor model). The empirical tests performed using these more recent pricing models suggest that they are less ineffective at forecasting actual returns than the CAPM or the APT. Despite this, and to conclude this part of the theoretical framework chapter, all of the asset pricing models reviewed above share the following common features:

a) They all propose that only common (systematic) risk factor(s) affect the returns of risky assets. Similarly, unsystematic risk is diversifiable and thus does not affect the returns of risky assets. In other words, systematic risk is priced by the market whereas unsystematic risk is unpriced;

b) They all assume that capital markets are frictionless and that all information is freely available to all market participants; and

c) They are all equilibrium models which either implicitly or explicitly assume that arbitrageurs exist and that there are no limits of arbitrage.

2.3 Review of the Market Efficiency Literature

Before proceeding to review the market efficiency literature, it is deemed apposite to set out the two, somewhat distinct, questions which this research field has sought, and continues to seek, to answer. These questions can be summarised as follows:

1. How well do markets price risky assets, does the secondary market price of a security approximate to its intrinsic value?; and

2. What is the nature and extent of the information which is incorporated in the secondary market price of a security?

In order to clarify the terms used in the first objective in relation to equity securities, shares issued by corporate entities, the secondary market price is the level at which the shares which have been previously issued by the company in the primary capital market are being bought and sold, trading, at a point in time. The intrinsic value of a share at a point in time is, as postulated by Williams (1938), the present value of the expected future cash flows from it, calculated by discounting them using a percentage rate which reflects their uncertainty, risk, in terms of the amount and timing of those cash flows. It therefore follows that, because the future is inherently unknowable, the owners or potential owners of shares in a particular company will have differing opinions on the intrinsic value and it is for this very reason that secondary security markets exist in order to facilitate trade between buyers, who believe that the market price is below intrinsic value, and sellers, who believe that the market price is above its intrinsic value.

Market efficiency was a term first coined by Fama (1965) who stated that "an efficient market for securities is a market where, given the available information, actual prices at every point in time represent very good estimates of intrinsic value" (p. 90). To arrive at this statement, Fama found strong empirical evidence to support the earlier theoretical work performed by researchers including Roberts (1959, cited in Fama 1965) that security returns are serially independent and have stable distributions. Serial independence implies that security prices follow a random walk and thus past prices have no predictive power. This echoes a similar theoretical postulate, that properly anticipated prices fluctuate randomly, which was advanced in the same year by Samuelson (1965). Although Fama does not make specific reference to the practice of arbitrage, he cited the work of Miller and Modigliani (1961, cited in

Fama 1965) in support of efficiency which explicitly states that arbitrageurs will trade to equalise returns from the equity of similar companies. Moreover, he asserts that the existence of sophisticated traders in the market who can consistently predict the appearance of new information and evaluate its effects on intrinsic values would be sufficient to ensure that actual market prices are, on the basis of all available (actual and anticipated) information, the best estimates of intrinsic values. However, whilst the existence of sophisticated traders should lead to new information being reflected fully, rationally and instantaneously in security prices, he recognises that this rarely occurs due to "vagueness or uncertainty concerning new information" (p. 39).

Fama et al. (1969) further researched the speed, extent and rationality of equity price reaction to new information by analysing stock splits using an event-study methodology with monthly equity price data. It was found that the information conferred about intrinsic value in the split was, on average, fully reflected in prices by the end of the month in which the split was announced. However, the use of monthly data precluded any precise evaluation of the time taken for new information to be assimilated into prices.

Fama (1970) reviewed the market efficiency work performed by himself and others since the publication of his first paper in 1965. He postulated that the level of information included in security prices could be empirically tested by sub-dividing it into three nested sub-sets or forms, as shown in table 2.1.

Table 2.1
Fama's Forms of Informational Efficiency

Form	**Security Prices Incorporate:** Historic price sequences	Publicly available information	Private (insider) information
Weak	Yes	No	No
Semi-strong	Yes	Yes	No
Strong	Yes	Yes	Yes

Fama contended that markets are efficient in the weak and semi-strong forms, which has three primary implications: i) prices react rationally and instantaneously to the release of new publicly available information which affects intrinsic value; ii) prices reflect all publicly available information; and iii) it is not possible to make consistent abnormal risk-adjusted (excess) returns on the basis of publicly available information. Conversely, he opined that markets were not strong form efficient which he suggests is "probably best viewed as a benchmark against which deviations from market efficiency (interpreted in its strictest sense) can be judged" (p. 415). Furthermore, he asserts that the assumptions which underpin Sharpe's (1964) Capital Asset Pricing model, in particular that markets are frictionless, all available information is freely available to all market participants and that there are no limits of arbitrage, are "…sufficient for market efficiency but not necessary" (p. 387). He concludes the paper by asserting that "the evidence in support of the efficient markets model is extensive, and (somewhat uniquely in economics) contradictory evidence is sparse” (p. 416).

Fama and Macbeth (1973) reaffirmed the earlier findings of weak and semi-strong efficiency from an empirical test of the relationship between the average return and risk of US equity securities between 1943 and 1968. However, papers which questioned the validity of what had, by that time, become known as the Efficient Markets Hypothesis (“EMH”) were subsequently published. In particular, Fama’s assertion that market efficiency is unaffected by the existence on non-sophisticated traders was challenged by Grossman and Stiglitz (1980). They posited that traders fall into two distinct categories, sophisticated traders (or informed arbitrageurs) who make investment decisions based on a full information set and make rational decisions based purely upon the expected returns and the variability (risk) of those returns and unsophisticated traders (or uninformed noise traders) who trade on a limited information set and who do not make investment decisions based upon expected returns and the variability of those returns. As a result of this bifurcation and the fact that information is not free in the real world, they argued that security prices will always deviate from intrinsic value due to the information acquisition costs borne by the informed arbitrageurs. Accordingly, they concluded that markets can never be efficient in the way described by Fama where prices always represent very good estimates of intrinsic value.

Figlewski (1978) provided further insight into how real-world markets differ from efficient markets by developing a model of security price formation when market participants have heterogeneous, rather than homogeneous information. He found that informational efficiency is impossible even in the absence of unsophisticated traders due to the heterogeneous nature of information and to the fact that even informed arbitrageurs have differing forecasting abilities and levels of risk aversion. His paper also drew the analogy of a security market as a voting mechanism whereby traders' information is weighted and assimilated into prices not by the quality of that information but rather by "dollar votes", the weight of money.

In addition to the theoretical challenges to market efficiency, Fama's hypothesis was also subject to extensive empirical investigation and a number of apparent anomalies were exposed such as the predictive power of price earnings ratios by Basu (1977), excess volatility by Shiller (1981) and over-reaction to news by Debondt and Thaler (1985).

Basu (1977) found evidence to suggest that portfolios of apparently cheap stocks which were trading on relatively low price earnings ratios, a widely used yet imprecise equity valuation measure, outperformed portfolios which contained apparently expensive stocks trading on relatively high price earnings ratios, an effect which would not be expected in an efficient market. Shiller (1981) argued that, in an efficient market, equity prices should only change when new information is put into the public domain whereas far greater volatility was observed in actual prices. Debondt and Thaler (1985) found evidence to suggest that prices of equities tended to over-react to new information pertaining to their intrinsic value before subsequently reaching a new equilibrium level rather than moving instantaneously to the new level as would be expected in an efficient market. Further, they ascribed these findings to investors' cognitive biases and thus established what has become known as the field of behavioural finance.

Black (1986) contrasted noise, a large number of pieces of non-information which have no effect on the intrinsic value of a security, to information which does affect intrinsic value and then considered the impact on security prices if traders unknowingly treat the former as the latter. He posited that the existence of uninformed noise traders cause prices to be inefficient yet are essential to provide market liquidity. Moreover, he states that “the price of a stock will be a noisy estimate of its value” (p. 534) and further suggests an alternative definition of an efficient market as “one in which price is within a factor of two of [intrinsic] value, i.e., the price is more than half of value and less than twice value” (p. 533).

Summers (1986) stated that a corollary implication of the failure to reject the EMH is that prices of securities represent rational assessments of intrinsic value. His review of the extant literature leads him to argue that the statistical testing methods have produced no evidence against the view that security prices deviate widely and frequently from rational valuations. He argues that this is consistent with Keynes’ (1936, cited in Summers 1986) notion that financial markets are sometimes driven by “animal spirits unrelated to economic realities” (p. 594) and with Tversky and Kahneman’s (1981, cited in Summers 1986) experimental evidence which suggests that market participants often overreact to new information.

Merton (1987) posited that security prices may exhibit informational inefficiency due to institutional complexities and information costs, despite the domination of rational informed traders in the market. He also suggested that the time taken to correct such pricing anomalies will depend upon the nature of the information and compares the rapid price adjustment to the announcement of expected information through standard channels such as earnings and dividends via the stock exchange to the gradual price adjustment to more esoteric information such as that published in academic journals.

Bernard and Thomas (1989) performed empirical research into the cause of post-earnings announcement drift where abnormal equity returns for companies which announce better or worse than expected financial results continue to drift up or down for sixty days after the earnings are announced. They concluded that the delayed price response to the new information was likely caused by traders' failure to fully and immediately recognise its implications for intrinsic value.

Although most of the anomalies to the EMH were refuted by Fama in his 1991 meta-analysis titled "Efficient Capital Markets: II", he does concede, in response to Grossman and Stiglitz (1980), that the existence of information and trading costs means that markets can never be perfectly efficient. Accordingly, he relaxes the definition of efficiency to be when prices reflect information to the point at which the marginal benefits of acting on this information are equal to the marginal costs of obtaining it.

In addition, Fama renamed and redefined the tests of the forms of informational efficiency as follows:

a) Weak form tests were renamed as tests for return predictability to include determinants of future returns other than solely past returns;

b) Semi-strong form tests were renamed as event studies which test how rapidly prices reflect new information; and

c) Strong form tests were renamed as tests for private information.

Tests for return predictability using a larger and more recent population of historic returns lent support to his earlier findings that they possess little predictive power over the short (daily and weekly) term. Historic returns appear to have greater, albeit still minimal, predictive power over the long (2 to 10 year) term suggesting a degree of slow mean reversion.

Event studies, especially those performed over the shortest (daily) time periods, have provided the strongest evidence to support market efficiency between the weak and semi-strong forms with Fama (1991) reporting that, on average, stock prices seem to adjust within a day of event announcement, particularly if it is firm specific. Moreover, he states that “the result is so common that this work now devotes little space to market efficiency” (p. 1601) rather than providing any specific citations. It is also interesting that the early works on behavioural finance by Debondt and Thaler (1985) and Summers (1986) are cited and yet effectively dismissed by Fama.

In response to the growing body of literature on behavioural finance, the impact of investor psychology on security pricing, as the primary reason for anomalies to market efficiency, Fama published his final paper on the EMH in 1998. His (unusually curt) conclusion to this paper continues to refute that anomalies actually exist and that the traditional paradigm should not be abandoned. In particular, he posits that “the apparent overreaction of stock prices to information is about as common as underreaction, that post-event abnormal returns are about as frequent as post-event reversals and that long-term return anomalies are fragile and tend to disappear with reasonable changes in the way in which they are measured” (p. 304). Perhaps of more interest is that he does not comment upon the emergent limits to arbitrage literature in this paper.

A number of theoretical studies into behavioural finance were published in the late 20th and early 21st century. These included Daniel and Titman (1999) who ascribed momentum in equity returns to investor overconfidence and Hirshleifer (2001) who postulated that human investors can only ever be, at best, imperfectly rational. These were followed by meta-analyses of the extant behavioural finance and, to a lesser extent, limits to arbitrage, research by Barberis and Thaler (2002), Schwert (2002) and Shiller (2003). Each of these challenged Fama's paradigm and this is perhaps best summarised by Shiller who asserted that "While theoretical models of efficient markets have their place as illustrations or characterisations of an ideal world, we cannot maintain them in their pure form as actual descriptors of actual markets" (p. 102) and by Hirshleifer who opined that "Over time I believe that the purely rational paradigm will be subsumed by a broader psychological paradigm that includes full rationality as a significant special case" (p. 1534).

A defence against the behavioural criticisms of the traditional efficient market paradigm was offered by Malkiel (2003) who acknowledged that market pricing is not always perfect and that psychological factors can influence security prices. He concludes this paper by stating that "The end result will not be an abandonment of the belief of many in the profession that the stock market is remarkably efficient in its utilisation of information" and that "If any $100 bills are lying around the stock exchanges of the world, they will not be there for long" (p. 80).

An attempt to reconcile the differences between the supporters of Fama and his behavioural finance critics was advanced by Lo (2004). He postulated that security markets were akin to biological systems which learn and evolve over time in order to survive. As such, there are periods when markets are learning and are thus inefficient. These periods are then followed by a period of consolidation and efficiency, then another period of inefficiency, ad infinitum.

Lo (2012) also reflected upon the effect of the financial crises on the continued relevance of the efficient markets paradigm vis-a-vis his adaptive markets hypothesis (2004). Perhaps unsurprisingly, he argues that "the adaptive markets hypothesis can explain not only departures from the efficient market hypothesis and behavioural regularities but also how markets shift from the wisdom of crowds to the madness of mobs and back again" (p. 28).

In 2014, both Eugene Fama and Robert Shiller were awarded, together with Lars Hansen, the prize in Economic Sciences in Memory of Alfred Nobel for their empirical analyses of asset prices. Shiller's (2014) lecture on receipt of the prize provides a broad overview of the debate between the proponents of the traditional efficient markets paradigm and the supporters of behavioural finance and he concludes by asserting that "the patterns of behaviour that have been observed in speculative asset prices are consistent with a view of market efficiency as a half-truth today and at the same time with a view that there are behavioural complexities in these markets" (p. 1512). Fama (Nobelprize.org 2013) countered by stating in his lecture on the same day and presumably in the same room that "the behavioural literature has not put forth a full-blown model for prices and returns that can be tested and potentially rejected - the acid test for any model proposed as a replacement for another model" (p. 378).

To summarise this sub-section, the EMH has evolved since the mid-1960s when its proponents theorised and provided empirical evidence that security prices followed a random walk, assimilated new information instantaneously and always provided a close guide to intrinsic value. The remainder of the last century saw this paradigm challenged by behavioural finance theorists and this has continued in the current millennium.

Despite these challenges, Fama's 1970 framework of informational efficiency remains a useful benchmark and it is possible to use it to argue that equity markets are close to, but not quite, semi-strong efficient. If this argument is accepted, the answer to the first question set out at the start of this sub-section, how well do markets price risky assets?, is reasonably well but not perfectly as share prices react rationally and quickly, albeit not instantaneously, to the release of new publicly available information which affects estimates of intrinsic values. Further, the answer to the second question, what is the nature and extent of the information which is incorporated in the secondary market price of a security?, is all historic and most, but not all, publicly available information. As a consequence of these answers, it can be deduced that it may be possible for equity investors to make abnormal returns (in excess of those rewarded for bearing systematic risk) using publicly available information albeit not on a consistent basis.

2.4 Review of the Limits of Arbitrage Literature

The preceding sub-sections of this review have identified that one of the key underpinning assumptions of the equilibrium asset pricing models which describe the risk return trade-off and a sufficient, but not necessary, condition for markets to be informationally efficient is the existence of arbitrageurs.

However, the first papers to explicitly consider how arbitrageurs, defined by their actual function, impact on market equilibrium and efficiency were by Delong et al. (1990) and Shleifer and Summers (1990). Delong et al. (1990) argued that arbitrageurs, traders who are continually seeking to exploit relative pricing differences between perfect-substitute or near-substitute securities, play a key role in keeping security prices close to intrinsic value. They developed a noise trader risk model in which the existence of noise traders with unpredictable opinions will deter arbitrageurs from aggressively trading against them. As a result, they argue that prices can diverge significantly from intrinsic value even if perfect-substitute securities are being traded. They further posit that their model can explain a number of efficient market anomalies including the observation of excess volatility in security prices. This noise trader approach to financial markets was refined by Shleifer and Summers in 1990 who argued that it was "in many ways superior to the efficient markets paradigm" (p. 20). Their paper also introduced the term "The Limits of Arbitrage" and explained that arbitrageurs face two types of risk (fundamental risk in the absence of perfect substitutes and resale price risk from the existence of noise traders) that could lead to losses in positions which are established to exploit the relative mispricing of securities. They argue that these risks and a finite time horizon will deter the arbitrageur from fully exploiting an apparent arbitrage opportunity as the mispricing may worsen before it improves. Accordingly, arbitrageurs will rarely be willing to force security prices back into line with one another.

Further theoretical work into the emergent strand on the limits to arbitrage was performed by Froot et al. (1992) who demonstrated that finite time horizons may encourage arbitrageurs to study information that is completely unrelated to fundamentals, Tuckman and Villa (1992) who argued that holding costs are an important impediment to arbitrage activity and Dow and Gorton (1994) who showed that holding costs will in themselves limit the time horizons of arbitrageurs.

However, the seminal theoretical work on the limits of arbitrage was published by Shleifer and Vishny (1997). They theorised that the limits of arbitrage, in addition to finite time horizons and holding costs as postulated by Shleifer and Summers (1990), also include market segmentation and information asymmetry. These latter factors arise from the fact there are relatively few arbitrageurs who manage funds rather than risking their own capital. Their agency model indicates that arbitrage can become ineffective (insofar as arbitrageurs will not trade) when prices of paired securities diverge significantly from each other and/or when arbitrage positions are particularly volatile.

Further advancements in the limits to arbitrage strand included an empirical study using US equity market data by Mitchell et al. (2002) together with theoretical papers by Abreu and Brunnermeier (2002), Liu and Longstaff (2004) and, most importantly for the purposes of this thesis, Pontiff (2006).

Mitchell et al. (2002) argued that the biggest friction impeding arbitrage activity were the costs associated with imperfect information, thus supporting the earlier theoretical work of Merton (1987). They also postulated that imperfect information together with transaction costs would encourage arbitrageurs to specialise in a particular type of opportunity i.e., merger or convertible arbitrage which would consequently limit their ability to reduce unsystematic (idiosyncratic) risk by diversification.

Abreu and Brunnermeier (2002) suggested that synchronisation risk was another limiting factor to arbitrage, in addition to noise trader and fundamental risk as posited by Schleifer and Vishny (1997). Synchronisation risk arises from each arbitrageur's uncertainty about the timing of other arbitrageurs' actions which, combined with a desire to minimise holding costs, causes them to delay trading until they are sufficiently confident of an arbitrage gain. As a consequence, security prices can stray significantly from intrinsic value for extended periods of time although they do find that there is a strong correlation between the extent of the mispricing and the speed at which it is ultimately corrected.

Liu and Longstaff (2004) posited that the collateral secured against the short position in an arbitrage trade is another factor which will limit the activity of arbitrageurs. Moreover, they find from their time-continuous model that it is often optimal to underinvest in an arbitrage opportunity to reduce the risk of the forced buy-in of the short and the consequent need to simultaneously liquidate the long position.

The paper published by Pontiff in 2006, titled "Costly arbitrage and the myth of idiosyncratic risk", is of particular relevance to this research. Having performed a meta-analysis of the extant limits of arbitrage literature and also empirical research into the risk and returns of different arbitrage strategies (including merger arbitrage), he demonstrates that the main cost borne by arbitrageurs and thus the single largest impediment to market equilibrium and, to a certain extent, efficiency is unsystematic (idiosyncratic) risk. Accordingly, he concludes that specialised arbitrageurs (e.g., merger arbitrageurs) are rewarded for bearing both systematic and unsystematic risk.

2.5 Review of the Risk of and Returns to Merger Arbitrage Literature

Before reviewing the literature concerning the risk of and returns to merger arbitrage, it is sensible to reiterate and expand upon how the strategy is implemented in practice. Most of the merger arbitrage literature does this relatively well but the most comprehensive account is provided by Moore et al. (2006). They explain that, once a takeover offer has been publicly announced by one listed company (the bidder) for another listed company (the target) and at least part of the consideration offered is by way of the bidder's equity, the share prices of the bidder and the target become linked.

Merger arbitrageurs establish positions by simultaneously buying (going long) shares in the target company and selling (going short) shares in the bidding company in the exchange ratio stipulated in the bidder's offer document. If the takeover completes then the long holding of the target company shares will convert into a long holding in the bidder to offset (close out) the originally established short position in the bidder. The merger arbitrageur's gross (before the net cost of financing the long and short positions) gain on this position for a completed deal is the merger arbitrage spread which is calculated using the formula given by Branch and Wang (2008) shown at equation 2.3.

$$S_t = \frac{XP_{B,t} + C - P_{T,t}}{P_{T,t}} \tag{2.3}$$

where S_t is the merger arbitrage spread at time t, X is the exchange ratio (number of bidder's shares offered for each target share), $P_{B,t}$ is the bidder's clean, dividend adjusted, share price at time t, C is the cash element per share of the target and $P_{T,t}$ is the target's clean share price at time t.

It should be reiterated that the spread achieved when setting up a position is the gross return that the arbitrageur captures if the deal completes with the original bidder. If, however, the takeover is withdrawn or fails to complete with the original bidder, the merger arbitrageur will be holding unlinked positions in the target (long) and the bidder (short). On the announcement of withdrawal, it is probable that the share price of the target will fall back towards its level immediately prior to the bid being announced leading to a loss on this leg of the position. Conversely, the announcement of a (typically higher) offer from a counterbidder is likely to result in a gain. However, and irrespective of the nature of deal failure, the bidder's share price is highly likely to rise back to its level before the bid was announced, leading to a loss on the short position. Accordingly, it is likely that the merger arbitrageur will incur an overall loss on the position if the deal fails to complete with the original bidder.

A simple illustrative example of the above (an actual deal could not be used for comparative purposes due to the binary nature of the outcome in the real-world, the deal either completes or fails to complete) is to suppose that a bidding company has announced its takeover offer which is comprised of 2 of its shares and £1 cash for each share in a target company. Further suppose that, as a result of the announcement, the bidder's share price drops by 40p from £2.60 to £2.20 and the target's share price jumps by 70p from £4.30 to £5.00. Movements in these directions and magnitudes occur in the real-world due to the premium payable for control of the target and the anticipation of other market participants of selling pressure in the bidder from merger arbitrageurs.

If an arbitrageur were to set up a position at the above post-announcement share prices, the merger arbitrage spread using equation 2.3 would be ((2 x 2.20) + 1.00 – 5.00) ÷ 5.00 = 8%. If the deal completes this spread will be captured and the gross gain will be (2 x 2.20) + 1.00 – 5.00 = £0.40 per target share bought. If, however, the deal fails to complete and the prices of the bidder and target return to their pre-bid levels, the loss per target share bought will be (2 x 0.40) + (1 x 0.70) = £1.50.

As a result of this asymmetry between the relatively small yet certain gains if the deal completes compared to the relatively large and uncertain losses if the deal fails to complete, Wyser-Pratt (1971) likened the practice of merger arbitrage to "picking up pennies in front of a steam-roller".

The earliest paper which addressed the risk of and returns to merger arbitrage was published by Larcker and Lys in 1987. They built upon the market efficiency work of Grossman and Stiglitz (1980) by using merger arbitrage to investigate the incentives that exist in order for security prices to be informationally efficient after allowing for the costs of information acquisition. Using trades made by known merger arbitrageurs in the US between December 1977 and December 1983 in 104 cash-only offers, they found evidence of significant excess returns due to the arbitrageurs' ability to acquire superior information about whether the takeovers would complete. Accordingly, they conclude that security prices are "sufficiently noisy" (p. 111) to create incentives for costly information acquisition and are thus informationally efficient. However, their analysis did not extend to a consideration of the risks associated with these significant returns.

The next contribution was from Dukes et al. (1992) who calculated that the return from a passive buy-and-hold merger arbitrage strategy involving 761 US cash-only transactions between 1971 and 1985 was 24.7% for the average offer period of 52.5 days, was over 100% on an annualised basis. However, a limitation of this study was the assumption that the merger arbitrageur in a failed deal would be able to dispose of their entire holding in the target at its closing market price on the day that the offer is withdrawn, an oversimplification which will significantly overstate the returns. In addition, the annualisation of the returns implicitly assumes that arbitrageurs have a continuous flow of opportunities. Moreover, the paper only briefly addresses the risks of merger arbitrage from a qualitative perspective and merely states that "Common sense would suggest this [negative returns from the strategy] is highly unlikely" (p. 53) which calls into question whether their assertion that “the findings are inconsistent with the efficient market hypothesis” (p. 48) can be fully justified.

There was a dearth of published papers which specifically addressed merger arbitrage throughout the rest of the decade but it is instructive that this changed in the early part of the new millennium following Shleifer and Vishny’s seminal 1997 paper on the limits of arbitrage.

Mitchell and Pulvino (2001) conducted a major empirical study which sampled 4,750 US takeovers over 36 years from 1963 to 1998 in an attempt to characterise the risks of and return to merger arbitrage. Their sample included 3,467 cash-only and 1,283 stock-only offers but excluded 4,276 offers with complicated terms because of a lack of accurate data regarding the exact terms of such transactions. They did not, however, state how many of these excluded offers were hybrid. Returns were calculated from the day after the announcement date until the day that the target’s equity is delisted for successful takeovers or until the day after the deal failure is announced. Their primary finding was that returns were uncorrelated with market returns in flat or appreciating markets but are correlated with market returns in declining markets, particularly for cash-only deals, and which can be likened to the returns achieved from writing uncovered out-the-money equity index put options. Accordingly, a contingent claims analysis was employed to control for this non-linearity which, after allowing for a number of practical portfolio management limitations faced by the merger arbitrageur (e.g., no more than 10% of available capital will be allocated to a single position), estimated a risk adjusted return of 9.3% per annum before costs and 4.2% after accounting for estimates of transaction, holding and market impact costs. This excess return is ascribed to deal completion risk, the liquidity provided by merger arbitrageurs to shareholders in the target company and the bearing of systematic risk. Further, they attributed the systematic risk to the fact that deal agreements in the US typically contain enforceable material adverse clauses so a bidder can walk away from a deal if, for example, there has been a short-term correction in the equity market.

Another notable aspect of this paper was the graphical representation of the evolution of the average spread for deals which ultimately completed and those which were ultimately withdrawn. This is shown below at figure 2.1.

Fig. 2.1 – Evolution of the Average Merger Arbitrage Spread (Mitchell and Pulvino 2001)

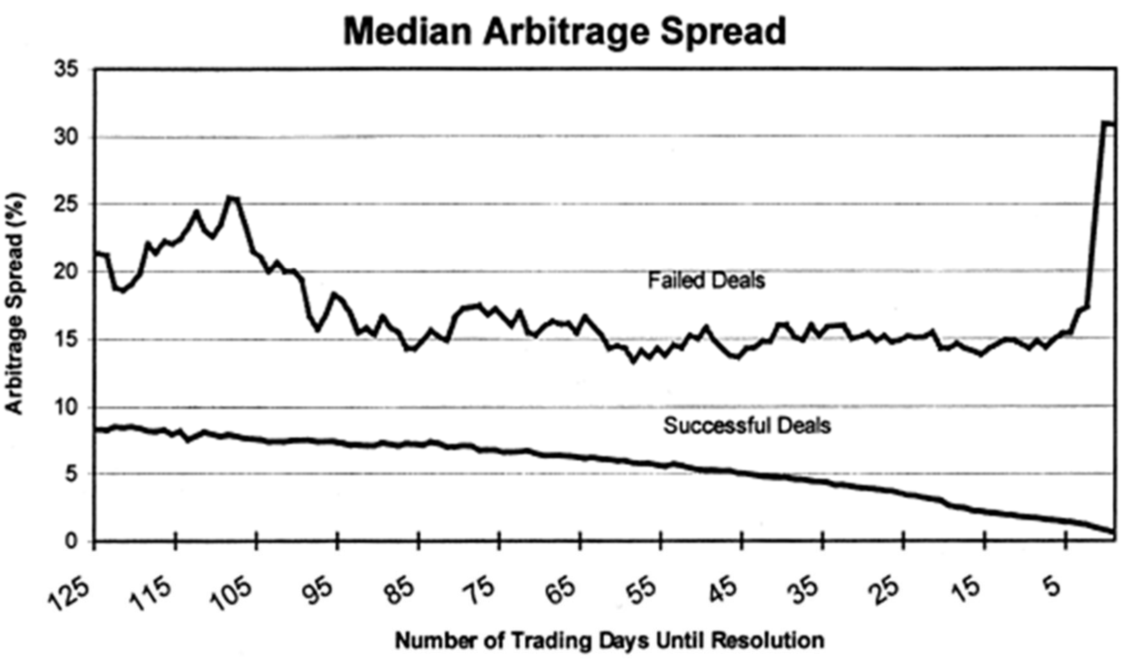


Figure 1. This figure plots the median arbitrage spread versus time until deal resolution. The arbitrage spread is defined to be the offer price minus the target price divided by the target price. For failed deals, the deal resolution date is defined as the date of the merger termination announcement. For successful deals, the resolution date is the consummation date.

Figure 2.1 clearly demonstrates that the average (median) spread for ultimately successful deals was lower than for deals which failed to complete. Furthermore, the trend for the successful deals is a gradual, monotonical, decline over time compared to the more volatile and increasing trend over time exhibited by the median spreads of the failed deals.

Whilst Mitchell and Pulvino's work was the most comprehensive performed on merger arbitrage by this stage and also sought to model a number of the institutional constraints faced by merger arbitrageurs, it should be emphasised that the estimated returns are underpinned by simplifying assumptions on pricing and timing. Further, it assumes that the merger arbitrageur acts in a passive manner and invests in all announced deals without any ex-ante discrimination between those that are expected to complete or to fail. Finally, the exclusion of hybrid offers from the sample will also have an effect on the realism of the findings.

Baker and Savasoglu (2002) sought to establish why abnormal returns to merger arbitrage were not competed away with a sample of 1,901 US takeovers in the 16 years between 1981 and 1996 which included 1,335 cash-only and 566 stock-only offers but excluded 1,485 hybrid offers. They also accounted for transaction, holding and market impact costs but, unlike the contingent claims approach adopted by Mitchell and Pulvino (2001), estimated the annualised excess risk returns at 10.6% using the Capital Asset Pricing Model of Sharpe (1964) and at 9.3% using the Three Factor Model of Fama and French (1992). They posit that these excess returns reflect the unsystematic deal completion risk borne by merger arbitrageurs and also assert that this is consistent with the limits of arbitrage literature, specifically that the collective risk bearing capacity of merger arbitrageurs is constrained by their limited capital.

The major finding of Mitchell and Pulvino (2001), that the risk return profile of merger arbitrage is akin to writing uncovered out-the-money equity index put options, was broadly replicated by Agarwal and Naik (2004) in their analysis of the Hedge Fund Research event driven arbitrage index of US hedge fund returns. However, they also find evidence that event driven hedge funds exhibit significant risk exposure to Fama and French's (1992) small minus big market capitalisation and high minus low book to market value factors.

Mitchell and Pulvino's (2001) approach was also applied to 193 Australian M&A transactions between 1991 and 2001 by Maheswaran and Yeoh (2005) who estimated an excess risk adjusted return of 10.6% per annum before costs and 6.0% per annum after costs. The other key finding of this paper is that the returns are uncorrelated with returns in both rising and falling markets which was attributed to the absence of material adverse change clauses in Australian offer documents. Further work in the Australian market was conducted by Hutson and Kearney (2005) who tested for the market neutrality of merger arbitrage positions constructed using a sample of takeovers between 1985 and 1994. They found that, whilst the volatility of the bidder remains largely unchanged after the offer announcement, the volatility of the target drops significantly which makes the beta of a merger arbitrage positions established using the exchange ratio negative. Accordingly, they argue that market neutrality could be achieved using a ratio based on post-announcement betas rather than the exchange ratio in the offer document.

Branch and Yang (2006a) extended the work of Mitchell and Pulvino (2001) by incorporating collar offers as well as cash-only and stock-only offers in their sample of 1,309 US M&A transactions between 1990 and 2000 although hybrid offers were excluded. They estimated that the return to collar offers (10.3% per annum before costs) exceeded that of stock-only offers (8.0% per annum) and cash-only offers (4.1% per annum) and suggest that these differentials may relate to the information asymmetry signalled by the payment method insofar as bidders are likely to offer shares when they believe that their equity is overvalued and/or when they are uncertain about the value of the target. Furthermore, cash-only offers are more likely to be approved by target shareholders due to the certainty of the consideration to be received. These findings broadly suggest that the market is efficient in discriminating between the nature of the consideration offered by the bidder for the target.

Branch and Yang (2006b) also published a separate paper in the same year which focussed purely upon US transactions which failed to complete with the original bidder between 1992 and 2001. From the sample of 146 transactions, they calculated an average merger arbitrage position loss of 13.0% on stock-only offers but a 3.1% gain on cash-only offers which was ascribed to the emergence of a successful rival bidder. This is beneficial in cash-only offers as the rival typically offers a higher price for the target but is problematic in stock offers as the arbitrageur has to buy back the short position in the original bidder and simultaneously establish a short position in the rival bidder. Their sample also included hybrid offers which gained 16.6% on average, a most surprising result and it was stressed that this should be treated with considerable caution as there were only nine such deals in the sample.

A review of the performance of merger arbitrage hedge funds was conducted by Block (2006) using an index provided by the Hennessee Group. Although hedge funds are notoriously secretive about the precise nature of their trading strategies, it is presumed that they invest in deals involving all payment types and, moreover, that they are actively managed and will thus only invest in transactions which are expected to complete. Over the 12-year period from 1993 to 2004, the annualised return of the merger arbitrage hedge fund index was 13.3% after fees, exactly the same as total return (i.e., with dividends included) of the S&P 500 equity index. However, in the bull market period between 1993 and 1999, the hedge fund index (+19.6% per annum) underperformed the rising equity index (+25.7% per annum) whereas it outperformed the falling index between 2000 and 2004 (+6.8% versus -2.6% per annum). This relative performance in the latter period runs contrary to the findings of Mitchell and Pulvino (2001) and suggests that the active merger arbitrage fund managers were generating significant alpha by successfully avoiding failed deals.

The first papers to consider the risk and returns to merger arbitrage in the UK were published by Kearney et al. (2007) and Sudarsanam and Nguyen (2008). Kearney et al. (2007) sampled 121 UK cash-only and stock-only offers in the 4 years between 2001 and 2004. They estimated that the risk adjusted return to merger arbitrage, using the same practical constraints as Mitchell and Pulvino (2001), was +2.3% per annum compared to an annualised return on the FTSE All-Share equity price index of -5.2% over the same period. Sudarsanam and Nguyen (2008) used a much larger sample of 1,105 UK cash-only and stock-only offers in the 21 years between 1987 and 2007 but excluded hybrid offers for consistency with the sample selection criteria of Mitchell and Pulvino

(2001). They estimated that the return to merger arbitrage was +6.4% per annum after costs compared to an annualised return on the FTSE All-Share index of +3.5% over the same period and ascribe this excess return to the limited diversification of and capital constraints placed upon arbitrageurs in accordance with the limits to arbitrage literature. It is, however, somewhat puzzling that they did not partly ascribe this to deal completion risk in the conclusion of the paper as it is fully acknowledged within its literature review and hypotheses development chapters. Furthermore, the findings in both papers provide strong evidence that the risk return profile of merger arbitrage in the UK does not exhibit the same non-linear pattern found in the US which Sudarsanam and Nguyen (2008) ascribe to the near impossibility of bidders being able to terminate takeovers for UK targets as a result of a material adverse change in circumstances, for example a sharp decline in the equity market. This is broadly similar to the earlier findings of Maheswaran and Yeoh (2005) in the Australian market but both are challenged by Hall et al. (2013) who argue that the linearity in returns is caused by the inclusion of cash-only deals in the samples rather than differences in takeover regulations.

Branch and Yang (2010) investigated the impact and likelihood of sweetened offers, defined as an increased offer for the target from either the initial or a rival bidder, on the returns to merger arbitrage. Using daily price data from a relatively small sample of 169 cash-only and stock-only deals, they found that sweetened offers significantly improve returns irrespective of whether the initial bidder is successful or unsuccessful in acquiring the target. They do not, however, distinguish between cash-only offers, where an unhedged long position in the target will necessarily guarantee higher returns, and stock-only offers, where the failure of the initial bidder to acquire the target would be expected to adversely affect returns as merger arbitrageurs attempt to buy back their short positions in the bidder. It was also found that targets were more likely to receive one or more sweetened offers if the initial bid was unsolicited and if it was a share-only offer. Other, albeit less significant, contributory factors were the bidder's level of financial gearing and the use of certain defence tactics by the target including the publication of a restructuring plan and the use of anti-takeover litigation.

Wang and Branch (2010) investigated the risks and returns to merger arbitrage for collared stock swap offers where the exchange ratio can vary and thus protect the bidder from overpaying if its share price rises significantly and protect the target's shareholders from being underpaid if the bidder's share price falls dramatically. As a result of the absence of a fixed exchange ratio and the consequent additional complexities in calculating merger arbitrage spreads and returns, collared offers have typically been excluded from empirical samples. It was found that the dominating factor affecting the probability of deal completion for collared offers, and thus the returns to merger arbitrage, was the performance of the equity market during the offer period whereas this was an insignificant factor for uncollared offers. As a result of this, it was found that the risk adjusted returns to merger arbitrage for collared offers were lower than for uncollared offers.

Ferguson et al. (2011) researched the nature of the risk in merger arbitrage using a sample of 4,382 US cash-only and stock-only offers, but no hybrid offers, between 1986 and 2006. Adopting a similar methodology to Mitchell and Pulvino (2001), they estimated a risk adjusted return to merger arbitrage of +7.4% per annum after some, but not all, costs. Furthermore, and echoing the limits to arbitrage work of Shleifer and Vishny (1997), they posit that the abnormal returns earned by merger arbitrageurs are compensation for both deal completion risk and liquidity risk. However, unlike Mitchell and Pulvino (2001) who ascribe the excess returns as compensation for providing liquidity to the market, Ferguson et al. (2011) define liquidity risk as the risk that funding will evaporate in a severe market downturn either due to investor redemptions or increased holding costs and thus preclude arbitrageurs from fully exploiting apparent mispricing opportunities.

Kahn (2012) investigated the impact of regulatory intervention on the returns to merger arbitrage in 96 US transactions between 2001 and 2011 using daily price data and found that the positive abnormal returns on the 89 of these deals that ultimately completed more than offset the negative abnormal returns on the 7 that were abandoned as a direct result of the intervention.

Cao et al. (2014) compared the returns to merger arbitrage achieved by hedge funds to other institutional investors such as mutual funds. Using a sample of 1,990 US target companies between 1994 and 2008, it was estimated that merger arbitrage hedge funds outperform other investors by approximately 4.0% per annum on a risk adjusted basis. This superior performance is attributed to hedge fund's ability to actively manage arbitrage and successfully avoid deals which fail to complete rather than their ability to affect the outcome of transactions due to their voting rights in the target company.

The annualised excess return to merger arbitrage and the reasons ascribed to this by the authors of the major empirical studies are summarised in table 2.2.

Table 2.2

The Risk of and Returns to Merger Arbitrage – Findings of Major Empirical Studies

Authors	Sample	Annualised excess return	Excess return ascribed to
Mitchell and Pulvino (2001)	4750 US deals from 1963 to 1998	+4.2%	Systematic risk Deal completion risk Liquidity provision
Baker and Savasoglu (2002)	1901 US deals from 1981 to 1996	+9.3%	Systematic risk Deal completion risk Capital constraints
Sudarsanam and Nguyen (2008)	1105 UK deals from 1987 to 2007	+6.4%	Capital constraints Limited diversification
Ferguson et al. (2011)	4382 US deals from 1986 to 2006	+7.4%	Systematic risk Deal completion risk Liquidity risk

Notes: *This table shows the key aspects of the major empirical studies into the risk and return of merger arbitrage as a passive buy-and-hold strategy. Samples include cash-only and stock-only but not hybrid offers for completed and failed deals.*

The most salient features of table 2.2 for the purposes of this research are as follows:

a) Merger arbitrage has delivered a positive excess return in both the US and the UK;

b) Merger arbitrageurs in US deals bear both systematic and unsystematic risk whereas those in the UK only bear unsystematic risk due to differences in takeover regulations, primarily that it is far easier for US bidders to enforce material adverse change clauses;

c) Three of the four studies conclude that deal completion risk is an unsystematic risk factor and it is fully acknowledged, albeit not part of the conclusion, in the other study; and

d) There is a divergence of opinion on the unsystematic risk factors, other than deal completion risk, which are ascribed to the excess returns.

However, all of the studies share the following limitations when estimating the excess returns:

a) It is assumed that the position for each transaction is established shortly after the offer announcement. In practice, merger arbitrage positions are built gradually over a period of time which commences as soon as the offer document and terms of the deal have been read and understood. Moreover, position building occurs only when there is a profitable opportunity (i.e., a positive spread after transaction and expected holding costs) and when there is sufficient liquidity to simultaneously go long the target and short the bidder in the stipulated exchange ratio;

b) The samples include a majority of cash-only offers which do not meet the definition of arbitrage as the only position taken is in the target. Furthermore, they exclude hybrid (shares and cash) offers; and

c) They reflect passively managed (buy-and-hold) portfolios of merger arbitrage positions and assume that a position is established in every announced deal. In reality, merger arbitrageurs will be actively seeking to avoid investing in deals which they believe may fail to complete. Further, some will even be setting up reverse positions (i.e., long bidder and short target) to profit from this belief rather than to merely avoid losses.

Despite these limitations, the literature on the risk of and return to merger arbitrage indicates that the returns in the UK are compensation for bearing unsystematic, but not systematic, risk. Moreover, the most significant element of unsystematic risk is deal completion risk.

2.6 Summary

The literature reviewed in this chapter strongly suggests that major and established equity markets, such as the UK, are reasonably efficient and incorporate new publicly available information into share prices at a level which is close to, but not exactly at, Fama's semi-strong efficiency form (1970). It also suggests that the returns to merger arbitrage in the UK equity market are compensation for bearing unsystematic risk only and that the primary element of this is deal completion risk.

Accordingly, and if the above holds for UK merger arbitrage, any information which is put into the public domain which increases deal completion risk should lead to an increase in the spread. Conversely, any information which is put into the public domain which decreases deal completion risk should be reflected in a lower spread.

The next chapter seeks to identify the possible determinants of the spread from the extant literature into the static factors which affect the probability of deal completion. It also considers the extant literature into the static factors which affect the spread itself.

Chapter 3 – Literature Review and Hypotheses Development

3.1 Introduction

The previous chapter concluded by positing that UK merger arbitrageurs operate in a market which is reasonably, but not perfectly, informationally efficient and that their return, via the merger arbitrage spread, is primarily compensation for bearing unsystematic deal completion risk.

In order to ascertain the potential determinants of the spread, this chapter starts with an overview of the salient aspects of the UK legal and regulatory framework concerning M&A. It then proceeds to review the extant literature on the probability of M&A transaction completion as a proxy for deal completion risk and the more recent literature on the determinants of the spread itself. It concludes by developing and articulating a number of testable hypotheses.

3.2 Overview of the UK Legal and Regulatory Framework

M&A which involves companies whose shares are listed on a recognised investment exchange in the UK (i.e., The London Stock Exchange ("LSE")) are subject to regulations devolved from statutory legislation and case law. The bulk of the regulations are contained in The Takeover Code (2016) which is issued and administered by The Panel on Takeovers and Mergers. These are supplemented by the Listing Rules (2016) laid down by The Financial Conduct Authority.

The primary objective of The Takeover Code is to ensure fair treatment for all shareholders of listed UK companies which are involved in M&A. Its most salient principles for the purposes of this thesis are that: i) the shareholders of the target company must have sufficient time and information to enable them to reach a properly informed decision on a bid; ii) the board of directors of the target company must act in the interests of the company as a whole and must not deny the shareholders the opportunity to decide on the merits of the bid; iii) the bidder must announce a bid only after ensuring that it can fulfil in full any cash consideration, if such is offered, and after taking all reasonable measures to secure the implementation of any other type of consideration; iv) the target company must appoint a competent independent adviser whose advice on the financial terms of the offer must be made known to all shareholders, together with the opinion of the board; v) favourable deals for selected shareholders are banned; and vi) all shareholders must be given the same information.

In addition to these principles, it also contains a raft of prescriptive rules on, for example, the timetable of a bid, the contents of the bidder’s offer document, the disclosure of dealings in the shares of the target by the bidder and on inducement (or break) fees payable by the target to solicit an offer, which are prohibited in most circumstances. It also states that, whilst the minimum level of acceptances required for a transaction to be made unconditional is 50%, bidders may set the level of acceptances at above this level. In addition to these rules, guidance is provided on which regulatory bodies which must be notified once a deal has been announced. The most important of these in the UK are The Competition and Markets Authority and The Pensions Regulator as they have the power to either block a transaction outright or to impose conditions that may significantly reduce the attractiveness of the target company to the bidding company.

The Listing Rules set out the information that the bidding and target companies must promptly put into the public domain during the offer period via the LSE's Regulatory News Service ("RNS"). The information which is of relevance to this research is as follows:

1. The number of shares in the target which have been purchased by the bidder in the open market;
2. The number of shares in the target which have been pledged to the bidder by target shareholders, known as irrevocable undertakings;
3. The advice given by the target company's directors to their shareholders on whether they should accept or reject the bidder's offer;
4. The presence of an actual or potential counterbidder for the target company, if and when its directors are made aware of this;
5. The decisions made by regulatory bodies on the deal; and
6. The results of any votes taken by the shareholders in the bidder or the target during the offer period.

Finally, and as asserted by Sudarsanam and Nguyen (2008), UK case law precedents effectively preclude the inclusion of material adverse clauses in the bidder's offer document which would allow it to terminate its offer if, for example, there is a significant fall in the equity market. This is in direct contrast to the US where, according to Denis and Macias (2013), such clauses are a common feature of offer documents and are, moreover, enforceable.

3.3 Review of the Probability of Deal Completion Literature

The earliest empirical investigations into the probability of M&A deal completion, a proxy for deal completion risk, were published in 1983. Asquith (1983), using an event study methodology and daily price data, found evidence to support the assertion that, as expected in an efficient capital market, "the probability of merger changes during the interim period [from the offer announcement to the deal resolution date] with new information" (p. 81). However, he does not analyse the nature of this information or its impact upon the share prices of the bidder and the target when it enters the public domain.

The analysis of Lewellen and Ferri (1983) was based on a single stock-only takeover event using weekly price data and found that the price of the target traded at a discount to the value of the consideration offered by the bidder throughout the offer period. This finding was ascribed to deal completion risk, the uncertainty over whether the transaction would be successfully consummated.

In addition, equations 3.1 to 3.3 were set out which relate the probability of deal completion (π) to the current market prices (P*) and the market prices immediately before the offer was announced (P) of the bidder, a, and the target, b, together with the exchange ratio (X), the number of shares in the bidder offered for one share in the target:

$$P'_a = \pi(P^*_a) + (1-\pi)(P_a) \quad (3.1)$$

$$P'_b = \pi(P^*_b) + (1-\pi)(P_b) \quad (3.2)$$

$$P^*_b = XP^*_a \quad (3.3)$$

Rearranging the above formulae for the market implied probability of deal completion, π, and using more easily understandable notation of B for the bidder, T for the target and subscripts of t for prices at time t and f for expected failure, or fall-back, prices gives:

$$\pi_t = \frac{P_{T,t} - P_{T,f} + XP_{B,f} - XP_{B,t}}{XP_{B,f} - P_{T,f}} \quad (3.4)$$

For illustrative purposes, and using the example presented in the paper, a bidder announced a share-only offer of 6 of its shares for every 5 shares in the target, an exchange ratio of 1.2. The market reaction was to mark-up the share prices of the bidder and the target from $50 to $55 and from $40 to $62 respectively. Hence the market implied probability of deal completion is calculated as 80% using the formula at 3.4 but this does assume that the prices of the bidder and target will return to their levels immediately prior to the announcement date in the event of deal failure.

Both Brown and Raymond (1986) and Samuelson and Rosenthal (1986) built upon the work of Lewellen and Ferri (1983) by performing empirical research into the evolution of the market implied probability of deal completion over the post announcement deal period.

Brown and Raymond (1986) sampled 71 US cash-only, stock-only and hybrid offers from 1980 to 1984 using weekly price data and found a clear and statistically significant delineation between the market implied probabilities of successful deals and failed deals. Based on failure prices set four weeks before deal announcement, the average probability for successful deals consistently exceeded 70% in each of the twelve weeks prior to the resolution of the deal whereas the average probability for failed deals never exceeded 50% over the same period. Furthermore, the probabilities of the completed deals steadily increase towards 100% as the resolution date is approached whereas the pattern for failed deals is more volatile. However, the market implied deal completion probability formula used in this paper only considers the price of the target company and thus fails to capture movements in the price of the bidder for stock-only or hybrid offers. It also caps the probability at unity thus fails to identify deals where the market is expecting a higher offer either from the incumbent bidder or a new bidder.

Samuelson and Rosenthal (1986) sampled 109 US cash-only takeovers between 1976 and 1981 and calculated market implied probabilities of deal completion using daily price data and formulae adapted from Lewellen and Ferri (1983) in an attempt to provide more realistic fall-back prices. Despite the modifications to the formulae and the use of cash-only deals, they achieved broadly similar results to Brown and Raymond (1986) and thus concluded that movements in target prices are informative of the success or failure of the takeover offer and that the market's probability predictions improve monotonically over time as the resolution date nears.

The first paper to combine empirical research into the risk and returns to merger arbitrage together with a consideration of deal completion probability was published by Dukes et al. (1992). Using the same formulae of Lewellen and Ferri (1983) to calculate the market implied probability of deal completion for 761 US cash-only deals between 1971 and 1985, they found that returns to merger arbitrage were inversely related to the probability of deal completion. This finding supports the notion that higher (lower) returns to merger arbitrage are generated by establishing positions in deals with lower (higher) market implied probabilities of completion which reflects the higher (lower) level of risk.

Further research into deal completion probability was performed by Goktan and Kieschnick (2012), who found that anti-takeover provisions in the legal constitution of the target do not significantly affect the probability of takeover completion; Denis and Macias (2013), who found that material adverse change clauses in takeover offer documents were the underlying cause of 69% of takeover cancellations in 755 US offers between 1998 and 2005; Skaife and Wangerin (2013), who found that low-quality financial reporting in target companies, measured using high accruals, weak internal controls, off-balance-sheet liabilities and analyst forecast dispersion, increased the probability of deal failure by 9%; and Moschieri and Campa (2014), who found that the factors affecting deal completion probability vary across EU member states due to differing rules of national regulatory bodies.

Alongside the literature concerning the market implied probability of deal completion during the offer period, empirical and theoretical research was also being performed into the determinants of this probability. The bulk of this research involved the estimation of static probability models using multivariate regression methodologies, predominantly logistic regression which is most simply expressed as:

$$P(y = 1|X) = \frac{1}{1 + e^{-\beta X}} \tag{3.5}$$

Where y=1 for successful takeovers, y=0 for failed takeovers, X are the observed independent predictor variables, $X=[X_1,X_2,\ldots,X_k]$, and β are the estimated parameters, $\beta=[\beta_0,\beta_1,\beta_2,\ldots,\beta_k]$.

The earliest paper to take this approach was published by Walkling (1985) who sampled 158 US cash-only offers between 1972 and 1977 using logistic regression. He found that the probability of deal completion is positively related to the initial bid premium offered for the target, the payment of solicitation fees to brokers and the initial level of ownership of shares in the target by the bidder, or toehold. Conversely, the probability of deal success is negatively related to target management opposition, or hostility, and the emergence of a rival bidder. His estimated model correctly classified 80% of the 108 offers in the estimation sample but this fell to 60% for the 50 offers in the validation sample.

Holl and Pickering (1988) applied discriminant analysis rather than multivariate regression to their sample of 133 UK hostile takeovers between 1965 and 1975 to analyse the impact of the relative size, financial performance and strength of the bidders and targets in the three years preceding an offer. They found that targets which were successfully acquired tended to be smaller, slower growing, less profitable and financially weaker than both their bidders and those targets which had successfully defended against an unwanted takeover approach.

In contrast to the empirical findings of Walkling (1985), Hirshleifer and Titman (1990) posited in a theoretical paper that target managerial resistance and its ensuing defence tactics (e.g. litigation, "poison pill" or "scorched earth" policies) to an unwanted takeover approach may actually increase the probability of deal completion, either by raising the incentive to make a high initial bid or by decreasing information asymmetry about the bidder's expected level of synergistic value to be obtained from the takeover.

Taffler and Holl (1991) used a composite measure of the financial performance and strength of bidders and targets in 55 abandoned hostile UK takeovers between 1977 and 1981. Their findings echoed the earlier results of Holl and Pickering (1988), that targets which successfully defended against unwanted takeover approaches were performing better than and were financially stronger than their bidders.

Further empirical investigations into the factors which contributed to deal completion success or failure in the UK were performed by Sudarsanam (1995 and 1996), Holl and Kyriazis (1996), Powell (1997) and O'Sullivan and Wong (1998).

Sudarsanam (1995) found that bidders which launched all-stock or hybrid offers with a compulsory stock element reduced their chances of success but that the level of bid premium had no direct influence on the outcome of the offer. Further, it was found that targets increased their chances of survival in hostile bids if they lobbied friendly shareholders, enlisted a “white knight” to launch a counteroffer, gained support from trade unions or initiated litigation but, conversely, divestments and advertising reduced the chances of survival. In addition, Sudarsanam (1996) found that a bidder’s toehold of over 5% in a potential target company makes an offer more likely but does not significantly alter the probability of success if an offer is made.

Holl and Kyriazis (1996) employed the logistic regression methodology on 238 UK takeover offers throughout the 1980’s and found that the primary determinants of bid success were target hostility and the level of bid premium. In addition, they posited that the level of managerial ownership in the target had a U-shaped impact on the probability of deal completion insofar as it is more likely in targets with either very low or very high levels of shares held by the directors. However, this was challenged by O’Sullivan and Wong (1998) who sampled 331 UK deals between 1989 and 1995 and found that the level of managerial ownership in the target was linearly and positively correlated to the probability of deal completion.

Powell (1997) used a relatively large sample of 943 UK takeover offers between 1984 and 1991 to model the likelihood of deal completion using both binominal and multinomial logistic regression with the characteristics of the target as the only independent variables. Whilst he found that multinomial logistic regression had better predictive power than a binomial regression he suggested that "models of takeover based solely on the characteristics of targets are not particularly powerful ways to understand this part of the market for corporate control" (p. 1027).

Papers which address the factors affecting takeover completion success in the US include those published by Flanagan et al. (1998), who considered a wide range of factors and found that the probability of success is increased when deal termination (break) fees are payable and when the bidder has a toehold but decreased when there is a hostile reaction from the management of the target and if a competing bidder is present; Lefanowicz and Robinson (2000), who suggested that target managerial opposition serves primarily as a tool to solicit additional bids; Schwert (2000), who argued that hostile (opposed by the target's directors) and friendly (unopposed by the target's directors) deals are indistinguishable from one another in economic terms and that care should be taken when defining a transaction using these terms; Wong and O'Sullivan (2001), who found that target managerial opposition reduces the probability of takeover success by 50%; Baker and Savasoglu (2002) who found that horizontal mergers were less likely to succeed than vertical or conglomerate mergers because of the potential for regulatory intervention but also stated that "acquirer attitude is the best single predictor of merger success" (p. 92), acquirer attitude being defined as whether the M&A database used in their study classifies the deal as hostile or friendly; Branch and Yang (2003), who found that the most significant variables to predict takeover success using stepwise logistic regression were target resistance, the relative sizes of the bidder and the target and the nature of the consideration offered with cash-only offers being the likeliest to succeed.

An interesting, albeit limited, emergent strand in the research on takeover likelihood concerned the ability of merger arbitrageurs themselves to influence the outcome of takeovers. Cornelli and Li (2002) hypothesised in a theoretical paper that merger arbitrageurs have an incentive to establish position as this gives them an informational advantage because they will necessarily accept the offer. However, this advantage will only be profitable if they do not reveal their presence to the rest of the market and thus disclosure (substantial acquisition) regulations can affect the size of the position that a single arbitrageur can take in addition to its capital constraints. This hypothesis was tested empirically by Hsieh and Walkling (2005) who found that the probability of deal completion in the US was positively correlated to the proportion of target shares owned by merger arbitrageurs. In addition, they found evidence that merger arbitrageurs' collective ownership in targets that are successfully acquired is significantly larger than in deals which fail to complete and they argue that this is a demonstration of their ability to actively select and only establish positions in deals which are expected to complete. It is also noteworthy that Cornelli and Li (2002) suggested that merger arbitrageurs may have an incentive to establish a short position (going long shares in the bidder and shorting the target in the exchange ratio) if their assessment of the probability that a particular takeover will complete is lower than the market implied probability.

Savor and Lu (2009) did not address merger arbitrage directly but their research involved an analysis and categorisation of the reasons why US takeovers announced between 1978 and 2003 failed to complete. They found that, of the 1,335 deals in their sample, 355 (20%) failed to complete and that, of these, 246 (69%) failed for endogenous reasons such as target managerial opposition to the offer and unexpected worsening conditions in the target's operations. The remaining 109 (31%) deals failed for exogenous reasons such as regulatory intervention or the emergence of a rival bidder for the target. Also in 2009, Betton et al. researched the reasons for the observed decline in the use of toeholds (shares acquired by the bidder in the target prior to the offer announcement) in the US and suggested that this was due to the decline in the proportion of takeovers which were hostile (unsolicited) compared to friendly (pre-negotiated) over the sample period from 1973 to 2002.

Wang and Branch (2009) found from a sample of 1,313 US takeover offers between 1995 and 2005 (of which 89% were successful) that the main predictors of success were the target's price cumulative abnormal return, or run-up, in the two weeks prior to the initial offer announcement, target resistance, the merger arbitrage spread two days after the announcement, the relative sizes of the bidder and the target and whether the offer was competing (either a higher offer from the initial bidder or from a different bidder). They also demonstrated how the use of weighted logistic regression could remove the biased parameter and probability estimates of pair-matched logistic regression and thus have greater predictive power.

Further papers addressing the factors affecting takeover completion success in the US include those published by Kau et al. (2008), who found that bidders were more likely to walk away from a takeover offer if the market reacts unfavourably to the announcement, as measured by the relative performance of its share price over the offer period; and Branch et al. (2008), who posited that a feed forward neural network model outperformed logistic regression in predicting failed takeover bids and at least as well in predicting successful bids.

To summarise this sub-section, table 3.1 below tabulates the significant and insignificant factors which contribute to the probability of deal completion (success) or withdrawal (failure) in the extant empirical studies.

Table 3.1
Probability of Deal Completion Factors - Summary of Empirical Studies

Author(s) Sample Methodology	Significant Factors of Deal Completion or Withdrawal (in descending order of significance)	Insignificant Factors of Deal Completion or Withdrawal (in alphabetical order)
Walkling (1985) 158 US cash offers 1972-1977 Logistic regression	Hostility Break fee Toehold Bid premium	Competing bidder
Holl and Kyriazis (1996) 238 UK cash and stock offers 1980-1989 Logistic regression	Hostility Bid premium Toehold Target profitability Target board shareholding	Competing bidder Target block holdings
Powell (1997) 431 UK cash and stock offers 1984-1991 Logistic regression	Hostility Target size	Target profitability
Flanagan et al. (1998) 991 US cash and stock offers 1985-1994 Logistic regression	Hostility Competing bidder Break fee Toehold Cross-border deal	Bid premium Percentage of target sought Target board shareholding Target profitability Target size

O'Sullivan and Wong (1998) 331 UK cash and stock offers 1989-1995 Logistic regression	Target board shareholding	Target block holdings Target board governance
Branch and Yang (2003) 1097 US cash and stock offers 1991- 2001 Logistic regression	Hostility Cash Relative size Percentage of target sought Target leverage	Bid premium
Branch et al. (2008) 1196 US cash and stock offers 1991- 2004 Feed forward neural network	Hostility Target size Cash Merger arbitrage Spread	
Betton et al. (2009) 7470 US cash and stock offers 1973-2002 Logistic regression	Cash Toehold Target run-up Hostility Competing bidder	Target size
Wang and Branch (2009) 1165 US cash and stock offers 1995-2005 Logistic regression	Hostility Relative size Competing bidder Target run-up Merger arbitrage spread	Bid premium Break fee Cash Percentage of target sought Toehold

Wang (2017) 1046 US cash and stock offers 1994-2004 Logistic regression	Hostility Target size Merger arbitrage spread	Bid premium Cash Target abnormal volume Target run-up Toehold

3.4 Review of the Determinants of the Merger Arbitrage Spread Literature

Before reviewing the empirical literature concerning the determinants of the merger arbitrage spread it should be reiterated that, whilst merger arbitrageurs invest in cash-only deals by buying shares in the target company, this is not actually arbitrage. Arbitrage requires the simultaneous taking of a long position in the target and a short position in the bidder and, accordingly, there is no merger arbitrage spread for cash-only deals. All of the following studies do, however, include cash-only offers, presumably to boost sample sizes, and calculate the "spread" as the percentage difference between the price per share offered by the bidder and the share price of the target. Furthermore, they all seek to ascertain the determinants of the spread on a cross-sectional basis at a single point in time, one or two days after the offer is announced.

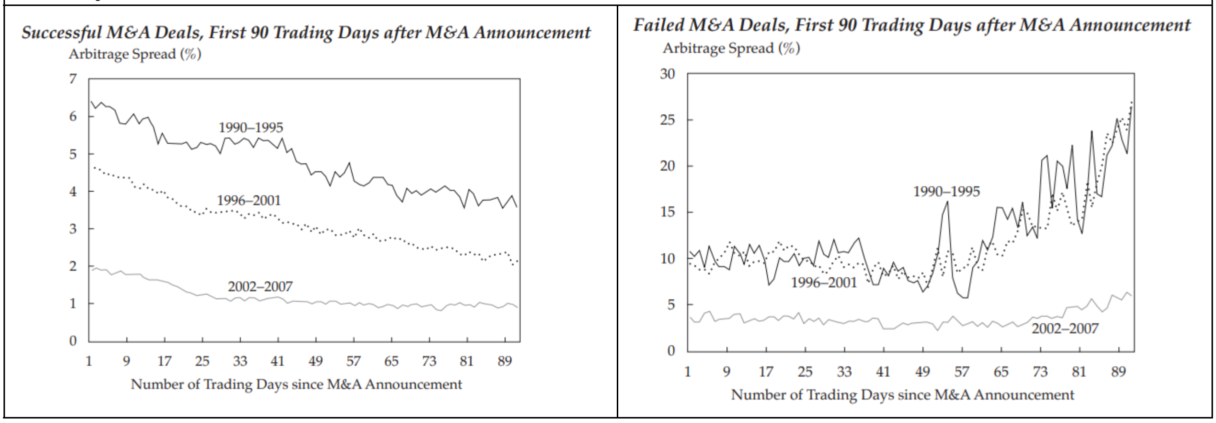
The first paper to explicitly consider the determinants of the spread was published in 2004 by Jindra and Walkling. Using a sample of 362 US cash-offers announced between 1981 and 1995 and calculating the spread using the closing market price of the target on the day following the offer announcement, they found that spreads were narrower when an improved bid was expected and wider when the offer duration was expected to increase due to higher holding costs. Moreover, they found that spreads were significantly and inversely related to the level of bid premium, the run-up in the target share price, target managerial attitude and the existence of rumours about the offer prior to its announcement. In addition, these variables were shown to have enhanced explanatory power for offers where high abnormal trading volumes were identified, indicating the presence of arbitrageurs.

Two papers were published in 2007 which, whilst not addressing its determinants, used the merger arbitrage spread to test the limits to arbitrage theory postulated by Shleifer and Vishny (1997). Officer (2007) used daily price data from a sample of 4,593 cash-only and stock-only US deals between 1985 and 2004 to investigate whether spreads on different deals exhibited co-movement over time and whether arbitrage disasters (large deals which fail to complete with the initial bidder) or the announcement of large deals cause a subsequent widening of spreads in all other existing deals due investor redemptions and constrained capital respectively. He found no evidence to support the co-movement conjecture and only relatively weak evidence to support the large deals conjecture but did find evidence that merger arbitrage spreads on deals announced shortly after arbitrage disasters were on average 1% to 2% wider than expected. Mitchell et al. (2007) investigated changes in the median spread of all ongoing cash-only and stock-only deals before, during and after the (19^{th} and 20^{th}) October 1987 market crash using daily price data. They found that the median spread on 1^{st} October was 3.3% and that this had widened to 5.4% by 16^{th} October in response to an announcement of proposed US legislation to ban hostile takeovers. On the days of the crash itself, the median spread peaked at 15.1% (10.7% for stock-only deals) before steadily, albeit slowly, declining throughout the remainder of the year. However, it remained above 5% at the end of the year despite the US Congress withdrawing the proposed ban on hostile takeovers in the middle of December 1987. The authors argue that these findings support the limits to arbitrage theory of Shleifer and Vishny (1997) when exogenous shocks occur and arbitrageurs' capital is constrained. Mitchell and Pulvino (2012) repeated this by investigated the impact of the 2008 crash on merger arbitrage spreads. They calculated the median spread for all ongoing US stock-only deals between January 2005 and December 2010 using weekly price data and were thus able to demonstrate the significant upwards spike in spreads which occurred in October 2008 in the aftermath of the Lehman Brothers collapse. It is noteworthy that they only used the spreads of stock-only deals to isolate the impact of the crisis on the liquidity of merger arbitrageurs. They found that the median spread peaked at 14.2% in October 2008 which compares to its 10.7% peak in October 1987 and its median for the entire six-year period of 2.1%. Furthermore, spreads did not return to their pre-crisis trading range until April 2009 which strongly suggests that significant exogenous shocks can lead to ineffective arbitrage for relatively long time periods.

Branch and Wang (2008) built upon the earlier work of Jindra and Walkling (2004) to develop a static predictive model for the spread calculated using multivariate linear regression on a data set of 1,223 cash-only, hybrid and stock-only US deals from 1995 to 2005. They found that, for deals involving stock, the significant determinants of the spread two days after the offer announcement were target price run-up, bidder's return volatility, bidder's systematic risk (beta), arbitrageur's activity (measured by abnormal trading volume), the relative size of the target and bidder and the bid premium. This paper is also notable for showing equation 2.3 for calculating the spread for stock-only or hybrid offers.

Jetley and Ji (2010) found that the statistically significant determinants of the spread one day after deal announcement were the bid premium, whether the deal was cash-only or hybrid, whether the directors of the target were hostile, abnormal trading volume in the target company and the market capitalisation (size) of the target relative to the bidder. These findings were based on a sample of 2,118 US cash-only, hybrid and stock-only deals announced between 1990 and 2007. However, the primary finding of this paper, entitled “The Shrinking Merger Arbitrage Spread: Reasons and Implications”, was that the average spread had declined over the three six-year periods in the sample (1990 to 1995, 1996 to 2011 and 2002 to 2007), as shown in figure 3.1 below for completed and failed deals.

Fig. 3.1 – Evolution of the Average Merger Arbitrage Spread (Jetley and Ji 2010)



This observed decline in the average spread over time was ascribed to the increased popularity of cash-only offers, a decrease in the popularity of hostile, or unsolicited, takeover approaches. However, they posited that most significant cause of it was the increased number of, and funds under management by, merger arbitrage hedge funds over the time periods which were competing away the returns from the strategy. However, and of particular interest for this thesis, figure 3.1 demonstrates that the shape and volatility of the average spread for completed and failed deals are broadly similar to those found by Mitchell and Pulvino (2001) at figure 2.1 which uses a sample of earlier (1963 to 1998) US deals.

The only study published to date which has attempted to model the probability of deal completion using logistic regression and to nest this within a linear model of the spread (at a fixed point in time) was by Wang (2017). Her logistic regression, summarised in table 3.1, found that the significant determinants of the probability of deal completion were hostility, the size of the target and the spread which was negatively related. This finding, that lower spreads are indicative of higher deal completion probabilities, supports the earlier work of Brown and Raymond (1986), Samuelson and Rosenthal (1986) and Larcker and Lys (1987). Her linear regression, summarised in table 3.2, found that the spread two trading days after the offer announcement is significantly and negatively related to the probability of success (as estimated by her logistic regression), abnormal trading volume in the shares of the bidder and the target and positively related to the bid premium.

The most recent journal article on the determinants of the spread was Redor (2019). He examined M&A transactions involving constituents of the Standard and Poor’s 500 equity index between 2004 and 2014. Using the spread on the day that the announcement is made as the dependent variable, he found that higher spreads are associated with bid hostility, the relative size of the target to the bidder and the bid premium. Conversely, lower spreads are associated with the proportion of cash in the offer and the existence of target termination (break) fees.

This more recent, and relatively scant, empirical literature which attempts to ascertain the determinants of the spread is summarised below in table 3.2.

Table 3.2
Merger Arbitrage Spread Determinants - Summary of Empirical Studies

Author(s) Sample Methodology	**Significant Determinants of Merger Arbitrage Spread (in descending order of significance)**	**Insignificant Determinants of Merger Arbitrage Spread (in alphabetical order)**
Jindra and Walkling (2004) 362 US cash offers 1981-1995 Linear regression	Target abnormal volume Bid premium Target run-up Toehold Hostility	Target block holdings Target board shareholding
Branch and Wang (2008) 1223 US cash, hybrid and stock offers 1995-2005 Linear regression	Relative size Target abnormal volume Bid premium Target run-up Bidder volatility	Bidder abnormal volume Hostility Target volatility Toehold
Jetley and Ji (2010) 2118 US cash, hybrid and stock offers 1990-2007 Linear regression	Bid premium Cash Hostility Target abnormal volume Target size	

Wang (2017) 1046 US cash, hybrid and stock offers 1994-2004 Linear regression	Target abnormal volume Bid premium Deal completion probability Bidder abnormal volume	
Redor (2019) 285 US cash, hybrid and stock offers 2004-2014 Linear regression	Break fee Bid premium Hostility Relative size Cash	Target leverage Target profitability

3.5 Hypotheses Development

The empirical research performed to date on the probability of deal completion, as a proxy for deal completion risk, and the determinants of the spread itself provides guidance on the independent variables to be considered and the data to be collected for this thesis.

However, the reviews also serve to elucidate the following gaps in the literature:

a) All of the studies have used data with either cross-sectional or temporal dimensions but not both (e.g., Jetley and Ji (2010) which considered why the average spread has declined over time and, separately, sought to ascertain the determinants of the spread at a single point in time);

b) All of the spread determinant studies include cash-only deals which do not involve arbitrage as the only position taken is in the target company's shares; and

c) The majority of the studies been based upon deals which involve US companies, where part of the return derives from bearing systematic risk and relatively few have investigated deals involving companies in non-US jurisdictions.

Accordingly, there appears to be a gap in the literature to address the determinants of the spread in the UK using panel data with both cross-sectional and temporal dimensions for the following two key reasons:

1) The use of a panel dataset will provide an insight into the common determinants of the merger arbitrage spread as it evolves throughout the whole offer period across a number of different deals. This approach will also facilitate the analysis of the impact of the release of important information which reflect the stages of reconciliation of deal completion uncertainty; and

2) The sample of UK transactions will provide an alternative perspective to the majority of the extant, US based, research. Specifically, that the returns to UK merger arbitrage are compensation for bearing unsystematic risk only, as identified in the previous chapter.

In addition, this research only considers M&A deals for which a merger arbitrage spread can be calculated, stock-only or hybrid offers, and it ignores cash-only deals where there is no arbitrage. Whilst necessarily restricting the sample size, this is considered to be more than offset by the use of panel data.

Turning to the potential determinants of the merger arbitrage spread for testing in this thesis, table 3.3 below summarises the determinants found to be significant in the 15 extant studies, 10 concerning the probability of deal completion as summarised in table 3.1 plus 5 studies concerning the spread itself in table 3.2.

Table 3.3 – Common Significant Factors and Determinants

Factor / Determinant	Number of studies where significant	Number of studies where insignificant	Percentage of studies where significant	Number of studies where not tested
Hostility	12	1	**92%**	2
Run-up	4	1	**80%**	10
Size	7	2	**78%**	6
Break fee	3	1	**75%**	11
Cash	5	2	**71%**	8
Abnormal trading volume	5	2	**71%**	8
Bid premium	7	4	**64%**	4
Toehold	5	3	**63%**	7
Competing bidder	3	2	**60%**	10
Target board shareholding	2	2	**50%**	11
Target profitability	1	3	**25%**	11

Notes: *This table shows the most commonly found statistically significant determinants in the 10 probability of deal completion studies summarised in table 3.1 and the 5 merger arbitrage spread studies summarised in table 3.2. Please refer to these tables for determinant definitions.*

It can be seen from table 3.3 that hostility, defined as the board of directors of the target recommending that its shareholders reject the bidder's offer, is the determinant which has been considered by the most studies. Moreover, it is found to be significant in 12 of the 13 (92%) studies which considered it and they all find that it reduces the probability of deal success or leads to higher spreads. Furthermore, hostility is the most significant determinant in 8 of these 12 studies.

The run-up in the target's share price is found to be a significant determinant 80% of the studies in which it was tested. The run-up is the percentage increase in the share price of the target in the period (typically one month) which immediately precedes the announcement of the bid. Although this may be an indication of information leakage and insider dealing prior to announcement of the offer, it is commonly found that higher run-ups are associated with higher deal completion probabilities and lower spreads due to the accumulation of shares in more neutral, possibly arbitrageurs', hands.

Size is found to be significant in 78% of the studies which test it. This determinant is typically defined as the target's market capitalisation on the day before the offer is announced and it is postulated that smaller targets (either in absolute or relative terms to the market capitalisation of the bidder) are more easily acquired.

The existence of a break fee, payable by the target to the bidder in the event of failure to complete, is significant in 75% of the studies which tested it. However, these are all US studies and break fees are generally prohibited for UK listed companies under The Takeover Code (2016) which would explain why it has not been considered by any of the UK studies.

Two determinants were found to be significant in 5 of the 7 studies (71%) in which they were tested, the abnormal trading volume in the shares of the bidder and/or the target, indicating merger arbitrage activity, and the nature of the consideration offered. For the latter, it is postulated that target shareholders prefer the certainty of cash and thus cash-only offers increase the probability of deal success or are reflected in lower spreads, compared to offers which contain equity as part or all of the consideration.

The bid premium, defined as the percentage difference between the value of the bidder's offer for the target and the closing market value of the target on the day before the offer is announced, is tested in 11 of the 15 studies. In all of these, it is hypothesised that a higher bid premium increases the probability of deal success or decreases the spread. Whilst 7 (64%) of the studies find that it is a significant determinant only 3 (2 probability of deal completion studies and 1 of the determinants of the spread studies) find the expected direction of the relationship. Conversely, 4 of the 5 determinants of the spread studies find that the relationship is positive rather than negative as hypothesised.

Toehold, defined as the percentage of the target's shares which are owned by or pledged to the bidder at the time that the bid is announced, is considered by 8 of the studies. 5 of these studies (63%) find it to be a significant determinant of deal success or the spread. The presence of a competing bidder for the target is also considered by 5 of the studies which hypothesise that this reduces the probability of deal completion by the extant bidder. 3 (60%) of these studies find that it is a significant determinant as hypothesised.

The remaining determinants tested by at least 4 of the 15 studies in tables 3.1 and 3.2 were found to be insignificant in at least as many studies that they were found to be significant (e.g., target board shareholding and measures of the target's profitability) and are not, therefore, considered as potential determinants for this research.

3.6 Testable Hypotheses

Drawing on the above, the following ten potential determinants of the merger arbitrage spread in the UK will be tested in this thesis:

1. The avoidance or receipt of regulatory clearance for the deal;
2. The receipt of approval for the deal from the target's shareholders;
3. The recommendation from the board of directors of the target company to its shareholders to accept the bid (i.e., when they move from being hostile to being non-hostile);
4. The actual or potential presence of a counterbidder for the target;

The first two potential determinants relate to the regulatory hurdles which must be passed in order for a UK transaction to complete and neither has been tested in any of the extant studies. The third and fourth potential determinants have been tested in a number of the extant studies but only on a static basis whereas in this research they are tested using panel data with both cross-sectional and longitudinal dimensions. Collectively, these four potential determinants are of key interest to provide evidence concerning the informational efficiency of the UK equity market.

The remaining six potential determinants shown below are drawn from table 3.3 where more than 50% of the studies in which they were tested found them to be statistically significant. The exception is the existence of a break fee as these are generally prohibited in the UK.

5. The percentage of the bidder's consideration which is in cash;
6. The abnormal trading volume in the shares of the bidder and the target;
7. The bid premium;
8. The toehold, percentage of target shares owned by or pledged to the bidder;
9. The relative size of the bidder and the target; and
10. The run-up in the share price of the target.

The testable hypotheses which consider these ten potential determinants and the expected direction of their relationship with the merger arbitrage spread are explained as follows:

H1: Abnormally high trading volume in the shares of bidder and the target reduce the merger arbitrage spread

Abnormally high trading volume is used as a proxy for the presence of merger arbitrageurs. The impact of their simultaneous trades in the bidder and the target companies' shares is to push the spread to the "right" level depending upon their collective opinion on whether the deal will complete or fail on the basis of the information available to them at that point in time. Accordingly, whether the relationship is positive or negative is an empirical issue although it is expected that the sign would be the same for both bidder and target if abnormal trading volume is indeed an effective proxy for arbitrage activity. However, the theoretical work of Cornelli and Li (2002) found that higher levels of arbitrageur involvement in a deal will tend to increase the probability of deal completion as they will always accept the bid. Overall and on balance, a negative relationship with the spread is hypothesised, particularly for those deals which ultimately complete.

H2: Higher bid premiums increase the merger arbitrage spread

Jindra and Walkling (2004), Branch and Wang (2008), Wang (2017) and Redor (2019) find a significant positive relationship between the spread and the bid premium. Although this appears to be counter-intuitive, as a higher bid premium ought to increase the probability of deal success and thus be negatively related to the spread, Branch and Wang (2008) postulate that the impact of this can be more than offset by the bid premium as it represents a significant part of the potential loss to be incurred by merger arbitrageurs if a deal fails to complete and thus a higher spread to is required to compensate for this increased risk. This is particularly valid when considering offers which contain equity, as in this research, as arbitrageurs are exposed to losses on both their long target holdings and short bidder holdings in the event of deal withdrawal. Accordingly, it is hypothesised that higher bid premiums increase the spread.

H3: A higher percentage of cash in the bidder's consideration reduces the merger arbitrage spread

Although this research does not consider cash-only offers, Jetley and Ji (2010) and Redor (2019) find that cash offers have lower "spreads" than the arbitrage spreads of offers where the bidder's consideration is either partly or wholly in its shares. This is consistent with target shareholders preferring the certainty of receiving cash over the risk of receiving overvalued equity in the bidder. Accordingly, it is hypothesised that there is a negative relationship between the percentage of cash in the bidder's consideration offered to the target's shareholders and the spread.

H4: Higher levels of target shares that are either owned by or pledged to the bidder reduces the merger arbitrage spread

The evidence from the extant studies on the direction of the relationship between the spread and the toehold is mixed. Of those that find it to be statistically significant, some find a negative relationship whereas others find a positive relationship. The latter finding would not, however, be expected in the UK as The Takeover Code (2016) stipulates that ultimately a deal can only complete if the percentage of shares in the target owned by the bidder exceeds at least 50% and thus it appears logical that a higher toehold should increase the probability of deal completion and thus be reflected in a lower spread. It is possible to test this assertion in the UK as shares which are either purchased by the bidder in the target during the offer period or pledged to it by way of irrevocable undertakings given by target shareholders have to be disclosed by the bidder in the UK under the Listing Rules (The Financial Conduct Authority 2016).

H5: The recommendation from the board of directors of the target company to its shareholders to accept the bid reduces the merger arbitrage spread

Hostility, of the target's board of directors to the bid, is the most commonly tested determinant in the extant studies shown in table 3.3 and all find that it reduces the probability of deal success. Accordingly, and for this research, it is hypothesised that the announcement of the cessation of hostility (i.e., when the target's directors move from advising its shareholders to reject the bid to advising them to accept the bid) will be reflected in lower spreads.

H6: The presence of a counterbidder for the target causes the merger arbitrage spread to change

If another bidder emerges for the target during the offer period, this will lead to an increase in its share price as the offer from the counterbidder will typically exceed that of the original bidder. However, the reaction of the bidder's share price may either rise, if it is expected that the original deal will fail to complete, or fall, if it is expected that the bidder will increase its offer for the target. Accordingly, the spread may either increase or decrease when an actual or potential counterbid is announced by the target and thus this hypothesis is non-directional.

H7: The avoidance of or receipt of regulatory approval for the deal reduces the merger arbitrage spread

H8: The receipt of approval for the deal from the target's shareholders is negatively correlated with the merger arbitrage spread

As both of these hypotheses consider hurdles which have to be passed for a UK deal to complete, it is hypothesised that achieving them will lead to a lower spread.

H9: The ratio of the bidder's equity market value to the target's equity market value reduces the merger arbitrage spread

As found in the extant studies, smaller targets, either in absolute terms or relative to the size of the bidder, can be financed and integrated more easily by the bidder than larger targets. Hence deals where the target is smaller relative to the bidder are expected to have lower spreads.

H10: The run-up in the target's share price is negatively correlated with the merger arbitrage spread

The extant studies which consider the increase in the target's share price in the days preceding the announcement of the deal argue and mostly find that higher run-ups are indicative of shifts in ownership structure which make deal more completion more likely. Accordingly, and on balance, it is hypothesised in this study that there is a negative relationship between the run-up and the spread.

Chapter 4 – Research Methodology

4.1 Introduction

This chapter starts with a description of the sample of UK M&A transactions and the data collected for use in this thesis. It then proceeds to describe the statistical methodologies employed to estimate the determinants of the merger arbitrage spread and the subsequent robustness checks.

4.2 Sample and Data

The population for this thesis is M&A transactions (deals) in the UK for which merger arbitrage spreads can be calculated over the offer period, from deal announcement to completion or withdrawal. Accordingly, stock-only and hybrid (stock and cash) deals are included and cash-only deals are excluded.

The sample was obtained from the Zephyr M&A database using the following five search criteria:

1. The deal type is either an acquisition or a merger as, whilst only acquisitions (where the shares of a target company are acquired by a bidding company) create arbitrage opportunities, deals which are classed as mergers (where a new company is formed and no arbitrage is possible) may in fact be acquisitions;
2. The deal announcement date is between 1st January 2000 and 31st December 2017 because intra-day price data is not available prior to the former date;

3. Both the bidder and target are UK public limited companies whose shares are listed on the LSE so that price, volume and regulatory news data are available;

4. The consideration offered by the bidder for the target is either wholly or partly in its shares (i.e., it is a shares-only or hybrid offer) to enable a spreads to be calculated; and

5. The deal size (the value of consideration offered by the bidder for the target company at the announcement date) is at least £100 million.

The fifth criterion above warrants further explanation. Firstly, a UK listed company which has a market capitalisation of below £100 million is classified a as small company as it would not be large enough for inclusion in the FTSE-350 index of large and medium LSE listed companies. Over the sample period, the smallest constituent of this index had a market capitalisation in excess of £100 million. A common feature of small companies is that the market in their shares is illiquid and it is therefore hypothesised that this would preclude institutional merger arbitrageurs (i.e., hedge funds) from taking positions in these deals. The absence of merger arbitrage activity in these small deals will give rise to significant amounts of stale data which will adversely affect the reliability of the results. This hypothesis was broadly confirmed by the data that was collected (see tables 4.1 and 4.2 below). Secondly, the cost of the intra-day data acquisition was a contributory factor in setting this criterion at £100 million.

There were 53 transactions which met the aforementioned criteria. The sample was further cleared to remove any transactions: i) which result in no change of managerial control because the bidder already owned over 50% of the target at the announcement date (4 removed); ii) where either the bidder or target were actually unlisted thus precluding the calculation of a merger arbitrage spread (3 removed); iii) where the form of the consideration offered included a contingent element thereby precluding the calculation of a merger arbitrage spread (3 removed) and; iv) where no formal offer was made (1 removed). A total of 11 transactions were therefore removed from the sample, reducing its size to 42.

For each transaction in the sample, the deal value, the form of consideration offered, whether the deal was completed or withdrawn were all recorded from the Zephyr database and are shown in table 4.1. The deal announcement date, completion or withdrawal date and the terms of the deal (the cash and/or number of shares offered by the bidder for one share in the target) were also recorded from the database.

Minute-by-minute share price and trade volume data were obtained for the bidder and target in these 42 deals from the LSE via Tick Data Inc. This enabled the total number of minutes from deal announcement to completion or withdrawal to be calculated and the percentage of the total minutes when shares in the bidder and target trade simultaneously, indicating merger arbitrage activity. These calculations are also shown in table 4.1 which is ranked in descending deal value.

Table 4.1
Original Sample of Transactions

#	Bidder	Target	Deal Value (£m)	Consideration Offered	Outcome	Duration (Minutes)	Minutes When Both Trade
1	Royal Dutch Shell	BG Group	39,355	Shares	Completed	110,190	91.8%
2	Glencore International	Xstrata	20,451	Shares	Completed	157,620	87.5%
3	Lloyds Banking Group	HBOS	14,769	Shares	Completed	41,430	78.2%
4	Melrose	GKN	8,061	Cash & shares	Completed	43,350	70.8%
5	Aviva	Friends Life Group	5,208	Shares	Completed	44,400	65.5%
6	Standard Life	Resolution	4,908	Cash & shares	Withdrawn	8,160	53.3%
7	Resolution	Friends Provident	4,223	Shares	Withdrawn	34,170	53.5%
8	Standard Life	Aberdeen Asset Management	3,776	Shares	Completed	56,610	60.8%
9	Tesco	Booker	3,649	Cash & shares	Completed	141,300	51.6%
10	Hammerson	Intu Properties	3,440	Shares	Withdrawn	48,240	57.7%
11	John Wood Group	Amec Foster Wheeler	3,250	Shares	Completed	73,950	51.2%
12	Taylor Woodrow	George Wimpey	2,749	Shares	Completed	33,660	49.1%
13	Barratt Developments	Wilson Bowden	2,200	Cash & shares	Completed	27,540	28.9%
14	Carphone Warehouse Group	Dixons Retail	1,860	Shares	Completed	29,580	27.5%
15	Derwent Valley Holdings	London Merchant Securities	1,500	Shares	Completed	26,550	13.3%
16	Babcock International Group	VT Group	1,326	Cash & shares	Completed	36,210	27.4%
17	WPP	Taylor Nelson Sofres	1,081	Cash & shares	Completed	50,490	32.6%
18	AG Barr	Britvic	855	Shares	Withdrawn	31,650	5.8%
19	Greene King	Spirit Pub Company	759	Cash & shares	Completed	80,100	18.2%
20	Just Retirement Group	Partnership Assurance Group	663	Shares	Completed	82,650	2.3%
21	Carillion	Alfred McAlpine	572	Cash & shares	Completed	20,940	29.3%

22	Travis Perkins	The BSS Group	558	Cash & shares	Completed	58,140	11.3%
23	GVC Holdings	Sportingbet	485	Cash & shares	Completed	16,320	0.4%
24	Melrose	FKI	478	Cash & shares	Completed	23,970	11.8%
25	Vectura Group	Skyepharma	441	Shares	Completed	29,580	12.0%
26	Ophir Energy	Salamander Energy	412	Shares	Completed	33,690	14.1%
27	RPC Group	British Polythene Industries	330	Cash & shares	Completed	18,870	5.8%
28	Investec	Kensington Group	283	Cash & shares	Completed	25,500	24.2%
29	Investec	The Evolution Group	233	Shares	Completed	37,740	13.1%
30	Kier Group	May Gurney Integrated Services	221	Cash & shares	Completed	24,990	5.7%
31	Premier Oil	Encore Oil	221	Shares	Completed	33,180	19.9%
32	Investec	Rensburg Sheppards	218	Shares	Completed	30,090	5.4%
33	BTG	Protherics	218	Shares	Completed	28,050	3.1%
34	London & Stamford Property	Metric Property Investments	209	Shares	Completed	25,530	3.0%
35	Synergy Healthcare	Isotron	181	Shares	Completed	44,370	0.1%
36	Costain Group	May Gurney Integrated Services	178	Cash & shares	Withdrawn	10,110	2.8%
37	BTG	Biocompatibles International	169	Cash & shares	Completed	22,980	2.1%
38	Clinigen Group	Quantum Pharma	151	Cash & shares	Completed	17,850	0.3%
39	Vectura Group	Innovata	129	Shares	Completed	20,910	0.5%
40	Segro	Brixton	114	Shares	Completed	16,320	11.5%
41	Phoenix IT Group	ICM Computer Group	108	Cash & shares	Completed	21,420	0.1%
42	Spice	Revenue Assurance Services	103	Cash & shares	Completed	27,030	0.4%

It can be seen from table 4.1 that the percentage of minutes where both bidder and target trade is less than 1% in 6 of the 42 deals. As this strongly suggests an absence of arbitrage activity and thus a large amount of stale price data, these 6 deals, shown in table 4.2 below, were also removed from the sample reducing its final size to 36 deals.

Table 4.2
Transactions Removed from Sample due to Insufficient Merger Arbitrage Activity

#	Bidder	Target	Deal Value (£m)	Consideration Offered	Outcome	Duration (Minutes)	Minutes When Both Trade
23	GVC Holdings	Sportingbet	485	Cash & shares	Completed	16,320	0.4%
35	Synergy Healthcare	Isotron	181	Shares	Completed	44,370	0.1%
38	Clinigen Group	Quantum Pharma	151	Cash & shares	Completed	17,850	0.3%
39	Vectura Group	Innovata	129	Shares	Completed	20,910	0.5%
41	Phoenix IT Group	ICM Computer Group	108	Cash & shares	Completed	21,420	0.1%
42	Spice	Revenue Assurance Services	103	Cash & shares	Completed	27,030	0.4%

It can be seen from table 4.2 that the percentage of minutes where both bidder and target shares trade exhibits a degree of correlation with deal value, insofar as the percentage is lowest for the smallest deals. This lends support to the minimum deal size criterion of £100 million for the original sample selection.

In the final sample of 36 transactions, shown at appendix 4.1, the consideration offered by the bidder for the target is in the form of shares in 20 (55.6%) transactions whereas it is the form of cash and shares in 16 (44.6%) transactions and 31 transactions (86.1%) completed whereas 5 (13.9%) were withdrawn. This completion rate is broadly comparable to the 92% found in the US study which provides descriptive statistics for the most comparable data set to this research, Jetley and Ji (2010), who analysed US transactions between 1990 and 2007.

The mean duration of the sample is 87 trading days (44,373 trading minutes) which is somewhat lower than the 129 days recorded by Jetley and Ji (2010). However, and alike Jetley and Ji (2010), the mean duration of the completed deals (93 days) is higher than that of the withdrawn deals (52 days).

The deal with the longest duration, Glencore International plc's acquisition of Xstrata plc, took 309 days to complete due to the many international regulatory clearances that were required. Conversely, the deal with the shortest duration, Standard Life plc's failed acquisition of Resolution plc, took just 16 days.

The dependent variable in this analysis, the merger arbitrage spread, was calculated on a minute-by-minute basis using the one-minute equity price data for the bidder and the target collected from the LSE via Tick Data Inc., the terms of the deal collected from the Zephyr database and the dividend per share data for both companies during the offer period collected from the LSE's RNS and equation 2.3 above from Branch and Wang (2008), which is repeated here for convenience purposes:

$$S_t = \frac{XP_{B,t} + C - P_{T,t}}{P_{T,t}} \quad (2.3)$$

where S_t is the merger arbitrage spread at time (minute) t, X is the exchange ratio (number of bidder's shares offered for each target share), $P_{B,t}$ is the bidder's average clean share price (i.e., adjusted for any dividend between the date of announcement and the ex-dividend date) at minute t, C is the cash offered by the bidder for each target share and $P_{T,t}$ is the target's average clean share price at minute t. The average price in each minute is calculated as the average of the opening and closing prices.

The spread can only be calculated in minutes where both the bidder and target shares trade. In minutes where they do not both trade, the merger arbitrage spread is held at the level in the most recent minute where both trade.

Turning to the independent variables, the announcements made by the bidder and target and also by relevant third parties (e.g., regulatory authorities) during the offer period and disseminated via the LSE's RNS, as required by The Takeover Code (2016), were obtained from the Investegate website (www.investegate.co.uk).

These announcements enabled the following dummy variables to be constructed for each minute of each transaction:

- The date and time that the transaction was recommended by the board of directors of the target company to its shareholders (1 if recommend, 0 if do not recommend) and named RBT;

- The date and time that an actual or potential counterbidder for the target was present (1 if present, 0 if not present) and named OBT;

- The date and time that the final regulatory approval for the transaction was received (1 if received, 0 if not received) and named REGC; and

- The date and time that the target's shareholders voted to approve the transaction (1 if received or when irrevocable undertakings exceeded 50%, 0 if not) and named SAT.

It should be noted that the final two approvals (REGC and SAT) are required under The Takeover Code (2016) for a deal to complete and typically occur in this same order (i.e., shareholders do not vote until after regulatory clearances are received).

In addition to the above time varying dummy variables, the following variables were also constructed for each minute of each transaction:

- The abnormal volume of the bidder's shares (AVB) and the target's shares (AVT) were calculated on the same basis as Lakonishok and Vermaelen (1990) as the volume during the offer period divided by the volume in pre-announcement trading days t-50 to t-25;

- The bid premium (PREM) calculated as the value of the bidder's consideration as a percentage of the value of the target at the close of trade on the day before the offer is announced;

- The percentage of the bidder's total consideration which was cash (CASH) calculated as the value of cash divided by the total value of cash and bidder's equity; and

- The percentage of shares in the target either owned by the bidder and/or irrevocably pledged to the bidder by target shareholders (IUT).

In addition, the following time invariant variables were constructed for each transaction:

- The ratio of the equity market value (capitalisation) of the bidder to the target at the close of business on the trading day before the deal is announced (SIZE); and

- The percentage change in the target share price in the 15 trading days prior to the announcement (RUNUP) in accordance with Branch and Wang (2008) and Wang and Branch (2009).

The pre-announcement data (closing price, market capitalisation and number of shares traded) for the 72 listed companies (36 bidders and 36 targets) to enable construction of these final two variables and for the abnormal volume of bidder and target was obtained from Datastream.

As a result of the differences in deal duration in the sample, minute-by-minute data was collected so that the time of each transaction could be standardised from natural time into percentiles and thus create a balanced (long-narrow) panel.

The primary benefit of this innovative standardisation of time is to improve the range and quality of the methodologies that may be employed to analyse and draw inferences from the data. Similarly, this benefit should more than offset the loss of potentially important information in the data between each time percentile.

It is also important to note that this is a true innovation as a systematic review failed to find any extant published literature in which time has been standardised into percentile. Accordingly, robustness checks will be performed to determine whether the inferences drawn from the data in natural time would be affected by the use of standardised time.

4.3 Panel Data Estimators

A panel dataset comprises both longitudinal and cross-sectional elements for a number of different objects, units or entities. Kennedy (2008) states that the primary advantages of using panel data compared to either cross-sectional (for a number of different entities at a single point in time) or longitudinal (for a single entity across a number of consecutive time periods) data are that they: i) can be used to deal with heterogeneity in the entities and thus reduce the problem of omitted variables; ii) allow for more efficient estimation of parameters by the reduction of multi-collinearity issues; iii) can be used to examine issues that cannot be studied using cross-sectional or longitudinal data alone; and iv) enable better analysis of dynamic adjustments in the data.

The generic regression model for panel data is shown at equation 4.1 below.

$$y_{it} = \alpha + \beta \boldsymbol{x}_{it} + u_{it} \tag{4.1}$$

where y_{it} is the dependent variable observed for entity i at time t, α is the intercept term, β is a k x 1 vector of parameters to be estimated on the independent variables, $\boldsymbol{x}_{it}$ is a 1 x k vector of observations on the independent variables and u_{it} is the error term. Here, k represents the number of independent variables in the model.

The desirable properties of a regression model are that it produces the best linear unbiased estimators ("BLUE"). Estimators are unbiased if the means of their sampling distributions are centred over the true mean value of the estimator and they are best, or efficient, when they have the smallest variance among all unbiased estimators. A further desirable property, alongside unbiasedness and efficiency, is consistency, the probability that the estimates of parameters α and β in equation 4.1 ($\hat{\alpha}$ and $\hat{\beta}$) converge to their true values as the sample size tends to infinity.

If the ordinary least squares ("OLS") or generalised least squares ("GLS") estimators are adopted, the estimated parameters ($\hat{\alpha}$ and $\hat{\beta}$) in equation 4.1 will be consistent, unbiased and efficient if the following four assumptions regarding the error term, u_{it}, hold:

1. The errors have zero mean;
2. The variance of the errors is constant (homoscedastic) and finite over all values of $\boldsymbol{x}_{it}$;
3. The errors arising from each independent variable are linearly independent of one another; and
4. There is no relationship between the error and corresponding independent variable.

In addition, if the error term is normally distributed then valid inferences about the population parameters (the actual α and β in equation 4.1) may be drawn from the sample parameters $\hat{\alpha}$ and $\hat{\beta}$ estimated using a finite amount of data.

The collected data for this thesis is a panel of 36 deals (31 completed and 5 failed) across 100 consecutive time percentiles. Econometrically, this dataset is termed as a small N (number of entities, deals) and large T (time periods), or a long-narrow panel, which is both heterogeneous and dynamic. Pesaran et al. (1999) posit that the following may be used to estimate such data:

a. The traditional panel data estimators, such as the fixed effects and random effects models, where the intercepts are allowed to differ across entities while all other coefficients and error variances are constrained to be the same;

b. The mean group panel data estimator which involves estimating separate regressions for each entity and averaging the coefficients; and

c. The pooled mean group ("PMG") panel data estimator which allows the intercepts, short-run coefficients and error variances to differ freely across entities but constrains the long run coefficients to be the same.

The first and third of these estimators are employed in this thesis and are, accordingly, now discussed in more detail.

4.3.1 Traditional Panel Data Estimators

According to Brooks (2014), the traditional panel estimator approaches that can be adopted in financial research are the fixed effects and random effects models. Both of these models allow the intercept to differ cross-sectionally for each deal but not over time, while all of the independent variable coefficients are fixed both cross-sectionally and over time. The primary difference between them is in the way in which the intercepts of the deals are assumed to arise and its effect on the error term.

In the fixed effects model, the error term, u_{it}, can be decomposed into an individual specific effect, μ_i, which captures all of the independent variables which affect the dependent variable cross-sectionally but do not vary over time plus a remainder disturbance, v_{it}, that varies over time and deals and which captures everything that is unexplained in the dependent variable y_{it}. Accordingly, equation 4.1 may be re-written as equation 4.2 below.

$$y_{it} = \alpha + \beta \boldsymbol{x}_{it} + \mu_i + v_{it} \tag{4.2}$$

To enable estimation of the parameters in the fixed effects model using the OLS estimator, the data is first transformed by subtracting the time-mean of each entity from the observed values of the variables (the within transformation) and OLS is then applied to the pooled sample of demeaned data. One effect of this is that the ability to determine the influences of any independent variables which do not vary over time on the dependent variable is lost.

In the random effects model, the intercepts for each cross-sectional entity are assumed to arise from a common intercept α which is the same for all entities over time, plus a random variable ϵ_i that varies by entity but which is constant over time and thus measures the random deviation of each entity's intercept term from α. Accordingly, equation 4.1 may also be re-written as equation 4.3 below.

$$y_{it} = \alpha + \beta \boldsymbol{x}_{it} + \epsilon_i + v_{it} \tag{4.3}$$

It should be noted that ϵ_i is assumed to have zero mean, is independent of the individual observation error term v_{it}, has constant variance and is independent of the matrix of independent variables.

To enable estimation of the parameters in the random effects model, OLS cannot be used as it produces inefficient parameter estimates. Instead, the GLS method is adopted where the data is first transformed by subtracting a weighted time-mean of each entity from the observed values of the variables. The weight is a function of the variance of the observation error term within each deal and the variance of the deal-specific error term between each deal.

Kennedy (2008) asserts that the primary implications of using a weighted average of the within and between estimators with the random effects model are that it produces more efficient estimators of the coefficients than the fixed effects model (as fewer degrees of freedom are lost) and it allows independent variables which are time invariant to be estimated, unlike the fixed effects model. However, the between estimator in the random effects model may also be a source of bias when any of the independent variables are correlated with the composite error term and this will be particularly problematic if variables are omitted. Conversely, the fixed effects model offers some protection against omitted variable bias.

To determine which estimator provides a greater degree of explanation, the Hausman (1978 cited by Asteriou and Hall 2007) test is applied to the results of the fixed and random effects regressions. The null hypothesis of this test is that the random effects estimator is consistent and efficient whereas the alternate is that it is inefficient. Accordingly, failure to reject the null indicates that random effects is preferred. Conversely, rejection of the null strongly indicates that the fixed effects estimator, which will always be consistent, provides a greater degree of explanation.

For the purposes of this research, the panel regression equation 4.4 below was estimated over the collected data for the completed and failed deals separately using both the fixed effects and random effects models. It was decided to estimate the completed and failed deals separately because the only way of differentiating between them would be to include a static dummy variable which would only be lost in the fixed effects estimation.

$$SPREAD_{it} = \alpha + \beta_{AVB} \cdot AVB_{it} + \beta_{AVT} \cdot AVT_{it} + \beta_{PREM} \cdot PREM_{it} + \beta_{CASH} \cdot CASH_{it} + \beta_{IUT} \cdot IUT_{it} + \beta_{RBT} \cdot RBT_{it} + \beta_{OBT} \cdot OBT_{it} + \beta_{REGC} \cdot REGC_{it} + \beta_{SAT} \cdot SAT_{it} + \beta_{SIZE} \cdot SIZE_{it} + \beta_{RUNUP} \cdot RUNUP_{it} + u_{it} \quad (4.4)$$

where:

SPREAD is the merger arbitrage spread

α is the constant

AVB is the abnormal trading volume in the bidder's shares

AVT is the abnormal trading volume in the target's shares

PREM is the bid premium

CASH is the percentage of consideration which is cash

IUT is the percentage of shares in the target either owned by and/or pledged to the bidder

RBT is the recommended by board of target dummy variable (1 if so, 0 if not)

OBT is the other (potential or actual) bidder for the target dummy variable (1 if so, 0 if not)

REGC is the all regulatory clearance(s) received dummy variable (1 if so, 0 if not)

SAT is the approval received from the target's shareholders dummy variable (1 if so, 0 if not)

SIZE is the ratio of the size of bidder to the size target

RUNUP is the percentage run-up in the target's share price

u_{it} is the error term

The next stage was to determine whether the fixed or random effects model could be used in the subsequent analysis by application of the Hausman test to the results from the fixed and random effects regressions for both the completed and failed deals.

The following diagnostic tests were then applied to ascertain whether the remaining least squares assumptions, homoscedastic and non-serially correlated errors, hold. The presence of either of these features in the data set will result in inefficient yet unbiased parameter estimates.

First, the Breusch-Pagan (1979 cited by Kennedy 2008) test was employed to determine whether the variance of the errors was constant, homoscedastic, or non-constant, heteroscedastic, over time. The null hypothesis of this test is that the errors are homoscedastic and the alternate is that the errors are heteroscedastic. If the latter is found in the data, robust standard errors may be used to take it into account.

Second, the Wooldridge (2002 cited by Kennedy 2008) test was applied to determine whether the covariance between the error terms was zero over time, not serially or auto correlated, or non-zero, serially correlated. The null hypothesis of this test is that the errors do not demonstrate serial correlation and the alternate is that they are serially correlated. If the latter is found in the data at levels, lags or first differences of the variables may be used in an attempt to eliminate the serial correlation.

If both heteroscedasticity and serial correlation is found in the data, it may be regressed using the fixed effects estimator with robust standard errors to take account of the former and also with first-differenced variables to correct for the latter.

4.3.2 The Pooled Mean Group Panel Data Estimator

The limitations of the traditional fixed effects model for estimating a long-narrow panel with serially correlated errors can be summarised as follows:

a) The regression results may be spurious if any of the variables are found to be non-stationary;

b) The coefficients on the time varying variables are estimated in first differences rather than in levels; and

c) It assumes that the entities (deals) are homogenous whereas they may exhibit a degree of heterogeneity.

Addressing each of these limitations in more detail, a non-stationary time-series is one that does not have a constant mean, variance and autocovariance for each given lag of the series. Accordingly, it will tend to diverge significantly from its mean value and rarely mean-revert whereas a stationary series will do so frequently over time. Econometrically, a non-stationary time series is said to contain at least one unit root and is denoted as I(d) where d is the number of times that the series must be differenced to make it stationary. Conversely, a stationary time-series is termed as integrated of order zero, denoted as I(0). The problem with regressing non-stationary variables on each other or a mix of stationary and non-stationary variables is that the results may appear to be plausible using standard measures (i.e., significant coefficient estimates and strong goodness of fit measures) despite the fact that no meaningful relationship between the variables actually exists. In other words, the regression results may be spurious.

However, if the dependent and one or more of the independent variables are found to be integrated of order one then it may be that particular linear combinations of them are stationary, or cointegrated. Cointegration, from the pioneering work of Engle and Granger (1987, cited by Asteriou and Hall 2007), implies that there is an underlying long-run relationship between the variables which can be estimated using a model with an error correction component which: i) disaggregates the short-run dynamics from the long-run equilibrium;

ii) enables a speed of adjustment (from short-run disequilibrium to long-run equilibrium) parameter to be estimated; and iii) estimates the long-run coefficients on the independent variables in levels rather than in first differences. Accordingly, and taking this approach, the first two limitations noted above will be addressed.

The third limitation, the assumption of homogenous deals, may be addressed by the use of the Pooled Mean Group ("PMG") estimator postulated by Pesaran et al. (1999) particularly as the dataset has been constructed as a balanced panel by the standardisation of time into percentiles. This estimator allows the intercepts and short-run coefficients and error variances to differ freely across units but constrains the long-run coefficients and error variances to be the same. It therefore imposes weaker homogeneity assumptions than the fixed effects model and allows for a degree of heterogeneity between the deals.

Accordingly, the initial stage was to test each non-dummy variable for the completed and failed deals for evidence of non-stationarity using the Levin, Lin and Chu test (2002, cited by Asteriou and Hall 2007) which is analogous to the Dickey-Fuller approach for unit root testing of individual (non-panel) time series. Any variables which were found to be integrated of higher than order one were removed from the subsequent analysis as the PMG can only estimate variables which are I(0) or I(1). The dummy variables were not tested as they cannot contain more than one unit root by their nature.

Next, and if the dependent variable and one or more of the independent variables were found to be integrated of order one, the data were tested for evidence of cointegration using the Kao test (1999, cited by Asteriou and Hall 2007). This test, which is an extension of the Engle-Granger residual based test for individual time series to the panel context, has a null hypothesis of no cointegration and an alternate that all of the panels are cointegrated.

Finally, and if evidence of cointegration was found, the re-parameterised autoregressive distributed lag ("ARDL") dynamic panel model specified at equation 4.5 was estimated using the PMG estimator.

$$\Delta y_{it} = \emptyset_i\left(y_{i,t-1} - \theta_i' \, x_{it}\right) + \sum_{j=1}^{p-1} \lambda_{ij}^{*} \, \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \delta_{ij}'^{*} \, \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \quad (4.5)$$

where:

y_{it} is the dependent variable, for groups i = 1, 2,…,N in time periods (percentiles) t = 1, 2,…T

$\emptyset_i$ is the error-correcting speed of adjustment term

θ_i' is the vector of long run relationships between the dependent and independent variables

$\boldsymbol{x}_{it}$ is a k x 1 vector of the independent variables

p is the optimal lag length of the dependent variable

λ_{ij} are the coefficients on the lagged dependent variables

q is the optimal lag length of the independent variables

δ'_{ij} are the coefficients on the lagged and unlagged independent variables

μ_i is the group specific (fixed) effect

ε_{it} is the error term

4.4 Robustness Checks

The robustness checks in this research were performed by estimating the individual time series of a randomly selected sub-sample of deals with the

Vector Error Correction Model ("VECM") of Engle and Granger (1987 cited by Brooks 2014) using the Johansen (1991 cited by Brooks 2014) method.

The VECM was employed as it enables a like-for-like comparison of the long-run coefficients on the independent variables in the panel ARDL model, re-parameterized with an error correction component, as shown at equation 4.5. Further, and following the approach taken by Maysami and Koh (2000), the Johansen method was preferred over the two-step method developed by Engle and Granger (1987 cited by Brooks 2014) as it is a full information maximum likelihood estimation model which allows for testing in one-step without the requirement for a specific variable to be normalised. Accordingly, it avoids carrying over the errors from the first step into the second step of the Engle-Granger method and thus yields more efficient estimators on the cointegrating vectors. Furthermore, it estimates the long-run coefficients on the independent variables in levels, making them easier to interpret and facilitating direct comparison to the panel ARDL estimates.

The first, and most important, objective of these checks was to assess whether the innovative use of standardised time in percentiles rather than natural time affects the conclusions drawn from the panel data estimations. If the standardisation has little or no impact then the innovation is underpinned and confidence can be placed in the results and the inferences which have been drawn from them. This was achieved by comparing the signs and statistical significance of the coefficients on the independent variables for the VECMs of each sampled deal in natural and standardised time.

The second objective was to check whether the underlying equilibrium relationship between the spread and its determinants for the typical completed deal also holds for the individual deals. This check will therefore provide evidence on the degree of heterogeneity between the individual deals which, if found, will support the use of the PMG estimator. This was achieved by comparing the signs and statistical significance of the coefficients on the independent variables for the VECMs of each individual deal and the average deal, estimated using equation 4.5, in standardised time.

The VECM estimated for each of the sub-sample of deals using both standardised time (percentiles) and natural time (hours) is shown at equation 4.6 below.

$$\Delta y_t = \sum_{j=1}^{p} \alpha \Delta y_{t-j} + \sum_{j=0}^{p} \delta_i \Delta \boldsymbol{x}_{t-j} + \varphi z_{t-1} + \mu + \varepsilon_t \qquad (4.6)$$

where:

y_t is the dependent variable

α is the short-run coefficient on the dependent variable at the j'th lag

δ_i is a matrix of short-run coefficients on the independent variables at the j'th lag

$\boldsymbol{x}_t$ is a matrix of independent variables

φ is the long-run speed of adjustment factor

z_{t-1} is the error correction term which is equal to $y_{t-j} - \beta_0 - \beta_1 \boldsymbol{x}_{t-j}$ where:

β_0 is a matrix of constants

β_1 is a matrix of long-run coefficients on the independent variables at the j'th lag

μ is a constant

ε_t is the residual term

The first stage of the estimation procedure for each of the individual deals was to remove any independent variables for which there was no data or which were time invariant or collinear. Second, an Augmented Dickey-Fuller test was applied to each remaining variable to determine its order of integration and any variables which were not stationary in first differences were removed as a VECM can only be estimated if all variables are integrated of order 1. Third, the optimal lag length was determined using the Schwarz Bayesian information criterion and, fourth, the Johansen test for cointegration was applied to ascertain if there was one or more underlying relationship between the variables. If evidence of cointegration at the optimal lag length was found, a VECM per equation 4.6 was estimated with the constants in the error correction component (β_0) set to zero to allow for a like for like comparison with the panel ARDL. Finally, the coefficients on the independent variables in the long-run element of the estimation were compared in terms of sign and significance. These comparisons were made between percentiles and hours for each individual deal time-series and then between the panel and the individual deal time series (both in percentiles).

Chapter 5 – The Determinants of the Merger Arbitrage Spread: Traditional Panel Data Estimators

5.1 Introduction

This chapter first presents and discusses the descriptive statistics of the sample of 36 M&A deals, in particular the dependent variable, the merger arbitrage spread. It then proceeds to present the panel data regression results using the traditional estimators, the fixed effects and the random effects. It concludes by considering the implications of these results.

5.2 Descriptive Statistics

The descriptive statistics for all, both completed and failed, deals in the sample are shown in table 5.1.

Table 5.1
Descriptive Statistics – All Deals

Variable	N	Mean	Std. Dev.	Min	Max
SPREAD	3600	0.029	0.060	-0.216	0.668
AVB	3600	1.167	1.703	0.019	63.036
AVT	3600	1.913	5.798	0.000	110.004
PREM	3600	0.081	0.187	-0.519	0.823
CASH	3600	0.144	0.219	0.000	0.751
IUT	3600	0.179	0.212	0.000	0.979
RBT	3600	0.934	0.248	0.000	1.000
OBT	3600	0.079	0.270	0.000	1.000
REGC	3600	0.401	0.490	0.000	1.000
SAT	3600	0.298	0.458	0.000	1.000
SIZE	3600	3.662	3.674	0.435	12.647
RUNUP	3600	0.023	0.160	-0.459	0.452

Notes: *This table reports the statistics of the variables for the sample of all 36 (completed and failed) deals. The dependent variable is the merger arbitrage spread (SPREAD), the independent variables are the abnormal trading volume of the bidder's shares (AVB), the abnormal trading volume of the target's shares (AVT), the bid premium (PREM), the percentage of consideration which is cash (CASH), the percentage of shares in the target which are owned by or pledged to the bidder (IUT), the dummy for the recommendation of the deal by the target's board of directors to its shareholders (RBT), the dummy for the presence of another bidder for the target (OBT), the dummy for the receipt of regulatory clearance for the deal (REGC), the dummy for the receipt of approval for the deal from the target's shareholders (SAT), the relative size of the bidder to the target (SIZE) and the percentage run-up of the target's share price in the 15 trading days ahead of the deal announcement. N is the number of observations (time percentiles x number of completed deals), Mean is the average value, Std. Dev. is the standard deviation, Min is the minimum value and Max is the maximum value.*

The data for the entire sample was also grouped into quartile ranges representing the four quarters of the offer period and the means of each variable are shown in table 5.2 below.

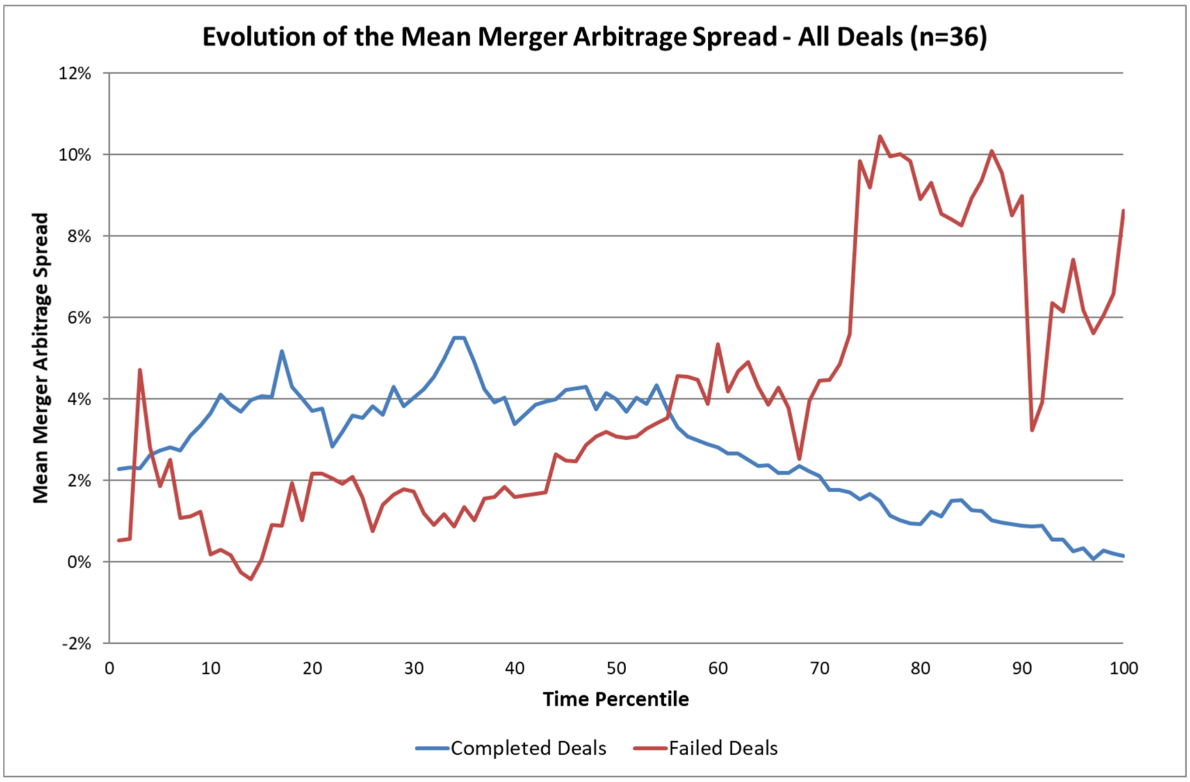
Table 5.2
Descriptive Statistics – All Deals by Offer Period Quartile

	Mean in Quartile Number				
Variable	**1**	**2**	**3**	**4**	**Overall**
SPREAD	0.031	0.039	0.029	0.018	0.029
AVB	1.437	0.957	1.045	1.227	1.167
AVT	3.355	1.274	1.373	1.650	1.913
PREM	0.100	0.071	0.071	0.080	0.081
CASH	0.141	0.143	0.145	0.146	0.144
IUT	0.158	0.162	0.185	0.211	0.179
RBT	0.923	0.917	0.946	0.952	0.934
OBT	0.111	0.081	0.068	0.056	0.079
REGC	0.222	0.239	0.444	0.697	0.401
SAT	0.003	0.089	0.323	0.778	0.298
SIZE	3.662	3.662	3.662	3.662	3.662
RUNUP	0.023	0.023	0.023	0.023	0.023

Notes: *This table reports the mean (average value) of each variable for the sample of all 36 deals in each quartile of the offer period. See table 5.1 for variable definitions.*

It can be seen from tables 5.1 and 5.2 that the dependent variable, the spread, has a mean value of 2.9% over the entire offer period for all of the sampled deals and is widely dispersed, as evidenced by the standard deviation of 6.0%. In the first quartile of the offer period is 3.1% which increases to 3.9% in the second quartile before period declining towards unity in the third (2.9%) and final (1.8%) quartiles. However, and as this study is taking a panel data approach, the evolution of the mean spread over each percentile of the offer period is of interest and, in particular, how it differs between the completed and failed deals. This is shown in figure 5.1 below.

Fig 5.1



The most striking feature of figure 5.1 is that the evolution of the mean spread for the 31 completed deals and the 5 failed deals over the time percentiles are visibly distinct, particularly in the latter half of the deal period (from time percentile 50 to 100). This indicates that the UK equity market can discriminate between those deals that ultimately complete and those that ultimately fail but not in the early stages of the deal period (when the mean spread of the failed deals exceeds that of the completed deals). This is somewhat contrary to earlier findings from the US equity market such as those depicted by Mitchell and Pulvino (2001) at figure 2.1 and Jetley and Ji (2010) at figure 3.1. Also evident from figure 5.1 is the difference in volatility of the mean spread of the completed and failed deals. The volatility of the spreads are comparable in the earlier stages of the deal period but then diverge significantly with that of the completed deals dying away as the spread declines to parity whereas that of the failed deals increases significantly as the spread itself increases. This feature is, however, broadly similar to the earlier findings in the US, despite the large difference in sample sizes.

The evolution of the mean, minimum and maximum spread for the completed and failed deals are shown below in figures 5.2 and 5.3 respectively.

Fig 5.2

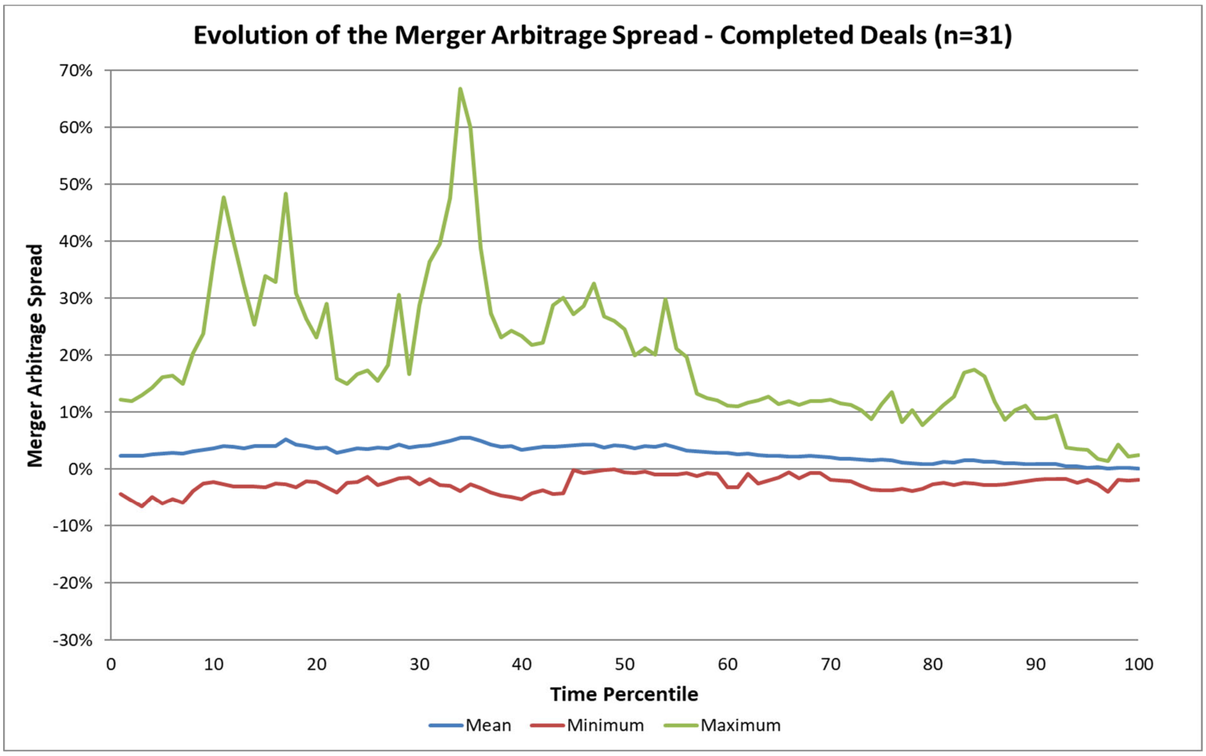
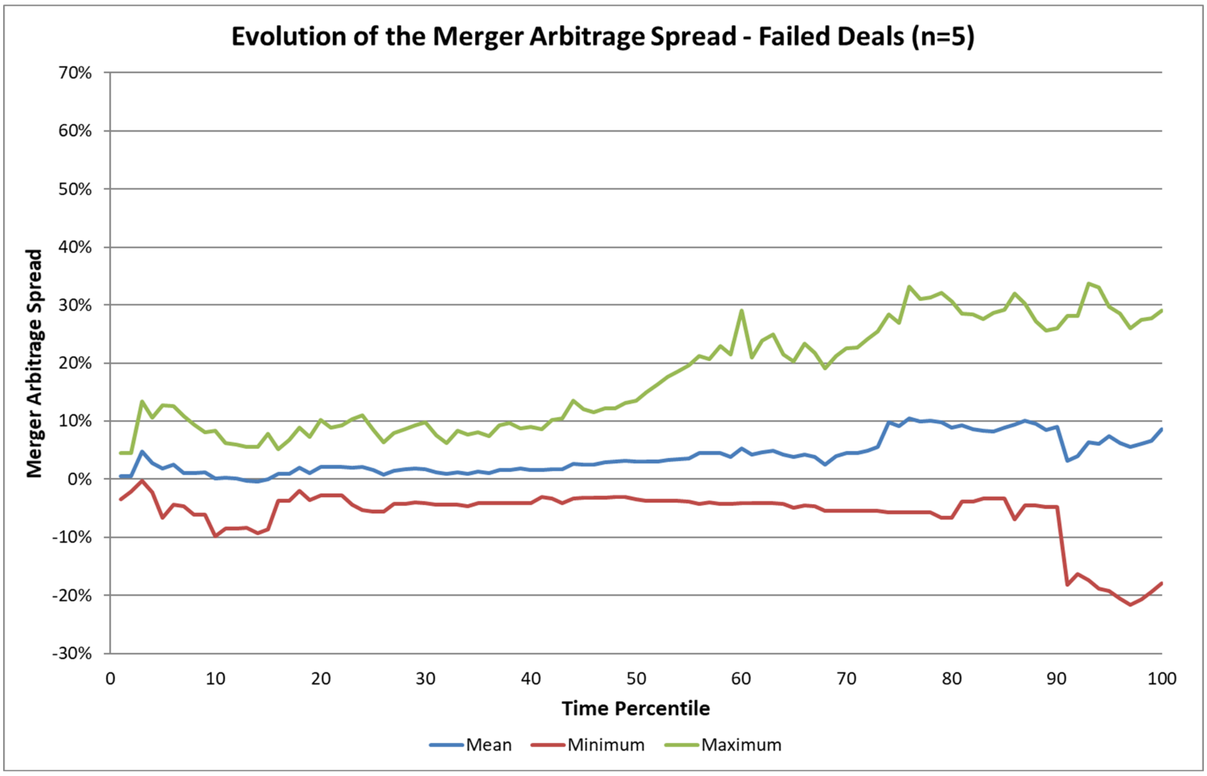


Fig 5.3



The maximum spread for the completed deals is primarily Lloyds Banking Group plc's bid for HBOS plc. Conversely, the minimum spread is mostly a combination of Melrose plc's bid for GKN plc and WPP plc's bid for Taylor Nelson Sofres plc. The spreads for these latter two deals were negative at times due to the expectation of a counterbid for the target although in neither deal did this ultimately materialise.

For the failed deals, the maximum spread is a combination of Resolution plc's failed takeover of Friends Provident plc and Hammerson plc's failed takeover of Intu Properties plc. The minimum spread is a combination of Standard Life plc's failed acquisition of Resolution plc and Costain plc's failed acquisition of May Gurney Integrated Services plc.

As a result of this bifurcation between the spreads of the completed and failed deals, it was deemed apposite to present the descriptive statistics separately in tables 5.3 and 5.4 below to facilitate a comparative discursive analysis.

Table 5.3
Descriptive Statistics - Completed Deals

Variable	N	Mean	Std. Dev.	Min	Max
SPREAD	3100	0.028	0.050	-0.066	0.668
AVB	3100	1.185	1.683	0.044	63.036
AVT	3100	1.860	5.528	0.000	110.004
PREM	3100	0.074	0.195	-0.519	0.823
CASH	3100	0.142	0.205	0.000	0.751
IUT	3100	0.181	0.213	0.000	0.979
RBT	3100	0.960	0.196	0.000	1.000
OBT	3100	0.028	0.165	0.000	1.000
REGC	3100	0.398	0.490	0.000	1.000
SAT	3100	0.333	0.471	0.000	1.000
SIZE	3100	4.061	3.809	0.435	12.647
RUNUP	3100	0.023	0.171	-0.459	0.452

Notes: *This table reports the statistics of the variables for the sample of 31 completed deals. See table 5.1 for variable definitions. N is the number of observations (time percentiles x number of completed deals), Mean is the average value, Std. Dev. is the standard deviation, Min is the minimum value and Max is the maximum value.*

Table 5.4
Descriptive Statistics - Failed Deals

Variable	N	Mean	Std. Dev.	Min	Max
SPREAD	500	0.039	0.102	-0.216	0.337
AVB	500	1.053	1.816	0.019	20.819
AVT	500	2.243	7.246	0.000	86.639
PREM	500	0.119	0.116	-0.063	0.346
CASH	500	0.151	0.291	0.000	0.751
IUT	500	0.164	0.211	0.000	0.506
RBT	500	0.776	0.417	0.000	1.000
OBT	500	0.394	0.489	0.000	1.000
REGC	500	0.416	0.493	0.000	1.000
SAT	500	0.086	0.281	0.000	1.000
SIZE	500	1.187	0.371	0.565	1.572
RUNUP	500	0.024	0.055	-0.070	0.100

Notes: *This table reports the statistics of the variables for the sample of 5 failed deals. See table 5.1 for variable definitions. N is the number of observations (time percentiles x number of failed deals), Mean is the average value, Std. Dev. is the standard deviation, Min is the minimum value and Max is the maximum value.*

The mean and standard deviation of the spread is higher for the failed deals than the completed deals, in accordance with the findings of Mitchell and Pulvino (2001). The maximum spread is actually observed in one of the completed deals, Lloyds Banking Group plc's acquisition of HBOS plc, although this can be explained by the timing and nature of this transaction which was essentially a UK government sponsored bail-out of a failed bank at the height of the credit crisis in September 2008. It is also worth noting that negative spreads are typically observed when there is an expectation of a counterbid for the target and thus they are far more prevalent in the failed deals (199 of the 500 observations, 39.8%) than in the completed deals (376 of the 3100 observations, 12.1%).

The following aspects of the time varying independent variables are of note:

a) For both the completed and failed deals, the mean trading volume per percentile of the bidder and the target during the offer period is abnormally high, particularly in the first and final quartiles of the offer period. Furthermore, the mean trading volume and standard deviation is higher for targets than bidders. Although the minimum abnormal trading volume for targets in both completed and failed deals is zero, this only occurs in 12 of the 3600 time percentiles.

b) The average bid premium is higher for the failed deals than the completed deals, which is broadly supportive of hypothesis two. However, the average percentage of cash in the bidder's consideration is also higher for the failed deals than the completed deals, which appears contrary to hypothesis three; and

c) The percentage of shares in the target owned by or pledged to the bidder and increases, as expected, over time. Further, the average percentage is higher for the completed deals than the failed deal which is broadly supportive of hypothesis four although the extent of this difference is not as high as expected.

Turning to the time varying dummy variables, it can be seen that:

a) The mean value for recommendation by the target board is very close to parity for the completed deals, reflecting the fact that 29 of the 31 completed deals had been negotiated prior to the offer announcement and effected by a scheme of arrangement compared to 2 which were hostile takeovers (Melrose plc's acquisition of GKN plc and WPP plc's takeover of Taylor Nelson Sofres plc). The mean value for the failed deals is still relatively high as the target board had recommended that its shareholders accept the bidders offer when the deal was announced in all 5 deals only for that recommendation to be reversed at a later stage;

b) The mean value for the presence of another bidder for the target is higher for the failed deals than the completed deals, this being the primary factor for the failure of 2 of the 5 failed deals (Standard Life plc's failed takeover of Resolution which was acquired by Pearl Group plc, an unlisted company at the time, and Costain plc's failed takeover of May Gurney Integrated Services plc which was acquired by Kier Group plc); and

c) The mean and standard deviation of the receipt (or avoidance of) regulatory approval are broadly similar for the completed and the failed deals and occur, as expected, before approval is received from the target's shareholders, as evidenced by its higher mean in each of the four quartiles of the offer period.

Finally, considering the variables which differ by deal but which are time-invariant:

a) The mean relative size of the bidder and target is higher for the completed deals than for the failed deals, which lends support to hypothesis nine. The lowest relative size in the sample is Melrose plc's acquisition of FKI plc and the highest is Segro plc's acquisition of Brixton plc; and

b) The mean run-up for the completed and failed deals is very similar which appears contrary to hypothesis ten. In 10 of the 36 deals in the sample, the share price of the target was actually lower on the day before the deal was announced than 20 trading days prior. The largest fall (45.9%) was in the share price of HBOS plc prior to Lloyds Banking Group plc's announcement which, as mentioned above, was attributed to the unusual conditions in the UK banking sector at the time. The highest increase (45.2%) is observed for the share price of GKN plc prior to the announcement of Melrose plc's takeover bid.

5.3 Regression Results

As discussed in the previous chapter, the regression equation shown at 4.4 which is repeated below for convenience purposes was estimated over the collected panel data for the completed and failed deals separately using both the fixed effects and random effects estimators.

$$\begin{aligned} SPREAD_{it} = {} & \alpha + \beta_{AVB} \cdot AVB_{it} + \beta_{AVT} \cdot AVT_{it} + \beta_{PREM} \cdot PREM_{it} \\ & + \beta_{CASH} \cdot CASH_{it} + \beta_{IUT} \cdot IUT_{it} + \beta_{RBT} \cdot RBT_{it} + \beta_{OBT} \\ & \cdot OBT_{it} + \beta_{REGC} \cdot REGC_{it} + \beta_{SAT} \cdot SAT_{it} + \beta_{SIZE} \cdot SIZE_{it} \\ & + \beta_{RUNUP} \cdot RUNUP_{it} + u_{it} \end{aligned} \tag{4.4}$$

where:

SPREAD is the merger arbitrage spread

α is the constant

AVB is the abnormal trading volume in the bidder's shares

AVT is the abnormal trading volume in the target's shares

PREM is the bid premium

CASH is the percentage of consideration which is cash

IUT is the percentage of shares in the target either owned by and/or pledged to the bidder

RBT is the recommended by board of target dummy variable (1 if so, 0 if not)

OBT is the other (potential or actual) bidder for the target dummy variable (1 if so, 0 if not)

REGC is the all regulatory clearance(s) received dummy variable (1 if so, 0 if not)

SAT is the approval received from the target's shareholders dummy variable (1 if so, 0 if not)

SIZE is the ratio of the size of bidder to the size target

RUNUP is the percentage run-up in the target's share price

u_{it} is the error term

The panel regression results are shown in tables 5.5 and 5.6 respectively.

Table 5.5
Panel Regression Results – Completed Deals

Independent Variable	Fixed Effects	Random Effects
AVB	0.0001 (0.0004)	0.0001 (0.0004)
AVT	-0.0001 (0.0001)	-0.0001 (0.0001)
PREM	0.0530 *** (0.0066)	0.0502 *** (0.0063)
CASH	-0.0097 (0.0631)	-0.0506 * (0.0276)
IUT	0.0826 *** (0.0166)	0.0624 *** (0.0143)
RBT	-0.0210 (0.0138)	-0.0045 (0.0120)
OBT	0.0022 (0.0044)	-0.0033 (0.0044)
REGC	-0.0323 *** (0.0019)	-0.0320 *** (0.0019)
SAT	-0.0141 *** (0.0015)	-0.0142 *** (0.0015)
SIZE	-	-0.0038 ** (0.0018)
RUNUP	-	-0.1397 *** (0.0392)
Constant	0.0483 *** (0.0136)	0.0608 *** (0.0145)
Number of observations	3,100	3,100
Number of panels (deals)	31	31
R^2 (overall)	0.0004	0.1342
F-statistic	89.72 ***	-
Wald Chi^2 statistic	-	802.85 ***

Notes: *This table reports panel regression results (OLS for fixed effects, GLS for random effects) where the dependent variable is the merger arbitrage spread. Standard errors of the parameter estimates are shown in parentheses. See equation 4.4 for variable definitions. SIZE and RUNUP are time invariant and are thus not estimated by the fixed effects model. *** denotes statistically significant at the 1% level, ** at the 5% level and * at the 10% level.*

Table 5.6
Panel Regression Results – Failed Deals

Independent Variable	Fixed Effects	Random Effects
AVB	0.0035 ** (0.0015)	0.0019 (0.0016)
AVT	-0.0008 ** (0.0004)	-0.0017 *** (0.0004)
PREM	0.5438 *** (0.0479)	0.4913 *** (0.0499)
CASH	0.4467 (0.6415)	0.4162 *** (0.0367)
IUT	0.4428 *** (0.0862)	0.3689 *** (0.0905)
RBT	0.0021 (0.0128)	-0.0001 (0.0135)
OBT	-0.0801 ** (0.0340)	-0.3251 *** (0.0133)
REGC	0.0636 *** (0.0210)	0.0451 ** (0.0220)
SAT	-0.0690 *** (0.0119)	-0.0673 *** (0.0126)
SIZE	-	-0.0289 (0.0342)
RUNUP	-	2.0645 *** (0.1972)
Constant	-0.1580 (0.1016)	-0.0418 (0.0272)
Number of observations	500	500
Number of panels (deals)	5	5
R^2 (overall)	0.0113	0.7043
F-statistic	25.69 ***	-
Wald Chi^2 statistic	-	1162.26 ***

Notes: *This table reports panel regression results (OLS for fixed effects, GLS for random effects) where the dependent variable is the merger arbitrage spread. Standard errors of the parameter estimates are shown in parentheses. See equation 4.4 for variable definitions. SIZE and RUNUP are time invariant and are thus not estimated by the fixed effects model. *** denotes statistically significant at the 1% level, ** at the 5% level and * at the 10% level.*

The results of the Hausman test, to determine whether the fixed or random effects model is preferred, are shown in table 5.7.

Table 5.7
Hausman Test for Fixed or Random Effects

	Completed Deals	Failed Deals
Chi-squared	17.79	60.76
Probability > chi-squared	0.0228	0.0000

Thus, the null hypothesis for the completed and failed deals that both fixed and random effects estimators are consistent but fixed effects is inefficient can be rejected in favour of the alternate that the fixed effects estimator is consistent and efficient for both the completed and failed deals whereas the random effects estimator is inconsistent. Accordingly, only the fixed effects estimator, which reduces the risk of omitted variable bias, was employed in the subsequent analysis.

The results of the Breusch-Pagan test, to determine whether the errors are homoscedastic or heteroscedastic, are shown in table 5.8.

Table 5.8
Breusch-Pagan Test for Heteroscedasticity

	Completed Deals	Failed Deals
Chi-squared	2525.29	244.63
Probability > chi-squared	0.0000	0.0000

Hence, the null hypothesis of homoscedasticity (constant variance in the residuals) is strongly rejected in favour of the alternate that the residuals are heteroscedastic for both the completed and failed deals. To take account of this feature of the data and to improve the efficiency of the estimators, robust (heteroscedastic-consistent) standard errors were used in the subsequent analysis.

The results of the Wooldridge test, to determine whether the errors demonstrate serial correlation, are shown in table 5.9.

Table 5.9
Wooldridge Test for Serial Correlation (Data in Levels)

	Completed Deals	Failed Deals
F-statistic	55.184	103.758
Probability > F	0.0000	0.0005

With the data in levels, the null hypothesis of no first order autocorrelation in the residuals is strongly rejected for both the completed and failed deals. Accordingly, the estimates using data in levels are highly likely to be biased and inconsistent.

To correct for the serial correlation in the data in levels, the dependent and independent variables were lagged by up to 5 percentiles but no combination was found which reduced the F-statistic sufficiently to reject the null hypothesis for either the completed or the failed deals. Therefore, the first differences of the dependent variable and the non-dummy independent variables were tested for serial correlation for the completed and failed deals. The results are shown in table 5.10.

Table 5.10
Wooldridge Test for Serial Correlation (Data in First Differences)

	Completed Deals	Failed Deals
F-statistic	3.327	2.481
Probability > F	0.0781	0.1904

With the data in first differences, the null of no serial correlation in the residuals cannot be rejected for either the completed or failed deals at the 5% significance level.

As a result of these findings, the data were subsequently regressed using the fixed effects estimator with first-differenced non-dummy variables to correct for the serial correlation and with robust standard errors to take account of the heteroscedasticity. The completed and failed deals were estimated separately using the regression equation specified at 5.1.

$$dSPREAD_{it} = \alpha + \beta_{dAVB} \cdot dAVB_{it} + \beta_{dAVT} \cdot dAVT_{it} + \beta_{dPREM} \cdot dPREM_{it} + \beta_{dCASH} \cdot dCASH_{it} + \beta_{dIUT} \cdot dIUT_{it} + \beta_{RBT} \cdot RBT_{it} + \beta_{OBT} \cdot OBT_{it} + \beta_{REGC} \cdot REGC_{it} + \beta_{SAT} \cdot SAT_{it} + u_{it} \tag{5.1}$$

where:

dSPREAD is the differenced merger arbitrage spread

α is the constant

dAVB is the differenced abnormal trading volume in the bidder's shares

dAVT is the differenced abnormal trading volume in the target's shares

dPREM is the differenced bid premium

dCASH is the differenced percentage of consideration which is cash

dIUT is the differenced percentage of shares in target either owned by and/or pledged to the bidder

RBT is the recommended by the board of the target dummy variable (1 if so, 0 if not)

OBT is the other (potential or actual) bidder for target dummy variable (1 if so, 0 if not)

REGC is the all regulatory clearance(s) received dummy variable (1 if so, 0 if not)

SAT is the approval received from the target's shareholders dummy variable (1 if so, 0 if not)

u_{it} is the error term

The results of the regressions for the completed and failed deals are presented in table 5.11.

Table 5.11
Fixed Effects Panel Regression Results

Independent Variable	Completed Deals	Failed Deals
dAVB	0.0000 (0.0001)	0.0003 (0.0004)
dAVT	0.0000 (0.0000)	-0.0002 *** (0.0000)
dPREM	0.1068 *** (0.0189)	0.7044 ** (0.1869)
dCASH	0.3942 ** (0.1906)	-0.3109 (0.4804)
dIUT	-0.0594 *** (0.0185)	0.0130 (0.0291)
RBT	-0.0004 (0.0005)	-0.0024 (0.0096)
OBT	0.0012 (0.0015)	-0.0110 ** (0.0033)
REGC	-0.0018 * (0.0009)	-0.0054 * (0.0022)
SAT	0.0001 (0.0003)	0.0014 ** (0.0004)
Constant	0.0009 ** (0.0004)	0.0086 (0.0094)
Number of observations	3069	495
Number of panels (deals)	31	5
R^2 (overall)	0.0227	0.3568
F-statistic	1400.59 ***	-

Notes: *This table reports fixed effects regression results where the dependent variable is the first difference of the merger arbitrage spread. Robust standard errors of the parameter estimates are shown in parentheses. See equation 5.1 for variable definitions. *** denotes statistically significant at the 1% level, ** at the 5% level and * at the 10% level.*

5.4 Key Findings

It is first salient to note that hypotheses nine and ten were not testable as the time-invariant independent variables, size and run-up, are not estimated by the fixed effects model. For the remaining eight hypotheses, evidence was found to support 3 of these for the completed deals and 4 for the failed deals.

For the completed deals, the independent variables which relate to the change in the merger arbitrage spread as hypothesised at or above the 10% significance level are: i) an increase in the bid premium, supporting hypothesis two; ii) a decrease in the percentage of shares in the target owned by or pledged to the bidder, supporting hypothesis four; and iii) the avoidance or receipt of regulatory clearance, supporting hypothesis seven.

For the failed deals, the statistically significant independent variables as hypothesised are: i) a decrease in the abnormal trading volume in the target's shares, providing some support for hypothesis one; ii) an increase in the bid premium, supporting hypothesis two; iii) the presence of another bidder for the target, supporting non-directional hypothesis six; and iv) the avoidance or receipt of regulatory clearance, supporting hypothesis seven.

Accordingly, only hypotheses two (that higher bid premiums increase the merger arbitrage spread) and seven (that avoidance or receipt of regulatory approval for the deal reduces the spread) are well supported by the data for both the completed and failed deals. The significant and positive relationship between the spread and the bid premium on the spread accords with the findings of Jindra and Walkling (2004), Branch and Wang (2008), Wang (2017) and Redor (2019). The finding that the avoidance or receipt of regulatory clearance for the deal is significantly and negatively related with the spread is, however, novel as it has not previously been tested.

Hypotheses one (abnormally high trading volume in the shares of the bidder and the target reduce the merger arbitrage spread), four (higher levels of target shares that are either owned by or pledged to the bidder reduces the merger arbitrage spread) and six (the presence of a counter-bidder for the target causes the merger arbitrage spread to change) are partly supported by the data although this is by the completed or failed deals but not both.

Hypothesis three (a higher percentage of cash in the bidder's consideration reduces the merger arbitrage spread) is rejected by the data for completed deals as the coefficient is statistically significant at the 5% level yet positive rather than negative. For the failed deals it is negative, as expected, but insignificant. Similarly, hypothesis eight (the receipt of approval for the deal from the target's shareholders is negatively correlated with the merger arbitrage spread) is rejected by the data for failed deals as the coefficient is statistically significant at the 5% level yet positive rather than negative. For the completed deals it is also positive yet insignificant.

Conversely, no evidence is found to support hypothesis five (the recommendation from the board of directors of the target company to its shareholders to accept the bid). The coefficient is negative yet statistically insignificant for both the completed and failed deals.

Overall, the results of ascertaining the determinants of the merger arbitrage spread using the fixed effects model, having accounted for the heteroscedasticity and correcting for serial correlation found in the data, are plausible, if far from conclusive. Indeed, only two of the eight hypotheses which were testable (hypotheses two and seven) are supported by the data for both the completed and the failed deals.

However, the fixed effects estimator, by constraining the parameter coefficients and error variances to be the same across all deals, treats them as homogenous but the reality is that there may be significant differences between them and thus the estimates may be biased, particularly as the nature of the dataset is a long-narrow panel. In addition, the first differencing of variables to correct for the serial correlation in the data produces a model where the dependent variable is the change in the merger arbitrage spread which is less intuitively appealing than one where it is in levels. Furthermore, the results may be spurious unless evidence of cointegration is found. These limitations will be discussed in more detail and addressed in the next chapter.

Chapter 6 – The Determinants of the Merger Arbitrage Spread: Pooled Mean Group Panel Data Estimator and Robustness Checks

6.1 Introduction

This chapter first presents the results and then discusses the key findings of the regression using the dynamic panel ARDL model with the PMG estimator. It then proceeds to present the results of the robustness checks and concludes by considering their implications for the regression results.

6.2 Regression Results

As set out in chapter 4, and before the data can be regressed, tests for unit roots, evidence of cointegration and the optimal lags of each variable must be performed.

The results of Levin-Lin-Chu unit root tests, with up to 5 lags of each variable chosen such that the Akaike information criterion was minimised, for the completed and failed deals are shown in tables 6.1 and 6.2 respectively.

Table 6.1
Levin-Lin-Chu Unit Root Tests – Completed Deals

	Undifferenced		Differenced		
Variable	**Adjusted t-statistic**	**p-value**	**Adjusted t-statistic**	**p-value**	**Order of integration**
SPREAD	-1.4614	0.0720	-48.5708	0.0000	1
AVB	-30.6159	0.0000	-	-	0
AVT	-34.8563	0.0000	-	-	0
PREM	0.6097	0.7290	-41.0961	0.0000	1
CASH	7.6501	1.0000	-14.6674	0.0000	1
IUT	12.4919	1.0000	13.8938	1.0000	>1

Notes: *This table reports the panel unit root test results of the non-dummy variables for the completed deals. See equation 6.1 for variable definitions. The number of panels is 31 and the number of periods is 99 and 100 for the differenced and undifferenced data, respectively. The order of integration is shown at the 5% significance level.*

Accordingly, the independent variable which measures the percentage shareholding in the target which is either owned by or pledged to the bidder (IUT) was removed from the panel ARDL analysis for completed deals as it is not stationary in either levels or in first differences.

Table 6.2
Levin-Lin-Chu Unit Root Tests – Failed Deals

Variable	Undifferenced Adjusted t-statistic	Undifferenced p-value	Differenced Adjusted t-statistic	Differenced p-value	Order of Integration
SPREAD	-1.5704	0.0582	-20.5997	0.0000	1
AVB	0.1173	0.5467	8.4616	1.0000	>1
AVT	-5.0503	0.0000	-	-	0
PREM	-0.8480	0.1982	-12.7191	0.0000	1
CASH	2.6556	0.9960	-1.0106	0.1561	>1
IUT	15.2636	1.0000	-1.2248	0.1103	>1

Notes: *This table reports the panel unit root test results of the non-dummy variables for the failed deals. See equation 6.1 for variable definitions. The number of panels is 5 and the number of periods is 99 and 100 for the differenced and undifferenced data, respectively. The order of integration is shown at the 5% significance level.*

Accordingly, the independent variables which measure the abnormal trading volume in the bidder (AVB), the percentage of consideration which is cash (CASH) and the percentage shareholding in the target which is either owned by or pledged to the bidder (IUT) were removed from the panel ARDL analysis for failed deals as they are not stationary in either levels or in first differences.

The completed and failed deals were next tested for cointegration. The variables which were integrated of order zero (stationary in levels) or one (stationary in first differences) were tested together for a cointegrating long-run relationship using the Kao test and the results are shown in table 6.3.

Table 6.3
Kao Cointegration Tests

	Completed Deals		Failed Deals	
	Statistic	**p-value**	**Statistic**	**p-value**
Augmented Dickey-Fuller t	-7.0055	0.0000	0.8333	0.2023

Notes: *This table reports the panel cointegration test results for the completed deals (31 panels and 98 time periods) and the failed deals (5 panels and 98 time periods).*

Hence the null hypothesis of no cointegration can be rejected in favour of the alternate that all panels are cointegrated for completed deals whereas it cannot for the failed deals. Accordingly, a panel ARDL model could only be estimated for the completed deals.

The final test before the PMG estimation was to determine the optimal lag structure of each completed deal. The maximum number of lags for the non-dummy and dummy variables is set as 5 and 1 respectively and the modal optimal lag for each variable is shown in table 6.4 below.

Table 6.4
Optimal Lags – Completed Deals

Variable	SPREAD	AVB	AVT	PREM	CASH	RBT	OBT	REGC	SAT
Mode	3	0	0	0	0	0	0	0	0

Notes: *This table reports the modal optimal number of lags of each variable for the completed deal time-series. See equation 6.1 for variable definitions and appendix 6.1 for the detailed results.*

The optimal lag structure is therefore 3 lags for the dependent variable, the merger arbitrage spread (SPREAD) and zero lags for all of the independent variables. This specification of the re-parameterized ARDL dynamic panel model shown at equation 4.5 (shown below at 6.1 with the independent variables defined) was estimated using the PMG estimator.

$$\Delta y_{it} = \emptyset_i\left(y_{i,t-1} - \theta_i' \, x_{it}\right) + \sum_{j=1}^{p-1} \lambda_{ij}^* \, \Delta y_{i,t-1} + \sum_{j=0}^{q-1} \delta_{ij}'^* \, \Delta x_{i,t-j} + \mu_i + \varepsilon_{it} \qquad (6.1)$$

where:

y_{it} is the dependent variable, the merger arbitrage spread (SPREAD), for groups (deals) i = 1, 2,…,N in time periods (percentiles) t = 1, 2,…T

$\emptyset_i$ is the error-correcting speed of adjustment term

θ_i' is the vector of long run relationships between the dependent and independent variables

$\boldsymbol{x}_{it}$ is a k x 1 vector the following independent variables:

AVB is the abnormal trading volume in the bidder's shares

AVT is the abnormal trading volume in the target's shares

PREM is the bid premium

CASH is the percentage of consideration which is cash

IUT is the percentage of shares in target either owned by and/or pledged to the bidder

RBT is the recommended by board of target dummy variable

OBT is the other (potential or actual) bidder for target dummy variable

REGC is the all regulatory clearance(s) received dummy variable

SAT is the approval received from target's shareholders dummy variable

p-1 is the optimal lag length of the dependent variable (3)

λ_{ij} are the coefficients on the lagged dependent variables

q-1 is the optimal lag length of the independent variables (0)

δ'_{ij} are the coefficients on the lagged and unlagged independent variables

μ_i is the group specific (fixed) effect

ε_{it} is the error term

The results of the underlying, long-run, cointegrating element of equation 6.1 are shown in table 6.5.

Table 6.5
Panel ARDL Regression Results using the PMG estimator - Long-Run Estimates for Completed Deals

Independent Variable	Coefficient
AVB	-0.0008 (0.0007)
AVT	0.0001 (0.0001)
PREM	0.0464 *** (0.0114)
CASH	0.2134 *** (0.0695)
RBT	-0.0436 ** (0.0208)
OBT	-0.0645 *** (0.0173)
REGC	-0.0085 *** (0.0015)
SAT	-0.0084 *** (0.0013)
Speed of adjustment	-0.1524 *** (0.0280)
Number of observations	3007
Number of panels (deals)	31

Notes: *This table reports the long-run results of the panel ARDL regression using the PMG estimator where the dependent variable is the merger arbitrage spread. Standard errors of the parameter estimates are shown in parentheses. See equation 5.1 for variable definitions and appendix 6.2 for short-run results. *** denotes statistically significant at the 1% level, ** at the 5% level and * at the 10% level.*

6.3 Regression Key Findings

The initial noteworthy feature of the results shown in table 6.5 is that the speed of adjustment from short-run disequilibrium to long-run equilibrium is both negative and statistically significant at the 99% confidence level. This provides further confirmation that an underlying cointegrating relationship in the long run between the spread and the independent variables exists for the completed deals.

It is also mentionable that three of the ten hypotheses could not be tested using this methodology, namely hypothesis four, that higher levels of target shares that are either owned or pledged to the bidder reduces the spread; hypothesis nine, that the ratio of the bidder's equity market value to the target's equity market value reduces the spread; and hypothesis ten, that the run-up in the target's share price is negatively related to the spread.

Turning now to the seven hypotheses which were testable, those which use dummy variables to represent a point in time when an element of uncertainty over deal completion is resolved are all negative as hypothesised and statistically significant at above the 95% confidence level. Accordingly, the data strongly supports the following hypotheses:

- Five, that the recommendation from the board of directors of the target company to its shareholders to accept the bid reduces the spread;
- Six, that the presence of a counter bidder for the target causes the spread to change;

- Seven, that the avoidance or receipt of regulatory approval reduces the spread; and
- Eight, that the receipt of approval from the target's shareholders is negatively correlated with the spread.

As this research is the first to consider such variables, these results are original. Furthermore, they lend considerable support to the assertion that the UK equity market is informationally efficient. This is particularly the case for hypotheses seven and eight because these relate to the regulatory requirements for a deal to complete thus receipt of each approval reduces uncertainty which is rationally reflected in a lower spread.

In addition, hypothesis two, that higher bid premiums increase the spread, is also strongly supported by the data which accords with the findings of Jindra and Walkling (2004), Branch and Wang (2008), Wang (2017) and Redor (2019).

However, no evidence is found to support hypothesis one, that abnormally high trading volume in the shares of the bidder and the target reduce the spread. This is contrary to the findings from the US of Jetley and Ji (2010) and Wang (2017) and may, therefore, be a feature of merger arbitrage in the UK.

Lastly, hypothesis three, that a higher percentage of cash in the bidder's consideration reduces the spread, is not supported by the data. Rather, the coefficient is positive and statistically significant at the 99% confidence level. Although the extant research, for instance Redor (2019), has only found evidence that the spread in deals where both cash and shares are offered tends to be lower than in deals where only cash is offered, the finding is nonetheless unexpected as it is presumed that shareholders in the target prefer the certainty of cash over other forms of consideration. Whilst this may also be a feature of merger arbitrage in the UK, an alternative and perhaps more plausible explanation is that the proportion of cash in the bidder’s consideration is interpreted as a signal that it has lower confidence in the ultimate success of the deal. Accordingly, a higher proportion of cash thus contributes to increased deal completion risk. If this is the case, the increase in deal completion risk appears to more than offset the assumed preference of the target’s shareholders for cash consideration.

In summary, and because evidence of a cointegrating relationship was found in the data for the completed deals, the use of the panel ARDL model with the PMG estimator offers considerable advantages over the use of the traditional estimators in ascertaining the significant determinants of the merger arbitrage spread. However, the degree of confidence which may be placed in the results is dependent upon the results of the robustness checks.

6.4 Robustness Check Results

As explained in chapter 4, VECMs using the formula at 4.6 were estimated for a sub-sample of completed deals using both standardised time (percentiles) and natural time (hours). This formula, with the independent variables defined, is shown below at equation 6.2.

$$\Delta y_t = \sum_{j=1}^{p} \alpha \Delta y_{t-j} + \sum_{j=0}^{p} \delta_i \Delta \boldsymbol{x}_{t-j} + \varphi z_{t-1} + \mu + \varepsilon_t \qquad (6.2)$$

where:

y_t is the dependent variable, the merger arbitrage spread (SPREAD)

α is the short-run coefficient on the dependent variable at the j'th lag

δ_i is a matrix of short-run coefficients on the independent variables at the j'th lag

$\boldsymbol{x}_t$ is a matrix of the following independent variables:

- AVB, the abnormal trading volume in the bidder's shares
- AVT, the abnormal trading volume in the target's shares
- PREM, the bid premium
- CASH, the percentage of consideration which is cash
- IUT, the percentage of target shares which are owned by or pledged to the bidder
- RBT, the recommended by the board of the target dummy
- OBT, the other bid (potential or actual) for target dummy
- REGC, the all regulatory clearance(s) received dummy
- SAT, the approval from target's shareholders dummy

φ is the long-run speed of adjustment factor

z_{t-1} is the error correction term which is equal to $y_{t-j} - \beta_0 - \beta_1 \boldsymbol{x}_{t-j}$ where:

β_0 is a matrix of constants

β_1 is a matrix of long-run coefficients on the independent variables at the j'th lag

μ is a constant

ε_t is the residual term

The randomly selected sub-sample of individual completed deals is as follows:

Bidder	Target
Royal Dutch Shell	British Gas
Tesco	Booker
Babcock International	VT Group
WPP	Taylor Nelson Sofres
Greene King	Spirit

Table 6.6 below compares the coefficients in the long run cointegrating equation between the panel ARDL and the sub-sample of individual deals where time is standardised in percentiles.

Table 6.6
Comparison of Panel ARDL and Individual VECM Results in Percentiles

Variable	Panel ARDL	Individual Deal VECMs				
		RDSB-BG	TSCO-BOK	BAB-VTG	WPP-TNS	GNK-SPRT
AVB	-0.0008 (0.0007)	0.1302*** (0.0206)	-	-	-	-
AVT	0.0001 (0.0001)	-	-	-	-	-
PREM	0.0464*** (0.0114)	0.1534* (0.0881)	-1.0304*** (0.2533)	0.5308*** (0.1116)	0.5578 (0.6123)	0.9726*** (0.2134)
CASH	0.2134*** (0.0695)	0.0387 (0.1017)	0.4724*** (0.1165)	-0.0611** (0.0271)	-0.0133 (0.0750)	0.7896*** (0.1685)
IUT	-	-	-	-	0.8423*** (0.1873)	-
RBT	-0.0436** (0.0208)	-	-	-	-	-
OBT	-0.0645*** (0.0173)	-	-	-	-	-
REGC	-0.0085*** (0.0015)	-0.1301*** (0.0334)	0.0796** (0.0386)	-0.0343*** (0.0116)	-0.4922*** (0.0806)	-0.0051 (0.0284)
SAT	-0.0084*** (0.0013)	-0.2262*** (0.0444)	-	-0.0177** (0.0075)	-0.3109** (0.1250)	-0.1200*** (0.0250)
Speed of adjustment	-0.1524*** (0.0280)	0.0089 (0.0256)	0.0067 (0.0222)	-0.0054 (0.0249)	-0.0083 (0.0159)	-0.0637*** (0.0227)

Notes: *This table compares the long-run results of the panel ARDL and individual VECMs where the dependent variable is the merger arbitrage spread and time is standardised in percentiles. See equation 6.2 for variable definitions. Standard errors are shown in parentheses. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. Blanks denote variables which for which there are no data, are time invariant or are not stationary in first differences.*

Figures 6.1 to 6.5 depict the evolution of the merger arbitrage spread for deals in standardised time (percentiles) and natural time (hours) for comparative purposes. Tables 6.7 to 6.11 present the salient results of the VECMs for the same.

Figure 6.1
Merger Arbitrage Spread Evolution: Royal Dutch Shell – British Gas

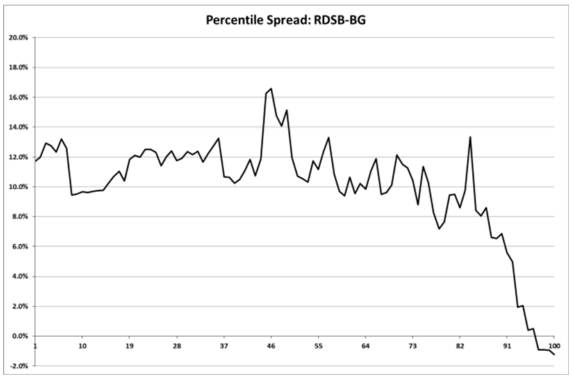
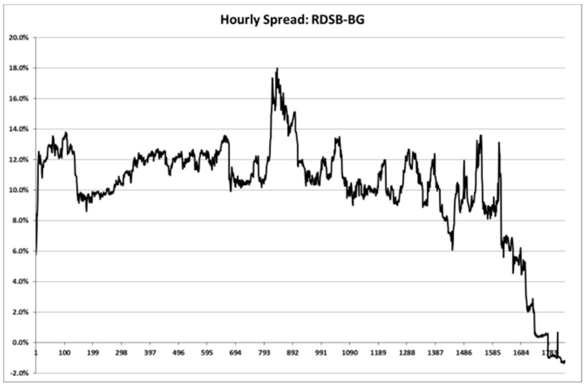
Percentiles	Hours
	

Table 6.7
Vector Error Correction Model Results: Royal Dutch Shell – British Gas

Independent Variable	Percentiles		Hours	
	Order of Integration	Long-run Coefficient	Order of Integration	Long-run Coefficient
AVB	1	0.1302 *** (0.0206)	0	-
PREM	1	0.1534 * (0.0881)	1	0.1299 *** (0.0406)
CASH	1	0.0387 (0.1017)	1	0.2352 *** (0.0397)
REGC	1	-0.1301 *** (0.0334)	1	-0.0220 (0.0143)
SAT	1	-0.2262 *** (0.0444)	1	-0.0930 *** (0.0193)
Optimal lags	1		2	
Cointegrating equations	1		1	
Speed of adjustment	0.0089 (0.0256)		-0.0120 *** (0.0039)	

Notes: *This table shows the long-run results of the vector error correction model where the dependent variable is the merger arbitrage spread. Standard errors are shown in parentheses. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. Order of integration determined using the Augmented Dickey-Fuller test for presence of a unit root. Optimal lags chosen using the Schwartz Bayesian information criterion. Number of cointegrating equations determined using the Johansen test. See equation 6.2 for variable definitions. Refer to appendix 6.3 for short-run coefficients.*

Figure 6.2
Merger Arbitrage Spread Evolution: Tesco – Booker

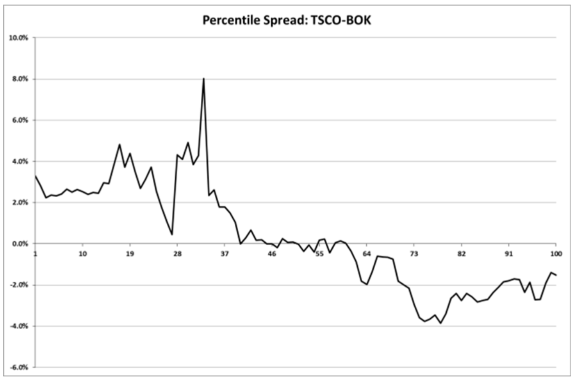
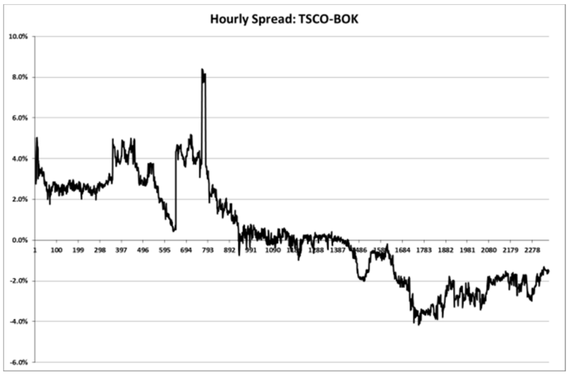
Percentiles	Hours
	

Table 6.8
Vector Error Correction Model Results: Tesco – Booker

Independent Variable	Percentiles		Hours	
	Order of Integration	Long-run Coefficient	Order of Integration	Long-run Coefficient
PREM	1	-1.0304 *** (0.2533)	1	-0.8564 *** (0.2497)
CASH	1	0.4724 *** (0.1165)	1	0.3865 *** (0.1171)
REGC	1	0.0796 ** (0.0386)	1	0.0644 * (0.0388)
SAT	-	-	1	-0.1511 (0.1278)
Optimal lags	1		3	
Cointegrating equations	1		1	
Speed of adjustment	0.0067 (0.0222)		-0.0009 (0.0012)	

Notes: *This table shows the long-run results of the vector error correction model where the dependent variable is the merger arbitrage spread. Standard errors are shown in parentheses. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. Order of integration determined using the Augmented Dickey-Fuller test for presence of a unit root. Optimal lags chosen using the Schwartz Bayesian information criterion. Number of cointegrating equations determined using the Johansen test. See equation 6.2 for variable definitions. Refer to appendix 6.3 for short-run coefficients.*

Figure 6.3
Merger Arbitrage Spread Evolution: Babcock – VT Group

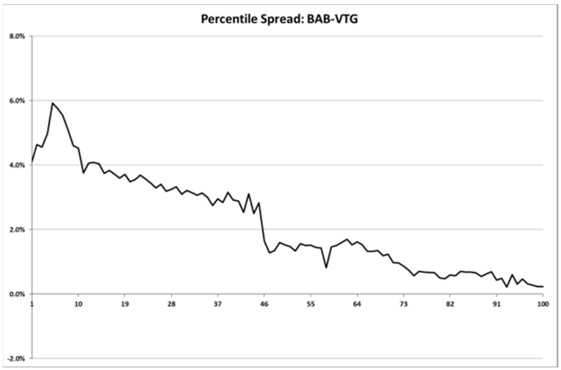
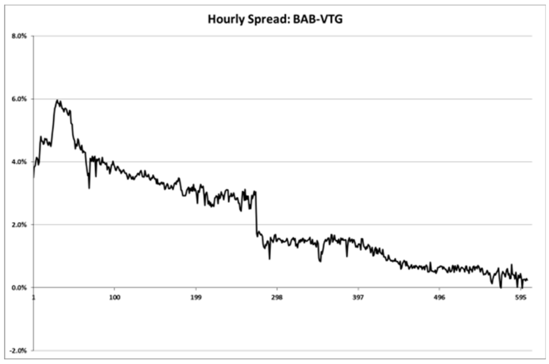
Percentiles	Hours
	

Table 6.9
Vector Error Correction Model Results: Babcock – VT Group

Independent Variable	Percentiles: Order of Integration	Percentiles: Long-run Coefficient	Hours: Order of Integration	Hours: Long-run Coefficient
PREM	1	0.5308 *** (0.1116)	1	0.5737 *** (0.1468)
CASH	1	-0.0611 ** (0.0271)	1	-0.0778 ** (0.0357)
REGC	1	-0.0343 *** (0.0116)	1	-0.0404 *** (0.0149)
SAT	1	-0.0177 ** (0.0075)	1	-0.0141 (0.0096)
Optimal lags	1		1	
Cointegrating equations	1		1	
Speed of adjustment	-0.0054 (0.0249)		-0.0028 (0.0051)	

Notes: *This table shows the long-run results of the vector error correction model where the dependent variable is the merger arbitrage spread. Standard errors are shown in parentheses. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. Order of integration determined using the Augmented Dickey-Fuller test for presence of a unit root. Optimal lags chosen using the Schwartz Bayesian information criterion. Number of cointegrating equations determined using the Johansen test. See equation 6.2 for variable definitions. Refer to appendix 6.3 for short-run coefficients.*

Figure 6.4
Merger Arbitrage Spread Evolution: WPP – Taylor Nelson Sofres

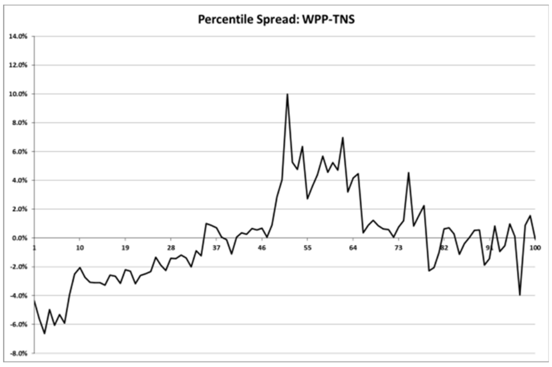
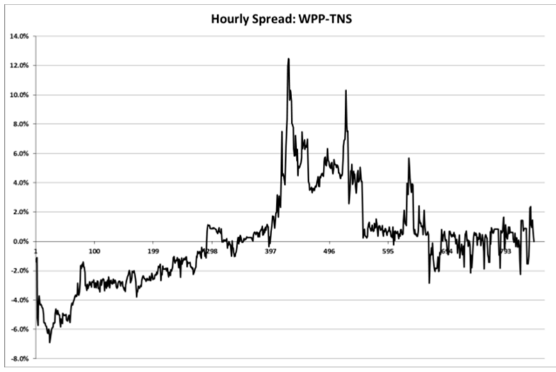
Percentiles	Hours
	

Table 6.10
Vector Error Correction Model Results: WPP – Taylor Nelson Sofres

Independent Variable	Percentiles		Hours	
	Order of Integration	Long-run Coefficient	Order of Integration	Long-run Coefficient
PREM	1	0.5578 (0.6123)	1	0.0313 (0.3606)
CASH	1	-0.0133 (0.0750)	1	-0.0445 (0.0443)
IUT	1	0.8423 *** (0.1873)	1	0.3408 *** (0.1073)
REGC	1	-0.4922 *** (0.0806)	1	-0.1553 *** (0.0436)
SAT	1	-0.3109 ** (0.1250)	1	-0.1345 * (0.0721)
Optimal lags	1		1	
Cointegrating equations	2		2	
Speed of adjustment	-0.0083 (0.0159)		-0.0074 * (0.0042)	

Notes: *This table shows the long-run results of the vector error correction model where the dependent variable is the merger arbitrage spread. Standard errors are shown in parentheses. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. Order of integration determined using the Augmented Dickey-Fuller test for presence of a unit root. Optimal lags chosen using the Schwartz Bayesian information criterion. Number of cointegrating equations determined using the Johansen test. See equation 6.2 for variable definitions. Refer to appendix 6.3 for short-run coefficients.*

Figure 6.5
Merger Arbitrage Spread Evolution: Greene King - Spirit

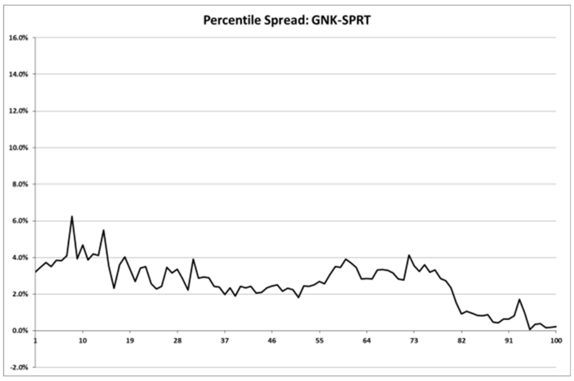
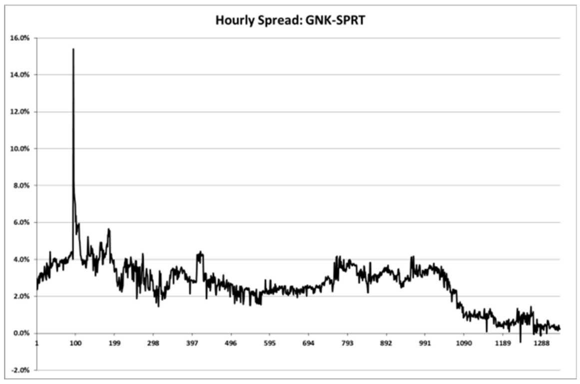
Percentiles	**Hours**
	

Table 6.11
Vector Error Correction Model Results: Greene King – Spirit

Independent Variable	**Percentiles**		**Hours**	
	Order of Integration	**Long-run Coefficient**	**Order of Integration**	**Long-run Coefficient**
PREM	1	0.9726 *** (0.2134)	1	0.0969 (0.0642)
CASH	1	0.7896 *** (0.1685)	1	0.6178 *** (0.0520)
REGC	1	-0.0051 (0.0284)	1	-0.0194 ** (0.0082)
SAT	1	-0.1200 *** (0.0250)	1	-0.0194 *** (0.0075)
Optimal lags	1		2	
Cointegrating equations	1		2	
Speed of adjustment	-0.0637 *** (0.0227)		-0.0614 *** (0.0125)	

Notes: *This table shows the long-run results of the vector error correction model where the dependent variable is the merger arbitrage spread. Standard errors are shown in parentheses. *** denotes significance at the 1% level, ** at the 5% level and * at the 10% level. Order of integration determined using the Augmented Dickey-Fuller test for presence of a unit root. Optimal lags chosen using the Schwartz Bayesian information criterion. Number of cointegrating equations determined using the Johansen test. See equation 6.2 for variable definitions. Refer to appendix 6.3 for short-run coefficients.*

6.5 Robustness Check Key Findings

The primary aspects of the results presented in table 6.6 are as follows:

a) The panel ARDL model, which can include variables which are either stationary in levels or in first differences, estimates eight of the nine independent variables whereas the VECM can only include variables which are integrated of order one. Thus, there are fewer independent variables estimated for the individual deals, ranging between three and five;

b) The speed of adjustment term for the panel ARDL is negative, as expected, and significant at the 99% level. However, it is only negative for three of the five individual deals and only significant at the 99% level for one, Greene King – Spirit; and

c) Only one of the independent variables, the approval by the target's shareholders (SAT), has the same sign for the panel ARDL and the individual deals VECMs. For the other independent variables, at least one of the individual deals has the opposite sign to the typical deals, estimated with the panel ARDL model.

Accordingly, the relationship, typical for the sample of completed deals as a whole, does not consistently hold for specific deals. The deals are, therefore, sufficiently heterogeneous to merit the use of the PMG estimator for the panel ARDL model to ascertain the general relationship between the merger arbitrage spread and its determinants.

However, the key finding for the purposes of this thesis is consistently demonstrated in tables 6.7 to 6.11. This is that the signs on the coefficients for the VECMs in percentiles are the same in hours in all cases where both could be estimated. This finding provides evidence that the use of percentiles rather than hours does not significantly affect the conclusions drawn and thus underpins the innovative use of standardised rather than natural time in the panel ARDL model using the PMG estimator. Accordingly, confidence may be placed in the significant determinants of the merger arbitrage spread which it has ascertained.

Chapter 7 – Summary and Conclusion

7.1 Summary of Findings

The primary research question which this thesis has sought to answer is what are the statistically significant determinants of the merger arbitrage spread in the UK equity market? Further, and because of the panel data approach taken and time varying nature of a number of the potential determinants tested, the ancillary research questions are: i) is the UK equity market informationally efficient?; and ii) is the return to merger arbitrage in the UK compensation for bearing unsystematic risk?

The literature reviewed in chapter 2 regarding the risk return trade-off, market efficiency, limits of arbitrage and the risk of and returns to merger arbitrage suggests that: i) the UK equity market is likely to be reasonably but not perfectly informationally efficient; and ii) merger arbitrageurs taking positions in UK M&A transactions are likely to be rewarded, via the spread, for bearing undiversifiable deal completion risk only.

The extant empirical research reviewed in chapter 3 to develop testable hypotheses fell into two main categories. Firstly, the factors which effect the probability of deal completion, as a proxy for deal completion risk. These studies all take a cross-sectional approach and employ multivariate logistic regression. Secondly, the determinants of the spread itself using multivariate linear regression but again on a cross-sectional basis. These studies, in addition to providing guidance on the hypotheses to be tested and the data to be collected for this thesis, also revealed a number of significant research gaps.

First, all of the extant research has been performed on a cross-sectional basis at a fixed point in time, no study has taken a panel data approach which estimates the determinants for a number of deals over the entire offer period. Second, all of the studies included cash-only deals in their samples. Such deals only involve taking a long position in the target company and do not, therefore, meet the definition of arbitrage. Third, the geographical focus of the studies has been on US M&A transactions.

Accordingly, and to address these gaps in the literature, minute-by-minute data was obtained for a sample of 36 UK M&A transactions over the 18 years from the start of 2000 to the end of 2017. This data enabled the calculation of the spread and a number of its hypothesised determinants (e.g., the abnormal trading volume in the shares of the bidder and the target, the bid premium, the percentage of target shares either owned or pledged to the bidder and also the percentage of the consideration offered by the bidder which is cash). Similarly, it enabled the construction of time series of independent variables which relate to the announcement of hurdles required for a deal to complete in the UK (e.g., the recommendation by the directors of the target company that their shareholders accept the bidder's offer, the receipt of regulatory approval for the deal and, ultimately, the receipt of approval for the transaction from the target's shareholders). If it was found that these latter determinants were statistically significant and negatively related to the spread then this would provide evidence for the ancillary research questions relating to market efficiency and nature of the risk borne.

The constructed dataset was an unbalanced panel because the duration of each deal was different thus limiting the range of estimators which could be used to regress it. To solve this problem, an innovative approach was taken to construct a balanced panel by converting the data from natural time (in minutes) to standardised time (in percentiles of the offer period). If the conclusions drawn from the regressions were found to be robust to the use of standardised rather than natural time, this methodological innovation would represent an additional contribution to knowledge.

The regression results using the traditional panel data estimators were plausible yet far from conclusive. However, and because evidence of a cointegrating relationship was found for the completed deals (which account for 31 of the sample of 36 deals), the regression results using the dynamic panel autoregressive distributed lag model together with the pooled mean group estimator of Pesaran et al. (1999), which disaggregates the underlying relationship between the spread and its determinants from the short-run disequilibrium via an error correction mechanism, were broadly as hypothesised.

The bid premium was found to be statistically significant and positively related to the spread, as hypothesised and in accordance with the bulk of the extant empirical research on the determinants of the spread in the US market (i.e., Jindra and Walkling 2004; Redor 2019). Conversely, the percentage of consideration which is cash was hypothesised to be negatively related to the spread as target shareholders are presumed to prefer the certainty of cash but the data shows that it is positively and significantly related. One potential explanation for this finding is that the proportion of cash in the bidder's consideration may be interpreted as a signal that it has lower confidence in the ultimate success of the deal and thus it contributes to increased deal completion risk. If this is the case, the increase in deal completion risk appears to more than offset the assumed preference of the target's shareholders for cash consideration. Neither the abnormal volumes in the shares traded in the bidder or the target, as proxies for merger arbitrage activity, were found to be significant determinants of the spread.

However, and of particular importance is the finding that the spread is negatively and statistically significantly related to the variables relating to the announcement of information which resolves deal completion uncertainty. As this is the first empirical merger arbitrage study which has tested potential determinants of this nature, these findings provide strong and original evidence that the UK equity market is informationally efficient and that the returns to merger arbitrage are compensation for bearing unsystematic risk. Furthermore, the results of the robustness checks provide assurance that the innovative standardisation of time to create a balanced panel dataset does not significantly affect the inferences drawn from the regressions.

7.2 Conclusions

This thesis has filled a number of the gaps in the literature by investigating the significant determinants of the merger arbitrage spread using a relatively recent sample of non-US (UK) M&A transactions over the whole deal period rather than on a purely cross-sectional basis by taking a panel data approach.

To answer the primary research question, the statistically significant determinants of the merger arbitrage spread in the UK have been found to be the: i) bid premium; ii) percentage of cash consideration; iii) hostility; iv) presence of a counterbidder; v) regulatory clearance; and vi) approval by target's shareholders. With respect to the ancillary research questions, it appears that the UK equity market is informationally efficient and that the returns to merger arbitrage in the UK are compensation for bearing unsystematic risk only.

Furthermore, and in addition to these contributions to empirical knowledge, methodological knowledge has also been advanced by the finding that standardising time to create balanced panel datasets does not significantly affect the inferences drawn from the regressions using dynamic panel models and powerful estimators.

7.3 Limitations and Recommendations

In common with empirical studies in the finance field, this doctoral research is subject to several limitations. Accordingly, some caution is suggested when interpreting the results. These limitations are: i) the use of abnormal trading volume as a proxy for merger arbitrageur activity due to the unavailability of information specifying the ultimate buyers and sellers of shares traded on the UK equity market; ii) the relatively small number of transactions in the sample, particularly for failed deals, although this was unavoidable as the intra-day price data was not available prior to 1st January 2000; iii) the inability to estimate the panel ARDL model for the failed deals with the PMG estimator due to the absence of a cointegrating relationship and; iv) the inclusion of stale merger arbitrage spreads in the sample as the panel data regressions would not be possible with missing data. However, this latter problem has been mitigated by the omission from the sample of transactions where the bidder and target shares trade together in less than one per cent of the minutes of the deal period.

For future research, the panel data approach using standardised time in percentiles, the dynamic ARDL model and the PMG estimator may be replicated to merger arbitrage in countries other the UK or, indeed, to cross-border transactions. The methodology may also be adopted to investigate other financial datasets, particularly those where arbitrage is known or expected to take place. In addition, and whilst not considered in this thesis, it may be possible for merger arbitrageurs to use the short-run error correction coefficients to improve their profitability by trading the spread when it deviates from the underlying equilibrium level. Further, and with a larger sample, it may be possible to use the volatility of the spread in standardised time as a basis for differentiation between those deals which are likely to complete and those which are likely to fail.

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Appendix 4.1
Sample of Transactions

#	Bidder	Target	Deal Value (£m)	Consideration Offered	Outcome	Duration (Minutes)	Minutes When Both Trade
1	Royal Dutch Shell	BG Group	39,355	Shares	Completed	110,190	91.8%
2	Glencore International	Xstrata	20,451	Shares	Completed	157,620	87.5%
3	Lloyds Banking Group	HBOS	14,769	Shares	Completed	41,430	78.2%
4	Melrose	GKN	8,061	Cash & shares	Completed	43,350	70.8%
5	Aviva	Friends Life Group	5,208	Shares	Completed	44,400	65.5%
6	Standard Life	Resolution	4,908	Cash & shares	Withdrawn	8,160	53.3%
7	Resolution	Friends Provident	4,223	Shares	Withdrawn	34,170	53.5%
8	Standard Life	Aberdeen Asset Management	3,776	Shares	Completed	56,610	60.8%
9	Tesco	Booker	3,649	Cash & shares	Completed	141,300	51.6%
10	Hammerson	Intu Properties	3,440	Shares	Withdrawn	48,240	57.7%
11	John Wood Group	Amec Foster Wheeler	3,250	Shares	Completed	73,950	51.2%
12	Taylor Woodrow	George Wimpey	2,749	Shares	Completed	33,660	49.1%
13	Barratt Developments	Wilson Bowden	2,200	Cash & shares	Completed	27,540	28.9%
14	Carphone Warehouse Group	Dixons Retail	1,860	Shares	Completed	29,580	27.5%
15	Derwent Valley Holdings	London Merchant Securities	1,500	Shares	Completed	26,550	13.3%
16	Babcock International Group	VT Group	1,326	Cash & shares	Completed	36,210	27.4%
17	WPP	Taylor Nelson Sofres	1,081	Cash & shares	Completed	50,490	32.6%
18	AG Barr	Britvic	855	Shares	Withdrawn	31,650	5.8%
19	Greene King	Spirit Pub Company	759	Cash & shares	Completed	80,100	18.2%
20	Just Retirement Group	Partnership Assurance Group	663	Shares	Completed	82,650	2.3%
21	Carillion	Alfred McAlpine	572	Cash & shares	Completed	20,940	29.3%

22	Travis Perkins	The BSS Group	558	Cash & shares	Completed	58,140	11.3%
23	Melrose	FKI	478	Cash & shares	Completed	23,970	11.8%
24	Vectura Group	Skyepharma	441	Shares	Completed	29,580	12.0%
25	Ophir Energy	Salamander Energy	412	Shares	Completed	33,690	14.1%
26	RPC Group	British Polythene Industries	330	Cash & shares	Completed	18,870	5.8%
27	Investec	Kensington Group	283	Cash & shares	Completed	25,500	24.2%
28	Investec	The Evolution Group	233	Shares	Completed	37,740	13.1%
29	Kier Group	May Gurney Integrated Services	221	Cash & shares	Completed	24,990	5.7%
30	Premier Oil	Encore Oil	221	Shares	Completed	33,180	19.9%
31	Investec	Rensburg Sheppards	218	Shares	Completed	30,090	5.4%
32	BTG	Protherics	218	Shares	Completed	28,050	3.1%
33	London & Stamford Property	Metric Property Investments	209	Shares	Completed	25,530	3.0%
34	Costain Group	May Gurney Integrated Services	178	Cash & shares	Withdrawn	10,110	2.8%
35	BTG	Biocompatibles International	169	Cash & shares	Completed	22,980	2.1%
36	Segro	Brixton	114	Shares	Completed	16,320	11.5%

Appendix 6.1

Optimal Lag Structure in Panel ARDL Model

Deal #	SPREAD	AVB	AVT	PREM	CASH	RBT	OBT	REGC	SAT
1	3	4	0	4	4	-	-	0	-
2	1	0	0	0	-	-	-	0	-
3	5	0	5	4	-	-	-	0	1
4	5	0	5	0	4	1	1	0	-
5	3	5	0	1	-	-	-	0	-
8	1	5	0	1	-	-	-	0	-
9	2	0	0	0	0	-	-	0	-
11	4	0	0	0	0	-	-	0	-
12	3	1	0	0	-	-	-	0	0
13	3	1	0	0	0	-	-	0	0
14	1	4	3	5	-	-	-	1	-
15	3	2	4	1	-	-	-	0	0
16	3	2	4	1	1	-	-	0	0
17	3	1	4	0	0	0	0	0	-
19	3	0	4	0	0	-	0	0	-
20	2	0	4	0	-	-	-	1	-
21	3	1	0	2	2	-	-	0	0
22	1	0	0	0	0	-	-	-	-
23	5	5	1	4	0	-	-	0	-
24	3	0	5	3	-	-	-	0	-
25	5	1	0	0	-	-	-	0	-
26	1	0	5	2	0	-	-	1	0
27	3	0	0	2	2	-	-	-	0
28	2	0	4	1	-	-	-	0	1
29	3	3	5	3	2	-	-	0	0
30	5	0	0	3	-	0	-	-	0
31	1	3	0	0	-	-	-	0	0
32	1	0	0	1	-	-	-	-	0
33	2	0	0	1	-	-	-	-	0
35	2	0	2	4	4	-	-	-	-
36	3	2	0	2	-	-	-	-	0
Mode	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Note: *deal numbers 6, 7, 10, 18 and 34 are excluded as these are the failed deals in the sample.*

Appendix 6.2

Short-run Coefficients in Panel ARDL model

Variable	Coefficient
dSpread (lag 1)	-0.2495 *** (0.0338)
dSpread (lag 2)	-0.1273 *** (0.0319)
dAVB	0.0025 (0.0025)
dAVT	-0.0019 (0.0021)
dPREM	0.0078 (0.0684)
dCASH	-0.0592 (0.1544)
dRBT	-0.0012 (0.0017)
dOBT	-0.0006 (0.0005)
dREGC	-0.0042 (0.0029)
dSAT	-0.0059 ** (0.0028)
Constant	0.0049 * (0.0026)

Notes: *This appendix reports the short-run coefficients of the panel ARDL model estimated with the PMG estimator. See equation 5.1 for variable definitions. Standard error of the parameter estimates are shown in percentiles. *** denotes statistically significant at the 1% level, ** at 5% and * at 10%.*

Appendix 6.3

Vector Error Correction Model Short-Run Coefficients

Royal Dutch Shell – British Gas		Time in	
Variable	**Lag**	**Percentiles**	**Hours**
Spread (dependent)	1	-0.0930 (0.1142)	-0.0471 ** (0.0245)
	2	-	0.0194 (0.0244)
AVB (independent)	1	0.0006 (0.0026)	-
	2	-	-
PREM (independent)	1	-0.5728 (0.4141)	-0.0643 (0.0530)
	2	-	0.0161 (0.0529)
CASH (independent)	1	-1.8469 (1.4771)	-0.0504 (0.1790)
	2	-	0.0660 (0.1784)
REGC (independent)	1	-0.0082 (0.0142)	0.0088 *** (0.0034)
	2	-	-0.0010 (0.0034)
REGC (independent)	1	-0.0021 (0.0145)	0.0021 (0.0034)
	2	-	-0.0005 (0.0034)

Notes: *This table reports the short-run VECM coefficients where the dependent variable is the merger arbitrage spread. Independent variable definitions are shown at equation 6.1. Standard errors are shown in parentheses. *** denotes significant at the 1% level, ** at 5% and * at 10%.*

Tesco - Booker		**Time in**	
Variable	**Lag**	**Percentiles**	**Hours**
Spread (dependent)	1	-0.2906 (0.1010)	-0.1524 *** (0.0208)
	2	-	-0.0490 ** (0.0210)
	3	-	-0.0217 (0.0206)
PREM (independent)	1	-0.1674 *** (0.3409)	-0.0515 * (0.0300)
	2	-	-0.0438 (0.0330)
	3	-	-0.0162 (0.0300)
CASH (independent)	1	-0.9549 (1.7632)	-0.1408 (0.1464)
	2	-	-0.1420 (0.1641)
	3	-	-0.1479 (0.1463)
REGC (independent)	1	-0.0008 (0.0091)	0.0036 (0.0025)
	2	-	-0.0006 (0.0025)
	3	-	0.0010 (0.0025)
SAT (independent)	1	-	-0.0009 (0.0025)
	2	-	-0.0002 (0.0025)
	3	-	-0.0003 (0.0025)

Notes: *This table reports the short-run VECM coefficients where the dependent variable is the merger arbitrage spread. Independent variable definitions are shown at equation 6.1. Standard errors are shown in parentheses. *** denotes significant at the 1% level, ** at 5% and * at 10%.*

Babcock - VT Group		**Time in**	
Variable	**Lag**	**Percentiles**	**Hours**
Spread (dependent)	1	-0.1573 (0.1061)	-0.2070 *** (0.0402)
PREM (independent)	1	-0.2500 (0.2782)	-0.0271 (0.0634)
CASH (independent)	1	-0.6488 (0.6516)	-0.1531 (0.1441)
REGC (independent)	1	0.0004 (0.0028)	-0.0012 (0.0016)
SAT (independent)	1	-0.0003 (0.0027)	-0.0000 (0.0016)

Notes: *This table reports the short-run VECM coefficients where the dependent variable is the merger arbitrage spread. Independent variable definitions are shown at equation 6.1. Standard errors are shown in parentheses. *** denotes significant at the 1% level, ** at 5% and * at 10%.*

WPP - Taylor Nelson Sofres		**Time in**	
Variable	**Lag**	**Percentiles**	**Hours**
Spread (dependent)	1	-0.3064 *** (0.1114)	-0.0844 * (0.0042)
PREM (independent)	1	0.1390 (1.1954)	-0.4410 (0.2742)
CASH (independent)	1	0.1490 (1.7556)	-0.6072 (0.3982)
IUT (independent)	1	-0.0066 (0.0499)	0.0039 (0.184)
REGC (independent)	1	0.0014 (0.0187)	-0.0080 (0.0065)
SAT (independent)	1	0.0031 (0.0188)	-0.0183 ** (0.0073)

Notes: *This table reports the short-run VECM coefficients where the dependent variable is the merger arbitrage spread. Independent variable definitions are shown at equation 6.1. Standard errors are shown in parentheses. *** denotes significant at the 1% level, ** at 5% and * at 10%.*

Greene King - Spirit		**Time in**	
Variable	**Lag**	**Percentiles**	**Hours**
Spread (dependent)	1	-0.2824 *** (0.0932)	-0.4333 *** (0.0277)
	2	-	-0.2118 *** (0.0270)
PREM (independent)	1	-0.0255 (0.0989)	0.0334 (0.0398)
	2	-	0.0420 (0.0398)
CASH (independent)	1	-0.0566 (1.5900)	-0.0115 (0.4136)
	2	-	0.7604 * (0.4130)
REGC (independent)	1	0.0010 (0.0058)	-0.0063 (0.0044)
	2	-	0.0031 (0.0044)
SAT (independent)	1	0.0204 *** (0.0060)	0.0003 (0.0043)
	2	-	0.0003 (0.0043)

Notes: *This table reports the short-run VECM coefficients where the dependent variable is the merger arbitrage spread. Independent variable definitions are shown at equation 6.1. Standard errors are shown in parentheses. *** denotes significant at the 1% level, ** at 5% and * at 10%.*